FIVE ESTUARIES OFFSHORE WIND FARM

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

VOLUME 2, CHAPTER 6: FISH AND SHELLFISH ECOLOGY

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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. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.
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.
Substation search area	The search area in which the final OnSS construction compound footprint and the final OnSS will be located.
Substation zone	The area in which the final onshore substation (OnSS) footprint will be located. The footprint will be confirmed between PEIR and ES.
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.

Term	Definition
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
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
PSA	Particle size analysis
RIAA	Report to Inform Appropriate Assessment

Term	Definition
RMS	Root Mean Square
RLB	Red Line Boundary
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
VE OWFL	Five Estuaries Offshore Wind Farm Limited
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 Offshore Wind Farm (hereafter referred to as VE) on fish and shellfish receptors.

6.1.2 This chapter has been informed by the following PEIR chapters:

- Volume 2, Chapter 1: Offshore Project Description;
- Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes;
- Volume 2, Chapter 3: Marine Water and Sediment Quality;
- Volume 2, Chapter 5: Benthic and Intertidal Ecology;
- Volume 2, Chapter 8: Commercial Fisheries;
- Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report;
- Volume 4, Annex 6.2: Underwater Noise Technical Report; and
- Volume 4, 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 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 (VE OWFL) 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 (as amended);
- 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 and East Offshore and South East Inshore Marine Plans (See Figure 6.1).

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:

- The Overarching National Policy Statement (NPS) for Energy (NPS EN-1; Department for Energy and Climate Change (DECC), 2011a);
- The National Policy Statement for Renewable Energy Infrastructure (NPS EN-3, DECC, 2011b);
- National Policy Statement for Electricity Networks Infrastructure EN-5 (DECC, 2011c);
- Draft revised Overarching NPS EN-1 (Department for Business, Energy and Industrial Strategy (BEIS), 2021a));
- Draft National Policy Statement for Renewable Energy Infrastructure (EN-3) (BEIS, 2021b);
- Draft National Policy Statement for Electricity Networks Infrastructure (EN-5) (BEIS, 2021c); and
    - The UK Marine Policy Statement (MPS; HM Government, 2011).

6.2.6 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 (DECC, 2011b)	*"Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed Offshore Wind Farm (OWF) and in accordance with the appropriate policy for OWF EIAs."* (Paragraph 2.6.64 of NPS EN-3).	Construction, operation, maintenance and decommissioning phases of VE have been assessed in Section 6.10 and Section 6.11.
	"Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate." (Paragraph 2.6.65 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." (Paragraph 2.6.66 of NPS EN-3).	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) has informed the assessment of VE (see Sections 6.4 and 6.7).
	"The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity." (Paragraph 2.6.67 of NPS EN-3).	The assessment methodology includes the provision for assessment of both positive and negative effects (Section 6.4)

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	"The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it." (Paragraph 2.6.68 of NPS EN-3).	The potential effects on fish and shellfish ecology are presented within this chapter, with the assessment of effects presented within Section 6.10 and Section 6.11.
	"The designation of an area as a protected site (including HRA sites, MCZs and SSSIs) does not necessarily restrict the construction or operation of offshore wind farms in or near that area." (Paragraph 2.6.69 of NPS EN-3).	Designated sites within the region have been identified in Section 6.7 as appropriate, as well as Volume 7, Report 7: Marine Conservation Zone Assessment. Any potential impacts to features of the sites have been assessed in Sections 6.10 and 6.11.
	"Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed" (Paragraph 2.6.70 of NPS EN-3).	Embedded mitigation relevant for the fish and shellfish ecology chapter is detailed in Section 6.9. No specific mitigation has been identified for impacts on fish and shellfish.
	"Ecological monitoring is likely to be appropriate during the construction and operational phases to identify the actual impact so that, where appropriate, adverse effects can then be mitigated and to enable further useful information to be published relevant to future projects."	The requirement for fish and shellfish monitoring has been considered within Section 6.4. In summary, no fish and shellfish monitoring for the construction, operation or decommissioning phases of VE is considered necessary or proposed by VE OWFL.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	(Paragraph 2.6.71 of NPS EN-3).	
	"Where it is proposed that mitigation measures are applied to offshore export cables to reduce electromagnetic fields (EMF) the residual effects of EMF on sensitive species from cable infrastructure during operation are not likely to be significant. Once installed, operational EMF impacts are unlikely to be of sufficient range or strength to create a barrier to fish movement." (Paragraph 2.6.75 of NPS EN-3).	The impacts of EMF on fish and shellfish receptors have been considered in Section 6.11.
	"EMF during operation may be mitigated by use of armoured cable for inter array and export cables which should be buried at a sufficient depth." (Paragraph 2.6.76 of NPS EN-3).	The impacts of EMF on fish and shellfish receptors have been considered in Section 6.11.
	"During construction, 24 hour working practices may be employed so that the overall construction programme and the potential for impacts to fish communities are reduced in overall time." (Paragraph 2.6.77 of NPS EN-3).	VE can confirm that 24 hour working practices will be employed for offshore construction works (Volume 2, Chapter 1: Offshore Project Description).

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	"There is the potential for the construction and decommissioning phases, including activities occurring both above and below the seabed, to interact with seabed sediments and therefore have the potential to impact fish communities, migration routes, spawning activities and nursery areas of particular species. In addition, there are potential noise impacts, which could affect fish during construction and decommissioning and to a lesser extent during operation." (Paragraph 2.6.73 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 6.10 and 6.11.
	The applicant should identify fish species that are the most likely receptors of impacts with respect to: > spawning grounds; > nursery grounds; > feeding grounds; > over-wintering areas for crustaceans; and > migration routes. (Paragraph 2.6.74 of NPS EN-3).	The key receptors of impacts are listed in Section 6.7. Consideration of receptors with regards to spawning grounds, nursery grounds, feeding grounds, over-wintering areas and migration routes has been given, with those receptors of potential sensitivity to impacts from the development of VE assessed within Sections 6.10 and 6.11.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	The construction and operation of offshore wind farms can have both positive and negative effects on fish and shellfish stocks. (Paragraph 2.6.122 of NPS EN-3).	The effects on fish and shellfish stocks have been assessed in Sections 6.10 and 6.11, as well as Volume 2, Chapter 8: Commercial Fisheries.
	"Effects of offshore wind farms can include temporary disturbance during the construction phase (including underwater noise) and ongoing disturbance during the operational phase and direct loss of habitat. Adverse effects can be on spawning, overwintering, nursery and feeding grounds and migratory pathways in the marine area. However, the presence of wind WTGs can also have positive benefits to ecology and biodiversity." (Paragraph 2.6.63 of NPS EN-3).	The assessment methodology includes the provision for assessment of both positive and negative effects (see Section 6.4). The potential effects on fish and shellfish ecology (inclusive of spawning, overwintering, nursery and feeding grounds and migratory pathways) are presented within this chapter, with the assessment of effects presented within Sections 6.10, 6.11, 6.12 and 6.13.
Draft NPS EN-3 (BEIS, 2021b)	*"Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed offshore wind farm and in accordance with the appropriate policy for OWF EIAs Applicants will also need to consider*	Construction, O&M and decommissioning phases of VE have been assessed in Sections 6.10, 6.11 and 6.12.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	environmental net gain as set out in the 25 Year Environment Plan." (Paragraph 2.24.5 of Draft NPS EN-3).	
	"Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate." (Paragraph 2.24.6 of Draft 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 with regard to fish and shellfish). Agreement on assessment methodologies and baseline characterisation has been sought with both statutory and non-statutory stakeholders via the Evidence Plan process.
	"Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate. Reference must be made to relevant scientific research and literature." (Paragraph 2.24.7 of Draft NPS EN-3).	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) has informed the assessment of VE (see Sections 6.4 and 6.7).
	"The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity." (Paragraph 2.24.8 of Draft NPS EN-3).	The assessment methodology includes the provision for assessment of both positive and negative effects (Section 6.4)
	"The Secretary of State should consider the effects of a	The potential effects on fish and shellfish ecology are presented within this chapter, with the

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	proposal on marine ecology and biodiversity taking into account all relevant information made available to it." (Paragraph 2.24.18 of Draft NPS EN-3).	assessment of effects presented within Sections 6.10, 6.11, 6.12 and 6.13.
	"The designation of an area as a protected site (including HRA sites, MCZs and SSSIs) does not necessarily restrict the construction or operation of offshore wind farms in, near or through that area." (Paragraph 2.24.19 of Draft NPS EN-3).	Designated sites within the region have been identified in section 6.7 as appropriate, as well as Volume 7, Report 7: Marine Conservation Zone Assessment. Any potential impacts to features of the sites have been assessed in Sections 6.10, 6.11 and 6.12.
	"Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed" (Paragraph 2.24.10 of Draft NPS EN-3).	Embedded mitigation relevant for the fish and shellfish ecology chapter is detailed in Section 6.9.
	"Ecological monitoring will be appropriate during the pre-construction, construction and operational phases to identify the actual impacts caused by the project and compare them to what was predicted in the EIA/HRA". (Paragraph 2.24.11 Draft NPS EN-3).	The requirement for fish and shellfish monitoring has been informed by the assessed undertaken in Sections 6.10, 6.11, 6.12 and 6.13. In summary, no fish and shellfish monitoring for the construction, operation or decommissioning phases of VE is considered necessary at this stage.
	"Review of up-to-date research should be undertaken and all	The impacts of EMF on fish and shellfish receptors have been considered in Section 6.11. Inclusion

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	potential mitigation options presented. 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 inter-array and export cables. Burial of the cable increases the physical distance between the maximum EMF intensity and sensitive species. However, what constitutes sufficient depth to reduce impact will depend on the geology of the seabed. It is unknown whether exposure to multiple cables and larger capacity cables may have a cumulative impact on sensitive species. Therefore monitoring EMF emissions may provide the evidence to inform future EIAs". (Paragraph 2.26.4 of Draft NPS EN-3).	of EMF within the scope of the assessment has been agreed via the Evidence Plan.
	"The applicant should identify fish species that are the most likely receptors of impacts with respect to: > *spawning grounds* > *nursery grounds* > *feeding grounds*	The key receptors identified are listed in Table 6.9Table 6.9. Consideration of receptors with regards to spawning grounds, nursery grounds, feeding grounds, over-wintering areas, migration routes and protected areas has been given, with those receptors of potential sensitivity to impacts from the development of VE assessed within Sections 6.10, 6.11, 6.12 and 6.13.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	> *over-wintering areas for crustaceans* > *migration routes* > *protected areas (e.g. HRA sites and MCZs)"* (Paragraph 2.26.2 of Draft NPS EN-3).	
	"The assessment should also identify potential implications of underwater noise from construction and unexploded ordnance (both sound pressure and particle motion) and EMF on sensitive fish species." (Paragraph 2.26.2 of Draft NPS EN-3).	Potential implications from underwater noise have been assessed in Sections 6.10 (Impact 1), 6.11 (Impact 8), 6.12 (Impact 17) and 6.13 (Impact 24). The impacts of EMF on fish and shellfish receptors have been considered in Section 6.11 (Impact 13).
NPS EN-1 (DECC, 2011a))	*"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, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental*	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 6.7, 6.10, 6.11 and 6.12). 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 Report to Inform Appropriate Assessment (RIAA).

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	information proportionate to the infrastructure where EIA is not required to help the Infrastructure Planning Commission (IPC) consider thoroughly the potential effects of a proposed project." (Paragraph 5.3.3 of NPS EN-1).	
	"Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance; those that are not, should be given a high degree of protection. Where a proposed development within or outside a SSSI is likely to have an adverse effect on a SSSI (either individually or together with other developments), development consent should not normally be granted. Where an adverse effect, after mitigation, on the site's notified special interest features is likely, an exception should only be made where the benefits (including need) of the development at this site clearly outweigh both the impacts on site features and on the broader network of SSSIs. The Secretary	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.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	of State should use requirements and/or planning obligations to mitigate the harmful aspects of the development, and where possible, ensure the conservation and enhancement of the site's biodiversity or geological interest." (Paragraphs 5.3.10 and 5.3.11 of NPS EN-1).	
	"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 Secretary of State is bound by the duties in relation to MCZs imposed by Sections 125 and 126 of the Marine and Coastal Access Act 2009." (Paragraph 5.3.12 and Paragraph 5.4.11 of NPS EN-1).	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 6.11Figure 6.11. Any potential impacts to features of the site have been assessed in Sections 6.10, 6.11 and 6.12.
	"Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the IPC	Designed-in measures to be adopted as part of the VE project are presented in Section 6.9.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate." (Paragraph 5.3.15 of NPS EN-1).	
	"Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Secretary of State should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations." (Paragraph 5.3.17 of NPS EN-1).	All species receptors, including those of conservation importance are summarised in Section 6.7 and listed in Table 6.9.
	"The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: *During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works;* *During construction and operation best practice will be*	Embedded mitigation relevant for the fish and shellfish ecology chapter is detailed in Section 6.9.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements; *Habitats will, where practicable, be restored after construction works have finished."* (Paragraph 5.3.18 of NPS EN-1).	
Draft NPS EN-1 (BEIS, 2021a)	*"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, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Infrastructure Planning Commission (IPC) consider thoroughly the potential effects of a*	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 6.7, 6.10, 6.11 and 6.12). 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 Report to Inform Appropriate Assessment (RIAA).

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	proposed project." (Paragraph 5.4.3 of Draft NPS EN-1).	
	"Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance; those that are not, should be given a high degree of protection. Most National Nature Reserves are notified as SSSIs. *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. The Secretary of State should use requirements and/or planning obligations to mitigate the harmful aspects of the development and, where possible, to*	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.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	ensure the conservation and enhancement of the site's biodiversity or geological interest." (Paragraphs 5.4.9 and 5.4.10 of Draft NPS EN-1).	
	"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. The Secretary of State is bound by the duties in relation to MCZs imposed by Sections 125 and 126 of the Marine and Coastal Access Act 2009." (Paragraph 5.4.11 of Draft NPS EN-1).	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 Sections 6.10, 6.11 and 6.12.
	"Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Secretary	All species receptors, including those of conservation importance are summarised in Section 6.7 and listed in Table 6.9.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	of State should ensure that these species and habitats are protected from the adverse effects of development by using requirements, planning obligations or licence conditions." (Paragraph 5.4.16 of Draft NPS EN-1).	
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 6.10, 6.11, 6.12 and 6.13).
	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 6.11 (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 Cumulative Effects Assessment (CEA) (Sections 6.10, 6.11, 6.12 and 6.13).
	Descriptor 4 – *"Elements of marine food web: All elements of marine food webs, to the extent they are known, occur at*	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 ES with inter

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity".	relationships described where appropriate and are summarised in Section 6.14.
	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 6.10, 6.11, 6.12 and 6.13).
	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 6.10 (Impact 3) and 6.12 (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 6.10 (Impact 3) and 6.12 (Impact 19).
	Descriptor 10 – *"Marine litter: Properties and quantities of marine litter do not cause harm to the coastal and marine environment".*	A Project Environmental Management Plan (PEMP) will be produced prior to construction and followed to cover the construction and operation phases of VE. The PEMP will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g., MMO, EA and Maritime

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
		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 levels that do not adversely affect the marine environment.	The effects of underwater noise on fish and shellfish have been assessed in Sections 6.10 (Impact 1), 6.11 (Impact 8), 6.12 (Impact 17) and 6.13 (Impact 24).
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 6.12.
	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 4, 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 6.10, 6.11,6.12 and 6.13.
	Policy FISH2: *"Proposals should demonstrate, in order of preference:* *a) that they will not have an adverse*	Potential impacts on fish and shellfish receptors have been assessed in Sections 6.10, 6.11,6.12 and 6.13, and embedded mitigation detailed in Section 6.9. To summarise, there are no significant effects concluded on fish and

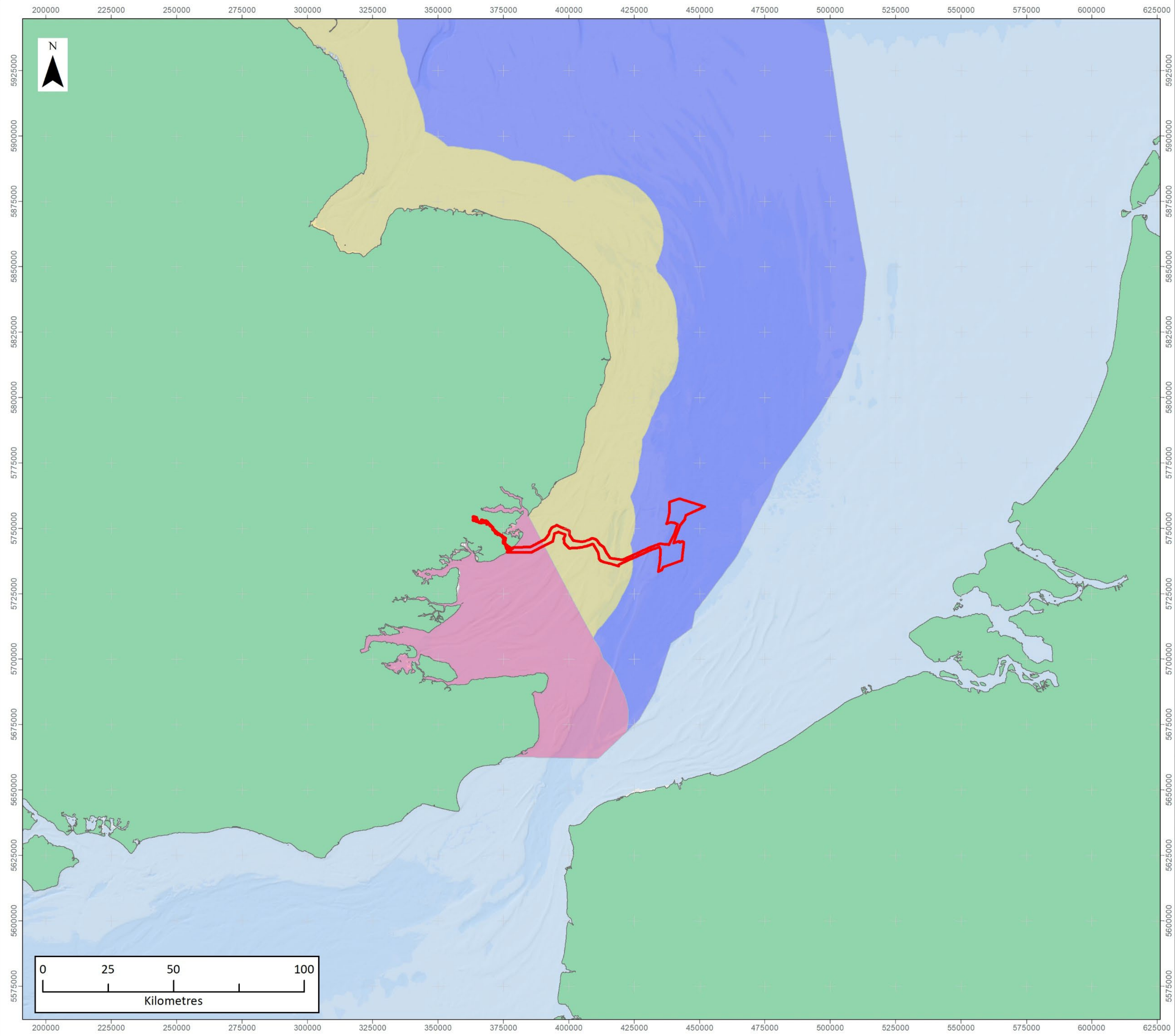
LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	impact upon spawning and nursery areas and any associated habitat *b) how, if there are adverse impacts upon the spawning and nursery areas and any associated habitat, they will minimise them* *c) how, if the adverse impacts cannot be minimised they will be mitigated* *d) the case for proceeding with their proposals if it is not possible to minimise or mitigate the adverse impacts."*	shellfish receptors, therefore no additional mitigation measures (other than the embedded mitigation) are proposed.
	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 Volume 4: Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. Potential impacts to features of designated sites have been assessed in sections 6.10, 6.11 and 6.12.
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:* *a) avoid* *b) minimise* *c) mitigate adverse impacts, with due*	Designated nature conservation sites within the VE study area have been described Volume 4: Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. Potential impacts to features of designated sites have been assessed in sections 6.10, 6.11 and 6.12.

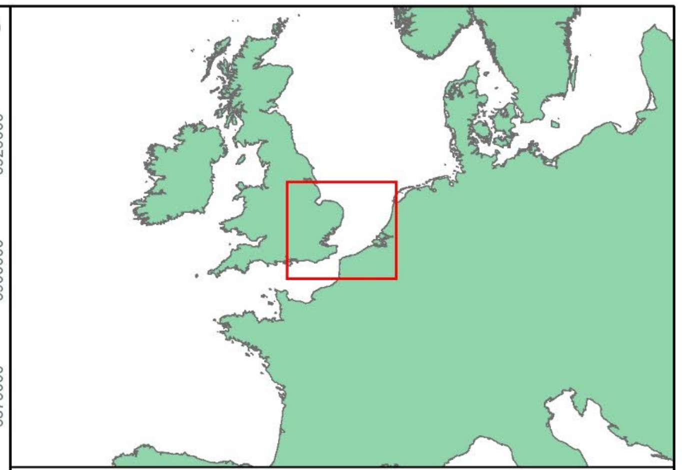
LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	regard given to statutory advice on an ecologically coherent network".	
	Policy SE-BIO-1: *"Proposals that may have significant adverse impacts on the distribution of priority habitats and priority species must demonstrate that they will, in order of preference:* *a) avoid* *b) minimise* *c) mitigate adverse impacts so they are no longer significant* *d) compensate for significant adverse impacts that cannot be mitigated".*	Priority fish and shellfish species within the VE study area have been described Volume 4: Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report. Potential impacts to priority species have been assessed in sections 6.10, 6.11 and 6.12.
	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:* *a) avoid* *b) minimise* *c) mitigate adverse impacts so they are no longer significant* *d) compensate for significant adverse*	Potential impacts on fish and shellfish receptors have been assessed in Sections 6.10, 6.11,6.12 and 6.13, and embedded mitigation detailed in Section 6.9. To summarise, there are no significant effects concluded on fish and shellfish receptors, therefore no additional mitigation measures (outwith the embedded mitigation) are proposed.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	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:* *1) moving equipment, boats or livestock (for example fish or shellfish) from one water body to another* *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, 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 6.11 (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:* *a) avoid* *b) minimise* *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 6.10 (Impact 5), 6.11 (Impact 14) and 6.12 (Impact 21). To summarise, there are no significant effects concluded on fish and shellfish receptors, therefore no additional mitigation measures (outwith the embedded mitigation) are proposed.
	Policy SE-FISH-3: *"Proposals that may*	Potential impacts on essential fish habitat, including spawning, nursery

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	have significant adverse impacts on essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes, must demonstrate that they will, in order of preference: *a) avoid* *b) minimise* *c) mitigate* *- adverse impacts so they are no longer significant".*	and feeding grounds, and migratory routes have been assessed in Sections 6.10 (Impact 7), 6.11 (Impact 11), 6.12 (Impact 23) and 6.13 (Impacts 26 and 27). To summarise, there are no significant effects concluded on fish and shellfish receptors, therefore no additional mitigation measures (outwith the embedded mitigation) are proposed.
	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:* *a) avoid* *b) minimise* *c) mitigate adverse cumulative and/or in-combination effects so they are no longer significant".*	Cumulative effects are considered within Section 6.12. To summarise, there are no cumulative significant effects concluded on fish and shellfish receptors, therefore no additional mitigation measures (outwith the embedded mitigation) 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:*	An assessment of potential impacts from underwater noise on fish and shellfish receptors has been undertaken in Sections 6.10 (Impact 1), 6.11 (Impact 8), 6.12 (Impact 17) and 6.13 (Impact 24). To summarise, there are no significant effects concluded on fish and shellfish receptors from underwater

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	a) avoid *b) minimise* *c) mitigate adverse impacts on highly mobile species so they are no longer significant".*	noise, therefore no additional mitigation measures (outwith the embedded mitigation) are proposed.





LEGEND

- Red Line Boundary
- Marine Plan Areas:
  - East inshore
  - East offshore
  - South East inshore

Data Source:
Basemap: 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	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.1

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:1,500,000	A3	WGS84	UTM31N

FIVE ESTUARIES OFFSHORE WIND FARM

Z:\GIS\GIS_Projects\0144 Five Estuaries\GIS\Figures\PEIR\Fish and Shellfish\VE_FS_PEIR_TR_Fig6_1_Marine_Plan_Areas.mxd

6.3 CONSULTATION

6.3.1 Consultation is a key part of the Development Consent Order (DCO) pre-application process. Consultation regarding fish and shellfish ecology has been undertaken with various statutory and non-statutory authorities, through the agreed Evidence Plan process (being used for the EIA process as well as for the 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 the Planning Inspectorate (PINS). A summary of the responses relevant to the fish and shellfish ecology chapter in the Scoping Opinion are summarised in Table 6.2 below.

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 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 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 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and summarised in Section 6.7. These data have been used to inform the assessments as undertaken in Sections 6.10, 6.11, 6.12 and 6.13.
February 2020 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 6.10 (Impact 1). It should be noted that UXO clearance will be consented under a separate Marine Licence (post-consent) and will therefore not be

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
		consented under the DCO. Potential impacts from EMF on fish and shellfish receptors have been assessed in Section 6.11 (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 4, 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 6.10, 6.11, 6.12 and 6.13.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
August 2021 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 6.10, 6.11, 6.12 and 6.13.
August 2021 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 6.10 (Impact 5), 6.11 (Impact 14) and 6.12 (Impact 21).
August 2021 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 6.10, 6.11, 6.12 and 6.13.
November 2021 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 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	Reference to spawning grounds can be found in Section 6.7. Impacts from noise are addressed in Sections 6.11 (Impact 8), 6.12 (Impact 17) and 6.13 (Impact 24).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	made clearer in the text and include known temporal spawning information as well.	
November 2021 Natural England, Scoping Opinion	*"The assessment should consider the potential for INNS spread via WTGs structures within the region."*	INNS are addressed in Section 6.11 (Impact 12).
November 2021 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 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."*	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 data sources. Therefore, twaite shad have been included as a VER.
November 2021 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*	Reference to spawning grounds within the study area as well as overlapping with array areas have been addressed in Section 6.7.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	text and include known temporal spawning information as well."	
November 2021 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 large areas of sand which may be important for this species, which should be considered in the ES."*	Impacts of SSC on sandeel spawning is addressed in Sections 6.10, (Impact 2) 6.11 (Impact 9), 6.12 (Impact 18) and 6.13 (Impact 25).
November 2021 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.* *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. VE OWFL's attention is drawn to the advice from the MMO on this point (see Appendix 2 of this report).* *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*	Damage and disturbance to mobile demersal and pelagic fish and shellfish species has been scoped into this assessment and are addressed in Sections 6.10 (Impact 5), 6.11 (Impact 14), and 6.12 (Impact 21).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	the absence of an LSE on the environment."	
November 2021 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.* *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. VE OWFL'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 6.10 (Impact 6), 6.11 (Impact 15) and 6.12 (Impact 22).
November 2021 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 effects is*	This is noted and Transboundary Effects on fish and shellfish receptors have not been assessed (Section 6.15).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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 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 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.
November 2021 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 period and geographic coverage of the data.*	Information on data sources, including temporal and spatial coverage are summarised in Table 6.3 and detailed in Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	Use of existing data should be done in agreement with consultees."	
November 2021 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 Section 6.10 (Impact 1).
November 2021 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 6.10 (Impact 5), 6.11 (Impact 14) and 6.12 (Impact 21). Potential impacts to commercial fisheries are assessed in Volume 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 6.10 (Impact 4)

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
		6.11 (Impact 10) and 6.12 (Impact 20).
November 2021 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 as a migratory species in Section 6.7 and the effects of noise on this species are assessed in Sections 6.10 (Impact 1), 6.11 (Impact 8), 6.12 (Impact 17) and 6.13 (Impact 24).
November 2021 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 6.10 and 6.11. The conservation objectives for all designated sites for migratory species will be referred to within VE Report to Inform Appropriate Assessment (RIAA) and Volume 7, Report 7: Marine Conservation Zone Assessment.
November 2021 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. Any measures relied upon in the ES should be discussed with relevant*	The potential spread of INNS is assessed in Section 6.11 (Impact 12).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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 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 Table 6.16 Sections 6.10 (Impact 1) 6.11 (Impact 8), 6.12 (Impact 17) and 6.13 (Impact 24).
November 2021 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 in Figure 6.12. For the presentation of individual years of IHLS data see Volume 4, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data).
November 2021 PINS on behalf of SoS Scoping Opinion	*"The ES should make clear whether it is proposed to undertake simultaneous piling (i.e. the installation of more than one pile at a time), in which case the*	Simultaneous piling has been evaluated as part of the maximum design scenario (Table 6.10), which is the basis for

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	underwater noise modelling for impacts to fish should be based on this scenario."	the assessment in Sections 6.10 (Impact 1), 6.11 (Impact 8) and 6.12 (Impact 17).
November 2021 PINS on behalf of SoS Scoping Opinion	*"Mitigation measures* *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 twinwalled 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."*	The mitigation measure to use soft start piles has been noted in Section 6.10 (Impact 1). Embedded mitigation relevant for the fish and shellfish ecology chapter is detailed in Section 6.9 and ecological cycles have been assessed throughout Sections 6.10, 6.11 and 6.12.
November 2021 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 these matters or evidence demonstrating agreement with the relevant consultation bodies that these activities are unlikely to give rise to LSE on the environment."*	The assessment of underwater noise from the operation and maintenance of VE can be found in Section 6.11 (Impact 8).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
November 2021 PINS on behalf of SoS Scoping Opinion	*"Impacts from increases in SSC and sediment deposition during operation* *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.* *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 in Sections 6.10 (Impact 2), 6.11 (Impact 9), 6.12 (Impact 18) and 6.13 (Impact 25). Further details of the SSC modelling are available in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes.
November 2021 PINS on behalf of SoS Scoping Opinion	*"Temporary habitat loss/physical disturbance (all phases)* *Temporary habitat loss/physical disturbance has not been included for further assessment. Construction activities such as sand wave 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. 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*	Temporary habitat loss is addressed in Sections 6.10 (Impact 7), 6.11 (Impact 16), 6.12 (Impact 23), and 6.13 (Impact 26).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	environment. The Applicant's attention is drawn to the comments from the MMO on this point (see Appendix 2 of this report).”	
November 2021 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 6.10 (Impact 1) and 6.11 (Impact 8) instead.
November 2021 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 MMO, Scoping Opinion	*“2.3.8. Baseline Environment, the report provides a high-level fish ecology baseline and correctly 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*	These species were recognised in Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and have been considered and assessed under the relevant impacts in Sections 6.10, 6.11, 6.12 and 6.13.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	elasmobranchs (sharks, skates and rays), have also been discussed and will be further considered within the EIA which is appropriate."	
November 2021 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 4, 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 6.10, 6.11 ,6.12 and 6.13.
November 2021 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*	The assessment of underwater noise from the operation and maintenance of the VE OWF can be found in Section 6.11 (Impact 8).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	generate underwater noise which must be considered in the assessment in the absence of such a rationale."	
November 2021 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 6.11 (Impact 9).
November 2021 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 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."*	Direct damage and disturbance to mobile demersal and pelagic fish species in all phases of the development have been assessed in Sections 6.10 (Impact 5) 6.11 (Impact 14) and 6.12 (Impact 21).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
November 2021 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 6.10 (Impact 7), 6.11 (Impact 16), 6.12 (Impact 23) and 6.13 (Impact 26).
November 2021 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 the implementation of an PEMP and a Marine Pollution Contingency Plan (MPCP)."*	This is noted by VE OWFL, however following consultation with PINS, this impact has been scoped into the assessment.
November 2021 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 6.11 (Impact 13).
November 2021 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*	This is welcomed. 10 years of IHLS data have been used to inform the baseline characterisation as presented in Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, and to inform the assessment of

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	proposed approach for data analysis are appropriate."	potential impacts on spawning herring in Sections 6.10, 6.11, 6.12 and 6.13. Annual IHLS data are presented in Volume 4, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data).
November 2021 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 4, 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 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and is summarised in Section 6.7, using the most appropriate and contemporary data.
November 2021 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*	Site-specific PSA data has been used to inform the baseline and habitat suitability for spawning sandeel and spawning herring in Volume 4, 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

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	support the characterisation of fish habitats."	assessments as presented in Sections 6.10, 6.11 and 6.12. PSA data from the North Falls OWF are not available to inform this PEIR.
November 2021 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:* > *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 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.* > *The assumption that a fish will flee from the source of noise is overly simplistic as it overlooks factors such as*	Underwater noise modelling has been carried out on fish as both stationary and fleeing receptors to present a range of responses. See Table 6.16, Sections 6.10 (Impact 1), 6.11 (Impact 8), 6.12 (Impact 17) and 6.13 (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.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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. > *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 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 in Figure 6.12. For the presentation of individual years of IHLS data see Volume 4, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data).
November 2021 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,*	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 6.10 (Impact

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	then underwater noise modelling for impacts to fish should be based on this scenario."	1), 6.11 (Impact 8), 6.12 (Impact 17) and 6.13 (Impact 24).
November 2021 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 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 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. Embedded mitigation can be found in Section 6.9 and best practices have been applied.
November 2021 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. The Marine Mammal Mitigation Protocol (MMMP) will include soft start procedures as discussed in Table 6.11. An outline MMMP is being submitted at PEIR.
November 2021	*"2.3.32. Species-specific mitigation has not been proposed at this*	This is noted, embedded mitigation

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
MMO, Scoping Opinion	*stage for fish receptors, which is to be expected as these can only be identified, as necessary, once the EIA has been completed."*	has however been detailed in Section 6.9.
November 2021 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 6.13, inter-relationships are addressed in Section 6.14 and transboundary effects are addressed in Section 6.15.
November 2021 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.
November 2021 MMO, Scoping Opinion	*"2.3.35. There are some minor and typographic errors within the scoping report which have been detailed below;* > *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).* > *Coull et al., 1998 is not referenced within Table 10.1 (section 10) though is properly cited throughout the document and reference list.*	> All instances of Ellis *et al.*, 2010 have been corrected to 2012. > Noted, reference to Coull *et al.*, 1998 has been added to Table 6.3Table 6.3. > The intended species of reference is the European smelt (*O. eperlanus*), due to its conservation status. > European seabass nursery

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	> *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).* > *European seabass Dicentrarchus labrax, although mentioned as a commercial species within Section 13, has not been further described in the fish baseline section."*	areas have been included in the baseline characterisation, as detailed in full in Volume 4, 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 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report and summarised in Section 6.7.
November 2021 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*	Direct damage and disturbance to mobile demersal and pelagic fish species during the operational phase is addressed in Section 6.11 (Impact 14). Temporary habitat loss/physical disturbance is addressed in Sections 6.10 (Impact 7), 6.11 (Impact 16), 6.12 (Impact 23) and 6.13 (Impact 26).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	decommissioning is included for further assessment in the PEIR and ES."	
November 2021 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 4, 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 6.10, 6.11, 6.12 and 6.13. European seabass and their nursery grounds across the region have been given due consideration in in Volume 4, 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 6.10, 6.11, 6.12 and 6.13.
November 2021 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 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*	This is welcomed. The impacts identified are listed in Section 6.4, and the assessment of potential impacts is

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	identify and assess potential impacts."	provided in Sections 6.10 to 6.15.
November 2021 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 6.10 (Impact 5) and Section 6.11 (Impact 14).
November 2021 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.
November 2021 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, embedded mitigation has however been detailed in Section 6.9.
November 2021 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*	Cumulative effects are addressed in Section 6.12 and inter-relationships are

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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."	addressed in Section 6.14.
November 2021 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 be caveated with this information and data from these surveys should only be used for presence/absence and not abundance estimates."*	Full details on the data sources and the utilisation of each data source is provided in Volume 4, 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 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.
November 2021 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 6.10 and 6.11. Potential impacts to commercial fisheries are assessed in Volume 2, Chapter 8: Commercial Fisheries.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
		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 6.10 and 6.11.
November 2021 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 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."*	Underwater noise modelling undertaken is detailed in full in Volume 4, 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 6.10 (Impact 1), 6.11 (Impact 8) 6.12 (Impact 17) and 6.13 (Impact 24). 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 6.10. 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.
November 2021	*"2.5.12. The potential spatial and temporal cumulative effects on fish*	This is welcomed. The assessment of

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
MMO, Scoping Opinion	*and finfish receptors have been adequately described in Section 10.5.10."*	cumulative effects on fish and shellfish receptors has been undertaken in Section 6.13.
December 2021 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 6.11 (Impact 9).
December 2021 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 6.11 (Impact 12).
December 2021 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 6.10, 6.11, 6.12 and 6.13.
December 2021 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 impacts on fish and shellfish receptors in Sections 6.10, 6.11, 6.12 and 6.13.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
November 2022 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 6.10. 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 6.13.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, 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 6.13.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, Annex	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
6.1: Fish and Shellfish Ecology Technical Baseline Report		
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, 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 6.13 and Table 6.15.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, 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 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 6.10 to 6.13, Impacts 1, 8, 7 and 24.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report	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.* (2014) 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 undertaken within a quiet loch on fish not involved in any particular activity (i.e. not spawning), and it is

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
		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 this threshold is not considered meaningful when attempting to describe the potential disturbance effects on spawning herring arising from piling activity.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report	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, broadscale BGS data and historic spawning grounds are presented in the PEIR and ES.	This is noted, and larger scale maps have been presented.
November 2022	Care should be taken when interpreting the findings go the	This has been noted and acknowledged

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Pre PEIR Submission. MMO comments following submission of Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report	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.	within Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, 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 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report	There is a typo in Section 3.1.41 and Tables 3.2 and 3.4 which refers to albacore tuna and 'Albracore'.	All instances of 'albracore' have been corrected to 'albacore'.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, Annex	There is a typo in Sections 3.1.63-65 which refers to twaite shad as 'thwaite' shad. Also, in reference to allis shad in Section 3.1.64 *'there are now no*	The typo has been corrected. This sentence has been removed and Hillman (2020) has been

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
6.1: Fish and Shellfish Ecology Technical Baseline Report	*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).	referred to within Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, 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 4, 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 Pre PEIR Submission. MMO comments following submission of Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report	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. and Cefas (2020). Lobster (*Homarus gammarus*). Cefas Stock Status Report 2019 18 pp.)	This is noted and the baseline characterisation within Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report has been updated to include reference to the crab and lobster stock assessments.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, 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 4, 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.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, 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 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report	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 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.	This is noted, and Volume 4, 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.
November 2022 Pre PEIR Submission. MMO comments following submission of Volume 4, 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.	This is acknowledged and the assessment has been carried out on juveniles and eggs as well as adult fish.
November 2022	Whilst unsuitable spawning grounds have been identified, this	Detailed description of spawning ground

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Pre PEIR Submission. Natural England comments following submission of Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report	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 extent of all suitable habitat within the ZoI should be clearly presented.	habitats across the study area and wider region have been provided in Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report, with a summary provided in Section 6.7.
Pre PEIR Submission. Natural England comments following submission of Volume 4, 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 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report.
Pre PEIR Submission. Natural England comments following submission of Volume 4, 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.	The Thames Blackwater herring stocks and Downs herring stocks have been assessed as separate stocks throughout the assessments in Sections 6.10 to 6.13.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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 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.

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 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

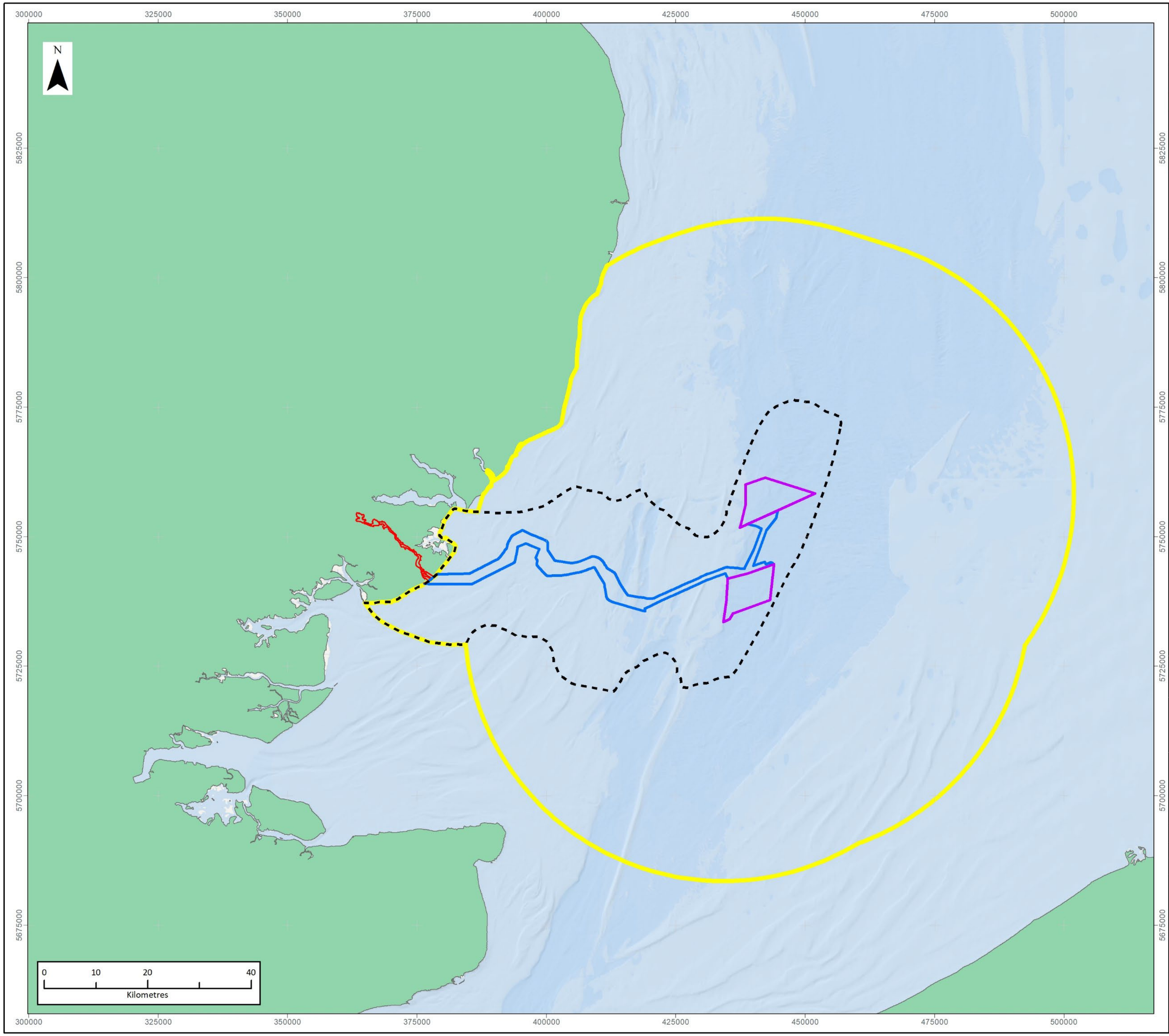
6.4.2 On the basis of the baseline environment and the project description outlined in Volume 2, Chapter 1: Offshore Project Description and in accordance with the Scoping Opinion (PINS, 2021), a number of impacts have been scoped out, these include:

- 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 phase 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 4, 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 µPa2 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 22.5km), 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.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

VE Fish and Shellfish Study Area

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.2

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

FIVE ESTUARIES
OFFSHORE WIND FARM

Z:\GIS\GIS_Projects\0144 Five Estuaries\GIS\Figures\PEIR\Fish and Shellfish\VE_FS_PEIR_TR_Fig6_2_Study_Area_ZOI.mxd

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 4, 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: > Gunfleet Sands OWF; > Galloper OWF; > Greater Gabbard OWF; and > London Array OWF.	Site specific fish and shellfish surveys for OWF Projects in the area. 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

Data Source	Data Summary	Spatial coverage	Temporal coverage
Marine Management Organisation (MMO) UK Sea Fisheries Monthly Reports and Annual Statistics Reports.	Commercial fisheries specific data (national and regional coverage). 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. 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
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	Coverage of the Thames Estuary. Partial	1989 to 2009

Data Source	Data Summary	Spatial coverage	Temporal coverage
	status of the Blackwater spawning herring stocks.	coverage of the inshore waters of the southwestern extent of the study area.	
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
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

Data Source	Data Summary	Spatial coverage	Temporal coverage
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 benthic survey data	Site specific benthic survey data, used to determine spawning habitat suitability.	Site specific survey along the VE ECC and within the array areas.	2021

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

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 1, Chapter 3: EIA Methodology).

6.5.2 Information about the project and the project 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 the project 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. 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. Regionally important receptors with low vulnerability and medium recoverability. Nationally important receptors with low vulnerability and medium to high recoverability.
Negligible	Receptor is not vulnerable to impacts regardless of value/ importance. 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	Negative				
		High	Major	Major	Moderate	Minor
	Negative	Medium	Major	Moderate	Minor	Negligible
		Low	Moderate	Minor	Minor	Negligible
	Neutral	Negligible	Minor	Minor	Negligible	Negligible
		Low	Moderate	Minor	Minor	Negligible
	Beneficial	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

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

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, 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 has 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 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 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.

6.6.8 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 4, 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 byAmerican 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.

6.7.7 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 Table 6.7 and in Figure 6.3 and Figure 6.3, Figure 6.4 and Figure 6.10. Table 6.8 provides a summary of spawning timings for the identified spawning grounds within and in proximity to VE.

6.7.8 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.

6.7.9 '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).

6.7.10 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.

6.7.11 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.

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

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.

Species	Spawning Habitats			Nursery Habitats		
	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
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

Species	Spawning Habitats Description	Distance to Arrays (km)	Distance to Offshore ECC (km)	Nursery Habitats Description	Distance to Arrays (km)	Distance to Offshore ECC (km)
Herring	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.	2.9 and 67.2	0 and 9.6	High intensity herring nursery ground overlaps the nearshore section of the offshore ECC.	23.5	0
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
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

Species	Spawning Habitats			Nursery Habitats		
	Description	**Distance to Arrays (km)**	**Distance to Offshore ECC (km)**	**Description**	**Distance to Arrays (km)**	**Distance to Offshore ECC (km)**
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
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												
Sole												
Cod												
Horse mackerel												
Sandeel												
Herring												
Mackerel												
Sprat												
Whiting												
Lemon sole												
Thornback ray												
Tope												
European seabass												

HERRING

6.7.13 A herring spawning ground intersects with the western side of the study area (Coull *et al*., 1998) (see Figure 6.5). Furthermore, there is a herring spawning ground located in the Blackwater estuary, approximately 10 km south of the nearshore section of the offshore ECC.

6.7.14 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).

6.7.15 Areas of potential herring spawning habitat are shown in Figure 6.5 and Figure 6.6.

6.7.16 Site specific PSA data (Fugro, 2022a,b) collected within the northern array area were primarily characterised by coarse sediments, with gravelly sediments located in the northern array area, which are characterised as ‘sub-prime, preferred’ and ‘suitable, marginal’ herring spawning habitats. Site specific PSA samples collected within the southern array area were largely classified as ‘unsuitable’, with two samples classified as ‘suitable, marginal’ herring spawning habitats (Fugro, 2022a,b). EUSeaMap (2021) data, as presented in Figure 6.5 and Figure 6.6 shows significant areas of sand and mixed sediments across the VE array areas. On a broader scale, as indicated by BGS sediment data (BGS, 2015), and broadscale marine habitat mapping (EUSeaMap, 2021) there are significant areas of ‘prime/preferred’ and ‘sub-prime/preferred’ habitats located across the wider Thames Estuary, to the north of VE and along the Norfolk coast (Figure 6.6).

6.7.17 Site specific PSA data (Fugro, 2022a,b) shows the ECC is largely dominated by ‘unsuitable’ herring spawning habitats (See Figure 6.5 and Figure 6.6). On a broader scale, as indicated by BGS sediment data (BGS, 2015), and broadscale marine habitat mapping (EUSeaMap, 2021) there are areas of ‘prime/preferred’ and ‘sub-prime/preferred’ habitats located to the north of the ECC, areas to the south of the VE ECC are classified as ‘unsuitable’ habitats for herring spawning.

6.7.18 Whist 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 6.7).

SANDEEL

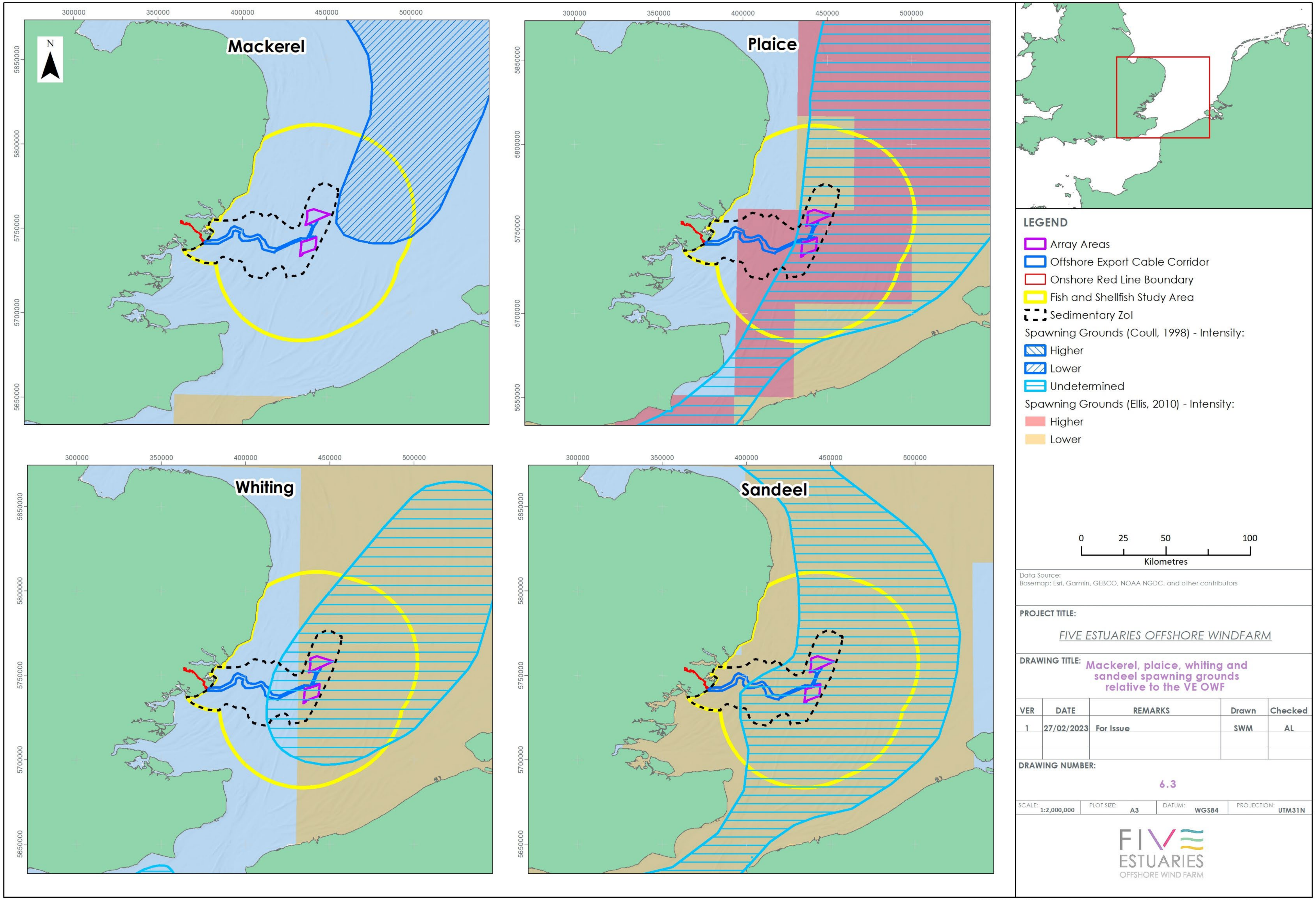
6.7.19 A sandeel spawning ground overlaps the fish and shellfish study area, and across the southern North Sea.

6.7.20 Areas of potential sandeel spawning habitat have been identified using site specific PSA data (Fugro, 2022a,b), BGS sediment data (BGS, 2015) and broadscale habitat mapping (EUSeaMap, 2021). Areas of potential sandeel spawning habitat are shown in Figure 6.8 and Figure 6.9.

6.7.21 Site specific PSA data (Fugro, 2022a,b) collected across the array areas were primarily characterised by coarse sediments, with sandy sediments located in both array areas, largely characterised as 'prime, preferred' and 'sub-prime, preferred' sandeel habitats. EUSeaMap (2021) data, as presented in Figure 6.8 and Figure 6.9 shows significant areas of sandy and mixed sediments across the VE array areas. Site-specific PSA data (Fugro, 2022a,b) collected along the ECC show areas of 'prime, preferred' and 'sub-prime, preferred' sandeel habitat in the mid-section of the ECC, with nearshore and offshore sections of the ECC dominated in 'unsuitable' sandeel habitats (See Figure 6.8 and Figure 6.9). On a broader scale, as indicated by BGS sediment data (BGS, 2015), and broadscale marine habitat mapping (EUSeaMap, 2021) there are areas of 'prime/preferred' and 'sub-prime/preferred' habitats located to the north of the ECC, and to the east of the array areas. Areas to the south of the nearshore section of the VE ECC are classified as 'prime/preferred' sandeel habitats, whilst areas to the south of the offshore ECC are classified as 'unsuitable' habitats for sandeel.

6.7.22 Given the sediment distribution envelope within the study area and broader region is considered to have remained consistent over the last 20 years, as evidenced through reference to the named sources above, the data are considered to remain robust and appropriate for the purposes of undertaking an EIA.

6.7.23 The offshore ECC and array areas are located within a low intensity sandeel spawning ground (Ellis *et al.*, 2012). Spawning grounds for sandeel area are significant in size, with spawning grounds identified across much of the southern North Sea (Coull *et al.*, 1998; Ellis *et al.*, 2010).



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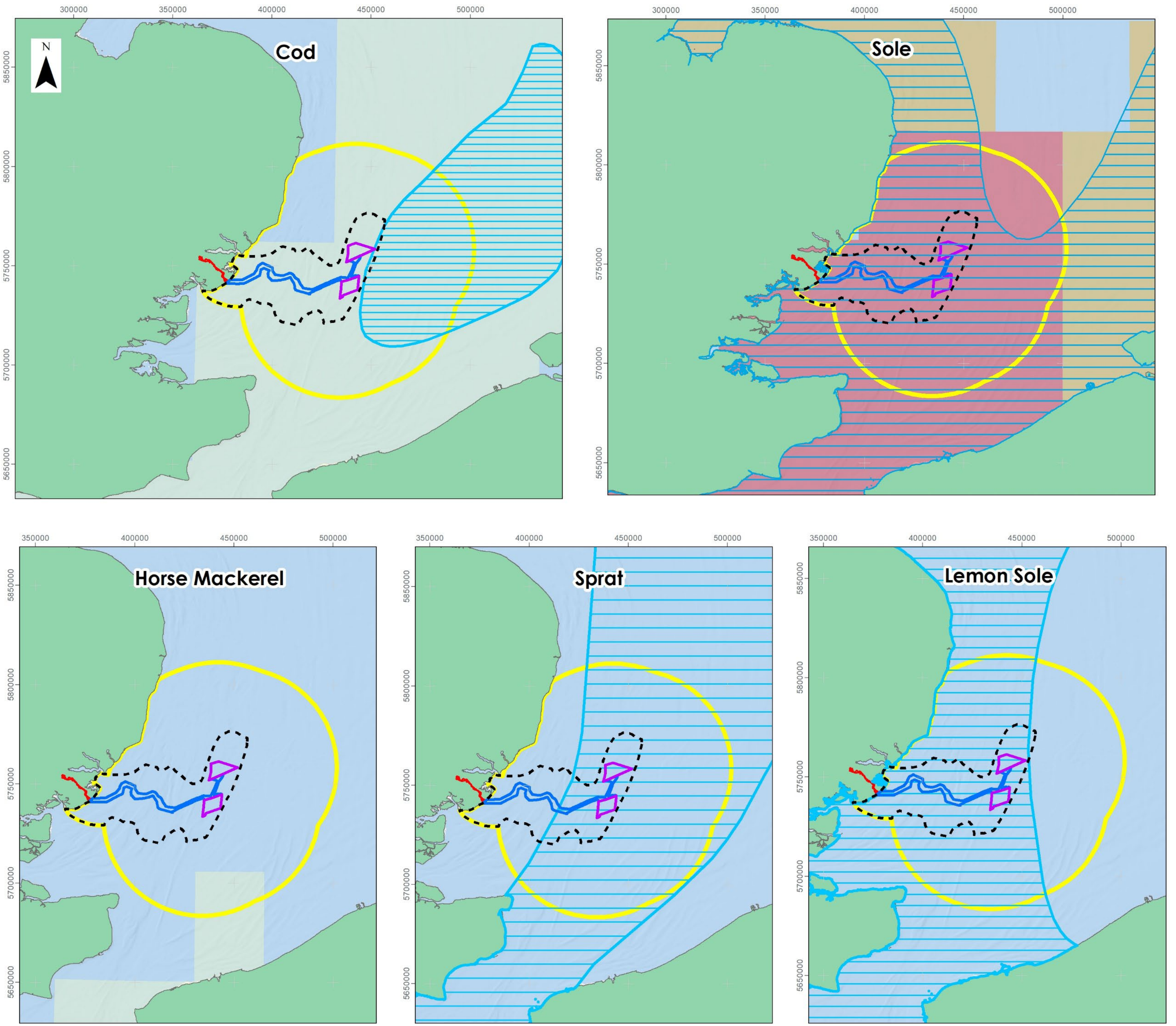

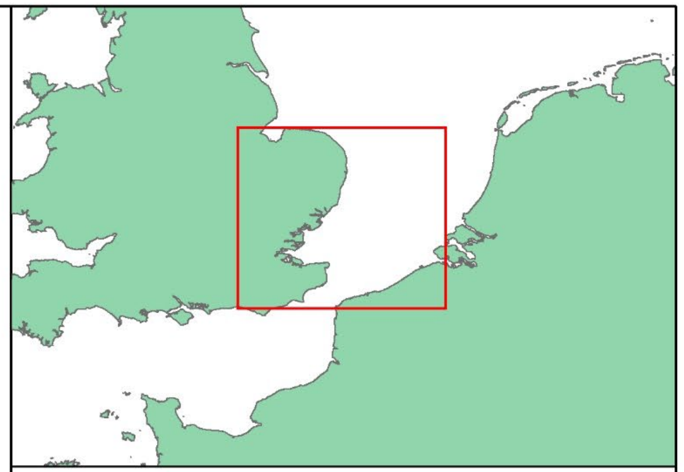

LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI

Spawning Grounds (Coull, 1998) - Intensity:

- Higher
- Lower
- Undetermined

Spawning Grounds (Ellis, 2010) - Intensity:

- Higher
- Lower

0 25 50 100
Kilometres

Data Source:
Basemap: 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 relative to the VE OWF

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.4

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:2,000,000	A3	WGS84	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

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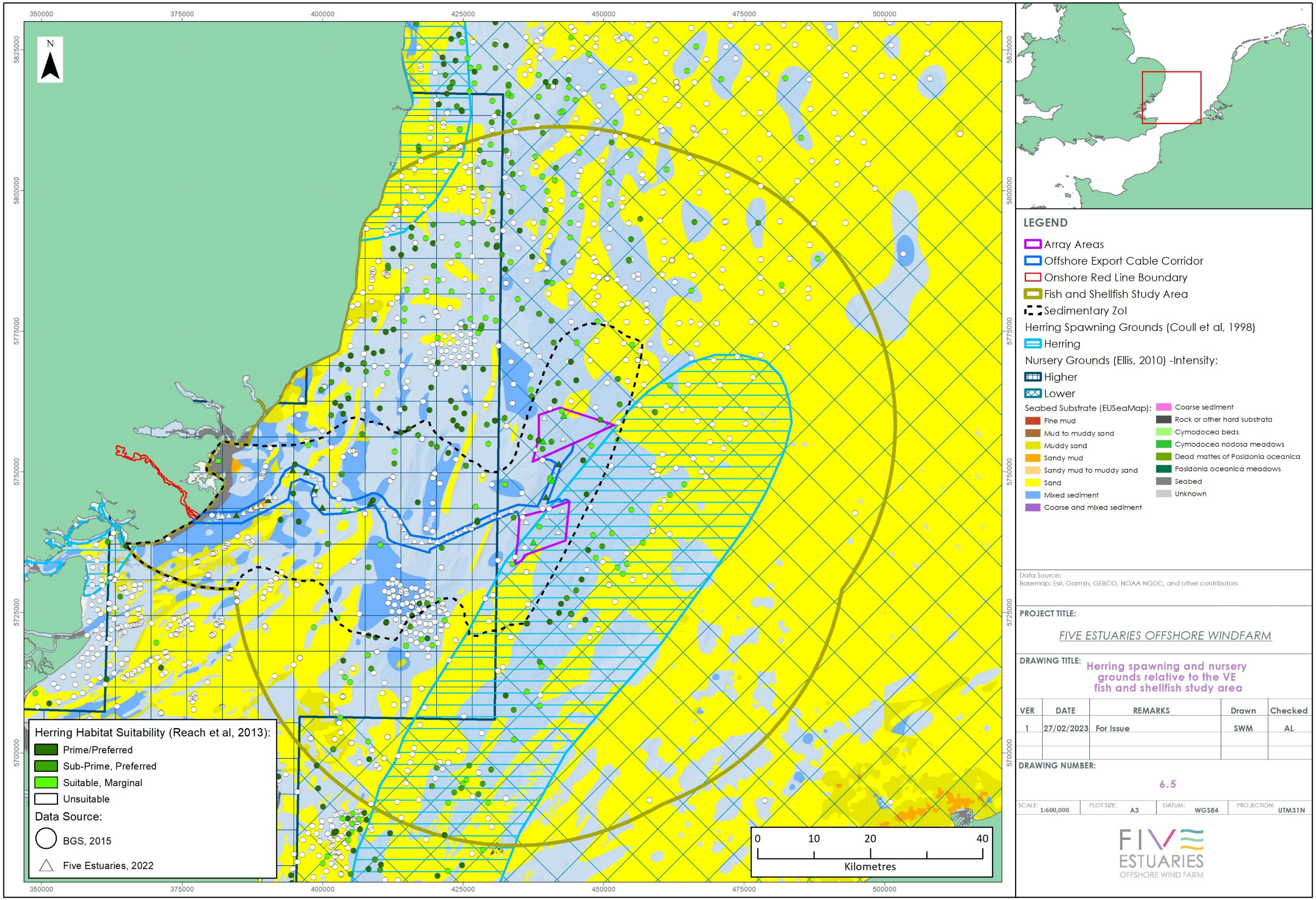

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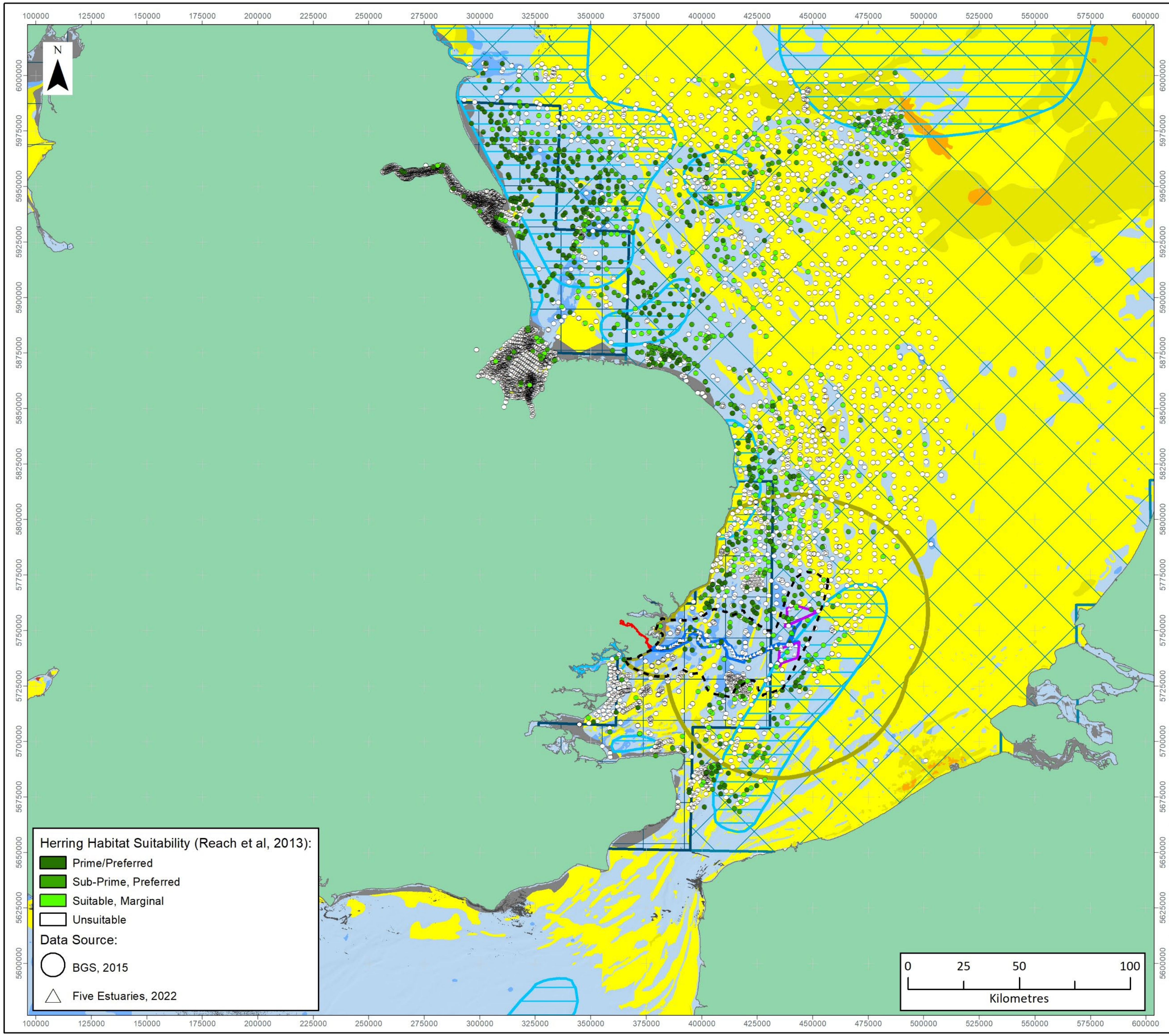

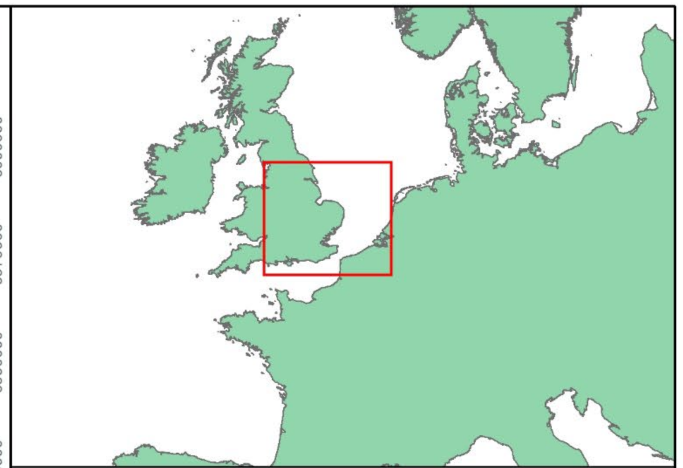

LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI

Herring Spawning Grounds (Coull et al, 1998)
- Herring

Nursery Grounds (Ellis, 2010) -Intensity:
- Higher
- Lower

Nursery Grounds (Coull, 1998) - Species:
- Herring

Seabed Substrate (EUSeaMap):
- Fine mud
- Mud to muddy sand
- Muddy sand
- Sandy mud
- Sandy mud to muddy sand
- Sand
- Mixed sediment
- Coarse and mixed sediment
- Coarse sediment
- Rock or other hard substrata
- Cymodocea beds
- Cymodocea nodosa meadows
- Dead mattes of Posidonia oceanica
- Posidonia oceanica meadows
- Seabed
- Unknown

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE: Herring spawning and nursery grounds relative to the VE fish and shellfish study area

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.6

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

FIVE ESTUARIES
OFFSHORE WIND FARM

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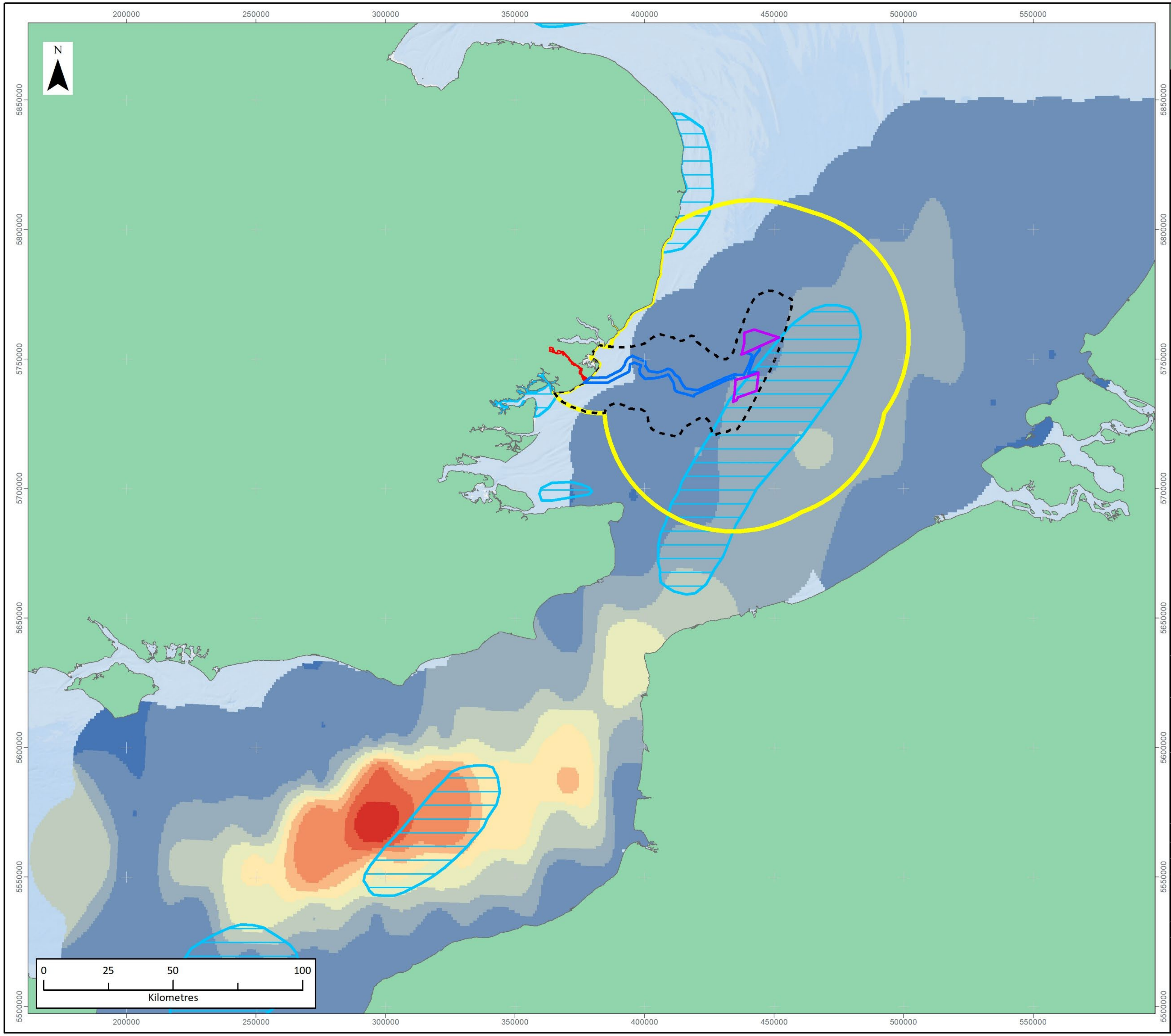

LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI

Spawning Grounds (Coull, 1998) - Intensity, Species:

- Herring

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

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Herring spawning grounds
IHLS comparision

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.7

SCALE: 1:1,500,000	PLOT SIZE: A3	DATUM: WGS84	PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

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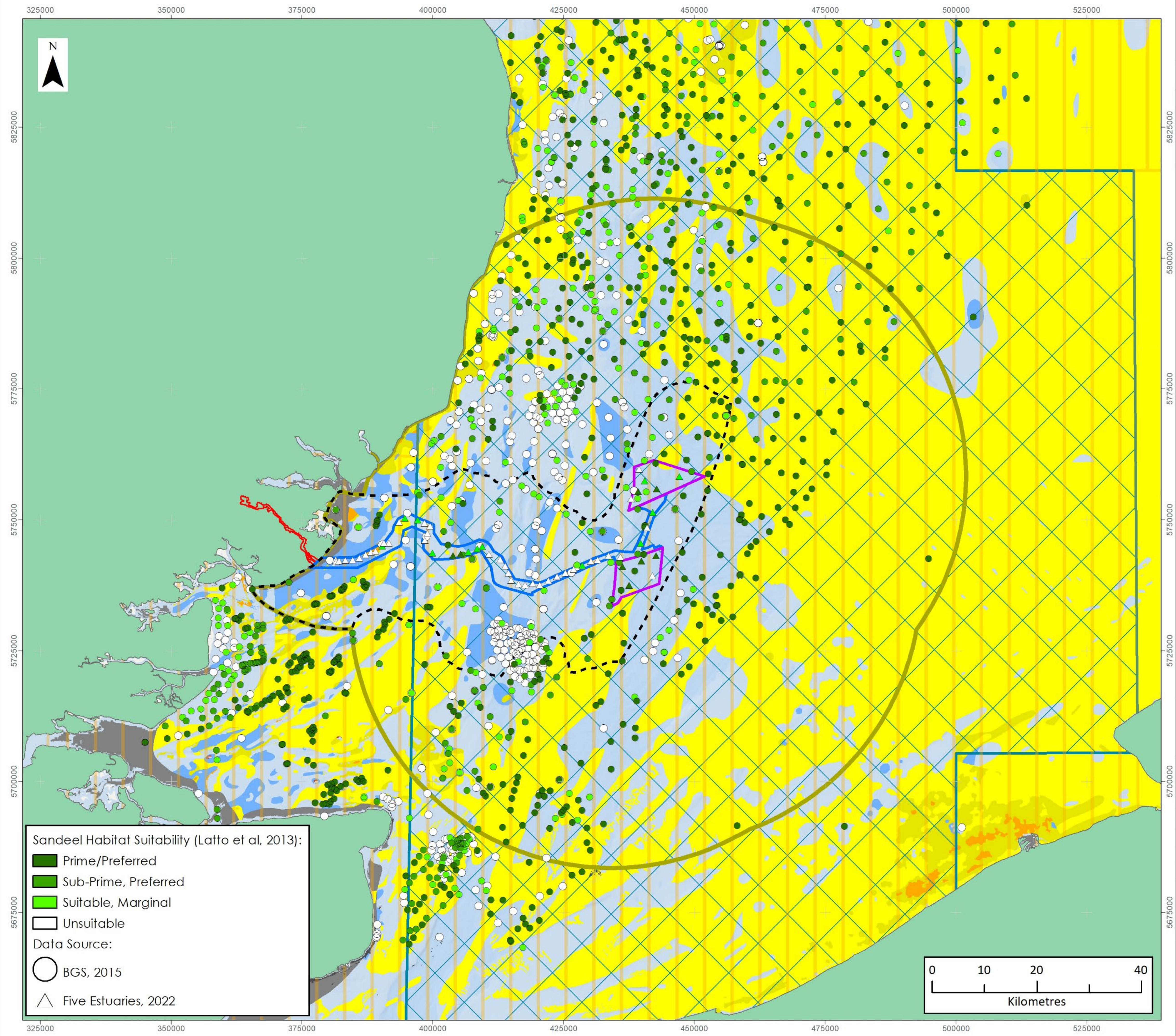

LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI

Sandeel Nursery Grounds (Ellis, 2010) - Intensity:
- Higher
- Lower

Sandeel Spawning Grounds (Ellis, 2010) - Intensity:
- Higher
- Lower

Seabed Substrate (EUSeaMap):
- Fine mud
- Mud to muddy sand
- Muddy sand
- Sandy mud
- Sandy mud to muddy sand
- Sand
- Mixed sediment
- Coarse and mixed sediment
- Coarse sediment
- Rock or other hard substrata
- Cymodocea beds
- Cymodocea nodosa meadows
- Dead mattes of Posidonia oceanica
- Posidonia oceanica meadows
- Seabed
- Unknown

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Sandeel spawning and nursery grounds relative to the VE fish and shellfish study area

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.8

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

FIVE ESTUARIES
OFFSHORE WIND FARM

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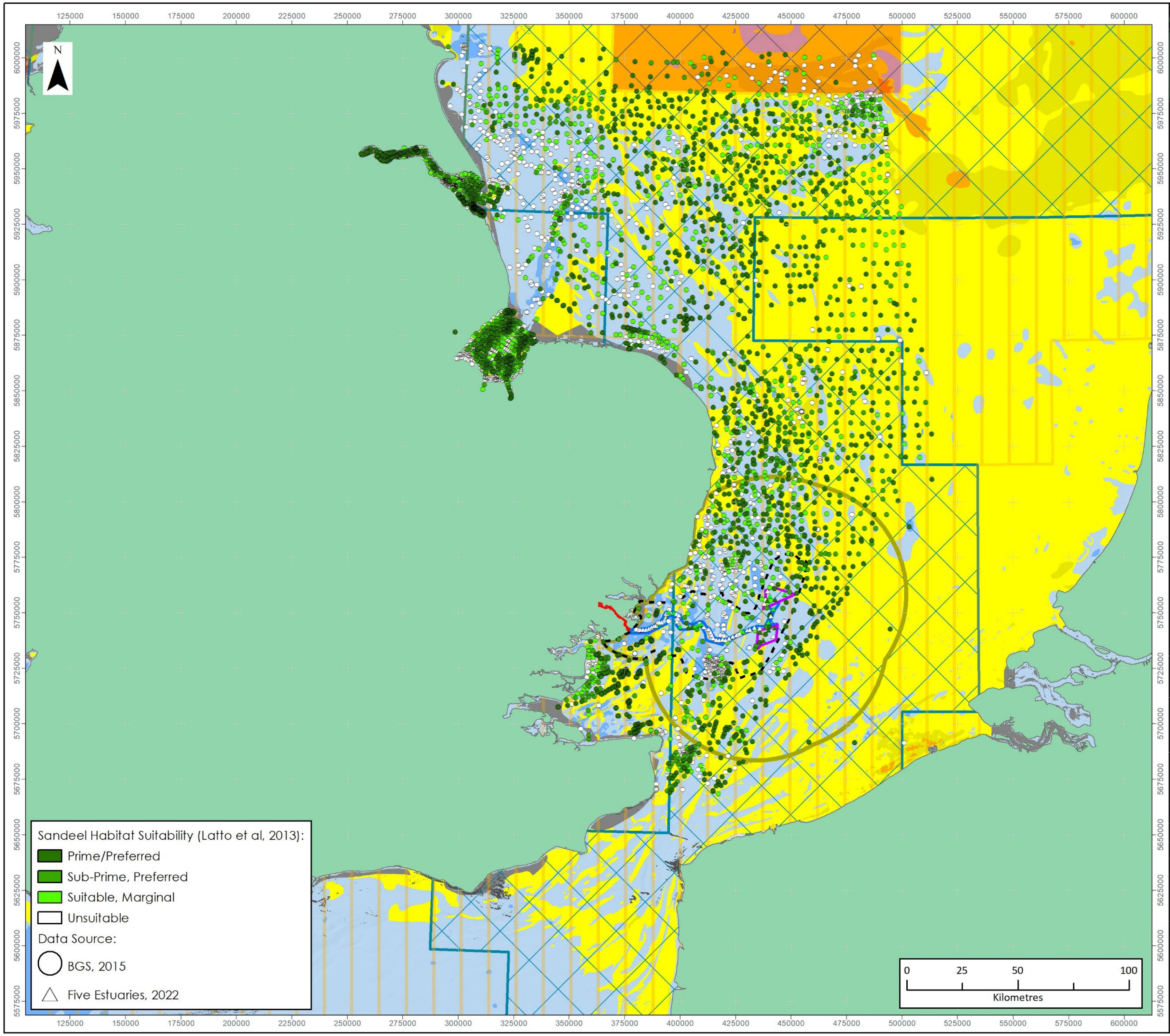

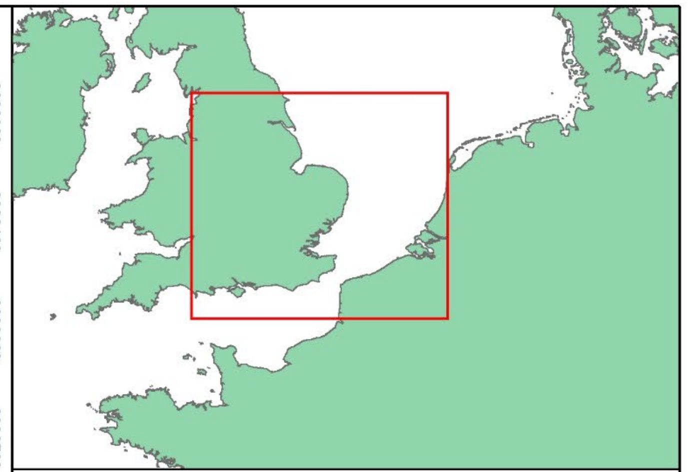

LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI

Sandeel Nursery Grounds (Ellis, 2010) - Intensity:
- Higher
- Lower

Sandeel Spawning Grounds (Ellis, 2010) - Intensity:
- Higher
- Lower

Seabed Substrate (EUSeaMap):
- Fine mud
- Mud to muddy sand
- Muddy sand
- Sandy mud
- Sandy mud to muddy sand
- Sand
- Mixed sediment
- Coarse and mixed sediment
- Coarse sediment
- Rock or other hard substrata
- Cymodocea beds
- Cymodocea nodosa meadows
- Dead mattes of Posidonia oceanica
- Posidonia oceanica meadows
- Seabed
- Unknown

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Sandeel spawning and nursery grounds relative to the VE fish and shellfish study area

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.9

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
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FIVE ESTUARIES
OFFSHORE WIND FARM

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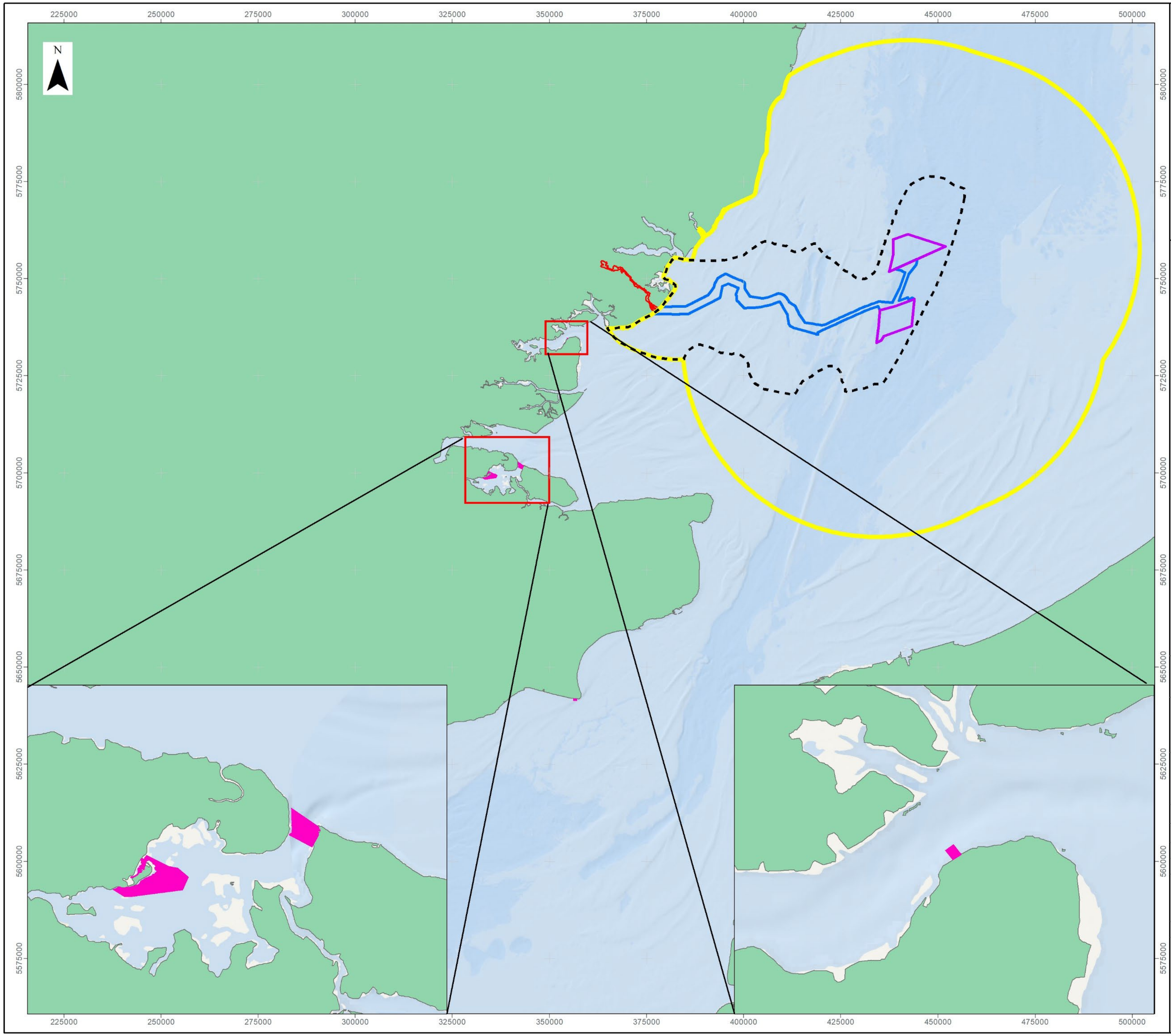

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Sea bass nursery areas relative to the VE a study area

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.10

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

FIVE ESTUARIES OFFSHORE WIND FARM

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SPECIES OF COMMERCIAL IMPORTANCE

6.7.24 Detailed information on species of commercial importance are provided in Volume 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.

6.7.25 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 31st January, 2022) to the regional fishing community (MMO, 2022b).

MIGRATORY SPECIES

6.7.26 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*).

6.7.27 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

6.7.28 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

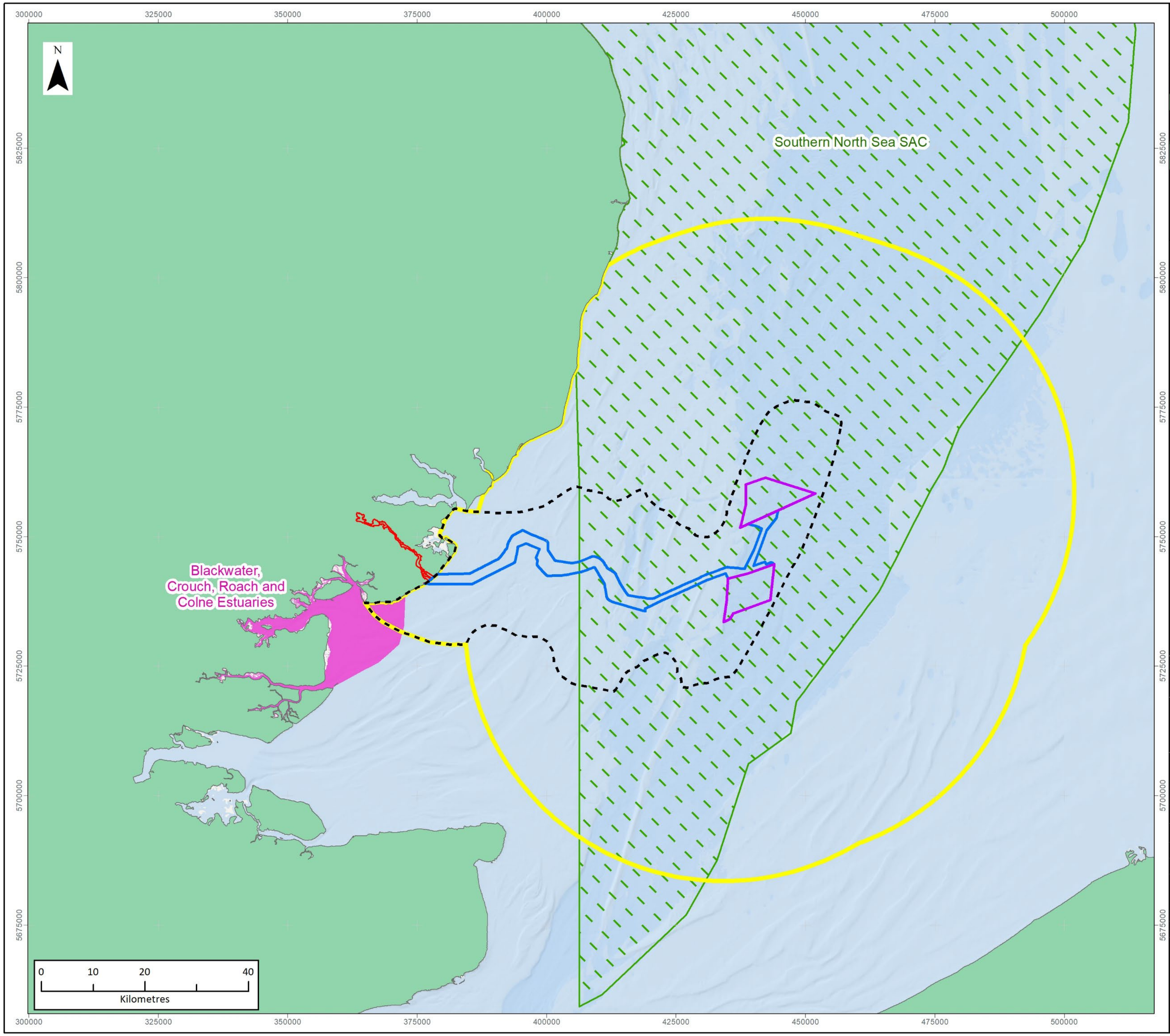
6.7.29 Several species of conservation importance have the potential to occur within the region, with the legislation under which each species is designated varying.

6.7.30 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).

6.7.31 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).

6.7.32 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 Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Special Areas of Conservation
- Marine Conservation Areas

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Designated sites relative to the VE OWF

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.11

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

FIVE ESTUARIES OFFSHORE WIND FARM

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VALUED ECOLOGICAL RECEPTORS

6.7.33 To summarise the above, Table 6.9 below details the Valued Ecological Receptors (VERs) identified within Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline Report to be brought forward into the assessment. See Volume 4, 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	Cod, common dragonet, dab, haddock, hooknose, goby species, lemon sole, lesser weaver, northern and five bearded rockling, plaice, pogge, poor cod, sole, solenette, tub gurnard, red gurnard, whiting, whiting-pout.
Species of Conservation Importance	Atlantic salmon, European eel, allis shad, twaite shad, river lamprey, sea lamprey, sea trout, smelt, native oyster, seahorse.
Migratory species	Atlantic salmon, European eel, allis shad, twaite shad, river lamprey, sea lamprey, sea trout, smelt.
Pelagic Fish	Albacore, sprat, mackerel, Norway pout, horse mackerel, sea bass, silvery pout.
Benthopelagic Fish	Sandeel, spawning herring.
Shellfish	Nephrops, cockle, common whelk, king and queen scallop, European lobster, brown crab, native oyster, pink shrimp, common hermit crab, flying crab, Night shrimp, harbour crab, velvet swimming crab, brown shrimp and marbled swimming 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

6.7.34 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 2026, 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.

6.7.35 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.

6.7.36 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 and overfishing.

6.7.37 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).

6.7.38 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).

6.7.39 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.

6.7.40 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.

6.7.41 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.

6.7.42 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.

6.7.43 The VE fish and shellfish baseline characterisation described in the preceding sections (and presented in detail in Volume 4, 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 the project (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 describes the MDS parameters on which the fish and shellfish ecology assessment has been based. 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 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 this ES using the MDS presented in Table 6.10.

Table 6.10: Maximum design scenario for the project 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	**Spatial MDS (for stationary receptors):** > Piling of 4 monopile in 24 hours; > 79 monopile WTG foundations (13 m diameter); > 2 OSP monopile foundations (15 m diameter); > Maximum hammer energy of 7,000 kJ; > 7.5 hour piling duration per pile; and > 607.5 hours of piling. **Spatial MDS for fleeing receptors and temporal MDS (for stationary and fleeing receptors):** > The sequential installation of piling 8 pin piles at the same WTG location in 24 hours > Total 340 pin piles > 79 small WTGs on piled jacket foundations (four 3.5m diameter pin piles per jacket) –316 pin piles	For the array area, the spatial MDS for stationary receptors results from the sequential piling of pin piles for 79 WTGs, and two OSPs using 3,000 kJ hammer energy (a total of 340 pin piles). This would result in the largest spatial noise impact at any given time when considering impacts to stationary receptors. The spatial MDS for fleeing receptors results from the 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. The temporal MDS for the array area would be associated with the sequential piling of pin piles for 79 WTGs, and two OSPs using 3,000 kJ

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

Potential effect	Maximum design scenario assessed	Justification
	> Two Offshore Substation Platform (OSP) foundations (six 3.5m diameter pin piles per jacket) –24 pin piles > Maximum hammer energy of 3,000 kJ > Four hours piling duration per pile > 1,360 hours of piling **Piling of sheet piles exit pits:** > Installation of 1,100 sheet piles using percussive drilling; > Maximum hammer energy of 300 kJ; and > In the shallow subtidal. **UXO clearance:** > Estimated 2,000 targets; > 60 UXO may require clearance; and > Up to 2 clearance events within 24 hours.	hammer energy. Total of 1,360 hours of piling across the whole project within a one-year construction window.
Impact 2: Temporary increase in SSC and sediment deposition	**Total subtidal sediment volume = 116,658,900 m^3** **Seabed preparation for foundations (1,193,600 m^3)** > 79 small GBS (Wind Turbine Generator (WTG)) foundations = 1,137,600 m^3; and	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

Potential effect	Maximum design scenario assessed	Justification
	> 2 GBS foundations for OSP = 56,000 m³. **Drill arisings from foundation installation in array area (567,430 m³)** > 79 small GBS (WTG) foundations and 2 GBS foundations for OSP = 567,430 m³ **Cable trenching (5,306,175 m³):** > Installation of 200 km of inter-array cables by jetting resulting in the suspension of 3,150,000 m³ of sediment; and > Installation of 370 km of export cables by jetting resulting in the suspension of 2,156,175 m³ of sediment. **Sandwave clearance for cable installation (99,750,000 m³):** > Sandwave clearance for 100 km of array cables resulting in the suspension of 35,000,000 m³ of sediment; and > Sandwave clearance for 185 km of export cables resulting in the suspension of 64,750,000 m³ of sediment. **Jack-up vessels (JUV) and anchoring operations = 9,832,320 m³**	from sandwave clearance and installation. This also assumes the largest number of cables and the greatest burial depth. 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. The MDS for temporary habitat disturbance in the intertidal area from the HDD works is included. 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
	> 504 JUV operations, with a maximum disturbance of 16,500 m^3 per operation = 8,316,000 m^3 > 81 anchoring locations, and 405 deployments (for WTG and OSP installation) = 1,516,320 m^3 **Total intertidal sediment volume = 9,375 m^3** > Five offshore HDD exit pits require excavation of 9,375 m^3 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 not been confirmed whether exit pits will occur in the subtidal or intertidal.	
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. Temporary safety zones of 50 m will be implemented around incomplete structures such as installed monopiles without transition pieces, or where	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

Potential effect	Maximum design scenario assessed	Justification
	construction works are completed but commissioning has yet to be completed.	the potential to lead to increased pressure from fishing on fish and shellfish populations outside of the safety zones.
Impact 5: Direct damage (e.g. crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from construction activities	**Temporary subtidal habitat disturbance of 50,255,630 m^2** **<u>Array areas:</u>** **Foundation seabed preparation = 298,400 m^2** > 79 small Gravity Base Structure (GBS) (Wind Turbine Generator (WTG)) foundations for WTG = 284,400 m^2; > 2 GBS foundations for Offshore Substation Platform (OSP) = 14,000 m^2; and > Areas impacted by placement of gravel bed would be within the footprint of the preparation and so are not considered to be additive. **Jack-up vessels (JUV) and anchoring operations = 933,480 m^2** > 504 JUV operations, with a maximum disturbance of 1,100 m^2 per operation = 554,400 m^2 > 81 anchor footprints for WTG and OSP installation = 379,080 m^2	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. The MDS for direct damage in the intertidal area from the HDD works is included.

Potential effect	Maximum design scenario assessed	Justification
	Cable seabed preparation in the array area = 13,600,000 m² > 100% of the inter-array cable route may require boulder clearance > Total area of seabed disturbed by boulder plough/ clearance for inter-array cables = 3,600,000 m² > Total area of seabed disturbed my pre-lay grapple run is = 3,000,000 m² (as this area overlaps it has only been calculated once to form the total) > 50% of the inter-array cable route may require sandwave clearance > Total area of seabed disturbed by sandwave clearance = 7,000,000 m² **Burial of inter-array cables (total length 200 km length) = 3,600,000 m²** **Offshore ECC** **Cable seabed preparation and installation in the offshore ECC = 25,160,000 m²** > 100% of the export cable route may require boulder clearance	

Potential effect	Maximum design scenario assessed	Justification
	> Total area of seabed disturbed by boulder plough/ clearance for export cables = 6,660,000 m^2 > Total area of seabed disturbed by pre-lay grapple run is = 5,550,000 m^2 (as this area overlaps with boulder clearance it has only been calculated once to form the total) > 50% of the export cable route may require sandwave clearance > Total area of seabed disturbed by sandwave clearance = 12,950,000 m^2 **Burial of export cables (total length 370 km length) = 6,660,000 m^2** The seabed footprint for cable jointing is within the design envelope for seabed preparation and cable installation **Temporary intertidal habitat disturbance of 3,750 m^2 (total area of all exit pits)** Temporary habitat disturbance from horizontal directional drilling (HDD) exit pit excavation within the intertidal: > HDD pits will be in either the intertidal or below lowest astronomical tide;	

Potential effect	Maximum design scenario assessed	Justification
	> Stage 1: Up to 5 HDD exit pits (10 m width x 75 m length x 3 m depth) excavated via backhoe dredger (or similar) with material side-cast for backfill; > 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 > 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 5,110 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. Potential contamination of intertidal habitats resulting from machinery use and vehicle movement. Potential contamination of intertidal habitats from drilling mud (e.g. bentonite) used to facilitate the installation of export cables via trenchless	These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during construction. .

Potential effect	Maximum design scenario assessed	Justification
	installation techniques (e.g. horizontal directional drilling (HDD), thrust boring, auger boring or pipe ramming).	
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		
Impact 8: Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration	Underwater noise during the operational phase from 79 WTGs and maintenance vessel operations over the design lifetime of the project (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 = 261,488 m^3** **Array cable repair/replacement:** > 8 cable repair/replacement events, with a maximum disturbance of 14,072 m^3 per event = 112,576 m^3 over lifetime of project **Export cable repairs** > 16 cable repair/replacement events, with a maximum disturbance of 9,307 m^3 per event = 148,912 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	Temporary 500 m safety zones around infrastructure that is undergoing major maintenance	This scenario represents the area of safety zones implemented during

Potential effect	Maximum design scenario assessed	Justification
	(for example a WTG blade replacement) will be implemented.	works, and therefore the maximum area of fishing displacement.
Impact 11: Long-term loss of habitat due to the presence of WTGs foundations, scour protection and cable protection	**Habitat loss of 3,611,128 m^2** > Turbine total structure footprint including scour protection, based on 79 GBS (WTG-type) foundations = 1,313,612 m^2 > OSP total structure footprint including scour protection, based on two GBS monopile foundations = 81,656 m^2 > Total area of seabed covered by cable protection (export cables and inter-array) required for cable crossings = 502,260 m^2 > Total area of seabed covered by cable protection (export cables and inter-array) = 1,428,000 m^2 > 20% replenishment of scour protection during operation and maintenance phase = 285,600 m^2	The MDS is defined by the maximum area of seabed lost as a result of the placement of structures, scour 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.
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 = 3,210,272 m^2** Total area of introduced hard substrate at seabed level = 2,766,322 m^2 (see **Impact 5**)	Maximum scenario for introduced hard substrate is as for the maximum scenario for loss of habitat.

Potential effect	Maximum design scenario assessed	Justification
	Total surface area of subsea portions of foundations in contact with the water column: 443,950 m^2 > 79 GBS (WTG-type) foundations, with a total surface area of 430,550 m^2 > OSP structure area, based on two GBS monopile foundations, assuming, with a total surface area of 13,400 m^2	
Impact 13: EMF effects arising from cables during operational phase	**Inter-array cables** > Up to 200 km of inter-array cable, operating up to 132 kV > Inter-array cable burial depth = 0 – 3.5 m **Offshore export cables** > Up to 370km of export cable, operating up to 400 Kv > Export cable burial 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 = 848,336 m^2** > Indicative max seabed disturbance per year from jacking-up activities = 312,400 m^2 > Total seabed area disturbed by array cable replacement through life = 276,656 m^2	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 seabed area disturbed by export cable replacement through life = 259,280 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 EMBEDDED MITIGATION

6.9.1 The embedded 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: Embedded mitigation relating to fish and shellfish ecology.

Project phase	Mitigation measures embedded into the project design
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 PEMP will be secured as a condition in the deemed Marine Licence(s). Typical measures will include: > Storage of all chemicals in secure designated areas with impermeable bunding (generally to 110% of the volume); and > Double skinning of pipes and tanks containing hazardous materials. 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	VE OWFL 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	Development of, and adherence to, a Cable Specification and Installation Plan (CSIP) post consent. The CSIP will set out appropriate cable burial depth in accordance with industry good

[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 embedded into the project design
Installation Plan (CSIP)	practice, minimising the risk of cable exposure. 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 include a detailed Cable Burial Risk Assessment (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. The CSIP will be Conditioned in the deemed Marine Licence.
Project design	A piling Marine Mammal Mitigation Protocol (MMMP) will be developed in accordance with the Outline MMMP 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 scour pits to develop around the foundations of structure, then scour protection will be implemented.
Scour Protection Management Plan	Development of a Scour Protection Plan (SPP) which will consider the need for scour protection where there is the potential for scour to develop around wind farm infrastructure, including turbine and substation/ platform foundations and cables. The plan will be secured via a condition in the deemed Marine Licence.
Maintenance	Assumed 50 m operating distances around infrastructure and temporary safety zones around infrastructure undergoing major maintenance.
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 embedded mitigation measure will be similar to those for the construction phase. The Decommissioning Plan will be secured as a condition in the deemed Marine Licence.

6.10 ENVIRONMENTAL ASSESSMENT: CONSTRUCTION

6.10.1 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.

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

6.10.2 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 impacts piling for exit pits), vessel disturbance and UXO clearance.

6.10.3 To inform the assessment of potential impacts associated with underwater noise 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 4, Annex 6.2: Underwater Noise Technical Report. 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.

6.10.4 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.

6.10.5 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).

6.10.6 The structure of the assessment of underwater noise impacts on fish and shellfish receptors is provided in Table 6.12 below:

Table 6.12: Scope of underwater noise assessment

Step of assessment	Description
Identification of the spatial and temporal underwater noise MDS	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.
Assessment of mortality and potential mortal injury of VER groups	Assessment of the following groups (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 the installation of sheet piled exit pits.	Qualitative assessment undertaken, as the worst case MDS from the piling of turbine foundation is modelled. Modelling of underwater noise impacts from the installation of sheet piled exit pits will be undertaken post-PEIR and will be used to inform the assessment at ES stage.
Noise and vibration arising from UXO clearance	Qualitative assessment undertaken, as the worst case MDS from the piling of turbine foundations is modelled.

6.10.7 The spatial and temporal MDS for underwater noise impacts from foundation installation (piling of monopiles or pin piles) are defined according to a maximum scenario, i.e., the maximum design parameters that may be utilised during the construction of the proposed development. 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.

6.10.8 The spatial MDS equates to the greatest area of effect from subsea noise at any one-time during piling of foundations, this results from the sequential piling of four monopiles within a 24 hour period (for stationary receptors). Note, that for fleeing receptors, the spatial MDS results from the sequential installation of eight pin piles within a 24 hour period.

6.10.9 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 6.13).

Table 6.13: MDS for foundations installation.

Parameter	Single Piling of Foundations		Sequential Piling of Foundations				Concurrent Piling of Foundations
	Monopile Foundations	**Pin Pile Foundations**	**Monopile Foundations**	**Pin Pile Foundations**	**Pin Pile Foundations**	**Monopile Foundations**	**Pin Pile Foundations**
Spatial MDS							
Installation Approach	Piling of 1 monopile within 24 hours.	Piling of 1 pin-pile within 24 hours.	Sequential piling of 4 monopiles at separate locations in 24 hours.	Sequential piling of 4 pin piles at one location in 24 hours.	Sequential piling of 8 pin piles at one location in 24 hours.	Concurrent piling of 2 monopile foundations at 2 locations.	Concurrent piling of 4 pin piles each at locations.
Hammer Energy (maximum)	7,000 kJ	3,000 kJ	7,000 kJ	3,000 kJ	3,000 kJ	7,000 kJ	3,000 kJ
Temporal MDS							
Maximum Number of Piles	81	340	81	340	340	81	340
Maximum Piling Duration (hours)	605.7 hours (7.5 hours per monopile)	1,360 hours (4 hours per pin pile)	605.7 hours (7.5 hours per monopile)	1,360 hours (4 hours per pin pile)	1,360 hours (4 hours per pin pile)	302.9 hours (7.5 hours per 2 monopiles)	340 hours (4 hours per 4 pin piles)

6.10.10 As part of the landfall works, it may be necessary to install five sheet piled exit pits for the trenchless installation techniques. The installation of the sheet piled exit pits will consist of the piling of up to 1,100 sheet piles, using a maximum hammer energy of 300 kJ.

6.10.11 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 RLB 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).

6.10.12 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.

6.10.13 Detonation of UXO would represent a short-term (i.e. seconds) increase in underwater noise (i.e. sound pressure levels and particle motion) and while noise levels will be elevated such that this may result in injury or behavioural effects on fish and shellfish species, UXO detonations are considered to have a lower likelihood of triggering a population level effect than that associated from piling operations, due to the significantly reduced temporal footprint that would arise from UXO operations.

RECEPTOR SENSITIVITY AND INJURY CRITERIA FOR ASSESSMENT

6.10.14 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; and
  - Monopile installation MDS
  - Pin pile installation MDS
- Underwater noise associated with UXO clearance.

6.10.15 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.

6.10.16 For the purposes of the assessment, Volume 4, 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

6.10.17 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 6.14 below. It is important to note that there are differences in impact thresholds for the different hearing groups.

6.10.18 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 6.14: Hearing categories of fish receptors (Popper *et al*, 2014).

Category	VERs Relevant to VE
Group 1 (least sensitive)	Sandeel, common sole, lemon sole, dab, solenette, plaice, mackerel, river and sea lamprey, elasmobranchs.
Group 2	Atlantic salmon, sea trout.
Group 3 (most sensitive)	Spawning herring, seahorse, sprat, cod, whiting, whiting-pout*, European eel*, allis and twaite shad, smelt*, haddock, horse mackerel*, common dragonet*, pogge*, poor cod*, hooknose*, goby species*, lesser weaver*, Northern and five bearded rockling*, tub gurnard*, red gurnard*, albacore*, Norway pout, silvery pout*, sea bass*.

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

Table 6.15: 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} 213 dB SPL_{peak}	216 dB SEL_{cum} 213 dB SPL_{peak}	>>186 dB SEL_{cum}
Group 2	210 dB SEL_{cum} 207 dB SPL_{peak}	203 dB SEL_{cum} 207 dB SPL_{peak}	>186 dB SEL_{cum}
Group 3	207 dB SEL_{cum} 207 dB SPL_{peak}	203 dB SEL_{cum} 207 dB SPL_{peak}	186 dB SEL_{cum}
Eggs and Larvae	210 dB SEL_{cum} 207 dB SPL_{peak}	N/A	N/A

6.10.19 The noise modelling for injury ranges for fleeing and stationary fish is presented in Volume 4, Annex 6.2: Underwater Noise Technical Report, and referred to, as appropriate in the following assessments. Table 6.16, Table 6.17, Table 6.18 and Table 6.19 below summarise the results for each of the relevant criteria against each of the MDS under consideration.

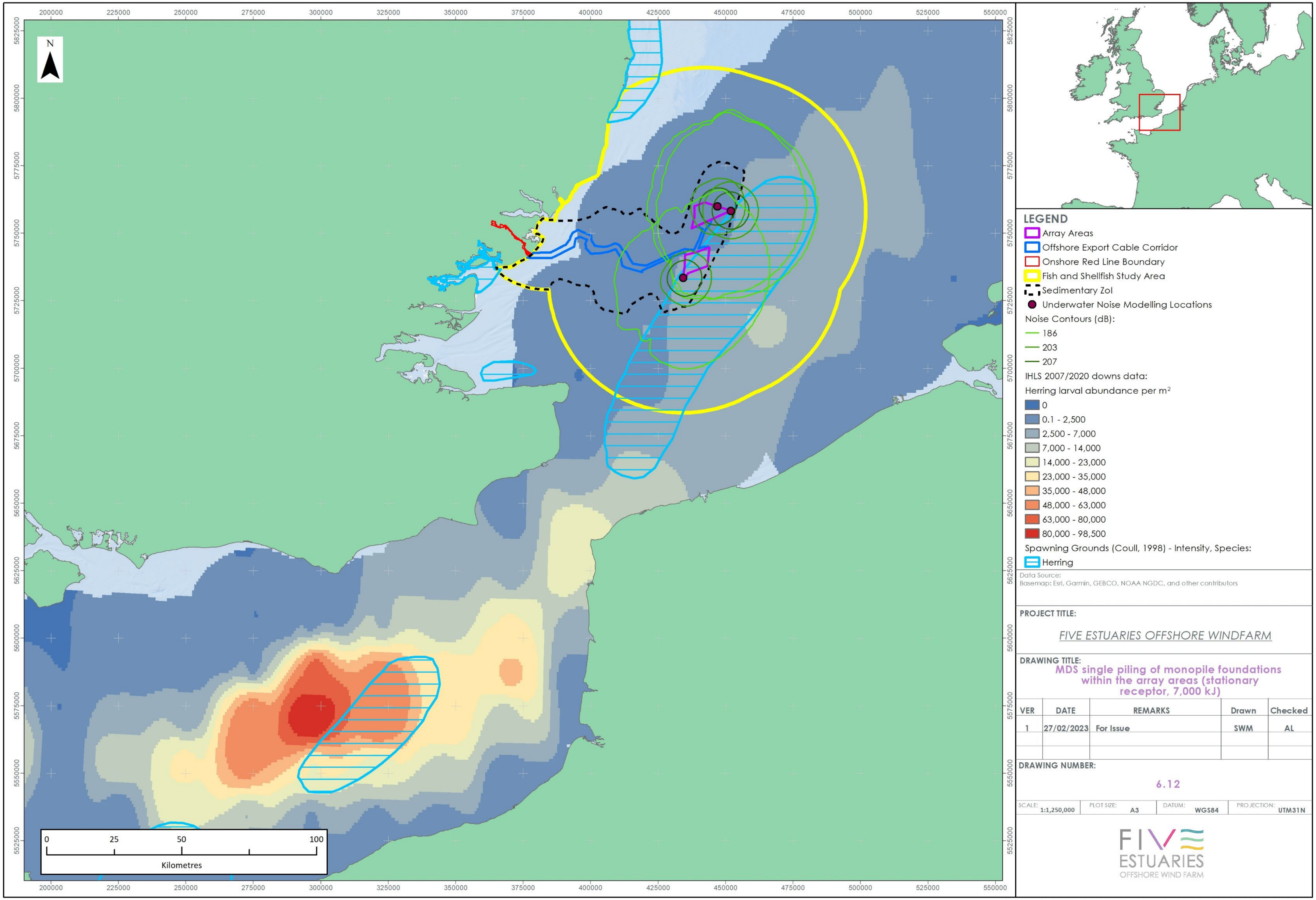
Table 6.16: Noise modelling results for injury ranges for fleeing and stationary receptors (single piling scenarios).

Receptor	Criteria	Noise Level *	Monopile Impact Ranges			Pin Pile Impact Ranges		
			South array SW corner	North array NE corner	North array N edge	South array SW corner	North array NE corner	North array N edge
Mortality and Potentially Mortal Injury								
Group 1 fish	SPL_{peak}	213	130m	130m	130m	100m	100m	100m
	SEL_{cum} (static)	219	1.4km	1.4km	1.4km	700m	730m	730m
	SEL_{cum} (fleeing)	219	<100m	<100m	<100m	<100m	<100m	<100m
Group 2 fish	SPL_{peak}	207	340m	340m	340m	270m	270m	270m
	SEL_{cum} (static)	210	4.9km	4.8 km	4.9km	2.7km	2.7km	2.7km
	SEL_{cum} (fleeing)	210	<100m	<100m	<100m	<100m	<100m	<100m
Group 3 fish	SPL_{peak}	207	340m	340m	340m	270m	270m	270m
	SEL_{cum} (static)	207	7km	7km	7.1km	4.1km	4km	4.1km
	SEL_{cum} (fleeing)	207	<100m	<100m	<100m	<100m	<100m	<100m
Eggs and larvae	SPL_{peak}	207	340m	340m	340m	270m	270m	270m
	SEL_{cum} (static)	210	4.9km	4.8km	4.9km	2.7km	2.7km	2.7km

Receptor	Criteria	Noise Level *	Monopile Impact Ranges			Pin Pile Impact Ranges		
			South array SW corner	North array NE corner	North array N edge	South array SW corner	North array NE corner	North array N edge
Recoverable Injury								
Group 1 fish	SPL_{peak}	213	130m	130m	130m	100m	100m	100m
	SEL_{cum} (static)	216	2.2km	2.2km	2.2km	1.1km	1.1km	1.1km
	SEL_{cum} (fleeing)	216	<100m	<100m	<100m	<100m	<100m	<100m
Group 2 fish	SPL_{peak}	207	340m	340m	340m	270m	270m	270m
	SEL_{cum} (static)	203	11km	11km	11km	6.6km	6.6km	6.7km
	SEL_{cum} (fleeing)	203	650m	630m	700m	<100m	<100m	<100m
Group 3 fish	SPL_{peak}	207	340m	340m	340m	270m	270m	270m
	SEL_{cum} (static)	203	11km	11km	11km	6.6km	6.6km	6.7km
	SEL_{cum} (fleeing)	203	650m	630m	700m	<100m	<100m	<100m
Temporary Threshold Shift								
Group 1 fish	SEL_{cum} (static)	186	36km	36km	36km	28km	28km	28km

Receptor	Criteria	Noise Level *	Monopile Impact Ranges			Pin Pile Impact Ranges		
			South array SW corner	North array NE corner	North array N edge	South array SW corner	North array NE corner	North array N edge
	SEL_{cum} (fleeing)	186	21km	22km	22km	17km	18km	18km
Group 2 fish	SEL_{cum} (static)	186	36km	36km	36km	28km	28km	28km
	SEL_{cum} (fleeing)	186	21km	22km	22km	17km	18km	18km
Group 3 fish	SEL_{cum} (static)	186	36km	36km	36km	28km	28km	28km
	SEL_{cum} (fleeing)	186	21km	22km	22km	17km	18km	18km

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


N
LEGEND
Array Areas
Offshore Export Cable Corridor
Onshore Red Line Boundary
Fish and Shellfish Study Area
Sedimentary ZoI
Underwater Noise Modelling Locations
Noise Contours (dB):
186
203
207
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
Spawning Grounds (Coull, 1998) - Intensity, Species:
Herring
Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
PROJECT TITLE:
FIVE ESTUARIES OFFSHORE WINDFARM
DRAWING TITLE:
MDS single piling of monopile foundations within the array areas (stationary receptor, 7,000 kJ)
VER | DATE | REMARKS | Drawn | Checked
1 | 27/02/2023 | For Issue | SWM | AL
DRAWING NUMBER:
6.12
SCALE: 1:1,250,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM31N
FIVE ESTUARIES
OFFSHORE WIND FARM
0 25 50 100
Kilometres
200000 225000 250000 275000 300000 325000 350000 375000 400000 425000 450000 475000 500000 525000 550000
5825000 5800000 5775000 5750000 5725000 5700000 5675000 5650000 5625000 5600000 5575000 5550000 5525000
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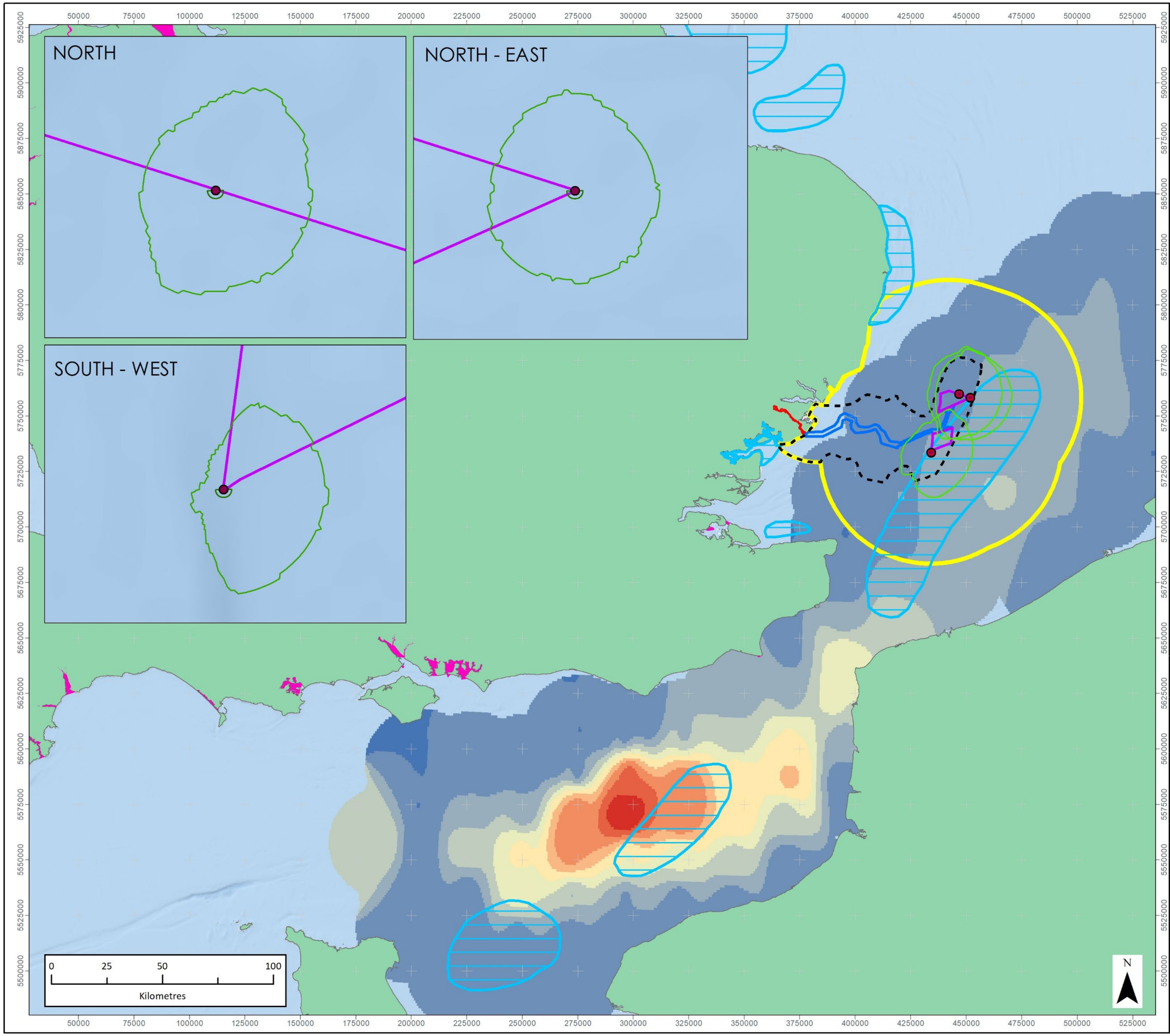

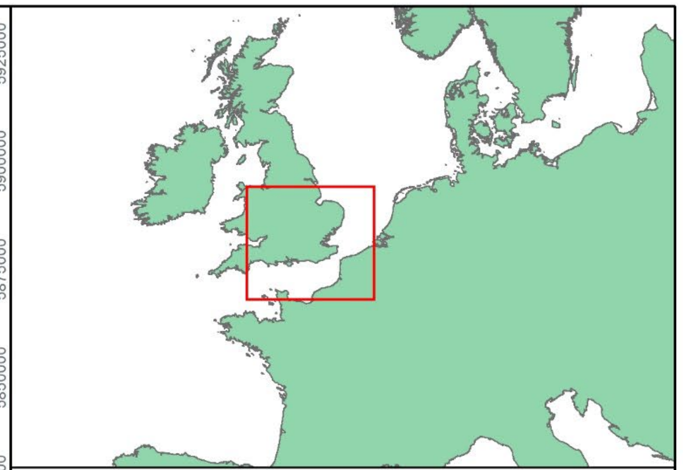

LEGEND
- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Underwater Noise Modelling Locations

Noise Contours (dB):
- 186
- 203
- 207

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
- Sea Bass Nursery Grounds (Cefas, 1999)

Spawning Grounds (Coull, 1998) - Intensity, Species:
- Herring

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

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

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:
6.13

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

FIVE ESTUARIES
OFFSHORE WIND FARM

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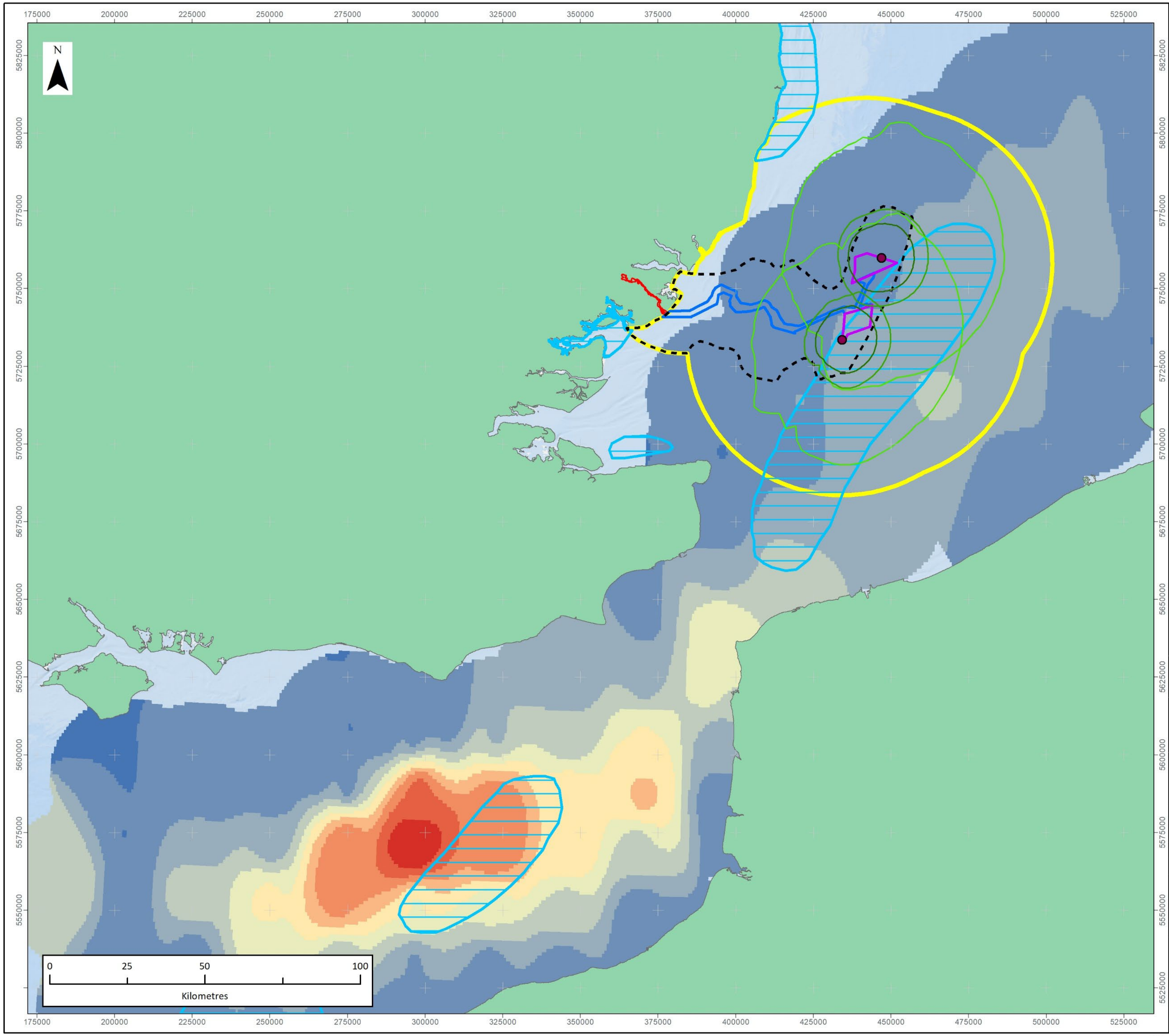
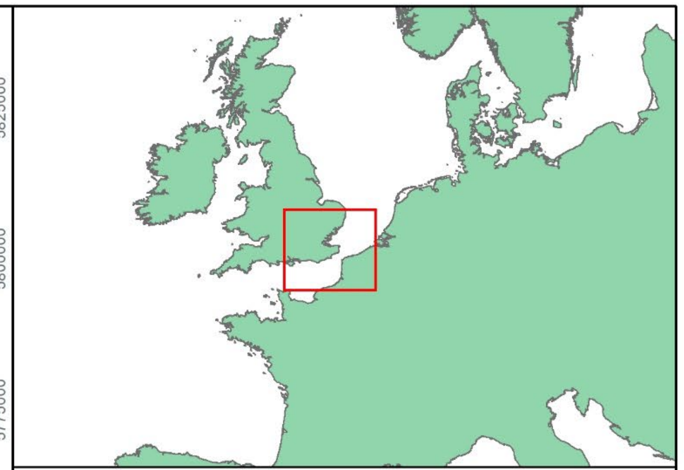
Table 6.17: Noise modelling results for injury ranges for fleeing and stationary receptors (sequential piling scenarios of pin pile foundations).

Receptor	Criteria	Noise Level *	Sequential Pin Pile Impact Ranges (x4)			Sequential Pin Pile Impact Ranges (x8)	
			South array SW corner	North array NE corner	North array N edge	South array SW corner	North array N edge
Mortality and Potentially Mortal Injury							
Group 1 fish	SPL_{peak}	213	100m	100m	100m	100m	100m
	SEL_{cum} (static)	219	1.8km	1.7km	1.8km	2.8km	2.9km
	SEL_{cum} (fleeing)	219	<100m	<100m	<100m	<100m	<100m
Group 2 fish	SPL_{peak}	207	270m	270m	270m	270m	270m
	SEL_{cum} (static)	210	5.9km	5.8km	6km	8.4km	8.5km
	SEL_{cum} (fleeing)	210	<100m	<100m	<100m	<100m	<100m
Group 3 fish	SPL_{peak}	207	270m	270m	270m	270m	270m
	SEL_{cum} (static)	207	8.3km	8.2km	8.5km	11km	12km
	SEL_{cum} (fleeing)	207	<100m	<100m	<100m	<100m	<100m

Receptor	Criteria	Noise Level *	Sequential Pin Pile Impact Ranges (x4)			Sequential Pin Pile Impact Ranges (x8)	
			South array SW corner	North array NE corner	North array N edge	South array SW corner	North array N edge
Eggs and larvae	SPL_{peak}	207	270m	270m	270m	270m	270m
	SEL_{cum} (static)	210	5.9km	5.8km	6km	8.4km	8.5km
Recoverable Injury							
Group 1 fish	SPL_{peak}	213	100m	100m	100m	100m	100m
	SEL_{cum} (static)	216	2.7km	2.7km	2.7km	4.2km	4.2km
	SEL_{cum} (fleeing)	216	<100m	<100m	<100m	<100m	<100m
Group 2 fish	SPL_{peak}	207	270m	270m	270m	270m	270m
	SEL_{cum} (static)	203	12km	12km	13km	16km	16km
	SEL_{cum} (fleeing)	203	<100m	<100m	<100m	1.1km	1.1km
Group 3 fish	SPL_{peak}	207	270m	270m	270m	270m	270m
	SEL_{cum} (static)	203	12km	12km	13km	16km	16km

Receptor	Criteria	Noise Level *	Sequential Pin Pile Impact Ranges (x4)			Sequential Pin Pile Impact Ranges (x8)	
			South array SW corner	North array NE corner	North array N edge	South array SW corner	North array N edge
	SEL_{cum} (fleeing)	203	<100m	<100m	<100m	1.1km	1.1km
Temporary Threshold Shift							
Group 1 fish	SEL_{cum} (static)	186	39km	39km	39km	44km	44m
	SEL_{cum} (fleeing)	186	17km	18km	18km	23km	23km
Group 2 fish	SEL_{cum} (static)	186	39km	39km	39km	44km	44km
	SEL_{cum} (fleeing)	186	17km	18km	18km	23km	23km
Group 3 fish	SEL_{cum} (static)	186	39km	39km	39km	44km	44km
	SEL_{cum} (fleeing)	186	17km	18km	18km	23km	23km





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Noise Modelling Locations

Noise Contours (dB):

- 186
- 203
- 207

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

Spawning Grounds (Coull, 1998) - Intensity, Species:

- Herring

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

MDS sequential piling of 8 pin piles within the array areas (stationary receptor, 3,000 kJ)

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.14

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:1,250,000	A3	WGS84	UTM31N

FIVE ESTUARIES OFFSHORE WIND FARM

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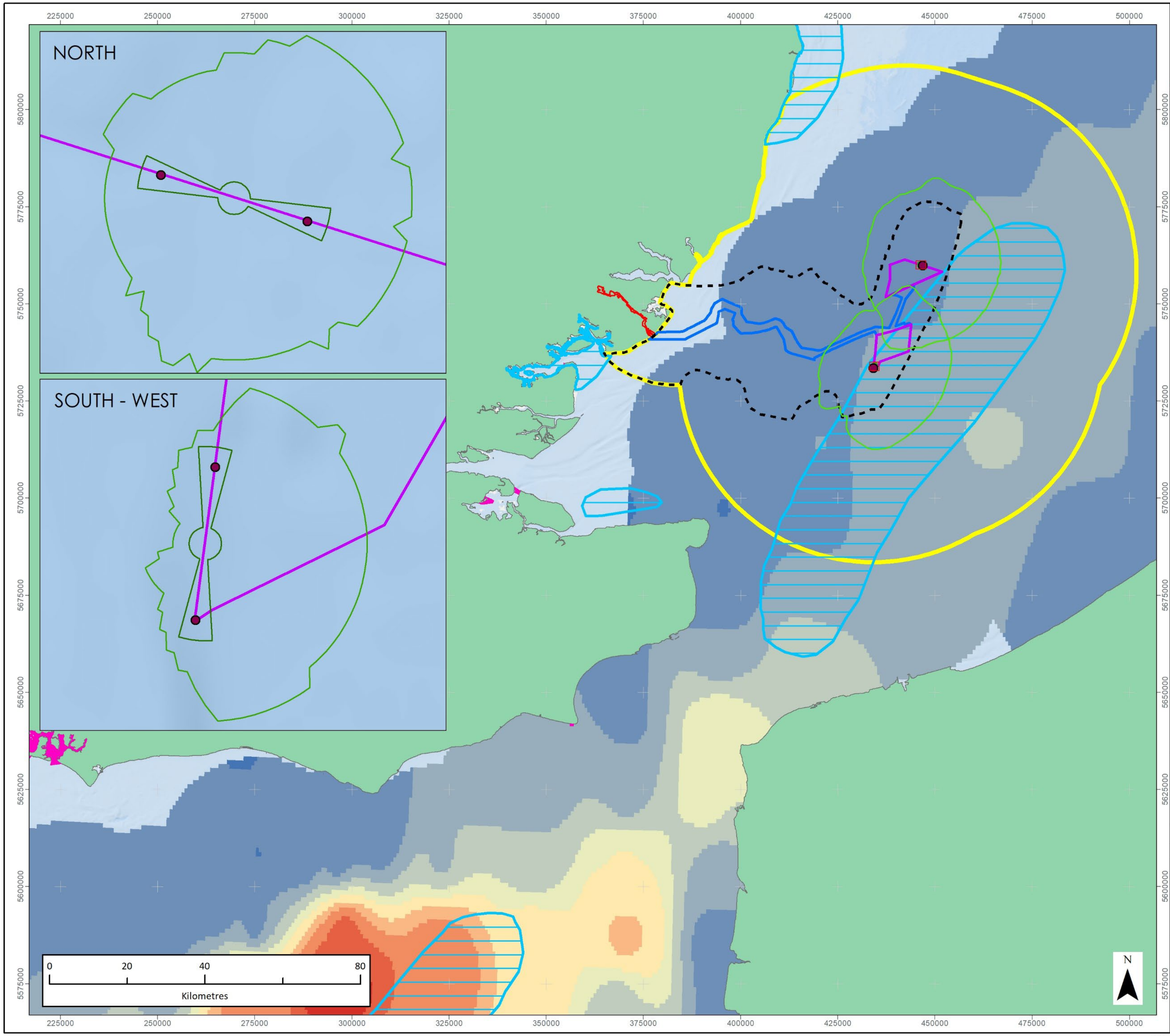

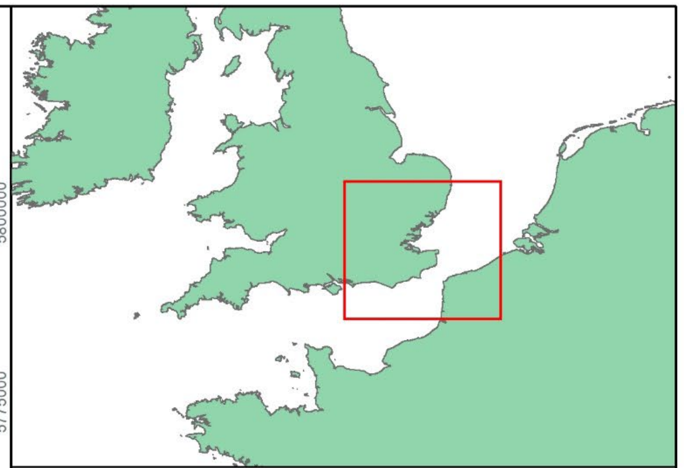

LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Noise Modelling Locations

Noise Contours (dB):

- 186
- 203
- 207

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
- Sea Bass Nursery Grounds (Cefas, 1999)

Spawning Grounds (Coull, 1998) - Intensity, Species:

- Herring

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

MDS sequential piling of 8 pin piles within the array areas (fleeing receptor, 3,000 kJ)

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.15

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

FIVE ESTUARIES
OFFSHORE WIND FARM

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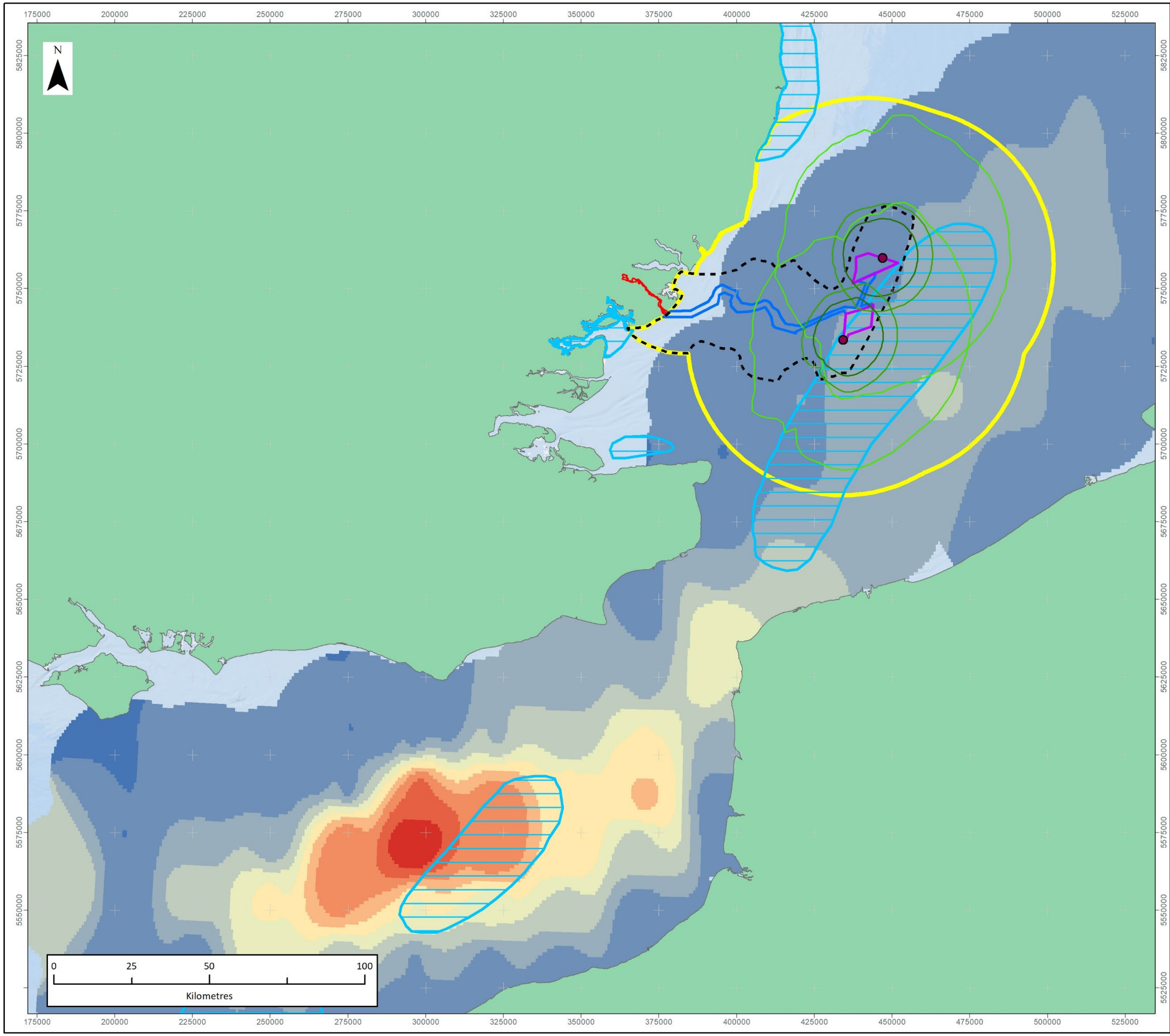
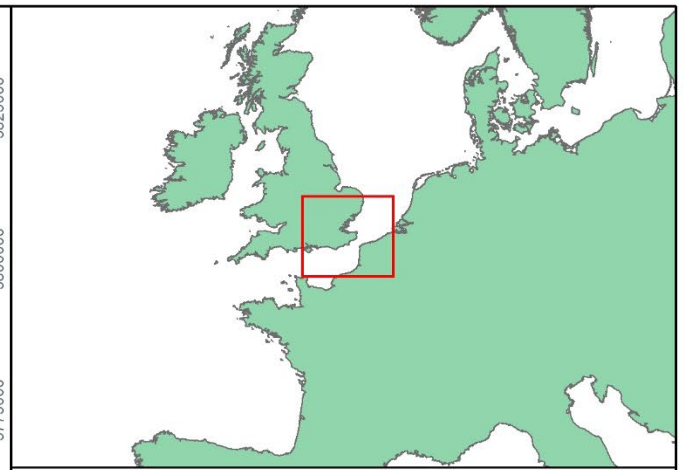
Table 6.18: Noise modelling results for injury ranges for fleeing and stationary receptors (sequential piling scenarios of monopile foundations).

Receptor	Criteria	Noise Level *	Sequential Monopile Impact Ranges (x4)	
			South array SW corner	North array N edge
Mortality and Potentially Mortal Injury				
Group 1 fish	SPL_{peak}	213	130 m	130 m
	SEL_{cum} (static)	219	5.1 km	5.1 km
	SEL_{cum} (fleeing)	219	<100 m	<100 m
Group 2 fish	SPL_{peak}	207	340 m	340 m
	SEL_{cum} (static)	210	11 km	11 km
	SEL_{cum} (fleeing)	210	<100 m	<100 m
Group 3 fish	SPL_{peak}	207	340 m	340 m
	SEL_{cum} (static)	207	14 km	13 km
	SEL_{cum} (fleeing)	207	<100 m	<100 m
Eggs and larvae	SPL_{peak}	207	340 m	340 m
	SEL_{cum} (static)	210	11 km	11 km

Receptor	Criteria	Noise Level *	Sequential Monopile Impact Ranges (x4)	
			South array SW corner	North array N edge
Recoverable Injury				
Group 1 fish	SPL_{peak}	213	130 m	130 m
	SEL_{cum} (static)	216	6.6 km	6.5 km
	SEL_{cum} (fleeing)	216	<100 m	<100 m
Group 2 fish	SPL_{peak}	207	340 m	340 m
	SEL_{cum} (static)	203	20 km	18 km
	SEL_{cum} (fleeing)	203	700 m	800 m
Group 3 fish	SPL_{peak}	207	340 m	340 m
	SEL_{cum} (static)	203	20 km	18 km
	SEL_{cum} (fleeing)	203	700 m	800 m
Temporary Threshold Shift				
Group 1 fish	SEL_{cum} (static)	186	48 km	47 km
	SEL_{cum} (fleeing)	186	22 km	22 km

Receptor	Criteria	Noise Level *	Sequential Monopile Impact Ranges (x4)	
			South array SW corner	North array N edge
Group 2 fish	SEL_{cum} (static)	186	48 km	47 km
	SEL_{cum} (fleeing)	186	22 km	22 km
Group 3 fish	SEL_{cum} (static)	186	48 km	47 km
	SEL_{cum} (fleeing)	186	22 km	22 km





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Noise Modelling Locations

Noise Contours (dB):

- 186
- 203
- 207

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

Spawning Grounds (Coull, 1998) - Intensity, Species:

- Herring

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

MDS sequential piling of 4 monopiles within the array areas (stationary receptor, 7,000 kJ)

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.16

SCALE: 1:1,250,000 | PLOT SIZE: A3 | DATUM: WGS84 | PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

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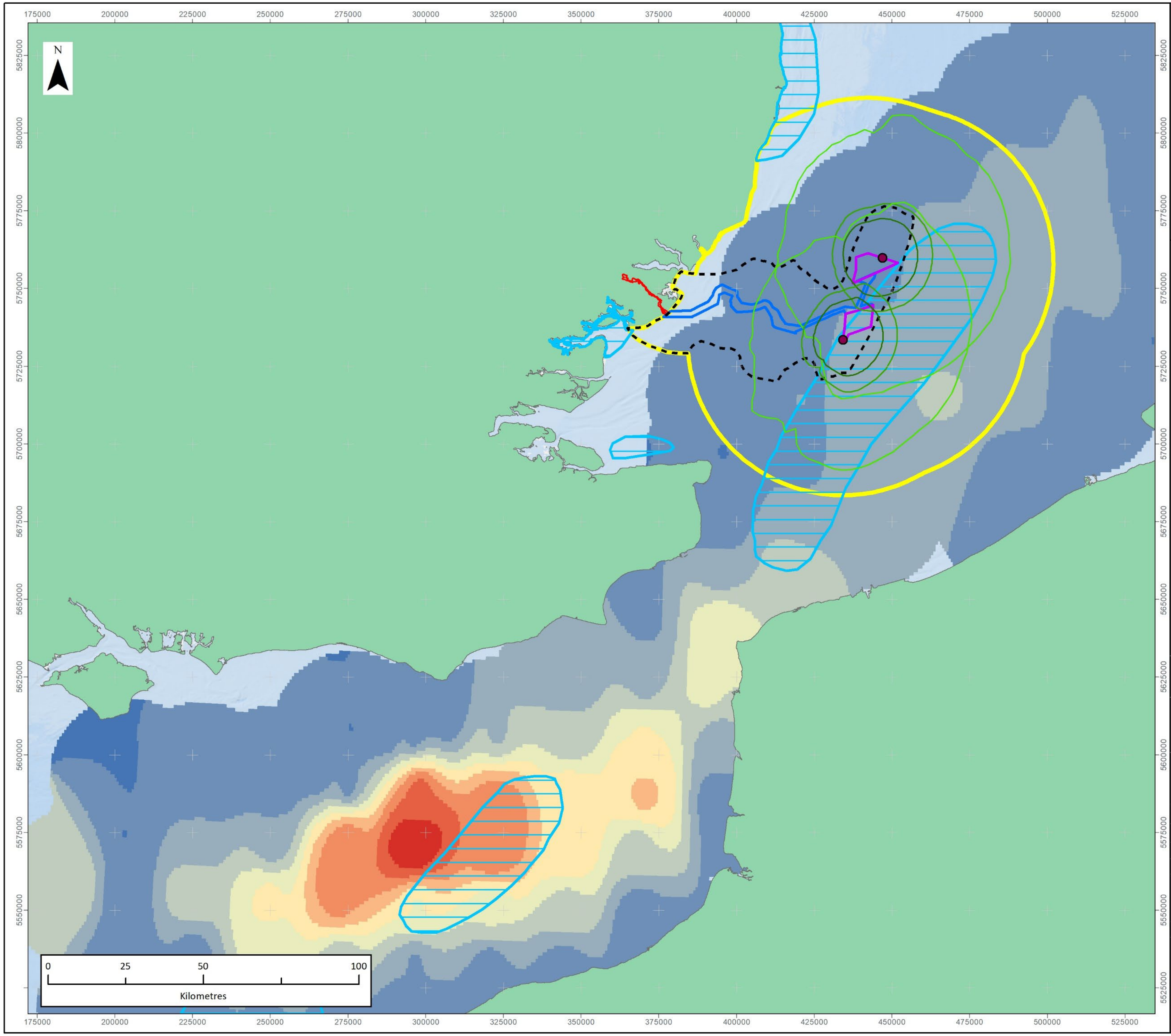

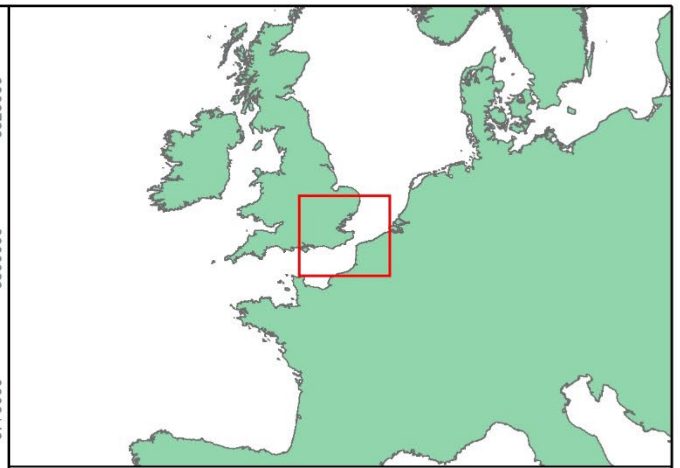

LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Noise Modelling Locations

Noise Contours (dB):
- 186
- 203
- 207

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

Spawning Grounds (Coull, 1998) - Intensity, Species:
- Herring

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

MDS sequential piling of 4 monopiles within the array areas (fleeing receptor, 7,000 kJ)

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.17

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:1,250,000	A3	WGS84	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

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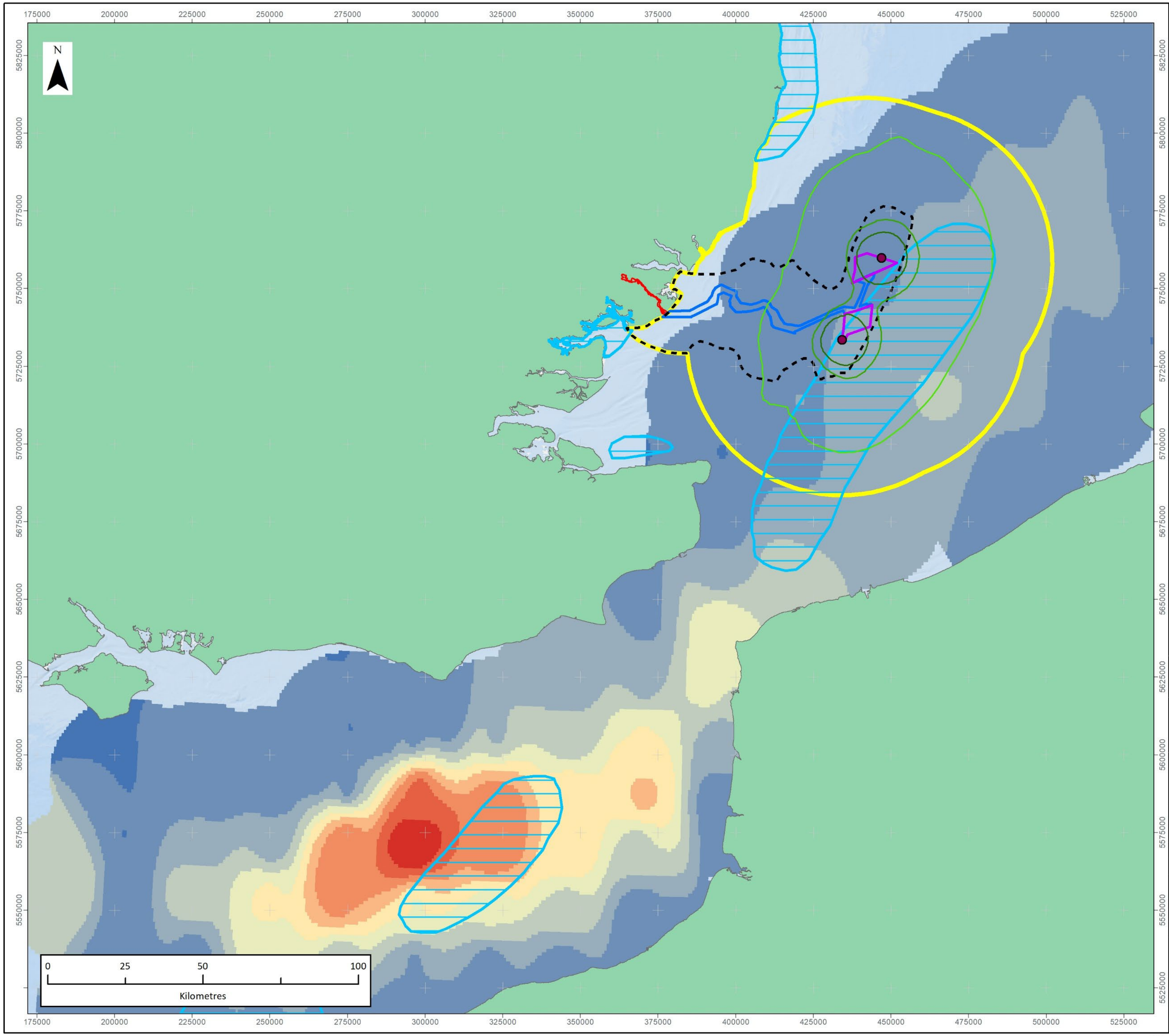
Table 6.19: Noise modelling results for injury areas for fleeing and stationary receptors (concurrent piling scenarios)[6].

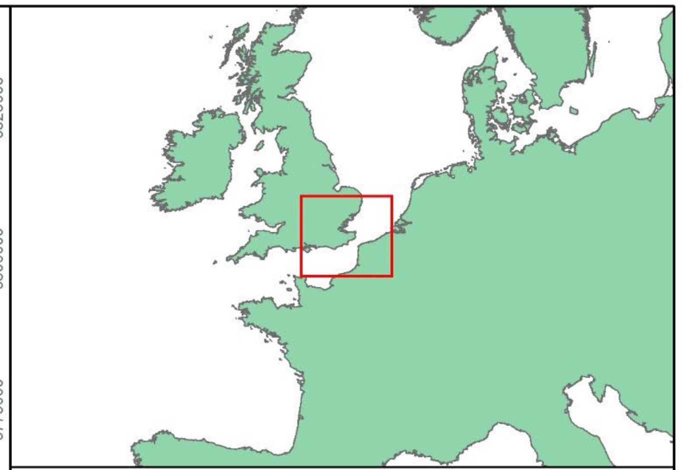
Receptor	Criteria	Noise Level *	In-combination area	
			Concurrent Pin Pile Impact Areas (4 pin piles at SW and N edge locations)	Concurrent Monopile Impact Areas (1 monopile at SW and N edge locations)
Mortality and Potentially Mortal Injury				
Group 1 fish	SEL_{cum} (static)	219	20 km^2	13 km^2
	SEL_{cum} (fleeing)	219	-	-
Group 2 fish	SEL_{cum} (static)	210	210 km^2	150 km^2
	SEL_{cum} (fleeing)	210	-	-
Group 3 fish	SEL_{cum} (static)	207	400 km^2	290 km^2
	SEL_{cum} (fleeing)	207	-	-
Eggs and larvae	SEL_{cum} (static)	210	210 km^2	150 km^2
Recoverable Injury				

[6] Fields with a dash "-" show where there is no in-combination effect when piling occurs at the two locations simultaneously, generally where the individual ranges are small enough that the distant site does not produce an influencing additional exposure.

Receptor	Criteria	Noise Level *	In-combination area: Concurrent Pin Pile Impact Areas (4 pin piles at SW and N edge locations)	In-combination area: Concurrent Monopile Impact Areas (1 monopile at SW and N edge locations)
Group 1 fish	SEL_{cum} (static)	216	45 km^2	31 km^2
	SEL_{cum} (fleeing)	216	-	-
Group 2 fish	SEL_{cum} (static)	203	920 km^2	670 km^2
	SEL_{cum} (fleeing)	203	-	210 km^2
Group 3 fish	SEL_{cum} (static)	203	920 km^2	670 km^2
	SEL_{cum} (fleeing)	203	-	210 km^2
Temporary Threshold Shift				
Group 1 fish	SEL_{cum} (static)	186	5,300 km^2	4,800 km^2
	SEL_{cum} (fleeing)	186	1,800 km^2	2,300 km^2
Group 2 fish	SEL_{cum} (static)	186	5,300 km^2	4,800 km^2
	SEL_{cum} (fleeing)	186	1,800 km^2	2,300 km^2
Group 3 fish	SEL_{cum} (static)	186	5,300 km^2	4,800 km^2

Receptor	Criteria	Noise Level *	In-combination area Concurrent Pin Pile Impact Areas (4 pin piles at SW and N edge locations)	 Concurrent Monopile Impact Areas (1 monopile at SW and N edge locations)
	SEL_{cum} (fleeing)	186	1,800 km^2	2,300 km^2





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- Sedimentary ZoI
- Noise Modelling Locations

Noise Contours (dB):

- 186
- 203
- 207

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

Spawning Grounds (Coull, 1998) - Intensity, Species:

- Herring

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

MDS concurrent piling of pin piles within the array areas (stationary receptor, 3,000 kJ)

VER	DATE	REMARKS	Drawn	Checked
1	27/02/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.18

SCALE: 1:1,250,000	PLOT SIZE: A3	DATUM: WGS84	PROJECTION: UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

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MORTALITY AND POTENTIAL MORTAL INJURY OF GROUP 1 VERS

6.10.20 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.

6.10.21 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

6.10.22 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. 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 therefore considered less sensitive to underwater noise. These VERs are pelagic spawners and are therefore not limited to specific

Group 1 VER	Sensitivity Justification
	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, solenette, 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

6.10.23 Regarding the spatial MDS for stationary receptors, 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 four monopiles within 24 hours (hammer energy 7,000 kJ). An impact range of up to 5.1 km is predicted from this piling within the array areas.

6.10.24 Regarding the spatial MDS for fleeing receptors, the maximum predicted range of impact for mortality and potential mortal injury of fleeing Group 1 receptors occurs from the piling of 8 pin piles (hammer energy 3,000 kJ). The maximum predicted range of impacts on fleeing Group 1 receptors are expected to be significantly less (<100 m) and within the immediate vicinity of the piling activity.

6.10.25 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.

6.10.26 There is 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 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 from the concurrent piling of four pin piles at both locations on stationary receptors is 20km^2. The maximum in-combination area of effect from the concurrent piling of one monopile at each location on stationary receptors is 13 km^2. There is no potential for an in-combination area of effect from concurrent piling on fleeing receptors.

6.10.27 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.

6.10.28 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 on these receptors is therefore considered to be of negligible magnitude.

SIGNIFICANCE OF EFFECT

6.10.29 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.

6.10.30 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.

6.10.31 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

6.10.32 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.

6.10.33 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. 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

6.10.34 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 is not considered.

6.10.35 Regarding the spatial MDS for fleeing receptors, the maximum predicted range of impact for mortality and potential mortal injury of fleeing Group 2 receptors (Atlantic salmon and sea trout) occurs from the sequential piling of eight pin piles within 24 hour period (hammer energy 3,000 kJ). The maximum predicted range of impacts on fleeing Group 2 receptors are expected to occur <100 m and within the immediate vicinity of the piling activity.

6.10.36 There is no potential for an in-combination area of effect from concurrent piling on fleeing receptors.

6.10.37 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

6.10.38 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

6.10.39 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. However, IHLS data indicates that in fact the main spawning activity (based on distribution of yolk-sac larvae) is in the eastern English Channel (from Côte d'Opale near Dunkerque to Cap d'Antifer near Le Havre on the French coast) 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). The annual IHLS data (2002 – 2020) as presented in Volume 4, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data) also reflect these trends. Suitable herring spawning substrates are located within the mid-section of the ECC, and the array

Group 3 VER	Sensitivity Justification
	areas, and are also widely distributed across the wider Thames Estuary and the English Channel. 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, and considering the low intensity spawning across VE, and wider availability of spawning habitats across the Thames Estuary and English Channel, herring are considered to be of high vulnerability, with medium recoverability and of regional importance (Section 41 priority species), therefore the 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

Group 3 VER	Sensitivity Justification
	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 (Whiting-pout, European eel, allis and twaite shad, smelt, haddock, common dragonet, pogge, poor cod, hooknose, goby species, lesser weaver, Northern and five bearded rockling, tub gurnard, red gurnard, albacore, Norway pout, silvery pout, 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, therefore, the sensitivity of these VERs to noise impacts is considered to be low.

MAGNITUDE OF IMPACT

6.10.40 Regarding the spatial MDS for stationary receptors (spawning herring, seahorse), the maximum predicted range of impact for mortality and potential mortal injury of stationary Group 3 receptors occurs from the sequential installation of four monopiles within 24 hours (hammer energy 7,000 kJ). An impact range of up to 14km is predicted from piling within the array areas. The noise contours shown in relation to herring spawning grounds and larvae abundances (Coull *et al.*, 1998 and IHLS data (2007 – 2021)) in Figure 6.14 indicate the potential for mortality and potential mortal injury of spawning herring. A partial overlap of the mortality and potential mortal injury noise contour with the Downs herring spawning ground can be observed in Figure 6.14, although as shown by annual IHLS data (ICES, 2007-2020 (Volume 4, 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. 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 across the Thames Estuary and English Channel. Therefore, underwater noise from piling is unlikely to have a population level effect of the Downs herring stock. 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.

6.10.41 Regarding the spatial MDS for fleeing receptors, the maximum predicted range of impact for mortality and potential mortal injury of fleeing Group 3 receptors occurs from the sequential piling of eight pin piles within 24 hours (hammer energy 3,000 kJ). The maximum predicted range of impacts on fleeing Group 3 receptors are expected to occur <100 m and within the immediate vicinity of the piling activity.

6.10.42 The maximum in-combination area of effect from the concurrent piling of four pin piles at both locations on stationary receptors is 400 km^2. The maximum in-combination area of effect from the concurrent piling of one monopile at each location on stationary receptors is 290 km^2. There is no potential for an in-combination area of effect from concurrent piling on fleeing receptors.

6.10.43 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)) 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.

6.10.44 Considering the small overlap of the mortality and potential mortal injury noise contours of the Downs herring spawning grounds and of areas of low-density herring larvae present within the noise contour extents (Figure 6.16), the magnitude of impact of spawning Downs stock herring from piling activities is considered to be low.

6.10.45 As there is no overlap of the mortality and potential mortal injury noise contours of the Blackwater herring spawning ground (Figure 6.16), the magnitude of impact on the Blackwater herring stock from piling activities is considered to be negligible.

6.10.46 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 that construction activities relating to the VE will have on seahorse is considered negligible.

6.10.47 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 their nursery grounds from piling activities is considered to be negligible.

6.10.48 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 piling activities on these receptors is therefore considered to be low.

6.10.49 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

6.10.50 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.

6.10.51 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.

6.10.52 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.

6.10.53 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.

6.10.54 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.

6.10.55 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

6.10.56 Plaice, sole, cod, horse mackerel, sandeel, herring, mackerel, sprat, whiting and lemon sole all have spawning grounds within the vicinity of VE (Volume 4, 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}.

6.10.57 With regards the spatial MDS, from the sequential piling of four monopiles within 24 hours, the modelling results indicate that the maximum potential range for mortality and potential mortal injury of eggs and larvae is up to 11km from the array areas (based on SEL_{cum} (static)).

6.10.58 Considering the small overlap of the mortality and potential mortal injury noise contours of the Downs herring spawning, the magnitude of impact on herring eggs and larvae from piling activities is considered to be low.

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

6.10.60 The maximum in-combination area of effect from the concurrent piling of four pin piles at both locations on eggs and larvae is 210 km^2. The maximum in-combination area of effect from the concurrent piling of one monopile at each location on eggs and larvae is 150 km^2.

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

6.10.62 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.

6.10.63 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.

6.10.64 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

6.10.65 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)).

6.10.66 Pile driving is recognised as a source particle motion, generating high levels of particle motion in the nearfield (Hazelwood and Macey, 2016) 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.

6.10.67 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.

6.10.68 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.

6.10.69 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.

6.10.70 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

6.10.71 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

6.10.72 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 underwater noise impacts from piling activities.

MAGINITUDE OF IMPACT

6.10.73 Regarding the spatial MDS for stationary receptors, the maximum predicted range of impact for recoverable injury of stationary Group 1 receptors (e.g., sandeel) occurs from the sequential installation of 4 monopiles within 24 hours (hammer energy 7,000 kJ). An impact range of up to 6.6 km is predicted from piling within the array areas.

6.10.74 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 and more distant areas and the localised range of any injurious impacts, there are not considered to be any population level effects on the species.

6.10.75 Regarding the spatial MDS for fleeing receptors, which results from the sequential installation of eight pin piles within 24 hours (3,000 kJ hammer energy) the maximum predicted range of impact is significantly less (<100 m) and within the immediate vicinity of the piling activity.

6.10.76 There is 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 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 from the concurrent piling of four pin piles at both locations on stationary Group 1 receptors (e.g. sandeel) is 45km^2. The maximum in-combination area of effect from the concurrent piling of one monopile at each location on stationary receptors is 31km^2. There is no potential for an in-combination area of effect from concurrent piling on fleeing receptors.

6.10.77 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 underwater noise are considered to be of local scale (based on the modelling results).

6.10.78 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.

6.10.79 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.

6.10.80 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.

6.10.81 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

6.10.82 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.

6.10.83 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.

6.10.84 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

6.10.85 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

6.10.86 Regarding the spatial MDS for fleeing receptors, the maximum predicted range of impact recoverable injury of fleeing Group 2 receptors (Atlantic salmon and sea trout) occurs from the sequential installation of eight pin piles within 24 hours (hammer energy 3,000 kJ). The maximum predicted range of impacts on Group 2 receptors is predicted to occur 1.1km from the pling activity.

6.10.87 There is the potential for an in-combination area of effect of 210km^2 to arise from the concurrent piling of monopiles on fleeing receptors.

6.10.88 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 is considered to be low.

SIGNIFICANCE OF EFFECTS

6.10.89 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

6.10.90 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

6.10.91 Regarding the spatial MDS for stationary receptors (e.g., spawning herring), the maximum predicted range of impact for recoverable injury of stationary Group 3 receptors occurs from the sequential installation of four monopiles within 24 hours (hammer energy 7,000 kJ). A maximum impact range of up to 20km is predicted from piling within the array areas. The noise contours shown in relation to herring spawning grounds and larvae abundances (Coull *et al.*, 1998 and IHLS data (2007 – 2021)) in Figure 6.14 indicate the potential for recoverable injury of spawning herring. A partial overlap of the recoverable injury noise contour with the Downs herring spawning ground can be observed in Figure 6.14, although, as shown by annual IHLS data (ICES, 2007-2020) the main spawning of Downs herring stock consistently occurs in the Eastern Channel. Furthermore, suitable herring spawning substrates are widely distributed across the wider Thames Estuary and the English Channel.

6.10.92 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.

6.10.93 Regarding the spatial MDS for fleeing receptors, the maximum predicted range of impact for recoverable injury of fleeing Group 3 receptors occurs from the sequential installation of eight pin piles within 24 hours (hammer energy, 3,000 kJ). The maximum predicted range of impacts on fleeing Group 3 receptors are expected to occur up to 1.1 km from the array areas.

6.10.94 The maximum in-combination area of effect from the concurrent piling of four pin piles at both locations on stationary Group 3 receptors (e.g. herring) is 920 km^2. The maximum in-combination area of effect from the concurrent piling of one monopile at each location on stationary receptors is 670 km^2.There is the potential for an in-combination area of effect of 210 km^2 to arise from the concurrent piling of monopiles on fleeing Group 3 receptors.

6.10.95 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.

6.10.96 Considering the partial overlap of the recoverable injury noise contours with the Downs herring spawning grounds and the main spawning activity of the Downs herring stock occurring outside of the noise contours within the English Channel (Figure 6.16), and considering the wide availability of suitable spawning habitats across the Thames Estuary and English Channel there will be no population effect on spawning herring, and therefore the magnitude of impact from piling activities on spawning herring is considered to be low.

6.10.97 As there is no overlap of the recoverable injury noise contours of the Blackwater herring spawning ground (Figure 6.16), the magnitude of impact on the Blackwater herring stock from piling activities is considered to be negligible.

6.10.98 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 underwater noise is considered to be negligible.

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

6.10.100 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 is therefore considered to be low.

6.10.101 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

6.10.102 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 the residual effect is therefore concluded to be **minor adverse**, which is significant in EIA terms.

6.10.103 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.

6.10.104 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.

6.10.105 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.

6.10.106 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.

6.10.107 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

6.10.108 Plaice, sole, cod, horse mackerel, sandeel, herring, mackerel, sprat, whiting and lemon sole all have spawning grounds within the vicinity of VE (Volume 4, 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.

6.10.109 Taking into consideration the Popper *et al*. (2014) criteria, the extent of noise disturbance potentially causing recoverable injury 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.

6.10.110 Considering the Popper *et al*. (2014) criteria, there is the potential for recoverable injury of Downs herring stock eggs and larvae. However, the main spawning activity of the Downs herring stock occurs within the English Channel and considering the wide availability of suitable spawning habitats across the Thames Estuary and English Channel, there will be no population effect on spawning herring, and therefore the magnitude of impact from piling activities on spawning herring is considered to be low.

6.10.111 Taking into consideration the Popper *et al*. (2014) criteria, and the distance of the Blackwater herring spawning ground from VE (Figure 6.16), recoverable injury is not anticipated to occur on Blackwater herring stock eggs and larvae, therefore the magnitude of impact from piling activities is considered to be negligible.

6.10.112 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 on eggs and larvae from piling activities is considered to be low.

6.10.113 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.

6.10.114 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.

6.10.115 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

6.10.116 There are no criteria for shellfish sensitivity to noise, and therefore a qualitative assessment has been undertaken using peer-reviewed literature in paragraph 6.10.52 *et seq.* which concluded shellfish to be of low sensitivity to underwater noise.

6.10.117 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.

6.10.118 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

6.10.119 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 4, 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

6.10.120 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 underwater noise impacts from piling activities.

MAGNITUDE OF IMPACT

6.10.121 Regarding the spatial MDS for stationary receptors, the maximum predicted range of impact for TTS of stationary Group 1 receptors (e.g., sandeel) occurs from the sequential installation of four monopiles within 24 hours (hammer energy 7,000 kJ). An impact range of up to 48 km is predicted from piling within the array areas.

6.10.122 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 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.

6.10.123 Regarding the spatial MDS for fleeing receptors, the maximum predicted range of impact of TTS on fleeing Group 1 receptors occurs from the sequential piling of eight pin piles within 24 hours (hammer energy 3,000 kJ). The maximum predicted range of impacts on fleeing Group 1 receptors are expected to occur up to 23km from piling in the array areas.

6.10.124 The maximum in-combination area of effect from the concurrent piling of four pin piles at both locations on stationary Group 1 receptors (e.g. sandeel) is 5,300 km^2. The maximum in-combination area of effect from the concurrent piling of one monopile at each location on stationary receptors is 4,800 km^2.There is the potential for an in-combination area of effect of 1,800 km^2 to arise from the concurrent piling of pin piles on fleeing Group 1 receptors, and 2,300 km^2 from the concurrent piling of monopiles.

6.10.125 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 underwater noise are considered to be of local scale (based on the modelling results).

6.10.126 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.

6.10.127 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.

6.10.128 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.

6.10.129 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

6.10.130 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.

6.10.131 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.

6.10.132 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

6.10.133 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

6.10.134 Regarding the spatial MDS for fleeing receptors, the maximum predicted range of impact TTS on fleeing Group 2 receptors (Atlantic salmon and sea trout) occurs from the sequential installation of eight pin piles within 24 hours (hammer energy 3,000 kJ). The maximum predicted range of impacts on fleeing Group 1 receptors are expected to occur up to 23km from piling in the array areas.

6.10.135 .There is the potential for an in-combination area of effect of 1,800 km^2 to arise from the concurrent piling of pin piles on Group 2 receptors, and 2,300 km^2 from the concurrent piling of monopiles.

6.10.136 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.

6.10.137 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 to Group 2 receptors from the spatial and temporal MDS is considered to be low.

SIGNIFICANCE OF EFFECTS

6.10.138 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

6.10.139 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

6.10.140 Regarding the spatial MDS for stationary receptors (e.g., spawning herring), the maximum predicted range of impact for TTS on stationary Group 3 receptors occurs from the sequential installation of four monopiles within 24 hours (hammer energy 7,000 kJ). An impact range of up to 48km is predicted from piling within the array areas. The noise contours shown in relation to herring spawning grounds and larvae abundances (Coull *et al*., 1998 and IHLS data (2007 - 2021)) in Figure 6.16 indicate the potential for TTS of spawning herring. However, as shown by annual IHLS data (ICES, 2007-2020 (Volume 4, Annex 6.3: Spawning Herring Heatmaps (International Herring Larval Survey Data)), the main spawning activity of the Downs stock, occurs in the Eastern Channel, 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, taking this into consideration, TTS from underwater noise will not have a population effect on the Downs herring stock.

6.10.141 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 piling on the spawning of the Blackwater herring stock.

6.10.142 Regarding the spatial MDS for fleeing receptors, the maximum predicted range of impact for TTS of fleeing Group 3 receptors occurs from the sequential piling of eight pin piles within 24 hours (hammer energy 3,000 kJ). The maximum predicted range of impacts on fleeing Group 3 receptors are expected to occur up to 23 km from the piling activity in the array areas.

6.10.143 The maximum in-combination area of effect from the concurrent piling of four pin piles at both locations on stationary Group 3 receptors (e.g. herring) is 5,300 km^2. The maximum in-combination area of effect from the concurrent piling of one monopile at each location on stationary receptors is 4,800 km^2.There is the potential for an in-combination area of effect of 1,800 km^2 to arise from the concurrent piling of pin piles on fleeing Group 3 receptors, and 2,300 km^2 from the concurrent piling of monopiles.

6.10.144 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.

6.10.145 Considering the lack of overlap of main spawning activity of the Downs herring stock, which is located in the Eastern Channel, and therefore the absence of a potential population level effect, the magnitude of impact of spawning herring from piling activities is considered to be low.

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

6.10.147 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 underwater noise is considered to be negligible.

6.10.148 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.

6.10.149 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).

6.10.150 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

6.10.151 The impact of TTS of spawning 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 the residual effect is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.10.152 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.

6.10.153 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.

6.10.154 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.

6.10.155 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.

6.10.156 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

6.10.157 Impacts on eggs and larvae were assessed using the Popper *et al*. (2014) criteria, in terms of risk of recoverable injury in paragraph 6.10.84 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 6.10.84 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.

6.10.158 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

6.10.159 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.

6.10.160 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.

6.10.161 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

6.10.162 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*., 2014). 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.

6.10.163 There are no quantitative thresholds advised to be used to assess behavioural impacts, however, Popper *et al*. (2014) provide qualitative behavioural criteria for fish from a range of sources. 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 (1000s of metres) respectively.

6.10.164 Information on the impact of underwater noise on marine invertebrates is scarce, and no attempt has been made to set exposure criteria (Hawkins *et al*., 2014b). Studies on marine invertebrates have shown sensitivity of marine invertebrates to substrate borne vibration (Roberts *et al*., 2016). It is generally their hairs which provide the sensitivity, although these animals also have other sensor systems which could be capable of detecting vibration. It has also been reported that slow, rolling interface waves that move out from a source like a pile driver can produce large particle motion amplitudes travelling considerable distances (Hawkins and Popper, 2016), with implications for demersal and sediment dwelling shellfish (e.g., Nephrops) in close proximity to piling operations.

BEHAVIOURAL IMPACTS OF GROUP 1 RECEPTORS

SENITIVITY OF GROUP 1 VERS

6.10.165 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

6.10.166 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 on Group 1 species is considered to be low.

SIGNIFICANCE OF EFFECT

6.10.167 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 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

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

MAGNITUDE OF IMPACT

6.10.169 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 to Group 2 receptors from the temporal MDS is considered to be low.

SIGNIFICANCE OF EFFECT

6.10.170 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 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

6.10.171 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

6.10.172 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. Whilst there is a paucity of evidence on migratory behaviour of European eel, it is possible that migration would be an equally strong biological driver, with similar damping of behavioural reactions. Taking this into consideration, the magnitude of impact on all Group 3 species is considered to be low.

SIGNIFICANCE OF EFFECT

6.10.173 The impact of behavioural effects of spawning herring are 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.

6.10.174 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 is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.10.175 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 is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

6.10.176 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 is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

EGGS AND LARVAE

6.10.177 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

6.10.178 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

6.10.179 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 on shellfish is considered to be low.

SIGNIFICANCE OF EFFECT

6.10.180 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 is therefore concluded to be **minor adverse**, which is not significant in EIA terms.

NOISE AND VIBRATION ARISING FROM UXO CLEARANCE

6.10.181 Prior to the start of construction UXO investigation works will be required which may require clearance of UXO through *in-situ* detonation, resulting in emission of underwater noise. VE OWFL 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.

6.10.182 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.

6.10.183 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 4, Annex 6.2: Underwater Noise Technical Report.

6.10.184 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.

6.10.185 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.

6.10.186 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 the project is granted.

IMPACT 2: TEMPORARY INCREASE IN SSC AND SEDIMENT DEPOSITION

6.10.187 Temporary localised increases in suspended sediment concentration (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 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 4, Annex 2.1: Physical Processes Baseline Technical Report which provides the detailed offshore physical environment assessment (including project specific modelling of sediment plumes).

MAGNITUDE OF IMPACT

6.10.188 Background surface SSCs 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. Within the offshore ECC, SSCs are much higher, reaching 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 (Volume 4, Annex 2.1: Physical Processes Baseline Technical Report).

6.10.189 Table 6.10 presents the MDS associated with increases in SSC and deposition predicted as a result of activities associated with VE. 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. Site-specific modelling of sediment plumes and deposition from seabed preparation and installation activities along the proposed VE offshore ECC, and within the offshore array areas 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.

6.10.190 In summary, sediment plumes caused by seabed preparation and installation activities are expected to be restricted to within a single tidal excursion from the point of release, which is captures in the sedimentary ZoI (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).

6.10.191 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. The majority of the offshore ECC is dominated by circalittoral mixed and circalittoral coarse sediments. Figure 4.3 within Volume 4, Annex 5.1: Main Array – Benthic Ecology Monitoring Report and Figure 4.6 in Volume 4, 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 array areas and offshore ECC.

6.10.192 Figure 2 within Volume 4, Annex 2.2: 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
    - 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.

6.10.193 Further information on sediment plume distances and modelling are provided in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 4, Annex 2.1: Physical Processes Baseline Technical Report.

6.10.194 Taking the above into consideration, it can be concluded that there will be a quick dissipation of the sediment plume and local nature (0-50 m) of deposition impacts where smothering effects on fish and shellfish receptors and might be observed. Taking the above into consideration, 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 fish and shellfish receptors is therefore considered to be low adverse.

6.10.195 Indirect impacts to the Blackwater, Crouch, Roach and Colne Estuaries MCZ (of which native oyster is a designated feature) are considered to be limited. As detailed above, smothering and deposition impacts that are most likely to significantly disturb fish and shellfish communities are considered to be local to the impact (within 0-50 m). Therefore, considering the distance of the MCZ from VE (located 4 km from the VE ECC), there are not anticipated to be any adverse effects on native oyster within the MCZ from increased SSC and deposition from the construction of VE. Therefore the magnitude of impact on designated native oyster within the MCZ is considered to be negligible.

6.10.196 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 (per bore) in suspension into the water column. This will result in localised high levels of SSC within the nearshore, shallow waters. As presented in Volume 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. Due to the small grain size, 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

6.10.197 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.23 below.

Table 6.23: 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 and the array area. 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. Maximum sediment plume dispersal extends across 5.85% of the sandeel spawning ground (Coull *et al.*, 1998). Furthermore, 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

VER	Sensitivity Justification
	species reduced sensitivity to increased SSC and deposition, sandeel are deemed to be of low vulnerability, medium recoverability and of regional importance, and therefore the sensitivity of the receptor is low. 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 a reduction in oxygen availability around the eggs. The VE site boundary has a slight overlap with the Downs herring spawning ground lying to the east of the array areas. The maximum sediment plume dispersal extends across 7.68% of the Downs stock herring spawning ground (Coull *et al.*, 2010). However, any impacts on this species will be relatively small in the context of the spawning habitat available across the southern North Sea and English Channel. In addition, the main spawning activity of the Downs herring stock occurs in the eastern portion of the English Channel, and therefore any effects form SSC and deposition are not likely to have a population level effect. The VE study area has a slight overlap with the Blackwater herring stock spawning ground, located in the southwestern corner of the study area. The maximum sediment plume dispersal extends across 0.5% of the Blackwater stock herring spawning ground (Coull *et al*., 2010). Adult herring are mobile and as such would be expected to avoid unfavourable areas. Taking into consideration the vulnerability of herring eggs and larvae to this impact, the availability of suitable herring spawning substrates across the wider Thames Estuary and the English Channel, and the location of active spawning outside of VE and within the English Channel, 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, plaice, whiting, sprat, mackerel, horse mackerel).	Cod, common sole, lemon sole, plaice, whiting, sprat, mackerel, horse mackerel all have spawning grounds overlapping the VE study area. 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. 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.

VER	Sensitivity Justification
	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).	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. 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. Therefore, taking into account their burrowing nature 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. 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. 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. 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. 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, and within the maximum sediment plume dispersal extent. 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. All other shellfish VERs and their respective spawning grounds 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 (common dragonet, dab, haddock, hooknose, goby spp., lesser weaver, northern and 5 bearded rockling, pogge, solenette, tub gurnard, whiting-pout,	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.

VER	Sensitivity Justification
albacore, Norway pout, silvery pout, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout smelt and elasmobranchs).	

SIGNIFICANCE OF EFFECT

6.10.198 The impact of increased SSC and sediment deposition on native oyster as designated as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ, 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.

6.10.199 The impact of increased SSC and sediment deposition 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.

6.10.200 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.

6.10.201 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.

6.10.202 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.

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

6.10.203 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.

6.10.204 A review of intertidal and subtidal sediment contamination within the VE site was undertaken in Volume 2, Chapter 3: Marine Water and Sediment Quality based on site-specific surveys within the VE array areas and along the offshore ECC (Volume 4, 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.

6.10.205 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 SQGs. All other samples collected in the VE offshore ECC had contaminant concentrations below Cefas Action Level 1.

6.10.206 Taking this into account, and considering the regional environment, contaminant concentrations from across the array areas and offshore ECC are considered unlikely to exert an effect on fish and shellfish receptors.

MAGNITUDE OF IMPACT

6.10.207 Due to known low contamination of the VE site and is consistent with the wider area, the risk of the potential release of sediment-bound contaminants above natural variation in the region will be very low.

6.10.208 Following disturbance as a result of construction activities, the majority of re-suspended sediments are expected to be deposited in the immediate vicinity of the works. The release of contaminants such as metals, hydrocarbons and organic pollutants 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. The contaminants levels found are all comparable to the wider regional background and not considered to be recorded at a level that could result in a significant effect-receptor pathway if made bioavailable. The impacts as a result of the release of sediment-bound contaminants are therefore considered to be of negligible magnitude.

SENSITIVITY OF THE RECEPTORS

6.10.209 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 6.24: Sensitivity of VERs to the release of sediment contaminants.

VER	Sensitivity Justification
Demersal spawning VERs (spawning herring and sandeel).	Potential sandeel spawning grounds and prime and sub-prime habitats (Figure 6.8) are located within the offshore ECC and the array area. The maximum sediment plume dispersal extends across 5.85% of the sandeel 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. Herring are demersal spawners that exhibit substrate dependency. The RLB has a slight overlap with the Downs herring spawning ground, and the maximum plume dispersal extends across 7.68% of the Downs stock herring spawning ground (Coull *et al*., 2010). 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 English Channel. The VE study area has a slight overlap with the Blackwater herring stock spawning ground, located in the southwestern corner of the study area. The maximum sediment plume dispersal extends across 0.5% of the Blackwater stock herring spawning ground (Coull *et al*., 2010). 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 English Channel. 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 (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

VER	Sensitivity Justification
	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 (common dragonet, dab, haddock, hooknose, goby spp., lesser weaver, northern and 5 bearded rockling, pogge, solenette, tub gurnard, whiting-pout, albacore, Norway pout, silvery pout, 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

6.10.210 The impact of sediment disturbance 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.

IMPACT 4: IMPACTS ON FISHING PRESSURE DUE TO DISPLACEMENT

6.10.211 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. 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. As such, the focus herein is on the array area.

6.10.212 Changes to the intensity of fishing activities during construction may result in increased fishing pressure on fish and shellfish populations outwith 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.

MAGNITUDE OF IMPACT

6.10.213 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.).

6.10.214 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 is therefore considered to be negligible.

SENSITIVITY OF THE RECEPTORS

6.10.215 Fish and shellfish receptors in the study area are deemed to be insensitive to this impact and of local to national importance. The sensitivity of these receptors is therefore considered to be low.

SIGNIFICANCE OF EFFECT

6.10.216 The impact of fishing activity displacement on fish and shellfish receptors 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.

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

6.10.217 Direct damage 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. 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

6.10.218 The maximum area of direct damage and disturbance of subtidal habitat due to construction activities is described in Table 6.10, and equates to approximately 0.6% of the fish and shellfish study area.

6.10.219 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.

6.10.220 In general, fish are able to avoid temporary direct disturbance (EMU, 2004). Shellfish species are considered to have a more limited ability to avoid direct effects due to the relative energetic costs or speed of movement or behaviours (e.g., during breeding) that may make them more susceptible to direct effects due to a sedentary habit.

6.10.221 It is predicted that the impact has the potential to affect spawning herring and sandeel receptors directly although will be of a localised extent.

6.10.222 The VE array areas have a slight overlap with the Downs herring spawning ground, with areas of preferred spawning habitat located within the array areas. However, suitable herring spawning substrates are also widely distributed across the wider Thames Estuary and the English Channel. The magnitude of impact from direct damage and disturbance on spawning Downs stock herring is therefore low.

6.10.223 There is no overlap of the RLB with the Blackwater herring spawning ground, therefore there will be no impact from direct disturbance on the spawning of the Blackwater herring stock. The magnitude of impact from direct damage and disturbance on spawning Blackwater herring is therefore negligible.

6.10.224 Sandeel preferred habitats are located within the VE array areas and in the mid and offshore portions of the offshore ECC. The RLB also lies within a sandeel spawning ground. However, the proportion of the preferred habitat within the fish and shellfish study area is considered small within the context of known sandeel habitats within the wider Southern North Sea. Considering the wide distribution of preferred sandeel spawning and nursery habitats across the Southern North Sea, and the short-term and localised nature of the impact, the magnitude of impact of direct damage and disturbance of VE on sandeel are considered to be low.

6.10.225 Direct impacts to the Blackwater, Crouch, Roach and Colne Estuaries MCZ (of which native oyster is a designated feature) are considered to be minimal. As detailed above, direct damage will only within the construction footprint, therefore, considering the distance of the MCZ from VE (located 4 km from the VE ECC), there are not anticipated to be any adverse effects on native oyster within the MCZ from direct disturbance from the construction of VE. Therefore the magnitude of impact on designated native oyster within the MCZ is considered to be negligible.

6.10.226 Due to their broadscale distribution and sedentary habit, the magnitude of impact on shellfish will be low.

6.10.227 Due to the predicted local spatial extent, short-term duration and intermittent and reversible nature of the impact, the magnitude of the impact on all other receptors will be negligible.

SENSITIVITY OF THE RECEPTOR

6.10.228 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.25 below.

Table 6.25: 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

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. Therefore, both spawning herring and sandeel are considered to be more vulnerable to direct damage and disturbance compared to other fish receptors as a result of this reliance on a specific habitat type (which is present for both receptors within the VE site). Herring spawning habitats are widely distributed across the southern North Sea and the English Channel, and therefore any impacts on this species will be relatively small in the context of the spawning habitat available (the overlap of VE with the Downs herring spawning grounds amounts to approximately 1.9 % of the herring spawning ground (Coull *et al*., 1998)). In addition, the main spawning activity of the Downs herring stock occurs in the Eastern Channel, and therefore any effects direct disturbance are not likely to have a population level effect. As stated above there is no direct overlap of the RLB of the Blackwater herring spawning ground, and therefore no population level impacts are anticipated on the Blackwater spawning stock. Sandeel habitats are widely distributed across the southern North Sea. In addition, the overlap of VE with sandeel spawning grounds is small compared to the overall extent of spawning grounds across the southern North Sea (overlap of VE of approximately 0.7% of sandeel spawning ground (Coull *et al*., 1998). 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 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,	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.

VER	Sensitivity Justification
plaice, whiting, sprat, mackerel, horse mackerel).	
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. 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. 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. 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. Native oyster and native oyster beds are a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ. 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. 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 (common dragonet, dab, haddock, hooknose, goby spp., lesser weaver, northern and 5 bearded rockling, pogge, solenette, tub	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.

VER	Sensitivity Justification
gurnard, whiting-pout, albacore, Norway pout, silvery pout, Atlantic salmon, European eel, allis shad, twaite shad, river ans sea lamprey, sea trout smelt and elasmobranchs).	

SIGNIFICANCE OF EFFECT

6.10.229 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.

6.10.230 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.

6.10.231 The impact of direct damage on spawning Blackwater herring 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.

6.10.232 The impact of direct damage on native oyster as designated as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ 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.

6.10.233 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.

6.10.234 The impact of direct damage and disturbance of all other fish receptors is considered to be of negligible 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.

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

6.10.235 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.

MAGNITUDE OF IMPACT

6.10.236 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

6.10.237 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 6.24, and were assessed as having a maximum sensitivity of medium.

1.1.1 SIGNIFICANCE OF EFFECT

6.10.238 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.

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

6.10.239 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).

MAGNITUDE OF IMPACT

6.10.240 The maximum area of temporary habitat loss due to the presence of foundations, scour protection and cable protection is presented in Table 6.10 and equates to

0.3% of the fish and shellfish study area. Comparable habitats are present and widespread within the wider area.

6.10.241 It is predicted that the impact has the potential to affect spawning herring and sandeel receptors directly although will be of a localised extent.

6.10.242 The VE array areas have a slight overlap with the Downs herring spawning ground, with areas of preferred spawning habitat located within the array areas. However, suitable herring spawning substrates are also widely distributed across the wider Thames Estuary and the English Channel. The magnitude of impact from temporary habitat loss/disturbance on spawning Downs stock herring is therefore low.

6.10.243 There is no overlap of the RLB with the Blackwater herring spawning ground, therefore there will be no impact from temporary habitat loss/disturbance on the spawning of the Blackwater herring stock. The magnitude of impact from temporary habitat loss/disturbance on spawning Blackwater herring is therefore negligible.

6.10.244 Sandeel preferred habitats are located within the VE array areas and in the mid and offshore portions of the offshore ECC. The RLB also lies within a sandeel spawning ground. However, the proportion of the preferred habitat within the fish and shellfish study area is considered small within the context of known sandeel habitats within the wider Southern North Sea. Considering the wide distribution of preferred sandeel spawning and nursery habitats across the Southern North Sea, and the short-term and localised nature of the impact, the magnitude of impact of from temporary habitat loss/disturbance of VE on sandeel are considered to be low.

6.10.245 Direct impacts to the Blackwater, Crouch, Roach and Colne Estuaries MCZ (of which native oyster is a designated feature) are considered to be minimal. As detailed above, temporary habitat loss will only within the RLB, therefore, considering the distance of the MCZ from VE (located 4 km from the VE ECC), there are not anticipated to be any adverse effects on native oyster within the MCZ from direct disturbance from the construction of VE. Therefore, the magnitude of impact on designated native oyster within the MCZ is considered to be negligible.

6.10.246 The impact is predicted to be of local spatial extent (i.e., within the RLB), 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 all other receptors is considered to be low.

SENSITIVITY OF RECEPTORS

6.10.247 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.26 below.

Table 6.26: Sensitivity of VERs to temporary 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,

VER	Sensitivity Justification
	sandeel also have specific habitat requirements throughout their juvenile and adult life history. Sandeel habitats are widely distributed across the southern North Sea. The overlap of VE with sandeel spawning grounds is small compared to the overall extent of spawning grounds across the southern North Sea (overlap of VE of approximately 0.7 % of sandeel spawning ground (Coull *et al.*, 1998). Sandeel are consequently deemed to be of high 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. Herring are also demersal spawners, reliant upon the presence of suitable substrates for spawning (i.e., gravelly sediments). Herring spawning habitats are widely distributed across the southern North Sea and the English Channel, and therefore any impacts on this species will be relatively small in the context of the spawning habitat available (the overlap of VE with herring spawning grounds amounts to approximately 1.9% of the Downs herring spawning ground (Coull *et al.*, 1998)). In addition, the main spawning of the Downs herring stock occurs in the Eastern Channel, and therefore any effects direct disturbance are not likely to have a population level effect. As stated above there is no direct overlap of the RLB of the Blackwater herring spawning ground, and therefore no population level impacts are anticipated on the Blackwater spawning stock. Herring are deemed to be of medium vulnerability to temporary 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 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. 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

VER	Sensitivity Justification
	region. Common cockle are adapted to life in a sedimentary environment and quite capable of burrowing, and therefore are considered potentially sensitive to temporary habitat loss. 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. Berried female brown crab, for example, 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) 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. 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, and outside of the area of potential impact. Therefore, there will be no adverse impacts on the feature of the MCZ from temporary habitat loss. It should be noted however, that common whelk, common cockle 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. 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 (common dragonet, dab, haddock, hooknose, gobe spp.,	These species do not display substrate dependency, and therefore are not considered vulnerable to temporary habitat

VER	Sensitivity Justification
lesser weaver, northern and 5 bearded rockling, pogge, solenette, tub gurnard, whiting-pout, albacore, Norway pout, silvery pout, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout smelt and elasmobranchs).	loss and as such the sensitivity of these species is considered to be negligible.

SIGNIFICANCE OF EFFECT

6.10.248 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.

6.10.249 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.

6.10.250 The impact of temporary habitat loss spawning Blackwater herring 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.

6.10.251 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 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.

6.10.252 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.

6.10.253 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.

6.11 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.

6.11.1 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.

SENSITIVITY OF RECEPTORS

6.11.2 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).

MAGNITUDE OF IMPACT

6.11.3 Underwater noise from an operational WTGs mainly originates 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.

6.11.4 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).

6.11.5 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.

6.11.6 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.

6.11.7 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.

6.11.8 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.

SIGNIFICANCE OF EFFECT

6.11.9 The impact of operational subsea noise on fish and shellfish receptors 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.

IMPACT 9: TEMPORARY INCREASE IN SSC AND DEPOSITION ARISING FROM OPERATION AND MAINTENANCE ACTIVITIES

6.11.10 Temporary localised increases in SSC and associated sediment deposition are expected from cable remedial burial and cable repairs. Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 4, Annex 2.1: Physical Processes Baseline Technical Report 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.

MAGNITUDE OF IMPACT

6.11.11 Table 6.10 presents the MDS associated with increases in SSC and deposition from the maintenance and repairs of the VE. The MDS for SSC and deposition during the operation and maintenance phase of VE is presented in Table 6.10.

6.11.12 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.

6.11.13 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

6.11.14 The sensitivities of fish and shellfish receptors to temporary increases in SSC and sediment deposition are detailed in Table 6.23Table 6.23 and were assessed as having a maximum sensitivity of medium.

SIGNIFICANCE OF EFFECT

6.11.15 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.

IMPACT 10: IMPACTS ON FISHING PRESSURE DUE TO DISPLACEMENT

6.11.16 Changes to fishing pressure may result in reduced fishing pressure within the RLB due to the presence of infrastructure, and maintenance activities, and could lead to increased pressure on fish and shellfish outwith the RLB due to displacement of fishing effort into the surrounding area.

MAGNITUDE OF THE IMPACT

6.11.17 Fishing activity may be reduced within VE project boundary 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 RLB include those targeted by commercial fisheries occurring within VE (e.g., whelk, cockle and oyster). 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.).

6.11.18 The impact is predicted to be of a local spatial extent (adjacent to the VE RLB), 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

6.11.19 When regarding the sensitivity of fish and shellfish receptors to the potential increase of fishing pressure outside of the RLB 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

6.11.20 Potential displacement of fishing activity within the RLB may lead to increases in fishing activity outside of VE. 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.

6.11.21 Overall, it is predicted that the sensitivity of fish and shellfish receptors to changes in fishing pressure 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 LOSS OF HABITAT DUE TO THE PRESENCE OF WTGS FOUNDATIONS, SCOUR PROTECTION AND CABLE PROTECTION

6.11.22 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).

MAGNITUDE OF IMPACT

6.11.23 The maximum area of long-term habitat loss due to the presence of foundations, scour protection and cable protection is presented in Table 6.10 and equates to 0.03% of the fish and shellfish study area. Comparable habitats are present and widespread within the wider area.

6.11.24 The impact is predicted to be of local spatial extent (i.e., within the RLB), of 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 of impact is therefore considered to be low.

6.11.25 The RLB has no direct overlap with the Blackwater herring spawning ground, and therefore the magnitude of impact is negligible.

6.11.26 The RLB has no direct overlap with the Blackwater, Crouch, Roach and Colne Estuaries MCZ, and therefore the magnitude of impact is negligible.

SENSITIVITY OF THE RECEPTOR

6.11.27 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.27 below.

Table 6.27: Sensitivity of VERs to long-term 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. Sandeel habitats are widely distributed across the southern North Sea. The overlap of VE with sandeel spawning grounds is small compared to the overall extent of spawning grounds across the southern North Sea (overlap of VE of approximately 0.7 % of sandeel spawning ground (Coull *et al.*, 1998). 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. Herring are also demersal spawners, reliant upon the presence of suitable substrates for spawning (i.e., gravelly sediments). 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 (the overlap of VE with herring spawning grounds equates to approximately 1.9 % of herring spawning ground (Coull *et al.*, 1998)). In addition, the main spawning of the Downs herring stock occurs in the Eastern Channel, and therefore any effects form long term habitat loss are not likely to have a population level effect on the Downs stock. There is no overlap of the RLB with the Blackwater herring stock spawning ground, and therefore there will be no impact from long term habitat loss on spawning Blackwater herring stock. 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,	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

VER	Sensitivity Justification
common sole, lemon sole, plaice, whiting, sprat, mackerel, horse mackerel).	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. Common cockles 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, and therefore are considered potentially sensitive to long-term habitat loss. 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 habitat loss. 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. 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, and outside of the area of potential impact. Therefore, there will be no adverse impacts on the feature of the MCZ from long term habitat loss. 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. 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 habitat loss.
Mobile VERs (common dragonet, dab, haddock,	These species do not display substrate dependency, and therefore are not considered vulnerable to long-term habitat

VER	Sensitivity Justification
hooknose, goby spp., lesser weaver, northern and 5 bearded rockling, pogge, solenette, tub gurnard, whiting-pout, albacore, Norway pout, silvery pout, Atlantic salmon, European eel, allis shad, twaite shad, river and sea lamprey, sea trout smelt and elasmobranchs).	loss and as such the sensitivity of these species is considered to be negligible.

SIGNIFICANCE OF EFFECT

6.11.28 Long-term 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.

6.11.29 The impact of long-term 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.

6.11.30 The impact of long-term 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.

6.11.31 The impact of long-term habitat loss on spawning Blackwater herring 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.

6.11.32 The impact of long-term habitat loss on native oyster as designated as a feature of the Blackwater, Crouch, Roach and Colne Estuaries MCZ 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.

6.11.33 The impact of long-term 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.

6.11.34 The impact of long-term 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.

IMPACT 12: INCREASED HARD SUBSTRATE AND STRUCTURAL COMPLEXITY AS A RESULT OF THE INTRODUCTION OF WTGS FOUNDATIONS, SCOUR PROTECTION AND CABLE PROTECTION

6.11.35 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 RLB. 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.

MAGNITUDE OF IMPACT

6.11.36 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 0.03% of the fish and shellfish study area. The potential impact is predicted to be of local spatial extent (within the RLB), and of long-term duration, continuous and irreversible (during the lifetime of the project). It is predicted that the impact has the potential to affect fish and shellfish receptors both directly and indirectly, and therefore the magnitude of effect is therefore considered to be low.

6.11.37 The RLB has no direct overlap with the Blackwater herring spawning ground, and therefore the magnitude of impact is negligible.

6.11.38 The RLB has no direct overlap with the Blackwater, Crouch, Roach and Colne Estuaries MCZ, and therefore the magnitude of impact is negligible.

SENSITIVITY OF THE RECEPTOR

6.11.39 The sensitivity rating assigned to each VER, and associated justification is provided in Table 6.28 below.

Table 6.28: Sensitivity of VERs to increased hard substrate and structural complexity.

VER	Sensitivity Justification
Demersal spawning VERs (spawning herring and sandeel).	Sandeel preferred habitats and spawning areas are typically dominated by coarse sediments and sandy habitats. The array areas and parts of the offshore ECC are located in preferred sandeel habitats and spawning grounds. 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. However, sandeel habitats are widely distributed across the southern North Sea, and the overlap of VE with sandeel spawning grounds is small compared to the overall extent of spawning grounds across the southern North Sea (overlap of VE of approximately 0.7 % of sandeel spawning ground (Coull *et al*., 1998). 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 low sensitivity. Herring are also demersal spawners, reliant upon the presence of suitable substrates for spawning (i.e., gravelly sediments). 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 (the overlap of VE with herring spawning grounds equates to approximately 1.9% of herring spawning ground (Coull *et al*., 1998)). In addition, the main spawning of the Downs herring stock occurs in the Eastern Channel, and therefore any effects form increased hard substrate and structural complexity are not likely to have a population level effect on the Downs stock. Herring are deemed to be of medium vulnerability to increased hard substrate and structural complexity, and of regional importance within the southern North Sea, and therefore are considered to be of low 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.

VER	Sensitivity Justification
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 (common dragonet, dab, haddock, hooknose, goby spp., lesser weaver, northern and 5 bearded rockling, pogge, solenette, tub gurnard, whiting-pout, albacore, Norway pout, silvery pout, 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

6.11.40 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.

6.11.41 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.

6.11.42 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 low. The significance of the residual effect is therefore concluded to be minor adverse, which is not significant in EIA terms.

6.11.43 The impact increased hard substrate and structural complexity on spawning Blackwater herring 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.

6.11.44 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 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.

6.11.45 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.

6.11.46 The impact increased hard substrate and structural complexity on 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.

IMPACT 13: EMF EFFECTS ARISING FROM CABLES DURING OPERATIONAL PHASE

6.11.47 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.

6.11.48 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).

MAGNITUDE OF IMPACT

6.11.49 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.

6.11.50 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.

6.11.51 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.

6.11.52 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.

6.11.53 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

6.11.54 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.

6.11.55 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.

6.11.56 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).

6.11.57 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.

6.11.58 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

6.11.59 The impact of increased EMFs on fish and shellfish receptors is considered to be of low magnitude, and the low 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.

IMPACT 14: DIRECT DAMAGE (E.G. CRUSHING) AND DISTURBANCE TO MOBILE DEMERSAL AND PELAGIC FISH AND SHELLFISH SPECIES ARISING FROM OPERATION AND MAINTENANCE ACTIVITIES

6.11.60 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).

MAGNITUDE OF IMPACT

6.11.61 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 and array cables). The maximum area of direct damage is presented in Table 6.10, and equates to approximately 0.006% of the fish and shellfish study area 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.

6.11.62 It is predicted that the impact has the potential to affect spawning herring and sandeel receptors directly although will be of a localised extent. The VE array areas have a slight overlap with the Downs herring spawning ground, with areas of preferred spawning habitat located within the array areas. However, suitable herring spawning substrates are also widely distributed across the wider Thames Estuary and the English Channel. Therefore, considering the localised and short-term nature of the impact, and the broadscale availability of suitable spawning habitats, the magnitude of impact from direct damage and disturbance, associated with the maintenance of VE on spawning herring is assessed as low.

6.11.63 The VE RLB has no overlap with the Blackwater herring spawning grounds, and therefore the magnitude of impact on spawning Blackwater stock herring is of negligible magnitude.

6.11.64 Sandeel preferred habitats are located within the VE array areas and in the mid and offshore portions of the offshore ECC. The RLB also lies within a sandeel spawning ground. However, the proportion of the preferred habitat within the fish and shellfish study area is considered small within the context of known sandeel habitats within the wider Southern North Sea. Considering the wide distribution of preferred sandeel spawning and nursery habitats across the Southern North Sea, and the short-term and localised nature of the impact, the magnitude of impact of direct damage and disturbance from maintenance activities of VE on sandeel are considered to be low.

6.11.65 Direct impacts to the Blackwater, Crouch, Roach and Colne Estuaries MCZ (of which native oyster is a designated feature) are considered to be minimal. Direct damage will be localised to the activity and therefore, considering the distance of the MCZ from VE (located 4 km from the VE ECC), there are not anticipated to be any adverse effects on native oyster within the MCZ from direct disturbance from the construction of VE. Therefore the magnitude of impact on designated native oyster within the MCZ is considered to be negligible.

6.11.66 Due to their broadscale distribution and sedentary habit, the magnitude of impact on shellfish will be low.

6.11.67 Due to the predicted local spatial extent, short-term duration and intermittent and reversible nature of the impact, the magnitude of the impact on all other receptors will be negligible.

SENSITIVITY OF THE RECEPTOR

6.11.68 The sensitivities of fish and shellfish receptors to direct damage and disturbance are detailed in Table 6.25 and were assessed as having a maximum sensitivity of medium.

SIGNIFICANCE OF THE EFFECT

6.11.69 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

6.11.70 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.

MAGNITUDE OF IMPACT

6.11.71 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 RLB would be subject to immediate dilution and rapid dispersal.

6.11.72 Given the embedded 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.

6.11.73 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

6.11.74 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 6.24, and were assessed as having a maximum sensitivity of medium.

SIGNIFICANCE OF EFFECT

6.11.75 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 16: TEMPORARY HABITAT LOSS/DISTURBANCE

6.11.76 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 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.

MAGNITUDE OF IMPACT

6.11.77 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 small in relation to the fish and shellfish study area, equating to 0.006% of the study area. 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.

6.11.78 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 negligible.

SENSITIVITY OF RECEPTOR

6.11.79 The sensitivities of fish and shellfish receptors to temporary habitat loss are detailed in Table 6.26 and were assessed as having a maximum sensitivity of medium.

SIGNIFICANCE OF EFFECT

6.11.80 The impact of temporary habitat loss 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.

6.12 ENVIRONMENTAL ASSESSMENT: DECOMMISSIOING PHASE

IMPACT 17: MORTALITY, INJURY, BEHAVIOURAL IMPACTS AND AUDITORY MASKING ARISING FROM NOISE AND VIBRATION

6.12.1 Decommissioning of offshore infrastructure for VE 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.

6.12.2 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.

6.12.3 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

6.12.4 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 6.10, Impact 2.

6.12.5 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.

6.12.6 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

6.12.7 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 6.10, Impact 3.

6.12.8 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.

6.12.9 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

6.12.10 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 6.10, Impact 4.

6.12.11 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.

6.12.12 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 DECOMMISSIOING ACTIVITIES

6.12.13 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 6.10, Impact 5.

6.12.14 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.

6.12.15 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

6.12.16 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 6.10, Impact 6.

6.12.17 To summarise, accidental pollution events are predicted to occur on a small scale, with pollutants predicted to be rapidly dispersed by the tide.

6.12.18 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

6.12.19 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 6.10, Impact 7.

6.12.20 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.

6.12.21 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.

6.13 ENVIRONMENTAL ASSESSMENT: CUMULATIVE EFFECTS

6.13.1 This cumulative impact assessment for fish and shellfish ecology has been undertaken in accordance with the methodology provided in Volume 1, Annex 3.1: Cumulative Effects Assessment Methodology.

6.13.2 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 1, Annex 3.1: Cumulative Effects Assessment Methodology of this PEIR screened in a number of projects and plans as presented in Table 6.30 and are illustrated in Figure 6.19. Note, Table 6.29 and Figure 6.19 only include the projects screened into the assessment for fish and shellfish ecology based on the criteria outlined above. All relevant longlist plans and projects were allocated into tiers reflecting varying levels of certainty. These are defined in Volume 1, Annex 1.3: Cumulative Effects Assessment Methodology, and outlined here in Table 6.29.

Table 6.29: 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.
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.

6.13.3 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 RLB 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 to fish and shellfish ecology associated with VE.

6.13.4 The operational projects included within Table 6.29 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 6.29 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.

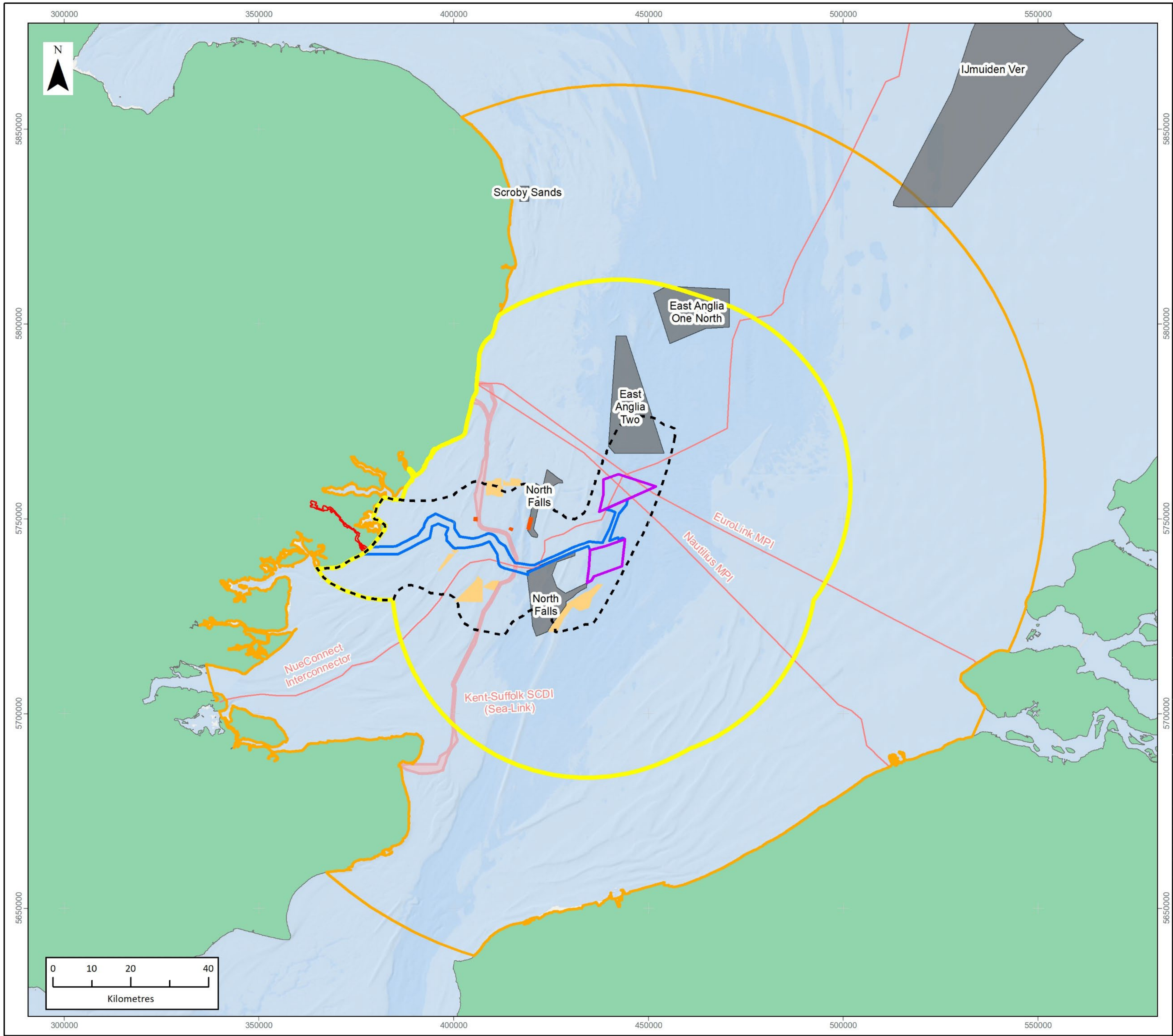
Table 6.30: Projects considered within the fish and shellfish ecology cumulative effect assessment.

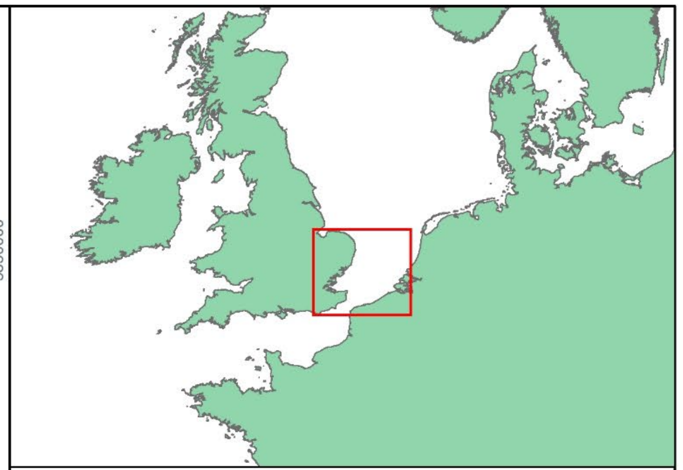
Development type	Project	Status	Data confidence assessment/ phase	Tier
OWF	North Falls	Pre-planning Application	High	Tier 2
	East Anglia TWO	Consented	High	Tier 1
	East Anglia ONE NORTH	Consented	High	Tier 1
	Scroby Sands	Active/In Operation	High	Tier 1
	IJmuiden Ver	Planned	Low	Tier 3
Aggregates and 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

6.13.5 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.

6.13.6 The cumulative MDS is described in Table 6.30 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 impacts 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.





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Fish and Shellfish Study Area
- 100km Array Areas Buffer
- Sedimentary ZoI
- Offshore Wind Farm
- Aggregates Site
- Disposal Sites
- Subsea Cable (Type - Status)
- Power - Proposed
- Sealink Interconnector

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

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Projects and plans screened into the VE cumulative effect assessment on Fish and Shellfish Ecology

VER	DATE	REMARKS	Drawn	Checked
1	01/03/2023	For Issue	SWM	AL

DRAWING NUMBER:

6.20

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

FIVE ESTUARIES OFFSHORE WIND FARM

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6.13.7 Certain impacts assessed for the project 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 significance of the impact from VE alone has been assessed as negligible.

6.13.8 The impacts excluded from the CEA for the above reasons area:

- Construction phase:
    - Impacts on fishing pressure due to displacement;
    - Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from construction activities;
    - Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors;
    - Direct and indirect seabed disturbances leading to the release of sediment contaminants.
- O&M phase:
    - Impacts on fishing pressure due to displacement;
    - Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from construction activities;
    - Accidental pollution events during the construction phase resulting in potential effects on fish and shellfish receptors;
    - Increased hard substrate and structural complexity as a result of the introduction of WTGs foundations, scour protection and cable protection; and
    - EMF effects generated by inter-array and export cables during operational phase.

6.13.9 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 habitat loss.

6.13.10 The cumulative MDS described in Table 6.30 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 the project 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 the project design envelope to that assessed here, be taken forward in the final design scheme.

Table 6.31: Cumulative MDS.

Potential Effect	Scenario	Justification
Cumulative mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Tier 1: > Construction of East Anglia ONE North OWF; and > Decommissioning of Scroby Sands OWF. Tier 2: > Construction of North Falls OWF. Tier 3: > Construction of IJmuiden Ver.	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: > 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); > O&M of East Anglia Two OWF; > Operation of sea disposal sites Inner Gabbard (TH052), Inner Gabbard East (TH056) and Harwich Haven (TH027); and	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 is potential for cumulative SSC and sediment deposition to occur within the modelled plume footprints

Potential Effect	Scenario	Justification
	> Construction of NeuConnect Interconnector Tier 2: > Construction of North Falls OWF > Construction and O&M of Sea Link interconnector cable Tier 3: > Construction of Nautilus MPI > Construction of EuroLink interconnector cable	
Cumulative temporary habitat loss	Tier 1: > O&M of East Anglia Two OWF; > 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) > Construction and O&M of NeuConnect Interconnector Tier 2: > Construction and O&M of OWF North Falls > Construction and O&M of Sea Link interconnector cable Tier 3: > Construction and O&M Nautilus MPI	If these intermittent activities overlap temporally with either the construction or maintenance of VE, there is potential for cumulative temporary habitat disturbance.

Potential Effect	Scenario	Justification
	> Construction and O&M of EuroLink interconnector cable	
Long term habitat loss	Tier 1: > O&M of East Anglia Two OWF; > O&M of NeuConnect Interconnector Tier 2: > O&M of North Falls OWF > Construction and O&M of Sea Link interconnector cable Tier 3: > O&M of Nautilus MPI > Construction and O&M of EuroLink interconnector cable	Maximum cumulative permanent habitat loss as 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.

6.13.11 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.

6.13.12 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

6.13.13 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.

6.13.14 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 and IJmuiden Ver OWF.

6.13.15 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.

6.13.16 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)

6.13.17 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 Statement for the IJmuiden Ver OWF is not publicly available, therefore as a worst-case assumption for the project, it is assumed that project parameters regarding underwater noise would be similar to those for VE.

6.13.18 As the North Falls OWF is only at the scoping stage, no application has been submitted, and therefore it is assumed that project parameters regarding underwater noise would be similar to those for VE.

6.13.19 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 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 North Falls 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 199.5 days (Table 6.31), equating to approximately 6.8% of the VE construction period. 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) 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 6.32: 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 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	1,360 hours (52.6 days)	Volume 2, Chapter 1: Offshore Project Description (as proxy for North Falls OWF ES).
Tier 3 OWFs		
IJmuiden Ver OWF	1,360 hours (52.6 days)	Volume 2, Chapter 1: Offshore Project Description (as proxy for IJmuiden Ver OWF ES).
Total duration	5,076.8 hours	

6.13.20 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 the project 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.

6.13.21 The project 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.

6.13.22 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.

6.13.23 The Scroby Sands OWF Environmental Statement concluded no detrimental effects on fish receptors from all phases of the project (PowerGen Renewables Offshore Ltd, 2001).

6.13.24 There is currently limited detail on the North Falls 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.

6.13.25 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.

6.13.26 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.

6.13.27 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.

6.13.28 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.

6.13.29 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.

6.13.30 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

6.13.31 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 6.29. For the purposes of this assessment, this additive impact has been assessed from projects that fall within the fish and shellfish ecology study area (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 6.29 identifies the projects that have the potential to contribute to cumulative temporary SSC's and deposition.

6.13.32 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. 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 minor.

6.13.33 The consented NeuConnect Interconnector is proposed to cross with approximately 79 km^2 of the VE fish and shellfish ecology study area. 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 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 study area compared to the interconnector's overall extent (0.67%), significant cumulative effects are not anticipated.

6.13.34 The magnitude of impacts from the Tier 1 projects identified is therefore considered to be worst-case low.

6.13.35 Tier 2 project 'North Falls OWF' and 'Sea Link' Interconnector and the Tier 3 projects 'Nautilus MPI' and 'EuroLink interconnector cable' 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 4, Annex 2.3: Physical Processes Technical Assessment.

6.13.36 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..

6.13.37 As presented in Table 6.23, the maximum sensitivity of the fish and shellfish receptors within the region to increases in SSC and sediment deposition is medium.

6.13.38 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

6.13.39 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 6.29. For the purposes of this assessment, this additive impact has been assessed from projects that fall within the fish and shellfish ecology study area.

6.13.40 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.

6.13.41 The consented NeuConnect Interconnector is proposed to cross with 78.99 km^2 of the VE fish and shellfish ecology study area. 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.

6.13.42 The magnitude of impacts from the Tier 1 projects identified is therefore considered to be worst-case low adverse.

6.13.43 The EIA Scoping Report was submitted for the North Falls OWF project in July 2021 (North Falls OWF Ltd, 2021). The Development Consent Order application and supporting environmental assessment and other documents is currently scheduled for submission in 2023. As North Falls is a Nationally Significant Infrastructure Project its DCO is anticipated in 2025. Construction would take place in the latter part of the decade, with a view to the project being operational by 2030. Whilst the project is still in the early days of its road to consent the construction and operation and maintenance of this Tier 2 project has the potential to cause cumulative temporary habitat loss with VE construction.

6.13.44 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 study area (Figure 6.19). 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

6.13.45 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, Eurolink 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. The magnitude of impacts from this Tier 2 project is deemed at worst-case low.

6.13.46 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.

6.13.47 The Tier 3 project ‘EuroLink’ 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, EuroLink and Nautilus MPI construction activities will overlap with VE construction.

6.13.48 As presented in Table 6.26, the maximum sensitivity of the fish and shellfish receptors within the region to temporary habitat loss is medium.

6.13.49 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.

6.13.50 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 HABITAT LOSS

6.13.51 Cumulative long term habitat loss is predicted to occur because of the presence of VE infrastructure and projects identified in Table 6.29. The Tier 1 project East Anglia Two OWF and transmission asset is expected to contribute to long term 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 habitat loss associated with the array assets is 1.91 km^2, the transmission assets do not overlap with the study area.

6.13.52 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.

6.13.53 The Tier 2 project North Falls OWF has the potential to create a cumulative permanent habitat loss with VE. Whilst there is currently limited detail on the area of loss, it is anticipated that as with the VE the magnitude for loss is likely to be negligible on account of the limited spatial extent of permanent infrastructure compared to the area of wider fish and shellfish habitats.

6.13.54 The Tier 2 project 'Sea Link' is 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 projects is therefore assessed as negligible.

6.13.55 The Tier 3 projects 'Nautilus MPI' and 'EuroLink MPI' are anticipated to have some cable protection associated with the routes, however there is currently limited in the public domain on this. The footprints of any cable protection are expected to be limited in extent and highly localised. The magnitude of habitat loss for the Tier 3 projects is therefore currently assessed as negligible.

6.13.56 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.

6.13.57 As presented in Table 6.27, the maximum sensitivity of the fish and shellfish receptors within the region to long term habitat loss is medium.

6.13.58 The impact of cumulative long term 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.

6.14 INTER-RELATIONSHIPS

6.14.1 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.

6.14.2 A description of the likely inter-related effects arising from VE on fish and shellfish ecology is provided in Volume 2, Chapter 14: 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.

6.15 TRANSBOUNDARY EFFECTS

6.15.1 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 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.

6.16 NEXT STEPS

6.16.1 The following steps will be undertaken in order to progress the fish and shellfish ecology assessment from PEIR stage to DCO Application stage.

- Further consultation and engagement will be undertaken through the Marine Ecology and Processes ETG. All feedback post-PEIR will be used to inform and update the benthic subtidal and intertidal ecology assessment and presented within the ES, where necessary; and
- Underwater noise modelling will be undertaken for piling of sheet pile exit pits.

6.17 SUMMARY OF EFFECTS

6.17.1 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 6.32.

6.17.2 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.

6.17.3 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 from underwater noise and vibration.

6.17.4 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 6.33: Summary of effects for fish and shellfish

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	**Group 1:** Negligible to Minor adverse significance of effect **Group 2:** Minor adverse significance of effect **Group 3:** Negligible to Minor adverse significance of effect **Eggs and larvae:** Minor adverse significance of effect **Shellfish:** Minor adverse significance of effect	No mitigation required.	No significant adverse residual effects
	Recoverable Injury	**Group 1:** Negligible to Minor adverse significance of effect **Group 2:** Minor adverse significance of effect **Group 3:** Negligible to Minor adverse significance of effect **Eggs and larvae:** Minor significance of effect	No mitigation required.	No significant adverse residual effects

Description of Impact		Significance of Effect	Additional mitigation measures	Residual significance of effect
		Shellfish: Minor adverse significance of effect		
	TTS	**Group 1:** Negligible to Minor adverse significance of effect **Group 2:** Minor adverse significance of effect **Group 3:** Negligible to Minor adverse significance of effect **Eggs and larvae:** Minor adverse significance of effect **Shellfish:** Minor adverse significance of effect	No mitigation required.	No significant adverse residual effects
	Behavioural effects	**Group 1:** Minor adverse significance of effect **Group 2:** Minor adverse significance of effect **Group 3:** Minor adverse significance of effect **Shellfish:** 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 2: Temporary increase in SSC and sediment deposition	Minor adverse significance of effect	No mitigation required.	No significant adverse residual effects
Impact 3: Direct and indirect seabed disturbances leading to release of sediment contaminants	Minor adverse significance of effect	No mitigation required.	No significant adverse residual effects
Impact 4: Impacts on fishing pressure due to displacement	Negligible significance of effect	No mitigation required.	No significant adverse residual effects
Impact 5: Direct damage (e.g. crushing) and disturbance to demersal and pelagic fish and shellfish species arising from shellfish activities	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	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	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	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	Minor adverse significance of effect	No mitigation required.	No significant adverse residual effects
Impact 10: Impacts on fishing pressure due to displacement	Negligible significance of effect	No mitigation required.	No significant adverse residual effects
Impact 11: Long term loss of habitat due to the presence of WTGs foundations, scour protection and cable protection	Negligible to minor adverse significance of effect	No mitigation required.	No significant adverse residual effects
Impact 12: Increased hard substrate and structural complexity as a result of the introduction of WTGs foundations, scour protection and cable protection	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	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	Negligible to 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
fish and shellfish species arising 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	Minor adverse significance of effect	No mitigation required.	No significant adverse residual effects
Impact 16: Temporary habitat loss	Negligible to 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	Negligible to 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 shellfish 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: Temporary habitat loss	Negligible to 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: Permanent habitat loss	Negligible to minor adverse significance of effect	No mitigation required.	No significant adverse residual effects

6.18 REFERENCES

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