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Rampion 2 WIND FARM

Volume 2, Chapter 8

Fish and shellfish ecology

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8. Fish and shellfish ecology

8.1 Introduction

8.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the preliminary results of the assessment of the likely significant effects of the Proposed Development with respect to fish and shellfish ecology during construction, operation and maintenance and decommissioning phases. It should be read in conjunction with the project description provided in **Chapter 4: The Proposed Development, Appendix 8.1: Fish and shellfish ecology – Herring annual heatmap, Volume 4**, and the relevant parts of the following chapters:

- **Chapter 6 Coastal processes:** Changes to coastal processes have the potential to directly or indirectly impact fish and shellfish ecology receptors, therefore the information from this assessment has been used to inform the fish and shellfish ecology assessment;
- **Chapter 9: Benthic subtidal and intertidal ecology:** The benthic subtidal and intertidal ecology aspect includes key benthos and subtidal habitats for fish and shellfish species (for example key spawning grounds) and therefore there is a degree of overlap between these topics. They must therefore be informed and assessed in unison, where this applies;
- **Chapter 10: Commercial fisheries:** The commercial fisheries aspect includes fish species of commercial importance and therefore there is a degree of overlap between these topics;
- **Chapter 11 Marine Mammals:** The marine mammal aspect includes information on underwater noise, which is detailed in **Appendix 11.2 Underwater Noise Assessment Report**, therefore the information from this assessment has been used to inform the fish and shellfish ecology assessment; and
- **Chapter 14: Nature conservation:** The nature conservation aspect will include designations that relate to protected fish and shellfish ecology features and therefore must be considered together.

8.1.2 This chapter describes:

- the legislation, planning policy and other documentation that has informed the assessment (**Section 8.2: Relevant legislation, planning policy, and other documentation**);
- the outcome of consultation engagement that has been undertaken to date, including how matters relating to fish and shellfish ecology within the Scoping Opinion received in August 2020 has been addressed (**Section 8.3: Consultation and engagement**);
- the scope of the assessment for fish and shellfish ecology (**Section 8.4: Scope of the assessment**);
- the methods used for the baseline data gathering (**Section 8.5: Methodology for baseline data gathering**);

- the overall baseline (**Section 8.6: Baseline conditions**);
- embedded environmental measures relevant to fish and shellfish ecology and the relevant maximum design scenario (**Section 8.7: Basis for PEIR assessment**);
- the assessment methods used for the PEIR (**Section 8.8: Methodology for PEIR assessment**);
- the assessment of fish and shellfish ecology effects (**Section 8.9 - 8.11: Preliminary assessment** and **Section 8.12: Preliminary assessment: Cumulative effects approach**);
- consideration of transboundary effects (**Section 8.13: Transboundary effects**);
- consideration of Inter-related effects (**Section 8.14: Inter-related effects**);
- a summary of residual effects for fish and shellfish ecology (**Section 8.15: Summary of residual effects**);
- an outline of further work to be undertaken for the Environmental Statement (ES) **(Section 8.16: Further work to be undertaken for ES**);
- a glossary of terms and abbreviations is provided in **Section 8.17: Glossary of terms and abbreviations**; and
- a references list is provided in **Section 8.18: References.**

8.2 Relevant legislation, policy and other information and guidance

Introduction

8.2.1 This section identifies the legislation, policy and other documentation that has informed the assessment of effects with respect to fish and shellfish ecology. Further information on policies relevant to the Environmental Impact Assessment (EIA) and their status is provided in **Chapter 2: Policy and legislative context**.

Legislation and national planning policy

8.2.2 **Table 8-1** lists the legislation relevant to the assessment of the effects on fish and shellfish receptors.

Table 8-1 Legislation relevant to fish and shellfish ecology

Legislation description	Relevance to assessment
EC Directive 92/43/EEC on Conservation of Natural Habitats and Wild Fauna and Flora, 1992 (the 'Habitats Directive')	
The Habitats Directive requires Member States to take measures to maintain or	The Proposed Development could have potential effects on several Annex II and

Legislation description	Relevance to assessment
restore natural habitats (listed on Annex I) and wild species (Annex II) at favourable conservation status by the designation of Special Areas of Conservation (SACs). The Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007 (as amended) implement the Habitats Directive in relation to marine areas where the UK has jurisdiction beyond territorial waters (broadly 12 nautical miles (nm) to 200nm). The Conservation of Habitats and Species Regulations 2017 (the Habitats Regulations) implement the Habitats Directive in relation to England and Wales as far as the limit of territorial waters (usually 12nm).	V migratory fish species, including sea lamprey (*Petromyzon marinus*) (Annex II only); Atlantic salmon (*Salmo salar*); allis shad (*Alosa alosa*); twaite shad (*A. fallax*). Under these regulations, these species that fall into specific categories are eligible for legal protection from activities that have the potential to damage them. The protection conferred to these fish species is accounted for within the scope of the assessment (see **Section 8.4**).
The Wildlife and Countryside Act 1981	
The Wildlife and Countryside Act 1981 protects several fish species found in the marine environment. Under the Variation of Schedule 5 (England) Order 2008. This protection means that it is an offence to intentionally or recklessly harm or disturb these species. Protection includes a prohibition of killing, injuring or taking, damage or destruction of their places of shelter, or disturbance while such animals are occupying places of shelter. The obligations of the Bern Convention on the Conservation of European Wildlife and Natural Habitats 1979 were transposed in UK law by means of the Wildlife and Countryside Act.	The Proposed Development could have potential effects on several fish species protected by The Wildlife and Countryside Act including both short-snouted (*Hippocampus hippocampus*) and spiny/long-snouted (*H. guttulatus*) seahorses and their habitat are fully protected out to the 12nm limit. Allis shad, twaite shad, basking shark (*Cetorhinus maximus*) and angel shark (*Squatina squatina*) are also protected. The protection conferred to these fish species is accounted for within the scope of the assessment (see **Section 8.4**) and the environmental measures embedded within the Proposed Development are detailed in **Section 8.7.**
Bern Convention on the Conservation of European Wildlife and Natural Habitats 1979	
The Bern Convention aims to ensure the conservation of wild flora and fauna species and their habitats. Particularly endangered and vulnerable species, including endangered and vulnerable migratory species. Annex II of the convention ensures special protection of Annex II species through	The Proposed Development could have potential effects on several fish species protected by the Bern Convention. This includes Atlantic salmon, sea lamprey, twaite shad and allis shad under Annex III as protected fauna species. The short-snouted seahorse and basking shark are both protected under Annex II as strictly

Legislation description	Relevance to assessment
particularly prohibiting deliberate killing, taking, disturbance, trade and possession.	protected fauna species. The protection conferred to these fish species is accounted for within the scope of the assessment (see **Section 8.4**) and the environmental measures embedded within the Proposed Development is detailed in **Section 8.7.**
Marine and Coastal Access Act 2009	
The Marine and Coastal Access Act 2009 created a new type of Marine Protected Area (MPA) called a Marine Conservation Zone (MCZ), which are of national importance. MCZs are intended to protect areas that are important to conserve the diversity of rare, threatened and representative marine habitats, species, geology and geomorphology in UK waters and they, together with other types of MPAs, deliver the Government's objective for an ecologically coherent network of MPAs. As part of the MCZ process, so-called 'reference areas' will be designated, in which all extractive, depositional and/or disturbing and damaging activities are excluded.	There are two MCZ within the vicinity of the Proposed Development fish and shellfish study area the Kingmere MCZ (protected feature includes black seabream (*Spondyliosoma cantharus*)) and the Selsey Bill and the Hounds MCZ (protected feature includes European native oyster (*Ostrea edulis*)). However, the PEIR Assessment Boundary does not cross any MCZs. An MCZ assessment is presented in **Chapter 14** and **Appendix 14.1 Marine Conservation Assessment, Volume 4**.

8.2.3 **Table 8-2** lists the national planning policy relevant to the assessment of the effects on fish and shellfish receptors.

Table 8-2 National planning policy relevant to fish and shellfish.

Policy description	Relevance to assessment
EN-1 NPS for Energy	
Paragraph 5.3.3 '*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 potential effects of the Proposed Development have been assessed concerning international, national and local sites designated for ecological or geological features of conservation importance (see **Section 8.6**).

Policy description	Relevance to assessment
the infrastructure where EIA is not required to help the Infrastructure Planning Commission [hereafter the Secretary of State (SoS)] consider thoroughly the potential effects of a proposed project.'	
Paragraph 5.3.10 '*Sites of Special Scientific Interest (SSSIs) that are not incorporated within internationally designated sites should be provided with a high degree of protection*.' Paragraph 5.3.11 '*Where a proposed development within or outside a SSSI is likely to have an adverse effect on an SSSI (alone or together with other developments) development consent should not normally be granted. If after mitigation an adverse effect is still likely then consent should only be given where the benefits (including need) for a development outweighs the impacts on the SSSI in question and also the wider SSSI network. The SoS should use requirements and/or planning obligations to mitigate the harmful aspects of the development, and where possible, ensure the conservation of the site's biodiversity or geological interest.*'	For SSSIs, where these are within European sites, the SSSI has been considered as part of that site in this environmental assessment. SSSIs within the region have been identified in **Section 8.6** and any potential impacts to features of SSSIs have been assessed in **Sections 8.9, 8.10** and **8.11**.
Paragraph 5.3.12 '*The SoS is bound by the duties in relation to Marine Conservation Zones (MCZs) imposed by sections 125 and 126 of the Marine and Coastal Access Act (MCAA) 2009*'	MCZs within the region have been identified in **Section 8.6** and any potential impacts to fish and shellfish features of the identified MCZs have been assessed in **Sections 8.9, 8.10** and **8.11.** MCZs within the region have been identified in **Section 8.6** and any potential impacts to fish and shellfish features of the identified MCZs have been assessed in **Sections 8.9, 8.10** and **8.11.** Although the PEIR Assessment Boundary does not cross any MCZs, an MCZ assessment is presented in **Chapter 14** and **Appendix 14.1, Volume 4**.
EN-3 NPS for Renewable Energy	
Paragraph 2.6.64 '*Assessment of offshore ecology and biodiversity should be*	The potential effects on offshore ecology and biodiversity associated with the

Policy description	Relevance to assessment
undertaken by the applicant for all stages of the lifespan of the proposed Offshore Wind Farm.'	construction, operation and maintenance and decommissioning phases of the Proposed Development have been assessed in **Section 8.9** to **8.11**.
Paragraph 2.6.65 '*Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate*'.	Consultation with relevant statutory and non-statutory stakeholders has been carried out from the early stages of the Proposed Development. See **Section 8.3** for details on consultation in terms of fish and shellfish.
Paragraph 2.6.66 '*Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore wind farms should be referred to where appropriate*.'	Relevant data collected as part of post-construction monitoring from the operational Rampion 1 offshore wind farm and any other offshore wind farm projects has informed the assessment of the Proposed Development (see **Section 8.9** to **8.11**).
Paragraph 2.6.67 '*The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity*'.	The assessment methodology includes the provision for assessment of both positive and negative effects (see **Section 8.8**).
Paragraph 2.6.72 '*Impacts arising from construction and decommissioning at the seabed with consequential effects on fish communities, migration routes, spawning activities and nursery areas of particular species*.'	The Proposed Development assessment has considered all phases of the Proposed Development on fish and shellfish species with key life stages in the vicinity of the development (see **Section 8.9** and **Section 8.11**).
Paragraph 2.6.73 '*In addition, there are potential noise impacts, which could affect fish during construction and decommissioning and to a lesser extent during operation*'.	The Proposed Development assessment has considered noise effects on fish and shellfish species arising from construction (piling) (see **Section 8.9, paragraph 8.9.1** and **paragraph 8.9.2**). Noise impacts are further assessed in **Chapter 11** and **Appendix 11.2, Volume 4**.
Paragraph 2.6.74 '*The applicant should identify fish species that are the most likely receptors of impacts with respect to:* *1) spawning grounds;* *2) nursery grounds;* *3) feeding grounds;*	Particular attention has been given to impacts on fish species at key life stages such as during spawning or on known nursery habitats (see **Section 8.6**).

Policy description	Relevance to assessment
4) over-wintering areas for crustaceans; and 5) *migration routes.'*	
Paragraph 2.6.75 '*Where mitigation measures are applied to offshore export cables to reduce electromagnetic fields (EMF) the effects on sensitive species during operation are unlikely to be a reason for the SoS to have to refuse to grant consent. Once installed, operational EMF impacts are unlikely to be of sufficient range or strength to create a barrier to fish movement'*.	EMF effects (including cable design and installation) are considered within the Proposed Development assessment (see **Table 8-10** and **paragraph 8.10.35** to **paragraph 8.10.58**).
Paragraph 2.6.76 '*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'*.	Mitigation of EMF through cable burial and cable protection has been considered within the Proposed Development assessment (see **Table 8-11**).
The Marine Policy Statement (MPS) (September 2011)	
Section 2.2 '*Living within environmental limits:* *Biodiversity is protected, conserved and where appropriate recovered and loss has been halted.* *Healthy marine and coastal habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems.* *Our oceans support viable populations of representative, rare, vulnerable, and valued species*.'	Environmental measures will aim to protect, and conserve fish and shellfish ecology features of ecological importance are provided in **Section 8.7**.
UK Biodiversity Action Plan (BAP) Priority Species and Habitats	
The UK BAP identified priority species and habitats as being the most threatened and requiring conservation action.	Environmental measures with the aim to protect and conserve UK BAP fish and shellfish species of relevance to the PEIR Assessment Boundary are considered in **Section 8.7**.

Local planning policy

8.2.4 **Table 8-3** lists the local planning policy relevant to the assessment of the effects on fish and shellfish receptors.

Table 8-3 Local planning policy relevant to fish and shellfish ecology.

Policy description	Relevance to assessment
South Inshore and South Offshore Coast Marine Plan (July 2018)	
Policy Reference: S-MPA-1 '*Any impacts on the objectives of marine protected areas and the ecological coherence of the marine protected area network must be taken account of in strategic level measures and assessments, with due regard given to statutory advice on an ecologically coherent network*.'	Designated nature conservation sites within the PEIR Assessment Boundary fish and shellfish ecology study area have been described in **Section 8.6** and **Table 8-9**Table 8-9 Marine nature conservation designations with relevance to fish and shellfish ecology. .
Policy Reference: S-FISH-4 '*Proposals that enhance essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes should be supported. Proposals must demonstrate that they will, in order of preference: a) avoid, b) minimise, c) mitigate significant adverse impact on essential fish habitat, including, spawning, nursery, feeding grounds and migration routes*.'	The Proposed Development has been through an iterative design process that has sought to avoid sensitive features wherever possible, however avoiding potential impacts on fish habitat may not be possible in all cases. Environmental measures designed to protect, and conserve fish and shellfish ecology features of ecological importance are provided in **Section 8.7**.
Policy Reference: S-FISH-4-HER '*Proposals will consider herring (Clupea harengus) spawning mitigation in the area during the period 01 November to the last day of February annually*.'	Consideration of herring spawning grounds of relevance to the PEIR Assessment Boundary is provided in **Section 8.7**.
Sussex Biodiversity Action Plan (BAP)	
A BAP addresses threatened species and habitats, designed to protect and restore biological systems. The overall aim of the Sussex BAP is to conserve and enhance the biological diversity of Sussex and contribute to the conservation and enhancement of both national and international biodiversity. Marine fish species on the Sussex BAP comprise the undulate ray (*Raja undulata*),	Environmental measures with the aim to protect and conserve all Sussex BAP fish and shellfish species of relevance to the PEIR Assessment Boundary are considered in **Section 8.7**.

Policy description	Relevance to assessment
herring, plaice (*Pleuronectes platessa*), horse mackerel (*Trachurus trachurus*), mackerel (*Scomber scombrus*), Dover sole (*Solea solea*) and short-snouted seahorse. Anadromous fish species listed comprise allis shad, twaite shad, European eel (*Anguilla anguilla*), European smelt (*Osmerus eperlanus*), Atlantic salmon and sea trout (*Salmo trutta*). The European native oyster is also on the Sussex BAP.	

Other relevant information and guidance

8.2.5 A summary of other relevant information and guidance relevant to the assessment undertaken for fish and shellfish ecology is provided below:

- EIA Directive (11/92/EU) (as amended). Requires adequate characterisation of the receiving environment;
- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017. Requires a description of the relevant aspects of the current state of the environment (baseline scenario);
- The Marine Strategy Framework Directive (MSFD), adopted in July 2008, and transposed into law (The Marine Strategy Regulations 2010), has also been considered in the PEIR Assessment Boundary for fish and shellfish ecology. The relevance of the MSFD to the Proposed Development is described in full in **Chapter 2: Policy and legislative context**. The overarching goal of the MSFD is to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment;
- Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal (Institute for Ecology and Environmental Management (IEEM, 2010)).

8.2.6 In accordance with Cefas *et al*. (2004) guidance the assessment phase of the EIA will consider the following aspects of the fish and shellfish resource in the study area:

- spawning grounds;
- nursery grounds;
- feeding grounds;
- overwintering areas for crustaceans; and
- migration routes.

8.3 Consultation and engagement

Overview

8.3.1 This section describes the outcome of, and response to, the Scoping Opinion in relation to fish and shellfish ecology assessment and also provides details of the ongoing informal consultation that has been undertaken with stakeholders and individuals. An overview of engagement undertaken can be found in **Section 1.5** of **Chapter 1: Introduction**.

8.3.2 Given the restrictions which have been in place due to the COVID-19 pandemic during this period, all consultation has taken the form of conference calls using Microsoft Teams and emails.

Early engagement

8.3.3 Early engagement was undertaken with a number of prescribed consultation bodies including Natural England, the Marine Management Organisation (MMO) and Centre for Environment, Fisheries and Aquaculture Science (Cefas) in relation to fish and shellfish ecology. This engagement was undertaken to introduce the Proposed Development and the proposed approach to scoping the EIA.

8.3.4 Rampion Extension Development Limited (RED) have engaged from the beginning of the process with Natural England, the MMO and Cefas, who attended a consultation meeting on 18 February 2019. Natural England, the MMO and Cefas also attended a meeting on 06 May 2020 to discuss the methodological approach for black seabream.

Scoping opinion

8.3.5 RED submitted a Scoping Report (RED, 2020) and request for a Scoping Opinion to the Secretary of State (administered by the Planning Inspectorate (PINS)) on 02 July 2020. A Scoping Opinion was received on 11 August 2020. The Scoping Report set out the proposed fish and shellfish ecology assessment methodologies, an outline of the baseline data collected to date and proposed, and the scope of the assessment. **Table 8-4** sets out the comments received in Section 4 of the PINS Scoping Opinion 'Aspect based scoping tables – Offshore' (PINS, 2020) and how these have been addressed in this PEIR. A full list of the PINS Scoping Opinion comments and responses is provided in **Appendix 5.1: Response to the Scoping Opinion**. Regard has also been given to other stakeholder comments that were received in relation to the Scoping Report.

8.3.6 The information provided in the PEIR is preliminary and therefore not all the Scoping Opinion comments have been able to be addressed at this stage, however all comments will be addressed within the ES.

Table 8-4 PINS Scoping Opinion responses – fish and shellfish ecology.

PINS ID number	Scoping Opinion comment	How this is addressed in this PEIR
4.3.1	Although the Inspectorate notes the basis of the evidence provided to support the Applicant's proposed approach (Orpwood *et al*. (2015) and Armstrong *et al*. (2015)), the MMO and its technical advisors do not support these findings. In their view, significant uncertainties concerning electromagnetic effects remain. The Inspectorate therefore does not agree that likely significant effects upon fish receptors from operational EMF can be excluded at this stage and this matter should remain scoped into the ES.	The impacts of EMF on sensitive fish and shellfish species have been addressed in **Section 8.10** using available literature to undertake a precautionary assessment.
4.3.2	The Inspectorate agrees that, with the implementation of measures to limit any potential pollution incidents, any potential impacts on fish and shellfish are unlikely to result in significant effects and therefore further assessment is not required. However, the Inspectorate seeks assurances as to the detail of such measures that would be employed and how they would be secured and therefore considers that this detail should be presented within the ES.	This comment is acknowledged. Proposed environmental measures and how they will be secured are set out in **Section 8.7**.
4.3.3	The Inspectorate agrees on the basis of the evidence provided and the nature of the Proposed Development that direct and indirect impacts to the seabed resulting in the release of sediment contaminants during construction and decommissioning on fish and shellfish receptors can be scoped out of the ES.	This comment is acknowledged.
4.3.4	Paragraph 5.4.29 states that the proposed development may impact on less mobile species such as whelk, lobster and scallop. This stands at odds with paragraph 5.4.44	The potential impact on these species is considered in **Section 8.9** to **8.11.**

PINS ID number	Scoping Opinion comment	How this is addressed in this PEIR
	which states "Species present that will be subject to disturbance are likely to be mobile and can therefore move away from the construction activities." In the absence of information such as evidence demonstrating clear agreement with relevant consultation bodies, the Inspectorate does not agree to scope this matter out. Accordingly, the ES should include an assessment of this matter where significant effects are likely.	
4.3.5	The Inspectorate is content that there is unlikely to be significant effects from underwater noise during operation and therefore agrees that this matter can be scoped out of the fish and shellfish assessment.	This comment is acknowledged.
4.3.6	The Inspectorate does not consider there is sufficient information in the Scoping Report to support scoping out direct disturbance resulting from maintenance within the array area and the offshore export cable corridor during operation (for example frequency, duration and nature of such activities). Depending on the nature of the maintenance works and the species present in the area there could be a likely significant effect that should be assessed as part of the ES on the basis of the anticipated maintenance programme.	Potential impacts from direct disturbance resulting from maintenance within the array area and the offshore export cable corridor have been considered in **Section 8.10.**
4.3.7	The Inspectorate is content that there is unlikely to be significant effects from maintenance within the offshore cable corridor during operation and therefore agrees that this matter can be scoped out of the fish and shellfish assessment.	This comment is acknowledged.

PINS ID number	Scoping Opinion comment	How this is addressed in this PEIR
4.3.8	The Inspectorate agrees that this matter can be scoped out of the ES on the basis that displacement is only expected to be short term in duration (construction phase) and of limited spatial extent as part of the wider study area. Relevant matters are considered as part of scope of the commercial fisheries section.	This comment is acknowledged.
4.3.9	It is noted that baseline section of the Scoping Report does not clearly identify the conservation status of the fish and shellfish species discussed. The ES should identify, value, and assess impacts on protected species and species of conservation concern, where significant effects are likely.	Species of conservation importance are identified in **Section 8.6**. The potential impact on these species is considered in **Section 8.9** to **8.11**.
4.3.10	There are locally important populations of undulate ray in the vicinity of the Proposed Development, and as such, impacts to undulate ray nursery grounds should be assessed within the ES.	The potential impact on elasmobranch, including undulate ray is considered in, **Section 8.9** to **8.11**.
4.3.11	The Scoping Report does not propose any updated fish or shellfish surveys as there is intent to rely upon data collected for Rampion 1. As Rampion 1 was completed in 2018, it is considered that the fish and shellfish numbers or species may have changed during this time, and potentially as a direct result of the operation of Rampion 1. The Inspectorate does not specifically agree it is appropriate that no additional data collection is required based on the information presented in the Scoping Report. The Inspectorate considers the need for fish and shellfish surveys to be updated should be specifically considered as part of the EPP and reported in the ES. The ES should then justify the validity of the evidence base in	Datasets used to inform the fish and shellfish ecology PEIR chapter are provided in **Section 8.5**. As part of the Evidence Plan Process (EPP), it was agreed with the Fish and shellfish Expert Topic Group (ETG) that adequate information had been provided for the baseline characterisation and, with the exception of black seabream, further fish and shellfish surveys were not considered necessary for this assessment. Site specific geophysical surveys were conducted across the entire PEIR Assessment Boundary, which allows consideration of the likely distribution of black seabream nests, and nesting habitat potential outside the Kingmere MCZ based

PINS ID number	Scoping Opinion comment	How this is addressed in this PEIR
	informing a robust assessment of significant effects.	on seabed characteristics (**Section 8.6, paragraph 8.6.78** to **8.6.80**). The site specific surveys complement long term black seabream nest distribution data collected within the export cable corridor, Kingmere MCZ and nearfield Zone of Influence (ZOI) to inform licensing decisions for the aggregate industry, black seabream catch and release data, and regional geological data, the composite of which is described in this chapter and completes a comprehensive baseline characterisation fit for the purposes of EIA.

Evidence Plan Process (EPP)

Overview

8.3.7 The EPP has been set up to provide a formal, non-legally binding, independently chaired forum to agree the scope of the EIA and Habitats Regulation Assessment (HRA), and the evidence required to support the Development Consent Order (DCO) Application. For fish and shellfish, formal consultation has been ongoing with a number of stakeholders, including Regulators (for example the MMO), Statutory Nature Conservation Bodies (SNCBS), local authorities, technical expert and interest groups in relation to fish and shellfish ecology as part of the Coastal Processes, Benthic Ecology and Fish Ecology ETG. A summary of consultation undertaken between the completion of the Scoping Report and up to March 2021 is outlined in this section.

The Marine Management Organisation (MMO)

8.3.8 Engagement with the MMO has been ongoing since 06 May 2020 in the form of conference calls and emails. On 17 September 2020 the first Coastal Processes, Benthic Ecology and Fish Ecology ETG Meeting was held here the scope of the assessment relating to the scoping opinion was discussed. The proposed methodology was presented and there was a brief discussion of key datasets. No agreements or disagreements were identified by the MMO.

8.3.9 An additional 'catch-up' ETG specific to fish and shellfish ecology was held on 21 October 2020. No agreements or disagreements were identified by the MMO during the ETG meeting. However, the MMO provided details comments in relation to the ETG meeting on 30 November 2020. The MMO agreed the source of literature, data and publications presented were appropriate for fisheries and fish ecology for the purpose of the EIA. The MMO also agreed that no new fisheries surveys were required to inform the characterisation. As noted in **paragraph 8.3.17** below Natural England defer to the MMO and Cefas on whether additional surveys are required. The MMO further agreed that the scoping in of effects on EMF on elasmobranch and electrosensitive species was appropriate. No disagreements or further agreements have been identified.

8.3.10 On 24 March 2021 the second Coastal Processes, Benthic Ecology and Fish Ecology ETG Meeting was held. The meeting presented a high-level summary of the baseline data gathered since the first ETG Meeting (17 September 2020), discussions were held on the benthic indicative habitat model approach and a discussion on the comments received on the fish and shellfish ecology method statement. In terms of the underwater noise thresholds the MMO considers the approach provided as sensible in relation to peak and single strike from piling location which gives the MMO an indication of the likely sound levels, rather than a fixed threshold approach. No further agreements or disagreements were identified.

Centre for Environment, Fisheries and Aquaculture Science (Cefas)

8.3.11 Engagement with the Cefas has been ongoing since 06 May 2020 in the form of conference calls and emails.

8.3.12 On 17 September 2020 the first Coastal Processes, Benthic Ecology and Fish Ecology ETG meeting were held here the scope of the assessment relating to the scoping opinion was discussed. The proposed methodology was presented and there was a brief discussion of key datasets. Cefas noted during the ETG meeting they require an assessment to recognise why EMFs can be scoped out. However, they agreed with the approach of underwater noise modelling of 10 to 15dB regarding the impact of unexploded ordnance (UXO). No further agreements or disagreements were identified.

8.3.13 An additional ‘catch-up’ ETG specific to fish and shellfish ecology was held on 21 October 2020. During this ETG meeting Cefas agreed that adequate information had been provided for the baseline characterisation and additional beam and otter trawls were not necessary.

8.3.14 On 24 March 2021 the second Coastal Processes, Benthic Ecology and Fish Ecology ETG Meeting was held. The meeting presented a high-level summary of the baseline data gathered since the first ETG Meeting (17 September 2020), discussions on the benthic indicative habitat model approach and a discussion on the comments received on the fish and shellfish ecology method statement. Cefas noted concern with extent of aggregate data available, however noted their support in the use of the sediment habitat approach which may be a useful tool to help characterise black seabream habitat distribution in the vicinity of the PEIR Assessment Boundary. Cefas also noted for underwater noise that using a different threshold for a different receptor is useful. No further agreements or disagreements were identified.

Natural England

8.3.15 Engagement with Natural England has been ongoing since 06 May 2020 in the form of conference calls and emails.

8.3.16 Natural England were unable to attend the first Coastal Processes, Benthic Ecology and Fish Ecology ETG meeting on 17 September 2020. However, an additional 'catch-up' ETG meeting was held on 21 October 2020. The proposed methodology for Fish and Shellfish Ecology and associated underwater noise modelling was presented and there was a brief discussion of key datasets. Natural England agreed that seahorses (*Hippocampus* species) should be included within the assessment. However, queried the undertaking of drop-down video (DDV) surveys outside of the bream nesting season. Natural England were therefore not in a position to agree with any conclusions on the absence or extent of nesting black seabream based on surveys undertaken outwith the nesting season. No further agreements or disagreements were identified.

8.3.17 Natural England provided a comment concerning the ETG meeting on 27 November 2020 and noted that Natural England defers to MMO/Cefas on whether additional surveys are required. This excludes black seabream.

8.3.18 On 24 March 2021 the second Coastal Processes, Benthic Ecology and Fish Ecology ETG Meeting was held. The meeting presented a high-level summary of the baseline data gathered since the first ETG Meeting (17 September 2020), discussions on the benthic indicative habitat model approach and a discussion on the comments received on the fish and shellfish ecology method statement. Natural England agreed with the precautionary approach to bream nesting, but also note that Natural England considers most bream nesting/spawning increases closer to the Kingmere MCZ and the rocks outside the Kingmere MCZ and should be treated with a higher level of risk. No further agreements or disagreements were identified.

Environment Agency

8.3.19 Engagement with the Environment Agency has been ongoing since 06 May 2020 in the form of conference calls and emails.

8.3.20 On 17 September 2020 the first Coastal Processes, Benthic Ecology and Fish Ecology ETG meeting was held and the scope of the assessment relating to the Scoping Opinion was discussed. The proposed methodology was presented and there was a brief discussion of key datasets. The Environment Agency raised that additional trawl surveys are useful to inform fish populations within the assessment area. No further agreements or disagreements were identified.

8.3.21 On 24 March 2021 the second Coastal Processes, Benthic Ecology and Fish Ecology ETG Meeting was held. The meeting presented a high-level summary of the baseline data gathered since the first ETG Meeting (17 September 2020), discussions on the benthic indicative habitat model approach and a discussion on the comments received on the fish and shellfish ecology method statement. No agreements or disagreements were identified.

The Wildlife Trust and Sussex Wildlife Trust

8.3.22 Engagement with The Wildlife Trust and the Sussex Wildlife Trust has been ongoing since 06 May 2020 in the form of conference calls and emails.

8.3.23 On 17 September 2020 the first Coastal Processes, Benthic Ecology and Fish Ecology ETG meeting was held here the scope of the assessment relating to the scoping opinion was discussed. The proposed methodology was presented and there was a brief discussion of key datasets. No agreements or disagreements were identified.

8.3.24 On 24 March 2021 the second Physical Processes, Benthic Ecology and Fish Ecology ETG Meeting was held. The meeting presented a high-level summary of the baseline data gathered since the first ETG Meeting (17 September 2020), discussions on the benthic indicative habitat model approach and a discussion on the comments received on the fish and shellfish ecology method statement. Clarification was provided on piling and UXO clearance and operational noise. No agreements or disagreements were identified.

Sussex IFCA

8.3.25 Engagement with Sussex IFCA has been ongoing since 19 February 2019 in the form of conference calls and emails.

8.3.26 On 17 September 2020 the first Coastal Processes, Benthic Ecology and Fish Ecology ETG meeting was held here the scope of the assessment relating to the scoping opinion was discussed. The proposed methodology was presented and there was a brief discussion of key datasets. No agreements or disagreements were identified.

8.3.27 On 24 March 2021 the second Physical Processes, Benthic Ecology and Fish Ecology ETG Meeting was held. The meeting presented a high-level summary of the baseline data gathered since the first ETG Meeting (17 September 2020), discussions on the benthic indicative habitat model approach and a discussion on the comments received on the fish and shellfish ecology method statement. Sussex IFCA provided details of the South Coast Regional Environmental Characterisation Report in relation to black seabream nest areas. Sussex IFCA confirmed agreement with other statutory authorities of no additional fish and shellfish surveys required for the Proposed Development. No further agreements or disagreements were identified.

The Seahorse Trust

8.3.28 Engagement with The Seahorse Trust had been ongoing since 06 May 2020 in the form of conference calls and emails until December 2020. The Seahorse Trust decided to withdraw from the consultation process (04 November 2020).

8.3.29 The Seahorse Trust did attend the first Coastal Processes, Benthic Ecology and Fish Ecology ETG meeting on 17 September 2020. The proposed methodology was presented and there was a brief discussion of key datasets. No agreements or disagreements were identified. The Seahorse Trust concurred with the Environment Agency in regard to the usefulness of additional trawl surveys to inform fish populations within the assessment area. No further agreements or disagreements were identified.

Informal consultation and engagement

7.1.1 Informal consultation and engagement has been ongoing with a number of prescribed and non-prescribed consultation bodies and local authorities in relation to benthic, subtidal and intertidal ecology.

7.1.2 An Informal Consultation exercise was undertaken between 14 January and 11 February 2021 which aimed to engage with a range of stakeholders including the prescribed and non-prescribed consultation bodies, local authorities, Parish Councils and general public with a view to introducing the Proposed Development and seeking early feedback on the emerging designs.

8.4 Scope of the assessment

Overview

8.4.1 This section sets out the scope of the PEIR assessment for fish and shellfish ecology. This scope has been developed as the Proposed Development design has evolved and responds to feedback received to date as set out in **Section 8.3**. As outlined in the PINS Advice Note Seven: Environmental Impact Assessment: Process, Preliminary Environmental Information and Environmental Statements (Version 7, PINS, 2020), the information presented in the PEIR is preliminary, therefore this scope will be reviewed and may be refined as the Proposed Development evolves and as a result of ongoing consultation.

Spatial scope and study area

8.4.2 The spatial scope of the fish and shellfish ecology assessment is defined as the PEIR Assessment Boundary together with the secondary impact ZOI. The secondary ZOI has been informed by the tidal excursion extent and coastal processes modelling undertaken to inform the previous Rampion 1 offshore wind farm EIA (ABPmer, 2012). The ZOI buffer, therefore, encompasses the area over which suspended sediments may travel following disturbance as a result of the Proposed Development activities, extending a precautionary 15km around the array area, and 10km surrounding the offshore export cable corridor (**Figure 8-1, Volume 3**) which has formed the basis of the study area described in this section.

8.4.3 It is also recognised that noise propagation (for example from piling) is likely to extend beyond this buffer and therefore the potential impact risk defined by underwater noise modelling will also define the area for assessment of underwater noise impacts. The study area for noise impacts on fish and shellfish has been informed by the noise propagation modelling.

Temporal scope

8.4.4 The temporal scope of the assessment of fish and shellfish ecology is the entire lifetime of Rampion 2, which therefore covers the construction, operational and decommissioning periods, as described in **Chapter 4**.

Potential receptors

8.4.5 The spatial and temporal scope of the assessment enables the identification of receptors that may experience a potential significant effect as a result of the Proposed Development. The receptors identified that may experience likely significant effects for fish and shellfish are described in detail within the baseline characterisation presented in **Section 8.6**. having been informed by the formal

Scoping Opinion, and a review of the receiving environment to identify receptors that may be subject to potentially significant effect. The receptors scoped into the assessment are outlined in **Table 8-5**.

Table 8-5 Receptors requiring assessment for fish and shellfish

Receptor group	Receptors included within group
Mobile fish species	Herring (*Clupea harengus*), black seabream (*Spondyliosoma cantharus*), sandeel (*Ammodytes tobianus, Hyperoplus lanceolatus*), plaice (*Pleuronectes platessa*), Dover sole (*Solea solea*), lemon sole (*Microstomus kitt*), cod (*Gadus morhua*), sprat (*Sprattus sprattus*), mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*), sea bass (*Dicentrarchus labrax*), cuttlefish (*Sepia officinalis*), spiny seahorse (*Hippocampus guttulatus*) and short-snouted seahorse (*Hippocampus hippocampus*)
Elasmobranch	Undulate ray (*Raja undulata*), thornback ray (*Raja clavata*), spurdog (*Squalus acanthias*), porbeagle shark (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), tope (*Galeorhinus galeus*), blue shark (*Prionace glauca*) and basking shark (*Cetorhinus maximus*)
Migratory species	European eel (*Anguilla anguilla*), sea lamprey (*Petromyzon marinus*), Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), European smelt (*Osmerus eperlanus*), allis shad (*Alosa alosa*) and twaite shad (*Alosa fallax*)
Shellfish	Brown crab (*Cancer pagurus*), European lobster (*Homarus gammarus*), king scallop (*Pecten maximus*) and whelks (*Buccinum undatum*).

8.4.6 The list of receptors will be kept under review during the EIA should more information be obtained during consultation, and other forms of data collection by other aspects and will be reflected in the final ES.

Potential effects

8.4.7 Potential effects on fish and shellfish receptors that have been scoped in for assessment are summarised in **Table 8-6**.

Table 8-6 Potential effects on fish and shellfish receptors scoped in for further assessment.

Receptor	Activity or impact	Potential effect
Construction		
Fish and shellfish ecology:	Mortality, injury, behavioural changes and auditory	Potential for a significant effect on fish and shellfish

Receptor	Activity or impact	Potential effect
Sandeel, herring, cod, plaice, cuttlefish, Dover sole, black seabream, seahorse, undulate ray and thornback ray	masking arising from noise and vibration	ecology through temporary underwater noise disturbance (**Section 8.9**)
Fish and shellfish ecology: Demersal spawners – sandeel, herring, black seabream, undulate ray and thornback ray	Direct disturbance resulting from the installation of the export cable	Potential for a significant effect on fish and shellfish ecology resource through temporary and direct habitat disturbance (**Section 8.9**).
Fish and shellfish ecology: Demersal spawners – sandeel, herring, black seabream, undulate ray and thornback ray	Direct disturbance resulting from construction within the array	Potential for a significant effect on fish and shellfish ecology resource through temporary and direct habitat disturbance (**Section 8.9**).
Fish and shellfish ecology: Demersal spawners – black seabream, herring, sandeel, seahorse, undulate ray and thornback ray Shellfish – brown crab, European lobster, scallop, native oyster and blue mussels	Temporary and localised increases in suspended sediment concentrations (SSC) and smothering	Potential for significant effect through smothering of important habitat to fish and shellfish, such as spawning areas (**Section 8.9**).
Fish and shellfish ecology: Demersal spawners – black seabream and sandeel	Direct and indirect seabed disturbances leading to the release of sediment contaminants	Potentially for significant effect through the release of sediment-bound contaminants into the water column (**Section 8.9**).
Operation and maintenance		
Fish and shellfish ecology: Demersal spawners – black seabream, herring, sandeel and undulate ray Shellfish species – European lobster and brown crab	Long-term loss of habitat and increased hard substrate and structural complexity due to the presence of turbine foundations scour protection and cable protection	Potential for significant effect through the loss of suitable substrate or sensitive habitat and potential impact on fish and shellfish ecology biodiversity due to the introduction of hard substrates (**Section 8.10**).
Fish and shellfish ecology:	Electromagnetic field (EMF) impacts arising from cables	Potential for significant negative impact on fish and

Receptor	Activity or impact	Potential effect
Elasmobranch species, migratory fish species and shellfish species		shellfish ecology (**Section 8.10**).
Fish and shellfish ecology: Demersal spawners – black seabream and sandeel	Direct disturbance resulting from maintenance within the array area and the offshore export cable corridor	Potential for a significant effect on fish and shellfish ecology resource through temporary and direct habitat disturbance (**Section 8.10**).
Decommissioning		
Fish and shellfish ecology: Sandeel, herring, cod, plaice, cuttlefish, Dover sole, black seabream, seahorse, undulate ray and thornback ray	Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Potential for a significant effect on fish and shellfish ecology through temporary underwater noise disturbance (**Section 8.11**).
Fish and shellfish ecology: Demersal spawners – sandeel, herring, black seabream, undulate ray and thornback ray	Direct disturbance resulting from the removal of the export cable	Potential for a significant effect on fish and shellfish ecology resource through temporary and direct habitat disturbance (**Section 8.11**).
Fish and shellfish ecology: Demersal spawners – sandeel, herring, black seabream, undulate ray and thornback ray	Direct disturbance resulting from decommissioning within the array	Potential for a significant effect on fish and shellfish ecology resource through temporary and direct habitat disturbance (**Section 8.11**).
Fish and shellfish ecology: Demersal spawners – black seabream, herring, sandeel, seahorse, undulate ray and thornback ray Shellfish – brown crab, European lobster, scallop, native oyster and blue mussels	Temporary and localised increases in SSC and smothering	Potential for significant effect through smothering of important habitat to fish and shellfish, such as spawning areas (**Section 8.11**).
Fish and shellfish ecology: Demersal spawners – black seabream and sandeel	Direct and indirect seabed disturbances leading to the release of sediment contaminants	Potential for significant effect through the release of sediment-bound contaminants into the water column (**Section 8.11**).

Activities or impacts scoped out of assessment

8.4.8 A number of potential effects have been scoped out from further assessment, resulting from a conclusion of no likely significant effect. These conclusions have been made based on the knowledge of the baseline environment, the nature of planned works and the wealth of evidence on the potential for impact from comparable projects more widely. Each scoped out activity or impact is considered in turn below and an indication is given of whether the scope has evolved since Scoping.

Table 8-7 Activities or impacts scoped out of assessment.

Activity or impact	Rationale for scoping out
Accidental pollution impacts during the construction phase resulting in potential effects on fish and shellfish receptors (Construction and Decommissioning).	Accidental pollution events are not considered to result in a significant effect on benthic subtidal and intertidal (and therefore fish and shellfish) receptors. 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 Monitoring and Management Plan (PEMMP) and Outline Marine Pollution Contingency Plan (MPCP) (embedded measure C-53, **Table 8-11**), which will be approved by the relevant stakeholders and secured through DCO. PINS agreed any potential impacts on fish and shellfish are unlikely to result in significant effects with the implementation of measures to limit any potential pollution incidents. PINS agreed that no further assessment is required (PINS, 2020).
Underwater noise as a result of operational WTGs (Operation).	PINS agreed that underwater noise during operation can be scoped out of the fish and shellfish assessment in the Scoping Opinion (PINS, 2020). The MMO has no major objections to scoping out the potential effects of underwater noise as a result of operational WTGs (MMO, 2021). It was noted by the MMO (2021) that the cumulative contribution to the soundscape from multiple Wind Turbine Generators (WTG) within a wind farm should not be ignored. However, given the anticipated localised extent of the operational noise, and the agreement to scope the impact out by PINS and MMO, operational noise has not been assessed. As a cumulative assessment of

Activity or impact	Rationale for scoping out
	underwater noise from operational WTG will give no meaningful contribution, it has not been assessed further.
Potentially reduced fishing pressure within the Rampion 2 array area and increased fishing pressure outside the array area due to displacement (Operation).	PINS agreed that this matter can be scoped out of the EIA in the Scoping Opinion (PINS, 2020)

8.5 Methodology for baseline data gathering

Overview

8.5.1 Baseline data collection has been undertaken to obtain information over the study areas described in **Section 8.4: Scope of the assessment**. The current baseline conditions presented in **Section 8.6: Baseline conditions** presents data currently available from the study area.

8.5.2 Additional fish and shellfish surveys are not proposed for the Proposed Development as existing site-specific data from the Rampion 1 offshore wind farm EIA, and from wider studies within the region (see **Table 8-8**), are considered sufficient in describing fish and shellfish receptors within the PEIR Assessment Boundary for the purposes of undertaking an EIA.

8.5.3 At this stage discussion has been held with ETG members and through the scoping process, and it is considered that the composite of data available adequately characterise the receiving environment with regards broad nursery and spawning areas for fish species, and specific regional species such as black seabream. The combined methods used for data collection align with existing best practice.

Desk study

8.5.4 A detailed desktop review was carried out to establish the baseline of information available on fish and shellfish populations in the fish and shellfish ecology study area from PEIR Assessment Boundary. Information was sought on fish shellfish ecology in general, spawning and nursery activity and on black seabream. The baseline characterisation utilises a broad combination of datasets providing a robust temporal analysis and validation of the site-specific and regional monitoring datasets. The data presented provide a characterisation that is appropriate and adequate for the purpose of undertaking an EIA and complies with existing policy and guidance provided within **Table 8-2**. The data sources that have been collected and used to inform this fish and shellfish ecology assessment are summarised in **Table 8-8**.

8.5.5 As agreed with stakeholders through the EIA EPP, sufficient information exists to enable a robust characterisation of the receiving environment and identification of relevant valued ecological receptors for the purposes of assessment. As such it has been agreed that further fish and shellfish surveys are not required for the Proposed Development EIA. The data sources described in this section allow a robust conclusion to be drawn that further survey would not be likely to identify additional receptors or materially alter the findings of the assessment with regards to the likely magnitude of impact, the receptor species considered or the need or otherwise for appropriate mitigation.

Table 8-8 Data sources used to inform the fish and shellfish ecology PEIR assessment.

Source	Date	Summary	Coverage of study area
Fisheries Sensitivity Maps in British Waters (Coull *et al*, 1998)	1998	Fisheries sensitivity maps showing spawning and nursery areas of commercially important fish and shellfish species.	Coverage of UK waters.
Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al*, 2010)	2010	Maps indicating the main spawning and nursery grounds for 14 commercially important species.	Coverage of UK waters.
Modelled distributions of ten demersal elasmobranchs of the eastern English Channel in relation to the environment (Martin *et al*, 2012)	2012	Modelled distributions of elasmobranch populations within the eastern English Channel.	Coverage across the eastern English Channel.
Distribution of skates and sharks in the North Sea: 112 years of change (Sguotti *et al*, 2016)	2012	Distributions of elasmobranch populations in the North Sea.	Coverage of the North Sea.
Assessing the status of demersal elasmobranchs in UK waters: a review (Ellis *et al*, 2005)	2005	Status of elasmobranch populations in UK waters.	Coverage of UK waters.
The International Herring Larvae Surveys (IHLS) (ICES, 1967-2019)	1967 to 2020	Herring larvae surveys conducted in the North Sea and adjacent areas, to provide quantitative	Coverage across the North Sea and the English Channel.

Source	Date	Summary	Coverage of study area
		estimates of herring larval abundance, used as a relative index of changes of the herring spawning-stock biomass.	
UK sea fisheries annual statistics report (MMO, 2020)	2015 to 2019	Information on landings of the UK fishing fleet, and the status of commercial fish stocks over the last five years (2015-2019).	Full coverage of the study area.
Rampion offshore wind farm Environmental Statement (E.ON, 2012)	2012	Site-specific fish and shellfish surveys undertaken to inform the existing Rampion 1 offshore wind farm.	Site-specific data across the existing Rampion 1 offshore wind farm.
Rampion offshore wind farm Preconstruction Fish and Shellfish Monitoring Report (Natural Power, 2017)	2017	Site-specific pre-construction fish and shellfish otter and beam trawl surveys undertaken to inform the existing Rampion 1 offshore wind farm ES.	Site-specific data across the existing Rampion 1 offshore wind farm.
Rampion offshore wind farm Year 1 Post-Construction Fish Monitoring Report (OEL, 2020a)	2019 to 2020	Site-specific post-construction fish and shellfish otter and beam trawl surveys undertaken within the array area, export cable route and in reference areas outside the Rampion 1 offshore wind farm.	Site-specific data across the existing Rampion 1 offshore wind farm and adjacent areas.
North Owers Black Bream Monitoring report (GoBe, 2015)	2015	Black seabream monitoring report for North Owers marine aggregate extraction area.	Regional and partial site-specific (nearshore export cable) context of black seabream populations.
Area 435/396, Area 453 and Area 488 Annual Monitoring Reports (EMU Limited, 2009;	2009 to 2014	Environmental monitoring reports for marine aggregate extraction areas (Area 435/ 396, Area 453	Regional and partial site-specific (nearshore export cable) context of

Source	Date	Summary	Coverage of study area
Fugro EMU Ltd. 2013 and 2014).		and Area 488) within the region.	black seabream populations.
A study of the Black Bream Spawning Ground at Littlehampton (Southern Science Ltd., 1995	1995	Black seabream spawning ground monitoring study.	Regional context.
Black Seabream tagging survey (Sussex IFCA, 2016)	2016	Black seabream monitoring data from tagging surveys have been used to further complement the baseline characterisation of black seabream distribution within the ZOI.	Regional context.
Black bream in the English Channel off the Sussex coast (EMU Limited, 2012a)	2012	Monitoring report of black seabream in the English Channel.	Regional context.
ICES Fish Map (ICES, 2006)	2006	North Sea fish species distribution maps.	Coverage of UK waters.
Offshore beam trawl surveys (ICES, 1985-2019)	1985 to 2019	Offshore beam trawl surveys providing species distribution data.	Coverage across the southern North Sea and the English Channel.
North Sea International Bottom Trawl Survey (ICES, 1965-2020)	1965 to 2019	Bottom trawl surveys providing species distribution data across the North Sea.	Coverage across the North Sea and the English Channel.
Marine Aggregates Regional Environmental Assessment (MAREA) (EMU Limited, 2010)	2010	Fisheries activity survey data, and sediment transport data across the English Channel.	Coverage across the English Channel.
Marine Aggregate Levy Sustainability Fund (MALSF) synthesis study in the central and eastern	2011	Fisheries activity survey data, and sediment transport data across the English Channel.	Coverage across the English Channel.

Source	Date	Summary	Coverage of study area
English Channel (James *et al*, 2011)			
Sussex Inshore Fisheries and Conservation Authority (IFCA)	N/A	Fisheries monitoring reports and research reports.	Regional context.
Licence areas 453 CEMEX UK Marine Ltd. (CMX) and 488 Tarmac Marine Ltd., Aggregate black seabream monitoring data.	2017 to 2019	Data covering seven survey boxes and two transects in and around the Kingmere MCZ.	Coverage within and outwith the Kingmere MCZ and partial coverage of the export cable corridor.
UKSeaMap	2018	EUNIS Level 4 model, detailing biological zone and substrate.	Complete modelled coverage up to Mean High Water Springs.
British Geological Survey (BGS) Marine Bedrock and Quaternary Deposit Thickness	2020	Maps detailing the type and location of marine bedrock and the thickness of deposits on the seabed.	Coverage of UK waters.

Site surveys

8.5.6 As detailed in **paragraph 8.5.2** no additional fish and shellfish surveys are proposed for the Proposed Development EIA, however, the data collected has provided important additional ground discrimination information and interpretation, which has been used to refine habitat mapping. A site-specific geophysical survey was undertaken between July and August 2020 across the offshore PEIR Assessment Boundary. The survey employed single-beam and multi-beam echo sounders (SBES and MBES), side scan sonar (SSS), magnetometer and a sub-bottom profiler (SBP) (Gardline, 2020). The geophysical survey data has provided important additional ground discrimination information, with interpreted outputs used to refine habitat mapping for the entire PEIR Assessment Boundary area. Notably, the results of the survey have been used to supplement existing data on likely black seabream nesting locations in areas relevant to the Proposed Development, but outside of areas previously subject to targeted survey (Kingmere MCZ). The geophysical data supplement several regional datasets already identified which focus specifically on the distribution of black seabream nests within the ZOI of the Proposed Development, the composite has been agreed as adequate for the purpose of characterising the receiving environment and informing the EIA as part of the EPP.

Data limitations

8.5.7 It is acknowledged that the site-specific black seabream nest survey was conducted outwith the optimum nesting period, and whilst there is evidence of nest longevity and persistence there remains uncertainty with regards the dataset potentially underestimating nest coverage. The uncertainty has been addressed through the composite of the 20-year dataset referred to in the previous section, which demonstrates the data to be representative and robust for the purposes of EIA. Notwithstanding that the assessment takes a precautionary approach.

8.5.8 Coull *et al*. (1998) and Ellis *et al*. (2010, 2012) are considered the key references for providing broad scale overviews of the potential spatial extent of spawning grounds and the relative intensity and duration of spawning. These publications provide an indication of the general location of spawning and nursery grounds. They do not define precise boundaries of spawning and nursery grounds. Both Coull *et al*. (1998) and Ellis *et al*. (2010, 2012) are based on a collection of various data sources. Many of the conclusions drawn by Coull *et al*. (1998), are based on historic research and may fail to account for more recent changes in fish distributions and spawning behaviour. Ellis *et al*. (2010, 2012) also faces limitations due to the wide scale distribution of sampling sites used for the annual international larval survey data, consequently resulting in broad scale grids of spawning and nursery grounds. Similarly, the spawning times given in these publications represent the maximum duration of spawning on a species/stock basis. In some cases, the duration of spawning may be much more contracted, on a site-specific basis, than reported in Coull *et al*. (1998) and Ellis *et al*. (2010; 2012). Therefore, where available, additional research publications have also been reviewed to provide site-specific information.

8.5.9 Mobile species such as fish, exhibit varying spatial and temporal patterns. All surveys, including the site-specific surveys for Rampion 1 offshore wind farm, were undertaken to provide semi-seasonal description of the fish and shellfish assemblages within the fish and shellfish study area. These datasets represent snapshots of the fish and shellfish assemblage at the time of sampling and the fish and shellfish assemblages may vary both seasonally and annually.

8.5.10 Furthermore, the efficiency of the survey methods employed at collecting species will vary depending on the nature of the survey methods deployed and the species recorded. Several survey sample stations during the Rampion 1 offshore wind farm post-construction survey had to be abandoned in the field either as a result of very hard ground and significant risk posed to the sampling gear and vessel or due to there being fishing gear in the target area. This included survey station 4 (spring 2020, otter trawl), station 7 (autumn 2019 beam trawl and spring 2020 beam and otter trawl), station 13 (autumn 2019 beam trawl and spring 2020 beam and otter trawl). Due to lack of data in these survey sample stations, it is difficult to compare variations between pre-and post-construction surveys at these stations, however they are considered fit for the purpose of characterisation.

8.5.11 It is important to note that although the data used in the characterisation of the fish and shellfish baseline conditions span a long time period, with some sources published over a decade ago, the information presented represents a long-term and therefore reliable 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.

8.5.12 The EUNIS and Folk (1954) (Stephens and Diesing, 2015) broadscale marine habitat data used to identify preferred sandeel and herring spawning habitats are limited by the broadscale nature of the data 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 datasets presented, to develop a clear overview of preferred sandeel and herring habitat.

8.5.13 It should also be noted that the use of PSA data and broadscale habitat mapping only provides a proxy for the presence of sandeels and herring in these locations (based on suitability of habitats; for instance, the potential for spawning rather than actual contemporary spawning activity); therefore, these data should be reviewed alongside other datasets presented in this chapter in determining the location and relative importance of spawning habitats.

8.6 Baseline conditions

Current baseline

Overview

8.6.1 A detailed literature review was undertaken to describe the use of the area by fish and shellfish species in relation to key life stages, spawning and juvenile behaviour and migratory pathways. The literature review was informed by the existing Rampion 1 offshore wind farm ES (E.ON, 2012), and broader surveys across the English Channel and its coastal waters. The two fishing techniques utilised during the survey produced very different types of catches. The otter trawl survey produced the bigger catches, with a relatively even mix of fish and shellfish species, whereas the beam trawl survey captured more invertebrate species.

Rampion 1 characterisation surveys: beam trawls

8.6.2 Rampion 1 offshore wind farm conducted several fish and shellfish characterisation surveys using 2m scientific beam trawls. A commercial beam trawl survey was also conducted in April 2012 to specifically sample flatfish, as commercial beam trawling catches relatively slow-moving fish that live on (or close to) the seabed.

8.6.3 A total of 21 fish species were recorded in July 2011 beam trawl survey, of which the most abundant fish species included gobies (*Gobiidae* species), dragonet (*Callionymus* species), solenette (*Buglossidium luteum*) and weever (*Trachinidae* species). The most common commercial fish was plaice, with smaller numbers of Dover sole, lemon sole, thornback and spotted rays (E.ON, 2012).

8.6.4 An additional survey conducted from October to November 2011, recorded similar fish species to that of the July 2011 survey. The majority of fish were small non-commercial teleosts, predominately sand goby (*Pomatoschistus minutus*), which made up over 70 percent of the fish recorded. The only commercial species recorded where two lemon sole and a single black seabream, plaice and John Dory, all within the Rampion 1 offshore wind farm project site. No elasmobranch species were recorded. A single short-snouted seahorse was recorded at a depth of approximately 29m in the north-eastern part of the Rampion 1 offshore wind farm site (Brown and May, 2012a). As noted in the Rampion 1 offshore wind farm ES (E.ON, 2012), this area is predominately sandy gravel substrate.

8.6.5 A further survey was conducted in February 2012, which also identified small non-commercial species as the most frequently recorded species. The only commercial fish species recorded were three plaice and a single specimen each of Dover sole and lemon sole, all of which were caught in the Rampion 1 offshore wind farm site. As with the survey in October to November no elasmobranch species were recorded. Three short-snouted seahorses were recorded, all within the Rampion 1 offshore wind farm site, one was caught in the same location as the seahorse recorded in the October to November survey. The two remaining seahorses were caught in water depths between 31 and 33m within the western part of the Rampion1 offshore wind farm site. As with the previous survey, these seahorses were caught from an area of sandy gravel.

8.6.6 In April 2012, a commercial beam trawl was carried out and 2,638 individuals were recorded. Approximately 39 percent of the individuals record were plaice, with lemon sole, black seabream and Dover sole also recorded. Non-commercial species included bib (*Trisopterus luscus*), dab (*Limanda limanda*), lesser weever (*Echiichthys vipera*) and common dragonet (*Callionymus lyra*).

Rampion 1 characterisation surveys: otter trawls

8.6.7 Rampion 1 offshore wind farm conducted several fish and shellfish characterisation surveys using a commercial otter trawl. In the October to November 2011 survey 2,024 individuals were recorded, with 25 percent of individuals recorded were whiting (*Merlangius merlangus*). Other commercial species included plaice, black seabream (both contributed to six percent of individuals caught), with smaller abundances of lemon sole, bass and cod. Non-commercial species included horse mackerel and dab. Elasmobranch species recorded included the lesser spotted dogfish (*Scyliorhinus canicula*), tope, smooth hound (*Mustelus* species) and rays (thornback, undulate, blonde (*Raja brachyura*), spotted (*Raja montagui*) and cuckoo (*Leucoraja naevus*)). Shellfish species recorded included long-finned squid (*Loligo forbesi*), which comprised of 20 percent of the individuals caught, king scallop, queen scallop (*Aequipecten opercularis*), cuttlefish, whelk and brown crab were all caught within the Rampion 1 offshore wind farm site.

8.6.8 A further survey was conducted in February 2012, where a total of 4,197 individuals were recorded. As found with the October to November survey, whiting were the most abundant species comprising of approximately 58 percent of individuals. Other commercial species recorded included, herring, plaice and lemon sole. Non-commercial species included flounder, dab and sprat comprising of around 20 percent of all individuals. However, in this survey no black seabream were recorded, with limited number of shellfish species captured. Elasmobranch species included the lesser spotted dogfish, which was the most commonly recorded, followed by low numbers of smooth hound and rays (spotted, blonde, cuckoo, thornback and undulate). A single twaite species was recorded within the Rampion 1 offshore wind farm site. Whelks dominated the shellfish individuals recorded (60 percent), with smaller numbers of king scallop, cuttlefish, queen scallop and European native oyster.

Pre-construction monitoring survey of Rampion 1

8.6.9 Otter trawl surveys sampling demersal species undertaken to inform pre-construction fish and shellfish monitoring for Rampion 1 offshore wind farm were dominated numerically by lesser spotted dogfish, plaice, whiting and thornback ray, with smaller quantities of dab and red gurnard (*Chelidonichthys cuculus*) also recorded (E.ON, 2012). The most abundant commercial species in the otter trawl were plaice, whiting and queen scallop and squid (*Loligo* species). Seasonal variation in trawls was driven by increased abundances of dab, whiting, bib and starry smooth hound (*Mustelus asterias*) captured during the May survey, and greater numbers of spotted ray and red gurnards captured during the September/October survey (Natural Power, 2017).

8.6.10 Beam trawl surveys targeting epibenthic and demersal species were also undertaken as part of the existing Rampion 1 offshore wind farm pre-construction monitoring. The beam trawl used a smaller mesh compared to the otter trawl and was towed at a slower rate, allowing larger fish to avoid capture. This enabled the tow to focus on small or juvenile fish. The trawls were dominated numerically by lesser weever, gobies, Dover sole and common dragonet. The most abundant commercial species recorded in the beam trawl surveys was Dover sole, queen scallop and common whelk. Seasonal variation within the beam trawl surveys was driven by the dominance of juvenile Dover sole during the May surveys, whereas in September thornback rays were captured at greater abundance. Variation in catches of invertebrates were attributed to larger catches of green sea urchin (*Psammechinus miliaris*), European squid (*Loligo vulgaris*), and queen scallop in the September/October survey, with the May survey dominated by brittle stars (*Ophiuroidea* species) in May (E.ON, 2012, Natural Power, 2017).

8.6.11 The results from the pre-construction monitoring of the existing Rampion 1 offshore wind farm largely reflect surveys undertaken on a broader scale across the English Channel. ICES offshore beam trawl surveys in the English Channel were dominated in plaice, European spider crab (*Maja squinado*), Dover sole, poor cod (*Trisopterus minutus*), common dragonet, thornback ray and lesser spotted dogfish. Bottom trawls undertaken across the English Channel to inform the ICES International Bottom Trawl Surveys were dominated in whiting, European squid, dab, herring, plaice, lesser spotted dogfish, sprat and poor cod (Natural Power, 2017).

8.6.12 These surveys undertaken for Rampion 1 offshore wind farm have enabled a picture of the usage of fish and shellfish populations in the area of the Rampion 2 PEIR Assessment Boundary fish and shellfish study area. The area supports a diverse assemblage of commercially and non-commercially important fish and shellfish species, all of which are typical of this eastern English Channel. In general, the fish species captured reflected those that will be expected from examining the commercial fishing information from this area.

Post-construction monitoring survey of Rampion 1

8.6.13 Year 1 post-construction fish and shellfish monitoring surveys were carried out in autumn (November) 2019 and spring (May) 2020 by OEL to provide an assessment of any long-term changes in the fish and shellfish communities within and adjacent to the areas of potential impact resulting from the construction of Rampion 1 offshore wind farm. The survey formed a repeat of the pre-construction surveys undertaken in autumn 2015 and spring 2016. These surveys involved the collection of commercial otter trawl and scientific beam trawl samples from 15 stations across the offshore wind farm, cable route and reference areas (which are control areas located outwith the Rampion 1 offshore wind farm. These reference areas are located within the PEIR Assessment Boundary). Sampling positions were consistent with those agreed previously with the MMO and as per the previous pre-construction baseline surveys.

8.6.14 During the post-construction otter trawl surveys, a total of 27 fish species and five commercial invertebrate species were recorded. Commercial fish species sampled were dominated by seabass, plaice, and horse mackerel. Elasmobranch communities were characterised by the presence of lesser spotted dogfish and thornback ray. European squid and queen scallop were the most numerous invertebrates. The community was dominated by lesser spotted dogfish, plaice and whiting during pre-construction, while the dominant species were lesser spotted dogfish, thornback ray and seabass during post-construction. There was also a reduction in other, less abundant, species between pre- and post-construction surveys, most notably queen scallop and common whelk. Conversely, several other species including black seabream, horse mackerel, squid and lemon sole increased in abundance between pre- and post-construction surveys.

8.6.15 A total of 11 species of conservation interest have been recorded during the Rampion 1 offshore wind farm pre- and post-construction (year 1) otter trawl monitoring surveys. Of these the allis shad, and Atlantic mackerel (*Scomber scrombrus*), were only sampled during the post-construction surveys while herring, monkfish (*Lophius piscatorius*) and European native oyster, were only recorded during the pre-construction survey. Black seabream were also noted during both monitoring periods, with five individuals recorded in the pre-construction survey and 18 recorded in the post-construction survey.

8.6.16 A total of 31 fish species were captured in the post-construction beam trawl surveys. The fish samples were dominated by gobies (*Gobiidae* species), solenette and gadoides (*Gadidae* species), while squid and queen scallops were the most abundant invertebrates sampled. The community was dominated by gobies, lesser weever, common dragonet and solenette. Although the community remained broadly comparable across years, a reduction in whiting was apparent between pre- and post-construction surveys. Conversely, juvenile gadoids, and the two-spotted cling fish (*Diplecogaster bimaculata*) appeared to have increased in abundance during post-construction.

8.6.17 A total of nine species of conservation interest have been recorded during the Rampion 1 offshore wind farm pre- and post-construction (year 1) beam trawl monitoring surveys. This included the short-snouted seahorse, which was noted in three separate trawl samples during the autumn post-construction survey but did not occur during the 2015/2016 pre-construction survey (OEL, 2020a. However, four short-snouted seahorses were recorded during the characterisation 2m scientific beam trawl 2011/2012 surveys at Rampion 1 offshore wind farm (RSK Environmental Limited, 2012). Two species deemed as non-native and invasive were also sampled including the American-slipper limpet (*Crepidula fornicata*), and the leathery sea squirt (*Styela clava*).

8.6.18 Significant changes were observed in the abundance of fish and shellfish between pre- and post-construction surveys, seasons, and treatment areas. Variations in the relative abundance of pouting (*Trisopterus luscus*), lesser spotted dogfish, seabass, scallop, and squid drove the observed differences between construction period, season, and treatment areas. This trend corresponds to previous studies which have associated offshore wind farms and the introduction of artificial hard substrata with increased fish abundance, particularly of pouting and lesser spotted dogfish (Wilhelmsson *et al*., 2006, Reubens *et al*., 2013, Griffin *et al*., 2016), as observed in these surveys. A higher abundance of black seabream, characterised the fish community during post-construction when compared to pre-construction surveys. Similarly, the population of undulate ray increased between pre- and post-construction surveys, as well as the abundance of other elasmobranchs including lesser spotted dogfish and thornback ray.

8.6.19 However, these changes were either reflected in reference area stations (control areas taken outwith the Rampion 1 offshore wind farm area), where no impact from Rampion 1 was expected or were in line with expected natural variability. Additionally, significant differences in the fish and shellfish communities were also found between the pre-construction survey and EIA characterisation, both carried out prior to construction of Rampion 1 offshore wind farm. This implies that naturally occurring temporal changes are to be expected and the observed changes in the composition and abundance of fish and shellfish communities with the English Channel can likely be attributed to natural variability rather than an effect of the operational Rampion 1 offshore wind farm.

8.6.20 Results from this first post-construction surveys indicate that no significant reduction in the abundance of commercially important fish species, elasmobranchs, or black seabream was observed due to the construction and operation of Rampion 1 offshore wind farm. Additionally, a number of species of conservation interest were sampled during the surveys across Rampion 1 offshore wind farm including the short-snouted seahorse and several commercial fish species of protected status under various national and international legislations.

Spawning and nursery grounds

8.6.21 Many species of fish and shellfish are known to either spawn or have nursery areas in relatively close proximity to, or potentially overlapping with the PEIR Assessment Boundary. Information on spawning and nursery grounds is based on data from Coull *et al*. (1998) and supported by data sources from Ellis *et al*. (2010; 2012). Nursery and spawning habitats within the PEIR Assessment Boundary fish and shellfish ecology study area were categorised by Ellis *et al*. (2012) as either high or low intensity, dependant on the level of spawning activity or abundance of juveniles recorded within these habitats. Coull *et al*. (1998) does not provide this level of detail but has been used for species where spawning activity data is scarce.

8.6.22 The Proposed Development lies within spawning grounds for lemon sole, grounds for which stretch widely across the eastern English Channel (**Figure 8-2, Volume 3**). Spawning grounds for plaice cross the PEIR Assessment Boundary array area and extend across the eastern English Channel **(Figure 8-3, Volume 3**). Whiting spawning grounds also clip the eastern extent of the study area, with areas of spawning activity present across the English Channel and into the southern North Sea (**Figure 8-4, Volume 3**).

8.6.23 In a wider context, the study area for the PEIR Assessment Boundary, has a spatially limited interaction with a small portion of the overall spawning sites for sprat, cod, Dover sole, lemon sole, plaice, whiting, herring and sandeel. With Ellis *et al*. (2010) data recording low intensity spawning grounds for sandeel, cod and plaice, with high intensity spawning grounds for Dover sole. Black seabream are also known to spawn in the eastern English Channel; spawning occurs in inshore areas where suitable substratum occurs. The nearest black seabream spawning ground to the PEIR Assessment Boundary lies along the 10m depth contour between Bognor and Worthing, and within the Kingmere MCZ.

8.6.24 Potential spawning grounds for herring and sandeel are considered in further detail in **paragraph 8.6.30** to **paragraph 8.6.32** (herring) and in **paragraph 8.6.33** to **paragraph 8.6.36** (sandeel).

8.6.25 Nursery grounds for lemon sole overlap the proposed offshore export cable corridor and array area, extending across the eastern English Channel and along most UK coastlines (**Figure 8-6, Volume 3**). Nursery grounds for whiting occur across the majority of the study area in the nearshore, and follow most of the UK coastlines, and cover most of the North Sea (**Figure 8-5, Volume 3**). Nursery areas for sandeel and mackerel both clip the eastern extent of the study area, approximately 12km, and 1.8km from the PEIR Assessment Boundary array area respectively (see Coull *et al.,* 1998 data; **Figure 8-6, Volume 3**).

8.6.26 Nursery grounds for both thornback ray and undulate ray also cross the offshore export cable corridor and the array area, with both nursery grounds also extending along much of the Sussex coastline **(Figure 8-5, Volume 3**). Thornback ray are one of the most dominant ray species within the English Channel (Ellis *et al.*, 2005). They migrate to inshore waters to breed and lay eggs on the seabed with spawning occurs between February and September (Fowler and Cavanagh, 2005) with a peak in May and June. Spawning data on thornback ray are insufficient, although should broadly overlap with nursery grounds (Cefas, 2010a). It can therefore be assumed that both spawning and nursery grounds are reported to overlap the PEIR Assessment Boundary fish and shellfish study area in low intensity (Ellis *et al.*, 2012). Martin *et al.* (2012) found low densities of juvenile thornback ray in inshore areas of the English Channel, where sediments comprised of mud, sand and gravel however noted thornback rays prefer habitat is gravel and pebbled sediments, which occur within the central part of the channel. A historical study in the North Sea noted similar habitat preference (Sguotti *et al.*, 2016). The undulate ray is commonly encountered in the Channel from the Channel Islands to the Solent and coast of Sussex with nursery grounds identified in these areas (Ellis *et al.*, 2012). Ellis *et al.* (2012) suggests that due to the lack of data on spawning grounds that they may broadly overlap nursery grounds. Coelho and Erzini (2006) reported that undulate ray may spawn in the winter on sandy or muddy flats. Juvenile undulate ray tended to occur in the coastal fringe of the

English Channel, with the Channel Islands the site of the most regular occurrence of juveniles (Cefas, 2010a). Martin *et al.* (2012) noted suitable habitat in both inshore and offshore regions, with undulate ray being similar to thornback ray in recorded preference for gravel and pebbled sediment habitats.

8.6.27 The key sensitive receptors with spawning or nursery grounds in the fish and shellfish study area comprise of sandeel, herring, cod, black seabream, Dover sole, plaice, undulate ray and thornback ray; these species have been taken through for further consideration in the fish and shellfish assessment (see **Table 8-6** for the key receptors scoped in for each potential impact). Black seabream are considered sensitive to increased SSC and subsequent sediment deposition due to the demersal nature of their spawning behaviours, as well as spawning habitat loss. Herring, although a species that displays substrate dependant spawning behaviours, is not considered a concern in relation to potential impacts to spawning grounds due to the limited extent of potential impacts arising from the Proposed Development and the separation distance of grounds from the PEIR Assessment Boundary (the nearest herring spawning ground to the Proposed Development is 34.2km) (**Figure 8-7, Volume 3**). Whilst sandeel also display demersal spawning behaviours, they are not considered sensitive to the effects of increased SSC and deposition; specifically, the regional assessment for sandeels concluded that the effects of smothering of individuals through deposition from sediment plumes and sediment mobilisation will not result in significant effects in the Regional Cumulative Impact Assessments for sandeel (MarineSpace Ltd *et al.*, 2013a).

8.6.28 In accordance with the Popper *et al.* (2014) noise sensitivity classifications for fish species, the following species with spawning grounds sandeel, herring, cod and black seabream, are all considered to be noise sensitive receptors for underwater noise impacts and will therefore be screened into the Proposed Development fish and shellfish underwater noise assessment (see **Table 8-6** for key receptors scoped in). Although herring spawning grounds are located beyond the PEIR Assessment Boundary fish and shellfish study area, herring are screened in on a precautionary basis as informed by the underwater noise propagation modelling.

Potential herring and sandeel habitats

Overview

8.6.29 The PEIR Assessment Boundary fish and shellfish ecology study area and associated ZOI are considered to be of low importance for herring (the determining receptor with regards noise sensitivity and the associated ZOI for consideration of underwater noise impacts on fish generally) on the basis of existing information. It is, however, relevant to consider whether there is the potential for herring spawning to occur in the future, or for the area to be of importance in the future. Sandeel and herring are of particular relevance when considering impacts to spawning areas as they are demersal spawners. As demersal spawners, herring and sandeel lay demersal eggs. As such, they have specific requirements in terms of spawning grounds, with seabed sediment being the primary determinant (Maravelias *et al*., 2000).

Herring

8.6.30 As well as being a UK BAP priority species, herring are important ecologically and form an important component of the diets of larger predators such as other fish, birds and marine mammals. Coull *et al.* (1998) identified two spawning areas in the eastern English Channel; one in French waters (Baie de Seine) and one due south of the Sussex coast. Herring stock in the eastern Channel and southern North Sea is known as the Downs stock (Vause and Clark, 2011). This large herring spawning ground lies 34.2km offshore of the fish and shellfish study area, in the eastern English Channel. Although Coull *et al.* (1998) cites spawning to occur from November to February, an extensive literature review by Orr (2013), suggests spawning occurs in December and January only. Herring are reported to spawn on well-oxygenated gravel and sandy gravel with little fine material (Ellis *et al.*, 2012). The International Herring Larvae Survey ('IHLS') (1967-2020) identifies that herring are present in the fourth quarter of the year in ICES rectangle 30E9 but not at high densities.

8.6.31 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). Atlantic herring spawning beds are typically discrete, 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 a wide area of suitable seabed spawning habitat at a regional scale (for example spawning grounds (MarineSpace *et al.*, 2013a)). Eggs are laid on the seabed, usually in water 10-80m deep, in areas of gravel, or similar coarse habitats (for example coarse sand, shell and maerl), with well-oxygenated waters (Aneer, 1989; Bowers, 1980; de Groot, 1980; Ellis *et al.*, 2012; Rakine, 1986; Stratoudakis *et al.*, 1998).

8.6.32 Herring spawning areas were identified using the IHLS dataset (ICES, 2007-2020), showing areas of high intensity spawning to the south-east of the PEIR Assessment Boundary fish and shellfish study area (**Figure 8-8, Volume 3**). The data largely reflect patterns shown by PSA data (data from EUNIS and Folk, 1954; Stephens and Diesing, 2015; UKSeaMap, 2018) and the predicted habitat model as developed by Ocean Ecology Limited (OEL, 2020). The PSA data were processed according to the methodologies described in Reach *et al.* (2013), which allowed the classification of 'preferred', 'marginal' and 'unsuitable' herring habitats in the fish and shellfish ecology study area (**Figure 8-10, Volume 3**). Whilst preferred habitat is illustrated in **Figure 8-10, Volume 3**, there is no evidence of herring spawning in the area. Data of high confidence is based on IHLS data overlaid with Coull *et al.* (1998) spawning, with sediment data assessed as low to medium confidence, as the BGS data may overrepresent the potential herring spawning grounds (MarineSpace Ltd *et al.*, 2013b).

Sandeel

8.6.33 A large low intensity sandeel spawning ground clips the eastern extent of the PEIR Assessment Boundary ZOI study area lying approximately 13km from the PEIR Assessment Boundary array area (see Coull *et al*., 1998 data; **Figure 8-3, Volume 3**), in a broader context the spawning ground also stretches across the eastern English Channel and much of the North Sea. Sandeels are highly abundant and a key prey species to larger fish, seabirds and marine mammals. Sandeels swim actively in the water column and are often associated with sandy substrates, into which they deposit their eggs and burrow into when threatened.

8.6.34 Sandeel also spawn in coarse sediments, though as their name suggests, their preferred spawning habitats are sandier than those of herring. Sandeel prefer habitats composed of sand to gravelly sand but will tolerate sandy gravels as a marginal spawning habitat. The PEIR Assessment Boundary is located within a low intensity sandeel spawning grounds identified across the English Channel (Ellis *et al*., 2010).

8.6.35 Sandeel are highly substrate specific (Wright *et al*., 2000); after an initial larval dispersal period, sandeel display a degree of site fidelity (Jensen *et al*., 2011) so their settled distribution reflects the distribution of preferred habitat. Sandeel rarely occur in sediments where the silt content (particle size <0.63μm) is greater than four percent, and they are absent in substrates with a silt content greater than 10 percent (Holland *et al*., 2005, Wright *et al*., 2000).

8.6.36 Potential sandeel habitats were mapped using PSA data (using data from EUNIS and Folk, 1954; Stephens and Diesing, 2015; UKSeaMap, 2018) and the predicted habitat model as developed by OEL (2020), which were processed according to the methodologies described by Latto *et al*. (2013). This analysis allowed for identification of 'preferred', 'marginal' and 'unsuitable' sandeel habitat in the PEIR Assessment Boundary fish and shellfish ecology study area (**Figure 8-9, Volume 3**).

Species of commercial importance

Overview

8.6.37 Detailed information on species of commercial importance is provided in **Chapter 10** aspect of the PEIR. On a regional basis, whelk, Dover sole, horse mackerel, sea bass, European lobster, scallop, cuttlefish and brown crab are noted as comprising species of commercial importance to the region.

8.6.38 Of these species, whelk, brown crab, European lobster, and scallop are considered to be characterising shellfish receptors in relation to the Proposed Development. These species have therefore been screened in on the basis of commercial importance. Cuttlefish are also considered to have the potential to be sensitive to noise impacts from percussive piling. These species will therefore be taken forward into the fish and shellfish assessment, with the following sub-sections describing the species of commercial importance that occur within the study area.

Fish

8.6.39 Sea bass are of high value for both commercial and recreational fishing. Sea bass are found around the UK and are often associated with seabed features such as reefs. They spawn directly into the water column and have nursery areas in estuaries and natural harbours, which can be designated and protected from fishing activity under The Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1999. The nearest designated bass nursery to the development area is in Chichester harbour approximately 26km west of the Proposed Development.

8.6.40 Similarly, Dover sole are recognised as a high value commercial species. Sole are usually found on sandy and muddy seabeds and estuarine waters; distribution within the ZOI is therefore considered to be lower than in other key spawning areas such as the Thames estuary. Within the region Dover sole are subject to IFCA byelaws for minimum landing size but are not currently subject to any specific fisheries measures.

8.6.41 Horse mackerel have a comparatively lower commercial value within the region, however it has been recognised in recent years that large ‘super trawlers’ can on occasion target species such as horse mackerel and sprat within the region. The Sussex IFCA, in an attempt to manage horse mackerel and other pelagic species, have sought to prohibit the use of pair trawling within the nearshore (6nm) but horse mackerel are not subject to any species-specific management measures, or measures in the area beyond the 6nm.

Shellfish

8.6.42 Brown crab can inhabit a variety of habitats, from the rocky intertidal to deeper shelf waters as adults. While both sexes can be found under boulders, some research suggests males prefer rocky habitat with females more abundant on sand and gravel. Mating occurs inshore in spring. Females initially store sperm, before moving offshore in late summer where the eggs are fertilized. The females then remain largely stationary (often buried in sediment) through the winter, incubating their eggs. In late spring, the larvae are released, which settle onto the seabed after two months in the plankton. Juveniles remain in shallow intertidal waters for around three years, before moving into deeper water (Vause and Clarke, 2011). Brown crab are also a commercial important species with an annual average landing weight of 2.4 tonnes (between 2015 to 2019) from ICES rectangle 30E9 (MMO, 2020).

8.6.43 Lobsters inhabit holes and crevices in or under rocks and artificial structures. Rocky substrates are abundant in ICES rectangle 30E9 (Sussex IFCA, 2020), this is reflected in commercial landings with some of the highest landings for lobster occurring in this rectangle between 2015 to 2019 (MMO, 2020). Studies have shown lobsters are largely sedentary and do not undertake significant migrations. Lobster breed in the summer, and berried females release planktonic larvae in the following spring, which settle to the seabed after about 3 weeks (Vause and Clarke, 2011).

8.6.44 Sussex IFCA (2020) identified the greatest fishing effort for lobster and brown crab occurred between Chichester harbour to Littlehampton and Shoreham to Eastbourne.

Molluscs

8.6.45 Gastropods include the commercially harvested whelk and a number of smaller species. Whelks are an important commercial species with some of the highest landings within the inshore rectangle 30E9 between 2015 to 2019 (MMO, 2020). Whelk potting is one of the most valuable fisheries in Sussex, with fishing effort occurring between Chichester Harbour and Shoreham and Newhaven and Hastings (Sussex IFCA, 2020). Whelks are occasionally found intertidally but are mainly subtidal and prefer muddy sand, gravel and rock. They lay masses of egg capsules which are attached to solid substrates such as rocks, seaweed or seagrass (Ager, 2008) from around November to April; the young do not have a planktonic phase and emerge as fully formed whelks in February and March (Vause and Clarke, 2011).

8.6.46 Commercial bivalve species include those that are attached to the seabed when adult (such as blue mussel (*Mytilus edulis*) and the European native oyster), or with limited mobility (using a predator-avoidance 'swimming'), such as the king scallop and queen scallop. All of these bivalve species spawn directly into the water column, with planktonic larvae. King scallop spawn in the spring (April/May), and possibly also in the autumn (late August). King scallop larvae settle to the seabed within about one month and attach themselves to the seabed until they are around 4-13 mm in length, after which they settle on the seabed (Vause and Clarke, 2011). The average annual landing weight for scallops within ICES rectangle 30E9 is 3.6tonnes between 2015 to 2019 (MMO, 2020).

8.6.47 Cephalopods in the study area include the highly mobile cuttlefish, which is regularly commercially exploited off Sussex. Cuttlefish spawn directly onto the seabed with adhesive eggs and spend the winter in the western English Channel, and move into shallow Sussex waters to breed, laying eggs from February to May (peaking from mid-April to mid-May) (Vause and Clarke, 2011). The eggs hatch after approximately three months and juveniles are thought to remain in shallow waters until around October when they move offshore. After the first winter, juvenile cuttlefish again move inshore (spring to autumn), before another winter offshore, after which they are fully mature; in the following spring they return inshore, breed, and die (Vause and Clarke, 2011; Sussex IFCA, 2020). The English Channel cuttlefish stock is the most commercially important cephalopod stock exploited in the Northeast Atlantic (Pierce *et al.*, 2010). The fishing effort for cuttlefish in Sussex from 2015 to 2019 occurred between Pagham to Shoreham and Eastbourne to Hastings (Sussex IFCA, 2020). The MMO (2020) recorded an average annual landing weight of two tonnes for ICES rectangle 30E9.

Species of conservation importance

Overview

8.6.48 The following species of conservation importance are considered to be sensitive receptors to the Proposed Development. Priority Species within the UK BAP include elasmobranch species that have the potential to occur within the PEIR Assessment Boundary fish and shellfish ecology study area. These include undulate ray, spurdog, porbeagle shark, shortfin mako, basking shark, tope and blue shark.

8.6.49 Other species of conservation importance that have the potential to occur in the PEIR Assessment Boundary fish and shellfish ecology study area include, black seabream, European smelt, sea trout, European eel, allis shad and twaite shad. In UK waters both the short-snouted and spiny seahorses are of conservation importance and have been recorded in the English Channel.

8.6.50 Several species of conservation importance have been recorded on occasion within the eastern English Channel region. There are records of several marine and estuarine species protected under national, European and international legislation.

8.6.51 A review was undertaken to identify designated sites in the study area which are either designated for fish and shellfish interest or habitats/species which are dependent on or associated with fish or shellfish (**Figure 8-11** and **Figure 8-12, Volume 3**). The sites are presented in **Table 8-9** Marine nature conservation designations with relevance to fish and shellfish ecology.

8.6.52 below.

8.6.53 It should be noted that National and International designated sites are covered in more detail within **Chapter 14** and the **Draft Report to Inform Appropriate Assessment (RIAA) (RED, 2021)**. On account of the presence of nature conservation designations within the study area, and the potential presence of features of interest of which the sites are designated for short-snouted seahorse, European native oyster, blue mussel beds and black seabream have been taken into consideration in the fish and shellfish assessment. The method statement in relation to fish and shellfish ecology, was submitted to stakeholders (23 December 2020) and agreed through the EIA EPP, and the inclusion of the following nature conservation designations have been incorporated into the PEIR.

Table 8-9 Marine nature conservation designations with relevance to fish and shellfish ecology.

Designated site	Location relevant to PEIR Assessment Boundary	Features or description
Kingmere MCZ	Lies adjacent to the eastern boundary of the offshore export cable corridor	Nesting black seabream are a protected feature of this MCZ.
Selsey Bill and the Hounds MCZ	10km west of the offshore export cable corridor	Short-snouted seahorse are a protected feature of this MCZ.
Beachy Head West MCZ	13km north-east of the array	Short-snouted seahorse, European native oyster and blue mussel beds are protected features of this MCZ.
Bembridge MCZ	20.4km west of the array (overlaps with underwater noise assessment)	Short-snouted seahorse, European native oyster and stalked jellyfish (*Calvadosia campanulate*, *Haliclystus* species) are protected features of this MCZ
Beachy Head East MCZ	21.3km north-east of the array (overlaps with underwater noise assessment)	Short-snouted seahorse are a protected feature of this MCZ.

Solent and Dorset Coast SPA	1km west of the offshore export cable corridor	Designated for common tern, sandwich tern and little tern of which sandeel are a key prey species.

8.6.54 The following sections describe the species of conservation importance occurring generally within the study area, and specifically in the context of the regional designated sites. Sandeel have been previously described within the baseline and that information is not therefore repeated here.

Elasmobranchs

8.6.55 Elasmobranch species that have been included as 'Priority Species' on the UK Biodiversity Action Plan (UK BAP) that have the potential to occur within the PEIR Assessment Boundary fish and shellfish study area include undulate ray, spurdog, porbeagle shark, shortfin mako, basking shark, tope and blue shark.

8.6.56 Elasmobranchs are cartilaginous fish including sharks, skates and rays that reproduce either by laying eggs on the seabed (dogfish and rays) or giving birth to live young (spurdog; tope). Elasmobranchs are also notable in that they have a highly developed ability to detect EMFs, which they use in hunting prey.

8.6.57 Using data collected from Cefas groundfish surveys, Ellis *et al.* (2005) noted twelve demersal elasmobranch species were recorded from beam trawl surveys within the eastern English Channel. Undulate ray were primarily caught within the English Channel, with juveniles dominating the catches. Species commonly found in the study area include thornback ray, undulate ray, tope, spurdog.

8.6.58 Larger, highly mobile shark species, including porbeagle, shortfin mako, tope and blue shark may also occur within the fish and shellfish study area. A study by Sguotti *et al*. (2016) of historical surveys between 1902 and 2013 found tope and spurdog to be the predominant demersal shark species. Spurdog were the most common (recorded in 13.3 percent of the hauls) followed by tope (recorded in 4.2 percent of the hauls) in the early hauls, however both species numbers were declining in hauls following the 1970s. Between 2010 and 2013 spurdog were recorded in only 2.2 percent of hauls. Overall distributions of tope and spurdog were associated with either fishing pressure within the North Sea or an increase in sea surface temperature within the region resulted in distribution changes. The preferred habitat of tope was recorded as regions of gravel and pebbled sediment within the English Channel (Martin *et al*., 2012). Sguotti *et al*. (2016) recorded a depth preference of <50m, however the study did not identify a habitat preference for tope. The same study identified a change in depth preference for spurdog with the species more associated with cooler deeper waters.

8.6.59 Around the UK in the summer months, basking shark can often be observed near the surface although the English Channel is not throughout to be an important area for this species.

Teleost

8.6.60 Teleosts of conservation importance that have the potential to occur within fish and shellfish study area include seahorse, black seabream (see **paragraph 8.6.73** to **paragraph 8.6.84** for further details) sea trout, European eel, European smelt, allis shad and twaite shad (see **paragraph 8.6.65** to **paragraph 8.6.72**). Of these species, black seabream was recorded in high numbers in pre-construction and post-construction otter trawl surveys conducted to inform the Rampion 1 offshore wind farm baseline and potential impact following construction, and is a feature of conservation importance for the Kingmere MCZ.

Seahorse

8.6.61 Both short-snouted and spiny seahorses are of conservation importance in UK waters. The species have been recorded in the English Channel, with the study area also being a potential overwintering area for both seahorse species. 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). Research suggests that seahorses are present in shallower waters during summer months for breeding and migrate to deeper water during winter months (usually around October to April) to avoid storms (The Seahorse Trust, 2013). During the breading season (spring to autumn) male seahorse can be pregnant on average five times within a single breeding season, with each pregnancy lasting around a month (Garrick-Maidment, 2011).

8.6.62 Globally ecological data on seahorses is lacking, due to their apparent patchy distribution and low density, as well as their cryptic nature (Foster and Vincent, 2004; Garrick-Maidment *et al.,* 2010). A study by Garrick-Maidment *et al.* (2010) found an average home range for seahorse of approximately 167m^2. This range is considerably larger than previous studies with Foster and Vincent (2004) noting smaller home ranges of 7.8m^2 for short-snouted seahorse and 12.1m^2 for spiny/long-snouted seahorse). A further study on the spiny/long-snouted seahorse in Portugal by Curtis and Vincent (2006) found a broadly similar mean home range of 19.9m^2 during breeding seasons.

8.6.63 Both spiny and short-snouted seahorses are known to frequent the south coast of England; however, they do not appear in any commercial landings data. Four short-snouted seahorses were recorded during surveys at Rampion offshore wind farm (RSK Environmental Limited, 2012) which confirms their presence in the wider area. With three short-snorted seahorses recorded during the post-construction survey (OEL, 2020a). Several short-snorted seahorse observations have been recorded in the region of West and East Sussex and the Isle of Wight by Seasearch, Sussex IFCA, Marine Biological Society, the most recent of which was a single observation at Brighton Marina in July 2020 (National Biodiversity Network Atlas, 2021a). Observations of spiny seahorse are limited in the region with a single spiny seahorse observation recorded near Brighton by Seasearch in 2019 (National Biodiversity Network Atlas, 2021b) As well as several unverified records submitted by the public from stranding and captures in the area (British Marine Life Study Society, 2020). The Bembridge MCZ and Selsey Bill and the Hounds MCZs are located at approximately 20.4km and 10km of the Proposed Development, respectively. Both of these sites are designated for short-snouted seahorses (see **Table 8-9**Marine nature conservation designations with relevance to fish and shellfish ecology.

8.6.64 above).

Migratory species

8.6.65 Migratory species are diadromous fish that spend part of their life cycle in freshwater and part in seawater. Fish which spawn in freshwater and feed at sea are anadromous and include salmon and sea trout. Fish which spawn at sea and feed in freshwater are catadromous, such as the European eel.

8.6.66 A number of migratory fish species have the potential to occur in the Rampion 2 PEIR Assessment Boundary fish and shellfish study area, migrating to and from rivers and other freshwater bodies in the area which these species use either for spawning habitat (for example sea lamprey, twaite shad, allis shad, Atlantic salmon and sea trout), or growth and development to the adult phase with spawning occurring at sea (for instance European eel).

8.6.67 European eels are likely to occur within the intertidal and subtidal environments of the fish and shellfish ecology study area. They are catadromous fish that spawns in the Sargasso Sea, returning to rivers to mature (Schmidt, 1923; Miller *et al.,* 2015). Adult eels descend to the sea around September for spawning, while young eels (elvers) return to ascend rivers in April/May. This species is of conservation importance and has been identified as present within channel sites at Medmerry during the small fish surveys (Sussex IFCA, 2018). Eels are known to be present in the rivers Arun (Environment Agency, 2013), Adur and Ouse, which are located within the fish and shellfish search area (European Agency, 2007).

8.6.68 The European smelt is a migratory species typically found inshore and in estuaries, which moves into rivers between February and April to spawn (Barnes, 2008). It is generally found on the east coast of the UK and western Scotland (Barnes, 2008) and rarely found far from the shore (English Nature, 2003). Although shoals have been seen off the Sussex coast, records in the Ouse and Adur are not known (English Nature, 2003) and their population status in the area requires further research (English Nature, 2003; Cefas, 2010a).

8.6.69 Salmonids such as salmon and sea trout are anadromous fish, which spend much of their life at sea but ascend rivers in summer to spawn on gravel beds in winter. While salmon and sea trout are not generally captured in great numbers in commercial landings, the location of the River Itchen SAC (designated for salmon) suggest this species may be in proximity to the PEIR Assessment Boundary during their migration (adult and smolt) to and from this river, though it is noted that the migratory route to the River Itchen is considered to be from the west, and therefore unlikely to interact with the construction of the Proposed Development. Sea trout are known to spawn in rivers (including Arun, Adur and Ouse) that discharge into the sea in the fish and shellfish study area, again following a westerly migration from Atlantic waters.

8.6.70 Shad (*Alosa* species) are members of the herring family, which ascend rivers to spawn, using the coastal shelf for nursery grounds and migration, are known to be present in the marine environment off the coast of Sussex; however, it is not known how these populations relate to rivers in the region (RSK Environmental

Limited, 2012). Landing data obtained from the MMO (2020) for fish caught in areas surrounding PEIR Assessment Boundary show some of the highest landings by weight for the inshore ICES rectangle 30E9 (average of 0.04 tonnes between 2015 to 2019 landings). Surveys for the operational Rampion 1 offshore wind farm, confirm the presence of both the allis shad and twaite shad, where one specimen of each was captured (RSK Environmental Limited, 2012).

8.6.71 Sea lamprey are a migratory species with adults travelling upstream into rivers to spawn in May or June on stony or gravely riverbed (Maitland, 2003). Following hatching lamprey will remain within the nursery area of the river for several years before metamorphosis into an adult, at which point they will then migrate downstream. Sea lamprey are rarely observed in UK coastal waters, estuaries and accessible rivers, with poor water quality considered a factor (JNCC, 2019). However, sea lamprey have been recorded within the River Arun catchment (Environment Agency, 2013), although very little is known about them after they have migrated to the sea (Maitland, 2003).

8.6.72 On account of the conservation importance of these species to the region, all species listed above are considered to be sensitive receptors to the Proposed Development, and therefore potential impacts to these species from the Proposed Development have been taken into consideration in the Rampion 2 PEIR Assessment Boundary fish and shellfish ecology assessment. The potential likely significant effects on black seabream as a designated feature of the Kingmere MCZ have been considered within the EIA, in the context of the EIA Regulations 2017, and in the **Chapter 14** and **Appendix 14.1, Volume 4** which accompanies the PEIR.

Black seabream

8.6.73 Whilst not forming a species of conservation importance, black seabream are recognised as a significant interest to commercial and recreational fishers with spawning grounds within the region that are considered important within regional Marine Plan Policies and Kingmere MCZ being designated in part to protect areas of spawning importance. The stock which occupies the English Channel overwinters in water depths of between 50 to 100m, prior to migrating inshore to breed between May and June in suitable habitats (Vause and Clark, 2011). Black seabream are known to nest in areas around the south coast of the UK with extensive nesting grounds off the West Sussex coast to the Isle of Wight and Dorset (Collins and Mallinson, 2012; EMU Limited, 2009; Southern IFCA, 2014). Black seabream specific studies identified black seabream nest areas off the coast of Littlehampton to Bogner Regis (EMU Limited, 2009), to Shoreham harbour in the east and to the north of Kingmere MCZ (EMU Limited, 2012a).

8.6.74 Historical analysis of black seabream monitoring data identified black seabream nesting areas tend to correspond to shallow waters (<10m) with thin layers of coarse sediments (10 to 30cm deep) overlying bedrock within the general vicinity of rocky outcrops (GoBe, 2015). BGS data identified areas of chalk beds within the intertidal area of the offshore export cable corridor and within the north-eastern tip of the array area (see **Figure 8-13, Volume 3**).

8.6.75 Black seabream arrive on the south coast in early spring and construct nests on the seafloor into which eggs are laid. Preferred spawning substrates are open gravel areas, gravel areas adjacent to chalk reefs, sandstone reefs and ships wreckage (Vause and Clark, 2011; Southern Science, 1995). A study by James *et al.* (2011) detailed the presence of underwater chalk features in the central and eastern English Channel. After fertilizing the eggs, males remain in close proximity to the nests protecting them from predators and keeping them clean from excessive siltation. After hatching, juveniles remain in the vicinity of the nests until they reach a length of 7 to 8cm, they then remain in the inshore area for a further two to three years (Vause and Clark, 2011). It is expected that the bream exhibit site fidelity, perhaps returning to the same sites to spawn annually (James *et al.,* 2011, Sussex IFCA, 2018).

8.6.76 The broader nearshore area, both within the proposed offshore export cable corridor and outwith the PEIR Assessment Boundary, is of noted importance for black seabream, with a significant body of evidence compiled by the marine aggregate industry (via the MALSF and site-specific monitoring) contributing to the understanding of black seabream spawning within the area. Black seabream is a designated feature of the Kingmere MCZ which lies to the north of the PEIR Assessment Boundary array area off the coast of Worthing, and adjacent to the offshore export cable corridor PEIR Assessment Boundary. Further afield, angling records note regular catches of black seabream along the coast of the English Channel from Eastbourne in the East, through to Devon and Alderney in the West, inclusive of inshore areas such as Kingmere Rocks and Swanage Bay, and mid-channel wrecks. Despite this range it is recognised that the core area for black seabream nesting appears to be from Shoreham harbour through to Swanage Bay.

8.6.77 During the period 2002 onwards site-specific studies have been undertaken to inform the characterisation and monitoring of predicted effects for a cluster of marine aggregate dredging sites (Licence Areas 453, 488, 396 and 435) in close proximity to the PEIR Assessment Boundary proposed offshore export cable corridor. The data have been collected specifically to understand the potential changes associated with aggregate extraction at Area 435 and 396 (for which seasonal restrictions were not required), and the characterisation and monitoring of impacts associated with the extraction at Area 453 and 488 (for which a seasonal restriction on activities was required for the period April to June inclusive). The following sections provide a summary of the conclusions drawn from the data, commencing with the most recent datasets which provide an overview of activities undertaken since designation of the Kingmere MCZ (within which 453 and 488 are located) and commencement of extraction in 2017.

8.6.78 Geophysical and DDV surveys were conducted by ABPmer between May and July 2020 for Tarmac Marine Ltd and CEMEX Marine Ltd, in relation to aggregate Areas 453 and 488. These surveys were to determine whether there had been any changes in black seabream nest density and distribution at the seven survey sites, since previous surveys in 2019, 2017 and during the period 2002 to 2013. In addition, two transect sites were surveyed to determine any changes in black seabream nest activity compared to previous surveys in 2019 and 2017 (note that data for the two additional (2017 and 2019) transect areas was not available in preceding years for comparison). Following the geophysical survey, and in line with previous surveys used to characterise the MCZ, black seabream nests were characterised into three distinct groups (dense nests, less dense nests and small patches of nests).

8.6.79 The comparisons within the 2020 report, appear to show an increase in black seabream nests within the majority of the study area, with the additional 2020 transects showing an increase in nest density in comparison to both 2019 and 2017 data (ABPmer, 2020a). DDV data were collected to ground truth the geophysical survey data. The video and photographic data from the DDV surveys were assessed for the distribution and abundance of black seabream nests, the presence of black seabream eggs during the spawning season, and to determine the seasonal extent of black seabream spawning (known breeding season in 2020 was April to June, this has since been updated in 2021 to reflect a breeding season between March to July (Natural England, 2021)). On 02 June 2020, 272 black seabream nests were identified, with 172 nests recorded on 30 July 2020 using high-resolution video and stills photography within seven monitoring areas, two within the PEIR Assessment Boundary offshore export cable corridor (survey Area 1 and 2) and five within the Kingmere MCZ, as well as two transect areas located within the Kingmere MCZ (ABPmer, 2020b).

8.6.80 Survey Area 1 and Area 2 are located within the Rampion 2 PEIR Assessment Boundary offshore export cable corridor. The 2020 data identified a small area of dense nests in the east of Survey Area 1; however, the area of nests appears to have decreased in size since 2019 (ABPmer, 2020b). Nest were present within areas of exposed chalk bedrock, with nest distribution running north and east of the rocky outcrop. Dense black seabream nests were observed across Survey Area 2 (which lies closest to the western extent of Kingmere MCZ), being located north of the rocky outcrops and extending across the full width of the survey area (ABPmer, 2020b). To the south, two further areas of 'dense nests' were recorded as well as narrow bands of less dense/patchy nests. Dense black seabream nests were recorded in areas containing exposed chalk bedrock features. It is notable that both the spatial extent and density of nests appear to have increased since the original 2002 survey (ABPmer, 2020b).

8.6.81 When considered in the context of previous studies these data demonstrate that whilst the region is of importance to black seabream nesting, the core areas of higher nesting density are spatially discrete, with limited areas of nesting apparent within the export cable corridor when reviewed in the context of the available data, inclusive of angling catch and release data.

8.6.82 As noted previously during the period 2002 to 2013 a number of monitoring studies were undertaken in compliance with the marine licence conditions for regional marine aggregates areas, and in support of the now licenced marine aggregate extraction areas 453 and 488. The areas surveyed focus primarily on discrete areas in and around Kingmere Rocks, and the subsequently designated Kingmere MCZ, with two areas (Area 1 and Area 2) corresponding with the eastern segment of the proposed export cable corridor adjacent to Kingmere MCZ (**Figure 8.14, Volume 3**). The monitoring confirms that nests exist to the west of the Kingmere MCZ, within a discrete section of the proposed offshore export cable corridor. During the period 2002 to 2013, and subsequently, in the period 2015 to 2020, there is a significant body of data available to confirm the distribution of black seabream nests during the critical spawning season. The data demonstrate that nests are present annually, within a discrete spatial area, within the offshore export cable corridor **(Figure 8.14, Volume 3**).Site specific data indicate that the area surveyed as part of the aggregate extraction monitoring is likely to represent a discrete area of sediment veneer that does not extend across the full export cable corridor, however for the purposes of this assessment consideration will be given to the risk of direct impacts occurring on areas of spawning potential.

8.6.83 Sussex IFCA catch and release black seabream data (**Figure 8.15, Volume 3**) illustrate higher site fidelity to areas within the Kingmere MCZ (in this context this is assumed as recapture points).The data further demonstrate that within the offshore export cable corridor itself nests are present in a discrete area to the east of the proposed export cable corridor, with bream captured in greater densities across Kingmere Rocks, and to the west of the proposed offshore export cable corridor PEIR Assessment Boundary, in addition to within the export cable corridor itself. The data appear to indicate capture of black seabream occur along a ridge feature with discrete areas of greatest focus – the Kingmere Rocks, an area within the proposed export cable corridor, and areas to the west of the proposed export cable corridor. **Figure 8.13, Volume 3** supports this assertion by illustrating the presence of thin veneer Quaternary sediments over a narrow band of sandstone and rock running broadly parallel to the coast in a west to east direction.

8.6.84 For the purposes of understanding potential effect-receptor pathways, these data provide appropriate information to inform the EIA and confirm that there is a risk of direct disturbance to areas of nesting and/or nesting potential that may not be avoidable.

Future baseline

8.6.85 From the point of assessment, over the course of the development and operational lifetime of the Proposed Development (operational lifetime anticipated to be approximately 30 years from first power), 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 the Proposed Development is not constructed, using available information and scientific knowledge of fish and shellfish ecology.

8.6.86 An assessment of the future baseline conditions in the absence of the Proposed Development has been carried out and is described within this section. The baseline environment is not static and will exhibit some degree of natural change over time, with or without the Proposed Development in place, due to naturally occurring cycles and processes. Therefore, when undertaking the impact assessment, it is necessary to place any potential impacts in the context of the envelope of change that might occur naturally over the timescale of the Proposed Development.

8.6.87 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 variation 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 activities such as climate change and overfishing.

8.6.88 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 ocean climate and plankton abundance, and bottom-up factors, such as predation. Fish and shellfish are important prey items for top marine predators including elasmobranchs, seabirds, cetaceans and humans, and small planktivorous species such as sandeel and herring act as important links between zooplankton and top predators (Frederiksen *et al*. 2006).

8.6.89 Climate change may influence fish distribution and abundance, affecting growth rates, recruitment, behaviour, survival and response to changes of other trophic levels. Over the past 30 years, warming has been most pronounced to the north of Scotland and in the North Sea, with sea-surface temperature increasing by up to 0.24°C per decade (MCCIP, 2020). Within the English Channel and the southern North Sea, increased sea surface temperatures may lead to an increase in the relative abundance of species associated with more southerly areas. For example, data on herring and sardine (*Sardina* sp.) landings at ports in the English Channel and the southern North Sea showed that higher herring landings were correlated with colder winters, while warm winters were associated with large catches of sardine (Alheit and Hagen, 1997). Studies have shown that anchovy (*Engraulis encrasicolus*) have extended their distribution throughout the North Sea, from which they were largely absent until the mid-1990s (Alheit *et al*. 2012) becoming more established within the English Channel. Moreover, a study on black seabream stocks within the English Channel found the mean annual frequency of occurrence of black seabream off Plymouth has increased with rising sea temperature between 1913 and 2003 (Arkley and Caslake, 2004). MCCIP (2020) suggest the warming of UK shelf seas is projected to continue over the coming century, with most models suggesting an increase of between 0.25°C and 0.4°C per decade. Warming is expected to be greatest in the English Channel and the North Sea, with smaller increases in the outer UK shelf regions (MCCIP, 2020).

8.6.90 A potential effect of increased sea surface temperatures is the distribution of some fish species will extend into deeper, colder waters. In these cases, however, habitat requirements are likely to play an important role, as some shallow water species will have specific habitat requirements found in shallow water areas which are not available in deeper areas. For example, due to the specific habitat requirements for coarse sandy sediment, sandeel are less likely to be able to adapt to increasing temperatures; 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 (Department for Business, Energy and Industrial Strategy (BEIS), 2016). For example, warming temperatures has led to earlier spawning for sole, with warming and associated oxygen solubility appears to be affecting the age at maturation, growth rates, and the maximum size fish can attain (MCCIP, 2020). However, climate change effects on marine fish populations are difficult to predict and the evidence is not easy to interpret, therefore it is difficult to make accurate estimations of the future baseline scenario for the entire lifetime of the Proposed Development (approximately 30 years).

8.6.91 In addition to climate change, overfishing subjects many fish species to considerable pressure, reducing the biomass of commercially valuable species, and non-target species (by-catch). 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). Conversely modelling by Beggs *et al*. (2013) indicated that cod may be more sensitive to climate variability during periods of low spawning stock biomass. There are indications that overfishing in UK waters is reducing to some degree, with declines in fishing mortality estimates in recent years for crustacean, demersal and benthic stock groups. ICES advice also suggests that some of the stocks (benthic and demersal) have shown signs of recovery since 2000. Similar, but less dramatic, changes are also evident for pelagic species (ICES, 2018). OSPAR's Quality Status Report (OSPAR, 2010) concluded that many fish stocks are still outside safe biological limits, although there have been some improvements in some stocks. Should these improvements continue, this may not result in significant changes in the species assemblage in the English Channel fish and shellfish study area, although may result in increased abundances of the characterising species present in the area.

8.6.92 The Proposed Development will offset greenhouse gas emissions and increase the security of electricity supply, thereby assisting with the delivery of Government policy and the meeting of renewable energy targets.

8.6.93 Therefore, the Proposed Development fish and shellfish baseline characterisation described in the preceding sections represents a 'snapshot' of the present fish and shellfish assemblages of the English Channel, within a gradual and continuously changing environment. Any changes that may occur during the lifetime of the Proposed Development (including construction, operation and maintenance and decommissioning) should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment, and the changes that would be expected to occur naturally in the absence of the Proposed Development.

8.7 Basis for PEIR assessment

Maximum design scenario

Overview

8.7.1 Assessing using a parameter-based design envelope approach means that the assessment considers a maximum design scenario whilst allowing the flexibility to make improvements in the future in ways that cannot be predicted at the time of submission of the DCO Application. The assessment of the maximum adverse scenario for each receptor establishes the maximum potential adverse impact and as a result impacts of greater adverse significance will not arise should any other development scenario (as described in **Chapter 4**) to that assessed within this Chapter be taken forward in the final scheme design.

8.7.2 The maximum assessment assumptions that have been identified to be relevant to fish and shellfish ecology are outlined in **Table 8-10** below and are in line with the Project Design Envelope (**Chapter 4**).

Table 8-10 Maximum assessment assumptions for impacts on fish and shellfish ecology.

Project phase and activity/impact	Maximum assessment assumptions	Justification
Construction		
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	**Maximum spatial design scenario:** Monopile WTG foundations 116 WTG foundations Up to 3 offshore substations Maximum hammer energy 4,400kJ 4-hour piling duration (24-hours) 2 monopiles per day 60 days piling. **Maximum temporal design scenario:** 116 WTGs on piled jacket foundations (3-4 legs per jacket, 3-4 piles per jacket) – 464 pin piles Up to 3 offshore substations (4-6 legs per jacket, up to 12 pins per jacket) – 36 pin piles Total of 500 pin piles in the array. Maximum hammer energy 2,500kJ 4 pin piles per day (24-hours) 125 piling days **Array and interconnector cable installation:** Number of interconnector cables: 2 Total interconnector cable length: 50km Total array cable length: 250km Total duration of cable installation: 12 months (2 x 6 months) **Export cable installation:** Where possible, the export cables will be buried below the seabed through to landfall (1.5m burial depth (maximum)) Total length of export cables: 4 x 19km Total duration of cable installation: 4 months. **WTG foundation installation:** 3 installation vessels (60 return trips) 10 support vessels (60 return trips) 6 transport vessels (40 return trips)	**Maximum spatial design scenario** The maximum spatial design scenario equates to the greatest effect from subsea noise at any one-time during piling. Piling fewer WTGs (75) 10m monopiles represents a greater spatial impact than a greater number (116) 10m monopiles. **Maximum temporal design scenario** The maximum temporal design scenario represents the longest duration of effects from subsea noise. This scenario assumes pin-pile foundations, which could result in a longer duration of piling per foundation.

Project phase and activity/impact	Maximum assessment assumptions	Justification
	6 crew transport vessels (500 return trips) **WTG installation** 2 installation vessels (40 return trips) 10 support vessels (100 return trips) 10 crew transport vessels (1,200 return trips). **Substation installation:** 3 installation vessels (12 return trips) 20 support vessels (12 return trips) 6 transport vessels (12 return trips) 6 crew transfer vessels (60 return trips). **Inter-array and interconnector cable installation:** 3 main cable laying vessels (12 return trips) 3 main burial vessels (6 return trips) 13 support vessels (300 return trips). **Offshore export cable installation:** 1 main laying vessel (6 return trips) 1 main cable joining vessel (6 return trips) 2 main cable burial vessels (6 return trips) 4 multicat-type vessels (16 return trips) 4 spoil barrages (128 return trips) 10 support vessels (60 return trips)	
Direct disturbance resulting from the installation of the export cable	**Offshore export cable installation** Total seabed disturbance = 2,015,000m^2 **Boulder clearance in the offshore export cable corridor:** Total clearance impact area - Pre-lay Plough = 1,900,000m^2 Total clearance impact area - subsea grab = 1,140,000m^2	The maximum adverse scenario for offshore export cable installation is defined by the largest area of disturbance as a result of installation and clearance of boulders within the offshore export cable area of search during construction.
Direct disturbance resulting from	**Interconnector cable installation**	The maximum adverse scenario for seabed

Project phase and activity/impact	Maximum assessment assumptions	Justification
construction within the array	Total seabed disturbance = 1,250,000m^2 **Array cable installation** Total seabed disturbance = 6,250,000m^2 **Boulder clearance in the array area:** Total clearance impact area - Pre-lay Plough for cables = 7,500,000m^2 Total clearance impact area - subsea grab for cables = 4,500,000m^2 Total clearance impact area - Foundations and Jack-up legs = 1,100,000m^2 **Sandwave clearance in the array area** Total sandwave clearance area = 1,375,000m^3 Total construction vessel anchorage footprint = 20,050m^2	preparation with the array area is defined by the largest area of disturbance as a result of installation and clearance of boulders within the array area during construction.
Temporary and localised increases in SSC and smothering	**Sandwave clearance** Total sandwave clearance volume in array area = 1,375,000m^3. **WTG foundations** Spoil volume per WTG foundation from drill arising (if drilling required due to pile driving refusal and assuming 10 m diameter 60 m embedment monopile) = 4,000m^3 Spoil volume per offshore substation foundation (jacket with pin piles foundations) from drilling arisings (if drilling required) = 12,000m^3 **Export cable installation** Burial spoil = 155,000m^3. Spoil from temporary floatation pits = 275,000m^3. **Interconnector cable installation** Burial spoil (jetting) = 100,000m^3 **Array cable installation** Burial spoil (ploughing) = 500,000m^3	The maximum adverse scenario for foundation installation results from largest volume suspended from seabed preparation (suction bucket jacket) or the largest volume suspended from potential drilling of foundations (monopiles) as these are mutually exclusive, both with the maximum number of foundations (116). For cable installation, the maximum adverse scenario results from the greatest volume from sandwave clearance and installation. This also assumes the largest

Project phase and activity/impact	Maximum assessment assumptions	Justification
		number of cables and the greatest burial depth.
Direct and indirect seabed disturbances leading to the release of sediment contaminants	Seabed disturbance arising from installation of foundations and cables as described above for localised increases in suspended sediment concentrations and smothering.	This represents the maximum design scenario for the Proposed Development and therefore the maximum volume of contaminated sediment that may be released into the water column during construction activities.
Operation and maintenance		
Long-term loss of habitat and increased hard substrate and structural complexity due to the presence of turbine foundations, scour protection and cable protection	**WTG and substation foundations:** WTG footprint (based on 75 WTG scenario) with scour protection = 9,200m^2 (per monopile). Offshore substation footprint (jacket with pin pile foundation) with scour protection = 8,800m^2 (per substation). **Array and interconnector cables** Maximum rock protection area for array cable crossing = 10,000m^2 per crossing (four crossing expected). Maximum rock protection area for array cables (based on 20 percent of cable requiring protection) = 260,000m^2. Maximum rock protection area for interconnector cables (based on 20 percent of cable requiring protection) = 40,000m^2. **Offshore export cable corridor protection:** Maximum rock protection area for export cables = 61,000m^2	This represents the maximum design scenario for the Proposed Development and therefore the maximum area of seabed lost as a result of the placement of structures, scour protection and cable protection. Habitat loss from drilling and drill arisings is of a smaller magnitude than presence of project infrastructure.

Project phase and activity/impact	Maximum assessment assumptions	Justification
Electromagnetic field (EMF) impacts arising from cables	**WTGs** 116 WTGs **Array Cables** Up to 250km of array cable operating at a maximum of 66kV. Target cable depth = 1m **Interconnector Cables** Up to 50km of interconnector cable (two cables approximately 25km in length), operating up to 275kV. Target cable depth = 1m **Offshore Export Cables** Length of cable corridor 19km (four cables approximately 19km length each in corridor), operating up to 275kV. Target cable depth = <1.5m.	The maximum adverse scenario associated with the use of 116 WTGs as this results in the greatest length of inter-array cable.
Direct disturbance resulting from maintenance within the array area and the offshore cable corridor	**WTG activities** *Major WTG component replacement* Maximum of 4 events per WTG over the lifetime of the Project = 350. The footprint of seabed disturbance for all events via jacking-up activities = 1,100m^2 (+ 10 percent) *WTG access ladder replacement* Maximum of 600 ladder replacement events. The footprint of seabed disturbance for all events via jacking-up activities = 1,100m^2 (+ 10 percent) *WTG anode replacement* Maximum of 600 anode replacement events. The footprint of seabed disturbance for all events via jacking-up activities = 1,100m^2 (+ 10 percent) *WTG J-tube replacement or modification* Maximum of 200 J-tube replacement or modification (2 per WTG over the lifetime). The footprint of seabed disturbance for all events via jacking-up activities = 1,100m^2 (+ 10 percent).	The maximum adverse scenario is defined by the maximum number of jack-up vessel operation and maintenance activities that could have an interaction with the seabed anticipated during operation.

Project phase and activity/impact	Maximum assessment assumptions	Justification
	Offshore substation and accommodation platform activities *Offshore substation platform major component replacement* Maximum of 27 exchange events (9 per platform). The footprint of seabed disturbance for all events via jacking-up activities = 1,100m^2 (+ 10 percent). *Offshore platform access ladder replacement* Maximum of 36 ladder replacement events (assumes 3 platforms, 2 ladders per platform). The footprint of seabed disturbance for all events via jacking-up activities = 1,100m^2 (+ 10 percent). *Offshore platform anode replacement* Maximum of 72 anode replacement events (assumes 4 legs on each of 3 platforms). The footprint of seabed disturbance for all events via jacking-up activities = 1,100m^2 (+ 10 percent). *Offshore platform J-Tube replacement* Maximum of 60 J-tube replacement or modification (assumes 2 per J-Tube over lifetime). The footprint of seabed disturbance for all events via jacking-up activities = 1,100m^2 (+ 10 percent) **Array cables** Maximum of 18 remedial burial events. The maximum temporary footprint of seabed disturbance for all array remedial burial events = 200,000m^2. Total footprint of seabed disturbance for array cable repairs via jacking-up activities = 1,100m^2. **Offshore export cables** Maximum of 3 remedial burial events per cable (4 export cables). The maximum temporary footprint of seabed disturbance for all export	

Project phase and activity/impact	Maximum assessment assumptions	Justification
	cable corridor remedial burial events = 20,000m^2. Total footprint of seabed disturbance for all export cable repairs via jacking-up activities = 1,100m^2.	
Decommissioning		
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Maximum levels of underwater noise during decommissioning will be from underwater cutting required to remove structures. This is much less than and therefore impacts will be less than as assessed during the construction phase/piled foundations will likely be cut approximately 1m below the seabed.	This will result in the maximum potential disturbance associated with noise associated with decommissioning activities including foundation decommissioning.
Direct disturbance resulting from the removal of the export cable	Removal of all cables and rock protection leading to a temporary loss/change. **Offshore export cable** Total seabed disturbance = 2,015,00m^2. Maximum rock protection area for export cables = 61,000m^2	The maximum design scenario is assumed to be similar to the construction phase, with all infrastructure removed in reverse-construction order. The removal of cables and rock protection is considered the maximum design scenario, however the necessity to remove cables and rock protection will be reviewed at the time of decommissioning
Direct disturbance resulting from decommissioning within the array	Removal of all foundations, cables and rock protection leading to leading to a temporary loss/change. **Interconnector cable** Total seabed disturbance = 1,250,000m^2 **Array cable**	The maximum design scenario is assumed to be similar to the construction phase, with all infrastructure removed in reverse-construction order.

Project phase and activity/impact	Maximum assessment assumptions	Justification
	Total seabed disturbance = 6,250,000m^2 **Array and interconnector cables** Maximum rock protection area for array cable crossing = 10,000m^2 per crossing (four crossing expected). Maximum rock protection area for array cables (based on 20 percent of cable requiring protection) = 260,000m^2. Maximum rock protection area for interconnector cables (based on 20 percent of cable requiring protection) = 40,000m^2.	
Temporary and localised increases in SSC and smothering	Maximum design scenario is identical (or less) to that of construction phase.	WTGs and offshore substations will be removed by reversing the methods used to install them. Pile foundations will likely be cut approximately 1m below the seabed. The area of seabed impacted during the removal of the WTGs will be the same as the area impacted during installation. It is likely that equipment similar to that which is used to install the cables could be used to reverse the burial process and expose them. Therefore, the area of seabed impacted during the removal of the cables could be the same as the area impacted during the installation of the cables. Any scour

Project phase and activity/impact	Maximum assessment assumptions	Justification
		protection will be left in situ.
Direct and indirect seabed disturbances leading to the release of sediment contaminants	Maximum design scenario is identical (or less) to that of construction phase.	See justification row above.

8.7.3 Details of the maximum assessment assumptions provided in the above table (**Table 8-10**) have been utilised to make further assumptions and calculations to determine the potential maximum area or volume affected by the Proposed Development. These assumptions have been calculated for the purposes of assessment on fish and shellfish ecology.

8.7.4 For temporary and localised increases in SSC and smothering (construction) the WTG foundations spoil volume for all WTGs is calculated as 4,000m^3 x 116 monopiles = 464,000m^3. The spoil volume for all offshore substation foundations is calculated as 12,000m^3 x 3 offshore substations = 36,000m^3. Moreover, the total volume disturbed as a result of sandwave clearance on spoils is 2,905,000m^3.

8.7.5 For long-term loss of habitat and increased hard substrate and structural complexity due to the presence of WTG foundations, scour protection and cable protection (operation and maintenance) the WTG foundation footprint with scour protection based on 75 WTGs is 9,200m^2 x 75 monopiles = 690,000m^2. The offshore substation footprint with scour protection based on three offshore substations is 8,800m^2 x 3 jackets = 26,400m^2. When taking all protections into account the total habitat loss/change is considered to be 1,117,400m^2.

8.7.6 For direct disturbance resulting from maintenance within the array area and the offshore cable corridor (operation and maintenance) the total direct disturbance to seabed from jack-up and cable maintenance activities is 5,330,500m^2. The calculations for maintenance are as follows.

WTG maintenance

- The maximum major WTG component replacement is 350 events x 1,100m^2 footprint = 385,000m^2 footprint of seabed disturbance for all events.
- The WTG access ladder and anode replacement are 600 events x 1,100m^2 footprint = 660,000m^2 footprint of seabed disturbance for all events.
- The WTG J-tube replacement or modification is 200 events x 1,100m^2 footprint = 220,000m^2 footprint of seabed disturbance for all events.

Offshore substation and accommodation

- The offshore substation platform major component replacement is 27 events x 1,100m^2 footprint = 29,700m^2 footprint of seabed disturbance for all events.

- The offshore platform access ladder replacement is 36 events x 1,100m^2 footprint = 39,600m^2 footprint of seabed disturbance for all events.
- The offshore platform anode replacement is 72 events x 1,100m^2 footprint = 79,200m^2 footprint of seabed disturbance for all events.
- The offshore platform J-Tube replacement is 60 events x 1,100m^2 footprint = 66,000m^2 footprint of seabed disturbance for all events.

Array and export cables

- The total footprint of seabed disturbance for all array remedial burial events = 3,600,000m^2 (18 x 200,000m^2) and the total footprint of seabed disturbance for array cable repairs = 6,600m^2 (6 x 1,100m^2).
- The maximum temporary footprint of seabed disturbance for all export cable corridor remedial burial events = 240,000m^2 (3 per cable (4 cables) x 20,000m^2) and the total footprint of seabed disturbance for all export cable repairs via jacking-up activities = 4,400m^2 (4 x 1,100m^2).

8.7.7 For direct disturbance resulting from the removal of the export cable (decommissioning) the total seabed disturbed is 2,015,000m^2 and the area of rock protection is anticipated to be 61,000m^2 therefore the total disturbance is predicted to be 2,076,000m^2.

8.7.8 For direct disturbance resulting from decommissioning within the array (decommissioning) the total seabed disturbed is 1,250,000m^2 (interconnector cable) + 6,250,000m^2 (array cable) = 7,500,000m^2. The area of rock protection for the interconnector and array cables is anticipated to be 40,000m^2 (four crossings 10,000m^2 per crossing) + 260,000m^2 + 40,000 m^2 = 340,000m^2. Therefore, the total disturbance is predicted to be 7,840,000m^2.

Embedded environmental measures

8.7.9 As part of the Proposed Development design process, a number of embedded environmental measures have been adopted to reduce the potential for impacts on fish and shellfish ecology. These embedded environmental measures will evolve over the development process as the EIA progresses and in response to consultation. They will be fed iteratively into the assessment process.

8.7.10 These measures typically include those that have been identified as good or standard practice and include actions that will be undertaken to meet existing legislation requirements. As there is a commitment to implementing these embedded environmental measures, and also to various standard sectoral practices and procedures, they are considered inherently part of the design of the Proposed Development and are set out in this PEIR.

8.7.11 **Table 8-11** sets out the relevant embedded environmental measures within the design and how these affect the fish and shellfish ecology assessment.

Table 8-11 Relevant fish and shellfish ecology embedded environmental measures.

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to fish and shellfish assessment
C-44	An Outline Scour Protection Management Plan will be developed. It will include details of the need, type, quantity and installation methods for scour protection.	Scoping	DCO requirements or deemed Marine Licence (dML) conditions.	This measure will minimise where possible long-term habitat loss.
C-45	Where possible, cable burial will be the preferred option for cable protection. Cable burial will be informed by the cable burial risk assessment and detailed within the Cable Specification Plan.	Scoping	DCO requirements or dML conditions	This measure will reduce the risk of EMF impacts on sensitive receptors.
C-52	A piling Marine Mammal Mitigation Protocol (MMMP) will be implemented during construction and will be developed in accordance with JNCC (2010) guidance and with the latest relevant guidance and information and in consultation with stakeholders. The piling MMMP will include details of soft starts to be used during piling operations with lower hammer energies used at the beginning of the piling sequence before	Scoping - updated at PEIR	DCO requirements or dML conditions	This measure will be of benefit to sensitive fish and shellfish receptors in relation to soft start pilling.

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to fish and shellfish assessment
	increasing energies to the higher levels.			
C-53	An Outline Marine Pollution Contingency Plan (MPCP) will be developed. This MPCP will outline procedures to protect personnel working and to safeguard the marine environment and mitigation measures in the event of an accidental pollution event arising from offshore operations relating to Rampion 2. The MPCP will also include relevant key emergency contact details.	Scoping	DCO requirements or dML conditions	This measure will minimise the risk of accidental pollution associated with the Proposed Development on sensitive receptors.
C-58	Offshore geophysical surveys (including UXO surveys) will be subject to full archaeological review in consultation with Historic England.	Scoping - updated at PEIR	DCO requirements or dML conditions	This measure will inform a UXO Marine Licence and appropriate mitigation measures will be defined.
C-95	The assessment will take into consideration the mitigation and control of invasive species measures that will be incorporated into an Outline Project Environmental Monitoring and Management Plan (PEMMP).	Scoping	DCO requirements or dML conditions	This measure will reduce where possible the risk of introducing invasive species into the region.
C-111	A Decommissioning Plan will be prepared	PEIR	DCO requirements or dML conditions	This measure will be developed to

ID	Environmental measure proposed	Project phase measure introduced	How the environmental measures will be secured	Relevance to fish and shellfish assessment
	for the project in line with the latest relevant available guidance.			cover the decommissioning phase and will minimise impact on fish and shellfish receptors, where appropriate.

8.8 Methodology for PEIR assessment

Introduction

8.8.1 The project-wide generic approach to assessment is set out in **Chapter 5: Approach to the EIA**. The assessment methodology for fish and shellfish ecology for the PEIR is consistent with that provided in the Scoping Report (RED, 2020) and no changes have been made since the scoping phase. Further method statements in relation to fish and shellfish ecology and underwater noise assessment, have also been submitted to stakeholders and agreed through the EIA EPP, and have been incorporated into the PEIR.

8.8.2 The assessment of potential impacts upon fish and shellfish receptors is based on the maximum design scenario as identified from the design envelope (see **Chapter 4**). The key assumptions are the layout of the wind farm, the number and size of offshore structures, the type and size of foundations used, as well as the timing and duration of the proposed offshore works (see **Table 8-10**).

8.8.3 The assessment method used in the fish and shellfish ecology impact assessment is in line with the Chartered Institute for Ecological and Environmental Management (CIEEM) guidance (CIEEM, 2018). For each of the identified receptors, impacts have been considered throughout the construction, operation and maintenance and decommissioning phases of the Proposed Development.

8.8.4 Cumulative effects have been assessed by taking into consideration all other relevant developments, proposed or existing, that are in the vicinity of the PEIR Assessment Boundary, and which have the potential to affect the same receptors. Where other developments are expected to be completed prior to the construction of the Proposed Development, and the effects of these developments are fully determined, the effects arising from the developments have been considered as part of the baseline and may also be considered as part of the construction and operational cumulative assessment. Developments forming part of the dynamic baseline, and those included in the cumulative assessment will be clearly identified in the ES.

Guidance

8.8.5 Guidance on the EIA process has been sought from the following resources:

- Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2018);
- Guidance note for Environmental Impact Assessment in respect of FEPA 1985 and CPA 1949 requirements (Cefas *et al*., 2004);
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Judd, 2012);
- Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR, 2008); and
- Renewable UK (2013) Cumulative impact assessment guidelines, guiding principles for cumulative impacts assessments in offshore wind farm.

8.8.6 In addition, the EIA will follow the legislative framework as defined by the Wildlife and Countryside Act 1981 (as amended); the Marine and Coastal Access Act 2009 (as amended); the Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007 (as amended); and the Conservation of Habitats and Species Regulations 2010 (as amended). The full EIA methodology is presented in **Chapter 5: Approach to the EIA**.

Impact assessment criteria

8.8.7 The approach to determining the significance of the effect 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. The terms used to define sensitivity and magnitude are informed by the EIA Regulations 2017, and the Ministry of Housing, Communities and Local Government's (MHCLG) EIA Planning Practice Guidance (DCLG, 2017) has been applied in undertaking the EIA, as part of the PEIR and will also be applied for the ES. Further details are provided in **Chapter 5**.

8.8.8 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. Throughout the assessment, receptor sensitivities have been informed by thorough review of the available peer-reviewed scientific literature, and assessments available on the Marine Life Information Network (MarLIN) database. It is acknowledged that the MarLIN assessments have limitations. These limitations have been taken into account and other information and data accessed where relevant.

The definitions of terms relating to sensitivity and magnitude are outlined in **Table 8-12** and **Table 8-13**

8.8.9 Table 8-13 below.

Table 8-12 Definition of terms relating to receptor sensitivity or value.

Sensitivity	Definition used in this chapter
Very High	Receptor is highly vulnerable to impacts that may arise from the project and recoverability is long term or not possible.
High	Receptor is generally vulnerable to impacts that may arise from the project and has low to medium recoverability.
Medium	Receptor is somewhat vulnerable to impacts that may arise from the project and has moderate levels of recoverability.
Low	Receptor is not generally vulnerable to impacts that may arise from the project and/or has high recoverability.

Table 8-13 Definition of terms relating to magnitude of impact.

Magnitude of impact	Definition used in this chapter
Major	Impact is of long-term duration and/or is of extended physical extent and is expected to result in one or more of the following: 1) loss of resource and/or quality and integrity of resource; and 2) severe damage to key characteristics, features or elements. (Adverse)
	Impact is expected to result in one or more of the following: 1) large scale or major improvement or resource quality; 2) extensive restoration or enhancement; and 3) major improvement of attribute quality. (Beneficial)
Moderate	Impact is of medium-term duration and/or is of moderate physical extent and is expected to result in one or more of the following: 1) loss of resource, but not adversely affecting integrity of resource; and 2) partial loss of/damage to key characteristics, features or elements. (Adverse)
	Impact is expected to result in one or more of the following: 1) benefit to, or addition of, key characteristics, features or elements; and 2) improvement of attribute quality. (Beneficial)
Minor	Impact is of short-term duration and/or is of limited physical extent and is expected to result in one or more of the following:

Magnitude of impact	Definition used in this chapter
	1) some measurable change in attributes, quality or vulnerability; and 2) minor loss or, or alteration to, one (maybe more) key characteristic, features or elements. (Adverse)
	Impact is expected to result in one or more of the following: 1) minor benefit to, or addition of, one (maybe more) key characteristic, features or elements; and 2) some beneficial impact on attribute or a reduced risk of negative impact occurring. (Beneficial)
Negligible	Impact is of short-term duration and/or is of negligible physical extent and is expected to result in the following: 1) very minor loss or detrimental alteration to one or more characteristics, features or elements. (Adverse)
	Impact is expected to result in the following: 1) very minor benefit to, or positive addition of one or more characteristics, features or elements. (Beneficial)

8.8.10 The significance of effect upon fish and shellfish ecology is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The method employed for this assessment is presented in Table **8-14** , with the final assessment for each effect based upon expert judgement. For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant in terms of the EIA Regulations.

Table 8-14 Matrix used for the assessment of the significance of residual effect.

		Magnitude of Change			
		Major	**Moderate**	**Minor**	**Negligible**
Sensitivity/importance/val	**Very High**	Major (Significant)	Major (Significant)	Moderate (Potentially significant)	Minor (Not significant)
	High	Major (Significant)	Moderate (Potentially significant)	Minor (Not significant)	Minor (Not significant)
	Medium	Moderate	Minor (Not significant)	Minor (Not significant)	Negligible (Not significant)

		(Potentially significant)			
	Low	Minor (Not significant)	Minor (Not significant)	Negligible (Not significant)	Negligible (Not significant)

8.9 Preliminary assessment: Construction phase

Introduction

8.9.1 The impacts of the construction of the Proposed Development have been assessed on fish and shellfish ecology in the study area. The effects arising from the construction of the Proposed Development are listed in **Table 8-10** along with the maximum design scenario assumptions against which each construction phase impact has been assessed.

8.9.2 A description of the significance of effects upon fish and shellfish receptors caused by each identified impact is given below.

Mortality, injury, behavioural changes and auditory masking arising from noise and vibration

Overview of assessment scenarios

8.9.3 Construction activities, particularly the pile-driving of foundations for offshore structures, will result in high levels of underwater noise that will be audible to fish over several kilometres around the Proposed Development (**Table 8-17**, **Table 8-18** and **Table 8-19**). At the highest levels of noise, sub-lethal and lethal effects may occur, resulting in injury and in extreme cases, the death of exposed fish. The assessment focuses on underwater noise from pile-driving for the installation of foundations for offshore structures (for instance WTGs and offshore substations). While other activities such as cable laying, dredging and vessel movements will result in underwater noise, these have the potential to affect a relatively small area in the immediate vicinity of activities and are therefore insignificant in the context of the underwater noise from piling operations.

8.9.4 To inform this impact assessment, predictive underwater noise modelling has been undertaken at three representative locations, with consideration of the key assumptions associated with these two scenarios (for example hammer energies and pile diameters). Full details of the modelling undertaken are presented in **Appendix 11.2: Underwater Noise Assessment Technical Report, Volume 4**.

8.9.5 Piling operations will take place within the PEIR Assessment Boundary array area during the construction phase, with piling operations taking place over a period of approximately 12 months.

8.9.6 As outlined in **Table 8-10**, the maximum design scenario considered with respect to underwater noise from piling is 116 WTG monopiles being driven with a 4,400kJ hammer energy. It should be noted this maximum hammer energy is considered highly conservative. Although the absolute maximum hammer energy identified within the design envelope is 4,400kJ, hammer energies will be considerably lower for the majority of the time, with the most likely maximum hammer energy of 4,000kJ. The hammer energy will only be raised to 4,400kJ when absolutely necessary. To minimise fatigue loading on the piles, hammer energies are continuous, set at the minimum required, which also reduces the likelihood of breakdown of the equipment. Hammer energies will likely start at low levels (soft start/ramp up) and gradually increase to the maximum required installation energy (see C-52, **Table 8-11**).

8.9.7 The temporal maximum design scenario represents the longest duration of effects from subsea noise and assumes a scenario whereby piled jacket foundations are used for all offshore structures. The temporal scenario includes a maximum hammer energy of 2,500kJ for pin-pile installation, which is also considered conservative with many of the assumptions discussed in **paragraph 8.9.6** above also expected to be relevant to this maximum hammer energy. The most likely maximum hammer energy is 2,000kJ for jacket foundations.

8.9.8 UXO removal will be sought in a separate future Marine Licence application, when there is greater certainty on the quantum of UXO requiring clearance, prior to construction, using high resolution geophysical survey data (see C-58, **Table 8-11**). Detonation of UXO will represent a short term (seconds) increase in underwater noise (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, these effects will be considerably reduced compared to those associated with piling operations. Clearance of UXO, if any are located prior to the construction of the Proposed Development, will be necessary to reduce the risk to personnel and equipment during the construction process. Until detailed pre-construction surveys are undertaken across the Proposed Development array area and offshore export cable corridor, the number of potential UXO which will need to be cleared is unknown. However, as the clearance of UXO is an activity which is likely to occur, for completeness it has been considered within this assessment.

8.9.9 With respect to the duration of piling activities, the maximum design scenarios detailed in **Table 8-10** also make conservative assumptions. The maximum duration of piling is assumed to be 24 hours per four pin-piles (four pin-piles per WTG and 12 pin-piles per offshore substation (up to three offshore substation), with the temporal maximum design scenario assuming a maximum total duration of piling of 3,000 hours, based on this maximum per pile duration. The duration will be considerably less in the event of fewer pin piles or different foundation types (monopiles).

Assessment thresholds

8.9.10 In order to quantify the spatial extent of any potential noise impacts on fish and shellfish populations, a semi-empirical underwater noise propagation model (INSPIRE) was undertaken using the maximum design hammer energy (4,400kJ for monopiles and 2,500kJ for pin-piles) at three noise modelling locations, one at the East of the PEIR Assessment Boundary, one at the North-west of the PEIR Assessment Boundary (the shallowest location closest to shore), and one to the South of the PEIR Assessment Boundary (the deepest location furthest from shore). Monopile foundations are only proposed to be installed at depth of up to 45m, with jacket foundations utilised in deeper locations. As a result, modelling in the South location only considers jacket foundations. The following sensitivity assessment provides a summary of the key results of this modelling in the context of the impact assessment on fish and shellfish receptors, with full details of the underwater noise modelling presented in the **Appendix 11, Volume 4**.

8.9.11 Underwater noise can potentially have a negative impact on fish species ranging from physical injury/mortality to behavioural effects. 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. However, when considering injury due to the energy of an exposure, the time of the exposure becomes important. For example, a continuous source operating at a given sound pressure level has a higher total energy and is, therefore, more damaging than an intermittent source reaching the same Sound Pressure Level (SPL).

8.9.12 Research 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 have highlighted some of the shortcomings of impact assessments, including the use of broad criteria for injury and behavioural effects based on limited studies. One of the key data gaps with respect to impacts on fish and shellfish populations relates to the effects of the particle motion element of underwater noise, which is considered to be more important for many fish species, and particularly invertebrates, than sound pressure which has been the main consideration in noise impact assessments to date.

8.9.13 Peer-reviewed guidelines published by the Acoustical Society of America (ASA) and provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish. For the purposes of this assessment, these Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.,* 2014) were considered to be most relevant for impacts of underwater noise on fish species. However, it should be noted that sea turtles have not been considered in this assessment. The Popper *et al.* (2014) guidelines broadly group fish into the following categories based on their anatomy and the available information on hearing of other fish species with comparable anatomies (see **Table 8-15** for relevant fish receptors):

- Group 1: Fishes lacking swim bladders that are sensitive only to sound particle motion and show sensitivity to a narrow band of frequencies (includes flatfishes and elasmobranchs).
- Group 2: Fishes with a swim bladder where the organ does not appear to play a role in hearing. These fish are sensitive only to particle motion and show sensitivity to a narrow band of frequencies (includes salmonids).
- Group 3: Fishes with swim bladders that are close, but not intimately connected to the ear. These fishes are sensitive to both particle motion and sound pressure and show a more extended frequency range than Groups 1 and 2, extending to about 500Hz (includes gadoids).

- Group 4: Fishes that have special structures mechanically linking the swim bladder to the ear. These fishes are sensitive primarily to sound pressure, although they also detect particle motion. These species have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in Groups 1, 2 and 3 (includes clupeids such as herring, sprat and shads).

8.9.14 There are only a few studies that investigate the effects of acoustic exposure on aquatic invertebrates (including shellfish and cephalopods) (Wale *et al.,* 2013; Roberts *et al.,* 2016), although these are insufficient to make firm conclusions about sensitivity. It is highly likely that aquatic invertebrates can detect particle motion, including seabed vibration, and what evidence there is indicates those species are primarily sensitive to particle motion at frequencies well below 1 kHz (Hawkins and Popper, 2016; Mooney *et al.,* 2012). Moreover, Mooney *et al.* (2012) suggest that cephalopods seem to be sensitive to the low frequency particle motion component of the sound field and not pressure. A laboratory study by Jones *et al*. (2020) on longfin squid (*Doryteuthis pealeii*) recorded a variety of alarm responses associated with anti-predator reactions at the onset of pile driving noise (the play-back stimuli source was pre-recorded piling noise from the Block Island Wind Farm in Rhode Island), this included a rapidly diminished alarm responses within the first minute of noise exposure in all trials and had re-sensitized to the noise after a 24-hour rest period. Furthermore, few studies have investigated the potential effects of underwater noise on bivalves. A study by Spiga *et al.* (2016) recorded blue mussels as having significantly higher clearance rates (the rate that filter-feeders remove suspended particles from water) during exposure to pile driving and suggested that pile driving conditions moved from a physiologically maintenance state to active metabolism as an adaption to the stress conditions caused by pile driving.

8.9.15 Both allis and twaite shad spawn in freshwater so are unlikely to be in large aggregations in the marine environment, with shoaling occurring within river systems prior to spawning. Shad are also pelagic and unlikely to be in the vicinity of the seabed for any length of time. Given the likely low numbers of this species to be within or in the vicinity of the Proposed Development and as they are highly mobile and can move away from an impacted area, it is considered that the impact of underwater noise and vibration is not significant for these species.

8.9.16 Little is known about hearing in seahorses, it is, therefore, difficult to assess the potential effects of anthropogenic sound on these animals. A study conducted by Hastings *et al.* (2010) determined hearing thresholds of lined seahorse (*H. erectus*) using exposures to tone bursts between 50 Hz and 21.6 kHz. At low frequencies the seahorses have thresholds similar to bony fishes, however, at frequencies above 2 kHz, their auditory sensitivity was similar to that of clupeiform species (such as herring) (Hastings *et al.,* 2020) and as such seahorse were placed in the Group 4 hearing category (see **Table 8-15** below).

8.9.17 The fish receptors within the PEIR Assessment Boundary have been grouped into the Popper *et al.,* (2014) categories based on their hearing system, as outlined in **Table 8-15** below.

Table 8-15 Hearing categories of fish receptors (Popper *et al.,* 2014).

Category	Fish receptor relevant to the PEIR Assessment Boundary
Group 1	Dover sole, lemon sole, dab, plaice, sandeel, mackerel, elasmobranch (thornback ray, undulate ray, tope and lesser spotted dogfish) and sea lamprey
Group 2	Atlantic salmon, sea trout and European eel[1]
Group 3	Black seabream, cod and whiting
Group 4	Herring, sprat and shad species and seahorses.

Injury criteria

8.9.18 The guidance also gives specific criteria (as both unweighted SPL_{peak} and unweighted SEL_{cum} values) for a variety of noise sources: in this case, the impact piling (pile driving) criteria have been considered. It does not specifically consider Permanent Threshold Shift (PTS) but rather direct injury from which individuals within the species can recover. The criteria used for modelling are summarised in **Table 8-16** below.

8.9.19 The modelling results for cumulative sound exposure level (SEL_{cum}) assume a fleeing animal, with the receptor fleeing from the source at a constant rate of $1.5ms^{-1}$. This is considered relatively slow in relation to data from Hirata (1999) and thus is considered conservative, however throughout the assessment a 'static receptor model' is also considered for the purposes of undertaking a precautionary assessment.

Table 8-16 Criteria for onset of injury in fish due to piling activity (Popper *et al.,* 2014).

Type of animal	Mortality and potential mortal injury	Impairment	
		Recoverable injury	TTS
Fish: no swim bladder (Group 1)	>219 dB SEL_{cum} >213 dB SPL_{peak}	>216 dB SEL_{cum} >213 dB SPL_{peak}	>>186 dB SEL_{cum}
Fish: swim bladder is not involved in hearing (Group 2)	210 dB SEL_{cum} >207 dB SPL_{peak}	203 dB SEL_{cum} >207 dB SPL_{peak}	>186 dB SEL_{cum}
Fish: swim bladder involved in hearing (Group 3 and 4)	207 dB SEL_{cum} >207 dB SPL_{peak}	203 dB SEL_{cum} >207 dB SPL_{peak}	186 dB SEL_{cum}

[1] Uncertainty or lack of current knowledge with regards to potential role of swim bladder in hearing for eels. Sand and Karlsen (1986) suggest the swim bladder is not thought to provide auditory gain in the infrasound frequency range (<20Hz).

Type of animal	Mortality and potential mortal injury	Impairment	
		Recoverable injury	TTS
Eggs and larvae	>210 dB SEL_{cum} >207 dB SPL_{peak}	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low
For eggs and larvae, relative risk (high, moderate low) is given for animals at three distances from the source in relative terms as near field (N: 10s of metres), intermediate field (I: 100s of metres), and far field (F: 1000s of metres); (Popper *et al.,* 2014). (>> (much greater than)).			

8.9.20 The following sections present the assessment of potential impacts on noise sensitive fish receptors, initially presenting consideration of mortality and mortal injury, before then presenting temporary threshold shift, and finally potential behavioural impacts. Each section initially presents the predicted magnitude of impact for each receptor, before then considering the sensitivity of the receptor, and finally presenting the predicted significance of effect with regards the EIA Regulations (2017 as amended).

8.9.21 The results of the noise modelling for mortality and potential mortal injury, recoverable injury and TTS in different receptor groups are presented in **Table 8-17**, **Table 8-18** and **Table 8-19** for modelling locations surrounding the array (North-West, East and South).

Table 8-17 Mean worst-case noise impact ranges for fleeing fish and stationary fish at the North West modelled location and noise levels for monopile installation (4,400kJ hammer energy), and pin pile installation (2,500kJ hammer energy) surrounding the array

Receptor	Criteria	Noise level (dB re 1 µPa SPL/ dB re 1 µPa2 s SEL)	Distance (m) from modelling locations surrounding the array			
			MP (f)	MP (s)	PP (f)	PP (s)
Mortality and potentially mortal injury						
Group 1	SPL_{peak}	>213	90	90	70	70
	SEL_{cum}	>219	<100	860 (800-900)	<100	910 (850-910)
Group 2	SPL_{peak}	>207	210	210	160	160
	SEL_{cum}	210	<100	2,500 (2,300 - 2,700)	<100	2,600 (2,400-2,700)
	SPL_{peak}	>207	210	210	160	160

Receptor	Criteria	Noise level (dB re 1 µPa SPL/ dB re 1 µPa2 s SEL)	Distance (m) from modelling locations surrounding the array			
			MP (f)	MP (s)	PP (f)	PP (s)
Group 3 and 4	SEL_{cum}	207	<100	3,400 (3,100-3,700)	<100	3,500 (3,200-3,900)
Eggs and larvae	SPL_{peak}	>207	210	210	160	160
	SEL_{cum}	>210	<100	3,400 (3,100-3,700)	<100	3,500 (3,200-3,900)
Recoverable injury						
Group 1	SPL_{peak}	>213	90	90	70	70
	SEL_{cum}	>216	<100	1,200 (1,200-1,300)	<100	1,300 (1,300-1,400)
Group 2	SPL_{peak}	>207	210	210	160	160
	SEL_{cum}	203	<100	4,900 (4,300-5,600)	<100	5,100 (4,400-5,900)
Group 3 and 4	SPL_{peak}	>207	210	210	160	160
	SEL_{cum}	203	<100	4,900 (4,300-5,600)	<100	5,100 (4,400-5,900)
TTS						
Group 1	SEL_{cum}	186	5,900 (2,800-10,000)	17,000 (10,000-26,000)	4,000 (2,000-7,000)	17,000 (10,000-26,000)
Group 2	SEL_{cum}	186	5,900 (2,800-10,000)	17,000 (10,000-26,000)	4,000 (2,000-7,000)	17,000 (10,000-26,000)
Group 3 and 4	SEL_{cum}	186	5,900 (2,800-10,000)	17,000 (10,000-26,000)	4,000 (2,000-7,000)	17,000 (10,000-26,000)

Receptor	Criteria	Noise level (dB re 1 µPa SPL/ dB re 1 µPa2 s SEL)	Distance (m) from modelling locations surrounding the array			
			MP (f)	MP (s)	PP (f)	PP (s)
f - fleeing fish (1.5ms^{-1}); s – stationary fish MP – monopile foundations; PP – pin-pile installation Where the maximum/minimum differs from the mean, these values are indicated in brackets.						

Table 8-18 Mean worst-case noise impact ranges for fleeing fish and stationary fish at the East modelled location and noise levels for monopile installation (4,400kJ hammer energy), and pin pile installation (2,500kJ hammer energy) surrounding the array.

Receptor	Criteria	Noise level (dB re 1 µPa SPL/ dB re 1 µPa2 s SEL)	Distance (m) from modelling locations surrounding the array			
			MP (f)	MP (s)	PP (f)	PP (s)
Mortality and potentially mortal injury						
Group 1	SPL_{peak}	>213	120	120	90	90
	SEL_{cum}	>219	<100	1,300 (1,300-1,400)	<100	1,600 (1,500-1,700)
Group 2	SPL_{peak}	>207	300 (300-310)	300 (300-310)	240	240
	SEL_{cum}	210	<100	4,300 (3,800 - 4,800)	<100	4,800 (4,300-5,400)
Group 3 and 4	SPL_{peak}	>207	300 (300-310)	300 (300-310)	240	240
	SEL_{cum}	207	<100	5,900 (5,100-6,700)	<100	6,600 (5,700-7,500)
Eggs and larvae	SPL_{peak}	>207	300 (300-310)	300 (300-310)	240	240
	SEL_{cum}	>210	<100	4,300 (3,800-4,800)	<100	4,800 (4,300-5,400)

Receptor	Criteria	Noise level (dB re 1 µPa SPL/ dB re 1 µPa2 s SEL)	Distance (m) from modelling locations surrounding the array			
			MP (f)	MP (s)	PP (f)	PP (s)
Recoverable injury						
Group 1	SPL_{peak}	>213	120	120	90	90
	SEL_{cum}	>216	<100	2,000 (1,900-2,200)	<100	2,300 (2,200-2,500)
Group 2	SPL_{peak}	>207	300 (300-310)	300 (300-310)	240	240
	SEL_{cum}	203	<100	8,700 (7,200-10,000)	<100	9,600 (7,700-11,000)
Group 3 and 4	SPL_{peak}	>207	300 (300-310)	300 (300-310)	240	240
	SEL_{cum}	203	<100	8,700 (7,200-10,000)	<100	9,600 (7,700-11,000)
TTS						
Group 1	SEL_{cum}	186	13,000 (6,800-21,000)	26,000 (15,000-37,000)	11,000 (5,900-17,000)	27,000 (15,000-40,000)
Group 2	SEL_{cum}	186	13,000 (6,800-21,000)	26000 (15000-37000)	11,000 (5,900-17,000)	27,000 (15,000-40,000)
Group 3 and 4	SEL_{cum}	186	13,000 (6,800-21,000)	26,000 (15,000-37,000)	11,000 (5,900-17,000)	27,000 (15,000-40,000)

f - fleeing fish (1.5ms^{-1}); s – stationary fish
MP – monopile foundations; PP – pin-pile installation
Where the maximum/minimum differs from the mean, these values are indicated in brackets.

8.9.22 No modelling data is provided for monopiles foundations in water depths greater than 45m (see **paragraph 8.9.10**). As a result, the model location in the south of the array area contains information on pin-pile jacket foundations only, as these will be utilised in deeper locations. The worst-case scenario for the pin piles is provided in **Table 8-19** below.

Table 8-19 Mean worst-case noise impact ranges for fleeing fish and stationary fish at the South modelled location and noise levels for pin pile installation (2,500kJ hammer energy) surrounding the array.

Receptor	Criteria	Noise level (dB re 1 μPa SPL/ dB re 1 μPa2 s SEL)	Distance (m) from modelling locations surrounding the array			
			MP (f)	MP (s)	PP (f)	PP (s)
Mortality and potentially mortal injury						
Group 1	SPL_{peak}	>213	N/A	N/A	100	100
	SEL_{cum}	>219	N/A	N/A	<100	1,700 (1,700-1,800)
Group 2	SPL_{peak}	>207	N/A	N/A	250	250
	SEL_{cum}	210	N/A	N/A	<100	5,800 (5,600-5,900)
Group 3 and 4	SPL_{peak}	>207	N/A	N/A	250	250
	SEL_{cum}	207	N/A	N/A	<100	8,100 (7,700-8,500)
Eggs and larvae	SPL_{peak}	>207	N/A	N/A	250	250
	SEL_{cum}	>210	N/A	N/A	<100	5,800 (5,600-5,900)
Recoverable injury						
Group 1	SPL_{peak}	>213	N/A	N/A	100	100
	SEL_{cum}	>216	N/A	N/A	<100	2,600 (2,600-2,700)
Group 2	SPL_{peak}	>207	N/A	N/A	250	250
	SEL_{cum}	203	N/A	N/A	<100	12,000 (10,00-13,000)
	SPL_{peak}	>207	N/A	N/A	250	250

Receptor	Criteria	Noise level (dB re 1 µPa SPL/ dB re 1 µPa2 s SEL)	Distance (m) from modelling locations surrounding the array			
			MP (f)	MP (s)	PP (f)	PP (s)
Group 3 and 4	SEL_{cum}	203	N/A	N/A	<100	12,000 (10,00-13,000)
TTS						
Group 1	SEL_{cum}	186	N/A	N/A	15,000 (9,400-21,000)	32,000 (20,000-43,000)
Group 2	SEL_{cum}	186	N/A	N/A	15,000 (9,400-21,000)	32,000 (20,000-43,000)
Group 3 and 4	SEL_{cum}	186	N/A	N/A	15,000 (9,400-21,000)	32,000 (20,000-43,000)
f - fleeing fish (1.5ms^{-1}); s – stationary fish MP – monopile foundations; PP – pin-pile installation Where the maximum/minimum differs from the mean, these values are indicated in brackets.						

Mortality and potential mortal injury

Sandeel

Overview

8.9.23 Sandeel (>219 dB SEL_{cum}) are considered stationary receptors (zero-flee speed), 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. Noise modelling suggests that the potential for mortality and potential mortal injury of spawning sandeel from noise impacts of monopile installation may occur up to 1,300m from the array area (4,400kJ hammer energy, based on SEL_{cum}). Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy in the east of the array) showed the potential for mortality and potential mortal injury may occur up to a maximum range of 1,000m from the array, a reduced impact than that proposed in from the maximum design scenario. Sandeel preferred habitats and spawning grounds are widely distributed across the English Channel and into the southern North Sea (**Figure 8-3, Volume 3**), and therefore in the context of the wider environment, the spatial impact is considered to be small.

Magnitude of impact

8.9.24 Low intensity sandeel spawning and nursery habitats are located in the PEIR Assessment Boundary fish and shellfish study area (see **Figure 8-3** and **Figure 8-9, Volume 3**). It should be noted however that the degree of overlap between spawning and nursery grounds of these species and the area with potential for potential injury will be very small relative to the total area that the species could use for spawning in the English Channel and the southern North Sea (Jensen *et al.,* 2011).Therefore taking this into account, the spatial extent of the impact in the context of the wider environment is considered small, with the overall short duration of piling and its intermittent nature, the magnitude of impact that construction activities relating to the Proposed Development will have on sandeel is therefore considered to be **minor**.

Sensitivity or value of receptor

8.9.25 Sandeel (Group 1) spawning and nursery habitats are present within the PEIR Assessment Boundary fish and shellfish study area, these tend to extend over a wide area, and the relative proportion of these habitats affected by piling operations at any one time will therefore be small in the context of the wider habitat available. The sensitivity of the receptor to noise impacts is therefore considered to be **high.**

Significance of residual effect

8.9.26 Sandeel lack a swim bladder and are therefore considered less sensitive to underwater noise. Sandeel spawning habitat occurs over a large area across the English Channel and into the southern North Sea, including within the PEIR Assessment Boundary. Due to their demersal nature, sandeel are considered a stationary receptor to underwater noise in this assessment, and therefore will be exposed to underwater noise from piling activity during the construction phase of the Proposed Development. However, due to their reduced sensitivity, and small degree of disturbance to spawning grounds in the context of the wider habitat availability in the English Channel and within the southern North Sea, the species are assessed as having **high** sensitivity to underwater noise during construction, and the magnitude of impact is deemed to be **minor**, therefore the effect on sandeel is predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Herring

Overview

8.9.27 Herring (207 dB SEL_{cum}) are mobile species and are expected to vacate the area in which the impact could occur with the onset of 'soft start' piling, however herring are considered sensitive due to their hearing ability and their demersal spawning nature. Due to a key herring spawning ground located south of Proposed Development array area (**Figure 8-8, Volume 3**) and the spawning site fidelity displayed by herring, and the consequential likelihood of herring not fleeing from piling noise when engaged in spawning activity, herring are considered stationary receptors for the sake of this assessment. Monopile installation (4,400kJ hammer energy) represents the maximum (spatial extent) scenario for noise impacts on herring. Noise modelling undertaken suggests the potential for mortality and potential mortal injury of herring during peak spawning season (Downs stock; November to January) may occur up to a maximum range of 6,700m from the array area (4,400kJ hammer energy in the east of the array, based on SEL_{cum}). On the basis of the static receptor modelling there is therefore no overlap between from the array noise contours (207 dB SEL_{cum}) and herring spawning grounds, or areas of high larval abundances.

8.9.28 Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy in the east of the array) showed the potential for mortality and potential mortal injury in this scenario may occur up to a maximum range of 5,200m from the array on spawning herring, a reduced impact than that arising from the maximum design scenario hammer energies, and again no direct overlap predicted. When considered in the context of a fleeing receptors the impact ranges reduce to <100m for both the worst case and most likely scenarios.

Magnitude of impact

8.9.29 Based on Hawkins *et al*. (2014a) 135 dB SEL_{cum} noise contours from the array area, an overlap does not occur with the Downs herring spawning grounds (see **Figure 8-18, Volume 3**), however the noise contours do overlap an area of high larval abundance (IHLS 2007-2020; 80,000 to 98,500 per m^2) from the southern piling locations within the array area, therefore the temporal impacts from piling on herring are predicted to be medium. However, as detailed in **paragraph 8.9.27** the injurious effect thresholds for monopiles in the east of the array area (4,400kJ) does not show an overlap from the array noise contours with herring spawning grounds, or areas of high larval abundances. Taking into consideration the locations of herring spawning grounds relative to the piling locations of the Proposed Development (**Figure 8-18, Volume 3**), and the limited temporal impacts, the magnitude of impact that construction activities relating to the Proposed Development will have on herring is therefore considered to be **negligible.**

Sensitivity or value of receptor

8.9.30 Herring (Group 4) are known to inhabit the English Channel with the PEIR Assessment Boundary and associated ZOI located 34.2km north of a regional important herring spawning ground. With reference to **Figure 8-18, Volume 3** the noise contours do not occur within areas of Coull *et al.* (1998) herring spawning grounds, however there is an overlap with areas of very high herring larval abundance (IHLS 2007 to 2020; 80,000 to 98,500 per m^2). However, the connection between the swim bladder and inner ear are not developed in both egg and larval stages with Bolle *et al.* (2014) finding no statistical differences in mortality between control larvae and those exposed to piling noise. The sensitivity of herring to noise impacts is therefore considered to be **high**.

Significance of residual effect

8.9.31 Herring have a swim bladder that is involved in hearing and therefore are known to be sensitive to underwater noise. Key herring spawning and nursery habitats are located outside of the fish and shellfish study area. Herring are demersal spawners and were therefore considered stationary receptors in the assessment, increasing their exposure to underwater noise from the construction phase of the Proposed Development. The magnitude of impact is considered to be **negligible** for injury. Due to their sensitivity to underwater noise, and likelihood of disturbance to spawning herring, the species were assessed as having **high** sensitivity to underwater noise during construction, and therefore the effect on herring is predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Black seabream

Overview

8.9.32 Black seabream (207 dB SEL_{cum}) are also mobile species and are likely to flee the immediate area in which piling will occur. Black seabream are considered sensitive to sound pressure components of underwater noise (Group 3), due to having a swim bladder involved in hearing, and from their demersal spawning nature. An important spawning/nesting area is located directly north of the Proposed Development array area. As described in **paragraph 8.6.83**, during the breeding season, black seabream are reported to return to the same area every year. As a result of this focused area of nesting activity, Kingmere MCZ was created to protect this important breeding and spawning site and enforced seasonal restrictions during the black seabream nesting period .

8.9.33 Male black seabream will largely remain with their nests until the eggs have hatched to protect them from smothering from sediment and predation. It should be noted that predation of eggs is be expected to be most prevalent while the male black seabream is away from the nest, therefore any disturbance from potential piling operations could result in unprotected nests, although it is likely that potential predators will also vacate the area during potential piling thus limiting this potential effect.

8.9.34 Noise modelling undertaken indicates the potential for mortality and potential mortal injury of black seabream during peak spawning/nesting season (assuming static receptors) may occur up to a maximum range of 3,700m from the array area (4,400kJ hammer energy in the north-west of the array, based on SEL_{cum}). Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) showed the potential for mortality and potential mortal injury in this scenario may occur up to a maximum range of 2,900m from the array, a significantly reduced impact than that proposed from the maximum design scenario hammer energies. When considered in the context of a fleeing receptors the impact ranges reduce to <100m for both the worst case and most likely scenarios. Black seabream are recorded across the English Channel with (angling) catches recorded from Eastbourne through to Devon and Alderney, and recognised primary spawning habitat from Shoreham harbour through to Swanage Bay. The modelled outputs indicate for both the worst case (maximum range 3.7km), and most likely scenarios (2.9km), there will be no interaction with the areas of highest density nesting (within Kingmere MCZ and a 5km buffer) and the piling activity for the proposed project.

Magnitude of impact

8.9.35 Black seabream spawning and nesting grounds are located within the noise contours of piling within the PEIR Assessment Boundary array area. Taking into consideration the locations of black seabream spawning and nesting grounds relative to the piling locations of the Proposed Development (**Figure 8-19, Volume 3**), and the limited temporal impacts, the magnitude of the impact that construction activities relating to the Proposed Development will have on black seabream is considered **negligible.**

Sensitivity or value of receptor

8.9.36 Black seabream (Group 3) spawning and nursery are present within the PEIR Assessment Boundary fish and shellfish study area, specifically within the proposed offshore export cable corridor, which is located adjacent to the Kingmere MCZ. Black seabream are considered sensitive to underwater noise associated with piling, with Bruintjes *et al.* (2016) identifying an increase in oxygen uptake during impact piling. The increased oxygen uptake suggests heightened stress during exposure to pile driving (Barton, 2002). The sensitivity of black seabream to noise impacts is therefore considered to be **high**.

Significance of residual effect

8.9.37 Black seabream have a swim bladder close to, but not intimately connected to the ear. Key spawning and nesting grounds for black seabream are located north of the array area within the fish and shellfish study area. Black seabream are demersal spawners and were therefore considered stationary receptors in the assessment, increasing their exposure to underwater noise from the potential piling operations during the construction phase of the Proposed Development. Due to their sensitivity to underwater noise, and likelihood of disturbance to spawning and nesting black seabream, the species were assessed as having **high** sensitivity to underwater noise during construction. For physical injury there is limited interaction with the areas of primary importance for breeding black seabream, and therefore the magnitude is considered **negligible**, and the associated effect therefore of **minor adverse significance** (**not significant** in EIA terms).

Other fish and shellfish receptors

Overview

8.9.38 The majority of other fish and shellfish receptors (see **Table 8-15**) of the Proposed Development are Group 1 fish receptors with the exception of cod, whiting (Group 3 receptors) and sprat (Group 4); these species are all considered mobile and will be expected to vacate the area in which the impact could occur with the onset of 'soft start' piling. Both sprat, cod and whiting have spawning and nursery grounds across and within the vicinity of the array area. Maximum design scenario noise impacts (4,400kJ hammer energy) from monopile installation in the context of eggs and larvae (>210 dB SEL_{cum}) may occur at a maximum range of 5,600m from the array area in the north-west. With the most likely noise impacts (4,000kJ) having the potential to occur up to a maximum of 4,400m from the array area in the north-west. In the context of the wider spawning and nursery grounds in the region, the impacts are considered to be small. In addition to this, prolonged exposure could be reduced by any drift of eggs/larvae due to water currents which may reduce the risk of mortality.

8.9.39 Seahorses can be found in a variety of habitats (see **paragraph 8.6.61**). Research suggests that seahorses are present in shallower waters during summer months for breeding and migrate to deeper water during winter months (usually around October to April) to avoid storms (The Seahorse Trust, 2013). Seahorses (207dB SEL_{cum}) have low swimming speeds, with very inefficient fins for conventional swimming (Ashley-Ross, 2002) and are therefore may have limited capacity to flee the area compared to other Group 4 receptors. However, seahorses are not expected in significant numbers in the area of the Proposed Development, as there are no records or data that suggest that the Proposed Development area itself is an area of particular importance for seahorse, even in the overwintering period when the species may move to deeper water areas. Noise modelling (assuming static receptors) has demonstrated that the potential for mortality effects on seahorse due the proposed piling activities could arise within a maximum range 6,700m from the array area (4,400kJ hammer in the east of the array area, based on SEL_{cum}) and a maximum range of 210m for fleeing receptors (4,400kJ hammer in the north-west of the array area, based on SPL_{peak}) from a piling operation. Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) showed the potential for mortality and potential mortal injury in this scenario may occur up to a maximum range of 5,200m from the array (assuming static receptors), a significantly reduced impact than that proposed from the maximum design scenario hammer energies. When considered in the context of a fleeing receptors the impact ranges reduce to <100m for the most likely scenario. The impact from underwater noise is considered to be most applicable in the winter months when seahorses are known to migrate to deeper water (Garrick-Maidment, 2013), as seahorses are considered more likely to be in shallower inshore waters outside of the Proposed Development (and therefore not exposed to lethal/physical injury levels) for breeding in summer. Moreover, as detailed **paragraph 8.6.63**, low numbers of spiny and short-snouted seahorse have been observed in the region and are known to be present in shallow inshore areas around Newhaven, (National Biodiversity Network Atlas, 2021a; 2021b) particularly in seagrass areas. Four short snouted seahorses were recorded during surveys at Rampion 1 offshore wind farm in the north-eastern and western regions of the project site (RSK Environmental Limited, 2012) in October to November 2011 and February 2012. Whilst there is the potential for seahorse to be present, the area is not of specific importance for the species above those waters of the wider region. Nevertheless, there is potential for seahorse to occur in deeper waters within the region generally, relating to overwintering migration (October to April) which could feasibly result in the seahorse species being present in the general area of the Proposed Development. 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 population numbers at even the preferred habitat locations inshore 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 6.7km of a foundation location at the time of active piling is very small.

Magnitude of impact

8.9.40 All other fish and shellfish species and their respective spawning grounds are distributed widely throughout the English Channel and into the southern North Sea, and therefore taking the wider environment into context, the magnitude of effect on all other fish and shellfish receptors are assessed as being **minor** from impacts associated with piling within the array area.

Sensitivity or value of receptor

8.9.41 There are no specific criteria currently published in respect of shellfish species. 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 will effectively be distractions from routine activities such as feeding. Studies on lobsters have shown no effect on mortality, appendage loss or the ability of animals to regain normal posture after exposure to very high sound levels (>220 dB) (Payne *et al.,* 2007). Similarly, studies of marine bivalves (blue mussels) exposed to a single airgun at a distance of 0.5m have shown no effects after exposure (Kosheleva, 1992). However, 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).

8.9.42 Reactions to noise and vibrations are not likely to interfere with the ecological function of shellfish, with some mobile mollusc species likely to return to the area after the impact activity has stopped. André *et al.* (2011) stated that acoustic trauma is seen in selected cephalopod species, such as the European squid, following exposure to low frequency sound. This was also observed by Samson *et al.* (2016) with a range of behavioural responses to underwater noise in cephalopods recorded, including inking, colour changes and startle responses. However, Fewtrell and McCauley (2012) suggest that such alterations are only temporary from experimental studies. The sensitivity of shellfish to underwater noise impacts is therefore considered to be **high**.

8.9.43 Cod, whiting, sprat, allis and twaite shad and European eel are considered to be of medium vulnerability, high recoverability and of regional to international importance. The sensitivity of these receptors is therefore considered to be **high**.

8.9.44 All other fish and shellfish within the study area are deemed to be of low vulnerability, medium recoverability and of local to international importance. The sensitivity of these receptors is therefore considered to be **high**.

Significance of residual effect

8.9.45 The majority of other fish species in this assessment lack swim bladders and were therefore considered to be less sensitive to underwater noise (Group 1). Whilst some species have spawning and nursery grounds within the fish and shellfish study area, they typically occur over a large area and into the southern North Sea, any disturbance to spawning is considered small in the context of the wider habitat availability. Cod and whiting (Group 3) have spawning and nursery grounds occurring over a large area and into the southern North Sea, and therefore any disturbance from construction noise to spawning is considered small in the context of the wider habitat availability. Both species are considered mobile, and therefore will be expected to vacate the area in which the impact could occur with the onset of 'soft start'/ramp up piling. Taking all of this into account, all other fish species are assessed as having **high** sensitivity to underwater noise during construction, and a **minor** magnitude of impact, the effects on these species are therefore predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Eggs and larvae

Overview

8.9.46 Eggs and larvae are considered potentially vulnerable to noise impacts due to reduced mobility and small size (Popper *et al.,* 2014). Modelling results show that for the maximum (spatial extent) scenario, assuming a hammer energy of 4,400kJ (monopile foundations), the greatest mortality and potentially mortal injury of eggs and larvae may occur up to a maximum range of 310m (for SPL_{peak}) from the array area in the east and up to 210m (for SPL_{peak}) from the array area in the north-west (**Figure 8-16, Volume 3**). For 2,500kJ hammer energy (pin pile foundations), the greatest mortality and potentially mortal injury effects may occur up to a maximum range of 250m (based on SPL_{peak}) from the array area in the south. Taking into consideration the cumulative sound energy, the modelling results for monopile installation (4,400kJ hammer energy) show that mortality and potential mortal injury of eggs and larvae may occur at a maximum range of 4,800m from the array area in the east and at a maximum range of 2,700m from the array area in the north-west. Mortality and potential mortal injury of eggs and larvae from noise impacts from pin pile installation (2,500kJ) in the array area may occur up to a maximum range of 5,900m (based on SEL_{cum}) from the array area in the south. The maximum range is up to 5,400m in the east and up to 2,800m in the north-west of the array area.

8.9.47 The most likely mortality and potentially mortal injury of eggs and larvae has also been modelled for the array area. The modelling results show that that for the most likely hammer energy of 4,000kJ (monopile foundations) the greatest mortality and potentially mortal injury of eggs and larvae may occur at a maximum range of 300m (based on SEL_{peak}) from the array area in the east model location and a maximum range of 210m (for SPL_{peak}) from the array area in the north-west. For 2,000kJ hammer energy (pin pile foundations), the greatest mortality and potentially mortal injury effects may occur at a maximum range of 230m (based on SEL_{peak}) from the array area in the south. The maximum range is up to 220m in the east and up to 150m in the north-west of the array area. Taking into consideration the cumulative sound energy, the modelling results for monopile installation (4,000kJ hammer energy) show that mortality and potential mortal injury of eggs and larvae may occur at a maximum range of 3,600m from the array area in the east and 2,100m in the north-west of the array area. Mortality and potential mortal injury of eggs and larvae for 2,000kJ hammer energy (pin piles) noise impacts in the array area may occur up to maximum range of 4,200m from the array area in the south (based on SEL_{cum}), 3,800m in the east and 2,100m in the north-west of the array area.

Magnitude of impact

8.9.48 Impact criteria for mortality and potential mortal injury in eggs and larvae have been described in Popper *et al.* (2014) (>210 dB SEL_{cum} or >207 dB SPL_{peak}). The criteria are based on work by Bolle *et al.* (2012) who reported no damage to larval fish at SEL_{cum} as high as 210 dB re 1 µPa 2·s. Therefore, the levels adopted in Popper *et al.* (2014) are likely to be conservative. Given that the levels proposed in Popper *et al.* (2014) are similar to those described for fish species with a swim bladder not involved in hearing (210 dB SEL_{cum} or >207 dB SPL_{peak}) the modelled impact ranges for this category have been used to provide an indication of the potential impacts on fish eggs and larvae. Taking into account the areas potentially affected and the temporary, short term and intermittent nature of piling activity the magnitude of the impact is considered to be **negligible**.

Sensitivity or value of receptor

8.9.49 Eggs and larvae will not be able to flee the vicinity of the foundations during piling, however prolonged exposure could be reduced by any drift of eggs/larvae due to water currents which may reduce the risk of mortality. Moreover, hearing specialist fish are sensitive to underwater noise due to the presence of a swim bladder and intricate connections to the inner ear. These connections are not developed in both egg and larval stages with Bolle *et al.* (2014) finding no statistical differences in mortality between control larvae and those exposed to piling noise for herring and sea bass. As a result, larval stages are considered of **high** sensitivity.

Significance of residual effect

8.9.50 As eggs and larvae lack swim bladders or the connection between the swim bladder and the inner ear has not yet formed at this stage, they are therefore considered to be less sensitive to underwater noise. Whilst some species have spawning and nursery grounds within the fish and shellfish study area, they typically occur over a large area and into the southern North Sea, any disturbance is considered small in the context of the wider habitat availability. Taking all of this into account, eggs and larvae are assessed as having **high** sensitivity to underwater noise during construction, and a **negligible** magnitude of impact, the effects on these species are therefore predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Recoverable injury

Introduction

8.9.51 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). Although the impact ranges for recoverable and mortality/potentially 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 pile installation, although the risk of this occurring will be reduced by use of soft start/ramp up techniques at the start of the piling sequence (see C-52, **Table 8-11**). This means that fish within close proximity to potential piling activity associated with the Proposed

Development will move outside of the impact range before underwater noise levels reach an intensity likely to cause irreversible injury.

Sandeel

Overview

8.9.52 The potential for recoverable injury of sandeel (>216dB) from the maximum (spatial extent) scenario noise impacts of monopile installation (4,400kJ hammer energy) may occur up to a maximum range of 2,200m from the array area (based on SEL_{cum} in the east of the array area). Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) show that the potential for recoverable injury in this scenario may occur up to a maximum range of 1,600m from the array area on stationary receptors. Sandeel preferred habitats and spawning grounds are widely distributed across the English Channel and into the Southern North Sea **(Figure 8-9, Volume 3**), and therefore in the context of the wider environment, the spatial extent of the potential impact is considered to be small.

Magnitude of impact

8.9.53 Low intensity sandeel spawning and nursery habitats are located in the PEIR Assessment Boundary fish and shellfish study area (see **Figure 8-3** and **Figure 8-9, Volume 3**). As described in **paragraph 8.9.24** the spatial extent of the impact in the context of the wider environment is considered small, with the overall short duration of piling and its intermittent nature, together with the fact that any effect will be temporary, the magnitude of impact that construction activities relating to the Proposed Development will have on sandeel is therefore considered to be **minor**.

Sensitivity or value of receptor

8.9.54 Sandeel (Group 1) spawning and nursery habitats are present within the PEIR Assessment Boundary fish and shellfish study area, as noted in **paragraph 8.9.25** these tend to extend over a wide area, and therefore the sensitivity of the receptor to noise impacts is therefore considered to be **high.**

Significance of residual effect

8.9.55 Sandeel lack a swim bladder and are therefore considered less sensitive to underwater noise. Sandeel spawning habitat occurs over a large area across the English Channel and into the southern North Sea, including within the PEIR Assessment Boundary. Due to their demersal nature, sandeel are considered a stationary receptor to underwater noise in this assessment, and therefore will be exposed to underwater noise from piling activity during the construction phase of the Proposed Development. However, due to their reduced sensitivity, and small degree of disturbance to spawning grounds in the context of the wider habitat availability in the English Channel and within the southern North Sea, the species are assessed as having **high** sensitivity to underwater noise during construction, and the magnitude of impact is deemed to be **minor**, therefore the effect on sandeel is predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Herring

Overview

8.9.56 Monopile installation (4,400kJ hammer energy) in the array area represents the maximum (spatial extent) scenario for noise impacts on herring. The potential for recoverable injury of herring during spawning season (Downs stock; November to January) may occur up to a maximum range of 10,000m from the array area (based on SEL_{cum} in the east of the array area) assuming a stationary receptor. However, there is no overlap from the array modelling locations with herring spawning grounds (Coull *et al.,* 1998; Ellis *et al.,* 2010), or areas of high larval abundances (IHLS 2007-2020 data). Noise impacts from monopile installation on fleeing (non-spawning) herring are expected to be significantly less (100m from piling surrounding the array), and within the immediate vicinity of the piling activity.

8.9.57 Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) showed the potential for recoverable injury in this scenario may occur up to a maximum range of 8,000m from the array area on stationary spawning herring, a reduced impact than that proposed from the maximum design scenario modelling. No overlap from the array modelling locations with herring spawning grounds (Coull *et al.,* 1998; Ellis *et al.,* 2010), or areas of high larval abundances (IHLS 2007-2020 data). Noise impacts from monopile installation on fleeing (non-spawning) herring are expected to be significantly less (<100m from piling surrounding the array), and within the immediate vicinity of the piling activity.

Magnitude of impact

8.9.58 Based on Hawkins *et al*. (2014a) 135 dB SEL_{cum} noise contours from the array area, an overlap does not occur with the Downs herring spawning grounds (see **Figure 8-18, Volume 3**), however the noise contours do overlap an area of high larval abundance (IHLS 2007-2020; 80,000 to 98,500 per m^2) from the southern piling locations within the array area, therefore the temporal impacts from piling on herring are predicted to be medium. However, as detailed in **paragraph 8.9.56** the injurious effect thresholds for monopiles in the east of the array area (4,400kJ) does not show an overlap from the array noise contours with herring spawning grounds, or areas of high larval abundances. Taking into consideration the locations of herring spawning grounds relative to the piling locations of the Proposed Development (**Figure 8-18, Volume 3**), and the limited temporal impacts, the magnitude of impact that construction activities relating to the Proposed Development will have on herring is therefore considered to be **negligible**.

Sensitivity or value of receptor

8.9.59 Herring (Group 4) are known to inhabit the English Channel with the PEIR Assessment Boundary and associated ZOI located 34.2km north of a regional important herring spawning ground. As noted in **paragraph 8.9.30** the sensitivity of herring to noise impacts is therefore considered to be **high**.

Significance of residual effect

8.9.60 Herring have a swim bladder that is involved in hearing and therefore are known to be sensitive to underwater noise. Key herring spawning and nursery habitats are located outside of the fish and shellfish study area. Herring are demersal spawners and were therefore considered stationary receptors in the assessment, increasing their exposure to underwater noise from the construction phase of the Proposed Development. The magnitude of impact is considered to be **negligible** for injury. Due to their sensitivity to underwater noise, and likelihood of disturbance to spawning herring, the species were assessed as having **high** sensitivity to underwater noise during construction, and therefore the effect on herring is predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Black seabream

Overview

8.9.61 The potential for recoverable injury of black seabream during peak spawning/nesting season from the maximum (spatial extent) scenario noise impacts of monopile installation (4,400kJ hammer energy) may occur between 5,600m and 4,300mfrom the array area (based on SEL_{cum} from the North-west model site, closest to Kingmere MCZ). The noise contour 203dB SEL_{cum} from monopile installation within the array area does not overlap with the highest intensity black seabream spawning and nesting grounds in and around the Kingmere MCZ, however there may be some interaction with black seabream to the south of the high intensity nesting grounds due to proximity of the Proposed Development to the Kingmere MCZ and areas of preferred black seabream nesting habitat. Noise impacts from monopile installation on fleeing (non-spawning) black seabream are expected to be significantly less (100m from piling surrounding the array), and within the immediate vicinity of the piling activity.

8.9.62 Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy in the north-west of the array area) showed the potential for recoverable injury in this scenario may occur up to a maximum range of 4,400m from the array, a significantly reduced impact than that proposed from the maximum design scenario hammer energies. Noise impacts from monopile installation on fleeing (non-spawning) black seabream are expected to be significantly less (<100m from piling surrounding the array), and within the immediate vicinity of the piling activity. Black seabream preferred nesting habitat is distributed across the inshore waters of the Eastern English Channel, with recognised habitat within the Kingmere MCZ and within the offshore export cable corridor.

Magnitude of impact

8.9.63 Black seabream spawning and nesting grounds are located within the noise contours of piling within the PEIR Assessment Boundary array area. Taking into consideration the locations of black seabream spawning and nesting grounds relative to the piling locations of the Proposed Development (**Figure 8-19, Volume 3**), and the limited temporal impacts, the magnitude of the impact that construction activities relating to the Proposed Development will have on black seabream is considered **negligible**.

Sensitivity or value of receptor

8.9.64 Black seabream (Group 3) spawning and nursery are present within the PEIR Assessment Boundary fish and shellfish study area, specifically within the proposed offshore export cable corridor, which is located adjacent to the Kingmere MCZ. As noted in **paragraph 8.9.36** the sensitivity of black seabream to noise impacts is therefore considered to be **high**.

Significance of residual effect

8.9.65 Black seabream have a swim bladder close to, but not intimately connected to the ear. Key spawning and nesting grounds for black seabream are located north of the array area within the fish and shellfish study area. Black sesbream are demersal spawners and were therefore considered stationary receptors in the assessment, increasing their exposure to underwater noise from the potential piling operations during the construction phase of the Proposed Development. Due to their sensitivity to underwater noise, and likelihood of disturbance to spawning and nesting black seabream, the species were assessed as having **high** sensitivity to underwater noise during construction. For physical injury there is limited interaction with the areas of primary importance for breeding black seabream, and therefore the magnitude is considered **negligible**, and the associated effect therefore of **minor adverse significance** (**not significant** in EIA terms).

Other fish and shellfish receptors

Overview

8.9.66 The majority of other fish and shellfish receptors (see **Table 8-15**) within the PEIR Assessment Boundary are Group 1 fish receptors with the exception of cod, whiting (Group 3 receptors) and sprat (Group 4); these species are all considered mobile and are expected to vacate the area in which the impact could occur with the onset of 'soft start'/ramp up piling. Both cod, whiting and sprat have spawning and nursery grounds across and within the vicinity of the array area. The area impacted by underwater noise during piling in the context of the wider spawning and nursery grounds in the region are considered to be small.

8.9.67 Noise modelling undertaken indicates the potential for recoverable injury of seahorse (203 dB SEL_{cum}) may occur between 10,000m and 7,200m from the array area (4,400kJ hammer energy in the east of the array area). Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) showed the potential for recoverable injury in this scenario may occur between 8,000m and 5,900m from the array.

Magnitude of impact

8.9.68 All other fish and shellfish species and their respective spawning grounds are distributed widely throughout the English Channel and into the southern North

Sea, and therefore taking the wider environment into context, the magnitude of effect on all other fish and shellfish receptors are assessed as being **minor** from impacts associated with piling within the array area.

Sensitivity or value of receptor

8.9.69 As noted above in **paragraph 8.9.41** the sensitivity of shellfish to underwater noise impacts is therefore considered to be **high**.

8.9.70 Cod, whiting, sprat, allis and twaite shad and European eel are considered to be of medium vulnerability, high recoverability and of regional to international importance. The sensitivity of these receptors is therefore considered to be **high**.

8.9.71 All other fish and shellfish within the study area are deemed to be of low vulnerability, medium recoverability and of local to international importance. The sensitivity of these receptors is therefore considered to be **high**.

Significance of residual effect

8.9.72 The majority of other fish species in this assessment lack swim bladders and were therefore considered to be less sensitive to underwater noise (Group 1). Whilst some species have spawning and nursery grounds within the fish and shellfish study area, they typically occur over a large area and into the southern North Sea, any disturbance to spawning is considered small in the context of the wider habitat availability. Cod and whiting (Group 3) have spawning and nursery grounds occurring over a large area and into the southern North Sea, and therefore any disturbance from construction noise to spawning is considered small in the context of the wider habitat availability. Both species are considered mobile, and therefore are expected to vacate the area in which the impact could occur with the onset of 'soft start'/ramp up piling. Taking all of this into account, all other fish species are assessed as having **high** sensitivity to underwater noise during construction, and a **minor** magnitude of impact, the effects on these species are therefore predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Eggs and larvae

Overview

8.9.73 Eggs and larvae close to or situated on substrate are considered vulnerable to vibration associated with the ground vibrations generated by pile driving activity (Popper *et al.,* 2014). Sandeel, herring and black seabream are all demersal spawners, with all three species having spawning grounds within or in the vicinity of the Proposed Development, and therefore the risks to eggs and larvae are considered in this assessment.

Magnitude of impact

8.9.74 Key spawning grounds for herring are located 34.2km from the array area 15km buffer (see **Figure 8-2, Volume 3**), whereas sandeel are located within the array area (**Figure 8-3, Volume 3**) with black seabream spawning grounds located in close proximity to the PEIR Assessment Boundary (**Figure 8-14, Volume 3**). Therefore in accordance to the Popper *et al.* (2014) criteria, the extent of noise disturbance potentially causing recoverable injury in black seabream, herring and sandeel eggs and larvae will result in a moderate degree of disturbance at a near field distance from the source (10s of m) and to a low degree in the intermediate (100s of meters) and far field (1000s of meters) (see **Table 8-16**). The magnitude of impact is therefore considered to be **negligible.**

Sensitivity or value of receptor

8.9.75 As noted in **paragraph 8.9.49** eggs and larvae will not be able to flee the vicinity of the foundations during piling, however prolonged exposure could be reduced by any drift of eggs/larvae due to water currents which may reduce the risk of mortality. As a result, larval stages are considered of **high** sensitivity.

Significance of residual effect

8.9.76 As eggs and larvae lack swim bladders or the connection between the swim bladder and the inner ear has not yet formed at this stage, they are therefore considered to be less sensitive to underwater noise. Whilst some species have spawning and nursery grounds within the fish and shellfish study area, they typically occur over a large area within the English Channel and into the southern North Sea, therefore for most species any disturbance is considered small in the context of the wider habitat availability. Taking all of this into account, eggs and larvae are assessed as having **high** sensitivity to underwater noise during construction, and a **negligible** magnitude of impact, the effects on these species are therefore predicted to be of **minor adverse significance** (not significant in EIA terms).

Temporary Threshold Shift (TTS)

Introduction

8.9.77 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 termination 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.

8.9.78 The maximum (spatial extent) scenario modelling results for monopile installation (4,400kJ) within the array area show that TTS will be greater for stationary receptors than fleeing receptors (fleeing at a rate of $1.5ms^{-1}$). The maximum design scenario noise impacts from monopile installation (4,400kJ in the east of the array) causing TTS on stationary receptors may occur between 37 and 15km from the array for most receptor groups (based on SEL_{cum}). The temporal modelling for jacket foundation installation (2,500kJ) TTS may occur in most receptor groups between 40 and 15km from the array (based on SEL_{cum}).

8.9.79 The most likely scenario modelling results for monopile installation (4,000kJ in the east of the array) within the array area show that TTS will be greater for stationary receptors than fleeing receptors (fleeing at a rate of $1.5ms^{-1}$). The noise impacts from monopile installation (4,000kJ) causing TTS on stationary receptors may occur between 33 and 14km from the array in most receptor groups (based on SEL_{cum}). For 2,500kJ hammer energy (jacket foundation installations) TTS may occur in most receptor groups between 34 and 14km from the array (based on SEL_{cum}).

8.9.80 In addition, due to modelling of Hawkins *et al.* (2014a) 135 dB SEL_{cum} for herring, the maximum design scenario noise impacts from jacket pile installation causing TTS (2,500kJ, modelled from the south location) may occur at a maximum range of 62km away from the array area.

Sandeel

Overview

8.9.81 The potential for TTS of sandeel (>>186 dB SEL_{cum}) may occur between 37 and 15km from the array area (assuming static receptors) (4,400kJ hammer energy in the east of the array, based on SEL_{cum}) and a maximum distance of 21km for a fleeing receptor. Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) showed the potential for TTS in this scenario may occur between 33 and 14km from the array area (assuming static receptors) and a maximum distance of 20km for a fleeing receptor, a reduced impact than that predicted from the maximum design scenario hammer energies (**Figure 8-17, Volume 3**).

Magnitude of impact

8.9.82 Low intensity sandeel spawning and nursery habitats are located in the PEIR Assessment Boundary fish and shellfish study area (see **Figure 8-3** and **Figure 8-9, Volume 3**). It should be noted however that the degree of overlap between spawning and nursery grounds of these species and the area with potential for TTS onset will be very small relative to the total area that the species could use for spawning in the English Channel and the southern North Sea (Jensen *et al.,* 2011).Therefore taking this into account, the spatial extent of the impact in the context of the wider environment is considered small, with the overall short duration of piling and its intermittent nature, together with the fact that any effect associated with TTS will be temporary, the magnitude of impact that construction activities relating to the Proposed Development will have on sandeel is therefore considered to be **minor**.

Sensitivity or value of receptor

8.9.83 Sandeel (Group 1) spawning and nursery habitats are present within the PEIR Assessment Boundary fish and shellfish study area, as noted in **paragraph 8.9.25** these tend to extend over a wide area, and therefore the sensitivity of the receptor to noise impacts is therefore considered to be **high.**

Significance of residual effect

8.9.84 Sandeel lack a swim bladder and are therefore considered less sensitive to underwater noise. Sandeel spawning habitat occurs over a large area across the English Channel and into the southern North Sea, including within the PEIR Assessment Boundary. Due to their demersal nature, sandeel are considered a stationary receptor to underwater noise in this assessment, and therefore will be exposed to underwater noise from piling activity during the construction phase of the Proposed Development. However, due to their reduced sensitivity, and small degree of disturbance to spawning grounds in the context of the wider habitat availability in the English Channel and within the southern North Sea, the species are assessed as having **high** sensitivity to underwater noise during construction, and the magnitude of impact is deemed to be **minor**, therefore the effect on sandeel is predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Herring

Overview

8.9.85 The potential for TTS on herring (186dB SEL_{cum}) during spawning season (Downs stock; November to January) and therefore assuming a stationary receptor, may occur up to 26km from the array area (4,400kJ hammer energy based on SEL_{cum}). Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) showed the potential for TTS in this scenario may occur up to 22km from the array area. When considered in the context of a fleeing receptors the impact ranges reduce to 10km for both the worst case and most likely scenarios.

8.9.86 Modelling locations from the array area show noise contours (186 dB SEL_{cum}) do not overlap with herring spawning grounds which is located 34.2km away from the 15km fish and shellfish buffer around the PEIR Assessment Boundary array area (Coull *et al.,* 1998; Ellis *et al.,* 2010, **Figure 8-17, Volume 3**).

Magnitude of impact

8.9.87 Based on Hawkins *et al*. (2014a) 135 dB SEL_{cum} noise contours from the array area, an overlap does not occur with the Downs herring spawning grounds (see **Figure 8-18, Volume 3**), however the noise contours do overlap an area of high larval abundance (IHLS 2007-2020; 80,000 to 98,500 per m^2) from the southern piling locations within the array area, therefore the temporal impacts from piling on herring are predicted to be medium. However, as detailed in **paragraphs 8.9.27** and **8.9.56** the injurious effect thresholds for monopiles in the east of the array area (4,400kJ) does not show an overlap from the array noise contours with herring spawning grounds, or areas of high larval abundances. Taking into consideration the locations of herring spawning grounds relative to the piling locations of the Proposed Development (**Figure 8-18, Volume 3**), and the limited temporal impacts, the magnitude of impact that construction activities relating to the Proposed Development will have on herring is therefore considered to be **negligible** for TTS.

Sensitivity or value of receptor

8.9.88 Herring (Group 4) are known to inhabit the English Channel with the PEIR Assessment Boundary and associated ZOI located 34.2km north of a regional important herring spawning ground. As noted in **paragraph 8.9.30** the sensitivity of herring to noise impacts is therefore considered to be **high**.

Significance of residual effect

8.9.89 Herring have a swim bladder that is involved in hearing and therefore are known to be sensitive to underwater noise. Key herring spawning and nursery habitats are located outside of the fish and shellfish study area. Herring are demersal spawners and are therefore considered stationary receptors in the assessment, increasing their exposure to underwater noise from the construction phase of the Proposed Development. The magnitude of impact is considered to be **negligible** for TTS. Due to their sensitivity to underwater noise, and likelihood of disturbance to spawning herring, the species are assessed as having **high** sensitivity to underwater noise during construction, and therefore the effect on herring is predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Black seabream

Overview

8.9.90 The potential for TTS of black seabream (186 dB SEL_{cum}) may occur up to a maximum range of 26km from the array area (assuming static receptors) (4,400kJ hammer energy in the north-west of the array area, based on SEL_{cum}). Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) showed the potential for TTS in this scenario may occur up to a maximum range of 22km from the array area (assuming static receptors). Modelling locations from the array area show noise contours from monopiles (186 dB SEL_{cum}) will overlap with black seabream spawning/nesting grounds. When considered in the context of a fleeing receptors the impact ranges reduce to 10km for both the worst case and most likely scenarios.

Magnitude of impact

8.9.91 Black seabream spawning and nesting grounds are located within the noise contours of piling within the PEIR Assessment Boundary array area. Taking into consideration the locations of black seabream spawning and nesting grounds relative to the piling locations of the Proposed Development (**Figure 8-19, Volume 3**), and the limited temporal impacts, the magnitude of the impact that construction activities relating to the Proposed Development will have on black seabream is considered **moderate** for TTS effects.

Sensitivity or value of receptor

8.9.92 Black seabream (Group 3) spawning and nursery are present within the PEIR Assessment Boundary fish and shellfish study area, specifically within the proposed offshore export cable corridor, which is located adjacent to the Kingmere MCZ. As noted in **paragraph 8.9.36** the sensitivity of black seabream to noise impacts is therefore considered to be **high**.

Significance of residual effect

8.9.93 Black seabream have a swim bladder close to, but not intimately connected to the ear. Key spawning and nesting grounds for black seabream are located north of the array area within the fish and shellfish study area. Black seabream are demersal spawners and are therefore considered stationary receptors in the assessment, increasing their exposure to underwater noise from the potential piling operations during the construction phase of the Proposed Development. Due to their sensitivity to underwater noise, and likelihood of disturbance to spawning and nesting black seabream, the species were assessed as having **high** sensitivity to underwater noise during construction. For TTS there is equally limited interaction with the areas of primary importance for breeding black seabream and the magnitude is considered to be **moderate**, and the associated effect therefore of **moderate adverse significance** (**not significant** in EIA terms).

Other fish and shellfish receptors

Overview

8.9.94 The majority of other fish and shellfish receptors (see **Table 8-15**) of the Proposed Development are Group 1 fish receptors with the exception of cod, whiting (Group 3 receptors) and sprat (Group 4); these species are all considered mobile and will be expected to vacate the area in which the impact could occur with the onset of 'soft start'/ramp up piling activity. Cod, whiting and sprat have spawning and nursery grounds across and within the vicinity of the array area. The areas impacted by noise in the context of the wider spawning and nursery grounds in the region are considered to be small.

8.9.95 The potential for TTS of seahorse (186 dB SEL_{cum}) may occur up to a maximum distance of 37km from the array area (assuming static receptors) (4,400kJ hammer energy in the east of the array area, based on SEL_{cum}) and a maximum distance of 21km for a fleeing receptor. Noise modelling for the most likely impacts from monopile installation (4,000kJ hammer energy) showed the potential for TTS in this scenario may occur up to a maximum distance of 33km (assuming static receptors) from the array area and a maximum distance of 20km for a fleeing receptor, a reduced impact than that predicted from the maximum design scenario hammer energies.

Magnitude of impact

8.9.96 All other fish and shellfish species and their respective spawning grounds are distributed widely throughout the English Channel and into the southern North Sea, and therefore taking the wider environment into context, the magnitude of effect on all other fish and shellfish receptors are assessed as being **minor** from impacts associated with piling within the array area.

Sensitivity or value of receptor

8.9.97 As noted above in **paragraph 8.9.41** the sensitivity of shellfish to underwater noise impacts is therefore considered to be **high**. Cod, whiting, sprat, allis and twaite shad and European eel are considered to be of medium vulnerability, high recoverability and of regional to international importance. The sensitivity of these receptors is therefore considered to be **high**.

8.9.98 All other fish and shellfish within the study area are deemed to be of low vulnerability, medium recoverability and of local to international importance. The sensitivity of these receptors is therefore considered to be **high**.

Significance of residual effect

8.9.99 The majority of other fish species in this assessment lack swim bladders and are therefore considered to be less sensitive to underwater noise (Group 1). Whilst some species have spawning and nursery grounds within the fish and shellfish study area, they typically occur over a large area and into the southern North Sea, any disturbance to spawning is considered small in the context of the wider habitat availability. Cod and whiting (Group 3) have spawning and nursery grounds occurring over a large area and into the southern North Sea, and therefore any disturbance from construction noise to spawning is considered small in the context of the wider habitat availability. Both species are considered mobile, and therefore are expected to vacate the area in which the impact could occur with the onset of 'soft start'/ramp up piling. Taking all of this into account, all other fish species are assessed as having **high** sensitivity to underwater noise during construction, and a **minor** magnitude of impact, the effects on these species are therefore predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Eggs and larvae

Overview

8.9.100 Impacts on sandeel, herring and black seabream eggs were assessed using Popper *et al.* (2014) criteria, in terms of risk of recoverable injury (see **paragraph 8.9.73**).

Magnitude of impact

8.9.101 For TTS the Popper *et al.* (2014) criteria are the same, and therefore a moderate degree of disturbance at near field distance (10s of meters) from the source is predicted on sandeel, black seabream and herring eggs and larvae, with a low degree of disturbance in the intermediate (100s of meters) and far field (1000s of meters) (see **Table 8-16**). The magnitude of impact is therefore considered **negligible**.

Sensitivity or value of receptor

8.9.102 As noted in **paragraph 8.9.49** eggs and larvae will not be able to flee the vicinity of the foundations during piling, however prolonged exposure could be reduced by any drift of eggs/larvae due to water currents which may reduce the risk of mortality. As a result, larval stages are considered of **high** sensitivity.

Significance of residual effect

8.9.103 As eggs and larvae lack swim bladders or the connection between the swim bladder and the inner ear has not yet formed at this stage, they are therefore considered to be less sensitive to underwater noise. Whilst some species have spawning and nursery grounds within the fish and shellfish study area, they typically occur over a large area within the English Channel and into the southern North Sea, therefore for most species any disturbance is considered small in the context of the wider habitat availability. Taking all of this into account, eggs and larvae are assessed as having **high** sensitivity to underwater noise during construction, and a **negligible** magnitude of impact, the effects on these species are therefore predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Behavioural impacts

Introduction

8.9.104 Different fish and shellfish have varying sensitivities to pilling noise, depending on how these species perceive sound in the environment. Behavioural effects in response to construction related underwater noise include a variety of responses including startle response (C-turn), strong avoidance behaviour, changes in swimming or schooling behaviour, or changes of position in the water column (for example Hawkins *et al.,* 2014a). Depending on the strength of the response and the duration of the impact, there is the potential for some of these responses to lead to significant effects at an individual level (for example reduced fitness, increased susceptibility to predation) or at a population level (for example 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. Popper *et al.* (2014) provide qualitative behavioural criteria for fish from a range of sources. These categories are noted in **Table 8-16** above and in **Table 8-20** below.

8.9.105 The behaviour response of fish and shellfish to underwater noise are highly dependent on factors such as the type of animal, sex, age and condition, as well as other stressors to which the fish/shellfish is or has been exposed.

Table 8-20 Criteria for onset of behavioural effects in fish due to piling activity (Popper *et al.,* 2014).

Type of animal	Impairment	
	Auditory masking	**Behaviour**
Fish: no swim bladder (Group 1)	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (Group 2)	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low

Fish: swim bladder involved in hearing (Group 3 and 4)	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Eggs and larvae	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low
Risk of effect category (high, moderate low) is given at three distances from the source in relative terms: near field (N: 10s of metres), intermediate field (I: 100s of metres), and far field (F: 1000s of metres); (Popper *et al.,* 2014).		

8.9.106 Fish from Group 1 and Group 2, and shellfish are considered to be less sensitive to sound pressure, with these species detecting sound in the environment through particle motion. Fish sensitivity to the acoustic particle velocity component of the sound field has been noted by a number of researchers (Hawkins, 2006; Nedwell *et al.,* 2007; Popper and Hastings, 2009) and the potential for piling activity to generate the type of sound fields that may contain substantial acoustic particle velocity components has been noted in the literature (Hawkins, 2009). Sensitivity to particle motion in fish is also more likely to be important for behavioural responses rather than injury (Hawkins, 2009; Mueller-Blenkle *et al.,* 2010; Hawkins *et al.,* 2014a).

8.9.107 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). Aquatic decapod crustaceans are equipped with a number of receptor types potentially capable of responding to the particle motion component of underwater noise (for example the vibration of the water molecules which results in the pressure wave) and ground-borne vibration (Popper *et al.,* 2001). It is generally their hairs that provide the sensitivity, although these animals also have other sensor systems which could be capable of detecting vibration. 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 fish (sandeel) and shellfish in close proximity to piling operations. Sandeel may be particularly affected by vibration through the seabed during winter hibernation when sandeel remain buried in sandy sediments.

8.9.108 When considering particle motion, it should be noted that little to no data exists on the effect on demersal fish or shellfish species or on the levels generated during marine impact piling (Hawkins and Popper, 2016). However, as indicated by the risk criteria outlined for Groups 1 and 2 in **Table 8-15**, particle motion generated from piling is expected to attenuate more rapidly than the acoustic pressure component in the water, with a low risk of behavioural effects in the far-field (for instance kilometres from the source). Behavioural effects on Group 1 and 2 fish and shellfish receptors in the Rampion 2 PEIR Assessment Boundary fish and shellfish ecology study area, for which particle motion is most relevant, are likely to be spatially limited to within kilometres of piling operations. Although spawning and nursery habitats are present within the Rampion 2 PEIR Assessment Boundary fish and shellfish study area, these extend over a wide area across the Eastern English Channel and into the southern North Sea (for example, Dover sole, lemon sole, plaice, and sandeel). The relative proportion of these habitats affected by piling operations at any one time will therefore be small in the context of the wider habitat available.

8.9.109 Group 3 and 4 fish are more sensitive to the sound pressure components of underwater noise (see **paragraph 8.9.13**) and therefore the risks of behavioural effects in the intermediate field and far field are greater for these species (as indicated in **Table 8-20**). A number of studies have examined the behavioural effects of the sound pressure component of impulsive noise (including piling operations and seismic airgun surveys) on fish species, including Group 3 gadoids. Mueller-Blenkle *et al.* (2010) measured behavioural responses of cod (and Dover sole) to sounds representative of those produced during marine piling, with considerable variation across subjects (for instance depending on the age, sex, condition etc. of the fish, as well as the possible effects of confinement in cages on the overall stress levels in the fish). This study concluded that it was not possible to find an obvious relationship between the level of exposure and the extent of the behavioural response, although an observable behavioural response was reported at 140 to 161 dB re 1 µPa SPL_{peak} for cod and 144 to 156 dB re 1 µPa SPL_{peak} for Dover sole. However, these thresholds should not be interpreted as the level at which an avoidance reaction will be elicited, as the study was not able to show this.

8.9.110 A study by Pearson *et al.* (1992) on the effects of geophysical survey noise on caged rockfish (*Sebastes* species) observed a startle or C-turn response at peak pressure levels beginning around 200 dB re 1 µPa, although this was less common with the larger fish. Studies by Curtin University in Australia for the oil and gas industry by McCauley *et al*. (2000) exposed various fish species in large cages, in open water to seismic airgun noise and assessed behaviour, physiological and pathological changes. The study made the following observations:

- a general fish behavioural response to move to the bottom of the cage during periods of high level exposure (greater than root mean square (RMS) levels of around 156 to161 dB re 1 µPa; approximately equivalent to SPL_{peak} levels of around 168 to 173 dB re 1 µPa);
- a greater startle response by small fish to the above levels;
- a return to normal behavioural patterns some 14 to 30 minutes after airgun operations ceased;
- no significant physiological stress increases attributed to air gun exposure; and
- some preliminary evidence of damage to the hair cells when exposed to the highest levels, although it was determined that such damage will only likely occur at short range from the source.

8.9.111 The authors did note that any potential seismic effects on fish may not necessarily translate to population scale effect or disruption to fisheries and McCauley *et al*. (2000) show that caged fish experiments can lead to variable results. While these studies are informative to some degree, these, and other similar studies, do not provide an evidence base that is sufficiently robust to propose quantitative criteria for behavioural effects (Hawkins and Popper, 2016; Popper *et al*., 2014).

Table 8-21 Behavioural noise response criteria (McCauley *et al.,* 2000; Hawkins *et al.,* 2014a; Pearson *et al.,*1992).

Potential response	Behavioural response criteria for fish species (SPL_{peak} (dB re 1 µPa))
Possible moderate to strong avoidance (McCauley *et al.,* 2000)	168 to 173
Possible avoidance of sprat (proxy for herring) (Hawkins *et al.,* 2014a)	163.2 (135 SEL)
Startle response or C-turn reaction (Pearson *et al.,* 1992)	200

8.9.112 Through reference to the available literature, it is proposed to adopt McCauley *et al.* (2000) thresholds using a precautionary approach of 163 dB re 1 µPa (SPL_{peak}) for the consideration of potential disturbance to black seabream, over the threshold of 168 dB re 1 µPa more frequently employed (see **Table 8-21** above). This corresponds with the point at which European seabass (*Dicentrarchus labrax*) demonstrate an observable response. (change in respiratory behaviour) (Radford *et al.,* 2016). Whilst Hawkins *et al.* (2014a) note that the observed behavioural effects in sprat and mackerel recorded within the publication should not be used as a broader threshold of effect, in particular as it is not representative of the receiving environment at locations such as the Proposed Development, it is considered to provide context when describing the potential for behavioural effects in herring, as it focuses on species from the Clupeidae family. The Hawkins et al. (2014a) study recorded 163.2 SPL_{peak} and estimated single strike SEL of 135dB re 1 µPa2·s for sprat.

8.9.113 As noted above, fish and shellfish behavioural responses to underwater noise are highly dependent on factors such as the type of fish/shellfish, sex, age and condition, as well as other stressors to which the fish/shellfish is or has been exposed. For example, it is expected that smaller fish might show behavioural responses at lower levels. In addition to this, the response of the fish will depend on the reasons and drivers for the fish being in the area. Foraging or spawning, for example, may increase the desire for the fish to remain in the area despite the elevated noise level (Peña *et al.,* 2013).

8.9.114 When considering lower levels of construction noise, such as that from vessels, cable installation, and other methodologies that do not involve percussive piling, the predicted noise levels are expected to be far lower. As such, the extent to which this noise may cause a behavioural response will be far lower. Effects from lower-level noise may include disturbance to predation behaviour and auditory masking of communication (Mueller-Blenkle *et al.,* 2010; Thomsen *et al.,* 2006).

8.9.115 This lower-level noise will however be generated more constantly compared to piling noise, which is more intermittent, however the lower level of noise generated will be short-term in the context of the construction phase and will not affect the same spatial extent over the entire construction phase. Considering the high levels of vessel traffic in the region, as well as various cable installations and aggregate production areas, it is likely that fish are at least in part habituated to high levels of background noise. It is therefore considered highly unlikely that such noise will have a significant impact on fish species.

Sandeel

Overview

8.9.116 Sandeel (Group 1) lack a swim bladder and therefore have low sensitivity to impacts from noise, therefore behavioural effects on this species are expected to be reduced. Sandeel spawning and nursery habitats are present within the PEIR Assessment Boundary fish and shellfish study area, these tend to extend over a wide area, and the relative proportion of these habitats affected by piling operations at any one time will therefore be small in the context of the wider habitat available. Therefore, considering the McCauley *et al.* (2000) 168dB SPL_{peak}, any risk of behavioural effects or auditory masking in sandeel from piling are expected to be low. Moreover, when taking into consideration the Popper *et al.* (2014) criteria, any risk of behavioural effects or auditory masking for sandeels from piling are expected to be a low degree of disturbance at a far-field distance. (see **Table 8-20**).

Magnitude of impact

8.9.117 Low intensity sandeel spawning and nursery habitats are located in the PEIR Assessment Boundary fish and shellfish study area (see **Figure 8-3** and **Figure 8-9, Volume 3**). It should be noted however that the degree of overlap between spawning and nursery grounds of these species and the area with potential for behavioural impacts is very small relative to the total area that the species could use for spawning in the English Channel and the southern North Sea (Jensen *et al.,* 2011).Therefore taking this into account, the spatial extent of the impact in the context of the wider environment is considered small, with the overall short duration of piling and its intermittent nature, together with the fact that any effect associated with behavioural impacts will be temporary, the magnitude of impact that construction activities relating to the Proposed Development will have on sandeel is therefore considered to be **minor**.

Sensitivity or value of receptor

8.9.118 Sandeel (Group 1) spawning and nursery habitats are present within the PEIR Assessment Boundary fish and shellfish study area, as noted in **paragraph 8.9.25** these tend to extend over a wide area, and therefore the sensitivity of the receptor to noise impacts is therefore considered to be **high.**

Significance of residual effect

8.9.119 Sandeel lack a swim bladder and are therefore considered less sensitive to underwater noise. Sandeel spawning habitat occurs over a large area across the English Channel and into the southern North Sea, including within the PEIR Assessment Boundary. Due to their demersal nature, sandeel are considered a stationary receptor to underwater noise in this assessment, and therefore will be exposed to underwater noise from piling activity during the construction phase of the Proposed Development. However, due to their reduced sensitivity, and small degree of disturbance to spawning grounds in the context of the wider habitat availability in the English Channel and within the southern North Sea, the species are assessed as having **high** sensitivity to underwater noise during construction, and the magnitude of impact is deemed to be **minor**, therefore the effect on sandeel is predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Herring

Overview

8.9.120 Group 4 fish are more sensitive to the sound pressure components of underwater noise and therefore the risks of behavioural effects in the intermediate and far-fields are greater for these species. Herring have a swim bladder which is involved with hearing, and therefore behavioural effects or auditory masking are expected to be greater, potentially occurring over the range of tens of kilometres, although as detailed above, this may not result in a strong avoidance reaction. Key spawning habitats for herring are located 34.2km to the south of the PEIR Assessment Boundary fish and shellfish study area (including the 15km buffer), and therefore the adult spawning herring within these habitats are expected to be affected by construction related underwater noise from piling operations. Therefore, considering Hawkins *et al.* (2014a) 135 dB, which results in a maximum range of 62km from the southern modelling location, there is a risk of potential disturbance; it is important in this context however to note that the use of the 135dB SEL threshold in an open water receiving environment characterised by shipping is highly precautionary and very unlikely to elicit a comparable response to that observed by Hawkins *et al.* (2014).

Magnitude of impact

8.9.121 Based on Hawkins *et al*. (2014a) 135 dB SEL_{cum} noise contours from the array area, an overlap does not occur with the Downs herring spawning grounds (see **Figure 8-18, Volume 3**), however the noise contours do overlap an area of high larval abundance (IHLS 2007-2020; 80,000 to 98,500 per m^2) from the southern piling locations within the array area, therefore the temporal impacts from piling on herring are predicted to be medium. However, as detailed in **paragraphs 8.9.27** and **8.9.56** the injurious effect thresholds for monopiles in the east of the array area (4,400kJ) does not show an overlap from the array noise contours with herring spawning grounds, or areas of high larval abundances. Taking into consideration the locations of herring spawning grounds relative to the piling locations of the Proposed Development (**Figure 8-18, Volume 3**), and the limited temporal impacts, the magnitude of impact that construction activities relating to the Proposed Development will have on herring is therefore considered to be **minor** for behavioural interactions, as only those southern piling location may cause an interaction.

Sensitivity or value of receptor

8.9.122 Herring (Group 4) are known to inhabit the English Channel with the PEIR Assessment Boundary and associated ZOI located 34.2km north of a regional important herring spawning ground. As noted in **paragraph 8.9.30** the sensitivity of herring to noise impacts is therefore considered to be **high**.

Significance of residual effect

8.9.123 Herring have a swim bladder that is involved in hearing and therefore are known to be sensitive to underwater noise. Key herring spawning and nursery habitats are located outside of the fish and shellfish study area. Herring are demersal spawners and are therefore considered stationary receptors in the assessment, increasing their exposure to underwater noise from the construction phase of the Proposed Development. The magnitude of impact is considered to be **minor** for behavioural interactions, as only those southern piling locations may cause an interaction. Due to their sensitivity to underwater noise, and likelihood of disturbance to spawning herring, the species are assessed as having **high** sensitivity to underwater noise during construction, and therefore the effect on herring is predicted to be of **minor adverse significance** (**not significant** in EIA terms).

Black seabream

Overview

8.9.124 Black seabream (Group 3) are sensitive to both particle motion and sound pressure and similarly to herring the risks of behavioural effects in the intermediate and far-fields are greater for these species. Black seabream have a swim bladder that is close, but not intimately connected to the ear, and therefore behavioural effects or auditory masking are expected to be greater, potentially occurring over the range of tens of kilometres, although as detailed above, this may not result in a strong avoidance reaction.

8.9.125 It should be noted that the maximum design scenario noise impacts from monopile installation (4,400kJ) causing a behavioural response on stationary black seabream may occur between 11km and 33km from the array. This is due to a conservative range of 163dB SPL_{peak} has been modelled based on the McCauley *et al.* (2000) study and using European seabass a suitable proxy. A number of scientific papers have been published on the implications for European seabass subjected to impulsive noise. Radford *et al.,* 2016 in particular noted that seabass exposed to impulsive noises (163dB SPL_{peak}) exhibited changes in behaviour and respiratory rates. Whilst any sound level used for the purposes of understanding potential behavioural responses the 163dB SPL_{peak} threshold is considered to be highly precautionary and suitable for the purposes of understanding the potential for interaction with black seabream present within the Kingmere MCZ.

8.9.126 Key spawning habitats for black seabream are located north of the Rampion 2 PEIR Assessment Boundary array area and within the offshore export cable corridor, and therefore the adult spawning black seabream within these habitats is expected to be affected by construction related underwater noise from piling operations. The modelled outputs, for both the worst-case and most likely scenarios, indicate that the area within Kingmere MCZ and the immediate surrounds (10km of the MCZ) within which black seabream are recognised to be present, will be subject to minimal interaction during piling within the eastern reaches of the proposed array, but may be subject to interaction during piling within the north-west reaches of the proposed array. Therefore, considering the McCauley *et al.* (2000) 163dB SPL_{peak}, any risk of behavioural effects or auditory masking in black seabream from piling are expected to be high.

Magnitude of impact

8.9.127 Black seabream spawning and nesting grounds are located within the noise contours of piling within the PEIR Assessment Boundary array area. Taking into consideration the locations of black seabream spawning and nesting grounds relative to the piling locations of the Proposed Development (**Figure 8-19, Volume 3**), and the limited temporal impacts, the magnitude of the impact that construction activities relating to the Proposed Development will have on black seabream is considered **moderate** for behavioural effects.

Sensitivity or value of receptor

8.9.128 Black seabream (Group 3) spawning and nursery are present within the PEIR Assessment Boundary fish and shellfish study area, specifically within the proposed offshore export cable corridor, which is located adjacent to the Kingmere MCZ. As noted in **paragraph 8.9.36** the sensitivity of black seabream to noise impacts is therefore considered to be **high**.

Significance of residual effect

8.9.129 Black seabream have a swim bladder close to, but not intimately connected to the ear. Key spawning and nesting grounds for black seabream are located north of the array area within the fish and shellfish study area. Black seabream are demersal spawners and are therefore considered stationary receptors in the assessment, increasing their exposure to underwater noise from the potential piling operations during the construction phase of the Proposed Development. Due to their sensitivity to underwater noise, and likelihood of disturbance to spawning and nesting black seabream, the species are assessed as having **high** sensitivity to underwater noise during construction. For behavioural effects, noting the interaction with the Kingmere MCZ and areas of highest spawning activity the magnitude is considered to be **moderate**, and the associated effect on spawning black seabream, therefore predicted to be of **moderate adverse significance** (potentially **significant** in EIA terms) in the absence of mitigation. Whilst a specific mitigation measure has not been embedded into the design of the Proposed Development at this stage there are a suite of suitable measures currently being considered. Such measures can provide a demonstrable reduction in magnitude and therefore could reduce the overall significance to below moderate significance (and therefore not significant with regards the EIA Regulations). The potential measures include noise abatement at source, through the use of appropriate technology, noting multiple different technology options are available. Mitigation options will be investigated and defined through the ES process, and therefore available to reduce the effect and as such it is not considered likely that a significant effect will be realised.

Other fish and shellfish receptors

Overview

8.9.130 The majority of other fish and shellfish receptors (see **Table 8-15**) of the Proposed Development are Group 1 fish receptors with the exception of cod and whiting (Group 3 receptors) and sprat (Group 4); these species are all considered mobile and are expected to vacate the area in which the impact could occur with the onset of 'soft start' piling. Moreover, spawning habitat for cod and sprat coincide with Rampion 2 PEIR Assessment Boundary fish and shellfish study area and extend across the English Channel and into the southern North Sea and effects on these habitats are expected to occur. The proportion of these habitats that are likely to be affected by underwater noise from piling operations within the Proposed Development are expected to be small in the context of the widespread nature of these habitats in the fish and shellfish study and in the English Channel and southern North Sea as a whole. Therefore, taking into consideration the Popper *et al.* (2014) criteria, any risk of behavioural effects or auditory masking in Group 1 fish receptors from piling are expected to be a low degree of disturbance at a far-field distance. The Group 3 fish receptors from piling are expected to be moderate in the far-field, and high within the intermediate field (see **Table 8-20**).

8.9.131 There is limited literature and research on the effects of underwater noise on seahorse. A study by Anderson *et al.* (2011) examined the behavioural response of the lined seahorse (*H. erectus*) exposed to 123dB to 137dB rms re 1µPa in a tank for one month. Seahorses responded both behaviourally and physiologically, displaying a chronic stress response. Seahorse exposed to loud noises showed a behavioural response such as irritation and distress, and a physiological response, including lower weight, worse body condition, higher plasma cortisol and other blood measures indicative of stress, and more parasites in their kidneys. In addition to the primary and secondary stress indices in the blood and plasma, seahorses exhibited tertiary indices (for example growth, behaviour, and mortality) (Anderson *et al.,* 2011). However, the study found that some of the variability in these measures (such as time spent mobile) subsided after the first week, presumably due to habituation. It is important to note that Radford *et al.* (2016) recorded shipping sound levels of 124 dB rms re 1µPa, seismic survey noise levels at 131dB rms, and pile driving at 141dB rms; in this context seahorses can be expected to habituate to the noise levels that may be experienced during piling for the Proposed Development.

8.9.132 Effects on migratory species may also occur as a result of construction related underwater noise from the Proposed Development. European eel are in Group 3 and are expected to have some sensitivity to both particle motion and sound pressure components of piling noise (see **paragraph 8.9.13**) and therefore may show some behavioural responses in the far field, although as discussed above, these may not necessarily include strong avoidance responses. Salmonids (including salmon and trout) are included in Group 2 Fish (see **paragraph 8.9.13**) and are therefore sensitive to the particle motion component of piling noise, with a low risk of behavioural effects in the far field. Sea lamprey are also in Group 2 and are similarly expected to be more sensitive to the particle motion component of piling noise (see **paragraph 8.9.13**), again with a low risk of behavioural effects in the far field. Due to the temporary and intermittent nature of any potential noise impacts, significant effects on migration, including barrier effects, effects on coastal migrations or movement to/from coastal habitats during key migration periods, is not expected.

Magnitude of impact

8.9.133 All other fish and shellfish species and their respective spawning grounds are distributed widely throughout the English Channel and into the southern North Sea, and therefore taking the wider environment into context, the magnitude of effect on all other fish and shellfish receptors are assessed as being **minor** from impacts associated with piling within the array area.

8.9.134 As detailed in **paragraphs 8.9.114** and **8.9.115**, construction noise from vessels, cable installation, and other methodologies that do not include pilling are considered unlikely to result in a significant impact on fish species. The impact of construction related underwater noise is predicted to be of local to regional spatial extent, short duration, intermittent and reversible (for non-injurious effects). It is predicted that the impact will directly affect fish and shellfish receptors. The magnitude of the impact is therefore considered to be **minor**.

Sensitivity or value of receptor

8.9.135 As noted above in **paragraph 8.9.41** the sensitivity of shellfish to underwater noise impacts is therefore considered to be **high**.

8.9.136 Cod, whiting, sprat, allis and twaite shad and European eel are considered to be of medium vulnerability, high recoverability and of regional to international importance. The sensitivity of these receptors is therefore considered to be **high**.

8.9.137 All other fish and shellfish within the study area are deemed to be of low vulnerability, medium recoverability and of local to international importance. The sensitivity of these receptors is therefore considered to be **high**.

Significance of residual effect

8.9.138 The majority of other fish species in this assessment lack swim bladders and are therefore considered to be less sensitive to underwater noise (Group 1). Whilst some species have spawning and nursery grounds within the fish and shellfish study area, they typically occur over a large area and into the southern North Sea, any disturbance to spawning is considered small in the context of the wider habitat availability. Cod and whiting (Group 3) have spawning and nursery grounds occurring over a large area and into the southern North Sea, and therefore any disturbance from construction noise to spawning is considered small in the context of the wider habitat availability. Both species are considered mobile, and therefore are expected to vacate the area in which the impact could occur with the onset of 'soft start'/ramp up piling. Taking all of this into account, all other fish species are assessed as having **high** sensitivity to underwater noise during construction, and a **minor** magnitude of impact, the effects on these species are therefore predicted to be of **minor adverse significance** (**not significant** in EIA terms).

UXO clearance and noise vibrations

Introduction

8.9.139 RED is not applying for permission to undertake UXO clearance works as part of this Application, however, it is acknowledged that UXO clearance is likely to comprise part of the Proposed Development, albeit under a separate Marine Licence application (see C-58, **Table 8-11**), and as such, it is appropriate to consider the potential impacts of this additional source of underwater noise on fish and shellfish species.

8.9.140 UXO clearance activities are one of the loudest anthropogenic noise sources that occur underwater. 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. 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. Existing information suggests that there may be temporary or partial loss of hearing at high sound levels, especially in fish where the swim bladder enhances sound pressure detection. In the case of behavioural impacts, it is considered that startle responses are likely to occur if the received signal is of sufficient magnitude. Such responses last less than a second and do not necessarily result in significant changes in subsequent behaviour (Popper *et al.,* 2014).

8.9.141 It is possible that UXO operations will be planned to take place year-round during the UXO clearance campaign pre-construction and therefore has 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 operations.

8.9.142 Due to the early stage for the Proposed Development and the consequent lack of detailed site-specific magnetometer data and the need for UXO clearance activities to be undertaken sufficiently close to construction to ensure the safety certification remains valid, it is not currently possible to define the number (if any) of UXO which may require clearance prior to the start of construction. Therefore, the assessment below presents potential impact ranges from a variety of charge sizes which will be expected within the PEIR Assessment Boundary.

8.9.143 The UXO clearance operations will follow the avoid, reduce, mitigate process, with first intention being to avoid the need to detonate the UXO by micrositing infrastructure. In many instances, this will not be possible and therefore, for clearance operations, two primary types of clearance will be considered:

- High order – this comprises using a donor charge of explosive (typically between 5 – 20kg) to trigger a detonation of the explosive within the UXO; and

- Low order – this comprises a number of methods which use a small amount (up to 2kg) of explosive to destroy the explosive material without detonating it, such as burning out the explosive (deflagration) or disrupting the explosive using high pressure water jets (named “low yield”).

8.9.144 The worst-case scenario will be all high order clearance, with impact ranges from low order techniques being smaller than those presented herein. The clearance techniques used at the time will employ industry best practice, with due consideration given to developing technology/techniques which are currently being introduced to the market (for instance low order techniques) and a full assessment of the potential impacts from UXO clearance works will be presented in a separate Marine Licence application at the time will be drafted accordingly. **Table 8-22** below details the expected mortality and potential mortal injury impact ranges for high order clearance from the potential variety of UXO sizes which may be encountered. While individual UXO detonations have the potential to result in greater impact ranges than piling activity, the discrete nature of a UXO detonation (a very short-term single noise event) is considered to result in a lesser overall effect on populations of fish and shellfish species.

8.9.145 The risks of mortality and potential mortal injury effects from UXO clearance will be managed through the development of a UXO specific MMMP which will mitigate impacts from UXO (which will be identified through targeted survey post-consent/pre-construction see C-58, **Table 8-11**), including consideration of alternative clearance techniques (for example low order instead of high) and displacement methods (acoustic deterrent devices (ADDs)) to remove animals from the risk area. A further potential environmental measure for UXO clearance is the use of bubble curtains for high order detonations which will reduce the impact ranges from those predicted herein (**Table 8-22**). However, these are not currently a commitment and therefore the assessment is not based on the use of these. It is likely that by the time RED applies for a separate UXO Marine Licence, industry knowledge around the contribution of bubble curtains to reducing underwater noise will be further advanced and this knowledge will be incorporated within the assessments and mitigation design (for example ongoing BEIS workstream of underwater noise impacts from UXO). Any required measures will therefore be applied to and secured in the Marine Licence application for UXO clearance to be made at that time.

8.9.146 In order to inform this assessment, estimated ranges of impact associated with UXO detonations for different charge weights have been calculated to provide an indication of the ranges at which mortality/potential injury may occur on fish species (see **Appendix 11.2, Volume 4**). As outlined in Popper *et al.* (2014) fish species are considered to be at risk of mortality or potential mortal injury at a peak SPL of 229 dB re 1µPa. The ranges at which this noise level could occur are provided in **Table 8-22**.

Table 8-22 Summary of the impact ranges for UXO detonation using the unweighted SPL_{peak} explosion noise criteria from Popper *et al.* (2014) for species of fish

Popper *et al.* (2014) Unweighted SPL_{peak}	25kg	55kg	120kg	240kg	525kg

Mortality and potential mortal injury	234 dB	170m	230m	290m	370m	490m
	229 dB	290m	380m	490m	620m	810m

8.9.147 The risk of recoverable injury (including PTS), TTS and behavioural impacts are presented qualitatively in line with Popper *et al.* (2014) approach in **Table 8-23** and **Table 8-20**. It should be noted that the risks outlined in **Table 8-23** provided gives specific impact criteria for explosions. As noted above MMMP for UXO clearance will be developed in the pre-construction period (in consultation with the relevant stakeholders and the MMO), detailing the required mitigation measures to minimise the potential risk of physical and auditory injury (PTS) as a result of underwater noise during UXO clearance. This will also reduce the risk to fish and shellfish species.

Table 8-23 Summary of the qualitative effects on species of fish from explosions (Popper *et al.,* 2014)

Type of animal	**Impairment**			**Behaviour**
	Recoverable injury	**TTS**	**Auditory masking**	
Fish: no swim bladder (Group 1)	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	N/A	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (Group 2)	(N) High (I) High (F) Low	(N) High (I) Moderate (F) Low	N/A	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing (Group 3 and 4)	(N) High (I) High (F) Low	(N) High (I) High (F) Moderate	N/A	(N) High (I) High (F) Moderate
Eggs and larvae	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	N/A	(N) Moderate (I) Low (F) Low
Risk of effect category (high, moderate low) is given at three distances from the source in relative terms: near field (N: 10s of metres), intermediate field (I: 100s of metres), and far field (F: 1000s of metres); (Popper *et al.,* 2014).				

Magnitude of impact

8.9.148 As detailed above, where the detonation of UXO within the PEIR Assessment Boundary is required, it may result in injury and disturbance to fish species in the vicinity of the UXO detonation. Physical injury/trauma will occur in close proximity to the UXO detonation, with TTS and behavioural effects occurring at greater distance. Given the short and intermittent nature of this activity (limited to instances when detonation of UXO is required) The effects from underwater noise (mortality and potential mortal injury) from UXO on fish and shellfish when considering the embedded environmental measures (see C-58 in **Table 8-11**) and the fact that for the most part any effects will be limited to the vicinity of the area where the detonation takes place, the magnitude of the effect is considered to be **minor**.

Sensitivity or value of receptor

8.9.149 There is potential for UXO detonations with the PEIR Assessment Boundary array area and offshore export cable corridor during site preparation. The clearance of UXO will result in elevated noise levels with consequent effects on fish and shellfish behaviour, potentially over the same extent expected for piling operations (for instance at a range of kilometres). However, these detonations will represent very short duration occurrences (for instance seconds) and therefore will have a considerably shorter overall duration than piling operations.

8.9.150 There are no specific data currently published in respect of shellfish species, however studies on lobsters have shown no effect on mortality, appendage loss or the ability of animals to regain normal posture after exposure to very high sound levels (>220 dB) (Payne *et al.,* 2007). Similarly, studies of marine bivalves (for example mussels) exposed to a single airgun at a distance of 0.5m have shown no effects after exposure (Kosheleva 1992).

8.9.151 Whilst it is well established that explosions can result in potential mortality or injury to fish species at close range, there are no data on the effects of explosions on fish hearing (for example TTS) or behaviour currently available. Existing information suggests that there may be temporary or partial loss of hearing at high sound levels, especially in fish where the swim bladder enhances sound pressure detection. In the case of behavioural impacts, it is considered that startle responses are likely to occur if the received signal is of sufficient magnitude. As noted in **paragraph 8.9.140** such responses last less than a second and do not necessarily result in significant changes in subsequent behaviour (Popper *et al.,* 2014).

8.9.152 Taking account of the severity of the impact particularly at close range but acknowledging that impacts will occur at individual rather than at population levels, fish species are considered receptors of **high** sensitivity.

Significance of residual effect

8.9.153 Overall, the maximum sensitivity of fish and shellfish to underwater noise from UXO is consider **high**, with a maximum magnitude of effect predicted to be **minor**. Therefore, the significance of effect of underwater noise from UXO clearance is predicted to be of **minor adverse significance** which is **not significant** in EIA terms.

Direct disturbance resulting from the installation of the export cable

Introduction

8.9.154 Cable installation methods include ploughing, trenching or jetting (see **Chapter 4**). Cable burial is the preferred option, however where this is not possible, cable protection may be required. Cable burial will be informed by the cable burial risk assessment and detailed within the Cable Specification Plan (see C-45, **Table 8-11**).

Magnitude of impact

8.9.155 Disturbance will occur during the installation of the offshore export cable corridor as well as sediment disturbance during seabed preparation works prior to cable burial operations (including potential sandwave clearance). All fish and shellfish receptors have the potential to be affected by this impact through loss of spawning, nursery or feeding habitats, though demersal fish and shellfish species and demersal spawning species have the greatest potential to be affected.

8.9.156 As detailed in **Table 8-10,** the installation of up to four offshore export cables over a total distance of 140km a will equate to a maximum area of approximately 2km^2 of seabed habitat within the PEIR Assessment Boundary potentially subject to direct disturbance or loss during construction phase. This equates to 3.4 percent of the offshore export cable corridor area of search. The disturbance will be temporary during the four months of offshore export cable installation activity and habitats will be expected to recover to pre-installation condition where cables have been successfully buried below the seabed surface and habitats can naturally revert to baseline condition over time once the works have completed. RED have committed to cable burial where seabed conditions allow (see C-45, **Table 8-11**) in order that direct impacts to important fish and shellfish habitats can be avoided as far as practicable . Where this is not possible, cable protection may be required at the seabed surface. The installation of cable protection and cable crossings is regarded as permanent habitat loss/modification and the effects arising from the use of such is considered under the operation and maintenance phase (**Section 8.10**).

8.9.157 As described in **Chapter 9** predictive habitat model areas of patchy hard substrate or rock outcrop can occur across the middle of the offshore export cable corridor, with soft chalk or clay outcrops expected to occur in discreet locations also across the middle of the offshore export cable corridor. It is therefore noted that it may not be possible to avoid such seabed features. However, considering the availability of similar suitable habitat both in the PEIR Assessment Boundary and in the wider context of the English Channel together with the intermittent and reversible nature of the effect, the magnitude of temporary seabed disturbance during installation of the offshore export cable for the Proposed Development is considered to be **minor** for all receptors, with the exception of black seabream for which it is considered to be **moderate**.

Sensitivity or value of receptor

Overview

8.9.158 Thornback ray, undulate ray, tope, herring, sandeel and black seabream are all demersal spawners. Sandeel, herring and black seabream are substrate specific spawners and therefore are potentially more susceptible to any impacts relating to physical disturbance and temporary habitat loss.

Elasmobranch

8.9.159 Data relating to spawning grounds of tope, thornback ray and undulate ray is lacking from the scientific literature and are undefined by Ellis *et al.* (2010) and Coull *et al.* (1998), due to insufficient data on the occurrence of egg cases or egg-bearing females to delineate spawning grounds for these species (Ellis *et al.,* 2012). Nursery areas are however defined, and undulate ray, thornback ray and tope show overlapping low intensity nursery areas with the PEIR Assessment Boundary (Ellis *et al.,* 2012). It should be noted that despite this overlap both thornback ray and tope have widely distributed nursery areas around the UK, so the extent of disturbance is negligible in comparison. The sensitivity of tope, spurdog, thornback ray is considered **low**.

8.9.160 The undulate ray is commonly encountered in the English Channel with Ellis *et al.* (2012) suggesting that due to the lack of data on spawning grounds that they may broadly overlap nursery grounds (see **Figure 8-5, Volume 3**). The PEIR Assessment Boundary offshore export cable corridor is located within a low intensity nursery area. The extent of the potential impact in relation to export cable installation is relatively small (2km wide corridor) in comparison with the available nursery/spawning area which encapsulates the sea along the south coast of the UK within the English Channel, especially from the Channel Islands to the Solent and coast of Sussex (DEFRA, 2010). In addition, the works are short in duration and where the offshore export cable is buried the habitat important to undulate ray spawning (spawn on sandy or muddy flats (Coelho and Erzini,2006)) will recover quickly post construction. It is considered that as undulate ray are highly mobile other nursery/spawning areas will be utilised during this temporary impact and population size will not be affected. The sensitivity of undulate ray is considered **low**.

Sandeel

8.9.161 As shown in **Figure 8-3, Volume 3**, the offshore export corridor overlaps with low intensity sandeel spawning grounds as identified by Ellis *et al.* (2010). Due to their limited mobility, and their overall spatial distribution throughout the English Channel and within the southern North Sea, sandeels are considered to be of **medium** sensitivity.

Herring

8.9.162 The offshore export cable corridor does not overlap with the recorded herring spawning ground as detailed in **Figure 8-2** and **Figure 8-8, Volume 3**, with the spawning ground located some 34.2km to the south of the Proposed Development boundary (including the 15km buffer) at its closest point (the array area).

Therefore, there is no scope for direct temporary habitat disturbance on herring spawning grounds as a result of installation of the proposed offshore export cables. It can be seen from **Figure 8-8, Volume 3** although herring larvae have been recorded within the study area, this was at relatively low abundances within the PEIR Assessment Boundary (IHLS 2007 to 2020: 0.1 to 2,500 per m^2) and the area is clearly not of importance to the Downs stock herring population. Moreover, with the exception of a spike in herring larval intensity in the area between 2009 and 2010, and between 2016 and 2017 (see **Appendix 8.1: Fish and shellfish ecology – Herring annual heatmap, Volume 4**), the remaining years between 2007 and 2020 should relatively low herring larval intensity in the east English Channel. As the preferred herring spawning ground is located 64.3km away from the PEIR Assessment Boundary offshore export cable corridor area of search, **low** sensitivity has been assigned.

Black seabream

8.9.163 The offshore export cable corridor is located within proximity to the Kingmere MCZ which contains important chalk habitat for black seabream nests which have been identified within the proposed offshore export cable corridor area of search. Black seabream favour a particular type of substrate to build their nests and lay eggs (generally hard and coarse substrate (gravel; chalk reefs)) hence, cable laying through a preferred region of habitat represents the worst case for this receptor. The majority of the recently active nest sites have been located within the Kingmere MCZ and within the PEIR Assessment Boundary offshore export cable corridor (**Figure 8-14, Volume 3**). Seabed disturbances resulting from construction activities such as cable trenching within the black seabream nesting area may damage nests and could potentially prevent future use of the seabed for nest building due to a physical change in its character in discrete locations. Whilst the cable will not be installed within the Kingmere MCZ the cable installation may, in discrete locations, have a long-term negative effect on areas of high intensity black seabream nesting. Previous works within the south coast region, for the existing Rampion 1 offshore wind farm, has demonstrated that it is possible to reinstate the chalk habitat, however for the purposes of this PEIR it is assumed to be a long-term loss of spawning habitat. Due to the location of potential nesting habitat across the offshore export cable corridor, the sensitivity for black seabream is considered **very high**.

Shellfish

8.9.164 For crustaceans such as brown crab and European lobster, the proposed methods for cable route preparation and installation on soft and clay sediment are not considered to be a potential impact due to the habitat preference of these crustacea. Lobster prefer rocky substrata, and crabs prefer to live under boulders, mixed coarse grounds, or offshore in muddy sand (Ager, 2008). Given this, ground preparation and installation techniques for soft sediment areas within the offshore export cable corridor have not been assessed for these species.

8.9.165 In terms of physical impacts on crabs and lobsters, it is considered that berried females are at a higher risk, given their propensity to bury themselves in sediment or hide in rock crevices during this sensitive period. While the route preparation and installation activities may lead to mortality of or injury to some individuals, it is expected that other crabs and lobsters will recolonise the area quickly and no population level effect will therefore be expected. The majority of shellfish have adopted a reproductive strategy of high egg production to compensate for losses during egg extrusion and the extended incubation period (McQuaid *et al.,* 2009). During cable installation, the area will likely be subject to some restrictions on fishing activity, this will allow larger shellfish, with an attendant capacity to produce a greater number of eggs, to contribute to the spawning stock without fishing pressures (Roach *et al.,* 2018). Due to the limited area and temporary nature of the works, combined with the ability of crabs and lobsters to recolonise, it is considered that the sensitivity of brown crabs and European lobster is **low**.

8.9.166 The king scallop is an important commercial shellfish which is represented in the ICES rectangle along the offshore export cable corridor. Commercial fisheries landings data highlights the importance of the centre of the English Channel for this species. Scallops prefer areas of clean firm sand, fine or sandy gravel and also muddy sand, therefore will be impacted by construction activities for installation in a range of sediment habitat types. The areas where dredging will occur (sandwaves) therefore are not ideal habitat for scallop given its dynamic (mobile) nature of the seabed feature. In terms of impact from ploughing, trenching and jetting, the king scallop is capable of swimming in response to predators, and some individuals of this species may therefore be able to avoid direct impacts from the works (Marshall and Wilson, 2008). The MarESA sensitivity assessment by MarLIN (Marshall and Wilson, 2008) identifies that scallops have low sensitivity and high recoverability to abrasion and physical disturbance. Given the limited area impacted by the offshore export cable installation activities and the high recoverability of scallops, it is considered that the sensitivity of king scallop is **low**.

8.9.167 Although there is potential impact from disturbance on whelk, this species is capable of moving away from an impact at 11cm/minute (Magúnsdóttir, 2010) and therefore, able to return and recolonise the disturbed area post construction. In relation to a consultation response provided by whelk commercial fishermen to the on the Kent and Essex IFCA fisheries byelaw, recovery of whelk beds is anticipated within 12 months following disturbance (Kent and Essex IFCA, 2017). In addition, given its extensive habitat preferences (muddy sand, gravel and rock), alternative habitat is widely available outside the offshore export cable corridor. Therefore, it is considered that the sensitivity of whelks is **low**.

8.9.168 Native oysters are identified as having a high sensitivity to disturbance (Perry *et al.,* 2017). The impacted area however represents a small proportion of the available habitat and although oysters may be affected, the numbers are likely to be low. Therefore, it is considered that the sensitivity of native oyster to temporary direct disturbance is **low**.

Significance of residual effect

8.9.169 Direct disturbance occurring outside the PEIR Assessment Boundary offshore export cable corridor area of search (for example anchor placement) will be highly limited in extent, and as the species found to either side of the offshore export cable corridor are comparable to those within, it is considered that the assessments presented above include provision for this impact.

8.9.170 As stated above, the magnitude for physical disturbance and temporary loss of habitat for the offshore development area is considered as **minor**. The sensitivity for herring and sandeel is considered to be **negligible** to **minor** respectively. Therefore, for sandeel an impact of **minor adverse significance** and for herring an impact of **negligible adverse significance** is expected for the installation associated with the offshore export cable corridor, which are both **not significant** in EIA terms.

8.9.171 Black seabream, however, in the absence of mitigation, will potentially experience physical disturbance and temporary and/or permanent loss of habitat. As a result, the magnitude of impact is consider **moderate** and the sensitivity of black seabream is considered **very high**. Therefore, an impact of **major adverse significance** is expected for the installation associated with the offshore export cable corridor in the absence of mitigation, which is **significant** in EIA terms. Whilst a specific mitigation measure has not been embedded within the design of the Proposed Development at this stage, there are a number of measures available currently being considered. Such measures can provide a deliverable and could demonstrable reduction in magnitude and therefore significance. For this impact, the potential measures available include constraining the installation method to minimise the area of physical impact, and development of a reinstatement plan to ensure any disturbed bedrock feature is appropriately stored during installation and reinstated following installation. The latter method of reinstatement was previously employed on the existing Rampion 1 offshore wind farm and is considered proven and therefore with a high likelihood of successfully reducing the magnitude and effect significance to non-(EIA) significant levels.

8.9.172 In comparison to most finfish species, shellfish have more limited mobility and may not be capable of escaping construction activities causing physical disturbance to the seabed. In particular, the egg masses of ovigerous species will be potentially vulnerable to physical damage. However, due to the temporary and short-term nature of the effects, the sensitivity of these receptors is considered to be **high**. As previously stated, the magnitude of the effect is **negligible** to **minor**; therefore, resulting in an impact of **minor adverse significance**, which is **not significant** in EIA terms.

Direct disturbance resulting from construction within the array

Magnitude of impact

8.9.173 Disturbance will occur during construction operations within the array area and is likely to include sediment compaction and disturbance during foundation installation (for instance jack-up operations and anchor placements), sediment disturbance during seabed preparation prior to suction bucket jacket foundations installation and interarray cable burial operations (including potential sandwave and boulder clearance). All fish and shellfish receptors have the potential to be affected by this impact through loss of spawning, nursery or feeding habitats, though demersal fish and shellfish species and demersal spawning species have the greatest potential to be affected. The Proposed Development commitments (as shown in **Table 8-11**) include the use of, where feasible, cable burial to avoid direct impacts to the fish and shellfish (see C-45, **Table 8-11**).

8.9.174 A maximum of approximately 2.5km^2 of seabed within the PEIR Assessment Boundary array area is predicted to be directly impacted within the array area during construction of the Proposed Development, with the potential for direct disturbance to mobile demersal species and pelagic fish and shellfish within this area. This equates to 0.93 percent of the array area (270km^2). Considering the availability of similar suitable habitat both in the array area and in the wider context of the English Channel and into the southern North Sea, the impact is predicted to be of local spatial extent, of short-term duration, intermittent and reversible. It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be **minor**.

8.9.175 In general, mobile fish species are expected to be able to avoid temporary disturbance (EMU Limited, 2004). The most vulnerable species are likely to be shellfish which are much less mobile than fish. The fish species in the fish and shellfish study area which are likely to be most sensitive to temporary habitat loss are those species that spawn on or near the seabed sediment (black seabream, herring, sandeel and elasmobranchs).

Sensitivity or value of receptor

Overview

8.9.176 As noted in **paragraph 8.9.158** substrate specific spawners, such as sandeel, herring and black seabream are potentially more susceptible to impacts relating to direct disturbance. Sandeel, herring and black seabream are known to have spawning habitats within, or in close proximity to the PEIR Assessment Boundary fish and shellfish study area, although these are predicted to be of low intensity for sandeel and herring.

Elasmobranch

8.9.177 As detailed previously in **paragraphs 8.9.159** to **8.9.160** impacts to elasmobranch species within the fish and shellfish study area will not exceed that assessed for sandeel, herring and black seabream. As noted in **paragraph 8.9.159**, the PEIR Assessment Boundary array area overlaps low intensity nursery grounds for undulate ray, thornback ray and tope. However, both thornback ray and tope have widely distributed nursery areas around the UK, so the extent of disturbance is low to negligible in comparison. As detailed in **paragraph 8.9.160**, the undulate ray nursery grounds and suspected spawning grounds (Ellis *et al.,* 2012) are located within the PEIR Assessment Boundary array area. The proportion of undulate ray spawning/nursery grounds potentially affected is considered relatively small in the context of the wider spawning/nursery habitat within the English Channel and within the southern North Sea (see **paragraph 8.9.160**). Undulate ray are considered highly mobile and other nursery/spawning areas could be utilised during this temporary direct impact during construction and therefore population size will not be affected. As a result, the sensitivity of undulate ray to temporary direct impact during construction within the array area is consider **low** to **medium** for undulate ray.

Sandeel

8.9.178 As shown in **Figure 8-3, Volume 3**, the array area overlaps with low intensity sandeel spawning grounds as identified by Ellis *et al.* (2010). Due to their limited mobility (particularly during their winter hibernation period) and their overall spatial distribution throughout the English Channel and within the southern North Sea, sandeels are considered to be of **medium** sensitivity.

Herring

8.9.179 The PEIR Assessment Boundary array area does not overlap with the recorded herring spawning ground as detailed in **Figure 8-2** and **Figure 8-8, Volume 3**, with the spawning ground located some 34.2km to the south of the PEIR Assessment Boundary (including the 15km buffer) at its closest point. Therefore, there is no scope for direct temporary habitat disturbance on herring spawning grounds as a result of installation of the proposed array area. It can be seen from **Figure 8-8, Volume 3** although herring larvae have been recorded within the study area, this was at relatively low abundances within the PEIR Assessment Boundary (IHLS 2007 to 2020: 0.1 to 2,500 per m^2) and the area is clearly not of importance to the Downs stock herring population. As the preferred herring spawning ground is located 34.2km away from the PEIR Assessment Boundary array area, a **medium** sensitivity has been assigned.

Black seabream

8.9.180 The PEIR Assessment Boundary array area is located within proximity to the Kingmere MCZ. Black seabream favour a particular type of substrate to build their nests and lay eggs (generally hard and coarse substrate (gravel; chalk reefs)). Construction activities within the PEIR Assessment Boundary array area will be outwith the Kingmere MCZ and therefore direct impacts to designated black seabream within the MCZ are considered low. However, seabed disturbances resulting from construction activities in proximity to black seabream nesting area may disturb male black seabream protecting the nests, potentially leaving them unprotected and eggs vulnerable to predation. Black seabream are deemed to be of high vulnerability, medium recoverability and of regional importance, although there is limited opportunity for an effect to be realised on black seabream nesting in the nearshore area. The sensitivity of this receptor is therefore considered to be **medium**.

Shellfish

8.9.181 As noted in **paragraphs 8.9.165** to **8.9.168** above, shellfish species such as brown crab, European lobster, king scallop, whelk and native European oyster are present within the fish and shellfish study area. As the area of seabed predicted to be directly disturbed is greater for the PEIR Assessment Boundary array area (approximately $7km^2$), than the offshore export cable corridor (approximately $2km^2$), it is noted that the sensitivity of the receptor may be greater, due to the extent of area disturbed. Due to the temporary nature of the works within the array area and the ability of brown crab, European lobster and king scallop to recolonise/recover, the sensitivity of this receptor is considered to be **medium**.

8.9.182 Moreover, the sensitivity for whelk is considered to be **medium** due to its wide habitat preferences and similarly wide availability of alternative habitat beyond the array area (muddy sand, gravel and rock). As noted in **paragraph 8.9.168** native oysters have a high sensitivity to disturbance (Perry *et al.,* 2017). However, the impacted area as a result of the Proposed Development is not located within any MCZ designated areas for native oyster (see **Table 8-9 Marine nature conservation designations with relevance** to fish and shellfish ecology.) and therefore no direct impacts are anticipated. The sensitivity of these receptors is therefore considered to be **medium**.

Significance of residual effect

8.9.183 The effect of direct disturbance to all mobile demersal and pelagic fish and shellfish species within the total installation footprint will therefore be of **minor adverse significance**, which is **not significant** in EIA terms.

Temporary localised increases in SSC and smothering

Introduction

8.9.184 Temporary localised increases in SSC and associated sediment deposition are expected from foundation and cable installation works and seabed preparation works (including sandwave and boulder clearance). **Chapter 6** provides a full description of the offshore physical environment assessment, with a summary of the maximum design scenario associated with the impact, as detailed in **Table 8-10** of this PEIR chapter.

8.9.185 It should be noted that until the layout of the array is finalised, and the associated geophysical data is analysed in detail, it will not be known if sand waves will be affected by the works. As a result, sandwave clearance estimates have been provided.

Magnitude of impact

Overview

8.9.186 **Table 8-10** presents the maximum design scenario associated with increases in SSC and deposition. The maximum design scenario for SSC and deposition during the construction phase of the Proposed Development is predicted to be a total release of 2,905,000m^3 of sediment in the array area and offshore export cable corridor, from seabed preparation.

8.9.187 Seabed preparation for sandwave clearance, cable trenching (array and export cables), drilling for foundations and spoil dispersal are all predicted to cause sediment plumes. The resulting initial SSC is dependent on the rate of release and the height at which the displaced sediment is initially dispersed. Some details on the Proposed Development are not presently available and therefore assumptions have been made, such as use of cable protections. Typically, the initial SSC at the point of release will be very high (in the order of thousands to low tens of thousands of mg/l) for all sediment types (**Chapter 6**). However, the change will only be present for a very short time locally, in the order of seconds to tens of seconds for sand or gravel, before the material resettles to the seabed. Therefore, it is considered spatially limited to within meters (up to 20m) downstream for gravels and within tens of metres (up to a few hundred metres) for sands. The initial plume will act under gravity to sink down through the water column (dynamic phase). Coarser sediments in the plume settle relatively quickly (0.33 to 1.67ms^{-1}) and so may return to the seabed within a matter of seconds to minutes after being suspended. The downstream extent of the plume is therefore limited to the distance that the plume can be dispersed by water current speeds in that short time period. In the passive plume phase, finer sediments may persist in the water column for longer (within two to three days) and so can be advected over greater distances by ambient currents. SSC will reduce to near background levels with time due to natural dispersion and deposition. The maximum extent of this plume will initially be limited to the tidal excursion buffer distance, although low level effects can be advected further by longer-term residual currents, SSC is likely to be below background levels beyond this point.

8.9.188 Across much of the array area and offshore export cable corridor, the seabed sediment comprises sand, coarse sand and gravel (**Chapter 6**). As such, dredging/trenching/jetting of this material is not expected to create persistent plumes as the coarse material will quickly settle to the seabed (0.33 to 1.67ms^{-1}) within a matter of seconds to minutes after being suspended. However, the disturbance of the finer grained sediments has the potential to give rise to more persistent plumes that settle out of suspension over a wider area than for coarse grained sediments. Within the PEIR Assessment Boundary array area values typically range between 10 to 20mg/l during winter months and generally <4mg/l during the summer period. Turbidity significantly increases at the coastline and during higher energy events, such as storms where SSC can be naturally much higher (order of tens to hundreds of mg/l). During stormier conditions, near bed current speeds can be increased due to the influence of waves stirring of the seabed, causing a short-term increase in SSC (order of hundreds of mg/l) (**Chapter 6**).

8.9.189 It has been predicted for drilling operations for monopile foundations (**Chapter 6**) that fine sediments could remain in suspension for up to 25 minutes (depending on the local water depth and current speed) and therefore be transported up to approximately 0.7km, with increase in SSC in excess of natural ranges over a short period of timescale. Away from release locations, elevations of SSC above background levels are expected to reduce (approximately 300mg/l, 5km from the source). After approximately 72 hours, sufficiently fine sediment may become diluted to low concentrations (<10mg/l).

8.9.190 The cable installation operations will result in localised and temporary re-suspension and settling of sediments. The exact nature of the disturbance will be determined by the sediment conditions, the length of installed cable, burial depth and burial method. Cable installation within the array area and the offshore export cable corridor will be a relatively short-term operation and as a result, the effect from installation will be temporary. The maximum design scenario for cable installation involves jetting, ploughing and trenching. For cable installation a trench measuring 2m wide by 1m deep (although this may be up to 1.5m in very localised areas of the export cable corridor, where soft sediment is present). Within 100 to 200m downstream from active trenching (depending on the initial height of ejection and the local current speed) in a relatively narrow plume (up to tens of metres wide), mainly resuspended sands and gravels will cause high SSC in the order of thousands to tens of thousands of mg/l. The volumes of material being displaced and deposited locally are relatively limited (up to 1.7m^3 per metre of cable (export, interconnector and array), assuming a maximum depth of 1m). The distance to which sand sediment material may be spread to an increase in bed level of up to 6cm over an area of up to 200m downstream, along the length of the trench. However, it is expected that the extent (and so area) of deposition will be smaller for gravelly sediment (leading to a greater thickness of tens of centimetres to a few metres), and that fine material will be distributed more widely, becoming so dispersed that it is unlikely to settle in a measurable thickness.

8.9.191 The magnitude of the maximum potential increase in SSC resulting from construction activities is within the natural range of SSC, within the region and the impact will be short-term, intermittent and of localised extent and reversible.

Sandeel

8.9.192 Due to the presence of sandeel habitats across the English Channel and the southern North Sea, the magnitude of impact from increased SSC resulting from construction within the array area is also considered to be **minor**.

Herring

8.9.193 Due to the distance between the PEIR Assessment Boundary and the herring spawning ground, the magnitude of impact from an increase in SSC from construction within the array area on herring is assessed as **minor**.

Black seabream

8.9.194 Taking into consideration the localised nature of black seabream spawning and nesting grounds to the PEIR Assessment Boundary, the magnitude of impact from an increase in SSC from construction within the array area and offshore export cable corridor on black seabream is assessed as **moderate** as any interaction will inherently be of short-term duration.

Shellfish

8.9.195 Due to the distance between the PEIR Assessment Boundary and the Beachy Head West MCZ (for which native oyster and blue mussel are a feature), which is located 13km from the Proposed Development, the magnitude of impact from an increase in SSC from construction within the array area and offshore export cable corridor is assessed as **negligible**.

Other fish and shellfish receptors

8.9.196 Other species which spawn in the study area, such as cod, plaice and lemon sole, are broadcast spawners with buoyant eggs that are dispersed within the water column over a wide area, so their eggs will not be susceptible to potential sediment smothering. The magnitude of impact from an increase in SSC from construction within the PEIR Assessment Boundary array area on these fish species is assessed as **negligible**.

8.9.197 Thornback and undulate ray eggs are likely to be tolerant of a degree of suspended sediment and smothering as a result of natural sediment movement within inshore waters (Guillou *et al.,* 2017). As smothering is predicted only to occur in a small area (predominantly within the PEIR Assessment Boundary offshore export cable corridor), it is considered that the magnitude of impact from suspended sediment and smothering is **negligible** on thornback or undulate ray eggs.

8.9.198 Short-snouted seahorse and long-snouted are unlikely to be affected by an increase in suspended sediment and smothering from construction activities as they are mobile and are able to slowly swim away from the affected area. Moreover, habitat preference is within shallow water, amongst seagrass and algae, although short-snouted seahorse can also be found in rocky areas to a depth of 77m (Sabatini and Ballerstedt, 2007). Therefore, intolerance to smothering is low, with high recoverability for both species (Neish, 2007; Sabatini and Ballerstedt, 2007). Temporary smothering from increased SSC is likely to result in indirect effects to seahorses as a result of potential localised habitat disturbance. The magnitude of impact from an increase in SSC from construction within the PEIR Assessment Boundary on seahorse species is assessed as **minor**.

Migratory species

8.9.199 All of the Annex II fish species in the Habitats Directive (92/43/EEC) undergo migrations between freshwater and the sea at some stages in their life cycles and therefore significant increases in SSC could present a barrier to migratory pathways (Posford Duvivier Environment and Hill, 2001). However, estuarine fish generally show tolerance to variations in suspended sediment loadings and turbidity as a result of natural adaptation to living in a dynamic and environmentally variable habitat (ABPmer, 2005). Furthermore, due to the proximity of a number of rivers to the PEIR Assessment Boundary fish and shellfish study area, it is possible that juvenile European eels will be present at the time of construction, however, both juvenile and adult European eel are highly tolerant to elevated level of SSC (Avant, 2007). SSC can only be a barrier to migration if the conditions extend across the entire width of the water body comprising the migration route at any given point (ABPmer, 2011), as fish can move around the adverse condition area, avoiding impacts.

8.9.200 Overall, the magnitude of this effect is judged to be **negligible** due to the small proportion of the overall water column that will be subjected to increased suspended sediments and the fact that any such plume effects will not be expected to impact the overall size or structure of Annex II fish populations. The PEIR Assessment Boundary array area and offshore export cable corridor do not encompass an estuary mouth and as such does not form an unbroken barrier to migration. All diadromous species spend time within the river and estuary environments where SSC levels are considerably higher than those present within the open sea, and as such, they are likely to have an increased tolerance to suspended sediments (ABPmer, 2005). While some small scale and temporary avoidance may occur, this is not at a scale where migration will be hindered significantly.

Sensitivity or value of receptor

Overview

8.9.201 Construction activities may increase levels of suspended sediments and reduce light levels within the water column. Reduction in light levels within the water column can create a number of adverse effects particularly upon species reliant on their visual acuity to detect and locate prey (BERR, 2008).

8.9.202 Adult fish will normally be able to detect significantly elevated levels of suspended sediment and avoid the affected area (ABP Research, 1999; EMU Limited, 2004). Juvenile fish, including those likely to occur in nursery habitats in the vicinity of the PEIR Assessment Boundary fish and shellfish study area, are generally considered to be more sensitive to suspended sediment plumes than adults (Wilber and Clarke, 2001). This may arise as a consequence of their reduced mobility compared to adults and increased biological susceptibility (for instance smaller gill surface areas (ABP Research, 1999)). The PEIR Assessment Boundary fish and shellfish study area has been identified as supporting both foraging and nursery grounds for a number of commercially and ecologically important species. These species are expected to be resilient to any increase in SSC as winter storm events in their natural environment cause temporary increases in suspended sediment concentration of a similar magnitude to that which will be produced by the construction operations. However, the SCC levels within the immediate vicinity of construction works will be localised in extent and short-term in duration, with coarse material anticipated to settle to the seabed (0.33 to 1.67ms^{-1}) within a matter of seconds to minutes after being suspended. Fine sediments, however, could remain in suspension for up to 25 minutes (see **paragraph 8.9.189**) and transported up to approximately 0.7km. As further detailed in **paragraph 8.9.189** elevations of SSC above background levels are expected to reduce (approximately 300mg/l, 5km from the source) with fine sediments potentially becoming diluted to low concentrations (<10mg/l) after approximately 72 hours.

8.9.203 The species likely to be affected by sediment deposition are those which either feed or spawn on or near the seabed. The majority of species that have known spawning grounds in close proximity to the Proposed Development are herring, sandeel and black seabream. Eggs and larvae stages of fish and shellfish do not however have the same capacity to avoid increased SSCs as juvenile or adult fish as they are either passively drifting in the water column or present on/attached to benthic substrates. The sensitivity of eggs and larvae is therefore considered to be higher than for later life stages and is the main focus of this assessment. The re-deposition of sediments may affect fish eggs and larvae through smothering. Of the fish species, by being demersal spawners and the adhesive properties of the membranes, black seabream, herring and sandeel eggs have the greatest potential to be affected by increased SSCs and sediment re-deposition.

Sandeel

8.9.204 Sandeel spawning grounds and preferred habitats (**Figure 8-3** and **Figure 8-9, Volume 3**) are located across the array area and offshore export cable corridor, however any impacts on this species are expected to be relatively small in the context of the spawning habitat available in the wider region. Furthermore, the secondary effects of increased concentrations of SSC in the water column and smothering (from deposition of particles), have been shown to be inconsequential to sandeel species (MarineSpace Ltd *et al.,* 2013a). Sandeel eggs are likely to be tolerant to increases in SSC and deposition due to the nature of resuspension and deposition within their natural high energy environment. Sandeels deposit eggs on the seabed in the vicinity of their burrows between December and January. Grains of sand may become attached to the adhesive egg membranes. Tidal currents can cover sandeel eggs with sand to a depth of a few centimetres, however experiments have shown that the eggs are capable of developing normally and hatch as soon as currents uncover them again (Winslade, 1971). Buried eggs experiencing reduced current flow, and therefore lower oxygen tension, can have delayed hatching periods, which is considered a necessary adaptation to survival in a dynamic environment (Pérez-Domínguez and Vogel, 2010, Hassel *et al.,* 2004). High intensity spawning sites for sandeel do not occur within the PEIR Assessment Boundary fish and shellfish study area, and so effects on sandeel spawning are expected to be minimal. Based on the 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 **medium**.

Herring

8.9.205 As shown in **Figure 8-8, Volume 3**, the main area of herring spawning is located to the south of the PEIR Assessment Boundary, and therefore effects on spawning herring populations will be limited. Furthermore, it has been shown that herring eggs are tolerant of very high levels of SSC (Kiørboe *et al.,* 1981; Messieh *et al.,* 1981). It was concluded by Kiørboe *et al.* (1981) that herring eggs suffered no adverse effects from suspended sediment concentrations in excess of the maximum levels expected from mining, dredging and similar operations. Detrimental effects may be seen if smothering occurs (Griffin *et al.,* 2009) and the deposited sediment is not removed by currents (Birklund and Wijsmam, 2005), however this is expected to occur quickly with the small amount of sediment deposition forecast. Adult herring are mobile and therefore may show avoidance behaviour to the impact. Spawning herring may not show these avoidance behaviours, however as any increases in SSC are expected to be short term and within the natural range of SSC, herring are expected to be largely unaffected by this impact. Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of low vulnerability, high recoverability and of regional importance, and therefore the sensitivity of this receptor is considered to be **medium**. This is due to the distance between known spawning grounds and the PEIR Assessment Boundary fish and shellfish study area, no effects of increased SSC and sediment deposition are predicted to occur on herring spawning habitats.

Black seabream

8.9.206 Direct disturbance to the seabed will have the potential to temporarily increase suspended sediments within and around the area of activity. When these sediments drop out of suspension, they may form a smothering layer over favourable substrates in the immediate vicinity of the activity, but also at some distance from the source.

8.9.207 Based on current information there is the potential for suspended sediments to drift into nesting areas within the offshore export cable corridor. Black seabream, like most marine fish, will be able to tolerate a degree of suspended sediment. As previously mentioned, storm events can reportedly raise SSC in nearshore naturally turbid environments in the Channel by a factor of 10 to 20 (Guillou *et al.,* 2017; RSK Environmental Limited, 2012). There is potential that SSC may exceed those experienced during natural storm events with a return to background levels within a short period (up to three days). However, there was no evidence of black seabream nests being impacted from suspended sediment from nearby aggregate extraction work (EMU Limited, 2012a). Based on the increase in sensitivity of black seabream nests and eggs to the smothering effects of increased sediment deposition, black seabream is deemed to be of high vulnerability, medium recoverability and of regional importance, and therefore the sensitivity of this receptor is considered to be **high**.

Shellfish

8.9.208 More sedentary species (such as shellfish) are likely to be more vulnerable to increases in SSCs, which may result in reduced growth or increased mortality, particularly when spatfall occurs (ABP Research, 2007). Brown crabs have a high tolerance to suspended sediment and are reported to be insensitive to increases in turbidity, although they are likely to avoid areas of increased SSC as they rely on visual acuity during predation (Neal and Wilson, 2008). However, berried crustaceans (for example brown crab and European lobster) are likely to be more vulnerable to increased SSC as the eggs carried by these species require more regular aeration and as they are considered to have limited mobility, remaining sedentary while egg bearing. Increased SSCs will only affect a small area at any one time and will be temporary in nature (two to three days and return to background levels in a short time frame). Furthermore, these species are mobile and can move outside of the affected area if necessary. Smothering may cause some temporary displacement of these mobile invertebrates if sedimentary conditions change markedly, however, due to their mobility and ability to burrow out of sediments, no mortality is predicted (Neal and Wilson, 2008).

8.9.209 Brown crab and European lobster are deemed to be of medium vulnerability, high recoverability and regional importance in the southern North Sea fish and shellfish study area. The sensitivity of the receptor is, therefore, considered to be **medium**.

8.9.210 Whelks' ability to utilise the finer sediment fractions suggests they are not affected by a degree of suspended sediment, as these finer sediments are often suspended during storm or current induced sediment mixing. Whelk are known to spend much of their time buried in soft sediment (Himmelman, 1988). It was also shown that whelk species such as *Busycon carica* can be naturally buried to depths of 14.4cm in intertidal areas and can dig themselves out quickly (Walker *et al.* 2004). Given the whelks tolerance to smothering and elevated suspended sediment, the sensitivity of the receptor is, therefore, considered to be **low**

8.9.211 Smothering can result in significant mortalities on shellfish beds as they are less mobile than fish species, with many having life stages that are sensitive to variations in sediment particle size within the water. Filter feeders such as, oyster, mussel and scallop are therefore among the most vulnerable to smothering effects (BERR, 2008). As scallops are capable of swimming away from threats and can dig their way out of deposits of under 5cm, some scallops are likely to be able to survive, however a burial depth of 5cm is conservatively considered to be fatal (Marshall and Wilson, 2008). Native oyster and blue mussels are sessile and are therefore unable to move to avoid an impact such as smothering or increases in suspended sediment. Conversely, Widdows *et al.* (2002) noted that mussels buried by 6cm of sandy sediment (caused by resuspension of sediment due to turbulent flow across the bed) were able to move to the surface within one day.

8.9.212 Outside the array area and offshore export cable corridor native oyster, mussels and scallops are unlikely to be affected, as the depth of sediment deposition is expected to reduce with distance from the construction activity (5km downstream, may have reduced to approximately 10mg/l) and will happen gradually over time. Moreover, as detailed in **paragraph 8.9.188** the SSC values within the Proposed Development are 10 to 20mg/l during winter months with storm raising the SSC in these areas by a factor of 10 to 20 (Guillou *et al.,* 2017). Therefore, native oysters and blue mussels must be tolerant of a degree of natural variation in suspended sediments. Scallops have high recoverability from smothering due to their high fecundity (Le Pennec *et al.,* 2003) and widely dispersed pelagic larvae (Beaumont and Gjedrem, 2007), which can originate from unaffected scallop beds in the vicinity and repopulate smothered areas. Furthermore, scallops exhibit specialised behaviours which mitigate potential negative effects of increases in SSC, such as increased clapping rate (Last *et al.,* 2011), food selectivity and particle excretion (Shumway *et al.,* 1997). Native oysters have also adapted a filtering mechanism to separate inorganic particles from food in suspension (Perry *et al.,* 2017). There is the potential for short-term impacts on reproductive and larval life stages, however the impact will not have any long-lasting effects with adult spawning behaviour and recruitment cycles returning to normal upon cessation of the impact. Given the high recoverability of scallops to SSC and smothering, it is therefore considered that the sensitivity of scallops are considered to be **low**. However, as native oyster and blue mussels are more susceptible to smothering the sensitivity is **very high.**

Other fish and shellfish receptors

8.9.213 All other fish and shellfish receptors within the fish and shellfish study area are deemed to be of low vulnerability, high recoverability and of local to international importance. The sensitivity of the receptor is therefore considered to be **medium**.

Significance of residual effect

Overview

8.9.214 An increase in SSC and associated sediment deposition will represent a temporary and short-term intermittent impact, affecting a relatively small portion of the fish and shellfish habitats in the study area. Most receptors are predicted to have some tolerance to this impact. Overall, the sensitivity of fish and shellfish receptors is considered to be **medium** to **high** and the magnitude of the impact is deemed to be **minor**. The effect will, therefore, be of **minor adverse significance**, which is **not significant** in EIA terms.

Black seabream

8.9.215 Damage or smothering of active black seabream nests from export cable installation will represent a temporary and short-term intermittent impact. However, based on the **moderate** magnitude and **high** sensitivity of the impact the effect will be **moderate adverse significance** in the absence of mitigation, which is potentially **significant** in EIA terms. Whilst a definitive mitigation has not been embedded in the design of the project at this stage, there are a suite of measures currently been explored with which it will be possible to reduce the magnitude, and therefore significance of effect. The likelihood of a significant effect being realised is therefore considered low, and the overall significance is considered to be **not significant** with regards the EIA Regulations.

Shellfish

8.9.216 Although native oyster and blue mussels have a **very high** sensitivity from smothering during the installation of the offshore export cable, the magnitude is considered **negligible**. Therefore, the impact will be **minor adverse significance** and is therefore considered to be **not significant** with regards the EIA Regulations.

Migratory species

8.9.217 Due to the small scale of the impact, the **medium** sensitivity and the absence of barrier effects, the effects on migratory fish species (for instance sea lamprey, allis shad, twaite shad and European eels) in the fish and shellfish study area are predicted to be of **minor adverse significance**, which is **not significant** in EIA terms.

Direct and indirect seabed disturbances leading to the release of sediment contaminants

Introduction

8.9.218 As identified in **Table 8-10** and assessed in the section above, construction activities will re-suspend sediment. 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, as a result of construction activities and associated sediment mobilisation.

8.9.219 Evidence from the nearby IFA-2 interconnector suggests that the area is not heavily contaminated. IFA-2 is situated at a minimum distance of 300m west of the Proposed Development. Contaminated sediment surveys undertaken for IFA-2 detected arsenic at two sites, located approximately 10km west of the Proposed Development, and measurable amounts of Dibutyltin (DBT) and Tributyltin (TBT) at the mouth of Southampton Water (IFA-2, 2016).

8.9.220 The assessment of subtidal sediment contaminants undertaken across the Rampion 1 offshore wind farm baseline characterisation, which covers part of the PEIR Assessment Boundary and wider fish and shellfish ecology study area, revealed that the levels of contaminants within the sediments were generally low, suggesting sediments will not present any concern for seabed disturbance. However, eleven of the sites sampled supported levels of contaminants in excess of Action Level 1 for Arsenic and Chromium, at four of the sites (EMU Limited, 2011).

8.9.221 The results of the sediment contaminant survey that has been undertaken across PEIR Assessment Boundary were not available for inclusion within this PEIR assessment but will be fully reported within the final EIA.

Magnitude of impact

8.9.222 The maximum design scenario for the potential release of sediments contaminants of the Proposed Development that is likely to be disturbed by construction activities, with the associated potential release of sediment-bound contaminants, is predicted to be a total release of 2,905,000m^3 of seabed sediment in the array area and offshore export cable corridor, from seabed preparation which is localised in extent with the PEIR Assessment Boundary. In addition, the nature of the subtidal sediments is predominantly coarse and mixed sediments, in the western section of the PEIR Assessment Boundary and offshore export cable corridor, and sand and muddy sediments in the eastern section of the PEIR Assessment Boundary. 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 (see **paragraph 8.9.187**). The release of contaminants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and/or currents and therefore increased bioavailability resulting in adverse eco-toxicological effects are not expected.

8.9.223 The impacts to fish and shellfish receptors as a result of the release of sediment-bound contaminants are therefore considered to be of **negligible** magnitude.

Sensitivity or value of receptor

8.9.224 The sensitivity of fish and shellfish receptors will vary depending on a range of factors including species and life stage. Due to their increased mobility, adult fish are less likely to be affected by marine pollution. However, eggs and larvae are likely to be particularly sensitive, with potentially toxic effects of pollutants on fish eggs and larvae (von Westernhagen, 1988). Effects of resuspension of sediment bound contaminants (for example 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). Any such events therefore will have varying levels of effect dependent on the species present and pollutants involved. As sediment bound contaminants will be expected to be dispersed quickly in the subtidal environment, the level of effect is predicted to be small. Moreover, an Outline MPCP will outline mitigation measures in the event of an accidental pollution event arising from offshore operations relating to the Proposed Development (see C-53, **Table 8-11**).

8.9.225 The fish and shellfish receptors are deemed to be of medium vulnerability, high recoverability and local to international importance in the English Channel. The sensitivity of all receptors is therefore considered to be **high**.

Significance of residual effect

8.9.226 The direct and indirect impact of seabed disturbances leading to 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. Overall, the magnitude of the impact is deemed to be **negligible**, and the sensitivity of the receptors is considered to be **high**. The effect on fish and shellfish receptors will therefore be of **minor adverse significance**, which is **not significant** in EIA terms.

8.10 Preliminary assessment: Operation and maintenance phase

Introduction

8.10.1 The potential impacts of the operation and maintenance phase of the Proposed Development have been assessed on fish and shellfish ecology in the study area. The effects arising from the operation of the Proposed Development are listed in **Table 8-10** along with the maximum assessment assumptions against which each construction phase impact has been assessed.

8.10.2 A description of the significance of effects upon fish and shellfish receptors caused by each identified impact is given below.

Long-term loss of habitat and increased hard substrate and structural complexity due to the presence of turbine foundations, scour protection and cable protection

Long-term habitat loss

8.10.3 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 (for example spawning, nursery and feeding habitats).

8.10.4 The introduction of foundations and scour protection will result in a permanent loss of seabed habitat (the methodology of scour protection will be defined within an Outline Scour Protection Management Plan (see C-44, **Table 8-11**)). Fish and shellfish that are reliant on the presence of suitable sediment/habitat for their survival are considered to be more vulnerable to change depending on the availability of habitat within the wider geographical region. The Proposed Development fish and shellfish study area coincides with fish spawning and nursery habitats including sandeel and black seabream.

Magnitude of impact

8.10.5 The long-term habitat loss due to the presence of foundations, scour protection and cable protection is expected to be up to a maximum of 368,300m^2, which represents 0.12 percent of the area within the Rampion 2 PEIR Assessment

Boundary area, and a much smaller proportion of the wider study area. Comparable habitats are present and widespread within the wider area.

8.10.6 The impact is predicted to be of local spatial extent (for instance within the Rampion 2 PEIR Assessment Boundary), 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 **minor**. Furthermore, due to the wide distribution of herring and sandeel habitat across the English Channel, the magnitude is therefore also considered **minor**. The localised nature of black seabream spawning and nesting grounds to the Proposed Development, the magnitude of impact from long term habitat loss, associated with construction within the array and in particular the offshore export cable is assessed as **moderate** in the absence of mitigation, as the Proposed Development does not overlap the Kingmere MCZ, but it is recognised that some spawning habitat may potentially be lost through the introduction of cable protection.

Sensitivity or value of receptor

Overview

8.10.7 Fish and shellfish species that are reliant upon the presence of suitable sediment/habitat for their survival are considered to be more vulnerable to change depending on the availability of habitat within the wider region. The fish species most vulnerable to habitat loss include Black seabream and sandeel (demersal spawners) as these have specific habitat requirements for spawning.

Sandeel

8.10.8 The Proposed Development fish and shellfish study area overlaps with low intensity spawning and nursery habitat for sandeel. As well as laying demersal eggs, sandeel also have specific habitat requirements throughout their juvenile and adult life history and loss of this specific habitat could impact this species. Effects of offshore wind farm construction (Jensen *et al.,* 2004) and operation and maintenance (van Deurs *et al.,* 2012) on sandeel populations have been examined through short-term and long-term monitoring studies at the Horns Rev offshore wind farm. These monitoring studies have shown that offshore wind farm construction and operation and maintenance phase have not led to significant negative effects on sandeel populations. The proportion of habitat affected within PEIR Assessment Boundary in comparison to the wider potential sandeel habitat within the English Channel and the southern North Sea is small. Sandeel sensitivity to permanent habitat loss is therefore considered to be **medium**.

Herring

8.10.9 The PEIR Assessment Boundary is located 34.2km outside the main herring spawning grounds (**Figure 8-2, Volume 3**) and therefore will not be affected by long-term habitat loss. Herring sensitivity to permanent habitat loss is therefore considered to be **low**.

Black seabream

8.10.10 The PEIR Assessment Boundary is in close proximity to the Kingmere MCZ, with the offshore export cable corridor crossing over areas which contain important chalk habitat for black seabream nests and black seabream nests have been identified within the proposed offshore export cable corridor area of search (ABPmer, 2020) (see **Figure 8-13** and **Figure 8-14, Volume 3**). Black seabream are deemed to be vulnerable to permanent changes in substrate, with a low ability to recovery and are of regional importance. Due to the location of potential nesting habitat across the offshore export cable corridor and the specific habitat requirement of these species, the sensitivity of this receptor is considered to be **high**.

Elasmobranch

8.10.11 The PEIR Assessment Boundary array area and offshore export cable corridor will overlap with nursery areas for undulate ray (**Figure 8-5, Volume 3**). Due to the mobile nature of adults, there is expected to be no impact. However, undulate ray spawning grounds are thought to broadly overlap nursery areas (Ellis *et al.,* 2012) and the sediments in the inshore area (sand) may be suitable for undulate ray spawning. Even so, alternative nursery areas (and therefore potential spawning grounds) are available along the entire south coast with scour and cable protection representing only a very small proportion of this. It is therefore considered that the impact of permanent habitat loss on undulate ray is not significant, and the sensitivity is therefore considered to be **medium**.

Other fish and shellfish receptors

8.10.12 A 10-year research programme conducted in Germany provides a multiyear perspective and a synopsis of wind effects on a broad range of marine resources (Lüdeke, 2015). Overall, the programme results could not confirm negative effects on fish from the presence of WTGs. A second pre-construction and operation study (over a period of seven years) observed an increase in the number of species during the operation phase along with greater total fish biomass and increased biomass of shore crab (*Carcinus maenas*; Langhamer *et al.,* 2016) and cod (Bergstrom *et al.,* 2013). Furthermore, when comparing the difference in fish densities between the foundation and through the water column, and the surrounding seawater, Andersson and Öhman (2010) found a positive effect around the foundations.

8.10.13 Research has also shown an increase in fish assemblages (Wilhelmsson *et al.,* 2006) over both short (Lindeboom *et al.,* 2011) and long term (Stenberg *et al.,* 2015), and has documented observations of increased biodiversity and biomass of certain shellfish species, including brown crab (Krone *et al.,* 2017) and lobster (Roach *et al*., 2018) on hard substrate habitat created by WTG foundations and the associated scour protection. Both the hard substrate of the pile foundations and the scour protection created new habitats and areas of shelters that were immediately colonised by marine species. Reubens *et al.* (2011) indicated that fish communities are influenced by the type of epifaunal food resource colonising WTG foundations, with species selecting prey that live specifically on these structures. While attraction to this new habitat has been recorded for certain species such as cod, brown crab and lobster, observations also indicate avoidance by other species, such as flatfish species (common dab, Dover sole, and solenette) and whiting. However, these differences could not be distinguished between the physical structures and the impacts that season and weather conditions also have on fish presence (van Hal *et al.,* 2017).

8.10.14 Most fish and shellfish receptors in the study area are deemed to be of low vulnerability and of local to international importance (recoverability is not applicable for this impact due to the impact occurring over the lifetime of the project). Given the widespread nature of spawning and nursery habitat in the wider area, the sensitivity of these receptors is considered to be **medium**.

Significance of residual effect

Overview

8.10.15 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 within the PEIR Assessment Boundary and wider study area are likely to be affected. Most receptors are predicted to have some tolerance to this impact.

Black seabream

8.10.16 Black seabream are predicted to have a **high** sensitivity, with a **moderate** magnitude. The effect will therefore be of **moderate adverse significance** in the absence of mitigation, which is potentially **significant** in EIA terms. Whilst at this stage mitigation to reduce the impact magnitude has not been embedded in the design of the Proposed Development there is regional precedent for successful mitigation being feasible. The feasibility of mitigating construction phase impacts are currently being considered. Such measures are anticipated to reduce the impact magnitude and therefore significance of effect, and these measures are anticipated to equally reduce the potential for long term habitat loss being realised in the operational phase of the Proposed Development. The measures, which have regional and site-specific precedent, will provide a deliverable and demonstrable reduction in magnitude and therefore significance. For this impact the potential measures available include constraining the installation method to minimise the area of physical impact, and development of a reinstatement plan to ensure any disturbed bedrock feature is appropriately stored during installation and reinstated following installation. The latter method of reinstatement was previously employed on the existing Rampion 1 offshore wind farm and is considered proven and therefore with a high likelihood of successfully reducing the magnitude and effect significance to non-(EIA) significant levels.

All other fish and shellfish receptors

8.10.17 It is predicted that the sensitivity of all other fish and shellfish receptors are considered to be **medium** and the magnitude is deemed to be **minor**. The effect will therefore be of **minor adverse significance**, which is **not significant** in EIA terms.

Increased hard substrate and structural complexity

8.10.18 Any introduction of infrastructure such as foundations and scour protection will result in the introduction of hard substrate to the currently predominantly soft seabed habitat of the PEIR Assessment Boundary study area (the methodology of scour protection will be defined within an Outline Scour Protection Management Plan (see C-44, **Table 8-11**)). This will 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 if the benthic community in the vicinity of the area where hard substrate is introduced is expected to occur (Wilhelmsson and Malm, 2008).

8.10.19 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 (Hoffman *et al.*, 2000). The potential for marine structures, whether man-made or natural, to attract and concentrate fish is well documented (Bohnsack, 1989; Bohnsack and Sutherland, 1985; Hoffman *et al.*, 2000; Sayer *et al.*, 2005; Wilhelmsson and Malm, 2008). However, whether these structures act only to attract and aggregate fish or increase biomass is currently unclear.

8.10.20 It should be noted that the increase of hard substrate as a result of the Proposed Development may provide habitat for seahorses, which are known to visit artificial habitats and structures, including marinas (Garrick-Maidment, 2011), gas platforms (Fabi *et al.,* 2002) and jetty piles and piers (Foster and Vincent, 2004). Field experiments have shown that by increasing the structural complexity of artificial habitats, high abundances of seahorse were supported (Hellyer *et al.,* 2011).

Magnitude of impact

8.10.21 Up to 368,300m^2 of new hard substrate is likely to be created by the Proposed Development as a result of foundation installation, scour protection and cable protection. The impact is predicted to be of local spatial extent (within PEIR Assessment Boundary), long-term duration, continuous and irreversible (during the lifetime of the Proposed Development). It is predicted that the impact has the potential to affect fish and shellfish receptors both directly and indirectly and therefore, the magnitude is therefore considered to be **minor**.

Sensitivity or value of receptor

Overview

8.10.22 Hard substrate created by the introduction of WTG foundations and scour/cable protection are likely to be primarily colonised within hours or days after construction by demersal and semi-pelagic fish species (Andersson, 2011). Continued colonisation has been seen for a number of years after the initial construction, until a stratified re-colonised population is formed (Krone *et al.,* 2013). Fish aggregate from the surrounding areas, attracted by feeding opportunities or the prospect of encountering other individuals which may increase the carrying capacity of the area (Andersson and Öhman, 2010; Bohnsack, 1989; Lindeboom *et al*., 2011). Research has shown in some cases that artificial structures have no apparent reef effect for certain fish species, suggesting that there is no noticeable increase or decrease for a given species. For example, abundances of adult individuals of several pelagic species, including horse mackerel, mackerel, herring, and sprat were unaffected by the presence of scour protection (van Hal *et al*., 2017). While these pelagic species seemed unaffected by scour protection, they may still utilise scour protection as spawning or rearing habitat. Hard-bottom substrates are often important for the spawning of herring (Johannessen, 1986; Šaškov *et al*., 2014), suggesting that scour protection could have a similar function. The loss of soft-bottom substrate arising from offshore wind farm installations may occasionally decrease the abundance of soft-bottom fish species (Krone *et al*., 2017; Lindeboom *et al*., 2011; van Hal *et al*., 2017); however, due to the small amount of area covered by scour protection within an offshore wind farm (<1 percent), possible negative impacts are considered insignificant at the population level, on sand-dwelling species such as dab and sandeel as indicated by previous studies (Stenberg *et al*., 2015; van Hal *et al*., 2017). Even though scour protection may have negative effects on soft-bottom species at the local scale, the effects should be evaluated at larger spatial scales and related to fish population sizes and movements (Glarou *et al*., 2020).

8.10.23 The dominant natural substrate character of the construction area (for example soft sediment or hard rocky seabed) will determine the number of new species found on the introduced vertical hard surface and associated scour protection. When placed on an area of seabed which is already characterised by rocky substrates, few species will be added to the area, but the increase in total hard substrate could sustain higher abundance (Andersson and Öhman, 2010). Conversely, when placed on a soft seabed, most of the colonising fish will be normally associated with rocky (or other hard bottom) habitats, thus the overall diversity of the area may increase (Andersson *et al.,* 2009). A new baseline species assemblage will be formed via re-colonisation and the original soft-bottom population will be displaced (Desprez, 2000). This was observed in studies by Stenberg *et al.* (2015) at the Horns Rev offshore wind farm, Lindeboom *et al*. (2011) at the Egmond aan Zee offshore wind farm, and Bergström *et al*. (2013) at the Lillgrund offshore wind farm, where an increase in fish species associated with reefs, such as sole, whiting, striped red mullet (*Mullus surmuletus*) goldsinny wrasse (*Ctenolabrus rupestris*), lumpsucker (*Cycloplerus lumpus*) and eelpout (*Zoarces viviparous*), and a decrease in the original sandy-bottom fish population, were reported at all three offshore wind farms. Lindeboom *et al*. (2011) and Stenberg *et al*. (2015) also found that fish species such as cod were attracted to the new hard substrate within the offshore wind farm due to the provision of shelter and a food source.

8.10.24 Stenberg *et al*. (2011) found the introduction of hard substrates such as WTG foundations resulted in minor changes in the fish community and species diversity and only affected the local soft-bottom assemblage of sandeel species temporarily, with no change to the sandeel population noted seven years later. Furthermore, a long running fish monitoring survey conducted at the Lillgrund offshore wind farm showed no overall increase in the total abundance of fish, although redistribution towards the foundations within the offshore wind farm area was noticed for some species (for instance cod, European eel and eelpout; Andersson, 2011). More species were recorded after construction than before, which is consistent with the hypothesis that localised increases in biodiversity may occur following the introduction of hard substrates in a soft sediment environment.

These studies correlate with the MMO (2014) study, where there were minor changes in fish communities due to the addition of hard substrate at sites including North Hoyle and Kentish Flats. Overall, results from earlier studies reported in the scientific literature did not provide robust data (for example some were visual observations with no quantitative data) that could be generalised to the effects of artificial structures on fish abundance in offshore wind farm areas (Wilhelmsson *et al*., 2010). More recent papers are, however, beginning to assess population changes and observations of re-colonisation in a more quantitative manner (Krone *et al*., 2013).

8.10.25 Post-construction fisheries surveys conducted in line with the FEPA licence requirements for the Barrow and North Hoyle offshore wind farms, found no evidence of fish abundance across these sites being affected, either positively or negatively, by the presence of the offshore wind farms (Cefas, 2010b) therefore suggesting that any effects, if seen, are likely to be highly localised. The post-construction survey conduction for Rampion 1 offshore wind farm noted a significant change in abundance between the pre- and post-construction surveys, seasons and treatment areas. However, it was noted that these changes were either observed in reference stations, where no impact from Rampion 1 offshore wind farm was expected or were in line with expected natural variability.

Sandeel

8.10.26 Sandeel preferred habitats and spawning areas are typically dominated by gravel and sandy gravel. The PEIR Assessment Boundary and associated fish and shellfish study area are located within a preferred sandeel habitat and spawning ground (**Figure 8-3** and **Figure 8-9, Volume 3**). However, it should be noted that this is a low intensity spawning ground with a wide distribution of spawning grounds within the English Channel and into the southern North Sea. Sandeel sensitivity to a permanent increase in hard substrate is therefore considered to be **medium**.

Herring

8.10.27 Herring preferred spawning grounds consist of coarse sediments, typically sandy, and gravelly sand. However, the fish and shellfish study area does not directly overlap the defined herring spawning grounds (**Figure 8-2, Volume 3**), with the PEIR Assessment Boundary located outwith the identified herring spawning ground to the south of the array area. Herring sensitivity to a permanent increase in hard substrate is therefore considered to be **low**.

Black seabream

8.10.28 Black seabream prefer hard substrate for spawning and nesting grounds, with the nearshore section of the offshore export cable corridor located within potential black seabream nesting sites (see **Figure 8-14, Volume 3**) and is located within close proximity to the Kingmere MCZ. Therefore, black seabream sensitivity to a permanent increase in hard substrate may therefore be considered to be **medium**, however for the purposes of a worst-case assessment it is assumed that there may be discrete areas of spawning habitat lost in the absence of a seabed reinstatement plan.

Shellfish

8.10.29 Crustacean species such as the brown crab and European lobster are expected to exhibit the greatest potential for positive effects from foundations and scour protection material through the expansion of their natural habitats (Linley *et al*., 2007) and the creation of additional refuge areas. Where foundations and scour protection are placed within areas of sandy and coarse sediments, this will represent novel habitat and new potential sources of food in these areas and could potentially extend the habitat range of some shellfish species. Post-construction monitoring surveys at the Horns Rev offshore wind farm noted that the hard substrates were used as a hatchery or nursery grounds for several species and were particularly successful for brown crab. They concluded that larvae and juveniles rapidly invade the hard substrates from the breeding areas (BioConsult, 2006). Studies in the UK have identified increases of benthic species including crabs and lobsters from colonisation of sub-surface structures by subtidal sessile species on which they can feed (Linley *et al*., 2007). The new hard substrate increases shelter for shellfish and has been found to increase. biodiversity and biomass of associated fauna in some areas (Roach *et al*., 2018). Sensitivity is therefore categorised as **medium**.

8.10.30 Fish and shellfish receptors in the study area are deemed to be of low vulnerability and local to international importance (recoverability is not relevant to this impact). The sensitivity is therefore considered to be **medium**.

Invasive species

8.10.31 The colonisation of new habitats may potentially lead to the introduction of non-indigenous and invasive species. With respect to fish and shellfish populations, this may have indirect adverse effects on shellfish populations as a result of competition. There is little evidence of adverse effects resulting from colonisation of other offshore wind farms by non-indigenous species; the post-construction monitoring report for the Barrow offshore wind farm demonstrated no evidence of invasive or alien species on or around the monopiles (EMU Limited, 2008a), and a similar study of the Kentish Flats monopiles only identified slipper limpet (EMU Limited, 2008b), which was also recorded within the Thanet Extension study area (OEL, 2017). Although not prevalent in the area, two non-native invasive species were collected during the pre- and post-construction fish monitoring beam trawl surveys for Rampion 1 offshore wind farm, with both slipper limpet and leathery sea squirt collected in the 2015/16 pre-construction surveys and only slipper limpet collected in the post-construction surveys in 2019/20 (OEL, 2020a).

8.10.32 As detailed in **Table 8-11**, a PEMMP will incorporate mitigation and control of invasive species (C-95).

Significance of residual effect

8.10.33 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 European lobster) will benefit from the introduction of hard substrates.

8.10.34 Overall, it is predicted that the sensitivity of fish and shellfish receptors is **medium,** and the magnitude is predicted to be **minor**. The effect, therefore, will be of **minor adverse significance**, which is **not significant** in EIA terms.

Electromagnetic field (EMF) impacts arising from cables

Introduction

8.10.35 EMF will result from the operation of up to 250km of High Voltage Alternating Current (HVAC) inter-array (at a likely operating voltage of 33kV (kilo volts) or 66kV), 50km of HVAC interconnector cable (operating up to 275kV) and 140km of HVAC export cable (comprising of up to four cables operating at a capacity up to 275kV). The transport of electricity through cables has the potential to emit a localised EMF which could potentially affect the sensory mechanisms of some species of fish and shellfish, particularly electro-sensitive species (including elasmobranchs) and migratory fish species (CMACS, 2003).

Magnitude of impact

8.10.36 EMF comprise both the electric (E) fields, measured in volts per metre (Vm^{-1}) and the magnetic (B) fields, measured in tesla (T). In nature, E-fields are induced in the sea when saltwater, a conductor, moves in the natural B-field, and vary with the B-field strength and current speeds. For example, in the English Channel electric fields usually measure 0.5 to 50μV (micro volt) m^{-1} (Kalmijn, 1999). Background measurements of B-fields are approximately 50μT (micro tesla) in the North Sea and the naturally occurring E-field in the North Sea is approximately 25μVm^{-1} (Tasker *et al*., 2010). The naturally occurring fields are static (Direct Current (DC)), meaning their direction and magnitude are constant. The B- and induced electric (iE) fields produced by Alternating Current (AC) change in direction and magnitude over time as the current flow alternates. It is common practice to block the direct E-field using conductive sheathing, meaning that the EMFs that are emitted into the marine environment are the B-field and the resulting iE-field. A key misconception in the understanding of the effects of EMF has been the assertion that cable burial will work to mitigate iE- and B-field effects and that there will be no externally detectable E-fields generated by industry standard subsea power cables. It has been shown that industry-standard AC (Alternating Current) cables can be effectively insulated to prevent E-field emissions but not B-field emissions (Scott *et al*., 2018). The conclusion of the COWRIE EMF study (Gill *et al*., 2005) and subsequent clarification in the Phase 2 COWRIE EMF report (Gill *et al*., 2009) highlights the fact that it is impractical to assume that cables can be buried at depths that will reduce the magnitude of the B-field, and hence the sediment-sea water interface iE-field, below that at which they could be detected by certain marine organisms on or close to the seabed.

8.10.37 A series of investigations have taken place at the Nysted Wind Farm at Rødsand, in Denmark, on the effects of EMF on fish. Due to difficulties and high complexity within the sampling and analysis phase, only the post-construction monitoring data from 2003 and 2004 were used in the final analysis (Hvidt *et al*., 2004). While the voltage of the export (and inter-array) cables are not the same (132kV at Nysted and maximum 275kV for the Proposed Development), this difference is not considered to be significant in terms of the EMF fields produced, as the strength of

EMF fields depends on the electrical power (amperes) of the current rather than the voltage. Evidence suggests B-field strength rapidly declines with distance from the cable, typically decreasing to 200μT at 1m from a 1000A cable (Normandeau *et al*., 2011). When the Nysted farm is at full production (600A), the B-field does not exceed 5μT at 1m from the cable. In all cases, the predicted B-field is less than the Earth's magnetic field (~50μT). The Nysted studies, using pound nets to collect data on the directional movement of individual species around the cables, were able to determine that there was no change in the overall distribution of any species outside of natural variation that could be attributed to the presence of the cables. In support of the conclusions for the Nysted studies, and in a more comparable study, post-construction monitoring at Burbo Bank offshore wind farm, which has a cable voltage of 220kV, has shown that there has been no change in any electro-sensitive species during the first three years of operation (with the cables buried at 1m depth).

8.10.38 The iE-fields emitted from AC and DC cables are not directly comparable, though modelling studies have shown average iE-fields from submarine DC cables of 194μVm^{-1} at 0m horizontal distance from the cable (assuming cable burial to 1m below the seabed and a 5-knot current), with field strength decreasing with horizontal and vertical distance from the cable. As fish and other mobile marine organisms also cause movement of electrical charges even in still water, the movement of a fish at 5 knots will also experience a similar electrical field. The modelling of iE-fields for AC cables requires consideration of the size of an organism and its distance from the cable. Modelling of iE-fields in a small shark of 150cm length, swimming 0.6m above and parallel to a 60Hz (hertz) AC cable buried to 1m produced a maximum iE-field strength of 765μVm^{-1} (Normandeau *et al*., 2011). Other orientations will result in lower values of iE-fields. Ultimately, the effects will depend on site and project specific factors related to both the magnitude of EMFs and the ecology of local populations including spatial and temporal patterns of habitat use.

8.10.39 The strength of the B-field (and consequently, iE-fields) decreases rapidly horizontally and vertically with distance from source. Modelling studies have indicated that the range of the field is in the order of 10m each side of the cable (assuming 1m burial) (Normandeau *et al*., 2011).

8.10.40 A recent study (Love *et al*., 2016) investigated the effects of EMF from energised cables (35kV) on marine biological receptors, including fish, by comparing ecological data from cables, pipes and natural habitats. No significant differences were observed in the fish communities living around energised and un-energised cables, and natural habitats. Although fish at un-energised cables were marginally larger than those at energised ones, this result was very slight, and likely biologically insignificant. Species diversity, as well as the density of the most important fish species, was higher at cables when compared to natural habitats, although this was likely as a result of greater heterogeneity of habitat afforded by the cables than the soft sediment natural habitats.

8.10.41 Despite observing very few electro-sensitive species such as elasmobranchs (sharks, skates and rays) at any location, no compelling evidence was found to suggest EMF produced by the energised cables were either attracting or repelling such species. It was also found that measured EMFs produced by the cables diminished to background levels at about 1m from the cable. Given the rapidity with which the EMF produced by the cable diminished with distance from the cable, and the lack of response to EMF by marine biological receptors, it was concluded that cable burial (at a sufficient depth) is an adequate tool to prevent EMF from being present at the seafloor. This was concluded by Dunlop *et al*. (2016) suggesting factors such as substrate or depth were more relevant than proximity to the cable in explaining the variation of fish community and density in association with a 245kV HVAC transmission cable in Lake Ontario, Ontario (Canada).

8.10.42 For the Proposed Development, as part of the embedded environmental measures, offshore cables will be buried (see C-45, **Table 8-11**) at a target depth of 1.0 to 1.5m below the seabed surface for the majority of the route (see **Chapter 4**). The final burial depth will be defined post consent following the outcome of the CBRA (or similar) when a detailed study has been completed to assess the relevant factors for each part of the cable route. This will be detailed within the Cable Specification Plan (see C-45, **Table 8-11**).

8.10.43 The impact is therefore predicted to be highly localised, of long-term duration (over the lifetime of the project), continuous and irreversible (over the lifetime of the project). It is predicted that the impact will affect fish and shellfish receptors directly. Due to the localised spatial extent, the magnitude is considered to be **minor**.

Sensitivity or value of receptor

Overview

8.10.44 Molluscs, crustaceans and fish (particularly elasmobranchs) are able to detect applied or modified B-fields. Species for which there is evidence of a response to E- and B- fields include elasmobranchs (sharks, skates and rays), river lamprey, sea lamprey, cod (E-field only), European eel, plaice and Atlantic salmon (Gill *et al*., 2005). Data on the use that marine species make of these capabilities is limited, although it can be inferred that the life functions supported by an electric sense may include detection of prey, predators or conspecifics to assist with feeding, predator avoidance, and or social or reproductive behaviours. Life functions supported by a magnetic sense may include orientation, homing, and navigation to assist with long or short-range migrations or movements (Gill *et al*., 2005; Normandeau *et al*., 2011). Therefore, the EMF emitted by subsea cables may interfere with these functions in areas where cable EMF levels are detectable by the organism, causing expenditure of energy moving to areas that may not be suitable for finding either prey species or members of the same species, or expenditure of energy to moving away from areas where predators are mistakenly located.

Shellfish

8.10.45 Crustacea, including lobster and crabs, have been shown to demonstrate a response to B-fields. The similar magneto-sensory abilities of the Caribbean spiny lobster (*Palinurus argus*) and the American lobster (*Homarus americanus*) have both been shown to use a magnetic map for navigation (Boles and Lohmann, 2003; Hutchison *et al*., 2020). However, it is uncertain if other crustaceans including commercially important brown crab and European lobster are able to respond to B-fields in this way. Although experimental studies showed low impact of EMF exposure on the behavioural activity (for example exploratory response) of a similar species, the American lobster (Hutchison *et al*., 2020), limited research has been undertaken with the European lobster. Normandeau *et al* (2011) and Ueno *et al* (1986) found no neurological response to B-field strengths considerably higher than those expected directly over an average buried power cable. Taormina *et al*. (2020) showed that juvenile lobsters did not exhibit any change of behaviour, in relation to exploratory or shelter seeking behaviours, when submitted to an artificial B-field gradient (maximum intensity 200μT) compared to non-exposed lobsters in the ambient B-field. It appears that static (DC) and time-varying (AC) anthropogenic B-fields, at these intensities, do not significantly impact the behaviour of juvenile European lobsters in daylight conditions. A study by Scott *et al.* (2018) on the effects of simulated EMF on brown crab suggests that the natural roaming behaviour, where individuals will actively seek food and/or mates has been overridden by an attraction to the source of the EMF (strength 2800μT to 40000μT). However, the exposure to EMF does not affect the activity levels of the crabs but affects their ability to select a site to rest. Indirect evidence from post-construction monitoring programmes undertaken in operational wind farms does not suggest that the distribution of potentially magnetically sensitive species of crustaceans or molluscs have been affected by the presence or absence of submarine power cables and associated B-fields. However, it should be noted that there have been no shellfish specific EMF monitoring programmes.

Fish

8.10.46 Elasmobranchs (sharks, skates and rays), especially demersal species, are known to be the most electro-receptive of all fish. They possess specialised electro-receptors which enable them to detect very weak voltage gradients (down to 0.5μVm^{-1}) in the environment naturally emitted from their prey (Gill *et al*., 2005). Both attraction and repulsion reactions to electric fields have been observed in elasmobranch species. A Collaborative Offshore Wind Research into the Environment (COWRIE) sponsored mesocosm study demonstrated that the lesser spotted dogfish and thornback ray were able to respond to EMF of the type and intensity associated with subsea cables; the responses of some ray individuals suggested an increase in searching effort when the cables were switched on. However, the responses were variable between both species and individuals and were not predictable and did not always occur (Gill, *et al*., 2009). In addition to the experimental work, Gill *et al*. (2009) measured EMF in the field above cable landfalls from two operational wind farms. Based on these measurements, and the results of the experimental work, it was predicted that the elasmobranchs studied could potentially detect the active cables at a distance of 295m.

8.10.47 Hutchison *et al*. (2018) conducted an EMF study in water depths of <50m on the movement and migration of elasmobranch species. The B-field extended out to 5 and 10m on either side of the cable, whereas the E-fields extended out to 100m from either side of the AC cable. However, this field survey found the E-field (1000 to 2500μVm^{-1}) and B-field (0.05 to 0.3μT) produced by an HVAC cable (sea2shore) were significantly lower than modelled values commissioned by the National grid operator, indicating that the AC cables are likely to mitigate possible biological effects. (Hutchison *et al*., 2018). Overall, EMFs associated with DC cables were modelled as higher than those associated with AC cables of similar voltages, and research suggests that marine organisms are more likely to detect and change behaviour in response to the EMFs produced by DC cables (Hutchison *et al*., 2018). A further study by Hutchison *et al*. (2020) demonstrated an increase in the exploratory/foraging behaviour in Little skate (*Leucoraja erinacea*) in response to EMF emissions of a subsea high voltage direct current (HVDC) transmission cable. In situ measurements were taken from two cables in the USA, the ‘Cross Sound Cable’ (minimum burial depth 0.58m, maximum 1.74m) and the ‘Neptune Cable’ (minimum burial depth 1.16m and maximum 2.62m), in order to provide measurements for EMF models. The behaviour of individuals at the control site (no EMF) versus the treatment site (EMF from cable, with a burial depth of 1.3m). The increased distance travelled in the treatment site suggests that periods of rest were less frequent when Little skate were exposed to EMF. An increase in distance travelled was previously observed in situ enclosure studies of thornback ray in response to an AC cable, emitting EMF within the range of detectability of the skate (Gill *et al*., 2009).

8.10.48 A study commissioned by the MMO (2014) evaluated the results of post environmental data associated with post-consent monitoring of licence conditions of offshore wind farms. This included UK and European sites. The report concluded that from the results of post-consent monitoring conducted to date, there is no evidence to suggest that EMF pose a significant risk to elasmobranchs at the site or population level, and little uncertainty remains (MMO, 2014).

Migratory species

8.10.49 Another concern with EMF is the potential for interference with the navigation of sensitive migratory species. However, few studies assess interactions of migratory species with cable EMFs. Lampreys possess specialised ampullary electroreceptors that are sensitive to weak, low frequency electric fields (Bodznick and Northcutt, 1981; Bodznick and Preston, 1983), but information regarding what use they make of the electric sense is limited. Chung-Davidson *et al*. (2008) found that weak electric fields may play a role in the reproduction of sea lamprey and it was suggested that electrical stimuli mediate different behaviours in feeding-stage and spawning-stage individuals. This study (Chung-Davidson *et al*, 2008) showed that migration behaviour of sea lamprey was affected (adults did not move) when stimulated with electrical fields of intensities of between 2.5 and 100mVm^{-1}, with normal behaviour observed at electrical field intensities higher and lower than this range. These levels were considerably higher than modelled iE-field expected from AC subsea cables (0.765mVm^{-1}, Normandeau *et al*., 2011).

8.10.50 Species such as Atlantic salmon and European eel have both been found to possess magnetic material of a size suitable for magnetoreception, and these species can use the Earth’s magnetic field for orientation and direction-finding during migration (Gill and Bartlett, 2010). Mark and recapture experiments undertaken at the operational Nysted offshore wind farm showed that eel did cross the export cable (Hyidt *et al*., 2003) but studies on European eel have highlighted some limited effects of subsea cables. The swimming speed during migration was shown to change during the short-term (tens of minutes) with exposure to AC electric subsea cables, even though the overall direction remained unaffected (Westerberg and Langenfelt, 2008). The authors concluded that any delaying effect (which was found to be on average 40 minutes) will not be likely to influence fitness in a 7,000km migration. A similar study conducted by Marine Scotland Science (Orpwood *et al.,* 2015) that exposed European eels to an AC magnetic field of 9.6μT found no evidence of a difference in movement, nor observations of startle or other obvious behavioural changes associated with the magnetic fields. A study of Chinook salmon (*Oncorhynchus tshawytscha)* smolts migrating through the San Francisco Bay found a higher proportion of smolts crossed the HDVC cable at some locations while further away at others with the smolts more likely to be detected south of their normal migration route. However, the study found the HVDC cable had a mixed but limited effected on the movements and migration success of smolts (Wyman *et al.,* 2018). Studies conducted by Marine Scotland Science (Armstrong *et al.,* 2015) and Walker (2001) found no evidence of unusual behaviour in Atlantic salmon associated with magnetic fields and EMFs produced by cables. Similarly, a study by Swedpower (2003) found no measurable impact on fish behaviour and movement when subjecting salmon and sea trout to magnetic fields twice the magnitude of the geomagnetic field (48μT). This is further confirmed by a study undertaken by the Bureau of Ocean Energy Management (BOEM) which found that energised cables do not appear to present a strong barrier to the natural seasonal movement patterns of migratory fish (BOEM, 2016).

8.10.51 Woodruff *et al*. (2012) undertook a study on the effects of EMF on representative fish and shellfish species. Species were chosen for the laboratory tests based on their ecology, commercial value and potential to encounter EMF in their natural habitat and included: juvenile coho salmon (*Oncorhynchus kisutch*), Atlantic halibut (*Hippoglossus hippoglossus*), California halibut (*Paralicthys californicus*), rainbow trout (*Oncorhynchus mykiss*), and Dungeness crab (*Metacarcinus magister*) (Woodruff *et al*., 2012). Throughout the laboratory tests, these species were subjected to a range of EMF intensities which may be encountered under field conditions in order to observe any effects on development, physiology or behaviour. Woodruff *et al*. (2012) summarised that few statistically significant effects were observed over all laboratory tests from preliminary results and that replication of these tests was needed to confirm the negligible effects of EMF on these species.

8.10.52 The review by Gill and Bartlett (2010) highlights the mixed results from the few studies that have been reported and that there is no clear evidence as to what, if any, the overall effect of EMFs on migration and movement behaviour of these species is likely to be. It concludes that EMFs from subsea cables may interact with migratory eel if their migration route takes them over the cables, particularly in shallow waters. It was also concluded that salmonids may encounter artificial EMF from marine renewable energy installations (MREIs) along their coastal migration routes where these overlap with sub-sea cable networks, particularly in shallow waters below 20m (Gill *et al*., 2012). Exposure to artificial EMF may be most likely to occur during spring when Atlantic salmon smolts migrate downstream into the sea, or at times of peak adult return migrations, when the fish have the greatest probability of encountering MREIs. However, the insulation of cables and their burial at adequate depth normally ensures the absence of detectable EMFs in the water column (Russell *et al*., 2018). Therefore, limited effects may be expected in fish migration, should indeed the cable route be used by migratory species, although such effects are likely to be short-lived affecting only a small area of habitat within metres of the buried cable.

8.10.53 Elasmobranch species in the study area are deemed to be of medium vulnerability and local importance and therefore are considered to have **medium** sensitivity.

8.10.54 Migratory fish species are deemed to be of medium vulnerability and regional to international importance and therefore are considered **medium** to **high** sensitivity.

8.10.55 All other fish and shellfish receptors are deemed to be of low vulnerability and are of local to regional importance. The sensitivity of these receptors is therefore considered to be **medium**.

Significance of residual effect

8.10.56 The cable burial depth for the Proposed Development (including interarray, interconnector and offshore export cable corridor) may not be attained due to seabed conditions and in these areas, cable protection will be used. Burial of a marine cable acts as a buffer between the potential source of EMF and the receptor. The ZOI from EMF around a cable remains the same regardless of the substrate that surrounds it. Accordingly, the use of cable protection acts in the same way as burial, by distancing the receptor from the source.

8.10.57 Potential EMF from the Proposed Development offshore cables will represent a long term and continuous impact throughout the lifetime of the project. However, effects will be highly localised, affecting a relatively small portion of fish and shellfish habitats in the study area. The Proposed Development commitments (as shown in **Table 8-11**) include the use of, where feasible, cable burial to avoid direct impacts to the fish and shellfish (see C-45, **Table 8-11**). Overall, the sensitivity of fish and shellfish (excluding migratory fish species) is **medium,** and the magnitude of the impact is deemed to be **minor**. The effect, therefore, will be of **minor adverse significance**, which is **not significant** in EIA terms.

8.10.58 For migratory fish species, due to the small scale of the impact, the **medium** to **high** sensitivity and the absence of barrier effects, effects on migratory fish species are predicted to be of **minor adverse significance**, which is **not significant** in EIA terms.

Direct disturbance resulting from maintenance within the array area and the offshore cable corridor

Introduction

8.10.59 Temporary habitat loss/disturbance is likely to occur during the operation and maintenance phase of the Proposed Development as a result of spud-can impacts from jack-up vessels and also cable re-burial works (where necessary). The impacts associated with these operations are likely to be similar (at least in nature) to those associated with the construction phase (see **paragraphs 8.9.158** to **paragraph 8.9.172** for export cable installation disturbance and **paragraphs 8.9.173** to **paragraph 8.9.183** for array area construction disturbance).

Magnitude of impact

8.10.60 Direct impacts to the seabed arising from jack-up vessels and cable maintenance (31 jack-up vessel visits per year over an approximate 30-year period, in addition to cable maintenance including re-burial) will affect a maximum footprint of 20,000m^2. These impacts will be temporary and localised to the immediate area around the WTG foundations, where jack-up legs come into contact with the seabed. Similarly, subtidal cable reburial/repair works (if and when necessary) will affect habitats in the immediate vicinity of cable reburial operations. These maintenance operations will represent intermittent occurrences throughout the lifetime of the Proposed Development, with only a small proportion of the total area of temporary habitat loss/disturbance being affected at any one time.

8.10.61 Given that the habitats affected are common and widespread throughout the region (with the exception of black seabream preferred habitat), this impact represents a small footprint compared to their overall extent. The impact is predicted to be of local special extent (for instance within PEIR Assessment Boundary), short term duration, intermittent and reversible. It is predicted that the impact has the potential to affect fish and shellfish receptors directly. Therefore, the magnitude is assessed as **minor**.

Sensitivity or value of receptor

Overview

8.10.62 The sensitivity of receptors to disturbance is discussed in detail in **paragraph 8.9.158** to **8.9.168** (construction sensitivity for export cable installation) and in **paragraph 8.9.176** to **8.9.182** (construction sensitivity for array area). The receptors affected by this impact during the operation and maintenance phase will be largely restricted to those within the PEIR Assessment Boundary, for instance, the proposed array area and, if cable reburial is required, at discrete sections within the PEIR Assessment Boundary offshore export cable corridor. The species most likely to be affected are demersal fish species and shellfish species whose life strategies are strongly connected to the use of the seabed for shelter (for instance through burrowing) or reproduction (for example the demersal spawners; black seabream and sandeel).

8.10.63 Most fish and shellfish receptors in the fish and shellfish study area are deemed to be of low vulnerability, high recoverability and of local to international importance. The sensitivity of these receptors is therefore considered to be **medium**.

Sandeel

8.10.64 Sandeel spawning and nursery habitats are present within the PEIR Assessment Boundary fish and shellfish study area, these tend to extend over a wide area, and the relative proportion of these habitats affected by operation and maintenance operations at any one time will therefore be small in the context of the wider habitat available (**Figure 8-3, Volume 3**). Sandeel are deemed to be of medium vulnerability, medium recoverability and of regional importance. The sensitivity of these receptors is therefore considered to be **low**.

Herring

8.10.65 Key spawning habitats for herring are located south of the PEIR Assessment Boundary fish and shellfish study area (**Figure 8-2, Volume 3**), and therefore the adult spawning herring within these habitats are unlikely to be affected by operation and maintenance operations within PEIR Assessment Boundary. Herring are deemed to be of low vulnerability, medium recoverability and of regional importance. The sensitivity of these receptors is therefore considered to be **medium**.

Black seabream

8.10.66 Key spawning and nesting habitat for black seabream is located north of the PEIR Assessment Boundary array area (Kingmere MCZ) and within the PEIR Assessment Boundary offshore export cable corridor, and therefore the adult spawning black seabream within these habitats will be expected to be affected by operation and maintenance operations at discrete locations within the PEIR Assessment Boundary offshore export cable corridor. Black seabream are deemed to be of high vulnerability, medium recoverability and of regional importance. The sensitivity of these receptors is therefore considered to be **high**.

Shellfish

8.10.67 Brown crab and European lobster are deemed to be of high vulnerability, medium to high recoverability and of regional importance within the fish and shellfish study area. The sensitivity of these receptors is therefore considered to be **high**.

Significance of residual effect

8.10.68 Disturbance as a result of maintenance during the operational lifetime of the Proposed Development is predicted to affect a very small proportion of fish and shellfish habitats within the PEIR Assessment Boundary study area, with limited effects on fish and shellfish receptors. Overall, it is predicted that the sensitivity of fish and shellfish is considered to be **medium** to **high** and the magnitude is deemed to be **minor**. The effect, therefore, will be of **minor adverse significance**, which is **not significant** in EIA terms.

8.11 Preliminary assessment: Decommissioning phase

Introduction

8.11.1 Impacts from decommissioning are expected to be similar to those listed for construction if Rampion 2 infrastructure is removed from the seabed at the end of the development's operational life phase. The nature and scale of impacts arising from decommissioning are expected to be of a similar or reduced magnitude to those generated during the construction; certain activities such as piling will not be required. The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment.

8.11.2 The sensitivity of receptors during the decommissioning is assumed to be the same as given for the construction phase (see **Section 8.9**). The magnitude of effect is considered to be no greater or potentially less than those considered for the receptors within the construction phase. Therefore, it is anticipated that any decommissioning impacts will be no greater, and probably less than those assessed for the construction phase.

8.11.3 If it is deemed closer to the time of decommissioning that removal of certain parts of the development (for example export and inter-array cables) will have a greater environmental impact than leaving in situ, it may be preferable to leave those parts in situ. In this case, the impacts will be similar to those described for the operation and maintenance phase. If certain parts of the development were left in situ, effects dependent on the operation of the wind farm such as EMF effects will not occur.

8.11.4 To date, no large offshore wind farm has been decommissioned in UK waters. It is anticipated that any future programme of decommissioning will be developed in close consultation with the relevant statutory marine and nature conservation bodies. This will enable the guidance and best practice at the time to be applied to minimise any potential impacts (see C-111, **Table 8-11**).

Mortality, injury, behavioural changes and auditory masking arising from noise and vibration

8.11.5 Decommissioning of offshore infrastructure for the Proposed Development 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 WTG 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. As detailed in **Chapter 4**, the maximum levels of underwater noise during decommissioning will be from underwater cutting required to remove structures, with piled foundations cut approximately 1.0m below the seabed. The noise levels from this process are expected to be much less than pile driving and therefore impacts will be less than as assessed during the construction phase (**paragraph 8.9.30** to **paragraph 8.9.138**).

8.11.6 Studies of underwater construction noise (decommissioning) reported source levels that are similar to those reported for medium-sized surface vessels and ferries (Malme *et al*., 1989; Richardson *et al*., 1995). The noise resulting from WTG decommissioning employing abrasive cutting is unlikely to result in any injury, avoidance or significant disturbance of local marine animals. Some temporary minor disturbance might be experienced in the immediate vicinity of the decommissioning activity, for example, from jack-up vessels or from cutting piled foundations. The impact is predicted to be of highly local spatial extent, short term duration, intermittent and reversible.

Direct disturbance resulting from the removal of the export cable

8.11.7 Although it is expected that most of the Proposed Development array and offshore export cables will be left in situ, for the purposes of the EIA it has been assumed that all cables will be removed during decommissioning, though any cable protection installed will be left in situ. Exposed cables are more likely to be removed to ensure they do not become hazards to other users of the seabed. At this point in time, it cannot be accurately determined whether and which cables will be exposed at the time of decommissioning.

8.11.8 It is likely that equipment similar to that which is used to install the cables could be used to reverse the burial process and expose them. Therefore, the area of seabed impacted during the removal of the cables could be the same as the area impacted during the installation of the cables. Divers and/or ROVs may be used to support the cable removal vessels.

8.11.9 The nature and extent of disturbance during decommissioning of export cables is likely to be similar to that described for installation of these during the construction phase in **paragraph 8.9.1548.9.155** to **paragraph 8.9.172**. Therefore, the cables may be left buried in place or alternatively partially removed by pulling the cables back out of the ducts (see **Chapter 4**). However, this approach is precautionary, as there is no statutory requirement for decommissioned cables to be removed. Such details will be included within the Decommissioning Plan (see C-111, **Table 8-11**) which will be developed to minimise environmental disturbance and will be updated throughout the lifetime of the Proposed Development to account for changing best practice.

8.11.10 As described in **Table 8-10**, the magnitude of the impact is predicted to be lower than that described for the construction phase (see **paragraph 8.9.155** *et seq*.), as seabed preparation works will not be required.

Direct disturbance resulting from decommissioning within the array

8.11.11 WTGs and offshore substations will be removed by reversing the methods used to install them. Piled foundations will likely be cut approximately 1m below the seabed, with due consideration made of likely changes in seabed level and removed. This could be achieved by inserting a pile cutting device. Once the piles are cut, the foundations could be lifted and removed from the site. At this point in time, it is not thought to be reasonably practicable to remove entire piles from the seabed, but endeavours will be made to ensure that the sections of the pile that remain in the seabed are fully buried.

8.11.12 As detailed in **Table 8-10**, it is assumed that during the decommissioning phase, all offshore infrastructures will be removed from the seabed (for instance foundations and subsea cables) with the exception of scour protection and cable protection, which is assumed, based on current evidence, will be left in situ.

8.11.13 Further details will be included within the Decommissioning Plan (see C-111, **Table 8-11**) which will be developed to minimise environmental disturbance and will be updated throughout the lifetime of the Proposed Development to account for changing best practice.

Temporary localised increases in SSC and smothering

8.11.14 Increases in SSC and sediment deposition 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 increased SSC and sediment deposition are described in detail in **paragraph 8.9.184** to **paragraph 8.9.217**.

8.11.15 The magnitude of the impact has been assessed as **minor**, with the maximum sensitivity of the receptors being **very high**. Therefore, the significance of effect from changes in SSC and associated sediment deposition occurring as a result of decommissioning activities in the subtidal and intertidal area has a maximum of **minor adverse significance** of effect, which is **not significant** in EIA terms.

Direct and indirect seabed disturbances leading to the release of sediment contaminants

8.11.16 Direct and indirect disturbances of the seabed from the decommissioning works, leading to the release of sediment contaminants 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 release of sediment contaminants are described in detail in **paragraph 8.9.222** and **paragraph 8.9.223**.

8.11.17 To summarise, re-suspended sediments as a result of decommissioning activities are expected to be deposited in the immediate vicinity of the works, with the potential release of sediment-bound contaminants likely to be rapidly dispersed with the tide and/or currents. The nature and scale of impacts arising from decommissioning are expected to be of similar, or reduced magnitude to those generated during the construction; therefore, the magnitude of the impact has been assessed as **negligible** for fish and shellfish receptors and is therefore not considered further in the assessment.

8.12 Preliminary assessment: Cumulative effects

Approach

8.12.1 A preliminary cumulative effects assessment (CEA) has been carried out for the Proposed Development which examines the result from the combined impacts of the Proposed Development with other developments on the same single receptor or resource and the contribution of Rampion 2 to those impacts. The overall method followed in identifying and assessing potential cumulative effects in relation to the offshore environment is set out in **Chapter 5**.

8.12.2 The offshore screening approach corresponds to PINS Advice Note Seventeen and also takes into account the Cumulative Impacts Assessment Guidelines issued by RenewableUK (RenewableUK, 2013) accepted guidance which is specific to the marine elements of an offshore wind farm, addressing the need to consider mobile wide-ranging species (foraging species, migratory routes etc) and PINS Advice Note Nine.

Cumulative effects assessment

Overview

8.12.3 For fish and shellfish ecology, a ZOI (as described in **Section 8.4: Scope of assessment** and shown in **Figure 8-1, Volume 3**) has been applied for the CEA to ensure direct and indirect cumulative effects can be appropriately identified and assessed. The ZOI has been determined as the largest distance over which an impact may occur, for the purpose of the fish and shellfish ecology assessment, this is defined over the distance which increased SSC and deposition may occur and therefore extends 15km around the array area PEIR Assessment Boundary and 10km surrounding the offshore export cable corridor PEIR Assessment Boundary area of search. For the impact of underwater noise, a larger area of search was used (100km), as noise is predicted to have a greater area of effect than the other effects identified.

8.12.4 A short list of 'other developments' that may interact with the Proposed Development ZOIs during their construction, operation and maintenance or decommissioning is presented in **Appendix 5.4: Cumulative effects assessment shortlisted developments, Volume 4** and on **Figure 5.4.1**. This short list has been generated applying criteria set out in **Chapter 5** and has been collated up to the finalisation of the PEIR through desk study, consultation and engagement.

8.12.5 A tiering structure has been used for screening and assessment of other developments as in accordance with PINS Advice Note Seventeen (**Chapter 5**). Definitions of Tiers are set out in **Table 5-3** of **Chapter 5: Approach to EIA, Volume 4**. Where other projects are expected to be completed before construction of the Proposed Development and the effects of those projects are fully determined, effects arising from them are considered as part of the baseline and may be considered as part of both the construction and operational assessment.

8.12.6 Only those developments in the short list that fall within the fish and shellfish ecology ZOI have the potential to result in cumulative effects with the Proposed Development. The fish and shellfish ecology ZOI is shown in **Chapter 5**, **Figure 5.1, Volume 3**. All developments falling outside the fish and shellfish ecology ZOI are excluded from this assessment. Furthermore, the following types of other development have the potential to result in cumulative effects on fish and shellfish ecology.

- sub-sea cables, interconnectors and pipeline;
- aggregate production areas;
- tidal energy; and
- offshore wind farms.

8.12.7 On the basis of the above, the following specific other developments (as presented within **Table 8-24**) contained within the short list in **Appendix 5.4, Volume 4** are scoped into this cumulative impact assessment. It should be noted that developments which are proposed or under construction, at the time of writing this chapter, are included in the table below due to lack of certainty around any ongoing effect.

Table 8-24 Developments to be considered as part of the CEA

ID (Figure 5.4.1)	Development type	Project	Status	Confidence in assessment	Tier	Distance to Proposed Development offshore export cable corridor (km)	Distance to Proposed Development array area (km)
W10	Offshore wind farm	Dieppe – Le Treport (France)	Under construction (2019 to 2023)	Medium – Third-party project details published in the public domain but not confirmed as being ‘accurate’.	1	<50	<50
W20	Offshore wind farm	Fécamp (France)	Under construction (2020 to 2023)	High – Third-party project details published in the public domain and confirmed as being ‘accurate’ by the developer.	1	<50	<50
T1	Tidal Energy	Perpetuus Tidal Energy Centre (PTEC)	Proposed (assume offshore installation in 2026)	Medium – Third-party project details published in the public domain but not confirmed as being 'accurate'	1	47.8	<50
C1	Interconnector	AQUIND (UK to France)	Proposed (assume offshore	High – Third-party project details published in the public domain and confirmed as being	1	5.4	0

ID (Figure 5.4.1)	Development type	Project	Status	Confidence in assessment	Tier	Distance to Proposed Development offshore export cable corridor (km)	Distance to Proposed Development array area (km)
			installation in 2022)	'accurate' by the developer.			
A395/1	Aggregates	395/1 Off Selsey Bill – Aggregates Industries UK Ltd	Active (end date 05/03/2028)	High – Third-party project details published in the public domain and confirmed as being 'accurate' by the developer.	1	20.2	15
A396/1	Aggregates	396/1 Inner Owers – Tarmac Marine Ltd	Active (end date 07/07/2030)	High – Third-party project details published in the public domain and confirmed as being 'accurate' by the developer.	1	0.1	0
A396/2	Aggregates	396/2 Inner Owers – Tarmac Marine Ltd	Active (end date 07/07/2030)	High – Third-party project details published in the public domain and confirmed as being 'accurate' by the developer.	1	2	3.5

ID (Figure 5.4.1)	Development type	Project	Status	Confidence in assessment	Tier	Distance to Proposed Development offshore export cable corridor (km)	Distance to Proposed Development array area (km)
A435/1	Aggregates	435/1 Inner Owers – Hanson Aggregates Marine Ltd	Active (end date 07/07/2030)	High – Third-party project details published in the public domain and confirmed as being 'accurate' by the developer.	1	0.7	0.1
A435/2	Aggregates	435/2 Inner Owers – Hanson Aggregates Marine Ltd	Active (end date 07/07/2030)	High – Third-party project details published in the public domain and confirmed as being 'accurate' by the developer.	1	2.3	0.7
A453	Aggregates	453 Owers Extension – CEMEX UK Marine Ltd.	Active (end date 31/03/2032)	High – Third-party project details published in the public domain and confirmed as being 'accurate' by the developer.	1	0.5	5.5
A488	Aggregates	488 Inner Owers North – Tarmac Marine Ltd.	Active (end date 07/07/2030)	High – Third-party project details published in the public domain and confirmed as being	1	0.6	3.9

ID (Figure 5.4.1)	Development type	Project	Status	Confidence in assessment	Tier	Distance to Proposed Development offshore export cable corridor (km)	Distance to Proposed Development array area (km)
				‘accurate’ by the developer.			

8.12.8 Baseline data and further information on other developments will continue to be collected prior to the finalisation of the ES and iteratively fed into the assessment. An updated cumulative effects assessment will be reported in the ES.

8.12.9 The cumulative maximum design scenario is described in the table below (**Table 8-25**).

Table 8-25 Cumulative maximum design scenario for fish and shellfish ecology.

Potential impact	Scenario	Justification
Construction		
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	**Tier 1:** 1) offshore wind farm under construction (Dieppe – Le Treport and Fécamp) 2) planned PTEC (construction phase) **Tier 2:** No Tier 2 projects identified. **Tier 3:** No Tier 3 projects identified.	Maximum potential for interactive effects from underwater noise associated with construction and offshore wind farm piling activities is considered within a representative 100km buffer of the PEIR Assessment Boundary array area. This buffer was chosen as underwater noise effects are expected to occur over a wider area.
Cumulative temporary increase in SSC and smothering	**Tier 1:** 1) operation and maintenance of operational cables (AQUIND) 2) active aggregates (operation and maintenance phase) **Tier 2:** No Tier 2 projects identified. **Tier 3:** No Tier 3 projects identified.	Maximum cumulative increases in SSC and smothering is calculated within a representative buffer of the PEIR Assessment Boundary to represent the maximum distance sediments may travel in one tidal excursion buffer distance (15km).
Operation and maintenance		
Long-term loss of habitat and increased hard substrate and structural complexity due to the presence of turbine foundations,	**Tier 1:** 1) operation and maintenance of operational cables (AQUIND) **Tier 2:** No Tier 2 projects identified. **Tier 3:** No Tier 3 projects identified.	Maximum cumulative long-term habitat loss and increase in hard substrate and structural complexity is calculated within a representative buffer of the PEIR Assessment Boundary as habitats within this buffer are representative of those

Potential impact	Scenario	Justification
scour protection and cable protection		within the PEIR Assessment Boundary fish and shellfish study area.

8.12.10 A description of the significance of cumulative effects upon fish and shellfish ecology arising from each identified impact is given below. The cumulative effects assessment has been based on information available in the ESs for the other developments where these are available; it is noted that the maximum assessment assumptions quoted within these ESs are often refined during the determination period and in the post-consent phase such that the final schemes built out may have a reduced impact compared to what has been concluded in the ES. The other developments considered in this CEA are illustrated in **Figure 8-20, Volume 3** below.

Cumulative mortality, injury, behavioural changes and auditory masking arising from noise and vibration.

8.12.11 There is potential for mortality, injury, behavioural changes and auditory masking arising from noise and vibration as a result of construction activities associated with the Proposed Development and other projects (**Table 8-24**). For the purposes of this PEIR, this additive impact has been assessed within 100km of PEIR Assessment Boundary, which is considered the maximum extent of impacts from noise as highlighted in noise modelling undertaken as part of their PEIR assessment.

8.12.12 The only Tier 1 projects identified within the 100km buffer that may be under construction at the same time as the Proposed Development, is PTEC (see **Table 8-24**). PTEC is aimed at the deployment of up to full scale single units and, in particular, small arrays of tidal devices. As PTEC is a tidal energy demonstration facility, to date no known tidal WTG construction is detailed, however various tidal devices and array configurations have the potential to be deployed at PTEC over its 25-year life. As a result, the demonstration facility is also categorised as Tier 3 to take into consideration potential deployment of tidal testing infrastructure which may require drilling or piling activities. Both French offshore wind farm Dieppe – Le Treport and Fécamp will be operation by 2023 with no temporal overlap or piling or drilling activities with the Proposed Development. No Tier 2 projects have been identified.

8.12.13 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 at other offshore wind farm sites in the wider study area. Injury or mortality of fish from piling noise is not expected to occur cumulatively due to the small range within which potential injury effects will be expected (for instance, predicted to occur within tens of kilometres of piling activity within each of the offshore wind farm projects). Cumulative effects of underwater noise are therefore discussed in the context of behavioural effects, particularly on spawning or nursery habitats

8.12.14 Due to the lack of temporal overlap (construction to be completed for both Dieppe – Le Treport and Fécamp by 2023), there is not considered to be a cumulative impact of these three projects on fish and shellfish receptors. PTEC Tier 1 and Tier 3 related construction and associated underwater noise during installation may result in a cumulative impact with the Proposed Development construction phase. Particularly as PTEC is a demonstration facility and underwater noise may result from the drilling of foundations, and removal of infrastructure at repowering phases or on final decommissioning. However, as it is a demonstration facility the number of tidal WTGs and type of WTGs will vary, for example the use of mooring chains and anchors, gravity-based foundations (PTEC, 2014). Furthermore, these impacts will be highly localised, temporary in nature and unlikely to greatly exceed background underwater noise levels (PTEC, 2014). As evidenced by McCauley *et al.* (2000), it is expected that fish will resume to normal behaviour and distribution well within this time period, and as such, significant effects are not expected to occur in terms of cumulative duration of exposure. The cumulative impact of underwater noise on fish and shellfish receptors is predicted to be of regional spatial extent, short-term duration, intermittent and reversible. It is predicted that the impact will affect the receptor directly. The magnitude of the cumulative impact is therefore considered to be **minor**.

8.12.15 The sensitivities of fish and shellfish receptors to underwater noise are discussed in **paragraphs 8.9.23 to paragraph 8.9.103***.* Fish injury as a result of piling noise will only be expected within the immediate vicinity of piling operations, and the area within which effects on eggs and larvae is expected is similarly small.

8.12.16 Behavioural effects on fish species as a result of piling noise are predicted to be dependent on the nature of the receptors. The predicted behavioural response may be sufficient to result in temporary avoidance by some 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. This is evidenced by 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 of time and the extent that behavioural reactions will cause a negative effect in individuals (Mueller-Blenke *et al.,* 2010).

8.12.17 Herring, sandeel and black seabream are considered to be of high vulnerability, with medium to low recoverability and of regional importance. The sensitivity of these receptors is therefore considered to be **high**.

8.12.18 All other fish and shellfish receptors are considered to be of low vulnerability, high recoverability and of local to international importance. The sensitivity of these receptors is therefore considered to be **medium.**

8.12.19 Overall, it is predicted that the sensitivity of fish and shellfish receptors is **medium** to **high** and the magnitude is deemed to be **minor**. The cumulative effect will therefore by of **minor adverse significance**, which is **not significant** in EIA terms.

Cumulative temporary increases in SSC and smothering during construction

8.12.20 There is potential for cumulative increases in SSC and smothering as a result of construction activities associated with the Proposed Development and other developments (see **Table 8-25**). For the purposes of this assessment, this additive impact has been assessed within the fish and shellfish ecology ZOI, which extends 15km around the array area boundary and 10km surrounding the offshore export cable corridor, representing the maximum tidal excursion in the area, and therefore the furthest distance sediments can travel from the site. The projects identified in Tier 1 are the AQUIND interconnector cables and aggregate licence areas 395/1, 396/1, 396/2, 435/1, 435/2, 453 and 488. There are no Tier 2 or Tier 3 projects.

8.12.21 The AQUIND interconnector cable is located within the Proposed Development array area and it is assumed that construction will coincide with the construction of the Proposed Development. From kilometre point 21 to 109 the worst-case scenario for increased SSC is considered to be surface release of up to 1,754,000m^3 of sediment (AQUIND Limited, 2019a). Cumulatively with the Proposed Development construction this may result in the disturbance and deposition of up to 4,645,000m^3 of sediment. However, only a small portion of the AQUIND interconnector cable intersects with the PEIR Assessment Boundary (9.34km of cable) with a total of 24.72km overlapping the fish and shellfish ecology study area, and therefore, the maximum amount of sediment released cumulatively with the Proposed Development will be considerably less. Any cable maintenance repairs undertaken within the operational phase of the developments will be short term, intermittent and localised to the site and therefore cumulative impacts are expected to be minimal. Additionally, due to the naturally dynamic environment of the site, any sediment released from these operations during the construction and operational phases of the development will likely be dispersed in the faster flows. Therefore, taking this into consideration, there are not predicted to be any significant cumulative impacts from the construction or operation of the AQUIND interconnector cable.

8.12.22 Aggregate licence areas 395/1, 396/1, 396/2, 435/1, 435/2, 453 and 488 will be operational during the construction of the Proposed Development, therefore the potential for cumulative temporary increases in SSC and sediment deposition from these active dredge operations. The target material at these marine aggregate areas is sands and gravels and characteristically, the aggregate deposits in the MAREA region contain 1 to 3 percent mud (silt and clay) in situ and therefore the suspended sediment concentrations in the overflow from dredging vessels are relatively low compared to other regions of the UK (EMU Limited, 2012b). As part of the Rampion 1 offshore wind farm ES changes to seabed sediment thickness as a result of combined foundation installation and aggregate extraction works were modelled as part of the impact assessment (ABPmer, 2012). The modelling predicted that bed level changes of up to around 1mm could occur; however, it was expected that this sediment will be widely remobilised. The addition of 1mm of sediment is not anticipated to cause any significant impacts to fish or shellfish associated with the PEIR Assessment Boundary. Furthermore, EMU Limited (2012a) reported that there was no evidence of black seabream nests being impacted by nearby aggregate extraction work. ABPmer (2012) also considered that there was only a minimal potential for of any interaction between suspended sediment from export cable installation and aggregate extraction. Similar observations are anticipated for the Proposed Development. Overall, it is therefore considered that there will be limited scope for cumulative impacts to fish and shellfish from seabed disturbance.

8.12.23 Cumulative effects can also be considered in terms of duration of exposure from multiple projects which do not overlap but happen consecutively. However, as the effects from the majority of the projects will be short-lived, there are likely to be significant temporal gaps between the discrete construction and maintenance events, which will have localised effects. As aggregate activities are not considered to cause a significant cumulative increase to SSC and deposition and as a result of the **medium** to **high** sensitivity fish and shellfish receptors in the fish and shellfish ecology study area (**paragraph 8.9.201** to **paragraph 8.9.213**), cumulative effects in terms of duration of exposure are not expected.

8.12.24 The cumulative impacts of increased SSC and sediment deposition is considered to be **minor**, indicating that the potential is for localised disturbance that does not threaten the long-term viability of the resource.

8.12.25 The sensitivity of fish and shellfish ecology receptors to increase SSC and smothering is detailed in **paragraph 8.9.201** to **paragraph 8.9.213** which conclude that most fish and shellfish receptors are not sensitive to increased SSC and deposition. The maximum sensitivity of receptors in the area is therefore assessed as **high**, with a **minor to moderate** magnitude of impact. Taking into consideration the localised, short-term nature of the SSCs and deposition rates and the tolerance and recoverability of the majority of fish and shellfish receptors, it is concluded that the significance of the cumulative effect from temporary disturbance of the Proposed Development with Tier 1 projects/developments is deemed **minor adverse significance**, which is **not significant** in EIA terms.

Cumulative long-term loss of habitat and increased hard substrate and structural complexity due to the presence of turbine foundations, scour protection and cable protection.

8.12.26 Cumulative long-term habitat loss is predicted to occur as a result of the presence of the Proposed Development infrastructure and cable installation projects identified in **Table 8-24**. Long-term habitat loss may result from the physical presence of foundations, scour protection and cable protection (see **paragraph 8.10.3** to **paragraph 8.10.34**) which are assumed to be in place for the lifetime of the relevant offshore wind and cable project and potentially beyond the lifetime of these projects. Conversely, the introduction of hard substrate into areas of predominantly soft sediment has the potential to alter fish and shellfish community composition including potentially acting as fish aggregation devices (see **paragraph 8.10.18** to **paragraph 8.10.20**).

8.12.27 The CEA has been based on information available within ESs where available and it is noted that the maximum assessment assumptions quoted in ESs are often refined during the determination period of the application or post consent. The assessments presented within this assessment are therefore considered to be conservative, with the level of impact on benthic ecology expected to be reduced from those presented here. No Tier 2 or 3 projects have been identified.

8.12.28 As presented in **Table 8-26** the predicted cumulative long-term habitat loss from all Tier 1 projects is estimated to be 1.67km^2 which equates to 0.51 percent of the PEIR Assessment Boundary fish and shellfish ecology study area. As previously discussed, some of these projects do not fully overlap with the PEIR Assessment Boundary fish and shellfish ecology study area, therefore the total long-term habitat loss that should be considered as part of this assessment is likely to be significantly less. Comparable spawning and nursey grounds and habitats are widely distributed in the English Channel (see **Section 8.6**) so this loss is not predicted to impact the majority of fish and shellfish species.

8.12.29 The AQUIND interconnector aim to bury the majority of the interconnector cable where applicable. However, if cable protection is used for the AQUIND interconnector, the significance of effect of habitat loss/change from the AQUIND interconnector has been assessed as being not significant (AQUIND Limited, 2019b). While the impact is permanent and irreversible (during the lifetime of the project), the area affected is highly localised and small compared to the wider region and is small relative to the habitat loss/change associated with PEIR Assessment Boundary. The impact will therefore be of **negligible** magnitude.

8.12.30 While the cumulative impact of from long-term habitat loss will be locally significant and comprise a long-term or permanent change in seabed habitat within the footprint of the structures and scour and cable protection, the footprint of the area affected is highly localised. As the habitats are common and widespread throughout the wider region, the loss of these habitats is assessed as discernible and the magnitude is assessed as **minor**, indicating that the loss of habitat does not threaten the long-term viability of the benthic resource.

8.12.31 The sensitivity of fish and shellfish receptors is discussed in **paragraph 8.10.7** to **paragraph 8.10.14** and **paragraph 8.10.22** to **paragraph 8.10.32**. The sensitivity of most fish and shellfish receptors is deemed to be low, while the sensitivity of species with specific habitat requirements, such as black seabream, is considered to be **very high**.

8.12.32 Cumulative long-term habitat loss will represent a long-term and continuous impact throughout the lifetime of the projects. However, only a relatively small proportion of the fish and shellfish habitats in the wider area are likely to be affected. Overall, it is predicted that the sensitivity of fish and shellfish receptors is considered to be **medium** to **high** (and **very high** for black seabream), and the magnitude is deemed to be **negligible**. The cumulative effect will therefore be of **minor adverse significance**, which is **not significant** in EIA terms.

Table 8-26 Cumulative magnitude of impact for long-term habitat loss/change from the presence of foundations, scour protection and cable protection.

Project/Development	Total predicted long-term habitat loss (km^2)	Source
PEIR Assessment Boundary (array area and offshore export cable corridor)	0.97	Chapter 4
AQUIND interconnector cable	0.7 (maximum area/footprint of original habitat loss due to non-burial protection)	Total habitat loss taken from ES (AQUIND Limited, 2019b)

Project/Development	Total predicted long-term habitat loss (km²)	Source
Total Tier 1 Developments	1.67	

8.13 Transboundary effects

8.13.1 Transboundary effects arise when impacts from a development within one European Economic Area (EEA) states affects the environment of another EEA state(s). A screening of transboundary effects has been carried out and is presented in Appendix B of the Scoping Report (RED, 2020).

8.13.2 The potential transboundary impacts screened into the assessment for fish and shellfish ecology were:

- direct effects as a result of underwater noise exposure to fish during construction (piling operations); and
- indirect effects may occur in relation to spawning and nursery grounds arising from habitat disturbance/loss during all project phases.

8.13.3 Underwater noise levels expected to elicit behavioural responses in certain fish and shellfish are predicted to extend to several tens of kilometres beyond the Proposed Development and therefore have the potential to affect fish and shellfish habitats of France, an EEA state (39km from the PEIR Assessment Boundary) during the construction phase. These impacts were predicted to be short term and intermittent, with recovery of fish and shellfish populations to affected areas following completion of all piling activities during construction. Overall, the sensitivity of fish and shellfish receptors to this impact were assessed as **high** and the magnitude predicted to be **minor**. The effect was therefore considered to be a **minor adverse significance**, which is considered not significant in EIA terms. Although TTS and behavioural effects for black seabream were considered to have a **high** sensitivity and a **moderate** magnitude, resulting in **moderate adverse significance**, which is considered potentially **significant** in EIA terms. However, this is specific to the north-west of the array area, which is approximately 55km from an EEA state and therefore no direct effects to an EEA state from underwater noise is anticipated due to this distance.

8.13.4 Effects of habitat disturbance/loss are predicted to be limited in extent to within a number of kilometres of the Proposed Development and are therefore not predicted to extend into the waters of other EEA states (such as France). Effects on the Downs herring spawning stock from habitat disturbance/loss were predicted to be **not significant** in EIA terms.

8.14 Inter-related effects

8.14.1 The inter-related effects assessment considers likely significant effects from multiple impacts and activities from the construction, operation and maintenance and decommissioning of the Proposed Development on the same receptor or group of receptors. The potential inter-related effects that could arise in relation to fish and shellfish ecology are presented in **Table 8-27**. These are considered to be:

- Proposed Development lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the Proposed Development (construction, operation and maintenance, decommissioning) to interact to potentially create a more significant effect on a receptor than if just assessed in isolation.
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor or group. Receptor led effects might be short-term, temporary or transient effects, or incorporate longer-term effects.

8.14.2 The assessment of effects on fish and shellfish ecology receptors, as presented in **Sections 8.9**, **8.10** and **8.11**, has already taken into account the potential for multiple impacts from the Proposed Development affecting particular receptors. For example, long-term loss of habitat and increased hard substrate and structural complexity have been assessed together.

Table 8-27 Inter-related effects assessment for fish and shellfish ecology.

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
Proposed Development-lifetime effects			
Construction and decommissioning	Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Impacts were assessed as being of **minor significance** for herring, sandeel and black seabream in the construction phase. However, behavioural effects were considered **moderate significance** for black seabream.	The majority of disturbance from underwater noise (resulting in greatest potential for injury or behavioural effects) is predicted to result from piling during the construction phase. Noise associated with the decommissioning phases was assessed to result in effects of similar or less than construction phase with little potential for physiological damage or behavioural effects to fish and shellfish. Therefore, across the Proposed Development lifetime, the effects on fish and shellfish receptors are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
Construction, operation and maintenance and decommissioning	Direct disturbance on fish and shellfish ecology within the array area and offshore export cable corridor through all phases of the project.	Impacts were assessed as being of **minor significance** for herring and sandeel and of **major significance** for black seabream in the construction phase and **minor significance** for black seabream in the decommissioning phase.	The majority of fish and shellfish disturbance will be within the construction and decommissioning phase for both the array area and export cable corridor. There is potential for some disturbance within the operational phase however, these activities will be spatially localised and temporally discrete. It is therefore considered that impacts in the operation phase will not materially contribute to inter-related effects, and that the construction and decommissioning phases are significantly temporally separate such that there will be no interaction between the two. There will therefore be no inter-related effects of greater significance compared to the impacts considered alone.
Construction and decommissioning	Increased SSC and smothering resulting in indirect effects on fish and shellfish ecology (for instance through avoidance behaviour, physiological effects, effects on eggs and larvae, smothering effects)	Impacts were assessed as being of **minor significance** for herring and sandeel and of **moderate significance** for black seabream in the construction and decommissioning phases.	The majority of seabed disturbance resulting in increased SSC and smothering will be within the construction and decommissioning phases. There is potential for some disturbance within the operational phase however, these activities will be spatially localised and temporally discrete. It is therefore considered that impacts in the operation phase will not materially contribute to inter-related effects, and that the construction and decommissioning phases are significantly temporally separate such that there will be no interaction between the two.

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
			There will therefore be no inter-related effects of greater significance compared to the impacts considered alone.
Receptor-led effects			
Inter-related effects from the interaction of increased SSC and smothering, and underwater noise.	With respect to the interaction with increased SSC and smothering, and underwater noise, these individual impacts were assigned a **moderate adverse significance** as standalone impacts for black seabream and **minor adverse significance** for all other fish and shellfish receptors and although potential inter-related impacts may arise, it is important to recognise that some of the activities are mutually exclusive. Furthermore, underwater noise from piling which is predicted to result in displacement of mobile fish species will in turn mean that these species will not be exposed to the greatest predicted increases in SCC from smothering and drilling in the array area. Therefore, effects of greater significance than the individual impacts in isolation are not predicted for mobile fish species.		
Inter-related effects from the interaction of increased SSC and smothering, and habitat loss/disturbance	The greatest potential for inter-related effects is predicted to occur through the interaction of both temporary and permanent habitat loss/disturbance from foundation installation/jack-up vessels/anchor placement/scour, indirect habitat disturbance due to sediment deposition and indirect effects of changes in physical processes due the presence of infrastructure in the operational offshore wind farm. With respect to this interaction, these individual impacts were assigned a significance of **moderate adverse significance** as standalone impacts for black seabream and **minor adverse significance** for all other fish and shellfish receptors and although potential combined impacts may arise (for instance, spatial and temporal overlap of direct habitat disturbance), it is predicted that this will not be any more significant than the individual impacts in isolation. As a result, the combined amount of habitat potentially affected will be very limited, the preferred habitat types in relation to herring, sandeel and black seabream are not geographically restricted to the PEIR Assessment Boundary, and where temporary disturbance occurs, full recovery is predicted for most habitats. In addition, any effects due to changes in the physical processes are likely to be limited, both in extent and in magnitude, with receptors having low sensitivity to the scale of changes predicted. As such, these interactions are predicted to be no greater in significance than that for the individual effects assessed in isolation.		

8.14.3 Overall, the inter-related assessment for the Proposed Development does not identify any significant inter-related effects that were not already covered by the topic-specific assessment set out in the preceding chapters. However, certain individual effects were identified that did interact with each other whilst not leading to any greater significance of effect.

8.15 Summary of residual effects

8.15.1 **Table 8-28** presents a summary of the preliminary assessment of significant impacts, any relevant embedded environmental measures and residual effects on fish and shellfish receptors.

Table 8-28 Summary of preliminary assessment of residual effects.

Activity and impact	Magnitude of impact	Receptor and sensitivity or value	Embedded environmental measures	Preliminary assessment of residual effect (significance)
Construction				
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Black seabream: Moderate (TTS and Behavioural) All other receptors: Negligible to Minor	High	C-52, C-58	Black seabream (TTS and behavioural effects): **Moderate adverse (significant)** All other receptors: **Minor adverse (not significant)**
Direct disturbance resulting from the installation of the export cable	Black seabream: Moderate All other receptors: Minor	Black seabream: Very High All other receptors: Medium	C-44	Black seabream: **Major adverse (significant)** All other receptors: **Minor adverse (not significant)**

Activity and impact	Magnitude of impact	Receptor and sensitivity or value	Embedded environmental measures	Preliminary assessment of residual effect (significance)
Direct disturbance resulting from construction within the array	Minor	Medium	C-44	**Minor adverse (not significant)**
Temporary localised increases in SSC and smothering	Black seabream: Moderate Native oyster and blue mussels: Negligible All other receptors: Negligible to Minor	Black seabream: High Native oyster and blue mussels: Very High All other receptors: Medium	N/A	Black seabream: **Moderate adverse (significant)** All other receptors: **Minor adverse (not significant)**
Direct and indirect seabed disturbances leading to the release of sediment contaminants	Negligible	High	C-53	**Minor adverse (not significant)**
Operation and maintenance				
Long-term loss of habitat and increased hard substrate and structural complexity due to the presence of turbine foundations, scour protection and cable protection	**Long-term habitat loss** Black seabream: Moderate All other receptors: Minor **Increase hard substrate** Minor	**Long-term habitat loss** Black seabream: High All other receptors: Low to Medium **Increase hard substrate** Medium	C-44, C-95	**Long-term habitat loss** Black seabream: **Moderate adverse (significant)** All other receptors: **Minor adverse (not significant)** **Increase hard substrate**

Activity and impact	Magnitude of impact	Receptor and sensitivity or value	Embedded environmental measures	Preliminary assessment of residual effect (significance)
				Minor adverse (not significant)
EMF impacts arising from cables	Minor	Migratory species: Medium to High All other receptors: Medium	C-45	**Minor adverse (not significant)**
Direct disturbance resulting from maintenance within the array area and export cable	Minor	Black seabream, brown crab and European lobster: Medium All other receptors: Low	N/A	**Minor adverse (not significant)**
Decommissioning				
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Minor	Medium	C-52, C-58	**Minor adverse (not significant)**
Direct disturbance resulting from the removal of the export cable	Minor	Black seabream: Very High All other receptors: Medium	C-45	Black seabream: **Moderate adverse (not significant)** All other receptors: **Minor adverse (significant)**

Activity and impact	Magnitude of impact	Receptor and sensitivity or value	Embedded environmental measures	Preliminary assessment of residual effect (significance)
Direct disturbance resulting from decommissioning within the array	Minor	Medium	C-45	**Minor adverse (not significant)**
Temporary localised increases in SSC and smothering	Minor	Very High	N/A	**Minor adverse (not significant)**
Direct and indirect seabed disturbances leading to the release of sediment contaminants	Negligible	High	C-53	**Minor adverse (not significant)**

8.16 Further work to be undertaken for ES

Introduction

8.16.1 Further work that will be undertaken to support the fish and shellfish ecology assessment and presented within the ES is set out below.

Baseline

8.16.2 The ES baseline will be informed using the same baseline data as used within this PEIR (see **Section 8.6**). Where data sources have been updated, the baseline data and conditions will be updated. The ES baseline will be updated to include the site-specific subtidal data that has been collected across Proposed Development, as detailed within **Chapter 9**.

Assessment

8.16.3 The assessment methodology will be consistent with the Scoping stage methodology and the PEIR methodology as presented in **Section 8.7**. The methodology will be informed by the baseline and, where appropriate, will be revised as necessary following any updates to the baseline data.

Consultation and engagement

8.16.4 Further consultation and engagement that will be undertaken to inform the fish and shellfish ecology assessment and presented within the ES. As detailed in **Section 8.3** under Expert Topic Group engagement the following stakeholders: the MMO, Cefas, Natural England, Environment Agency, The Wildlife Trust, Sussex Wildlife Trust and Sussex IFCA, will addresses any issues that may arise, through ongoing consultation as part of the EPP Steering Group and Fish and Shellfish Ecology ETG to confirm that the assessment is satisfactory.

Environmental measures

8.16.5 Further environmental measures that will be considered, incorporated into the design of the Proposed Development, and presented within the ES are set out in **Table 8-29.** As the design plan regarding the decommissioning phase is not complete, a Decommissioning Plan has not yet been developed.

Table 8-29 Further environmental measures.

Receptor	Changes and effects	Environmental measures and influence on assessment
An offshore Decommissioning Plan, including consideration on fish and shellfish receptors, will be developed prior to decommissioning	It is expected that the embedded environmental measures as presented in **Table 8-11** will be applied in the Decommissioning Plan.	No changes are expected on the assessment.
Black seabream	Potential exposure to increased underwater noise during foundation installation activities	Detail of environmental measures to be confirmed at ES; anticipated reduction in impact magnitude.
Black seabream	Potential exposure to an increase SSC during offshore export cable installation	Detail of environmental measures to be confirmed at ES; anticipated reduction in impact magnitude.
Black seabream	Potential long-term habitat loss associated with the operation and maintenance of the Proposed Development	Detail of environmental measures to be confirmed at ES; anticipated reduction in impact magnitude.

8.17 Glossary of terms and abbreviations

Table 8-30 Glossary of terms and abbreviations

Term (acronym)	Definition
Aspect	Used to refer to the individual environmental topics.
Barrier effect	Barrier effect is experienced by bird species which intend forage beyond or migrate past the array but due to avoidance behaviour, have to navigate around the array. Barrier effect is often not discernible from displacement behaviour.
Baseline	Refers to existing conditions as represented by latest available survey and other data which is used as a benchmark for making comparisons to assess the impact of development.
Baseline conditions	The environment as it appears (or would appear) immediately prior to the implementation of the Proposed Development together with any known or foreseeable future changes that will take place before completion of the Proposed Development.
Beam trawl	A trawl where the mouth or opening of the net is kept open by a beam, which is mounted at each end on guides which travel along the seabed.
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment.
BGS	British Geological Survey
Bottom trawl/Otter trawl	A large, usually cone shaped net, which is towed across the seabed.
Centre for Environment Fisheries and Aquaculture Science (Cefas)	The Government's marine and freshwater science experts, advising the UK government and overseas partners.
Climate Change	A change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes, to external forcing or to persistent anthropogenic changes in the composition of the atmosphere, ocean or in land use.

Term (acronym)	Definition
Coastal processes	The processes that interact to control the physical characteristics of a natural environment, for example: winds, waves, currents, water levels, sediment transport, turbidity, coastline, beach and seabed morphology.
Compensation	Loss of value is remedied or offset by a corresponding compensatory action on the same site or elsewhere, determined through the process of Environmental Impact Assessment.
Construction effects	Used to describe both temporary effects that arise during the construction phases as well as permanent existence effects that arise from the physical existence of development (for example new buildings).
Crustacea	Arthropod of the large, mainly aquatic group Crustacea, such as a crab, lobster, shrimp, or barnacle.
Cumulative effects	Additional changes caused by a Proposed Development in conjunction with other similar developments or as a combined effect of a set of developments, taken together' (SNH, 2012)
Cumulative Effects Assessment (CEA)	Assessment of impacts as a result of the incremental changes caused by other past, present and reasonably foreseeable human activities and natural processes together with the Proposed Development.
Cumulative impact	Impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the Proposed Development.
Decommissioning	The period during which a development and its associated processes are removed from active operation.
Demersal	Relating to the seabed and area close to it. Demersal spawning species are those which deposit eggs onto the seabed.
Department for Business, Energy & Industrial Strategy (BEIS)	The Government department responsible for business; industrial strategy; science; research and innovation; energy and clean growth; and climate change.
Department for Environment, Food and Rural Affairs (DEFRA)	The lead UK Government Department for overall environmental policy.
Development Consent Order (DCO)	This is the means of obtaining permission for developments categorised as Nationally Significant Infrastructure Projects, under the Planning Act 2008.

Term (acronym)	Definition
Development Consent Order (DCO) Application	An application for consent to undertake a Nationally Significant Infrastructure Project made to the Planning Inspectorate who will consider the application and make a recommendation to the Secretary of State, who will decide on whether development consent should be granted for the Proposed Development.
Drop Down Video (DDV)	A survey method in which imagery of habitat is collected, used predominantly to survey marine environment.
Ecological feature	Ecological feature is the term used to refer to biodiversity receptors. This term is taken directly from Ecological Impact Assessment guidance from the Chartered Institute of Ecology and Environmental Management.
Elasmobranchs	Cartilaginous fishes such as sharks, rays, and skates
Electromagnetic field (EMF)	An electromagnetic field is an electric and magnetic force field that surrounds a moving electric charge.
Elements	Individual parts which make up the landscape, such as, for example, trees, hedges and buildings.
Embedded environmental measures	Equate to ‘primary environmental measures’ as defined by Institute of Environmental Management and Assessment (2016). They are measures to avoid or reduce environmental effects that are directly incorporated into the preferred masterplan for the Proposed Development.
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed project or development over and above the existing circumstances (or ‘baseline’).
Environmental Impact Assessment (EIA) Regulations, 2017	The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017. The EIA regulations require that the effects of a project, where these are likely to have a significant effect on the environment, are taken into account in the decision-making process for the project.
Environmental measures	Measures which are proposed to prevent, reduce and where possible offset any significant adverse effects (or to avoid, reduce and if possible, remedy identified effects. (GLVIA3, 2013 Para 3.37).
Environmental Statement (ES)	The written output presenting the full findings of the Environmental Impact Assessment.

Term (acronym)	Definition
ETG	Expert Topic Group
EUNIS habitat classification	A pan-European system which facilitates the harmonised description and classification of all types of habitat, through the use of criteria for habitat identification.
European site	European sites are those that are designated through the Habitats Directive and Birds Directive (via national legislation as appropriate). Within England additional sites designated through international convention are given the same protection through policy – overall all of these are referred to as European sites. European sites in England are considered to be SPAs, SACs, candidate SACs and Sites of Community Importance (SCI). Potential SPAs (pSPA), possible SACs (pSACs), Ramsar sites (designated under international convention) and proposed Ramsar sites.
Evidence Plan Process (EPP)	A voluntary consultation process with specialists' stakeholders to agree the approach, the information to support, the EIA and HRA for certain aspects.
Feature	Particularly prominent or eye-catching elements in the landscape such as tree clumps, church towers or wooded skylines OR a particular aspect of the Proposed Development.
Fish larvae	The developmental stage of fish which have hatched from the egg and receive nutrients from the yolk sac until the yolk is completely absorbed.
Formal consultation	Formal consultation refers to statutory consultation that is required under Section 42 and Section 47 of the Planning Act 2008 with the relevant consultation bodies and the public on the preliminary environmental information.
Future Baseline	Refers to the situation in future years without the Proposed Development.
Geographical Information System (GIS)	A system that captures, stores, analyses, manages and presents data linked to location. It links spatial information to a digital database.
Geophysical	Relating to the physical properties of the earth.
Habitats Regulations	EC Council Directive 92/43/EEC, known as the Habitats Directive, was transposed in the UK by the Habitats Regulations 1994 (as amended). The Habitats Regulations apply to UK land and territorial waters and

Term (acronym)	Definition
	act to ensure biodiversity of natural habitats and of wild flora and fauna through a range of measures including designation of SACs.
Habitats Regulation Assessment (HRA)	The assessment of the impacts of implementing a plan or policy on a European Site, the purpose being to consider the impacts of a project against conservation objectives of the site and to ascertain whether it would adversely affect the integrity of the site.
Heatmaps	Map-based, pictorial representation of the relative usage of routes from collated 'tracks' gathered from Strava users.
Horizontal Directional Drill (HDD)	An engineering technique avoiding open trenches.
Impact	The changes resulting from an action.
Indirect effects	Effects that result indirectly from the Proposed Development as a consequence of the direct effects, often occurring away from the site, or as a result of a sequence of interrelationships or a complex pathway. They may be separated by distance or in time from the source of the effects. Often used to describe effects on landscape character that are not directly impacted by the Proposed Development such as effects on perceptual characteristics and qualities of the landscape.
Informal consultation	Informal consultation refers to the voluntary consultation that RED undertake in addition to the formal consultation requirements.
Inshore	The sea up to two miles from the coast.
Inshore Fisheries and Conservation Authority (IFCA)	There are 10 Inshore Fisheries and Conservation Authorities (IFCAs) in England. The 10 IFCA Districts cover English coastal waters out to 6 nautical miles from Territorial Baselines. The IFCAs have shared powers and duties which are found in the Marine and Coastal Access Act, 2009.
Institute of Environmental Management and Assessment (IEMA)	International membership organisation for environment and sustainability professionals.
Intertidal	The area of the shoreline which is covered at high tide and uncovered at low tide.

Term (acronym)	Definition
Iterative design	A process by which the design is repeated to make improvements, solve problems, respond to environmental measures and engage local communities and statutory stakeholders.
Joint Nature Conservation Committee (JNCC)	JNCC is the public body that advises the UK Government and devolved administrations on UK-wide and international nature conservation.
Level of effect	Determined through the combination of sensitivity of the receptor and the proposed magnitude of change brought about by the development.
Likely Significant Effects (LSE)	It is a requirement of Environmental Impact Assessment Regulations to determine the likely significant effects of the Proposed Development on the environment which should relate to the level of an effect and the type of effect.
Magnitude (of change)	A term that combines judgements about the size and scale of the effect, the extent of the area over which it occurs, whether it is reversible or irreversible and whether it is short term or long term in duration'. Also known as the 'degree' or 'nature' of change.
Marine aggregate	Marine dredged sand and/or gravel.
Marine Conservation Zone (MCZ)	Marine Conservation Zone (MCZ) is a type of marine nature reserve in UK waters. They were established under the Marine and Coastal Access Act (2009) and are areas designated with the aim to protect nationally important, rare or threatened habitats and species.
Marine Mammal Mitigation Protocol (MMMP)	To include measures to minimise the risk of injury (PTS) in marine mammals.
Marine Management Organisation (MMO)	MMO is an executive non-departmental public body, sponsored by the Department for Environment, Food & Rural Affairs. MMO license, regulate and plan marine activities in the seas around England so that they're carried out in a sustainable way.
Marine Policy Statement	Framework for preparing Marine Plans and taking decisions affecting the marine environment.
MBES	Multi-beam Echo Sounders
National Policy Planning Framework	The National Policy Planning Framework sets out the Governments planning policies for England and how these are expected to be applied. It provides a framework

Term (acronym)	Definition
	within which local plans can be developed which reflect the community's needs.
Nationally Significant Infrastructure Project (NSIP)	Nationally Significant Infrastructure Projects are major infrastructure developments in England and Wales that bypass normal local planning requirements. These include proposals for renewable energy projects.
Natural England	The government advisor for the natural environment in England.
Noise sensitive receptors	Locations or receptors that may potentially be adversely affected by the addition of a new source of noise. These can include residential properties, people and sensitive species.
Nursery habitat	Habitats where high numbers of juveniles of a species occur, having a greater level of productivity per unit area than other juvenile habitats.
Offshore	The sea further than two miles from the coast.
Offshore area	An area that encompasses all planned offshore infrastructure.
Offshore Wind Farm	An offshore wind farm is a group of wind turbines in the same location (offshore) in the sea which are used to produce electricity.
PEIR Assessment Boundary	The PEIR Assessment Boundary combines the search areas for the offshore and onshore infrastructure associated with the Proposed Development. It is defined as the area within which the Proposed Development and associated infrastructure will be located, including the temporary and permanent construction and operational work areas
Pelagic	Any part of the water column (for example the sea from surface to bottom sediments) that is not close to the seabed. Pelagic spawning species release their eggs into the upper layers of the sea.
Permanent Threshold Shift (PTS)	A permanent reduction in an animal's sensitivity to sound.
Planning Act 2008	The legislative framework for the process of approving major new infrastructure projects.
Planning Inspectorate (PINS)	The Planning Inspectorate deals with planning appeals, national infrastructure planning applications,

Term (acronym)	Definition
	examinations of local plans and other planning-related and specialist casework in England and Wales.
Preliminary Environmental Information Report (PEIR)	The written output of the Environmental Impact Assessment undertaken to date for the Proposed Development. It is developed to support public consultation and presents the preliminary findings of the assessment to allow an informed view to be developed of the Proposed Development, the assessment approach that has been undertaken, draw preliminary conclusions on the likely significant effects of the Proposed Development and environmental measures proposed.
Proposed Development	The development that is subject to the application for development consent, as described in Chapter 4.
Rampion 1	The existing Rampion Offshore Wind Farm located in the English Channel in the south of England.
Receptor	These are as defined in Regulation 5(2) of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 and include population and human health, biodiversity, land, soil, water, air, climate, material assets, cultural heritage and landscape that may be at risk from exposure to pollutants which could potentially arise as a result of the Proposed Development.
Recoverable injury	Recoverable injury is a survivable injury with full recovery occurring after exposure.
RED	Rampion Extension Development Limited
SBES	Single-beam Echo Sounders
Scoping Boundary	This boundary was used to inform the Scoping Report by combining the areas of search for the offshore and onshore infrastructure at the Scoping stage of the project.
Scoping Opinion	A Scoping Opinion is adopted by the Secretary of State for a Proposed Development.
Scoping Report	A report that presents the findings of an initial stage in the Environmental Impact Assessment process.
Scour	A localised sediment erosion feature caused by local enhancement of flow speed and turbulence due to interaction with an obstacle.

Term (acronym)	Definition
Secretary of State (SoS)	The body who makes the decision to grant development consent.
Sediment deposition	Settlement of sediment in suspension back to the seabed, causing a localised accumulation.
Sediment transport	The movement of sediment by natural processes, as individual grains or as a collective volume.
SEL	Sound Exposure Level
Semi-pelagic (or benthopelagic)	Partially living their life on the seabed (benthic) and partially living their life in the water column above (pelagic).
Sensitivity	This boundary was used to inform the Scoping Report by combining the areas of search for the offshore and onshore infrastructure at the Scoping stage of the project.
Significance	A measure of the importance of the environmental effect, defined by criteria specific to the environmental aspect.
Significant effects	It is a requirement of the EIA Regulations to determine the likely significant effects of the development on the environment which should relate to the level of an effect and the type of effect. Where possible significant effects should be mitigated. The significance of an effect gives an indication as to the degree of importance (based on the magnitude of the effect and the sensitivity of the receptor) that should be attached to the impact described. Whether or not an effect should be considered significant is not absolute and requires the application of professional judgement. Significant – 'noteworthy, of considerable amount or effect or importance, not insignificant or negligible'. The Concise Oxford Dictionary. Those levels and types of landscape and visual effect likely to have a major or important/noteworthy or special effect of which a decision maker should take particular note.
Site of Special Scientific Interest (SSSI)	Sites designated at the national level under the Wildlife & Countryside Act 1981 (as amended). They are a series of sites that are designated to protect the best examples of significant natural habitats and populations of species.
SNCB	Statutory Nature Conservation Body

Term (acronym)	Definition
Spatial Scope	Spatial scope is the area over which changes to the environment are predicted to occur as a consequence of a Proposed Development.
Spawning	The release or deposition of eggs and sperm, usually into water, by aquatic animals.
Special Area of Conservation (SAC)	International designation implemented under the Habitats Regulations for the protection of habitats and (non-bird) species. Sites designated to protect habitats and species on Annexes I and II of the Habitats Directive. Sufficient habitat to maintain favourable conservation status of the particular feature in each member state needs to be identified and designated.
Special Protection Area (SPA)	Sites designated under EU Directive (79/409/EEC) to protect habitats of migratory birds and certain threatened birds under the Birds Directive.
SPL	Sound Pressure Level
SSS	Side Scan Sonar
Stakeholder	Person or organisation with a specific interest (commercial, professional or personal) in a particular issue.
Study area	Area where potential impacts from the Proposed Development could occur, as defined for each aspect.
Subtidal	The region of shallow waters which are below the level of low tide.
Susceptibility	The ability of a defined landscape or visual receptor to accommodate the specific Proposed Development without undue negative consequences.
Suspended sediment concentration (SSC)	The mass concentration (mass/volume) of sediment in suspension.
Sustainability	The principle that the environment should be protected in such a condition and to such a degree that ensures new development meets the needs of the present without compromising the ability of future generations to meet their own needs.
Temporal Scope	The temporal scope covers the time period over which changes to the environment and the resultant effects are predicted to occur and are typically defined as either being temporary or permanent.

Term (acronym)	Definition
Temporary or permanent effects	Effects may be considered as temporary or permanent. In the case of wind energy development, the application is for a 30-year period after which the assessment assumes that decommissioning will occur and that the site will be restored. For these reasons the development is referred to as long term and reversible.
Temporary Threshold Shift (TTS)	A temporary reduction in an animals sensitivity to sound.
The Applicant	Rampion Extension Development Limited (RED).
The Proposed Development/Rampion 2	The onshore and offshore infrastructure associated with the offshore wind farm comprising of installed capacity of up to 1,200MW, located in the English Channel in the south of England
Tidal excursion buffer	The greatest distance and direction that water carrying an impact might be carried during one mean spring tide, from a given location or area.
Transboundary effects	Assessment of changes to the environment caused by the combined effect of past, present and future human activities and natural processes on other European Economic Area Member States.
Type or Nature of effect	Whether an effect is direct or indirect, temporary or permanent, positive (beneficial), neutral or negative (adverse) or cumulative.
Unexploded Ordnance (UXO)	Unexploded ordnance are explosive weapons (bombs, shells, grenades, land mines, naval mines, etc.) that did not explode when they were employed and still pose a risk of detonation, potentially many decades after they were used or discarded.
WTG	Wind Turbine Generator
Zone of Influence (ZOI)	The area surrounding the Proposed Development which could result in likely significant effects.

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