MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Preliminary Environmental Information Report

Volume 2, chapter 8: Fish and shellfish ecology


Image of an offshore wind farm

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Final

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Glossary

Term	Meaning
Cumulative Effects	Changes to the environment caused by a combination of present and future projects, plans or activities.
Demersal fish	Demersal fish are species that live and feed on or near the seabed.
Demersal spawning species	Species which deposit eggs onto the seabed during spawning.
Elasmobranch	The term refers to cartilaginous fishes which include sharks, rays, and skates.
Evidence Plan Expert Working Group (EWG)	Expert working groups set up with relevant stakeholders as part of the Evidence Plan process.
Important Ecological Features	Habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Proposed Development.
Marine licence	The Marine and Coastal Access Act 2009 requires a marine licence to be obtained for licensable marine activities. Section 149A of the Planning Act 2008 allows an applicant for a DCO to apply for 'deemed marine licences' as part of the DCO process.
Masking	Masking occurs when noise emissions interfere with a marine animal's ability to hear a sound of interest.
Morgan Offshore Wind Project: Generation Assets	The Morgan Offshore Wind Project: Generation Assets is comprised of the generation assets and associated activities, specifically within the Morgan Array Area.
Nursery habitat	A habitat where juveniles of a species regularly occur as a population.
Pelagic fish	Pelagic fish are species which live and feed within the water column.
Shellfish	For the purposes of this assessment, shellfish is considered a generic term to define molluscs and crustaceans.
Spawning grounds	Spawning grounds are the areas of water or seabed where fish spawn or produce their eggs.

Acronyms

Acronym	Description
AC	Alternating Current
AFBI	The Agri-Food and Biosciences Institute
CBRA	Cable Burial Risk Assessment
CEA	Cumulative Effects Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMACS	Centre for Marine and Coastal Studies Ltd
COWRIE	Collaborative Offshore Wind Research into the Environment
CSIP	Cable Specification and Installation Plan
DC	Direct Current
DCO	Development Consent Order
DDV	Drop Down Video
DECC	Department of Energy and Climate Change
EcIA	Ecological Impact Assessment
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EMODnet	European Marine Observation and Data Network
EMU	Ecological Marine Unit
FEPA	Food and Environmental Protection Act
HDD	Horizontal Directional Drilling
HRA	Habitat Regulations Assessment
HVAC	High Voltage Alternation Current
HVDC	High Voltage Direct Current
ICES	International Council for the Exploration of the Sea
IEF	Important Ecological Features
IEMA	Institute of Environmental Management and Assessment
IFCA	Inshore Fisheries Conservation Authority
IMO	International Maritime Organisation
INNS	Invasive Non-Native Species
IoM	Isle of Man
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LID	Lynn and Inner Dowsing
MarLIN	Marine Life Information Network
MARPOL	International Convention for the Prevention of Pollution from Ships
MBES	Multi-beam echo-sounder
MCZ	Marine Conservation Zone
MDS	Maximum Design Scenario
MMO	Marine Management Organisation
MNR	Marine Nature Reserve
MPA	Marine Protected Area

Acronym	Description
MPCP	Marine Pollution Contingency Plan
NBN	National Biodiversity Network
NEQ	Net Explosive Quantity
NIGFS	Northern Irish Ground Fish Trawl Survey
NINEL	Northern Ireland Herring Larvae Survey
NPS	National Policy Statement
NRW	Natural Resources Wales
NSIPs	Nationally Significant Infrastructure Projects
OSP	Offshore Substation Platform
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PEI	Preliminary Environmental Information
PEIR	Preliminary Environmental Information Report
PSA	Particle Size Analysis
SAC	Special Area of Conservation
SBES	Single Beam Echosounder
SBP	Sub-Bottom Profilers
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
SNCB	Statutory Nature Conservation Body
SPI	Species of Principal Importance
SSC	Suspended Sediment Concentration
TAC	Total Allowable Catch
UHRS	Ultra-High Resolution Seismic
UKCS	UK Continental Shelf
UKOOA	United Kingdom Offshore Operators Association
UXO	Unexploded Ordnance
ZoI	Zone of Influence

Units

Unit	Description
%	Percentage
mm	Millimetres
cm	Centimetres
m	Metres
km	Kilometres
m^2	Square metres
km^2	Square kilometres
m^3	Cubed metres
m/h	Metres per hour
mg/l	Milligrams per litre
kV	Kilovolts
mG	Milligauss

8 Chapter 8 – Fish and shellfish ecology

8.1 Introduction

8.1.1 Overview

8.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the assessment of the potential impact of the Morgan Offshore Wind Project: Generation Assets (hereafter referred to as the Morgan Generation Assets) on fish and shellfish ecology. Specifically, this chapter considers the potential impact of the Morgan Generation Assets, with a study area encompassing the area seaward of Mean High Water Springs (MHWS) during the construction, operations and maintenance and decommissioning phases.

8.1.1.2 The assessment presented is informed by the following technical chapters:

- Volume 2, chapter 6: Physical processes of the PEIR
- Volume 2, chapter 7: Benthic subtidal ecology of the PEIR
- Volume 2, chapter 9: Marine mammals of the PEIR.

8.1.1.3 This chapter also draws upon information contained within:

- Volume 3, annex 3.1: Underwater noise technical report of the PEIR
- Volume 4, annex 6.1: Physical processes technical report of the offshore PEIR
- Volume 4, annex 7.1: Benthic subtidal ecology technical report of the PEIR
- Volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR
- Volume 4, annex 11.1: Commercial fisheries technical report of the PEIR.

8.1.2 Purpose of chapter

8.1.2.1 The primary purpose of the PEIR is outlined in volume 1, chapter 1: Introduction of the PEIR. In summary, the primary purpose of an Environmental Statement is to support the Development Consent Order (DCO) application for the Morgan Generation Assets under the Planning Act 2008 (the 2008 Act). The PEIR constitutes the Preliminary Environmental Information (PEI) for the Morgan Generation Assets and sets out the findings of the Environmental Impact Assessment (EIA) to date to support the pre-application consultation activities required under the 2008 Act. The EIA will be finalised following completion of pre-application consultation and the Environmental Statement will accompany the application to the Secretary of State for Development Consent.

8.1.2.2 The PEIR forms the basis for Statutory Consultation which will last for 47 days and conclude on 4 June 2023 as outlined in volume 1, chapter 2: Policy and legislation of the PEIR. At this point, comments received on the PEIR will be reviewed and incorporated (where appropriate) into the Environmental Statement, which will be submitted in support of the application for Development Consent scheduled for quarter one of 2024.

8.1.2.3 In particular, this PEIR chapter:

- Presents the existing environmental baseline established from desk studies, relevant data collected during site-specific surveys used to inform the baseline characterisation for fish and shellfish ecology and consultation with stakeholders
- Identifies any assumptions and limitations encountered in compiling the environmental information
- Presents the potential environmental effects on fish and shellfish ecology arising from the Morgan Generation Assets, based on the information gathered and the analysis and assessments undertaken
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects of the Morgan Generation Assets on fish and shellfish ecology.

8.1.3 Study area

8.1.3.1 Fish and shellfish are spatially and temporally variable, therefore for the purposes of the fish and shellfish ecology characterisation, a broad study area has been defined. This is shown in Figure 8.1, as agreed with stakeholders through consultation (see section 0):

- The Morgan Fish and Shellfish Ecology study area covers the east Irish Sea, extending from MHWS west from the Mull of Galloway in Scotland to the western tip of Anglesey, following the territorial waters 12nm limit of the Isle of Man (IoM). This study area has been selected to account for the spatial and temporal variability of all relevant fish and shellfish populations, including fish migration. This area was considered appropriate as it will ensure the characterisation of all fish and shellfish receptors within the east Irish Sea and is therefore large enough to consider all direct (e.g. habitat loss/disturbance within project boundaries) and indirect impacts (e.g. underwater noise over a wider area) associated with the Morgan Generation Assets on the identified receptors.

8.1.3.2 The offshore topic of the fish and shellfish ecology study area include intertidal habitats up to MHWS, although these habitats at the landfall are likely to be less important for fish and shellfish species. More specific effects on intertidal ecology receptors are assessed in detail in volume 2, chapter 7: Benthic subtidal ecology of the PEIR.

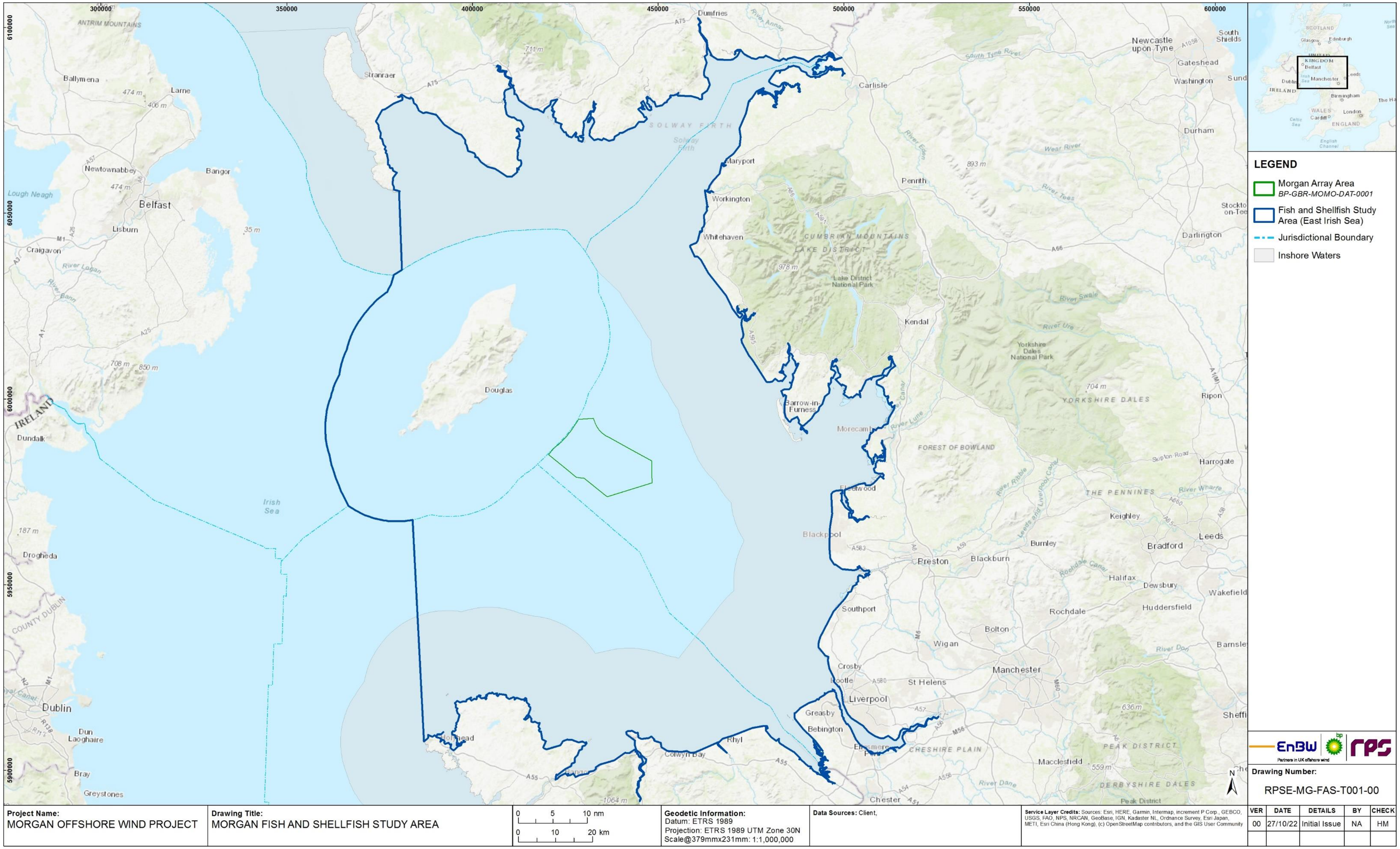


Figure 8.1: Morgan Fish and Shellfish Ecology study area.

8.2 Policy context

8.2.1 National Policy Statements

8.2.1.1 Planning policy on renewable energy infrastructure is presented in volume 1, chapter 2: Policy and legislation of the PEIR. Planning policy on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to fish and shellfish ecology, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; Department of Energy and Climate Change (DECC), 2011a), and the NPS for Renewable Energy Infrastructure (EN-3, DECC, 2011b).

8.2.1.2 NPS EN-1 and NPS EN-3 include guidance on what matters are to be considered in the assessment. These are summarised in Table 8.1 below. NPS EN-1 and NPS EN-3 also highlight a number of factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 8.16 below.

8.2.1.3 Table 8.1 refers to the current NPSs, specifically NPS EN-1 (DECC, 2011a) and NPS EN-3 (DECC, 2011b). If the NPSs are updated prior to the application for Development Consent, the revised NPSs will be fully considered in relation to Fish and Shellfish Ecology within the Environmental Statement.

Table 8.1: Summary of the NPS EN-1 and NPS EN-3 provisions relevant to fish and shellfish ecology.

Summary of NPS EN-3 and EN-1 provision	How and where considered in the PEIR
[EN-1, 4.2.3] For the purposes of this NPS and the technology-specific NPSs the Environmental Statement should cover the environmental, social and economic effects arising from pre-construction, construction, operation and decommissioning of the project.	The assessment of significant effects (section 8.8) examines the impacts of all stages of the project on the environmental factors, and specifically the fish and shellfish ecology receptors, impacted by the Morgan Generation Assets.
[4.2.10] The applicant should instead provide information proportionate to the scale of the project on the likely significant environmental, social and economic effects.	Volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR; the baseline (section 8.4); maximum design scenario (MDS) (section 8.6.1), and assessment of impacts (section 8.8) sections examine the scale of potential impacts on the fish and shellfish ecology receptors.
[4.10.4] Applicants should consult the Marine Management Organisation (MMO) on nationally significant projects which would affect, or would be likely to affect, any relevant marine areas as defined in the Planning Act 2008 (as amended by s.23 of the Marine and Coastal Access Act 2009).	Section 0 covers the consultation process, including any communications with the MMO.
[5.3.3] Where the development is subject to EIA the applicant should ensure that the Environmental Statement 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.	Designated sites are set out in section 8.4.3, with important ecological features (IEFs) defined in section 8.4.4 based on their conservation, ecological and commercial importance. The impact assessment (section 8.8) has been undertaken to consider the effects of the Morgan Generation Assets on these IEFs.
[5.3.4] The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests.	The conservation of biodiversity interests has been considered directly in the impacts assessment (section 8.8), with designed in mitigation measures (section 8.7) proposed to reduce impacts where possible.
[5.3.18] The applicant should demonstrate that: • During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works; • during construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements; • habitats will, where practicable, be restored after construction works have finished; and • opportunities will be taken to enhance existing habitats and, where practicable, to create new habitats of value within the site landscaping proposals.	The MDS has been developed with project engineers to ensure it is appropriately precautionary and not over-conservative to ensure habitat loss is minimised wherever possible. It represents a realistic scenario without overcompensating for any one activity, in this sense it represents the maximum area required to work (section 8.6.1 and Table 8.14). Any specific mitigation measures, to minimise disturbance or damage to habitats have been identified and justified (Table 8.16).
[EN-3, 2.6.5] The applicant should identify the impacts of a proposal and these impacts, together with proposals for their avoidance or mitigation wherever possible, should be set out in an Environmental Statement (ES) that should accompany each project application.	The impacts of construction, operational and maintenance, and decommissioning phases have been identified in the key parameters for assessment (section 8.6) and assessed in the assessment of significant effects (section 8.8). Measures adopted as part of the project are set out in section 8.7.
[2.6.32] The onus is on the applicant to ensure that the foundation design is technically suitable for the seabed conditions and that the application caters for any uncertainty regarding the geological conditions. Whilst the technical suitability of the foundation design is not in itself a matter for the Secretary of State, it will need to be satisfied that the foundations will not have an unacceptable adverse effect on marine biodiversity, physical environment and marine heritage assets in accordance with the policy below. The applicant should have provided the necessary details to allow the Secretary of State to assess such impacts.	Potential impacts from the range of possible foundation design parameters are addressed in the MDS calculation (section 8.6.1 and Table 8.14), with the levels of impact on ecologically important fish and shellfish receptors assessed in the assessment of significant effects (section 8.8).
[2.6.51] Owing to the relatively new and complex nature of offshore wind development, the Secretary of State should consider requiring the applicant to undertake monitoring prior to and during construction and during its operation in order to measure and document the effects of the development. This enables an assessment of the accuracy of the original predictions and may inform the scope of future EIAs.	Monitoring requirements are set out in section 8.8.8.
[2.6.64] Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed offshore wind farm and in accordance with the appropriate policy for offshore wind farm EIAs.	The existing ecology and biodiversity of the fish and shellfish ecology study area has been examined in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR and the baseline assessment (section 8.4.2). Any changes expected have been identified in the MDS calculation (section 8.6.1 and Table 8.14), with the levels of impact on fish and shellfish receptors assessed in the assessment of significant effects (section 8.8).
[2.6.65] Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate.	Consultation has been undertaken through the Benthic Ecology, Fish and Shellfish Ecology and Physical Processes Expert Working Group (EWG) as detailed in section 0.

Summary of NPS EN-3 and EN-1 provision	How and where considered in the PEIR
[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.	The impact assessment (section 8.8) has been undertaken considering post-construction monitoring from offshore wind farms in the UK and overseas.
[2.6.67] The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity.	Both potential negative and positive effects on fish and shellfish ecology have been considered in the impact assessment presented in section 8.8.7.
[2.6.74] The applicant should identify fish species that are the most likely receptors of impacts with respect to: • spawning grounds; • nursery grounds; • feeding grounds; • over-wintering areas for crustaceans; and • migration routes.	Important habitats for fish and shellfish, including spawning, nursery and migration routes have been considered in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR and summarised in section 8.4. Effects on these have been assessed in section 8.8.
[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. Some research has shown that where cables are buried at depths greater than 1.5m below the seabed impacts are likely to be negligible. However sufficient depth to mitigate impacts will depend on the geology of the seabed.	These specifications have been examined in the MDS (section 8.6.1), with specific impacts assessed in section 8.8.6.
[2.6.77] During construction, 24 hour working practices may be employed so that the overall construction programme and the potential for impacts to fish communities is reduced in overall time.	This is highlighted and considered in the construction phases of the MDS (section 8.6.1).

Table 8.2: Summary of NPS EN-1 and NPS EN-3 policy on decision making relevant to fish and shellfish ecology.

Summary of NPS EN-1 and EN-3 provision	How and where considered in the PEIR
[EN-1, 5.3.5] The Government's biodiversity strategy aim is to ensure a halting, and if possible, a reversal, of declines in priority habitats and species, with wild species and habitats as part of healthy, functioning ecosystems.	The conservation status of habitats and species is considered throughout this chapter, with the baseline 8.4.4), and assessment of significant effects (section 8.8) examining this in detail.
[5.3.6] In having regard to the aim of the Government's biodiversity strategy the Secretary of State should take account of the context of the challenge of climate change: failure to address this challenge will result in significant adverse impacts to biodiversity.	The potential future impact of climate change is examined in the future baseline scenario (section 8.4.5).
[5.3.7] Development should aim to avoid significant harm to biodiversity and geological conservation interests, including through mitigation and consideration of reasonable alternatives; where significant harm cannot be avoided, then appropriate compensation measures should be sought.	Mitigation is broadly assessed in the measures adopted as part of the Morgan Generation Assets (section 8.7), and where appropriate in each impact assessment if the impact was deemed to be moderate or above.
[5.3.8] In taking decisions, the Secretary of State should ensure that appropriate weight is attached to designated sites of international, national and local importance; protected species; habitats and other species of principal importance for the conservation of biodiversity; and to biodiversity and geological interests within the wider environment.	Nearby designated sites, and their associated habitats and species of principal importance (SPIs), have been identified in volume 4: annex 8.1: Fish and shellfish ecology technical report of the PEIR and are listed in section 8.5.3, with the identified IEFs listed in section 8.4.4.
[EN-3, 2.6.68] The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it.	The existing ecology is laid out in the baseline environment (section 8.4), with all relevant information used to inform the associated assessment of significant effects on this baseline (section 8.8).
[2.6.75] Where it is proposed that mitigation measures applied to offshore export cables to reduce electromagnetic fields (EMF) the residual effects of EMF on sensitive species from cable infrastructure during operation are not likely to be significant. Once installed, operational EMF impacts are unlikely to be of sufficient range or strength to create a barrier to fish movement.	This has been examined in the assessment of the limited effects of electromagnetic fields (section 8.8.6).

8.2.2 North West Inshore and North West Offshore Coast Marine Plans

8.2.2.1 The impact assessment on fish and shellfish ecology has also been made with consideration to the specific policies set out in the North West Inshore and North West Offshore Coast Marine Plans (MMO, 2021). Key provisions are set out in Table 8.3 along with details as to how these have been addressed within the assessment.

Table 8.3: North-West Inshore and North-West Offshore Marine Plan policies of relevant to Fish and Shellfish Ecology.

Policy	Key provisions	How and where considered in the PEIR
NW-FISH-3	Proposals that enhance essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes, should be supported. Proposals that may have significant adverse impacts on essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes, must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts so they are no longer significant.	The areas of essential fish habitat potentially impacted have been identified in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR; the baseline (section 8.4.2), and assessed in detail in Section 8.8.

Policy	Key provisions	How and where considered in the PEIR
NW-MPA-1	Proposals that support the objectives of marine protected areas and the ecological coherence of the marine protected area network will be supported. Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts, with due regard given to statutory advice on an ecologically coherent network.	Marine protected areas (MPAs) with fish and shellfish features have been identified in section 0. Assessment of impacts on features of these sites, where relevant, are presented in section 8.8, with site specific assessments presented in section 8.4.3, and section 8.10 of volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.
NW-BIO-2	Proposals that enhance or facilitate native species or habitat adaptation or connectivity, or native species migration, will be supported. Proposals that may cause significant adverse impacts on native species or habitat adaptation or connectivity, or native species migration, must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts so they are no longer significant d) compensate for significant adverse impacts that cannot be mitigated.	Volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR presents a detailed characterisation of the fish and shellfish ecology in the fish and shellfish ecology study area, which is summarised in section 8.4.4. Assessment of impacts, with consideration of mitigation measures, on these receptors is presented in section 8.8.
NW-INNS-1	Proposals that reduce the risk of introduction and/or spread of non-native invasive species should be supported. Proposals must put in place appropriate measures to avoid or minimise significant adverse impacts that would arise through the introduction and transport of invasive non-native species, particularly when: 1) moving equipment, boats or livestock (for example fish or shellfish) from one water body to another 2) introducing structures suitable for settlement of invasive non-native species, or the spread of invasive non-native species known to exist in the area.	The prevention of the spread of invasive non-native species (INNS) has been highlighted and considered in section 8.7, dealing with measures adopted as part of the Morgan Generation Assets, with justifications given. These are also considered in the impact assessment section 8.8.
NW-DIST-1	Proposals that may have significant adverse impacts on highly mobile species through disturbance or displacement must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts so they are no longer significant.	This has been examined specifically in the impacts of noise during all phases of the development, as detailed in section 8.8.3, as well as the whole of section 8.8 more broadly.
NW-UWN-2	Proposals that result in the generation of impulsive or non-impulsive noise must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts on highly mobile species so they are no longer significant. If it is not possible to mitigate significant adverse impacts, proposals must state the case for proceeding.	The potential impacts of noise resulting from the construction, operational and maintenance, and decommissioning phases have been considered in the noise impact assessment (section 8.8.3).
NW-CE-1	Proposals which may have adverse cumulative effects with other existing, authorised, or reasonably foreseeable proposals must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse cumulative and/or in-combination effects so they are no longer significant.	The potential impacts on other existing, authorised, or reasonably foreseeable proposals have been examined in the Cumulative Effects Assessment (CEA) (section 8.10).
NW-CBC-1	Proposals must consider cross-border impacts throughout the lifetime of the proposed activity. Proposals that impact upon one or more marine plan areas or terrestrial environments must show evidence of the relevant public authorities (including other countries) being consulted and responses considered.	Any potential cross-border impacts have been assessed in the transboundary effects (section 8.11) and inter-related effects (section 8.12) sections.

8.3 Consultation

8.3.1 Overview

8.3.1.1 A summary of the key issues raised during consultation activities undertaken to date specific to fish and shellfish ecology is presented in Table 8.4 below, together with how these issues have been considered in the production of this PEIR chapter. Further detail is presented within volume 4, annex 8.1: Fish and shellfish technical report of the PEIR.

8.3.2 Evidence plan

8.3.2.1 The purpose of the Evidence Plan process is to agree the information the Morgan Generation Assets needs to supply to the Secretary of State, as part of a DCO application for Morgan Generation Assets, with NRW, Natural England, MMO, Joint Nature Conservation Committee (JNCC), Environment Agency, Cefas and The Wildlife Trusts. The Evidence Plan seeks to ensure compliance with the Habitat Regulations Assessment (HRA) and EIA. Consultation on the fish and shellfish ecology topic was undertaken via the Benthic Ecology, Fish and Shellfish Ecology and Physical Processes EWG, with meetings held prior to the PEIR in February 2022 and November 2022.

8.3.2.2 The first EWG meeting (February 2022) provided an update on current site-specific surveys and approach to baseline characterisation (including desktop data sources), as set out in the Scoping Report for the Morgan Generation Assets. A summary of discussions and key issues raised is set out in Table 8.4 below. The second EWG (November 2022) outlined the most up-to-date assessments of potential impacts likely to be caused by the construction, operations and maintenance, and decommissioning of the Morgan Generation Assets and highlighted to all relevant stakeholders the potential significant impact of underwater noise on a range of fish species including herring with important spawning grounds within the local area.

Table 8.4: Summary of key consultation issues raised during consultation activities undertaken for the Morgan Generation Assets relevant to fish and shellfish ecology.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
February 2022	Cefas – First Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	Walney and Ormond have data from surveys. The desktop data sources listed appear appropriate. Landings and VMS data for the region would also be a good source of data for the region.	Full details of the baseline characterisation, including those additional data sources indicated, are presented in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.
February 2022	Cefas – First Evidence Plan Expert Working Group	Cod should be specifically considered for piling noise impacts.	Cod *Gadus morhua* included as an IEF in the volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR and baseline (section 8.4.2), and cod sensitivity has been given consideration throughout the impact assessment (section 8.8) including underwater noise.
February 2022	Cefas – First Evidence Plan Expert Working Group	Elasmobranchs (e.g. basking shark) around the IoM may be present. This would be something that the IoM would have more information on (rather than Cefas).	Nearby and IoM elasmobranch sightings datasets assessed in the baseline (section 8.4.2), with sensitivities examined in relation to possible impacts in the noise impact assessment section (section 8.8.3).
February 2022	Cefas – First Evidence Plan Expert Working Group	In terms of migratory fish, particularly at the north coast of Wales and coast of Cumbria there are some SACs and MCZ for lamprey and salmon.	Lamprey and salmonid species included as IEFs, and Marine Conservation Zones (MCZs) and Special Areas of Conservation (SACs) within the fish and shellfish ecology study area have been examined in detail in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR, and where relevant within this chapter.
February 2022	Cefas – First Evidence Plan Expert Working Group	Cefas would advise that the underwater noise assessment treats fish as a static receptor rather than a fleeing receptor for spawning fish within the spawning season.	This has been examined in the underwater noise impact assessment (section 8.8.3).
February 2022	Natural Resources Wales – First Evidence Plan Expert Working Group	The Zone of Influence (ZOI) was shown as one tidal excursion. For a lot of fish species, underwater noise may be a key impact. Noise contours may go outside one tidal excursion therefore impacts may go beyond that definition of the ZOI.	Comment was noted and a wider ZOI has been used for the underwater noise assessment. Effects of underwater noise on fish and shellfish receptors is presented in section 8.8.3.
February 2022	Natural Resources Wales – First Evidence Plan Expert Working Group	Consider use of data from Cefas PELTIC surveys in baseline characterisation.	Full details of the baseline characterisation are presented in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.
February 2022	Natural Resources Wales – First Evidence Plan Expert Working Group	NRW Advisory support the approach of treating fish as static receptors of underwater noise within the spawning season and further advise that where fish are modelled as fleeing receptors, the fleeing speed and timeframes should be evidence-based and species specific.	This has been examined in the underwater noise impact assessment (section 8.8.3).
February 2022	Natural Resources Wales – First Evidence Plan Expert Working Group	The fish and shellfish main receptors in the region will be scallop and *Nephrops*.	King scallop *Pecten maximus*, and queen scallop *Aequipecten opercularis*, and *Nephrops* included as IEFs, with a specific paragraph for scallop in baseline (section 8.4), with details given in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.
February 2022	Natural Resources Wales – First Evidence Plan Expert Working Group	Bangor University and the IoM government have undertaken surveys for scallop and may provide a useful data source.	Examined in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR for all relevant IEFs and included in the baseline (section 8.4) of this chapter.
June 2022	The Planning Inspectorate – Scoping Opinion	Seabed preparation - The Environmental Statement should provide further detail on the proposed seabed preparation activities and identify the worse-case scenario assessed in relation to seabed disturbance. The need for dredging, quantities of material and likely disposal location should be identified, and likely significant effects assessed in the Environmental Statement. The Inspectorate understands that the requirements for Unexploded Ordnance (UXO) clearance are not known at this stage and that a dedicated UXO survey will be conducted prior to construction. The Environmental Statement must explain the informed assumptions applied to establish the worst-case scenario assessed.	Seabed preparation activities have been outlined in the MDS (section 8.6.1), with details of potential temporary habitat loss (section 8.8.2) and UXO (section 8.8.3) impacts of fish and shellfish receptors assessed.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
June 2022	The Planning Inspectorate – Scoping Opinion	The Environmental Statement should provide a full description of the nature of the operation and maintenance activities, including type, frequency, and potential for overlapping activities with those associated with existing and planned wind farms in the area, or set out the assumptions made where exact information is not known.	The potential effects of operations and maintenance activities have been assessed for the project alone in section 8.8 for the Morgan Generation Assets and, where relevant, cumulatively with other projects (section 8.10).
June 2022	The Planning Inspectorate – Scoping Opinion	In light of the number of ongoing developments within the vicinity of the Proposed Development application site, the Environmental Statement should clearly state which developments will be assumed to be part of the baseline and those which are to be considered as other development for the purposes of the cumulative effects assessment. It is noted from the Scoping Report that the proposed onshore operations and maintenance base will be progressed under a separate consent application (it is not stated as intended to be part of the transmission assets application). The Environmental Statement should take this into account in the cumulative effects assessment. Respondents to the Scoping Report have identified proposed developments or provided advice on the types of projects, plans, or activities that should be included; these should be taken into account in the cumulative effects assessment. The Applicant should seek to agree the scope of the projects assessed with these consultation bodies.	Section 8.9.1 sets out the approach and methodology for the cumulative effects assessment, which has been undertaken in line with the Planning Inspectorate Advice Note Seventeen: Cumulative effects assessment (August 2019). All relevant projects are detailed in the cumulative MDS (section 8.9.2).
June 2022	The Planning Inspectorate – Scoping Opinion	Effects of the particle motion element of underwater noise on fish and shellfish receptors during operation. The assessment of particle motion on fish and shellfish is restricted to construction and decommissioning, but the reasoning for this is unclear. In the absence of information such as evidence demonstrating clear agreement with relevant consultation bodies, the Inspectorate is not in a position to agree to scope these matters out from the assessment. Accordingly, the Environmental Statement should include an assessment of these matters, or the information referred to demonstrating agreement with the relevant consultation bodies and the absence of a likely significant effect.	The potential impacts of particle motion and noise have been assessed in section 8.8.3, with specifically provided references incorporated where relevant. Operational wind turbine noise has been scoped out, as justified in section 8.6.2, which includes consideration of additional site-specific modelling of underwater noise from operational wind turbines.
June 2022	The Planning Inspectorate – Scoping Opinion	The Scoping Report proposes to assess the effects of underwater noise on marine life due to jacket or monopile cutting and removal during decommissioning. However, the Scoping Report does not specifically identify this potential impact within the Fish and shellfish ecology section. The outcomes of this assessment should be presented within the relevant Environmental Statement chapters.	Noise modelling in volume 3, annex 3.1: Underwater noise technical report of the PEIR indicates that cutting and removal sound levels during decommissioning will be significantly less than during construction, and therefore only construction impacts have been assessed in section 8.8.3.
June 2022	The Planning Inspectorate – Scoping Opinion	Section 3.2.7 Potential for injury and behavioural disturbance. The Environmental Statement should describe the Permanent Threshold Shift (PTS), Temporary Threshold Shift (TTS) and disturbance ranges used for all species assessed, as well as the potential for the disturbance impact footprints to overlap with the boundary of offshore designated sites.	These thresholds have been explained and used to indicate potential disturbance in the underwater noise impact assessment (section 8.8.3).
June 2022	The Planning Inspectorate – Scoping Opinion	The Environmental Statement should clearly identify all sources of underwater and vibration noise (piling, vessels, drilling), for all phases of the Proposed Development, and assess the impacts from these activities where significant effects are likely to occur. The Environmental Statement should set out the methodology and assumptions for all modelling undertaken.	This has been examined in the underwater noise impact assessment (section 8.8.3).

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
June 2022	The Planning Inspectorate – Scoping Opinion	Concurrent piling – The Scoping Report explains that piles may be being installed at two locations at the same time. The Environmental Statement should demonstrate that the worst-case scenario accounts for concurrent piling activities that are located as far apart from each other as would be possible in the design envelope, and thus result in the greatest potential extent of noise impacts.	The impacts of concurrent piling have been assessed in the underwater noise assessment (section 8.8.3).
June 2022	The Planning Inspectorate – Scoping Opinion	The MMO and Natural England both provide advice on fleeing fish swim speed in their consultation responses. The Environmental Statement should base modelling on a stationary rather than a fleeing receptor for fish unless otherwise agreed with the relevant consultation bodies.	Fish have been modelled as both stationary and fleeing receptors in volume 3, annex 3.1: Underwater noise technical report of the PEIR, with these results assessed in section 8.8.3.
June 2022	The Planning Inspectorate – Scoping Opinion	Accidental pollution during all phases of the development. The Scoping Report proposes to scope out accidental pollution resulting from all phases of the Proposed Development. The Inspectorate agrees that such effects are capable of mitigation through standard management practices and can be scoped out of the assessment. The Environmental Statement should provide details of the proposed mitigation measures to be included in the offshore Environmental Management Plan and its constituent Marine Pollution Contingency Plan (MPCP). The Environmental Statement should also explain how such measures will be secured.	The proposed mitigation measures are listed and justified in section 8.7, including reference to management plans which is proposed to be secured through a condition in the marine licence.
June 2022	The Planning Inspectorate – Scoping Opinion	Underwater wind turbine noise during operation. This is scoped out on the basis that the impact of operational noise from wind turbines on marine species is generally small with behavioural responses occurring within meters of the wind turbines; this information is based on studies conducted in 2011 and 2014. Considering the age of the studies and the increase in size and capacity of wind turbines since 2014, the potential gaps in the baseline data due to a lack of fish/shellfish specific surveys being undertaken and the crossover of multiple nurseries and spawning grounds the Inspectorate is not content to scope this matter out. The Environmental Statement should quantify the extent of impact both alone and cumulatively with other developments on marine receptors and assess significant effects where they are likely to occur.	This impact has been scoped out based on site specific noise information and up to date research and post-construction monitoring of nearby wind farms, including modelling of noise emissions from the proposed wind turbines and effects on fish and shellfish receptors (section 8.8.30).
June 2022	The Planning Inspectorate – Scoping Opinion	Underwater vessel noise during operation – Impacts to fish and shellfish from underwater vessel noise during operation is scoped out on the basis that noise generation is likely to be low and effects would only occur if fish were within close proximity to the vessels. The Scoping Report has not provided any evidence to support this assertion. Provided the Environmental Statement demonstrates the number of vessels during operation, and reasoning as to why significant effects on fish and shellfish are unlikely (both alone and cumulatively with other development), the Inspectorate is content to scope this matter out.	This impact has been scoped out based on site specific noise information, including modelling of noise emissions from the vessels during all phases and effects on fish and shellfish receptors (section 8.6.20).

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
June 2022	The Planning Inspectorate – Scoping Opinion	Impacts from sediment-bound contaminants. Impacts from contaminant release are proposed to be scoped out on the basis that baseline levels are low and based on the projected results of site-specific surveys and consultation with Statutory Nature Conservation Bodies (SNCBs). Since the surveys and consultation have not yet been undertaken, the Inspectorate does not have enough evidence to support scoping out this matter. The Environmental Statement should include an assessment of significant effects where they are likely to occur.	The potential impacts of resuspension of sediment-bound contaminants in all phases on fish and shellfish receptors has been assessed in section 8.8.4.
June 2022	The Planning Inspectorate – Scoping Opinion	Baseline surveys proposed are not specific to fish and shellfish species and utilise surveys characterising baselines for the benthic and marine mammal chapters to establish the baseline for fish and shellfish based on incidental observations of species and particle size analysis to inform habitat suitability for sandeel and herring. No further surveys are proposed to characterise the baseline. The baseline is supported by a desk-based analysis of multiple records set out in Scoping Report Table 4.7 and any records are assumed to occur in the Morgan study area for generation assets. However, considering the age of previous surveys within the area and that the proposed surveys are not specific to fish and shellfish, there is a risk that the baseline may not be robust. This also does not take into account the effectiveness of the surveys (for example, trawl surveys are not designed to capture shellfish) or the behaviour of species (for example, herring are also known to change specific locations of spawning each year and do not necessarily return to the same spot). Effort should be made to agree the approach to baseline characterisation with the relevant consultation bodies and the approach should be sufficiently justified in the Environmental Statement.	Up to date datasets and publications have been incorporated into the baseline, providing a robust and up to date desktop review baseline, including data and reports from the IoM government and Bangor university, post-construction surveys of offshore wind farms in the local area, recent International Council for the Exploration of the Sea (ICES) fish ecology data, and recent data on fish spawning and nursery habitats. This was supplemented by opportunistically collected fish and shellfish data from benthic site-specific surveys and commercial fisheries data (as presented in volume 4, annex 11.1: Commercial fisheries technical report of the PEIR).
June 2022	The Planning Inspectorate – Scoping Opinion	Mitigation measures adopted as part of the project specify that soft-start piling and ramp-up measures will be implemented during construction. The Applicant should consider controlling the timing of activities during construction and operation to avoid key and sensitive periods to species, for example fish spawning and migration periods. The Environmental Statement should describe the proposed mitigation measures and signpost where they are secured in the application based on a worst-case scenario of noise impact, and this should include any overlapping sources of noise e.g. multiple piles and UXO detonation, with relevant mitigation measures. Effort should be made to agree the approach with the relevant consultation bodies.	Mitigation measures have been outlined and justified in section 8.7, with relevant mitigation measures recommended where impacts are found likely to be significant. Information on spawning periods is provided for consideration in the baseline (section 8.4), with more detailed descriptions provided in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.
June 2022	The Planning Inspectorate – Scoping Opinion	The Inspectorate considers that direct damage and disturbance to mobile demersal and pelagic fish and shellfish species should be scoped into the assessment for all phases of the development. Accordingly, the Environmental Statement should include an assessment of these matters or evidence demonstrating agreement with the relevant consultation bodies that significant effects are not likely to occur.	Direct damage and disturbance have been considered in the impact assessments (section 8.8).
June 2022	The Planning Inspectorate – Scoping Opinion	Fish feeding grounds and overwintering areas for crustaceans. The Scoping Report does not address potential impacts on fish feeding grounds or over-wintering areas for crustaceans. The Environmental Statement should assess these impacts where significant effects are likely to occur.	Effects from the project activities on all fish habitats, including fish feeding, spawning and nursery habitats and crustacean overwintering grounds have been considered throughout the impact assessment in Section 8.8.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
June 2022	The Planning Inspectorate – Scoping Opinion	Vessel collision with basking shark - The Environmental Statement should assess the potential for vessel collision on basking shark and any significant effects that are likely to occur.	This was scoped in for basking shark and has been assessed in the potential for injury due to vessel collisions (section 8.8.8).
June 2022	The Planning Inspectorate – Scoping Opinion	Geophysical surveys cumulative noise - Geophysical surveys are a source of underwater noise and should be assessed in the Environmental Statement where significant effects are likely to occur, both alone and cumulatively with other noise sources.	The potential impacts of these surveys have been assessed in the underwater noise assessment section (section 8.8.3).
July 2022	Marine Management Organisation – Scoping Opinion	The MMO is content that the following impacts can be scoped out of further assessment at EIA stage: • Accidental pollution during construction, operation and maintenance and decommissioning phases. • Underwater noise from wind turbine operation during operation and maintenance phase. • Underwater noise from vessels during all phases. • Impacts from the release of sediment-bound contaminants.	The majority of these have been scoped out and justified in section 8.6.2, but the impacts from the release of sediment-bound contaminants was scoped in upon further stakeholder consultation and has been assessed in section 8.8.4.
July 2022	Marine Management Organisation – Scoping Opinion	The MMO agree that Boyle and New (2018) herring larval survey data present the most up to date information and provide the greatest confidence for determining areas where active spawning is taking place, it is unclear from reviewing the scoping report how the Applicant intends to make use of the particle size analysis (PSA) data for the purpose of determining herring spawning habitat suitability, this is of relevance because historic herring spawning grounds can be recolonised over time (Corten, 1999) and although herring will return to a broad area to spawn annually, the exact locations change year on year. I recommend that the Applicant also reviews and adapts their herring and also sandeel spawning habitat suitability assessment using the method described by MarineSpace (2013a) which uses a suite of data to determine habitat suitability including PSA data, British Geological Survey (BGS) data, Regional Seabed Monitoring Plan (RSMP) data, herring larval survey data, as well as fishing fleet data and scientific publications, and then assigns a score to the heat map outputs based on confidence of the data.	Long-term Northern Ireland Herring Larvae Survey (NINEL) herring larvae survey data from the north Irish Sea have been presented as bubble plots in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR, with this data supplemented by relevant up to date references and guidance notes recommended by stakeholders and described alongside PSA data in the baseline (section 8.4). Sandeel were also identified as IEFs and assessed in the baseline, similarly considering the guidelines of Latto *et al*. as recommended. Data limitations were identified and assessed in section 8.4.6.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
July 2022	Marine Management Organisation – Scoping Opinion	The MMO supports the use of Popper *et* al. (2014) guidelines in assessing underwater noise impacts on fish and shellfish. However, the MMO does have major concerns regarding the proposed use of a generic swim speed for fish of 0.5m/s for the purpose of underwater noise modelling. The MMO do not support the use of a fleeing animal model for fish the reasons outlined below: I. Fish will respond to loud noise and vibration, through observed reactions including schooling more closely; moving to the bottom of the water column; swimming away, and; burying in substrate (Popper *et al.* 2014). However, this is not the same as fleeing, which would require a fish to flee directly away from the source over the distance shown in the modelling. We are not aware of scientific or empirical evidence to support the assumption that fish will flee in this manner. II. The assumption that a fish will flee from the source of noise is overly simplistic as it overlooks factors such as fish size and mobility, biological drivers, and philopatric behaviour which may cause an animal to remain/return to the area of impact. This is of particular relevance to herring, as they are benthic spawners which spawn in a specific location due to its substrate composition. III. Eggs and larvae have little to no mobility, which makes them vulnerable to barotrauma and developmental effects. Accordingly, they should also be assessed and modelled as a stationary receptor, as per the Popper *et al.* (2014) guidelines. The MMO therefore recommend that all underwater modelling is based on a stationary rather than a fleeing receptor for fish as the MMO is not aware of any supporting peer- reviewed literature for fleeing in fish.	The modelling in volume 3, annex 3.1: Underwater noise technical report of the PEIR has considered fish as both fleeing and static receptors, with these both presented in section 8.8.3. Behaviour in response to noise impacts has also been assessed using up to date scientific literature for various fish and shellfish species.
July 2022	Marine Management Organisation – Scoping Opinion	For the purpose of modelling behavioural responses in herring at their spawning ground, the MMO recommend the inclusion of a 135dB threshold based on startle responses observed in sprat by Hawkins *et al.* (2014). Sprat is considered a suitable proxy species for herring for the purpose of modelling likely behavioural responses in gravid herring at the spawning ground. It would be useful if the 135dB noise contour was presented in mapped form (i.e., as an additional contour to the 186dB, 203dB and 207dB, as per Popper *et al.,* 2014).	This has been included where relevant in the underwater noise assessment (section 8.8.3).
July 2022	Marine Management Organisation – Scoping Opinion	The Applicant has identified a range of suitable data sources of various timescales. The MMO would expect to see data collected within the last 5 years as the primary data source used as this data will provide the most accurate view of current baseline conditions. This should be updated in the Environmental Statement.	The most up-to-date literature available has been incorporated into volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR, the baseline (section 8.4) and the impact assessments (section 8.8), and generally throughout the entire chapter.
July 2022	Marine Management Organisation – Scoping Opinion	The MMO would expect to see MMO Landings Data for the relative ICES rectangles used to support survey data. Landings data will highlight species of commercial importance and general areas of high abundance. This should be provided in the Environmental Statement.	The volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR and the baseline (section 8.4) identify IEF species based on relevant data sources and stakeholder recommendations.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
July 2022	Marine Management Organisation – Scoping Opinion	The MMO notes trawl survey data has been used to highlight which shellfish species were present at site. The applicant has stated that Queen Scallops were the most numerous. While this maybe what the data shows at face value, this is not a scientifically robust interpretation of the data. Trawl fishing gear is not designed to capture shellfish species and therefore does not present an accurate representation of the quantities of shellfish present at a site. Information on shellfish caught using anything other than gear designed to catch the species should be used only for presents/absence data and not an assessment of abundance. This data should be modified for presentation in the Environmental Statement to reflect the correct scientific interpretation. It is also considered good practice to caveat any data used that has been collected using non-shellfish specific fishing gears.	The volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR and the baseline (section 8.4) assess queen and king scallop populations based on relevant data sources and stakeholder recommendations.
July 2022	Natural England – Scoping Opinion	Natural England consider that the transmission assets are an integral part of the project and therefore the Environmental Statement should, at the point of submission, be in a position to consider the project as a whole. Therefore the final Environmental Statement, when considering the project as a whole, will include additional impacts and designated sites than those mentioned within the Morgan Offshore Wind Farm Generation Assets Scoping Report.	The impacts of the construction of the Morgan and Morecambe Transmission Assets have been assessed for all impacts where relevant in the cumulative assessment (section 8.10). These have been considered separately from the Morgan Generation Assets and Morecambe Offshore Wind Farm Generation Assets as part of the Pathways to 2030 Offshore Transmission Network Review, to improve transmission assets coordination between developers. As and when more information becomes available on this project, this will be incorporated into the cumulative effects assessment, in the final DCO application.
July 2022	Natural England – Scoping Opinion	The Environmental Statement should be fully informed by the recommendations in the Best Practice Advice and we will increasingly be appraising Environmental Statements with respect to the extent to which the guidance has been followed.	All relevant guidance has been taken into account, as highlighted in the impact assessment methodology (section 8.5).
July 2022	Natural England – Scoping Opinion	We advise that secondary scour protection impacts on seabed habitats are scoped in until further detailed methods and impacts can be assessed, and justification provided to scope out of the Environmental Statement.	Potential impacts from this and other infrastructure have been examined in the colonisation of hard structures (8.8.7).
July 2022	Natural England – Scoping Opinion	We recommend that underwater noise modelling of the operational wind farm noise is undertaken using the best available evidence and reasonable assumptions based on wind turbines that are of representative size for the Morgan Offshore Wind Farm. The size of the wind turbines proposed for this project are significantly larger than those that were the subject of the various referenced studies. Discussion and agreement should be sought through the Evidence Plan process with the relevant Expert Working Groups (EWG).	This impact has been scoped out and justified based on site specific noise modelling information (section 8.6.20).
July 2022	Natural England – Scoping Opinion	In regard to modelling fish for the purpose of exposure, we advise that all fish hearing groups (Group 1 to 4 fish) should be assessed as static receptors for the purpose of exposure modelling.	Fish have been modelled as both stationary and fleeing receptors in volume 3, annex 3.1: Underwater noise technical report of the PEIR, with these results assessed in section 8.8.3.
July 2022	Natural England – Scoping Opinion	We do not agree, at this stage, that sufficient evidence has been provided to scope out impacts to benthic invertebrates due to electromagnetic fields or the release of sediment-bound contaminants.	The potential impacts of EMFs surrounding cables have been assessed in section 8.8.6.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
July 2022	Natural England – Scoping Opinion	It will be important for any assessment to consider the potential cumulative effects of this proposal, including all supporting infrastructure, with other similar proposals and a thorough assessment of the 'in combination' effects of the proposed development with any existing developments and current applications – specifically including existing, approved, and ongoing projects, and applications and foreseeable projects. A full consideration of the implications of the whole scheme should be included in the Environmental Statement. All supporting infrastructure and activities should be included within the assessment.	This has been examined and assessed using a tiered system to describe levels of potential impact in the cumulative effects assessment (section 8.10).
July 2022	Natural England – Scoping Opinion	Natural England advises that the potential impact of the proposal upon features of nature conservation interest and opportunities for habitat creation/enhancement should be included within this assessment in accordance with appropriate guidance on such matters (e.g. Ecological Impact Assessment (EcIA) from the Chartered Institute of Ecology and Environmental Management (CIEEM), and the National Planning Policy Framework).	All relevant guidance has been taken into account, as highlighted in the impact assessment methodology (section 8.5).
July 2022	Natural England – Scoping Opinion	The Environmental Statement should thoroughly assess the potential for the proposal to affect designated sites. Internationally designated sites (e.g. designated SACs and Special Protection Areas (SPAs)) fall within the scope of the Conservation of Habitats and Species Regulations 2017 (as amended), and under regulation 8 of the National Planning Policy Framework. The Environmental Statement should identify such mitigation measures as may be required in order to avoid, minimise or reduce any adverse significant effects on these sites.	Nearby potentially impacted designated sites have been identified in volume 4, annex 8.1: Fish and shellfish technical report of the PEIR, and in section 8.4.3. Mitigation measures to reduce or prevent impacts have been outlined in section 8.7.
July 2022	Natural England – Scoping Opinion	The Environmental Statement should assess the impact of all phases of the proposal on fish and shellfish species protected by the Wildlife and Countryside Act 1981 (as amended); the Conservation of Habitats and Species Regulations 2017 (as amended); the England Biodiversity List; published under the requirements of S41 of the Natural Environment and Rural Communities (NERC) Act 2006; the Habitats and Species of Principal Importance Biodiversity Action Plan, and Part IV and Annex A of Government Circular 06/2005 Biodiversity and Geological Conservation: Statutory Obligations.	Protected and ecologically important species have been identified through extensive desktop review of relevant literature and guidance, and stakeholder consultation, and are listed as IEFs in section 8.4.4 and assessed where relevant in section 8.8.
July 2022	Natural England – Scoping Opinion	The area likely to be affected by the proposal should be thoroughly surveyed at optimal times and based on best practice guidance by competent ecologists at appropriate times of year for relevant species and the survey results, impact assessments and appropriate accompanying mitigation strategies included as part of the Environmental Statement.	Baseline characterisation surveys have been performed in line with Natural England best practice advice with some data collected on fish and shellfish receptors incorporated into the baseline (section 8.4).
July 2022	Natural England – Scoping Opinion	Records of protected species should be sought from appropriate local biological record centres, nature conservation organisations, National Biodiversity Network (NBN) Atlas, groups and individuals; and consideration should be given to the wider context of the site, for example in terms of habitat linkages and protected species populations in the wider area, to assist in the impact assessment.	Extensive desktop review and stakeholder consultation has been undertaken to allow incorporation of the most up to date scientific literature and datasets at all stages throughout the chapter.
November 2022	Cefas - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	Will simultaneous and concurrent piling be modelled if that is a potential construction plan.	Output injury ranges from modelled simultaneous and concurrent piling are presented in section 8.8.3.15 to 8.8.3.21. The full results of the underwater noise modelling are presented in volume 3, annex 3.1: Underwater noise technical report of the PEIR.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
November 2022	Cefas - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	We generally expect to see spatial and temporal maximum design scenarios presented, however we don't provide specific advice on how to do this.	Temporal and spatial maximum design scenario parameters for underwater noise in relation to fish and shellfish receptors are presented in Table 8.14.
November 2022	Cefas - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	In reference to the 'high recoverability' of herring, we assume that means recoverability of herring populations. If this is the case, the Applicant must provide appropriate peer-reviewed literature to support this statement. Herring are considered to be highly sensitive to noise and vibration in terms of physiological and behavioural effects. It should be noted that physiological effects caused by changes in pressure from explosions and impulsive sounds such as piling include death and potential mortal injuries such as barotrauma, blood gases coming out of solution, rapid expansion and contraction of swim bladders, damage to tissue and organs, and potential rupture of the swim bladder (Popper et al., 2014). Barotrauma can result in lethal injury through either immediate, or delayed mortality (McKinstry et al. 2007). Whilst some physical injuries such as fin hematomas, capillary dilation, and loss of sensory hair cells are potentially recoverable, they can still lead to death either through a decreased level of fitness or through predation and disease (Halvorsen, 2011 & 2012). For these reasons, herring, as a receptor, are considered to have low recoverability to underwater noise from pile driving, explosions and other impulsive sounds.	High recoverability is referred to in terms of disturbance to herring, and it is appreciated that where injury occurs, this may not be recoverable from. Herring are fully assessed in relation to the effects of underwater sound in relation to pile driving and explosions in section 8.8.3, and a review of the existing literature surrounding herring is presented in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.
November 2022	Cefas - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	The recommendation was for modelling to be carried out based on a 135dB threshold (rather than 145dB) as this is recommended by Cefas fisheries advisors as a conservative indicator for determining the impact range in which clupeid species (including herring) are likely to exhibit behavioural responses. The 135dB threshold is based on research by Hawkins et al. (2014), who exposed wild schooling sprat to short sequences of repeated impulsive playback sounds at different sound pressure levels, to resemble that of a percussive pile driver. Observed behavioural responses included the break-up of fish schools. The sound pressure levels to which the fish schools responded on 50% of the presentations were 163.2 and 163 dB re 1 µPa (peak-to-peak), and as a result the concluded single strike sound exposure level was 135 dB re 1 µPa2 ·s. 11. Cefas Fisheries and Noise and Bioacoustics advisors recognise that this is a conservative threshold as the Hawkins study was carried out in an enclosed, quiet coastal sea loch, where fish were not accustomed to heavy disturbance from shipping and other sounds (Hawkins et al., 2014). However, sprat is a clupeid species, closely related and anatomically similar to herring, and similarly sensitive to underwater sound (sprats also possess a swim bladder involved in hearing). Given an absence of other peer-reviewed empirical evidence of behavioural responses in clupeid fishes to support an alternative threshold for impulsive noise, Hawkins et al., (2014) is currently considered the best available scientific evidence by Cefas Fisheries and Underwater Noise specialists, and as such a 135dB threshold is deemed appropriate.	Modelling has been carried out based upon both 135dB and 160dB thresholds. The outputs of which are presented in section 8.8.3. The full results of the underwater noise modelling are presented in volume 3, annex 3.1: Underwater noise technical report of the PEIR.
November 2022	Isle of Man Government - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	Have the angel shark areas off north Wales been considered?	An extensive desktop review has been undertaken to incorporate angel shark records from the regional study area to determine whether this species needed to be taken forward as an IEF. This information is presented in provided in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
November 2022	Natural England - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	Natural England broadly agree with the scoping of impacts for the EIA and HRA for Fish and Shellfish Ecology, as presented at the expert working group meeting on 29th November 2022.	Noted
November 2022	Natural England - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	Natural England agree to the approach to noise modelling and approach to assessment as presented at the expert working group meeting on 29th November 2022.	Noted
November 2022	Natural Resources Wales - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	Are spawning areas for cod considered.	Spawning areas for cod are presented and discussed in the underwater noise assessment in section 8.8.3, with specific reference to section 8.8.3.32.
November 2022	Natural Resources Wales - Second Benthic Ecology, Fish and Shellfish and Physical Processes EWG meeting	The slides presented that sensitivity of herring to underwater sound is medium. We would assume that herring have the highest sensitivity to underwater sound.	An extensive desktop study has been undertaken to review and ensure inclusion of the most up-to-date and appropriate scientific literature regarding the sensitivity of herring to underwater sound. The desktop study is provided in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR. A detailed assessment of the effects to herring, and other fish and shellfish from underwater sound is presented in section 8.8.3

8.4 Baseline environment

8.4.1 Methodology to inform baseline

Desktop study

8.4.1.1 Information on fish and shellfish ecology within the fish and shellfish ecology study area was collected through a detailed desktop review of existing studies and datasets. These are summarised at Table 8.5 below, with full details presented in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.

Table 8.5: Summary of key desktop reports.

Title	Source	Year	Author
Herring larvae surveys of the north Irish Sea	The Agri-Food and Biosciences Institute (AFBI)	1993 to 2021	AFBI
Fisheries Sensitivity Maps in British Waters	United Kingdom Offshore Operators Association (UKOOA) Ltd.	1998	Coull *et al.*
Rhyl Flats Offshore Wind Farm, Fish and Fisheries Baseline Study	Marine Data Exchange	2002 to 2006	Coastal Fisheries Conservation and Management
Walney and West of Duddon Sands Offshore Wind Farms, Baseline Benthic Survey – Epifaunal Beam Trawl Results	Marine Data Exchange	2005	Titan Environmental Surveys Ltd.
Burbo Bank Offshore Wind Farm, Pre-construction Commercial Fish Survey (2m Beam Trawl)	Marine Data Exchange	2006	Centre for Marine and Coastal Studies Ltd. (CMACS)
Burbo Bank Offshore Wind Farm, Electromagnetic Fields and Marine Ecology Study	Marine Data Exchange	2007	CMACS
Walney Offshore Wind Farm Pre-Construction Fish Survey	Marine Data Exchange	2009	Brown and May Marine Ltd.
Burbo Bank Offshore Wind Farm, Post-construction (Year 3) Commercial Fish Survey	Marine Data Exchange	2010	CMACS
Ormonde Offshore Wind Farm, Construction (Year 1) Environmental Monitoring	Marine Data Exchange	2010	RPS Energy
Celtic Array (Zone 9) Autumn Fish Trawl Survey	Marine Data Exchange	2010	CMACS
Gwynt y Môr Offshore Wind Farm, Pre-construction Baseline Beam Trawl Data	Marine Data Exchange	2011	CMACS
West of Duddon Sands Offshore Wind Farm, Adult and Juvenile Fish and Epibenthic Pre-Construction Surveys	Marine Data Exchange	2012	Brown and May Marine Ltd.
Mapping the Spawning and Nursery Grounds of Selected Fish for Spatial Planning	Cefas	2012	Ellis *et al*.
Walney Offshore Wind Farm, Year 2 Post-construction Monitoring Fish and Epibenthic Survey	Marine Data Exchange	2013	Brown and May Marine Ltd.
Welsh waters scallop survey – Cardigan Bay to Liverpool Bay July-August 2013	Bangor University	2013	Lambert *et al.*

Title	Source	Year	Author
Celtic Array offshore wind farm preliminary environmental information chapter 10: fish and shellfish ecology	Marine Data Exchange	2013	Celtic Array Ltd.
Northern Irish Ground Fish Trawl Survey (NIGFS)	ICES	2013	ICES
Updating Fisheries Sensitivity Maps in British Waters	Scottish Marine and Freshwater Science Report	2014	Aires *et al.*
Marine Life Information Network (MarLIN)	Mar(LIN)	2018	Tyler Walters *et al*.
Celtic Seas ecoregion fisheries overview	Summary of commercial fisheries in the Celtic Sea	2018	ICES
Manx Marine Environmental Assessment	Isle of Man Government - Fisheries Division	2018	Howe *et al*.
NBN Atlas	NBN Atlas	2019	NBN Atlas
Welsh Waters Scallop Surveys and Stock Assessment	Bangor University	2019	Delargy *et al*.
JNCC MPA Mapper	JNCC	2019	JNCC
Marine Recorder Public UK Snapshot	JNCC	2020	JNCC
Bass and Ray Ecology in Liverpool Bay	Bangor University Sustainable Fisheries and Aquaculture Group.	2020	Moore *et al.*
UK Sea Fisheries Annual Statistics Report	MMO	2020	MMO
ICES working group on surveys on ichthyoplankton in the North Sea and adjacent seas	ICES	2021	ICES
Fisheries & Conservation Science Group	Bangor University	2022	Bangor University
SeaLifeBase	https://www.sealifebase.ca/	2022	https://www.sealifebase.ca/
Cefas Pelagic ecosystem in the western English Channel and eastern Celtic Sea (PELTIC) surveys	Cefas	Various	Cefas
Fish and shellfish survey results for the east Irish Sea	Environment Agency	Various	Environment Agency
Fish and shellfish sensitivity reports	https://www.marlin.ac.uk/activity/pressures_report	Various	Various

Identification of designated sites

8.4.1.2 All designated sites within the fish and shellfish ecology study area and qualifying interest features that could be affected by the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets were identified using the three-step process described below:

- Step 1: All designated sites of international, national and local importance within the fish and shellfish ecology study area were identified using a number of sources. These sources included the JNCC MPA mapper (JNCC, 2019), and the IoM Government Fisheries Division publications (Howe *et al*., 2018)
- Step 2: Information was compiled on the relevant fish and shellfish ecology qualifying interests for each of these sites, such as protected, vulnerable, and commercially important species, and protected habitat types
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - A designated site directly overlaps with the Morgan Generation Assets – specifically the Morgan Array Area
  - Sites and associated qualifying interests were located within the potential ZOI for impacts associated with the Morgan Generation Assets, and
  - Sites which are designated to protect mobile features (e.g. diadromous fish) and where the range of those features has the potential to overlap with either the Morgan Generation Assets and/or the ZOI of impacts associated with the development.

Site specific surveys

8.4.1.3 In order to inform the PEIR, site-specific surveys were undertaken, as agreed with the members of the Benthic Ecology, Fish and Shellfish and Physical Processes EWG (see section 0 for further details). A summary of the surveys undertaken to inform the fish and shellfish ecology impact assessment is outlined in Table 8.6 below. Note that the surveys were primarily designed to inform the benthic subtidal ecology baseline characterisation, but provide useful information on general seabed types, sediment suitability for fish spawning and/or habitat for benthic species. These also provide opportunistic fish and shellfish records which have been extracted from these to inform the baseline characterisation.

Table 8.6: Summary of site-specific survey data.

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Benthic Subtidal Survey	Morgan and Mona Array Areas	Grab samples, Visual survey outputs (Drop Down Video (DDV) sampling) and laboratory testing	Gardline Ltd.	2021	Gardline Ltd., 2021
Benthic Subtidal Survey	Morgan and Mona Offshore Cable Corridors, Array Areas and ZOI.	Grab samples, Visual survey outputs (DDV sampling) and laboratory testing	Gardline Ltd.	2022	These findings, when available, will be further reported within the final version of volume 4, annex 8.1: Fish and shellfish ecology technical report of the Environmental Statement and will be submitted as part of the final DCO application.

8.4.2 Baseline environment

8.4.2.1 The baseline environment has been described in detail within volume 4, appendix 8.1: Fish and shellfish ecology of the PEIR. The fish and shellfish ecology receptors that could be potentially impacted by the Morgan Generation Assets have been determined by the desktop review of available data/information as detailed in Table 8.5, and through use of fish and shellfish ecology data from site-specific surveys, as detailed in Table 8.6 (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR for further detail regarding baseline data collection and site-specific surveys). Through this process a number of demersal, pelagic, elasmobranch and diadromous fish species were identified, along with shellfish species. The baseline environment was described for the fish and shellfish ecology study area. Spawning and nursery areas within the vicinity of the fish and shellfish ecology study area were also described, followed by detailed characterisations of particularly sensitive and important fish and shellfish species, including sandeel Ammodytidae spp., herring *Clupea harengus* (focusing on spawning habitats), elasmobranchs, king and queen scallop, and diadromous species.

8.4.2.2 Species identified as likely to be found within the fish and shellfish ecology study area include:

- Demersal species – sandeel, whiting *Merlangius merlangus*, lemon sole *Microstomus kitt*, ling *Molva molva*, plaice *Pleuronectes platessa*, cod, and European hake *Merluccius merluccius*
- Pelagic species – herring, mackerel *Scomber scombrus*, sprat *Sprattus sprattus*, and European sea bass *Dicentrarchus labrax*
- Elasmobranch species – basking shark *Cetorhinus maximus*, lesser spotted dogfish *Scyliorhinus canicular*, tope shark *Galeorhinus galeus*, spurdog *Squalus acanthias*, common skate *Dipturus batis*, spotted ray *Raja montagui*, and thornback ray *Raja clavata*
- Diadromous species – Atlantic salmon *Salmo salar*, European eel *Anguilla anguilla*, sea trout *Salmo trutta*, river lamprey *Lampetra fluviatilis*, sea lamprey *Petromyzon marinus*, Allis shad *Alosa alosa*, twaite shad *Alosa fallax*, sparling/European smelt *Osmerus eperlanus*; and freshwater pearl mussel *Margaritifera margaritifera* (included here due to reliance on Atlantic salmon and sea trout at specific life stages), and
- Shellfish species – king scallop, queen scallop, European lobster *Homarus gammarus*, edible crab *Cancer pagurus*, velvet swimming crab *Necora puber*, squid *Loligo* spp., common whelk *Buccinum undatum*, and *Nephrops*.

8.4.2.3 The spawning and nursery habitats present in the fish and shellfish ecology study area are summarised in Table 8.7 and are based on Ellis *et al*. (2012) and Coull *et al*. (1998) with the seasonality of each species covered in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR. Nursery and spawning habitats were categorised by Ellis *et al. (*2012) as either high or low intensity dependent on the level of spawning activity or abundance of juveniles recorded. Spawning grounds identified by Coull *et al. (*1998) are classified as low, high or undetermined, again based on the level of spawning activity. Intensity of nursery grounds were not specified by Coull *et al*. (1998). Further detail on nursery and spawning grounds is presented in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR.

8.4.2.4 However, the particular sensitivities of herring, sandeel, and elasmobranch species to offshore wind development impacts, and the commercial importance of king and queen scallop mean these species require specific attention and more detailed characterisation. Therefore, a summary of the baseline characterisation for each of these groups as presented in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR is presented below.

Table 8.7: Key species with spawning and nursery grounds overlapping the Morgan Generation Assets Array Area (Coull *et al*., 1998 and Ellis *et al*., 2012).

Common Name	Species Name	Spawning	Nursery
Anglerfish	*Lophius piscatorius*		✓
Cod	*Gadus morhua*	✓	✓
Haddock	*Melanogrammus aeglefinus*		✓
Herring	*Clupea harengus*		✓
Horse Mackerel	*Trachurus trachurus*	✓	
Lemon Sole	*Microstomus kitt*	✓	✓
Ling	*Molva molva*	✓	
Mackerel	*Scomber scombrus*	✓	✓
Nephrops	*Nephrops norvegicus*	✓	✓

Common Name	Species Name	Spawning	Nursery
Plaice	*Pleuronectes platessa*	✓	✓
Sandeels	Ammodytidae spp.	✓	✓
Sole	*Solea solea*	✓	✓
Spotted Ray	*Raja montagui*		✓
Sprat	*Sprattus sprattus*	✓	
Spurdog	*Squalus acanthias*		✓
Thornback Ray	*Raja clavata*		✓
Tope Shark	*Galeorhinus galeus*		✓
Whiting	*Merlangius merlangus*	✓	✓

Herring

8.4.2.5 Herring utilise specific benthic habitats during spawning, specifically coarse gravelly sediments with a minimal fine sediment fraction, (Dickey-Collas and Nash, 2001), which increases their vulnerability to activities impacting the seabed (ICES, 2006). Further, as a hearing specialist, herring are vulnerable to impacts arising from underwater noise. Herring spawning grounds have been identified by Coull *et al*. (1998) as being present within the fish and shellfish ecology study area. However, data presented by Coull *et al*. (1998) is broad scale, and therefore confidence in the presence of spawning grounds can be increased through spawning assessments using larval data available from the NINEL for understanding spatial distribution and interannual variation and using International Bottom Trawl Survey Working Group acoustic data for population sizes (ICES, 2021a).

8.4.2.6 Monitoring of herring larval abundances and sediment type data can be used to identify herring spawning grounds, with NINEL having conducted an annual survey across the northeast Irish Sea in November since 1993, immediately after the peak herring spawning period every year. This approach ensured that collected data was consistent and comparable between years, with the number of larvae per m^2 able to be calculated for this analysis. Larvae are identified based on size, with small larvae <10mm (in line with standard International Herring Larvae Survey (ICES, 2020a) practice) assumed to have recently been spawned near to the area they were caught, as these will not have drifted far from the location where eggs were spawned on the seabed. High abundances of these larvae are therefore a good indication of recent spawning activity local to where these were sampled. Due to population underestimations compared to acoustic data (see section 8.4.6), the NINEL data is most useful as an indicator of spatial distribution of spawning grounds, although does not give an indication of the size of the herring spawning population.

8.4.2.7 The larval densities were mapped and compared to the spatial distribution of spawning grounds presented in the Coull *et al*. (1998) data and the PSA data from the benthic surveys within and around the Morgan Array Area (Figure 8.2). This PSA data, when presented alongside European Marine Observation and Data Network (EMODnet) seabed substrate data in Figure 8.2, can be used to assess habitat suitability for herring spawning. This data demonstrated overlaps between the spawning ground datasets, with year-to-year variability in preferred spawning locations accounted for by the relatively high resolution and consistency of the data collection process. Specifically, both the Coull *et al*. (1998) and NINEL datasets showed significant spawning areas to the west and northwest of the fish and shellfish ecology study area, and to the north, east and northeast of the IoM. The most suitable spawning grounds were located entirely outside of, but within 10km to the north and northwest of, the Morgan Array Area, which is further supported by results from detailed site-specific survey PSA data (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR for full results). As shown in Figure 8.2, the site-specific survey data (labelled as 'Habitat Suitability, Reach' in Figure 8.2 below) found that the majority of the fish and shellfish ecology study area had unsuitable sediment for herring spawning, with only small patches of suitable habitat mainly in the northern section of the Morgan Array Area.

Sandeel

8.4.2.8 Sandeel high and low intensity spawning grounds have been identified by Ellis *et al*. (2012) as being present throughout the fish and shellfish ecology study area. However, data presented by Ellis *et al*. (2012) is relatively broad scale, and therefore, confidence in the presence of spawning grounds can be increased through completing analysis on site-specific surveys and drawing on more recently published data which can provide increased resolution and any differences based on seasonal population changes.

8.4.2.9 Figure 8.3 shows the results of site-specific PSA survey data alongside EMODnet seabed substrate data which can also be used to assess habitat suitability for sandeel. To appropriately assess the suitability of habitats for sandeel spawning across the fish and shellfish ecology study area, gravelly sand, (gravelly) sand, and sand were classified from the EMODnet data as preferred habitat, and sandy gravel as marginal habitat (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR for further details). No shading in the figure represents unsuitable spawning habitat, while the PSA results were categorised into unsuitable, suitable, subprime, and prime, based on mud and sand ratios in grab samples, as defined by Latto *et al*. (2013). The site-specific benthic surveys and EMODnet seabed substrate data shows overall good alignment within the Morgan Array Area, showing that the majority of stations sampled represented unsuitable habitat, however in the west and south of the Morgan Array Area a number of suitable and sub-prime habitats were identified, with further sparse prime habitats dispersed throughout. Benthic site-specific surveys found no sandeel within the Morgan Array Area, although this particular survey was not designed to target sandeel species and would not be appropriate to inform overall abundance without further studies to specifically sample sandeel.

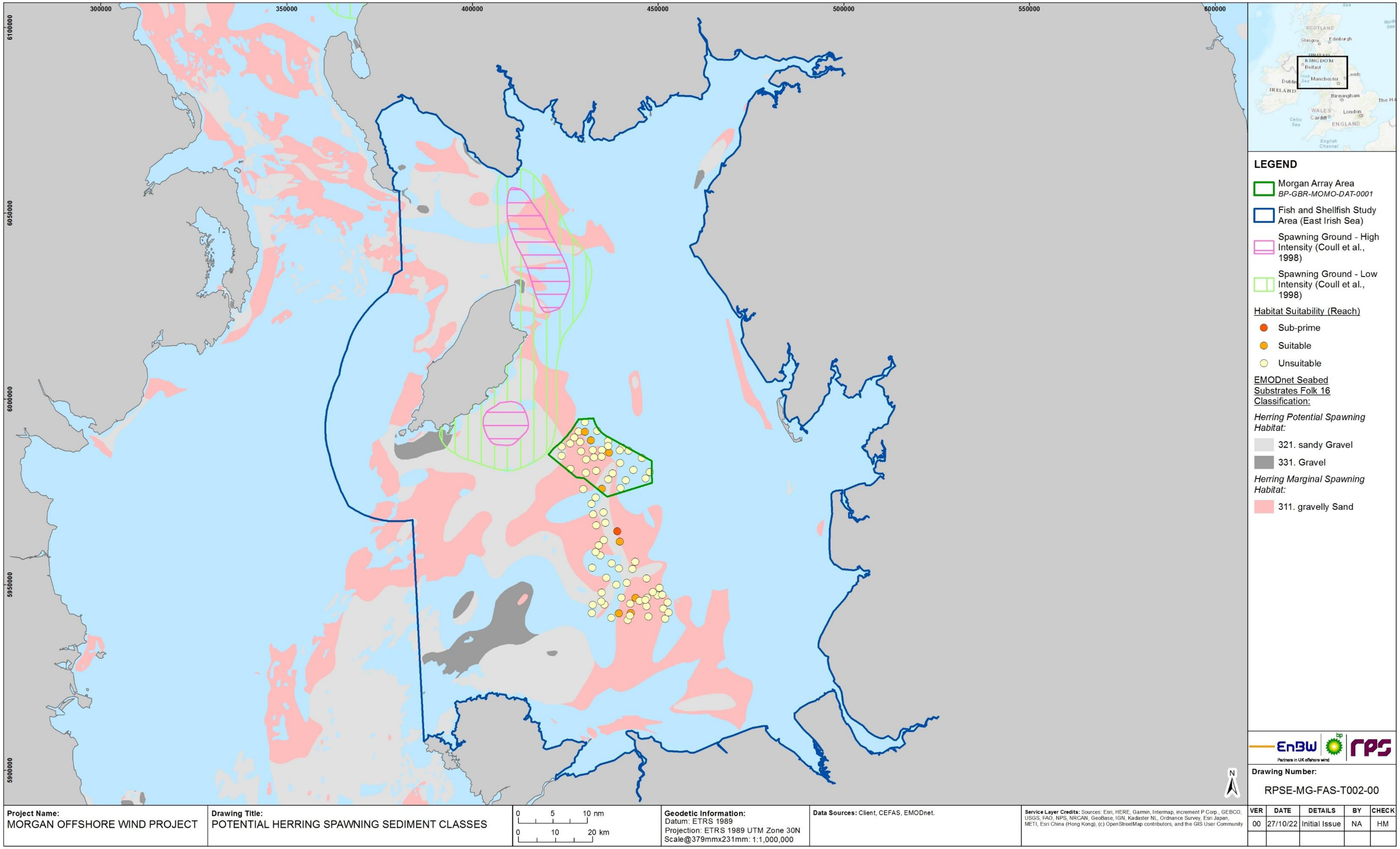


Figure 8.2: Herring spawning habitat preference classifications from EMODnet and site-specific survey data.

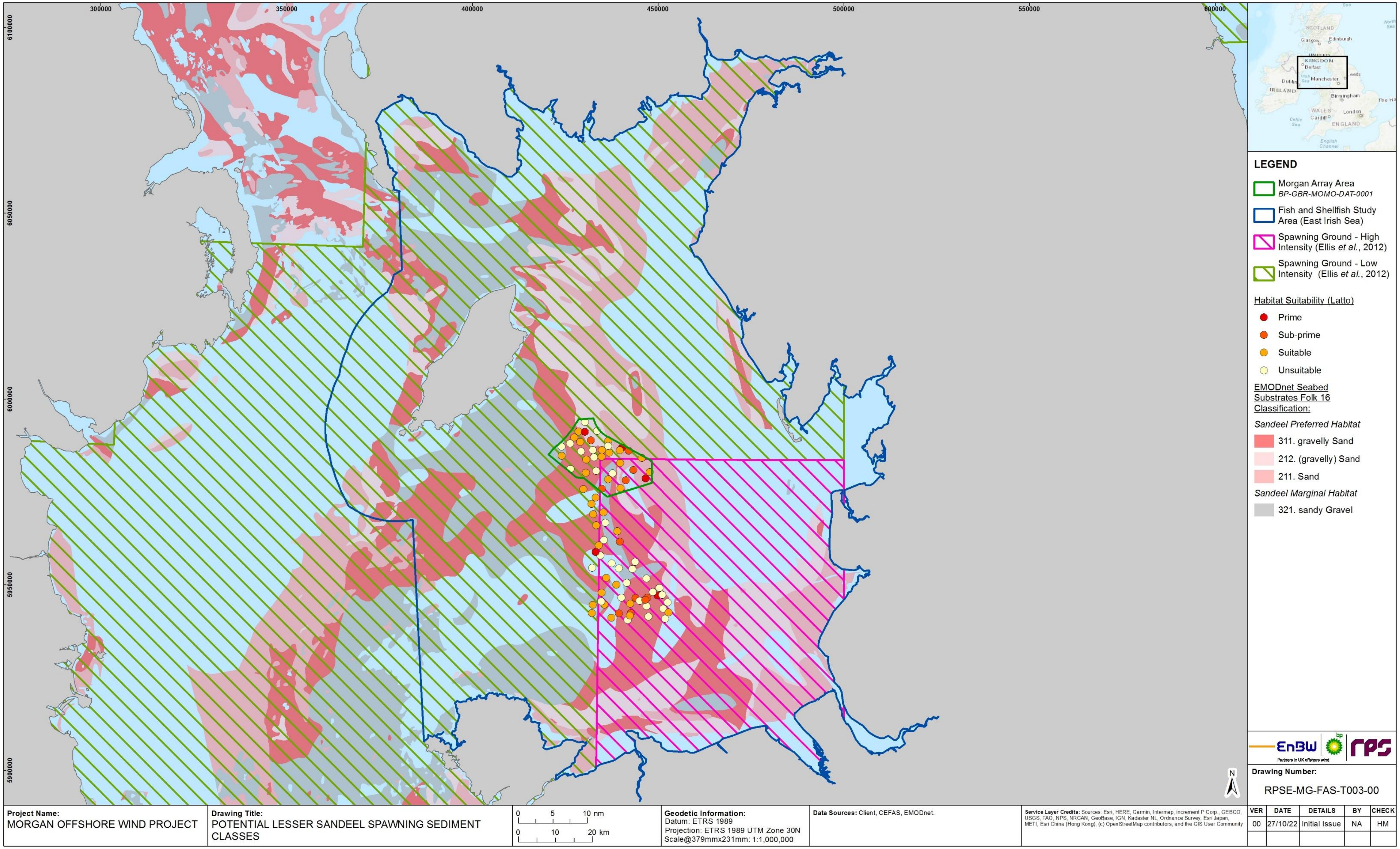


Figure 8.3: Sandeel habitat suitability and spawning ground intensity based on Ellis *et al*. (2012).

Elasmobranchs

8.4.2.10 Elasmobranch species occurring within the Irish Sea include the spotted and thornback ray. Inshore Fisheries Conservation Authority (IFCA) data has indicated these species inhabit the fish and shellfish ecology study area year-round, with stable population levels despite regular fishery activity, peaking in August (Moore *et al*., 2020). Thornback ray have important spawning grounds in the east Irish Sea around Anglesey, within the fish and shellfish ecology study area (Ellis *et al*., 2012). Other species, including the lesser spotted dogfish and cuckoo ray, are also found throughout the east Irish sea, with both preferring gravelly or coarse sandy substrates for feeding. Spawning occurs in shallow coastal waters or on sessile invertebrates in deeper water for the lesser spotted dogfish (Ellis and Shackley, 1996), and in deep offshore waters for the cuckoo ray (Moriarty *et al*., 2015), potentially overlapping with the fish and shellfish ecology study area.

8.4.2.11 Basking shark migrate north to south through the Irish and Celtic Seas in August to October while travelling between north Africa and Scotland to overwinter in the 50-200m continental shelf depth range (Doherty *et al.*, 2017). They pass through the same region in March to June while returning, and thus have the potential to be encountered in the fish and shellfish ecology study area during both of these periods. Specifically, high numbers have been sighted near the IoM (NBN Atlas, 2019), with 28 tagged individuals travelling a median distance of 1057km each in their post-summer migration within a single tracking period of 165 days in one year (Doherty *et al*., 2017), including through the fish and shellfish ecology study area. However, during site-specific aerial surveys to inform the topic assessments and presented in volume 2, annex 9.1: Marine mammals technical report of the PEIR, no sightings of basking shark were recorded during the investigated time-period, although this does not rule out their presence, as basking shark are known to spend a majority of time in depths of 0-200m (Doherty *et al*., 2017), and therefore could be present within the Morgan Array Area, where depths average <50m.

King and Queen Scallop

8.4.2.12 King and queen scallop both show preferences for clean firm sand, fine or sandy gravel, and are found in high densities on muddy sand (MarLIN, 2022). High levels of commercial fishing of king scallop have been recorded within the wider fish and shellfish ecology study area (ICES, 2020), and queen scallop in the west of the Morgan Array Area, as examined in detail with relevant mapping from fisheries data in volume 4, annex 11.1: Commercial fisheries technical report of the PEIR. Queen scallop have been reported by Bloor *et al*. (2019) to be found in densities of 1-11 individuals per 100m^2 within IoM territorial waters west and northwest of the Morgan Array Area, with high potential for overlap between these areas due to the high mobility of queen scallop in the summer months.

8.4.3 Designated sites

8.4.3.1 Designated sites identified for the fish and shellfish ecology chapter are described below in Table 8.8.

Table 8.8: Designated sites and relevant qualifying interests within the fish and shellfish ecology study area with distance from the Morgan Generation Assets.

* IoM designated site

Designated site	Closest distance to the Morgan Array Area (km)	Relevant qualifying interest
Little Ness Marine Nature Reserve (MNR)*	20.41	• Horse mussel beds (*Modiolus modiolus*) • Spiny lobster (Palinuridae) • European eel (*Anguilla anguilla*)
Douglas Bay MNR*	22.22	• European eel (*Anguilla anguilla*) • Horse mussel beds (*Modiolus modiolus*)
Laxey Bay MNR*	22.42	• Icelandic clam/Ocean quahog (*Arctica islandica*) • European eel (*Anguilla anguilla*)
Ramsey Bay MNR*	26.42	• Horse mussel beds (*Modiolus modiolus*) • Icelandic clam/Ocean quahog (*Arctica islandica*) • European eel (*Anguilla anguilla*)
Wyre Lune MCZ	47.06	• Smelt (Osmeridae)
Ribble Estuary MCZ	58.44	• Smelt (Osmeridae)
River Ehen SAC	62.77	• Atlantic salmon (*Salmo salar*) • Freshwater pearl mussel (*Margaritifera margaritifera*)
Dee Estuary SAC/Aber Dyfrdwy SAC	70.09	• Sea lamprey (*Petromyzon marinus*) • River lamprey (*Lampetra fluviatilis*)
River Derwent and Bassenthwaite Lake SAC	71.28	• Sea lamprey (*Petromyzon marinus*) • River lamprey (*Lampetra fluviatilis*) • Atlantic salmon (*Salmo salar*) • Brook lamprey (*Lampetra planeri*)
Solway Firth SAC	84.32	• Sea lamprey (*Petromyzon marinus*) • River lamprey (*Lampetra fluviatilis*)
River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC	91.60	• Sea lamprey (*Petromyzon marinus*) • River lamprey (Lampetra fluviatilis) • Atlantic salmon (*Salmo salar*) • Brook lamprey (*Lampetra planeri*)
Solway Firth MCZ	98.90	• Smelt (Osmeridae)

8.4.4 Important ecological features

8.4.4.1 IEFs are habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Morgan Generation Assets. Guidance from the Chartered Institute of Ecology and Environmental Management (CIEEM) was used to assess IEFs within the area (CIEEM, 2018). IEFs can be attributed to individual species (such as plaice) or species groups (for example flat fish species). Each IEF is assigned a value or importance rating which are based on commercial, ecological and conservation importance, including Species of Principal Importance (SPI) and qualifying features of SACs. SPIs are those species most threatened, in greatest decline, or where England and Wales hold a significant proportion of the world's total population in some cases. Table 8.9 details the criteria used for determining IEFs and Table 8.10 applies the defining criteria to specific species, providing justifications for importance rankings. Specific reference is made to each species' commercial, conservation and ecological importance, where this is known. These species will be taken forward for assessment. Diadromous species refer to specific species that migrate between fresh water and the marine environment, and marine fish and shellfish species refer to all other IEF species identified within this chapter (Table 8.10).

Table 8.9: Defining criteria for IEFs (adapted from CIEEM, 2018).

Value of IEF	Defining Criteria
International	Internationally designated sites. Species protected under international law (i.e. Annex II species listed as qualifying interests of SACs under Annex II of the EU Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (The Habitats Directive).
National	Nationally designated sites. Species protected under national law. Annex II species which are not listed as qualifying interests of SACs in the Morgan Fish and Shellfish Ecology study area. Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) List of Threatened or Declining Species, and International Union for Conservation of Nature (IUCN) Red List species that have nationally important populations within the Morgan Generation Assets, particularly in the context of species/habitat that may be rare or threatened in English and Welsh waters. Priority habitats and species (SPIs) have been deemed features characteristic of the English and Welsh marine environment and where nationally important habitats/communities are present in the fish and shellfish ecology study area. Species that have spawning or nursery areas within or in the immediate vicinity of the Morgan Generation Assets that are important nationally (e.g. may be primary spawning/nursery area for that species).
Regional	OSPAR List of Threatened or Declining Species, and IUCN Red List species that have regionally important populations within the Morgan Generation Assets (i.e. are locally widespread or abundant). Priority habitats and species (SPIs) have been deemed features characteristic of the English and Welsh marine environment. Species that are of commercial value to the fisheries which operate within the Morgan Generation Assets. Species that form an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages within the Morgan Generation Assets. Species that have spawning or nursery areas within the Morgan Generation Assets that are important regionally (i.e. species may spawn in other parts of English and Welsh waters, but this is a key spawning/nursery area within the Morgan Generation Assets).
Local	Species that are of commercial importance but do not form a key component of the fish assemblages within the Morgan Generation Assets (e.g. they may be exploited in deeper waters outside the Morgan Generation Assets). The spawning/nursery area for the species are outside the Morgan Generation Assets. The species is common throughout English and Welsh waters but forms a component of the fish assemblages in the Morgan Generation Assets.

Table 8.10: IEF species and representative groups within the Morgan Generation Assets.

IEF	Specific Name/ Representative Species	Importance	Justification
Plaice	*Pleuronectes platessa*	Regional	Listed as a SPI. High intensity spawning and low intensity nursery grounds identified throughout the Morgan Generation Assets. Plaice is an important commercial species throughout the Morgan Generation Assets and within the surrounding east Irish Sea.
Lemon Sole	*Microstomus kitt*	Local	Spawning and nursery grounds are undetermined and unspecified within the Morgan Generation Assets and wider east Irish Sea. It is an important and abundant commercial fish species, but not in the immediate vicinity of the Morgan Generation Assets and within the surrounding east Irish Sea.
Sole	*Solea solea*	Regional	Listed as a SPI. High intensity spawning and nursery grounds identified throughout the Morgan Generation Assets. Sole is an important commercial species throughout the Morgan Generation Assets and within the surrounding east Irish Sea.

IEF	Specific Name/ Representative Species	Importance	Justification
Other flatfish species		Local	Other flatfish species including common dab, (*Limanda limanda*), solenette (*Buglossidium luteum*), and flounder (*Platichthys flesus*) are likely to occur within the Morgan Generation Assets. These species either have no known spawning or nursery grounds or low intensity/undetermined spawning and nursey grounds within the area.
Cod	*Gadus morhua*	Regional	Listed as a SPI. Listed by OSPAR as threatened or declining and listed as vulnerable on the IUCN Red List. High intensity spawning and nursery grounds are present throughout the Morgan Generation Assets. It is an important commercial fish species, but not in the immediate vicinity of the Morgan Generation Assets and in the wider east Irish Sea.
Whiting	*Merlangius merlangus*	Regional	Listed as a SPI. Low intensity spawning and high intensity nursery grounds identified throughout the Morgan Generation Assets. Whiting is an important commercial species throughout the Morgan Generation Assets and within the surrounding east Irish Sea.
Other demersal species		Local	Species including anglerfish *Lophius piscatorius,* ling and hake are common throughout English and Welsh waters and are likely to be in the Morgan Generation Assets. They are important commercial species, but not in the immediate vicinity of the Morgan Generation Assets and in the wider east Irish Sea.
Sandeel species	Ammodytidae spp.	Regional	Listed as a SPI. There are five species of sandeel found in UK waters with lesser sandeel *Ammodytes tobianus* and greater sandeel *Hyperoplus lanceolatus* being the most commonly found species in British waters. Sandeel are important prey species for fish, birds and marine mammals. High intensity spawning grounds and low intensity nursery grounds are present throughout the Morgan Generation Assets. Identified as likely to be present in the Morgan Generation Assets based on historic data and habitat preference.
Herring	*Clupea harengus*	National	Listed as a SPI. Low intensity spawning grounds present immediately outside of the Morgan Generation Assets and within the Fish and shellfish ecology study area. High intensity nursery grounds present within the Morgan Generation Assets. Although herring spawning grounds do not directly overlap the Morgan Array Areas, this specific area of the Irish Sea has been denoted as key spawning habitat for the species. Herring is an important commercial species, but not in the immediate vicinity of the Morgan Generation Assets or in the wider east Irish Sea.
Mackerel	*Scomber scombrus*	Regional	Listed as a SPI. Important prey species for larger fish, birds and marine mammals. Low intensity spawning and nursery grounds throughout the Morgan Generation Assets and the wider east Irish Sea. Mackerel is an important commercial species, but not in the immediate vicinity of the Morgan Generation Assets or. in the wider east Irish Sea.
Sprat	*Sprattus sprattus*	Regional	Important prey species for larger fish, birds and marine mammals. Unspecified intensity spawning and nursery grounds within the Morgan Generation Assets. Sprat is an important commercial species, but not in the immediate vicinity of the Morgan Generation Assets or in the wider east Irish Sea.
Basking Shark	*Cetorhinus maximus*	National	The northeast Atlantic population are classed as Endangered on the IUCN Red List. Additionally, they are listed under Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Annex II and classified as a Priority Species under the UK Post-2010 Biodiversity Framework. Protected in the UK under the Wildlife and Countryside Act. Basking shark are likely to be present in low abundances if present at all near the IoM and in proximity to the Morgan Generation Assets.
Tope	*Galeorhinus galeus*	Regional	Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds within the Morgan Generation Assets.
Spurdog	*Squalus acanthias*	Regional	Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. High intensity nursery grounds within the Morgan Generation Assets.

IEF	Specific Name/ Representative Species	Importance	Justification
Ray species		Regional	Ray species including spotted ray, and thornback ray. These species either have low intensity nursery grounds and/or no known spawning grounds within the Morgan Generation Assets.
Shellfish IEF Species			
Edible crab	*Cancer pagurus*	Regional	Commercially important species. Identified as being likely to be present within the Morgan Generation Assets.
Norway lobster	*Nephrops norvegicus*	Regional	Commercially important species. Identified as being likely to be present within the Morgan Generation Assets.
European lobster	*Homarus gammarus*	Regional	Commercially important species. Identified as being likely to be present within the Morgan Generation Assets.
King scallop	*Pecten maximus*	Regional	Commercially important species. Identified as being present within the Morgan Generation Assets.
Queen scallop	*Aequipecten opercularis*	Regional	Commercially important species. Identified as being present within the Morgan Generation Assets.
Velvet swimming crab	*Necora puber*	Local	Commercially important species. Identified as being likely to be present within the Morgan Generation Assets.
Other crustaceans		Local	Other crustaceans including, swimming crab, spider crab and shrimp have been identified as being likely to occur within the Morgan Generation Assets. These are all important commercial species, but not in the immediate vicinity of the Morgan Generation Assets (i.e. in the wider east Irish Sea).
Diadromous Fish IEF Species			
Sea trout	*Salmo trutta*	National	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List. Listed as a OSPAR threatened/declining species. Likely to migrate through the Morgan Generation Assets. Not a feature of any designated sites in the vicinity of the Morgan Generation Assets.
European eel	*Anguilla anguilla*	National	Listed as a SPI. Listed as Critically Endangered by the IUCN Red List. Listed as an OSPAR threatened/declining species. Likely to migrate through the Morgan Generation Assets. This species is a qualifying feature of multiple MNRs in the vicinity of the Morgan Generation Assets.
Sea lamprey	*Petromyzon marinus*	International	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Morgan Generation Assets. Likely to migrate through the Morgan Generation Assets.
River lamprey	*Lampetra fluviatilis*	International	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Morgan Generation Assets. Likely to migrate through the Morgan Generation Assets, although only in coastal/estuarine areas.
Twaite shad	*Alosa fallax*	National	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Likely to migrate through the Morgan Generation Assets.
Allis shad	*Alosa alosa*	National	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Likely to migrate through the Morgan Generation Assets.
Atlantic salmon	*Salmo salar*	International	Listed as a SPI. Listed as Vulnerable by the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Morgan Generation Assets. Likely to migrate through the Morgan Generation Assets.
Sparling/ European smelt	*Osmerus eperlanus*	National	Listed as a SPI. Listed as a species of Least Concern by the IUCN Red List. This species is a qualifying feature of multiple MCZs in the vicinity of the Morgan Generation Assets. Likely to migrate through the Morgan Generation Assets, although only in coastal/estuarine areas.
Freshwater pearl mussel	*Margaritifera margaritifera*	International	Listed in Annexes II and V of the Habitats Directive and Annex III of the Bern Convention. Listed as Endangered on the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Morgan Generation Assets.

8.4.5 Future baseline scenario

8.4.5.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 requires that "an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge" is included within the Environmental Statement. In the event that the Morgan Generation Assets does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.

8.4.5.2 The current baseline environment is accurately represented in the given description, accounting for seasonality and interannual variability. However, the baseline will exhibit larger degrees of natural change over longer time periods, due to naturally occurring cycles and processes and any potential changes resulting from climate change. This long-term change will occur even if the Morgan Generation Assets does not come forward. Therefore, when undertaking any impact assessments, it will be necessary to place any potential impacts into the context of the envelope of change that might occur over the expected operational lifetime of the Morgan Generation Assets.

8.4.5.3 Variability and long-term changes within the Irish Sea, including projected increases of average sea surface temperature of up to 1.9°C and changes in the timing of maximum and minimum temperatures (Olbert *et al*., 2012) may bring direct and indirect changes to fish and shellfish populations and communities. As sea temperatures rise, species adapted to cold water such as cod (Drinkwater, 2005) and herring will begin to seek cooler waters, while warm water adapted species will become more established in the previous locations. This potential future change will occur against the background of known overall dampening of production and stock recovery in Irish Sea fish populations due to the present impacts of climate change (Bentley *et al*., 2020). Future changes are expected to be exacerbated by increasing temperatures and extreme weather events causing increased stratification of phytoplankton food sources in the Irish Sea leading to decoupling of predator and prey interactions and impacting fish population survivability (Morrison *et al*., 2020).

8.4.5.4 Increasing temperatures can also potentially expand the geographical range and virulence of diseases affecting economically important shellfish populations (Rowley *et al*., 2014), causing potential threats to long-term survivability, and thus negatively impacting overall population levels. A combination of this impact, increasing temperature, and ocean acidification could also negatively impact shell strength (Mackenzie *et al*., 2014) and thus reduce their protection against predators, with significant reductions in the economic value projected from these impacts to the shellfish population (Narita *et al*., 2012).

8.4.5.5 Climate change presents many uncertainties as to how the marine environment will change in the future; therefore, the future baseline scenario is difficult to predict with accuracy. Any changes that may occur during the proposed operational lifespan of the Morgan Generation Assets development should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment.

8.4.6 Data limitations

8.4.6.1 The data sources used in this chapter are detailed in Table 8.5 and volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR. This largely comprises a desk-based assessment of the fish and shellfish ecology study area, although the desktop data used is the most up to date publicly available information which can be obtained from the applicable data sources as cited. Data that has been collected is based on long-term existing literature and survey datasets (including scientific literature, grey literature, and commercial fisheries information); consultation with stakeholders, and identification of habitats which may support fish and shellfish species, and to ensure all relevant IEFs were appropriately identified and assessed within the defined fish and shellfish ecology study area, to be carried forward into the EIA.

8.4.6.2 Site-specific surveys were carried out for benthic ecology requirements (volume 2, chapter 7: Benthic chapter of the PEIR) and were used to determine suitable herring spawning and sandeel habitats within the Morgan Array Area. While these may not provide the same information as targeted fish and shellfish surveys, the collected data was reviewed alongside wider long-term existing datasets and stakeholder consultation (including commercial fisheries organisations), to characterise the fish and shellfish ecology study area most appropriately. Similarly, the data available from Coull *et al*. (1998) and Ellis *et al*. (2012) provide a general overview of spawning grounds and times for many species in the area, but might not fully represent current habitat preferences alone. As such these have been supplemented with the most up to date information available (e.g. NINEL herring larvae surveys and site-specific seabed sediment data) during the desk-based study to best overcome this limitation and ensure a robust EIA.

8.4.6.3 One other limitation identified was that the NINEL herring larvae survey was benchmarked in 2012, and no longer used in Irish Sea herring stock assessments after that point, due to underestimating spawning populations significantly compared to higher resolution acoustic data. However, this data continued to be collected using the same methodology and was still mapped and assessed within volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR due to being a useful indicator of the spatial distribution of the spawning population, alongside Coull *et al*. (1998) and Ellis *et al*. (2012). The underestimation limitation was dealt with through incorporation of recent acoustic survey and stock assessment data (ICES, 2021a), which is further examined in volume 4, annex 8.1: Fish and shellfish technical report of the PEIR, and should not represent a significant impact on the predictability of the EIA.

8.5 Impact assessment methodology

8.5.1 Overview

8.5.1.1 The fish and shellfish ecology impact assessment has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. Specific to the fish and shellfish ecology impact assessment, the following guidance documents have also been considered:

- The Planning Inspectorate Advice Note Seven: Environmental Impact Assessment: Preliminary Environmental Information, Screening and Scoping (the Planning Inspectorate, 2020a)
- The Planning Inspectorate Advice Note Nine: Rochdale Envelope (the Planning Inspectorate, 2018)
- The Planning Inspectorate Advice Note Twelve: Transboundary Impacts and Process (the Planning Inspectorate, 2020b)
- The Planning Inspectorate Advice Note Seventeen: Cumulative effects assessment (the Planning Inspectorate, 2019)
- Guidelines for EcIA in the UK and Ireland (CIEEM, 2019)

- Environmental Impact Assessment Guide to: Delivering Quality Development (Institute of Environmental Management and Assessment (IEMA), 2016)
- Delivering Proportionate EIA, A Collaborative Strategy for Enhancing UK Environmental Impact Assessment Practice (IEMA, 2017)
- Cumulative Impact Assessment Guidelines, Guiding Principles for Cumulative Impact Assessment in Offshore Wind Farms (RenewableUK, 2013)
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Cefas, 2012)
- Marine Evidence-based Sensitivity Assessment – A Guide (Tyler-Walters *et al*., 2018).

8.5.1.2 In addition, the fish and shellfish ecology impact assessment has considered the legislative framework as defined by:

- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (as amended) (the 2017 EIA Regulations)
- The Planning Act 2008.

8.5.2 Impact assessment criteria

8.5.2.1 The criteria for determining the significance of effects are based on a two-stage process that involves defining the magnitude of the impacts and the sensitivity of the receptors. This section describes the criteria applied in this chapter to assign values to the magnitude of potential impacts and the sensitivity of the receptors. The terms used to define magnitude and sensitivity are based on those which are described in further detail in volume 1, chapter 5: EIA methodology of the PEIR.

8.5.2.2 The criteria for defining magnitude in this chapter are outlined in Table 8.11 below.

Table 8.11: Definition of terms relating to the magnitude of an impact.

Magnitude of impact	Definition
High	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (Adverse)
	Large scale or major improvement or resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial)
Medium	Loss of resource, but not adversely affecting integrity of resource; partial loss of/damage to key characteristics, features or elements (Adverse)
	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial)
Low	Some measurable change in attributes, quality or vulnerability, minor loss or, or alteration to, one (maybe more) key characteristics, features or elements (Adverse)
	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial)
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features or elements (Adverse)
	Very minor benefit to, or positive addition of one or more characteristics, features or elements (Beneficial)
No change	No loss or alteration of characteristics, features or elements; no observable impact either adverse or beneficial.

8.5.2.3 The definitions of sensitivities of fish and shellfish IEFs have been informed by the Marine Evidence based Sensitivity Assessment (MarESA) (MarLIN, 2021). The MarESA defines sensitivity as a product of the likelihood of damage (resistance) due to a pressure and the rate of recovery (recoverability) once the pressure has been removed. Recoverability is the ability of a habitat to return to the state of the habitat that existed before the activity or event which caused change. Full recovery does not necessarily mean that every component species has returned to its prior condition, abundance, or extent but that the relevant functional components are present, and the habitat is structurally and functionally recognisable as the initial habitat of interest. The MarESA defines pressures by a benchmark which describes the extent and duration of the pressure but does not consider the intensity, frequency of pressures or any cumulative impacts.

8.5.2.4 The sensitivities of fish and shellfish IEFs presented within this chapter of the PEIR have therefore been defined by an assessment of the combined vulnerability (i.e. resistance, following MarESA) of the receptor to a given impact and the likely rate of recoverability to pre-impact conditions. Here, vulnerability is defined as the susceptibility of a species to disturbance, damage or death, from a specific external factor. Recoverability is the ability of the same species to return to a state close to that which existed before the activity or event which caused change. Recoverability is dependent on an IEFs ability to recover or recruit subject to the extent of disturbance/damage incurred. Information on these aspects of sensitivity of the fish and shellfish IEFs to given impacts has been informed by the best available evidence following environmental impact or experimental manipulation in the field and evidence from the offshore wind industry and analogous activities such as those associated with aggregate extraction, electrical cabling, and oil and gas industries. These assessments have been combined with the importance of the relevant IEFs as defined in section 8.4.4 and as presented in Table 8.10 for the fish and shellfish IEFs considered in this assessment.

8.5.2.5 The criteria for defining sensitivity in this chapter are outlined in Table 8.12 below.

Table 8.12: Definition of terms relating to the sensitivity of the receptor.

Sensitivity	Definition
Very High	Nationally and internationally important receptors with high vulnerability and low to no recoverability.
High	Regionally important receptors with high vulnerability and no ability to recover.

Sensitivity	Definition
Medium	Nationally and internationally important receptors with medium vulnerability and medium recoverability. Regionally important receptors with medium to high vulnerability and low recoverability. Locally important receptors with high vulnerability and no ability to recover.
Low	Nationally and internationally important receptors with low vulnerability and high recoverability. Regionally important receptors with low vulnerability and medium to high recoverability. Locally important receptors with medium to high vulnerability and low recoverability.
Negligible	Locally important receptors with low vulnerability and medium to high recoverability. Receptor is not vulnerable to impacts regardless of value/importance.

8.5.2.6 The significance of the effect upon fish and shellfish ecology is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 8.13. Where a range of significance of effect is presented in Table 8.13, the final assessment for each effect is based upon expert judgement, with a clear justification provided in the impact assessment.

8.5.2.7 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 Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.

Table 8.13: Matrix used for the assessment of the significance of the effect.

Sensitivity of Receptor	Magnitude of Impact				
	No Change	**Negligible**	**Low**	**Medium**	**High**
Negligible	No change	Negligible	Negligible or Minor	Negligible or Minor	Minor
Low	No change	Negligible or Minor	Negligible or Minor	Minor	Minor or Moderate
Medium	No change	Negligible or Minor	Minor	Moderate	Moderate or Major
High	No change	Minor	Minor or Moderate	Moderate or Major	Major
Very High	No change	Minor	Moderate or Major	Major	Major

8.5.3 Designated sites

8.5.3.1 Where National Site Network sites (i.e. internationally designated sites) are considered, this chapter summarises the assessments made on the interest features of internationally designated sites as described within section 8.4.3 of this chapter (an assessment of the impact of the Morgan Generation Assets on the integrity of designated sites is contained within the Draft Information to Support Appropriate Assessment). A similar approach is taken for designated features of MCZs, with assessments made on the interest features of these sites presented in this chapter, but the assessment of the impact of the Morgan Generation Assets on the designated sites is contained within the Morgan Generation Assets MCZ Assessment. With respect to nationally and locally designated sites, where these sites fall within the boundaries of an internationally designated site (e.g. Sites of Special Scientific Interest (SSSIs) which have not been assessed within the Draft Report to Inform Appropriate Assessment), only the international site has been taken forward for assessment. This is because potential effects on the integrity and conservation status of the nationally designated site are assumed to be inherent within the assessment of the internationally designated site (i.e. a separate assessment for the national site is not undertaken).

8.5.3.2 The Information to Support Appropriate Assessment (ISAA) has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (Planning Inspectorate, 2022).

8.6 Key parameters for assessment

8.6.1 Maximum design scenario

8.6.1.1 The MDSs identified in Table 8.14 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the Project Design Envelope provided in volume 1, chapter 3: Project description of the PEIR. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g. different infrastructure layout), to that assessed here be taken forward in the final design scheme.

Table 8.14: Maximum design scenario considered for the assessment of potential impacts on fish and shellfish ecology.

[a] C=construction, O=operational and maintenance, D=decommissioning

Potential impact	Phase[a] C	O	D	Maximum Design Scenario	Justification
Temporary habitat loss/disturbance.	✓	✓	✓	**Construction phase** Up to 87,360,220m^2 of habitat loss/disturbance due to: • Jack-up events: up to 908,400m^2 of disturbance from the use of jack-up vessels during foundation installation, with up to four jack-up events at each of 107 wind turbines (two jack-up events for wind turbines and two jack-up events for the foundations), and two jack-up events at each of four Offshore Substation Platforms (OSPs) • Cable installation: up to 35,224,000m^2 of disturbance comprising: – Inter-array cables: up to 31,000,000m^2 disturbance from installation of up to 500km of inter-array cables – Interconnector cables: up to 4,224,000m^2 disturbance from installation of up to 60km of interconnector cables – seabed disturbance width of up to 104m for sandwave clearance, up to 20m for boulder clearance along inter-array and interconnector, and up to 3m for cable burial – Sandwave clearance: required for up to 50% of inter-array and 60% of interconnector cables. – Pre-lay preparation (boulder and debris clearance): is likely to be required across all inter-array and interconnector cables. Although, for the purposes of the MDS boulder clearance only has been assumed across, up to 50% of inter-array and 40% of interconnector (see justification) • Sandwave clearance deposition: Up to 50,107,820m^2 of habitat disturbance associated with the deposition of: – 25,053,910m^3 of sandwave clearance material within the Morgan Array Area affecting up to 50,107,820m^2 • Anchor placement: Up to 200,000m^2 of habitat disturbance from two 100m^2 anchor placements per inter-array cable link • Cable removal: Up to 920,000m^2 from the removal of 46km of disused cables • Maximum duration of the offshore construction phase is up to four years. **Operations and maintenance phase** Up to 11,566,500m^2 of temporary habitat loss/disturbance due to: • Up to 2,026,500 m^2 of temporary habitat loss/disturbance due to jack-ups at wind turbines, and OSPs over the lifetime of the Morgan Generation Assets for the following: – up to 937 major component replacements (one every four years for each location) for wind turbines – 12 major component replacements (three over the lifetime per OSP) for OSPs – four access ladder replacements and four modifications to/replacement of J-tubes for wind turbines – four access ladder replacements and four modifications to/replacement of J-tubes for OSPs • Up to 9,540,000m^2 of temporary habitat loss/disturbance due to inter-array and interconnector cables: – Inter-array cables: up to 20km for reburial events every five years and up to 8km for cable repair events every three years (assuming 20m width seabed disturbance for repair and remedial burial) – Interconnector cables: up to 3km for reburial events with one event every five years and up to 20km of cable in each of three events every 10 years for repair events (assuming 20m width seabed disturbance for repair and remedial burial) • Operational phase up to 35 years. **Decommissioning phase** Temporary subtidal habitat loss/disturbance due to: • Jack-up events: disturbance from the use of jack-up vessels during foundation removal, with up to four jack-up events at each of 107 wind turbines (two jack-up events for wind turbines and two jack-up events for the foundations), and two jack-up events at each of four OSPs • Cable removal: disturbance from the removal of 500km of inter-array and 60km of interconnector cables. • Anchor placements: habitat disturbance from two 100m^2 anchor placements per inter-array cable link.	<u>Site preparation:</u> Maximum footprint which would be affected during the construction, operations and maintenance and decommissioning phases. Based on the assumption that the width of disturbance for sandwave and pre-lay preparation (boulder and debris clearance) also includes subsequent burial. Pre-lay preparation (boulder and debris clearance) is likely to be required across all inter-array and interconnector. For the purposes of the MDS, and to avoid double counting of the total footprint with sandwave clearance activities, the MDS assumes up to 50% of inter-array and 40% of interconnector will be subject to pre-lay preparation (boulder and debris clearance) only. It is anticipated that the sandwaves requiring clearance in the Morgan Array Area are likely to be in the range 15m in height. The area of seabed affected by the placement of sandwave clearance material has been calculated based on the maximum volume of sediment to be placed on the seabed, assuming all this sediment is coarse material (i.e. is not dispersed through tidal currents; see "Increased suspended sediment concentrations" impact assessment below). The total footprint of seabed affected has been calculated, for the purposes of the MDS, assuming a mound of uniform thickness of 0.5m height. Temporary loss of benthic habitat is assumed beneath this. The disturbance width is driven by the need to survey for UXO over the cable route. The actual disturbance width for cable installation is likely to be considerably less. <u>Decommissioning phase:</u> Parameters for decommissioning will be significantly lower than for the construction phase as cables, cable protection and scour protection are assumed to be left *in situ*. MDS assumes the complete removal of all wind turbine and OSP foundations but that all cables, cable protection and scour protection is left *in situ*.
Underwater noise during the construction phase impacting fish and shellfish receptors	✓	×	×	**Construction phase** Monopiles: • Wind turbines: installation of up to 68 wind turbines with a 16m diameter monopile foundations installed by impact piling	For both monopiles and pin piles the largest hammer energy and maximum spacing between concurrent piling events would lead to the largest spatial extent of ensonification at any one time.

Potential impact	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• OSPs: installation of one OSP with foundations consisting of two 16m diameter piled monopile foundations installed by impact piling • Maximum hammer energy of up to 5,500kJ • Up to two vessels piling concurrently (minimum distance 875m, maximum distance 28.5km, between piling vessels) • Maximum of up to 9.5 hours of piling for a monopile with a cumulative total of up to 665 hours • Consecutive piling over a maximum of 24 hours • One monopile installed per 24 hours per vessel = 70 days for a single vessel (maximum temporal) or 35 days for two vessels (maximum spatial). Pin piles • Wind turbines: installation up to 68 3-legged jacket foundations with up to one pile per leg (a total of up to 204 piles), or up to 2 piles per leg (a total of 408 piles), and each pile with a diameter of 5.5m installed by impact piling • OSP: installation of one OSP with 6-legged jacket foundations, with up to three piles per leg (a total of 18 piles) and each pile with a diameter of 5.5 m installed by impact piling • Maximum hammer energy of up to 3,700kJ • Up to two vessels piling concurrently (minimum distance 875m, maximum distance 28.5km, between piling vessels) • Wind turbines: maximum duration of up to 8.02 hours per pile (where only a single pin-pile is used per leg) or up to 4.01 hours per pile (where two pin-piles are used per leg, which also equates to 8.02 hours per leg) with a cumulative total of up to 1,638 hours; installation of wind turbines over 102 days (=16.04 hours of piling per day; up to two piles per day) • OSP: maximum duration of up to 8.02 hours per pile with a cumulative total of up to 145 hours; installation of OSP over 9 days (=16.04 hours piling per day) • Consecutive piling over a maximum of 24 hours • Single piling of 102 days for wind turbine plus approx. 9 days for OSP = 111 days (maximum temporal) or 56 days for two vessels (maximum spatial). Total piling phase (foundation installation) of up to two years within a four-year construction programme. Geophysical site investigation • Geophysical site investigation activities will include the following activities: – Multi-beam echo-sounder (MBES) – Sidescan Sonar (SSS) – Single Beam Echosounder (SBES) – Sub-Bottom Profilers (SBP) – Ultra High Resolution Seismic (UHRS) For further detail regarding geophysical noise sources and levels, see volume 3, annex 3.1: Underwater noise technical report of the PEIR. UXO • For the purposes of this assessment, it has been assumed that the MDS will be clearance of UXO with a Net Explosive Quantity (NEQ) of 907kg cleared by either low order or high order techniques • Clearance of up to 13 UXOs within the Morgan Array Area • Most likely (common) size of 130kg UXO. • Up to 0.5kg NEQ clearance shot for neutralisation of residual explosive material at each location. • Clearance during daylight hours only.	Minimum spacing between concurrent piling represents the highest risk of injury to fish and shellfish as noise from adjacent foundations could combine to produce a greater radius of effect compared to a single piling event. For both monopiles and pin piles the maximum temporal scenario was assessed on the greatest number of days on which piling could occur based on the number of piles that could be installed within a 24-hour period. Consecutive piling is assumed over a maximum period of 24 hours. Range of geophysical and geotechnical activities likely to be undertaken using equipment typically employed for these types of surveys. Maximum number and maximum size of UXOs encountered in the Morgan Generation Assets Boundary. Donor charge is maximum required to initiate low order/low yield detonation. Assumption of a clearance shot of up to 0.5kg at all locations although noting that this may not always be required
Increased suspended sediment concentrations (SSCs) and associated sediment deposition	✓	✓	✓	**Construction phase** Site preparation: Sandwave clearance:	Construction Phase Site preparation: The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the

Potential impact	Phase[a] C	O	D	Maximum Design Scenario	Justification
				Sandwave clearance activities undertaken over a 12-month duration, with a further three months for inter-array cable seabed preparation • Wind turbines and OSP foundations: the MDS assumes that sandwave clearance for wind turbine foundations and OSP foundations is required at up to 60% of locations. Spoil volume per location has been calculated on the basis of 41 locations supporting the largest suction bucket four-legged jacket foundation with an associated base diameter of 205m to an average depth of 7.5m. This equates to a total spoil volume of 10,149,455m^3 and a volume of 247,548m^3 per location • Inter-array cables: sandwave clearance along 500km of cable length, with a width of 104m, to an average depth of 5.1m. Total spoil volume of 11,843,641m^3 • Interconnector cables: sandwave clearance along 60km of cable length, with a width of 104m, to an average depth of 5.1m. Total spoil volume of 3,060,814m^3 Removal of up to 46km of disused cables. Foundation installation: • Undertaken over a 12-month duration • Wind turbines: installation of up to 68 x 16m diameter monopiles, drilled to a depth of 60m at a rate of 0.73m/h. Two monopiles installed concurrently. Spoil volume of 13,460m^3 per pile • OSPs: installation one OSP with foundations consisting of two 16m monopiles, drilled to a depth of 60m at a rate of 0.73m/h. Two monopiles installed concurrently. Spoil volume of 13,460m^3 per pile Cable installation: • Inter-array cables: Installation via trenching of up to 500km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil volume of 2,250,000m^3 Installed over a period of 12 months • Interconnector cables: installation via jetting of up to 60km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil volume of 270,000m^3. Installed over a period of four-months. **Operation and maintenance phase** • Project lifetime of 35-years • Inter-array cables: repair of up 8km of cable in one event every three years. Reburial of up to 20km of cable in one event every five years • Interconnector cables: repair of up to 20km of cable in each of three events every 10 years. Reburial of up to 3km of cable in one event every five years **Decommissioning phase** • Scour and cable protection will remain *in situ*. If suction caissons are removed using the overpressure to release them then SSC will be temporarily increased. • Inter-array and interconnector cables will be removed and disposed of onshore.	sandwave (height, length and shape) and the level to which the sandwave must be reduced. These details are not fully known at this stage, however based on the available data, it is anticipated that the sandwaves requiring clearance in the array area are likely to average 5.1m in height, reaching up to 15m in height. Site clearance activities may be undertaken using a range of techniques, the suction hopper dredger will result in the greatest increase in suspended sediment and largest plume extent as material is released near the water surface during the disposal of material. Boulder clearance activities will result in minimal increases in suspended sediment concentrations and have therefore not been considered in the assessment. Foundation installation: Installation of foundations via augured (drilled) operations results in the release of the largest volume of sediment. The greatest volume of sediment disturbance by drilling at individual foundation locations and across the site as a whole is associated with the largest diameter monopile for wind turbines. The selected OSP scenario represents the greatest volume of sediment to be released for a drilling event. The greatest drilling rate represents the maximum level of increase in suspended sediment concentration. Cable installation: Cable routes inevitably include a variety of seabed material and in some areas 3m depth may not be achieved or may be of a coarser nature which settles in the vicinity of the cable route. The assessment therefore considers the upper bound in terms of suspended sediment and dispersion potential. Cables may be buried by ploughing, trenching or jetting with jetting mobilising the greatest volume of material to increase suspended sediment concentrations. Operations and maintenance phase The greatest foreseeable number of cable reburial and repair events is considered to the MDS for sediment dispersion. Decommissioning phase The removal of cables may be undertaken using similar techniques to those employed during installation, therefore the potential increases in SSC and deposition would be in-line with the construction phase.
Long term habitat loss.	✓	✓	✓	**Construction and operations and maintenance phase** Up to 1,519,092m^2 of long-term habitat loss over the lifetime of the Morgan Generation Assets associated with the following: • Presence of foundations and scour protection: up to 760,452m^2 of habitat loss comprising: – Wind turbines: up to 735,488m^2 from the presence of up to 68 wind turbine foundations on suction bucket 4-legged jacket foundations with associated scour protection – OSPs: up to 24,964m^2 from four OSPs on suction bucket 4-legged jacket foundations with associated scour protection • Presence of cable protection: up to 620,000m^2 of habitat loss comprising: – Inter-array cable protection: 500,000m^2 associated with up to 10% of 500km of inter-array cables (10m width of cable protection)	Largest wind turbine and OSP foundation type and associated scour protection, maximum length of cables and cable protection resulting in greatest extent of habitat loss. MDS for decommissioning (and permanent habitat loss following decommissioning) assumes removal of only the foundations, if any additional infrastructure is decommissioned, this will result in a reduced area of permanent habitat loss. Greatest amount of cable and scour protection resulting in the largest area of infrastructure to be left *in situ* after decommissioning.

Potential impact	Phase[a] C	O	D	Maximum Design Scenario	Justification
				– Interconnector cable protection: 120,000m² for up to 20% of 60km of interconnector cables (10m width of cable protection) • Presence of cable crossing protection: up to 138,640m² of habitat loss comprising: – Cable protection for cable crossings for inter-array cables: 128,640m² from 67 cable crossings (each up to 60m in length and 32m in width) – Cable protection for cable crossings for interconnector cables: 10,000m² from 10 cable crossings (each up to 50m in length and 20m in width) • Operational phase up to 35 years. **Decommissioning phase** • Up to 1,461,956m² of permanent subtidal habitat loss due to scour and cable protection left *in situ* post decommissioning.	
EMFs from subsea electrical cabling.	×	✓	×	**Operations and maintenance phase:** Presence of inter-array and interconnector cables: • Inter-array cables: up to 500km of inter-array cables of 66kV to 132kV • Interconnector cables: up to 60km of 275kV High Voltage Alternating Current (HVAC) cables • Minimum burial depth 0.5m • Assumes up to 10% of inter-array cables, and 20% of interconnector cables may require cable protection • Cable protection: cables will also require cable protection at asset crossings (up to 67 crossings for inter-array cables, and 10 crossings for interconnector cables) • Operations and maintenance phase of up to 35 years.	Maximum length of cables across the array area routes and minimum burial depth (the greater the burial depth, the more the EMF is attenuated).
Colonisation of hard structures	✓	✓	✓	**Operations and maintenance phase** Long term habitat creation of up to 1,995,525m² due to: • Wind turbines and OSPs: Presence of up to 68 wind turbines and four OSPs on suction bucket jacket foundations. • Scour protection: Presence of scour protection for wind turbine foundations, and OSP foundations. • Cable protection: Presence of cable protection associated with up to 500km of inter-array cables, and 60km of interconnector cables – Assumes up to 10% of inter-array and 20% of interconnector cables may require protection • Cable crossing protection: Presence of cable protection for cable crossings, 67 cable crossings for inter-array cables (each up to 60m in length and 32m in width) and 10 cable crossings for interconnector cables (each up to 50m in length and 20m in width) • Operational phase up to 35 years.	Maximum number of wind turbine and OSP foundations and associated scour protection, maximum length of cables and cable protection resulting in greatest surface area for colonisation. Cable protection involves the use of a combination of rock dumping, concrete mattresses, and rock bags to cover unburied cable lengths, or cables at risk of being exposed through natural sandwave movement. This protection prevents damage to the cable, and aids in limiting the impacts of EMFs surrounding cables. The estimate of habitat creation from the presence of foundations has been calculated as if the foundations were a solid structure. This is, therefore, likely to be a conservative estimate of habitat creation on the basis that the jacket foundations will have a lattice design rather than a solid surface as has been assumed.
Injury due to increased risk of collision with vessels (basking shark only)	✓	✓	✓	**Construction phase** **Vessels** • Up to a total of 63 construction vessels on site at any one time (22 main installation and support vessels, eight tug/anchor handlers, four cable lay installation and support vessels, one guard vessel, five survey vessels, seven seabed preparation vessels, 11 crew transfer vessels (CTVs), three scour protection installation vessels and two cable protection installation vessels) • Up to 1,878 installation vessel movements (return trips) during construction (521 main installation and support vessels, 74 tug/anchor handlers, 8 cable lay installation and support vessels, 50 guard vessel, 29 survey vessels, 18 seabed preparation vessels, 1,135 CTVs, 41 scour protection installation vessels and 2 cable protection installation vessels) • Maximum offshore construction duration of up to 4 years. **Operations and Maintenance Phase** • Up to a total of 16 operations and maintenance vessels on site at any one time (five CTVs/workboats, three jack-up vessels, three cable repair vessels, four service operation vessels (SOV) or similar and one excavator/backhoe dredger)	The MDS considers the maximum number of vessels on site at any one time and largest numbers of round trips during each phase of the Morgan Generation Assets. This represents the broadest range of vessel types and movements, and therefore greatest potential for collision risk.

Potential impact	Phase[a] C	O	D	Maximum Design Scenario	Justification
				• Up to 1,970 operations and maintenance vessel movements (return trips) each year (1,825 CTVs/workboats, 25 jack-up vessels, 12 cable repair vessels, 104 SOV or similar and 4 excavators/backhoe dredgers) • Operations and maintenance lifetime of up to 35 years. **Decommissioning Phase** • Vessels used for a range of decommissioning activities such as removal of foundations, cables and cable protection • Noise from vessels assumed to be as per vessel activity described for construction phase above.	

8.6.2 Impacts scoped out of the assessment

8.6.2.1 On the basis of the baseline environment and the description of development outlined in volume 1, chapter 3: Project description of the PEIR, a number of impacts are proposed to be scoped out of the assessment for fish and shellfish ecology. These impacts are outlined, together with a justification for scoping them out, in Table 8.15.

Table 8.15: Impacts scoped out of the assessment for fish and shellfish ecology.

Potential impact	Justification
Accidental pollution during construction, operations and maintenance and decommissioning phases.	There is a risk of pollution being accidentally released during the construction, operations and maintenance and decommissioning phases from sources including vessels/vehicles and equipment/machinery. However, the risk of such events is managed by the implementation of measures set out in standard post-consent plans, secured through conditions within the deemed marine licence (e.g. offshore Environmental Management Plan, including an MPCP). These plans include planning for accidental spills, address all potential contaminant releases and include key emergency contact details. It will also set out industry good practice and OSPAR, International Maritime Organisation (IMO) and International Convention for the Prevention of Pollution from Ships (MARPOL) guidelines for preventing pollution at sea. Therefore, the likelihood of an accidental spill occurring is very low and in the unlikely event that such events did occur, the magnitude of these will be minimised through measures such as an MPCP. As such, this impact will be scoped out of further consideration within the fish and shellfish ecology Environmental Statement chapter.
Underwater sound from wind turbine operation during operations and maintenance phase.	Noise generated by operational wind turbines is of a very low frequency and low sound pressure level (Andersson *et al*., 2011). Studies have found that sound levels are only high enough to possibly cause a behavioural reaction within metres from a wind turbine (Sigray and Andersson, 2011) and therefore such levels are not considered to have potentially significant effects on fish and shellfish receptors. The MMO (MMO, 2014) review of post-consent monitoring at offshore wind farms found that available data on the operational wind turbine noise, from the UK and abroad, in general showed that noise levels from operational wind turbines are low and the spatial extent of the potential impact of the operational noise is low. This is supported by project specific modelling which indicated that effects on fish (e.g. injury or behavioural effects) are unlikely to occur for the modelled operations wind turbines. See volume 3, annex 3.1: Underwater sound technical report of the PEIR for further detail. As such, this impact will be scoped out of further consideration within the fish and shellfish ecology Environmental Statement chapter.
Underwater sound from vessels during all phases.	Operational underwater sound generated from vessels, including dredging noise, is likely to be low and effects would only occur if fish species remained within immediate vicinity of the vessel (i.e. within metres). Specifically, project specific modelling indicated that for injuries on fish to occur individuals would need to be in close proximity (i.e. tens of metres) to vessels for extended periods (i.e. recoverable injury for 48 hours of continuous exposure and TTS would require 12 hours of continuous exposure). See volume 3, annex 3.1: Underwater noise technical report of the PEIR for further detail. As such, this impact will be scoped out of further consideration within the fish and shellfish ecology Environmental Statement chapter for construction, operations and maintenance and decommissioning phases.
Disturbance/remobilisation of sediment-bound contaminants	Scoped out initially on advice from The Planning Inspectorate and MMO and justified by site-specific surveys finding only one site in the southwest of the Morgan Array Area only slightly exceeding the Canadian Threshold Effect Level for Arsenic. All other sites surveyed did not exceed this effect level, Cefas Action Levels, or the Canadian Potential Effect Level for any metallic or organic contaminants, including polycyclic aromatic hydrocarbons and polychlorinated biphenyl levels. Given the standard level of activity and disturbance associated with other activities in the area, it is highly unlikely activities associated with the construction, operations and maintenance, or decommissioning phases will cause any significant resuspension of contaminants, and this impact can therefore be scoped out.

8.7 Measures adopted as part of the Morgan Generation Assets

8.7.1.1 For the purposes of the EIA process, the term 'measures adopted as part of the project' is used to include the following measures (adapted from IEMA, 2016):

- Measures included as part of the project design. These include modifications to the location or design envelope for the Morgan Generation Assets which are integrated into the application for consent. These measures are secured through the consent itself through the description of the development and the parameters secured in the DCO and/or marine licences (referred to as primary mitigation in IEMA, 2016)
- Measures required to meet legislative requirements, or actions that are generally standard practice used to manage commonly occurring environmental effects and are secured through the DCO requirements and/or the conditions of the marine licences (referred to as tertiary mitigation in IEMA, 2016).

8.7.1.2 A number of measures (primary and tertiary) have been adopted as part of the Morgan Generation Assets to reduce the potential for impacts on fish and shellfish ecology. These are outlined in Table 8.16 below. As there is a secured commitment to implementing these measures for the Morgan Generation Assets they have been considered in the assessment presented in section 8.8 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

Table 8.16: Measures adopted as part of the Morgan Generation Assets.

Measures adopted as part of the Morgan Generation Assets	Justification	How the measure will be secured
Primary measures: Measures included as part of the project design		
Implementation of piling soft-start and ramp-up measures	This measure will minimise the risk of injury to fish species in the immediate vicinity of piling activities, allowing individuals to move away from the area before noise levels reach a level at which injury may occur.	Committed with the project design (see volume 1, chapter 3: Project description of the PEIR)
Tertiary measures: Measures required to meet legislative requirements		
Development and adherence to a Cable Specification and Installation Plan (CSIP)	The project base case is to bury all inter-array and interconnector cables to a depth of at least 0.5m as informed by a cable burial risk assessment (CBRA), with cable protection used where cables are exposed. While burial of cables will not reduce the strength of EMF, it does increase the distance between cables and fish and shellfish receptors, thereby potentially reducing the effect on those receptors.	Proposed to be secured through a condition in the marine licence
Development of, and adherence to, an offshore Environmental Management Plan. Will include development of an MPCP which will include planning for accidental spills, address all potential contaminant releases and include key emergency details.	Measures will be adopted to ensure that the potential for release of pollutants from construction, operations and maintenance, and decommissioning plant is minimised. In this manner, accidental release of potential contaminants from rigs and supply/service vessels will be strictly controlled, thus providing protection for marine life across all phases of the Morgan Generation Assets development.	Proposed to be secured through a condition in the marine licence
Development of, and adherence to, an offshore Environmental Management Plan, which will include actions to limit the spread and introduction of INNS.	These measures will aim to manage and reduce the risk of potential introduction and spread of INNS so far as reasonably practicable to best protect the biological integrity of the local natural environment and communities.	Proposed to be secured through a condition in the marine licence
An offshore Environmental Management plan with provisions for vessels and vessel movements will be issued to all Project vessel operators, requiring them to not deliberately approach basking shark. The EMP will be adhered to at all times.	To minimise the potential for collision risk, or potential injury to, marine mammals and megafauna.	Proposed to be secured through a condition in the marine licence

8.7.1.3 Where significant effects have been identified, further mitigation measures (referred to as secondary mitigation in IEMA, 2016) have been identified to reduce the significance of effect to acceptable levels following the initial assessment. These are measures that could further prevent, reduce and, where possible, offset any adverse effects on the environment. These measures are set out, where relevant, in section 8.8 below.

8.8 Assessment of significant effects

8.8.1 Overview

8.8.1.1 The impacts of the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets have been assessed on fish and shellfish ecology. The potential impacts arising from the construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets are listed in Table 8.14, along with the MDS against which each impact has been assessed.

8.8.1.2 A description of the potential effect on fish and shellfish ecology receptors caused by each identified impact is given below.

8.8.2 Temporary habitat loss/disturbance

8.8.2.1 The construction, operations and maintenance, and decommissioning activities on the wind turbines, OSPs, and inter-array and interconnector cables may lead to temporary habitat loss/disturbance. The MDS is represented by jack-up events, cable installation, sandwave clearance, anchor placement, and cable removals, and is summarised in Table 8.14.

Construction phase

Magnitude of impact

8.8.2.2 The installation of the Morgan Generation Assets infrastructure within the fish and shellfish ecology study area will lead to temporary habitat loss/disturbance. The MDS accounts for up to 87,360,220m^2 of temporary habitat loss/disturbance during the construction phase (Table 8.14). This equates to approximately 33.12% of the Morgan Generation Assets area overall, although only a small proportion of this will be impacted at any one time.

8.8.2.3 Jack-up events for the installation of the foundations for the wind turbines and OSPs will result in up to 908,400m^2 of temporary habitat loss/disturbance. Up to four jack-up events will be necessary for each of the 107 wind turbines as well as two jack-up events for each of the four OSPs.

8.8.2.4 The depressions resulting from jack-up events will infill over time, although may remain on the seabed for a number of years, as demonstrated by monitoring studies of UK offshore wind farms (BOWind, 2008; EGS, 2011). Monitoring at the Barrow offshore wind farm showed depressions were almost entirely infilled 12 months after construction (BOWind, 2008). Monitoring at the Lynn and Inner Dowsing (LID) offshore wind farm also showed some infilling of the footprints, although the depressions were still visible two years post-construction (EGS, 2011). In areas where mobile sands are present, such as in the Morgan Array Area, jack-up depressions are likely to be temporary features which will only persist for a period of months to a small number of years. Specifically, evidence from the three years post-construction survey of the nearby Walney Wind Farm Extension showed that fine sands and muds in this area were highly mobile and likely to return to a uniform relatively undisturbed habitat within this short period of time (CMACS, 2014a).

8.8.2.5 Cable installation (including pre-lay preparation such as boulder and sandwave clearance) of inter-array and interconnector cables may result in up to 35,224,000m^2 temporary habitat loss/disturbance. The components of this activity include the installation of 500km of inter-array cable, and 60km of interconnector (assuming 100% of the cable is buried). Seabed preparation activities are expected to be required for inter-array cables and interconnector cables and for the purpose of the MDS, boulder clearance has been expected to occur for up to 50% of inter-array cables, and 40% of interconnector cables. Sandwave clearance is expected to be required for up to 50% of inter-array cables, and 60% of interconnector cables in line with the MDS.

8.8.2.6 Sand wave clearance and deposition may result in up to 50,107,820m^2 of temporary habitat loss/disturbance as a result of the deposition of 25,053,910m^3 of sandwave clearance material. The total footprint of seabed affected has been calculated, for the purposes of modelling MDS, assuming a mound of uniform thickness of 0.5m height, although it should be noted that real mounds may be taller and more unevenly distributed. Any mounds of cleared material will, however, erode over time and displaced material will re-join the natural sedimentary environment, gradually reducing the size of the mounds.

8.8.2.7 Anchor placement may result in up to 200,000m^2 of habitat disturbance from two 100m^2 anchor placements per inter-array cable link.

8.8.2.8 Additionally, the removal of disused cables within the fish and shellfish ecology study area may result in up to 920,000m^2 of temporary habitat loss/disturbance from the removal of 46km of disused cables.

8.8.2.9 A recent study reviewed the effects of cable installation on subtidal sediments and habitats, drawing on monitoring reports from over 20 UK offshore wind farms (RPS, 2019). This review showed that sandy sediments recover quickly following cable installation, with trenches infilling quickly following cable installation and little or no evidence of disturbance in the years following cable installation. It also presented evidence that remnant cable trenches in coarse and mixed sediments were conspicuous for several years after installation. However, these shallow depressions were of limited depth (i.e. tens of centimetres) relative to the surrounding seabed, over a horizontal distance of several metres and therefore did not represent a large shift from the baseline environment (RPS, 2019). Remnant trenches (and anchor drag marks) were observed years following cable installation within areas of muddy sand sediments, although these were also found to be relatively shallow features (i.e. a few tens of centimetres).

8.8.2.10 The maximum duration of the offshore construction phase for the Morgan Generation Assets is up to four years. Within this time period, construction activities will occur intermittently and will be spread across the full allotted four years with only a small proportion of the MDS footprint being affected at any one time.

8.8.2.11 The impact on all subtidal IEFs is predicted to be of local spatial extent, short- to medium-term duration, intermittent and high reversibility. It is predicted that the impact will affect only some of the receptors directly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

Marine species

8.8.2.12 In general, mobile fish species can avoid areas subject to temporary habitat disturbance (Ecological Marine Unit (EMU), 2004). The most vulnerable species are likely to be shellfish which are much less mobile than fish, with fragile slow-recruiting species being most highly impacted by short-term disturbance events (MacDonald *et al*., 1996). For example, egg bearing lobster are thought to be more restricted to an area based on a mark and recapture study in Norway which showed that 84% of berried female lobster remained within 500 m of their release site (Agnalt *et al*., 2007). Evidence from other stocks around the world are less clear, with limited movement recorded for some stocks and long-distance migrations documented for other stocks (Campbell and Stasko,1985; Comeau and Savoie, 2002).

8.8.2.13 Indirect effects on fish and shellfish species also include loss of feeding habitat and reduced prey availability. For example, crab and other crustaceans and small benthic fish species (as well as other benthic species; see volume 2, chapter 7: Benthic subtidal ecology of the PEIR) are considered important prey species for larger fish. However, since this impact arising from construction is predicted to affect only a small proportion of seabed habitats in the fish and shellfish ecology study area at any one time, with similar habitats (and prey species) occurring throughout the fish and shellfish ecology study area (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR for habitat distributions and extents), these effects are likely to be limited and reversible. Conversely, benthic disturbance during the construction phase will also expose benthic infaunal species from the sediment (see volume 4, annex 7.1: Benthic subtidal ecology technical report of the PEIR), potentially offering foraging opportunities to some opportunistic scavenging fish and shellfish species immediately after completion of works. The implications of changes in fish and shellfish prey species in the short-term are also discussed for higher trophic level receptors (i.e. marine mammals and birds) in volume 2, chapter 9: Marine mammals of the PEIR, and chapter 10: Offshore ornithology of the PEIR, respectively.

8.8.2.14 Within the Irish Sea, the year one post-construction monitoring of the Walney Wind Farm Extension found a significantly degraded benthic and demersal fish and shellfish community overall compared to pre-construction reference sites within the Walney Array Area, but no significant difference between the communities associated with the pre-construction and post-construction transmission assets (CMACS, 2012). This pattern was repeated in the year three post-construction survey CMACS (2014a), but with a smaller difference between pre- and post-construction studies than year one post-construction, showing a slow trend for recovery to baseline conditions, but relatively little overall impact.

8.8.2.15 The recoverability and rate of recovery of an area after large scale seabed disturbance (e.g. dredging or trawling activities) is linked largely to the substrate type (Newell *et al*., 1998; Desprez, 2000), with recovery rates improved by the presence of conspecifics within a radius of 6km following habitat disturbance (Lambert *et al.*, 2014), which applies to some species of interest within the fish and shellfish ecology study area (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the

PEIR for detailed habitat distributions and spawning grounds). Gravelly and sandy habitats, similar to those found in the fish and shellfish ecology study area, have been shown to return to baseline species abundance after approximately 5-10 years (Foden *et al*., 2009), depending on replenishment rates related to tidal stress, currents, and availability and transference of conspecifics from less impacted to more impacted environments.

Shellfish species

8.8.2.16 A number of commercially important shellfish species such as edible crab, European lobster, *Nephrops,* king and queen scallop, and velvet swimming crab are known to inhabit the fish and shellfish ecology study area. Habitat loss in this area during construction activities will represent a low magnitude overall during cable laying and seabed preparation. While the total habitat loss/disturbance footprint represents a relatively large proportion of the area of the Morgan Generation Assets only a small proportion of this area would be affected at any one time with relatively rapid recovery of sediments following these disturbances based on analysis of recovery trends at other offshore wind farms (RPS, 2019). Following this, recovery of associated communities is also expected (see volume 2, chapter 7: Benthic subtidal ecology of the PEIR) including shellfish populations moving back into these impacted areas.

8.8.2.17 King and queen scallop are known to be present within the fish and shellfish ecology study area and are targeted by commercial fisheries activities (see volume 2, chapter 11: Commercial fisheries chapter of the PEIR). Scallop are predominantly sessile organisms, however, they do have the ability to swim, which is ordinarily used as an escape response, although limited in distance (Marshall and Wilson, 2008). It has been documented that scallop have been able to move up to 30m from a release site during a tagging study (Howell & Fraser, 1984). This response may allow improved resilience to temporary habitat loss/disturbance compared to other sessile organisms, by being able to avoid areas of direct disturbance and relocate to areas nearby. Scallop tend to occur in aggregations as their larval distribution is reliant on relatively unpredictable hydrographic features (Brand, 1991, Delargy *et al*., 2019). As such, as scallop are expected to continue spawning outside the project boundaries, and within unimpacted areas of the fish and shellfish ecology study area. Given that suitable habitat for settlement will remain following cessation of construction, it is predicted that scallop will continue to be recruited into the Morgan Array Area. Therefore, scallop will likely recover well from any disturbance due to short term habitat loss. This is supported by the MarLIN sensitivity assessment (Marshall and Wilson, 2008) which concluded scallop have a high recovery potential (i.e. recovery within months, with full recovery in a small number of years).

8.8.2.18 Larger crustacea (e.g. *Nephrops* and European lobster) are classed as equilibrium species (Newell *et al*., 1998) and are only capable of recolonising an area once the original substrate type has returned. The sensitivity of these fish and shellfish IEFs is therefore higher than for smaller benthic organisms which move in and colonise new substrate immediately after the effect. Therefore, although recovery of benthic assemblages may occur over relatively fast timescales (i.e. within one to two years; see volume 2, chapter 7: Benthic subtidal ecology of the PEIR), recovery of the equilibrium species may take up to ten years in some areas of coarse sediments (Phua *et al*., 2002). It is notable that the absence of larger crustacean and flatfish species due to habitat disturbance can increase overall benthic abundance, due to a lowered rate of predation (Skold *et al*., 2018), suggesting resilience among smaller fish and shellfish species which could contribute to a minor short-term change in ecosystem function, which is likely to recover to the baseline in the long-term.

8.8.2.19 Construction activities (including inter-array and interconnector cable installation) within the fish and shellfish ecology study area may also impact on undetermined spawning and nursery habitats for *Nephrops* (Coull *et* al., 1998), as these areas overlap with the entire fish and shellfish ecology study area (volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR), and any impact will affect these *Nephrops* individuals and habitats directly. Larval settlement will also increase the rate of recovery in an area (Phua *et al*., 2002), with shellfish (*Nephrops*) spawning and nursery habitats in the vicinity of the fish and shellfish ecology study area (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR) potentially increasing the rate of recovery in disturbed areas.

8.8.2.20 A recent study undertaken during construction of the Westermost Rough Offshore Wind Farm located on the northeast coast of England, within a European lobster fishing ground, found that the size and abundance of lobster individuals increased following temporary closure or the area for construction of the windfarm. This study indicates that the activities associated with construction of the wind farm, which included installation of wind turbines and cables, did not negatively impact on resident lobster populations, and instead allowed some respite from fishing activities for a short time-period before reopening following construction (Roach *et al*., 2018).

Fish species

8.8.2.21 The fish species within the fish and shellfish ecology study area likely to be most sensitive to temporary habitat loss are those species that spawn on or near the seabed (e.g. herring, sandeel and elasmobranchs, including spotted ray). Other species are less likely to be impacted by temporary habitat loss from construction activities, especially most highly mobile elasmobranch species. Spotted ray (and other ray species), which spawn in demersal habitats, have broadscale low intensity spawning grounds overlapping the Morgan Array Area (Ellis *et al*., 2012), and these species have significant amounts of other habitat available to it within the rest of the fish and shellfish ecology study area, suggesting resilience in the local population to temporary habitat loss.

Herring and sandeel

8.8.2.22 Of the IEF fish species that spawn on or near the seabed, sandeel and herring are known to spawn at low to high intensities within the fish and shellfish ecology study area (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR). Therefore, any significant seabed disturbance activities carried out during spawning periods may result in mortality of eggs and reduced spawning opportunity due to removal of suitable habitat. Further, physical disturbance to sandeel habitats may also lead to direct effects on adult and juvenile sandeel (e.g. increased mortality), where individuals are not able to colonise viable sandy habitats in the immediate vicinity, or where habitats may be at carrying capacity (Wright *et al.,* 2000). It has been noted that sandeel species have high sensitivity to the impact of direct physical disturbance (Wright *et al.,* 2000). Sandeel may also be particularly vulnerable during their winter hibernation period when they bury themselves in the seabed substrates and are therefore less mobile.

8.8.2.23 However, the Morgan Array Area was found to be largely unsuitable for both herring and sandeel and therefore effects of habitat loss/disturbance on these species is expected to be limited within the Morgan Array Area, given the abundance of similar substrate types and the extensive nature of fish spawning grounds across the wider fish and shellfish ecology study area.

8.8.2.24 Recovery of sandeel populations would be expected following construction activities, with the rate of recovery dependent on the recovery of sediments to a condition suitable for sandeel recolonisation. Effects of offshore wind farm construction (Jensen *et al*., 2004) and operations and maintenance (i.e. post-construction) activities (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 in the Baltic Sea, Denmark. These monitoring studies have shown that offshore wind farm construction and operations and maintenance activities have not led to significant adverse effects on sandeel populations and that recovery of sandeel occurs quickly following construction activities.

8.8.2.25 The recovery potential of sandeel populations can also be inferred from a study by Jensen *et al*. (2010), which found sandeel populations mix within fishing grounds to distances of up to 28km. This suggests that some recovery of adult populations is likely following construction activities, with adults recolonising suitable sandy and gravelly substrates where available from adjacent un-impacted habitats. Recovery may also occur through larval recolonisation of suitable sandy sediments with sandeel larvae likely to be distributed throughout the fish and shellfish ecology study area during spring months following spawning in winter/spring (see Ellis *et al*., 2012; and volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR).

8.8.2.26 A recent monitoring study conducted at the Beatrice Offshore Wind Farm completed a post construction sandeel survey where sandeel abundance were compared pre and post construction (BOWL, 2021a). The results showed that sandeel abundance either increased or remained at similar levels when comparing abundance from 2014 to 2020, with offshore construction commencing in April 2017. The study concluded that there was no evidence that the construction of Beatrice Offshore Wind Farm resulted in adverse impacts on the local sandeel population. This conclusion should be seen in the context of general increase in sandeel populations in the area surrounding the Beatrice Offshore Wind Farm (using ICES set Total Allowable Catch (TAC) as an indicator), and an increase in bycatch abundance from the sandeel dredging, which may indicate the Beatrice Offshore Wind Farm site was generally healthier in 2020 than it was in 2014 (BOWL, 2021a). This study builds on previous work conducted by Stenberg *et al*. (2011) which concluded that the construction of the Horns Rev 1 Offshore Wind Farm posed neither a threat nor direct benefit to sandeel over a seven-year period.

8.8.2.27 Infrastructure installation will not occur simultaneously across the full Morgan Generation Assets Array Area during the construction phase, and once construction/infrastructure installation works are complete in a specific area, recovery of sediments and associated communities are expected to begin soon after. Drawing on information from the monitoring studies above, it is highly likely that the displaced individuals will repopulate these previously disturbed areas, with recovery occurring throughout the construction phase rather than once the entire construction phase is completed.

8.8.2.28 As effects on sandeel (and other prey species) are predicted to be limited in extent (particularly in the context of available habitats in the fish and shellfish ecology study area), temporary and reversible, with recovery of sandeel populations occurring during and post-construction, species reliant on sandeel and other small prey species (e.g. sea trout and cod) would similarly not be expected to be significantly affected. The implications of changes in fish and shellfish prey species are also discussed for higher trophic level receptors (i.e. marine mammals and birds) in volume 2, chapter 9: Marine mammals of the PEIR and volume 2, chapter 10: Offshore ornithology of the PEIR.

8.8.2.29 Most fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.8.2.30 King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of regional importance. The sensitivity of the receptor is therefore considered to be **low**.

8.8.2.31 European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be **medium**.

8.8.2.32 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be **medium**.

8.8.2.33 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally give a medium to high sensitivity. However, the sensitivity of herring to this impact is considered **low**, due to the limited suitable spawning sediments overlapping directly with the Morgan Array Area and the core herring spawning ground being located outside and to the northwest of the fish and shellfish ecology study area.

Diadromous species

8.8.2.34 Diadromous fish species are highly mobile and therefore are generally able to avoid areas subject to temporary habitat loss. Diadromous species that are likely to interact with the fish and shellfish ecology study area are only likely to do so by passing through the area during migrations to and from rivers located on the west coast of England and Wales, such as to rivers with designated sites with diadromous fish species listed as qualifying features (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR). The habitats within the fish and shellfish ecology study area are not expected to be particularly important for diadromous fish species and therefore habitat loss during the construction phase of the fish and shellfish ecology study area is unlikely to cause any direct impact to diadromous fish species and would not affect migration to and from rivers.

8.8.2.35 Indirect impacts on diadromous fish species may occur due to impacts on prey species, for example larger fish species for sea lamprey and sandeel for sea trout. As outlined for marine species above, the majority of large fish species would be able to avoid habitat loss effects due to their greater mobility but would recover into the areas affected following cessation of construction. Sandeel (and other less mobile prey species) would be affected by temporary habitat loss, although recovery of this species is expected to occur quickly as the sediments recover following installation of infrastructure and adults recolonise and also via larval recolonisation of the sandy sediments, which are known to occur throughout the fish and shellfish ecology study area and are known to recover quickly following cable installation (RPS, 2019).

8.8.2.36 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. However, the relatively short construction period and location of the Morgan Generation Assets Array Area likely reduces the probability of either spatial or temporal overlap with many migrating diadromous species, and so the sensitivity of the receptor is therefore considered to be **negligible**.

Significance of effect

Marine species

8.8.2.37 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.38 For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.39 For European lobster and *Nephrops*, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.40 For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.41 For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.2.42 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

8.8.2.43 Operations and maintenance activities within the fish and shellfish ecology study area will result in temporary habitat loss/disturbance. The MDS accounts for up to 11,566,500m^2 of temporary habitat loss/disturbance within this phase (Table 8.14). This equates to a small proportion (1.38%) of the Morgan Generation Assets area. It should also be noted that only a small proportion of the total temporary habitat loss/disturbance is likely to occur at any one time, with the MDS for temporary habitat loss/disturbance spread over the 35-year operational lifetime and therefore individual maintenance activities will be small scale and intermittent events.

8.8.2.44 The activities which contribute to temporary habitat loss/disturbance in this phase may include up to 2,026,500m^2 attributed to jack-up events at wind turbines, OSPs over the 35-year lifetime of the Morgan Generation Assets. This temporary habitat loss/disturbance is the result of up to 937 major component replacements (one every four years for each location) for wind turbines, and 12 major component replacements (three over the lifetime of each OSP) for OSPs. This figure also accounts for four access ladder replacements and four modifications to/replacement of J-tubes for wind turbines and four for OSPs.

8.8.2.45 Inter-array cable and interconnector cable remedial burial may also contribute up to 9,540,000m^2 of temporary habitat loss/disturbance. For inter-array cables this value accounts for up to 20km for reburial events every five years and up to 8km for cable repair events every three years (assuming 20m width seabed disturbance). For interconnector cables this value accounts for up to 3km for reburial events with one event every five years and up to 4km of cable in each of three events every 10 years for repair events (assuming 20m width seabed disturbance).

8.8.2.46 The impacts of jack-up vessel activities will be similar to those identified for the construction phase above and will be restricted to the immediate area around the wind turbine foundation or cable repair sites, where the spud cans are placed on the seabed, with recovery occurring following removal of spud cans. The spatial extent of this impact is small in relation to the total fish and shellfish ecology study area, although there is the potential for repeat disturbance to the habitats in the immediate vicinity of the foundations because of these activities. The repair and reburial of array and OSP interconnector cables will also affect benthic habitats and thus demersal IEFs in the immediate vicinity of these activities, with effects on seabed habitats and associated benthic communities expected to be similar to the construction phase, although much lower magnitude.

8.8.2.47 The impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

8.8.2.48 The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction phase assessment (paragraph 8.8.2.12 to paragraph 8.8.2.36), ranging from **negligible to medium** sensitivity, and these will equally apply in the operations and maintenance phase.

Significance of effect

Marine species

8.8.2.49 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.50 For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.51 For European lobster and *Nephrops*, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.52 For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.53 For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.2.54 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning

Magnitude of impact

8.8.2.55 Decommissioning activities within the fish and shellfish ecology study area will result in temporary habitat loss/disturbance. The MDS for the decommissioning phase assumes that all foundations and cables will be removed and that the decommissioning sequence will generally be a reverse of the construction sequence. This includes up to four jack-up events for each of the up to 68 wind turbines (two jack-up events for wind turbines and two jack-up events for the foundations), and two jack-up events at each of the four OSPs.

8.8.2.56 The extent of temporary habitat disturbance that may occur as a result of decommissioning activities is predicted to be in line with that described for the construction phase in paragraph 8.8.2.2 to 8.8.2.11. On the basis that there will be no requirement for sandwave clearance or pre-lay preparation during decommissioning, the magnitude of the impact is likely to be lower than during construction.

8.8.2.57 The impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

8.8.2.58 The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction phase assessment (paragraph 8.8.2.12 to paragraph 8.8.2.36), ranging from **negligible to medium** sensitivity, and these will equally apply in the decommissioning stage.

Significance of effect

Marine species

8.8.2.59 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.60 For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.61 For European lobster and *Nephrops*, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.62 For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.2.63 For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.2.64 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

8.8.3 Underwater noise impacting fish and shellfish receptors

8.8.3.1 The construction of the generation assets may lead to underwater noise impacting fish and shellfish receptors. The MDS is represented by the installation of monopiles and pin piles for wind turbines, and the OSPs, and is summarised in Table 8.14.

Construction phase

Magnitude of impact

8.8.3.2 The installation of foundations within the Morgan Array Area may lead to injury and/or disturbance to fish and shellfish species due to underwater noise during pile driving. The MDS considers the greatest effect from underwater noise on fish and shellfish IEFs, considering the greatest hammer energy for monopile installation and pin piling installation. A maximum hammer energy of 5,500kJ for monopiles and a maximum hammer energy of up to 3,700kJ for pin piles was modelled.

8.8.3.3 The pin piling activities are represented by the installation of up to 68 pin-piled 3-legged jacket foundations with one pile per leg (up to 204 piles total), or two piles per leg (up to 408 piles total), for wind turbines, and one 6-legged jacket foundations with three piles per leg (18 piles) for the OSP, with each pile installed via impact piling. Pin pile installation will take place over a period of a maximum of 8.02 hours per pile if a single leg per pile is used, or 4.01 hours per pile if two legs are used, for both wind turbines and OSPs, with up to two vessels piling concurrently. For each wind turbine foundation, there will be a total duration of 8.02 hours of pin piling activity (1,638 hours cumulatively for all wind turbine foundations). For the OSP, the total pin piling duration will be 145 hours with total installation of up to 9 days. Overall, pin piling for the wind turbines and OSP will equal 111 days for a single vessel (temporal maximum), or 56 days for two vessels (spatial maximum), out of a maximum two years of foundation installation for the entire piling phase.

8.8.3.4 The monopile piling activities are assessed based upon the installation of up to 68 wind turbine monopiles and one OSP monopiles, using up to two vessels concurrently at a minimum distance of 875m and a maximum of 28.5km between vessels. These numbers of wind turbine and OSP monopiles have been chosen based on maximum hammer energy compared to other lower energy installation scenarios, to best examine the maximum distance associated with noise impacts. This will take place over a maximum of 9.5 hours per monopile, with a cumulative total of 665 hours of piling, with a limit of a maximum of 24 hours of consecutive piling. One monopile is expected to be installed per vessel per 24 hours, giving a temporal maximum activity of 70 days for a single vessel, or a spatial maximum of 35 days for two vessels, out of a maximum two years of foundation installation for the entire piling phase.

8.8.3.5 UXO clearance (including detonation) also has the capability to cause injury and/or disturbance to fish and shellfish IEFs. Clearance will be completed prior to the construction phase (pre-construction). Until detailed pre-construction surveys are completed within the Morgan Array Area, the precise number of potential UXO which will need to be cleared is unknown. For the purposes of this assessment, it has been assumed that the MDS will be clearance of UXO with a NEQ of 907kg cleared by either low order or high order techniques. Detonation of UXO would represent a short term (i.e. seconds) increase in underwater noise (i.e. sound pressure levels and particle motion) which will be elevated to levels which may result in injury or behavioural effects on fish and shellfish species.

8.8.3.6 To understand the magnitude of noise emissions from piling and UXO clearance during construction activity, underwater noise modelling has been undertaken considering the key parameters summarised above. Full details of the modelling undertaken are presented in volume 3, annex 3.1: Underwater noise technical report of the PEIR.

8.8.3.7 Piling activities were modelled for monopile and jacket foundations at three locations within the Morgan Array Area taking into account the varying bathymetry and sediment type across the model areas (see volume 3, annex 3.1: Underwater noise technical report of the PEIR). Underwater noise modelling included the use of ‘soft start’ mitigation to reduce the potential for injury effects (as set out in Table 8.16). The implications of the modelling for fish and shellfish injury and behaviour are outlined in the following sensitivity section.

8.8.3.8 All other noise sources including cable installation and foundation drilling are non-percussive and will result in much lower noise levels and therefore much smaller injury ranges (in most cases no injury is predicted) than those predicted for piling operations. For further information on other noise sources see volume 3, annex 3.1: Underwater noise technical report of the PEIR, however these are not considered further here as the effect on fish and shellfish receptors will be negligible. The pre-construction geophysical surveys, using any of the available techniques outlined in Table 8.14, are likely to be very short term and spatially limited at any one time, reducing the magnitude of their likely impact on fish and shellfish receptors. They will also operate largely outside of the hearing frequencies of most fish and shellfish IEFs, thereby significantly reducing the potential for impacts to low or negligible levels.

8.8.3.9 The impact is predicted to be of regional spatial extent, relatively short-term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

8.8.3.10 The following sections apply to marine fish and shellfish species, and diadromous fish species, with a summary for each of these receptor groups provided below.

8.8.3.11 Underwater noise can potentially have an adverse impact on fish species ranging from physical injury/mortality to behavioural effects. Recent peer reviewed guidelines have been published by the Acoustical Society of America (ASA) and provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish. The Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al*., 2014) are considered to be most relevant and best available guidelines for impacts of underwater noise on fish species (see volume 3, annex 3.1: Underwater noise technical report of the PEIR). The Popper *et al*. (2014) guidelines broadly group fish into the following categories according to the presence or absence of a swim bladder and on the potential for that swim bladder to improve the hearing sensitivity and range of hearing:

- Group 1: Fishes lacking swim bladders (e.g. elasmobranchs and flatfish, lamprey). These species are only sensitive to particle motion, not sound pressure and show sensitivity to only a narrow band of frequencies
- Group 2: Fishes with a swim bladder but the swim bladder does not play a role in hearing (e.g. salmonids and some Scombridae). These species are considered more sensitive to particle motion than sound pressure and show sensitivity to only a narrow band of frequencies
- Group 3: Fishes with swim bladders that are close, but not connected, to the ear (e.g. gadoids and eels). 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; and
- Group 4: Fishes that have special structures mechanically linking the swim bladder to the ear (e.g. clupeids such as herring, sprat and shad). 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.

8.8.3.12 Relatively few studies have been conducted on impacts of underwater noise on invertebrates, including crustacean species, and little is known about the effects of anthropogenic underwater noise upon them (Hawkins and Popper, 2016; Morley *et al*., 2013; Williams *et al*., 2015). There are therefore no injury criteria that have been developed for shellfish (Hawkins *et* al., 2014) however, these are expected to be less sensitive than fish species and therefore injury ranges of fish could be considered to be conservative estimates for shellfish species (risk of behavioural effects are discussed further below for shellfish).

8.8.3.13 An assessment of the potential for injury/mortality and behavioural effects to be experienced by fish and shellfish IEFs with reference to the sensitivity criteria described above is presented in turn below.

Injury

8.8.3.14 Table 8.17 summarises the fish injury criteria recommended for pile driving based on the Popper *et al. (*2014) guidelines, noting that dual criteria are adopted in these guidelines to account for the uncertainties associated with effects of underwater noise on fish.

Table 8.17: Criteria for onset of injury to fish due to impulsive piling (Popper *et al*., 2014).

a Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near field (N; i.e. 10s of metres), intermediate (I; i.e. 100s of metres), and far field (F; i.e. 1000s of metres); Popper et al. (2014).

Group	Type of Animal	Parameter	Mortality and Potential Mortal Injury	Recoverable Injury
1	Fish: no swim bladder (particle motion detection)	SEL, dB re 1 μPa²s	>219	>216
		Peak, dB re 1 μPa	>213	>213
2	Fish: where swim bladder is not involved in hearing (particle motion detection)	SEL, dB re 1 μPa²s	210	203
		Peak, dB re 1 μPa	>207	>207
3 and 4	Fish: where swim bladder is involved in hearing (primarily pressure detection)	SEL, dB re 1 μPa²s	207	203
		Peak, dB re 1 μPa	>207	>207
N/A	Eggs and larvae	SEL, dB re 1 μPa²s	>210	(*Near*) Moderate[a] (*Intermediate*) Low (*Far*) Low
		Peak, dB re 1 μPa	>207	

8.8.3.15 The full results of the underwater noise modelling are presented in volume 3, annex 3.1: Underwater noise technical report of the PEIR. To inform this assessment, Table 8.18 displays the predicted injury ranges associated with the installation of one 16m diameter pile, for peak sound pressure levels (SPL_{pk}). Also, the predicted injury ranges for cumulative sound exposure level (SEL_{cum}) are displayed for when fish are modelled as a fleeing receptor in Table 8.19, and as a static receptor in Table 8.20. Other types of piling impacts were investigated (including pin piles, discussed below), but this modelled single monopile scenario resulted in the greatest realistic predicted injury ranges and therefore forms the focus of the assessment for injury.

8.8.3.16 For peak pressure noise levels when piling energy is at its maximum (i.e. 5,500kJ), mortality and recoverable injury to fish may occur within a maximum of 634m of the piling activity (smaller ranges for Group 1 fish species, highest range for Group 4 species; Table 8.18). The potential for mortality or mortal injury to fish eggs would also occur at distances of up to 634m (Table 8.18), with a low to moderate risk of recoverable injury to eggs and larvae within the range of hundreds of metres (see Table 8.17 for qualitative criteria). It should be noted that these ranges are the maximum ranges for the maximum hammer energy, and it is unlikely that injury will occur in this range due to the implementation of soft starts during piling operations (Table 8.16), which will allow fish to move away from the areas of highest noise levels, before they reach a level that would cause an injury. Stationary eggs will likely be protected through scheduling of operational timing to avoid peak egg densities where possible, based on the baseline knowledge available. The initial injury ranges for soft start initiation will be smaller than those maximum ranges presented (i.e. with a maximum of 297m, depending on the fish species considered; see Table 8.18).

8.8.3.17 For cumulative SEL, injury ranges were calculated for piling activities wherein fish are treated as fleeing and static receptors. These ranges indicate that with the implementation of soft start initiation, when fish are modelled as fleeing receptors, the mortality injury ranges are considerably smaller than those predicted for SPL_{pk}, in that the mortality thresholds were exceeded only for fish eggs and larvae, within a range of up to 2.12km. Similarly, the recoverability ranges were much lower, with thresholds not exceeded for group 1 fish, and groups 2-4 had a maximum range of 79m; see Table 8.19. However, when fish were modelled as static receptors (Table 8.20), mortality and recoverable injury ranges were significantly higher than for both SPL_{pk} and SEL_{cum} when fish are modelled as fleeing receptors, with a maximum mortality range of up to 2.98km in group 3 and 4 fish, and a recoverable injury range of up to 4.76km.

8.8.3.18 The injury ranges presented indicate that injury may occur out to ranges of hundreds of metres for SPL_{pk}. However, in reality, the risk of fish injury overall will be considerably lower due to the hammer energies being lower than the absolute maximum modelled, as demonstrated by the lower injury ranges associated with first strikes as part of the soft start procedure shown in Table 8.18. The expected fleeing behaviour of fish from the area affected when exposed to high levels of noise and the soft start procedure, modelled and presented in Table 8.19, mean that it is likely that fish will have sufficient time to vacate the areas where injury may occur prior to noise levels reaching a level causing mortality, with only recoverable injury predicted for group 2 and 3 fish out to 79m. If the fish were to remain in the area and not have any behavioural response to the piling noise, the potential range for both mortality and recoverable injury would be much greater, out to the range of thousands of metres, with this precautionary modelling approach shown in Table 8.20.

8.8.3.19 Modelling was also performed on pin piling activities, with these presented in volume 3, annex 3.1: Underwater noise technical report of the PEIR, but only the monopile piling ranges have been presented here. This is due to the majority of pin piling activities not exceeding the SPL or cumulative SEL threshold, and many that exceed the threshold having significantly lower ranges than the monopile installation activities.

Table 8.18: Fish injury ranges for single monopile installation based on the peak SPL metric.

Hearing Group	Response	Threshold (SPL_{pk}, dB re 1 μPa)	Range (m)	
			First Strike	Max
Group 1 Fish: No swim bladder (particle motion detection)	Mortality	213	120	386
	Recoverable injury	213	120	386
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	207	297	634
	Recoverable injury	207	297	634
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	297	634
	Recoverable injury	207	297	634
Sea turtles	Mortality	207	297	634
Fish eggs and larvae	Mortality	207	297	634

Table 8.19: Fish injury ranges for single monopile installation based on the cumulative SEL metric for fleeing fish (N/E – threshold not exceeded).

Hearing Group	Response	Threshold (SEL, dB re 1 µPa²s)	Range (m)
Group 1 Fish: No swim bladder (particle motion detection) – [*basking shark ranges shown in square brackets*].	Mortality	219	N/E
	Recoverable injury	216	N/E
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	210	N/E
	Recoverable injury	203	79
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	N/E
	Recoverable injury	203	79

Table 8.20: Fish injury ranges for single monopile installation based on the cumulative SEL metric for static fish (N/E – threshold not exceeded).

Hearing Group	Response	Threshold (SEL, dB re 1 µPa²s)	Range (m)
Group 1 Fish: No swim bladder (particle motion detection)	Mortality	219	745
	Recoverable injury	216	1,060
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	Mortality	210	2,120
	Recoverable injury	203	4,760
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	Mortality	207	2,980
	Recoverable injury	203	4,760
Fish eggs and larvae	Mortality	210	2,120

8.8.3.20 As outlined above, TTS is a temporary reduction in hearing sensitivity caused by exposure to intense sound. Normal hearing ability returns following cessation of the noise causing TTS, though the recovery period is variable, during which fish may have decreased fitness due to a reduced ability to communicate, detect predators or prey, and/or assess their environment. Table 8.21 shows the predicted ranges of effect for Temporary Threshold Shift (TTS) for all fish groups modelled as fleeing receptors which may occur as a result of piling for one 16m diameter pile, with TTS predicted to occur to a maximum range of 21.98km from single piling operations when fish are modelled as fleeing receptors. Table 8.22 shows the TTS ranges predicted for fish species modelled as static receptors, with consistently maximum ranges of 30.18km from piling operations.

8.8.3.21 When concurrent piling is considered and modelled, the TTS ranges for fish modelled as fleeing receptors have a maximum range of 23.88km, and fish modelled as stationary receptors have a maximum range of 32.34km. These ranges are not significantly further than the impacts of the single piling and are thus unlikely to significantly increase the level of impact.

Table 8.21: TTS injury ranges for fleeing fish due to single and concurrent monopile installation based on the cumulative SEL metric.

Hearing group	Response	Threshold (SEL, dB re 1 µPa²s)	Range (m) – Single Piling	Range (m) Concurrent Piling
Group 1 Fish: No swim bladder (particle motion detection) – [*basking shark ranges shown in square brackets*].	TTS	186	21,980 [15,740]	23,880 [17,440]
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	TTS	186	21,980	23,880
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	TTS	186	21,980	23,880

Table 8.22: TTS injury ranges for static fish due to single and concurrent monopile installation based on the cumulative SEL metric.

Hearing group	Response	Threshold (SEL, dB re 1 µPa²s)	Range (m) – Single Piling	Range (m) Concurrent Piling
Group 1 Fish: No swim bladder (particle motion detection) – [*basking shark ranges shown in square brackets*].	TTS	186	30,180	32,340
Group 2 Fish: Swim bladder not involved in hearing (particle motion detection)	TTS	186	30,180	32,340
Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection)	TTS	186	30,180	32,340

8.8.3.22 Underwater noise modelling has also been completed for underwater noise associated with UXO clearance and detonation, from a realistic worse case high order detonation to low order detonations (e.g. deflagration and clearance shots). For the purposes of this assessment, it has been assumed that the MDS will be clearance of UXO with a NEQ of 907kg cleared by either low order or high order techniques.

Table 8.23: Injury ranges for all fish groups relating to varying orders of detonation.

[a] Note: Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near field (N; i.e. 10s of metres), intermediate (I; i.e. 100s of metres), and far field (F; i.e. 1000s of metres); Popper *et al*. (2014).

Detonation Size (kg)	PTS range (m)	
	Fish Lower Range	Fish Higher Range
Low Order and Low Yield Detonations		
0.08 (donor charge)	44	22
0.5 (clearing shot)	81	49
0.75 (x2)	117	70

Detonation Size (kg)	PTS range (m)	
	Fish Lower Range	Fish Higher Range
0.75 (x4)	147	88
High Order Detonations		
1.2 (disposal donor)	108	65
3.5 (disposal donor)	154	93
25	297	179
130	514	309
907	985	590

Marine fish responses - behaviour

8.8.3.23 Fish species responses to construction-related underwater noise include a wide variety of behaviours, including startle (C-turn) responses; strong avoidance behaviour; changes in swimming or schooling behaviour, or changes of position in the water column. The Popper *et al*. (2014) guidelines provide qualitative behavioural criteria for fish from a range of noise sources. These categorise the risks of effects in relative terms as “high”, “moderate” or “low” at three distances from the source: “near” (i.e. tens of metres), “intermediate” (i.e. hundreds of metres) or “far” (i.e. thousands of metres).

8.8.3.24 Any potential short-term noise effects on fish may not necessarily translate to population scale effect or disruption to fisheries, with a relatively low amount of information available about in-situ behavioural effects, and a review by Carroll *et al*. (2017) showed that noise impact experiments on caged fish can lead to highly variable results. Therefore, many laboratory experiments are more useful for providing evidence of potential physiological impacts than behavioural or population-level effects. Also, the response between and even within species to noise impacts is noted to be so variable that an evidence base that is sufficiently robust to propose quantitative criteria for behavioural effects is not currently available (Hawkins and Popper, 2016; Popper *et al*., 2014). As such the qualitative criteria for the four fish groups outlined in Table 8.24 are proposed, which propose risk ratings for behavioural effects and masking in the near field (i.e. tens of metres), intermediate field (hundreds of metres) and far field (thousands of metres).

Table 8.24: Potential risk for the onset of behavioural effects in fish from piling (Popper *et al*., 2014)[a].

Type of fish	Masking[a]	Behaviour[a]
Group 1 Fish: no swim bladder (particle motion detection)	N: Moderate risk I: Low risk F: Low risk	N: High risk I: Moderate risk F: Low risk
Group 2 Fish: swim bladder is not involved in hearing (particle motion detection)	N: Moderate risk I: Low risk F: Low risk	N: High risk I: Moderate risk F: Low risk
Groups 3 and 4 Fish: swim bladder involved in hearing (pressure and particle motion detection)	N: High risk I: High risk F: Moderate risk	N: High risk I: High risk F: Moderate risk
Eggs and larvae	N: Moderate risk I: Low risk F: Low risk	N: Moderate risk I: Low risk F: Low risk

8.8.3.25 Group 1 Fish (e.g. flatfish, elasmobranchs, and lamprey), and Group 2 Fish (e.g. salmonids) are less sensitive to sound pressure, with these species typically detecting sound in the environment through particle motion. However, 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). Group 3 (including gadoids such as cod and whiting) and Group 4 fish (herring, sprat, and shad) are more sensitive to the sound pressure component of underwater noise and, as indicated in Table 8.24, the risk of behavioural effects in the intermediate and far fields are therefore greater for these species.

8.8.3.26 As discussed above, in terms of physical effects, injury up to and including mortality for many marine and diadromous fish species is to be expected for individuals within very close proximity to piling operations. However, this is unlikely to result in significant mortality due to soft start procedures allowing individuals in close proximity to flee the area, prior to maximum hammer energy levels which may cause injury to greater ranges.

8.8.3.27 Group 1 elasmobranch species do not possess a swim bladder, and thus will be most impacted by particle motion, with evidence of startle and fleeing responses to piling sounds a minimum of 20-30 dB re 1 μPa above background conditions due to increased particle motion (Casper *et al*., 2012a). It is likely that the designed-in soft start procedure will allow any individuals near the construction activities to avoid damage by fleeing the immediate area, suggesting low vulnerability overall to this impact. In terms of recoverability, the construction activities will be temporary, and once they have ceased, elasmobranch species have been noted to gather around operational offshore built infrastructure (Stanley and Wilson, 1991), indicating a high recoverability after the end of the initial construction activities.

8.8.3.28 A number of studies have examined the behavioural effects of the sound pressure component of impulsive noise (including piling operational and seismic airgun surveys) on fish species. Mueller-Blenkle *et al*. (2010) measured behavioural responses of cod and sole to sounds representative of those produced during marine piling, with considerable variation across subjects (i.e. depending on the age, sex, condition etc. of the fish, as well as the possible 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 dB to 161 dB re 1 μPa SPL_{pk} for cod and 144 dB to 156 dB re 1 μPa SPL_{pk} for sole (*Solea solea*). 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. More recent modelling work on Group 3 cod has shown an expected decrease in population growth rates in response to loud piling noise (Soudijn *et al*., 2020), due to a decrease in food intake and an increase in energy expenditure as part of an avoidance response to noise impacts. However, this model likely underestimates cod fecundity, and this, combined with the short-term nature of the noise impact from piling (i.e. up to 70 days of piling over a 2 year piling phase), suggests that long-term population-level effects are unlikely to occur within the fish and shellfish ecology study area.

8.8.3.29 A study by Pearson *et al*. (1992) on the effects of geophysical survey noise on caged Group 2 rockfish *Sebastes spp.* observed a startle (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 to seismic airgun noise and assessed behaviour, physiological and pathological changes, with a general fish behavioural response to move to the bottom of the cage during periods of high level exposure (greater than RMS levels of around 156 dB to 161 dB re 1 µPa; approximately equivalent to SPL_{pk} levels of around 168 dB to 173 dB re 1 µPa). This was followed by a return to baseline behaviour within 30 minutes of cessation of airgun activities, with no significant long-term physiological impacts noted, except for likely reversible hearing hair cell damage at shore range. The behaviour of moving towards the bottom of the water column was noted in-situ by Fewtrell and McCauley (2012), with significant alarm responses noted in all investigated species at noise levels exceeding 147–151 dB re 1 µPa SEL in every case, although these responses were also temporary and returned to baseline behavioural conditions shortly thereafter.

8.8.3.30 As outlined above, behavioural effect thresholds proposed by Popper *et al.* (2014) are qualitative, however in order to provide a more quantitative estimation of the range at which behavioural effects may occur, noise modelling was undertaken for SPL peak from three locations around the Morgan Array Area (i.e. these noise contours are presented and discussed below relative to spawning habitats for key species in the Fish and Shellfish Ecology study area. The contours show peak SPL associated with the greatest hammer energy for monopiles. Based on the studies summarised above, it can be expected that behavioural effects could be expected within the 160dB contours, noting that this is likely to be conservative given McCauley *et al*. (2000) noted behavioural effects on a range of species at approximately 168dB re 1 µPa. For Group 1 and Group 2 fish species this is likely to be highly precautionary as they are known to be less sensitive to underwater noise. Further, the noise contours are for the greatest hammer energy for monopiles and therefore in most scenarios this hammer energy will not be used, and smaller contours would be expected. These ranges and the results discussed below broadly align with qualitative thresholds for behavioural effects on fish as set out in Table 8.24, with moderate risk of behavioural effects in the range of hundreds of metres to thousands of metres from the piling activity, depending on the species.

8.8.3.31 For the ecologically important sandeel species in the fish and shellfish ecology study area previous modelling studies have indicated a possible temporary reduction in Group 3 sandeel populations in areas affected by piling noise (Serpetti *et al*., 2021). However, initial outputs of real-world post construction monitoring at the Beatrice Offshore Wind Farm (BOWL, 2021a) concluded that was no evidence of long-term adverse effects on sandeel populations between pre and post construction levels over a six-year period, demonstrating that any potential effect of piling on sandeel is temporary and reversible. Figure 8.4 and Figure 8.5 show the overlap between noise contours from the western piling location of the Morgan Array Area (chosen for proximity to the most sensitive habitats) relative to sandeel spawning and nursery habitats within the fish and shellfish ecology study area. These indicate that during piling for monopiles up to 12.38% of sandeel spawning habitats could be affected. However as set out above, it is likely that the 160dB contour shown is conservative as this is the maximum hammer energy (most hammer energies used will be considerably lower than this) and the expected reduced sensitivity of sandeels to noise, compared to other species. Further, as outlined above, piling operations will represent relatively short term (in the context of the sandeel spawning season of November-February) and intermittent disturbances, with piling expected to occur over approximately 70 days over a two-year piling phase. Pin piling activities will be smaller, involving up to 68 3-legged jacket foundations (204 piles) being installed at a maximum hammer energy of up to 3,700kJ over 102 days maximum. The noise impact from this on sandeel habitats will be smaller than the monopiles and should not represent a significant impact.

8.8.3.32 Cod spawning behaviour was also monitored pre and post construction (which included piling operations) at the Beatrice wind farm site (BOWL, 2021b) and similarly, it was concluded that there was no change in the presence of cod spawning between pre and post construction (although spawning intensity was found to be low across both surveys). From these studies, it can be inferred that noise impacts associated with installation of an offshore wind development are temporary and that fish communities (specifically cod and sandeel in the case of Beatrice offshore wind farm) show a high degree of recoverability following construction. Figure 8.4 and Figure 8.5 show the overlap between noise contours from the southeast piling location relative to cod spawning and nursery habitat. These indicate that during monopile piling, up to 12.56% of cod spawning habitats could be affected. However, the short term and intermittent nature of piling activities compared to the spawning period of cod (January-April, peaking in February and March), with piling occurring over up to 70 days in a two-year piling phase will likely limit the impact on cod spawning or populations significantly. Pin piling activities will be smaller, involving up to 68 3-legged jacket foundations (204 piles) being installed at a maximum hammer energy of up to 3,700kJ over 102 days maximum. The noise impact from this on cod habitats will be smaller than the monopiles and should not represent a significant impact.

8.8.3.33 Herring are known to be particularly sensitive to underwater noise (i.e. Group 4 species). Specifically, herring possess ancillary hearing structures which involve gas ducts extending into the skull, allowing detection of extremely high frequency sounds (Mann *et* al., 2001). Further, they have specific habitat requirements for spawning which makes them particularly vulnerable to disturbance. For herring, the core spawning grounds are located north and northwest of the Morgan Array Area, directly south-east and north-east of the IoM, with seabed sediments directly within the Morgan Array Area shown to be largely unsuitable for herring spawning. Noise contours shown in Figure 8.6 and Figure 8.7 indicate that there is overlap between the herring spawning grounds and the 160dB noise contour at the northern-most piling location, and most other planned piling locations. Significant but reversible diving reactions have been noted for sounds up to 168dB re 1 µPa SPL (Doksaeter *et al*., 2012; based on sonar noise sources), which is above the 160dB threshold suggested above.

8.8.3.34 However, to ensure a precautionary approach is taken for this sensitive species, it was recommended by the MMO and Cefas during the Benthic Ecology, Fish and Shellfish and Physical Processes EWGs in July and November 2022 that a threshold of 135dB re 1μPa^2 single strike SEL is used to assess herring spawning. This is based on Hawkins and Popper (2014), where the potential for behavioural responses including break up of schools and diving at this noise level were identified in sprat and mackerel in a naturally quiet coastal environment where fish were not habituated to vessel noise or other significant sound sources. This environment and lack of habituation varies significantly from the baseline conditions known to exist in the Irish Sea, and the value of comparison to this noise level is therefore limited. Hawkins and Popper (2014) do not recommend that the data from this study is used as a standardised impact threshold. A threshold of 160dB re 1μPa SPL peak is therefore considered more appropriate for detecting real impacts, based on the evidence set out above. For completeness and in response to stakeholder request, Figure 8.7 presents noise contours for single strike SEL for the maximum hammer energy associated with monopile installation and indicates that, based on a threshold of 135dB re 1μPa^2 single strike SEL, up to 58.12% of combined high and low intensity herring spawning ground could be affected for piling at the northernmost piling location. However as noted above, any effects of piling will be temporary and intermittent (i.e. approximately 70 days over a two year piling phase) and any potential effects on herring would only occur if piling occurs at the most northerly wind turbine locations and during the herring spawning season (September to October).

8.8.3.35 More broadly, other marine species utilise the fish and shellfish ecology study area for spawning or nursery purposes. However, the relative proportion of these habitats affected by piling operations at any one time (as indicated in the figures below) will be small in the context of the wider habitat available, and, as outlined above, piling operations will be temporary and intermittent throughout the construction phase of the Morgan Generation Assets. It should also be noted that for all fish and shellfish species, behavioural responses to underwater noise are highly dependent on a number of factors such as the type of fish/shellfish, its sex, age, condition, life history stage as well as other stressors to which the fish is or has been exposed. Another important factor is the reasons and drivers for fish being in a particular area, such as spawning, migration or feeding. One such example is from an investigation into the impact of impulsive seismic air gun surveys which found a slight but not significant reduction in swimming speed among feeding herring schools (Peña et al., 2013), which suggested that feeding herring were not displaying avoidance responses to seismic noise sources, even when the vessel came into close proximity to herring. This indicated an awareness of and response to impulsive anthropogenic noise, which would be expected in response to piling, but not a significant response when fish were highly motivated (in this case during feeding). It may therefore be expected that increased tolerance (and decreased sensitivity) to underwater noise may occur for some fish and shellfish during key life history stages, such as spawning or migration.

8.8.3.36 Effects on fish eggs and larvae are similarly expected to be limited with only low level of impacts which are limited in extent (relative to the wide-ranging nature of spawning nursery habitats) and high recoverability (Bolle *et al*., 2016). It is known that fish larvae tend to have low sensitivity to impulsive piling noise up to 210 dB re 1 μPa SPL (Bolle *et al*., 2016). Although evidence exists of noise impacts significantly interfering with demersal larval settlement (Stanley *et al*., 2012), no significant mortality was noted for herring larvae compared to control groups after exposure to piling noise up to 216 dB re 1 μPa cumulative SEL (Bolle *et al*., 2014).

8.8.3.37 Most marine fish IEFs species, including elasmobranch species, in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.8.3.38 Sprat, cod and sandeel are deemed to be of medium vulnerability, high recoverability and regional to national importance. The sensitivity of the receptor is therefore, considered to be **medium**.

8.8.3.39 Herring are deemed to be of high vulnerability, high recoverability and national importance. The sensitivity of the receptor is therefore, considered to be **medium**.

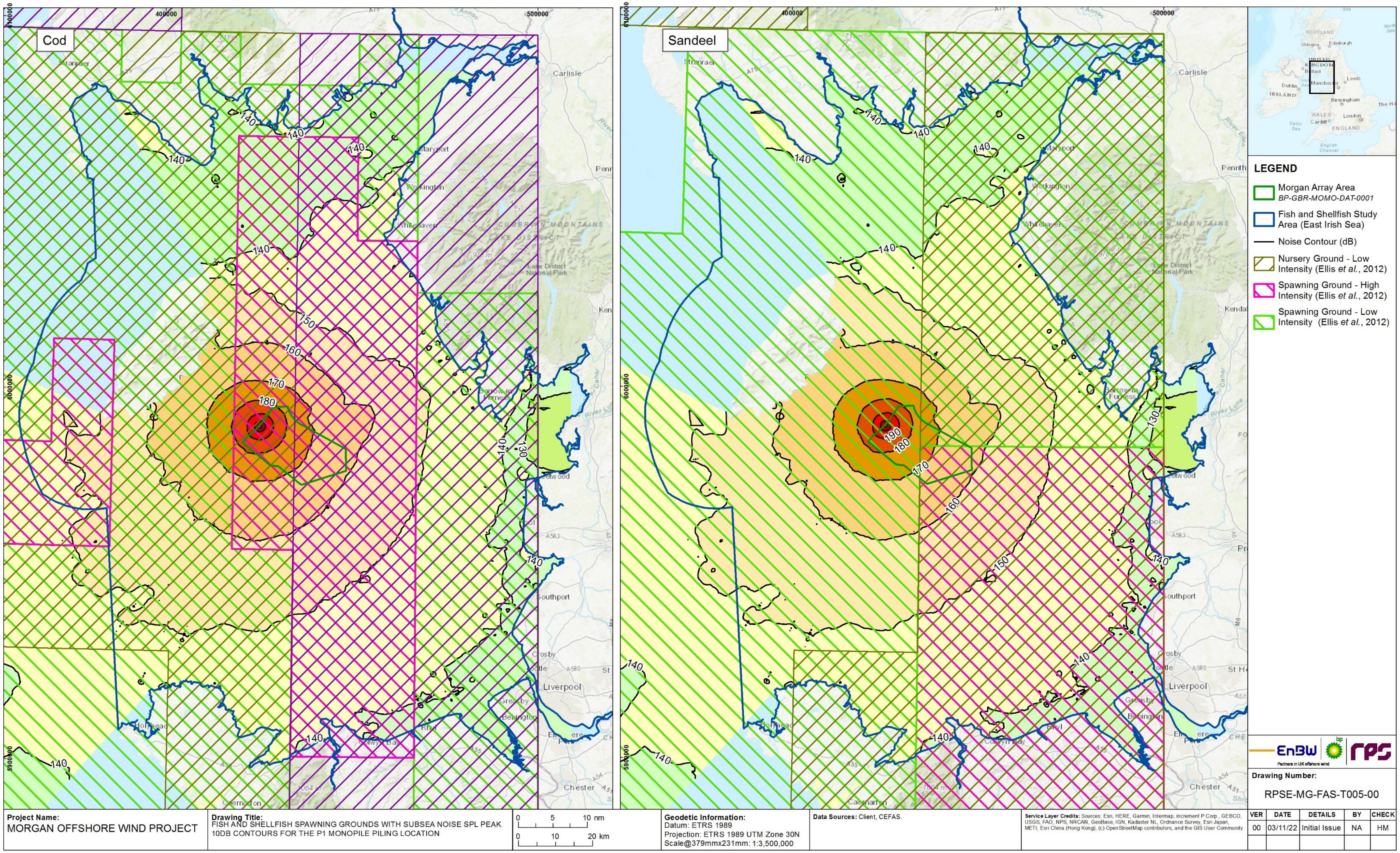


Figure 8.4: Cod and sandeel spawning grounds with subsea 10dB noise SPL peak contours for NW monopile piling location.

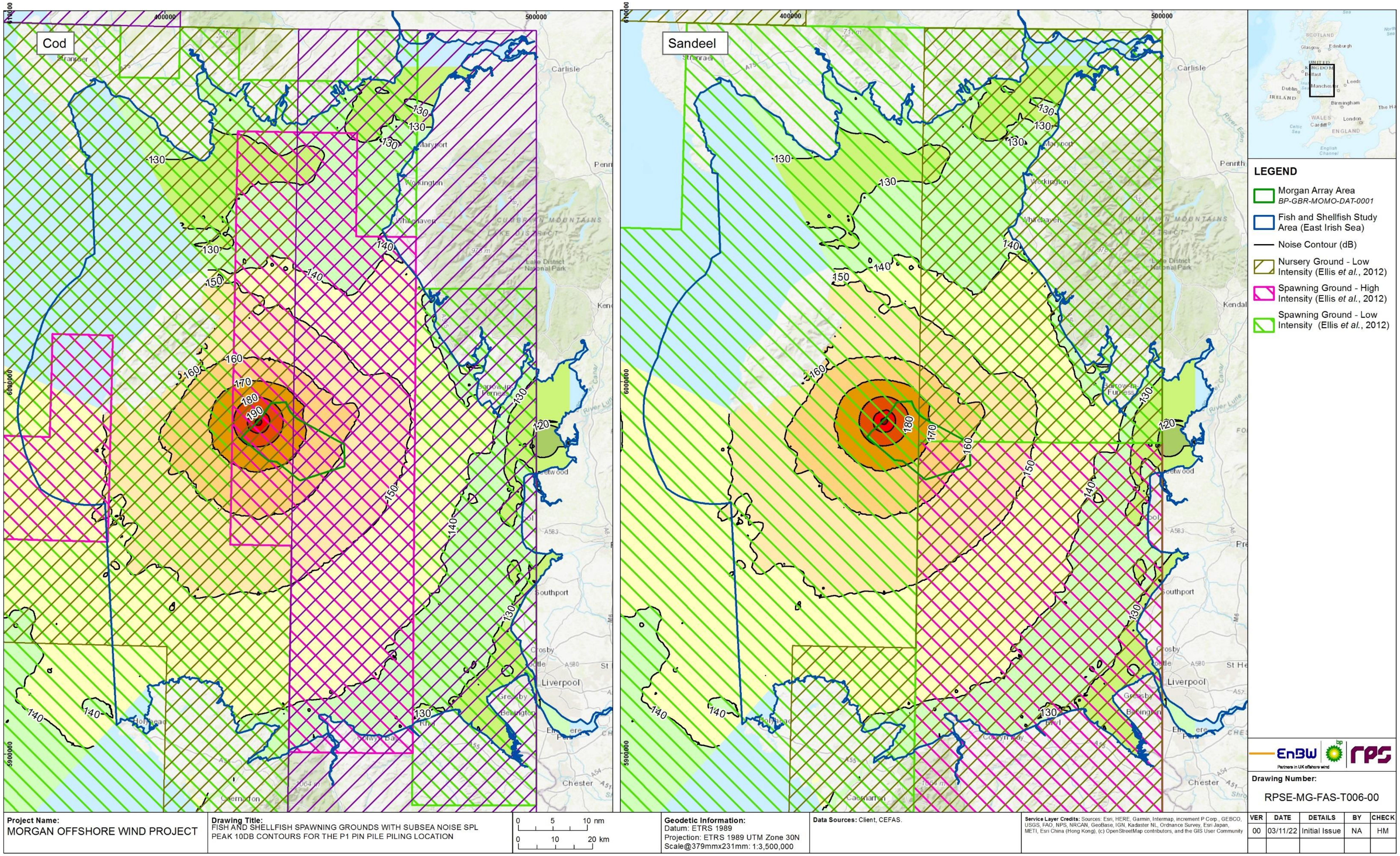


Figure 8.5: Cod and sandeel spawning grounds with subsea 10dB noise SPL peak contours for NW pin pile piling location.

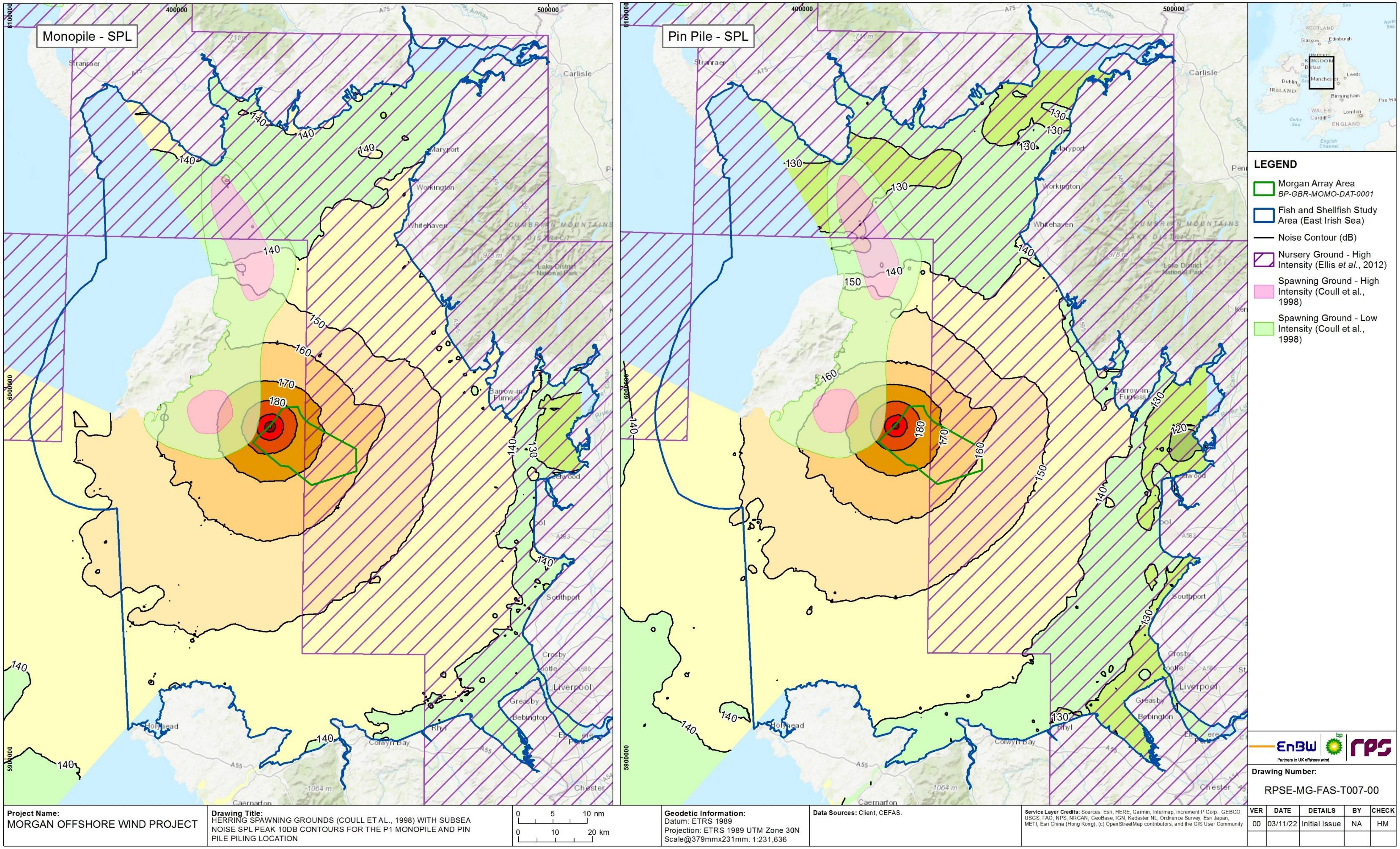


Figure 8.6: Herring spawning grounds with subsea 10dB noise SPL peak contours for monopile and pin pile piling locations.

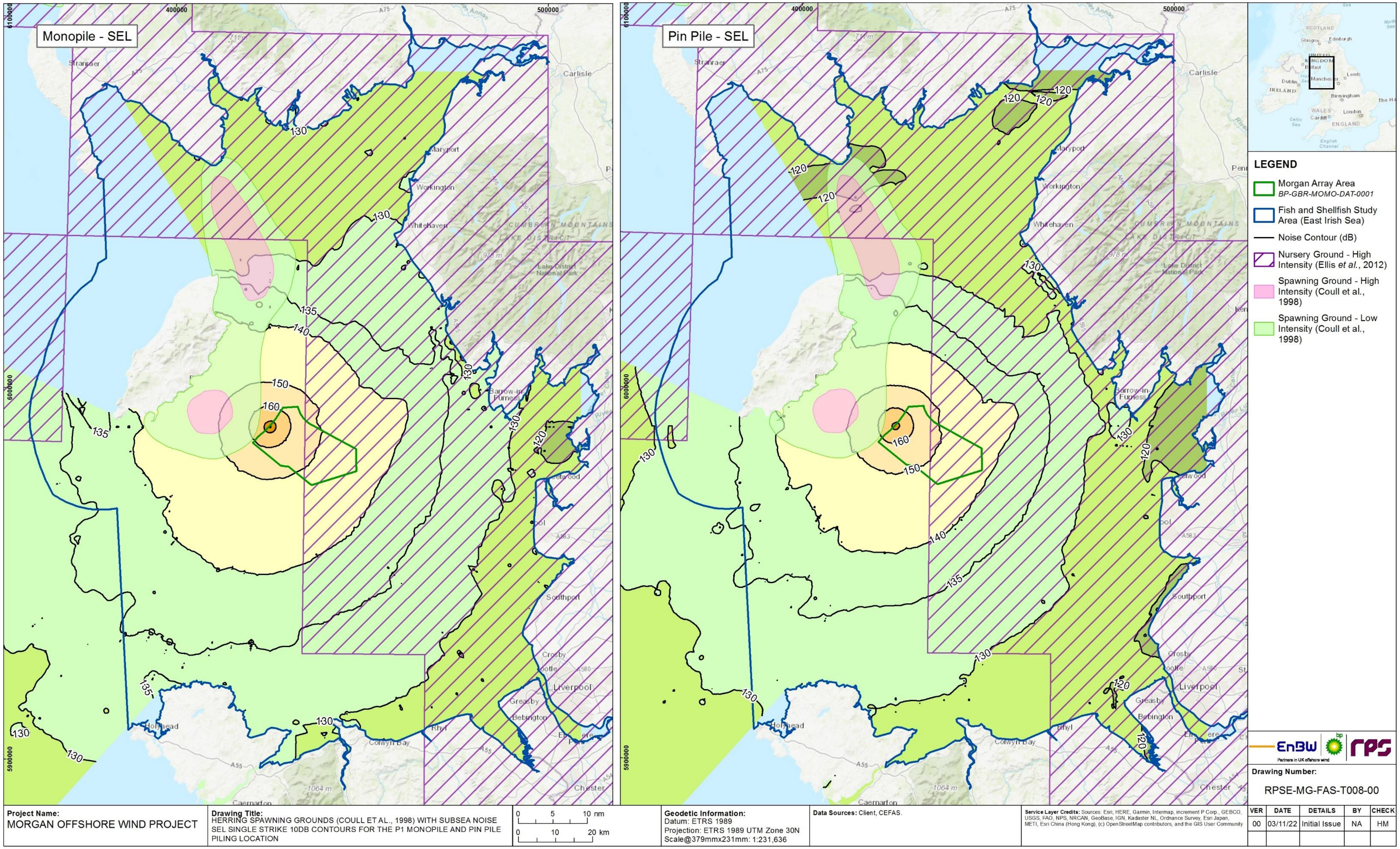


Figure 8.7: Herring spawning grounds with subsea 10dB noise SEL single strike contours for monopile north location.

Diadromous species responses - behaviour

8.8.3.40 As with marine species, diadromous fish species within close proximity to piling operations may experience injury or mortality. However, the nature of diadromous fish species being highly mobile and tending to only utilise the environment within the fish and shellfish ecology study area to pass through during migration, it is unlikely to result in significant mortality of diadromous species. The use of soft start piling procedures (see Table 8.16), allowing individuals in close proximity to piling to flee the ensonified area, further reduces the likelihood of injury and mortality on diadromous species.

8.8.3.41 Diadromous fish species may experience behavioural effects in response to piling noise, including a startle response, disruption of feeding, or avoidance of an area. As discussed in preceding sections, these behavioural responses may occur within a range of hundreds of metres to several kilometres from piling operations, depending on the species and their relative sensitivities to underwater noise (i.e. in order of lowest to highest sensitivities: Group 1 lamprey species, Group 2 Atlantic salmon and sea trout, Group 3 European eel, and Group 4 shad species). Lamprey species are known to have relatively simple ear structures (Popper and Hoxter, 1987), with very few responses to auditory stimuli noted overall (Popper, 2005), except a slight swimming speed increase and decrease in resting behaviour when exposed to continuous low frequency sound of 50-200Hz (Mickle *et al*., 2019), suggesting a low vulnerability to noise impacts overall. The noise modelling outputs (including noise contours) discussed in the previous sections indicated that piling related underwater noise would result in behavioural responses (e.g. as indicated by the 160dB re 1 µPa peak contours, which is likely to be highly precautionary for lamprey) in the vicinity of the Morgan Array Area and these would not extend close to the coasts of north Wales or northwest England, and would have only minimal overlap with the IoM. Further, the noise impacts will be short-term and intermittent in nature during the construction phase (i.e. piling occurring over approximately 70 days over a two year piling phase). As such, there is negligible risk of disruption to migration of lamprey.

8.8.3.42 Smelt have the potential to be impacted by noise, possibly in terms of disruption to migration to their preferred spawning habitats, such as in the Ribble Estuary and Wyre Lune MCZs as outlined in section 8.4.3. However, this species is largely restricted to coastal and estuarine habitats and the extent of the noise contours modelled and plotted in Figure 8.5 demonstrate no overlap of the 160dB re 1 µPa peak contours with coastal areas of North Wales or northwest England. Further, evidence from a port noise study indicates that smelt are able to habituate to repeated noise impacts with no significant loss of ecological function (Jarv *et al*., 2015). As the piling noise has little overlap with these habitats, and will be short term and intermittent, smelt are likely to have low vulnerability and high recoverability to this impact and are therefore at negligible risk to this impact.

8.8.3.43 Research from Harding *et al.* (2016) failed to produce physiological or behavioural responses in Atlantic salmon when subjected to noise similar to piling. However, the noise levels tested were estimated at <160 dB re 1 µPa RMS, below the level at which injury or behavioural disturbance would be expected for Atlantic salmon. Nedwell *et al*. (2006) used the slightly less sensitive sea trout as a model for comparison to Atlantic salmon, and found no significant behavioural response from piling activities, with modelling suggesting a similar response in Atlantic salmon and sea trout. Physical impacts on migrating salmonids have been noted from piling producing sounds of 218 dB re 1 µPa (Bagocius, 2015), although at these noise levels, it would be expected that avoidance reactions would occur, thus avoiding injury effects. The noise modelling outputs (including noise contours) discussed in the previous sections indicated that piling related underwater noise would result in behavioural responses (e.g. as indicated by the 160dB re 1 µPa peak contours; which is likely to be precautionary for Atlantic salmon and sea trout) in the vicinity of the Morgan Array Area and these would not extend close to the coasts of north Wales or northwest England, and would have only minimal overlap with the IoM. Further, the noise impacts will be short-term and intermittent in nature during the construction phase (i.e. piling occurring over approximately 70 days over a two year piling phase). As such, there is negligible risk of disruption to migration of these species. The low risk of effects on migration of Atlantic salmon and sea trout extends to the freshwater pearl mussel, as part of its life stage is reliant on diadromous fish species including Atlantic salmon and sea trout.

8.8.3.44 The Group 3 European eel is known to have a wide hearing range (Jerko *et al*., 1989), with startle responses (Sand *et al*., 2000) and more than a doubling of short-term migration distances close to sources of infrasound deterrents (Piper *et al*., 2019). However, these impacts were noted on juveniles migrating towards the sea, with there being no significant impact expected on juveniles as a result. Eels are also known to be more vulnerable to predation due to difficulty in detecting predators compared to control groups when exposed to simulated underwater noise (Simpson *et al*., 2014), with recovery noted when the noise source was removed. As noted above, the noise modelling outputs (including noise contours) discussed in the previous sections indicated that piling related underwater noise would result in behavioural responses (e.g. as indicated by the 160dB re 1 µPa peak contours) in the vicinity of the Morgan Array Area and these would not extend close to the coasts of north Wales or northwest England and would have only minimal overlap with the IoM. Further, given the short-term and intermittent nature of any construction activities (i.e. piling occurring over approximately 70 days over a two year piling phase) alongside the relatively short migration window of eels through the affected zones of the Morgan Fish and Shellfish study area, it is predicted that any impact to European eel will be minor.

8.8.3.45 Shad species (i.e. allis and twaite shad), like herring, are known to be sensitive to underwater noise, particularly ultrasonic tones (e.g. these were found to be able to detect ultrasonic tones of 171 dB re: 1 µPa SPL at a distance of up to 187m (Mann *et al*., 1998) and evasive behaviours were commonly seen in direct response to ultrasonic stimuli (Platcha and Popper, 2003)). Due to this sensitivity and evasiveness, it is unlikely that shad species will remain in the vicinity of construction activities, which will utilise the soft-start procedure, for a long enough period to cause significant harm, with this representing a low vulnerability to this impact. With regard to disruption to migration, as noted above, noise modelling outputs (including noise contours) discussed in the previous sections indicated that piling related underwater noise would result in behavioural responses (e.g. as indicated by the 160dB re 1 µPa peak contours) in the vicinity of the Morgan Array Area and these would not extend close to the coasts of north Wales or northwest England, and would have only minimal overlap with the IoM. It should also be noted that the ranges presented above are for the maximum hammer energy for monopiles and all other scenarios (i.e. lower hammer energies and other foundation types) would result in considerably smaller noise impact ranges. Further, the noise impacts will be short-term and intermittent in nature during the construction phase (i.e. piling occurring over approximately 70 days over a two year piling phase) and shad would only have the potential be affected if piling occurs during the migratory period for these species, which occurs over spring up until June, and peaks in April and May (Acolas *et al*., 2004). As such, there is low risk of disruption to migration of these species.

8.8.3.46 Most diadromous fish species IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.8.3.47 Allis shad and twaite shad are deemed to be of medium vulnerability, high recoverability, and national importance. The sensitivity of the receptor is therefore considered to be **medium**.

Shellfish responses – injury and behavioural

8.8.3.48 As information on the impact of underwater noise on marine invertebrates is scarce, no attempt has been made to set standardised exposure criteria (Hawkins *et al*., 2014). Studies on marine invertebrates have shown their general sensitivity to substrate borne vibration (Roberts *et al*., 2016), with aquatic decapod crustaceans possessing a number of receptor types potentially capable of responding to the particle motion component of underwater noise (e.g. the vibration of the water molecules which results in the pressure wave) and ground borne vibration (Popper *et al*., 2001). Noise is detected more as particle motion through stimulation of sensory setae within statoliths (Carroll *et al*., 2017), although these animals also have other mechanoreceptor systems which could be capable of detecting vibration. Broadly, evidence exists of crustaceans being sensitive to sounds of frequency <1kHz (Budelmann, 1992). It has also been reported that the sound wave signature of piling noise can travel considerable distances through sediments (Hawkins and Popper, 2016), with implications for demersal and sediment dwelling shellfish species (e.g. *Nephrops*) in close proximity to piling activities.

8.8.3.49 Scott *et al*. (2020) provides a review of the existing published literature on the influence of anthropogenic noise and vibration and on crustaceans, including IEF species. The review concluded that some literature sources identified behavioural and physiology effects on crustaceans from anthropogenic noise, however, there were several that showed no effect. The paper notes that to date no effect or influence of noise or vibrations has been reported on mortality rates or fisheries catch rates or yields. In addition, no studies have indicated a direct effect of anthropogenic noise on mortality, immediate or delayed (Scott *et al*., 2020).

8.8.3.50 Of the shellfish IEF species within the Morgan Fish and Shellfish Ecology Study Area, decapod crustaceans (e.g. European lobster, edible crab, and *Nephrops*) are believed to be physiologically resilient to noise as they lack gas filled spaces within their bodies (Popper *et al*., 2001). To date no lethal effects of underwater noise have been described for edible crab, European lobster or *Nephrops*, however a number of sub-lethal physiological effects have been reported among *Nephrops* and related species, specifically a reduction in burying, bioregulation, and locomotion behaviour in response to simulative shipping and construction noise, however, simulated shipping noise had no effect on the physiology of *Nephrops* (Solan *et al*., 2016).

8.8.3.51 Sub-lethal physiological effects have been identified from impulsive noise sources including bruised hepatopancreas and ovaries in snow crab exposed to seismic survey noise emissions (at unspecified SPLs) (DFO, 2004). Changes in serum biochemistry and hepatopancreatic cells (Payne *et al*., 2007); increase in respiration in brown shrimp *Crangon crangon* (Solan *et al*., 2016); metabolic rate changes and reduced feeding behaviour in green shore crab *Carcinus maenas* (Wale *et* al., 2013), and evidence of oxidative stress in blue mussel (Wale *et al*., 2019) have also been identified.

8.8.3.52 Another study on brown shrimp found elevated SPL are implicated in increased incidences of cannibalism and significantly delayed growth (Lagardère and Spérandio, 1981). The mud crab *Scylla paramamosain* and European spiny lobsters *Palinurus elephas* have been reported to have aspects of life history disrupted by anthropogenic noise (e.g. movement and anti-predation behaviour). In contrast to *Nephrops*, increased movement has been seen in these species in response to simulated shipping noise and offshore activities (Filiciotto *et al*., 2016; Zhou *et al*., 2016). Such findings have implications with regard to species fitness, stress and compensatory foraging requirements, along with increased exposure to predators. Although these species are not IEFs within the Morgan Fish and Shellfish Ecology Area, this research provides useful context for the sub-lethal effects from noise impacts which the shellfish IEF species will likely similarly be exposed to.

8.8.3.53 Behavioural impacts have been noted in the giant scallop *Placopecten magellanicus*, with piling noise travelling through the seabed out to 50m and causing significant increases in valve closures with no acclimation to multiple piling exposures (Jezequel *et al*., 2022), which could potentially have significant impacts on feeding success during construction at night. However, this only occurred in very close proximity to the piling impact, and the scallop returned to baseline natural behaviour almost immediately following cessation of piling. Therefore, it is unlikely that impact piling will cause any significant long-term impact on shellfish populations within the Morgan Array Area, given the relatively small proportion of the overall scallop population in the Morgan Generation Assets area potentially affected by this impact.

8.8.3.54 Other than piling and vessel noise, shellfish will likely be exposed to pre-construction geophysical surveys within the Morgan Array Area, which would include the use of sub-bottom profiling surveys. In evaluating this impact, a report by Christian *et al*. (2003) found no significant difference between acute effects of seismic airgun exposure (a similar impulsive high amplitude noise source to piling; >189 dB re 1 μPa (peak–peak) @ 1 m, which may be used in the pre-construction phase surveys) upon adult snow crabs *Chionoecetes opilio* in comparison with those in control cages with no exposure to seismic pulses. Another study investigated whether there was a link between seismic surveys and changes in commercial rock lobster *Panulirus cygnus* based on catch rates of surviving individuals, thereby providing a measurement of acute to mid-term mortality over a 26-year period. This found no statistically significant correlative link (Parry and Gason, 2006). A review of seismic survey impact studies found that comparison between laboratory and field studies was difficult due to differing sound properties in these controlled and uncontrolled environments (Carroll *et al*., 2017), and therefore setting standardised minimum injury and mortality thresholds was difficult for this impact (Wright and Cosentino, 2015). Despite this difficulty, direct observation has shown that scallop species show no evidence of increased mortality within 10 months of seismic airgun exposure (Parry *et al*., 2002), and lobsters show the same trend 8 months following exposure (Day *et al*., 2016), suggesting a low vulnerability and high recoverability to this noise source.

8.8.3.55 Regarding shellfish eggs and larvae, there is no direct evidence to suggest they are at risk of direct harm from high amplitude anthropogenic underwater noise such as piling (Edmonds *et al*., 2016). Evidence exists of underwater noise significantly decreasing the capacity of benthic shellfish larvae to settle following their planktonic larval phase (Stanley *et al*., 2012), potentially impacting long-term population recruitment. Of the few studies that have focused on the eggs and larvae of shellfish species, evidence of impaired embryonic development and mortality has been found to arise from playback of seismic survey noise among scallop, with up to 46% of affected larvae developing abnormalities compared to control groups (De Soto *et al*., 2013). There is limited information on the effect of impulsive sound upon crustacean eggs, and no research has been conducted on commercially exploited decapod species in the UK, with all available studies focusing on seismic survey noise impacts. Similar to scallop larvae, exposure to sounds from seismic source arrays could be implicated in delayed hatching of snow crab eggs, causing resultant larvae to be smaller than controls (DFO, 2004). However, Pearson *et al*. (1994) found no statistically significant difference between the mortality and development rates of stage II Dungeness crab *Metacarcinus magister* larvae exposed to single field-based discharges (231 dB re 1 μPa (zero-peak) @ 1 m) from a seismic airgun, highlighting the heterogeneity of results in this field, with further study required to refine this understanding. The existing evidence suggests a medium vulnerability of shellfish eggs and larvae to this impact, although recoverability of shellfish into spawning habitats is predicted to be high.

8.8.3.56 At a population level, monitoring of European lobster catch rates at the Westermost Rough Offshore Wind Farm indicated that there were no significant negative effects on shellfish species during and after construction compared to baseline conditions (Roach *et al*., 2018), with the respite from fishing activities from construction exclusion zones actually having short term benefits for some populations. While there may be some residual uncertainty with regard to behavioural effects while piling operations are ongoing, the evidence suggests that long term effects will not occur, and any effects will be reversible.

8.8.3.57 All shellfish IEFs, including European lobster, *Nephrops* edible crab, and king and queen scallops are deemed to be of low vulnerability, high recoverability and local to regional importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

8.8.3.58 For shellfish species, the magnitude of the impact is deemed to be low, and the sensitivity of all shellfish IEFs is considered low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.3.59 For most marine fish, the magnitude of the impact is deemed to be low, and the sensitivity of most marine fish IEFs is considered low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.3.60 For sprat, cod, and sandeel, the magnitude of the impact is deemed to be low, and the sensitivity is considered to be medium. The effect will, be of **minor adverse** significance, which is not significant in EIA terms. This is due to the short term, intermittent nature of the impact, and the relatively small proportion of spawning habitats affected at any one time (given the broadscale nature of these habitats), and the reversibility of these impacts as noted through post-construction monitoring at existing wind farm sites. Also, the effects would only arise if piling occurred during the peak spawning periods for these species, which all act to reduce the potential significance of the impact.

8.8.3.61 For herring, the magnitude of the impact is deemed to be low, and the sensitivity of herring is considered medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. However, there is potential for significant effects on herring spawning, due to the proximity of the Morgan Generation Assets to the nearby herring spawning grounds. This increased level of impact would likely occur, with disturbance to spawning herring, if piling takes place during the spawning period (September-October). Despite this potential impact, the overall significance is still considered to be minor adverse, due to the noted reversibility of disturbance effects and lack of long-term noise disturbance impacts to herring spawning populations, with herring expected to continue to spawn in existing spawning habitats post-construction.

8.8.3.62 For most diadromous fish species, the magnitude of the impact is deemed to be low, and the sensitivity of diadromous IEFs are considered low to medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms, due to the minimal risk of disruption to migration of diadromous fish species.

8.8.3.63 For allis shad and twaite shad, the magnitude of the impact is deemed to be low, and the sensitivity of allis and twaite shad is deemed to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. This is due to the short term, intermittent nature of the impact being unlikely to affect migration to or from key rivers, and the lack of direct noise impact on freshwater spawning habitats.

Further mitigation and residual effects

8.8.3.64 As noted above, no significant effects are predicted as a result of underwater noise impacts, and therefore further mitigation measures are not proposed for this impact. It is noted above that there is a residual risk of significant effects on herring spawning if piling occurs during the herring spawning season. Measures to minimise the risk of significant effects on herring spawning are currently being investigated and will be discussed with relevant stakeholders via the EWG and included in the Environmental Statement.

8.8.4 Increased SSCs and associated sediment deposition

8.8.4.1 The construction, operations and maintenance, and decommissioning activities on the wind turbines, OSPs, and inter-array and interconnector cables of the Morgan Generation Assets may lead to increased SSCs and associated sediment deposition. The MDS is represented by sandwave clearance, cable installation and burial, and wind turbine and OSP foundation installation, and is summarised in Table 8.14. Volume 4, annex 6.1: Physical processes technical report of the offshore PEIR provides a full description of the physical processes baseline characterisation, including numerical modelling used to inform the predictions made with respect to increases in suspended sediment and subsequent deposition.

8.8.4.2 For more generalised conditions the Cefas Climatology Report 2016 (Cefas, 2016) and associated dataset provides the spatial distribution of average non-algal Suspended Particulate Matter (SPM) for the majority of the UK Continental Shelf (UKCS). Between 1998 and 2005, the greatest plumes are associated with large rivers such as those that discharge into the Thames Estuary, The Wash and Liverpool Bay, which show mean values of SPM above 30mg/l. Based on the data provided within this study, the SPM associated with the Morgan Generation Assets has been estimated as approximately 0.9mg/l to 3mg/l over the 1998 to 2005 period.

Construction phase

Magnitude of impact

8.8.4.3 For the purposes of this assessment, the following activities have been considered (see Table 8.14):

- Seabed preparation (sandwave, boulder and debris clearance)
- Drilling for wind turbine and OSP foundation installation
- Installation of inter-array and interconnector cables.

8.8.4.4 The MDS for the inter-array sandwave clearance accounts for up to a 104m wide corridor along 250km of cable length and to an average depth of 5.1m, totalling a spoil volume of up to 9,542,806m^3. The interconnector cables sandwave clearance activities account for a much smaller total spoil volume of 3,060,814m^3, based on clearance in a 104m wide, 5.1m deep corridor along up to 30km of interconnector cables. Modelling of suspended sediment movement associated with the site preparation for the inter-array and interconnector cables assumed a speed of 100m/h for a period of four hours. Material was then deposited over a 45-minute period. The dredging phase plumes were smaller than the dumping phase with concentrations of <50mg/l. The release phase plume was larger than the dredging plume with concentrations reaching 3000mg/l at the release site. The 20km tidal excursion surrounding the site will experience the greatest area of increased SSC, with re-mobilisation of 500mg/l – 1000mg/l, with average levels of <500mg/l, on subsequent tides. Sedimentation one day following the cessation of the clearance activities results in deposited material at the site of release of up to 0.5mm in depth (considered in temporary habitat loss section 8.8.2 above), whilst in the wider area, approximately 100m from the release, deposited material reaches depths of typically 0.3mm, still detectable above background levels of <0.01mm, but expected to decrease on subsequent tidal cycles.

8.8.4.5 The MDS for foundation installation assumes all wind turbine foundations will be installed by drilling a 16m diameter pile to a depth of 60m at a rate of 0.89m/h (Table 8.14), with an expected spoil volume of 13,460m^3 per pile. OSPs are modelled as installation of two 16m diameter piles to a depth of 60m at a rate of 0.73m/h, resulting in 13,460m^3 of spoil per pile. A sample of three representative pile installation scenarios (A - northwest, B - northeast, and C - southeast) were simulated to cover the range of conditions in terms of water depth, tidal currents and sediment grading. At each location modelling assessed two piles being installed simultaneously.

8.8.4.6 Modelling of suspended sediments was performed for multiple scenarios involving different piling locations and durations, and specific details of the outcomes of these scenarios is available in volume 4, annex 6.1: Physical processes technical report of the PEIR, and in volume 2, chapter 6: Physical processes of the PEIR. Broadly, the modelling found that SSCs would increase by up to 50mg/l in the area immediately surrounding the piling, with a rapid reduction back to background levels of sedimentation as time and distance from the piling activity increased.

8.8.4.7 The modelling of post-construction sedimentology showed that the majority of changes will occur within 100m of the wind turbine foundation structures along the direction of principle tidal currents. This limited extent was derived from an expected ±10% change in local current speeds which was predicted to return to baseline conditions within days, and which is significantly below the changes associated with a standard storm event in the area. This indicates a low magnitude of impact associated with the wind turbine foundation installations.

8.8.4.8 The MDS for the installation of inter-array cables and interconnector cables assumes installation via trenching or jetting. Trenches are expected to have a width of 3m and a depth of 3m (Table 8.14), resulting in the mobilisation of up to 2,250,000m^3 of material along the 500km inter-array cable routes, and up to 270,000m^3 of mobilised material for the 60km of interconnector cables. The modelling presented in volume 4, annex 6.1: Physical processes technical report of the PEIR modelled peak increases in SSCs of 50-500mg/l in the immediate vicinity of the works, with the higher concentration associated with the inter-array cables. This sediment is subsequently re-suspended and dispersed on subsequent tides giving rise to concentrations of up to 1000mg/l for the interconnector cables three days later. The material settles during slack water and then is re-suspended to form a secondary plume which becomes amalgamated. Sedimentation is predicted to be greatest at the location of the trenching and may be up to 50mm in depth where the coarser material has settled within circa 100m and will reduce significantly with distance to depths of <0.5mm. Although the material is dispersed, it remains within the sediment cell and is therefore retained within the transport system.

8.8.4.9 The impact is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

Marine species

8.8.4.10 In terms of SSC, adult fish species are more mobile than many of the other fish and shellfish IEFs, and therefore would be likely to show avoidance behaviour within areas affected by increased SSC (EMU, 2004), making them less susceptible to physiological effects of this impact. Juvenile fish are more likely to be affected by habitat disturbances such as increased SSC than adult fish, which is well researched for commercially important salmonid species (Bisson and Bilby, 1982; Berli *et al*., 2014). This is due to the decreased mobility of juvenile fish, with these animals therefore being less able to avoid impacts. Juvenile fish are likely to occur throughout the fish and shellfish ecology study area, with some species using offshore areas as nursery habitats, while inshore areas, especially within the IoM territorial waters and inshore Welsh waters, are more important as nurseries for other species (full list of species with spawning and nursery grounds overlapping the fish and shellfish ecology study area available in volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR).

8.8.4.11 The north Irish Sea experiences regular temporary increases in SSC, linked heavily to interannual changes in general meteorological conditions and the frequency of spring storms (White *et al*., 2003), and juveniles typically inhabit inshore areas (where SSCs are typically higher). Also, seasonal variation of SSC is known to occur in the

Irish Sea, with an increase of up to a factor of 2.7 in winter compared to summer (Bowers *et al*., 2010). Therefore, given the extent of these natural changes, it can be expected that most fish juveniles expected to occur in the fish and shellfish ecology study area will be largely unaffected by the relatively low-level temporary increases in SSC resulting from the construction phase. These concentrations are likely to be within the range of natural variability - generally <5mg/l, but this can increase to over 100mg/l during storm events with increased wave heights and will likely reduce to background concentrations within a very short period (approximately two tidal cycles), leading to there being little to no impact on mobile species, such as the identified elasmobranch IEF species.

8.8.4.12 A study by Appleby and Scarratt (1989) found development of fish eggs and larvae have the potential to be affected by suspended sediments at concentrations of thousands of mg/l. Modelling undertaken of SSC associated with the fish and shellfish ecology study area construction phase identified peak maximum concentrations of approximately 3000mg/l predicted in the inter-array cables and interconnector cables sandwave clearance phases. These concentrations of SSC may affect the development of eggs and larvae; however, these concentrations are only expected to be present in the immediate vicinity of the release site with dispersion of the released material continuing on successive tides. Average increases in SSC associated with sandwave clearance activities are predicted to be of the order of less than 300mg/l. These levels are unlikely to affect the development of most eggs and larvae.

8.8.4.13 Many shellfish species, such as edible crab and king and queen scallop, have a high tolerance to SSC and are reported to be insensitive to increases in turbidity (Wilber and Clarke, 2001); however, they are likely to avoid areas of consistently increased SSC as they rely on visual acuity during predation and feeding (Neal and Wilson, 2008, Speiser and Johnsen, 2008). In the case of possible burial during settlement of SSC, both king and queen scallop have the potential to be impacted negatively. However, it has been found that any potential burial of queen scallop does not negatively impact emergence from sediment and survival rates in the short term of up to two days, with the caveat that they do have the potential to be negatively impacted when buried under several centimetres of sediment over longer time periods, up to seven days (Hendrick *et al.*, 2016). The MDS modelling of sediment plume movement and deposition depths have shown this is unlikely to occur in this case. King and queen scallop both have high intensity spawning grounds mostly overlapping the Morgan Array Area and are both more mobile than many other shellfish species and are expected to avoid active events causing increases in SSC. This potential avoidance behaviour is less prevalent in juvenile king scallop, where burial from up to 5cm of SSC deposition can reduce growth rates, potentially having impacts on future spawning times (Szostek, *et al*., 2013). However, the relatively low level of SSC and deposition, and the large area available alternatively for spawning, is unlikely to significantly impact king scallop populations in the short or long term.

8.8.4.14 Berried crustaceans (e.g. European lobster and *Nephrops*) are potentially more vulnerable to increased SSC as the eggs carried by these species require regular aeration. Increased SSC within the fish and shellfish ecology study area (potential habitat for egg bearing and spawning *Nephrops*, which overlaps with the entirety of the Morgan Array Area) is unlikely to impact *Nephrops*, as this species is not considered to be sensitive to increases in SSC or subsequent sediment deposition, since this is a burrowing species with the ability to excavate any sediment deposited within their burrows (Sabatini and Hill, 2008). Also, construction will only affect a small area at any one time and will be temporary in nature, with sediments settling to the seabed quickly following disturbance and becoming part of the background sediment transport regime (see assessment of magnitude above), therefore any impact on European lobster or *Nephrops* will be low within the Morgan Generation Assets Fish and Shellfish Ecology study area.

8.8.4.15 The fish species likely to be affected by sediment deposition are those which either feed or spawn on or near the seabed. Demersal spawners within the fish and shellfish ecology study area include sandeel and herring. Spawning areas for sandeel occur within the fish and shellfish ecology study area, however sandeel and their eggs are likely to be tolerant to some level of sediment deposition due to the nature of re-suspension and deposition within their natural high energy preferred habitat and spawning environment within the Irish Sea (MarineSpace Ltd, 2013). Therefore, effects on sandeel spawning populations are predicted to be limited. Sandeel populations prefer coarse to medium sands (Wright *et al*., 2000), with sensitivity to changes in this habitat, and show reduced selection or avoidance of gravel and fine sediments (Holland *et al*., 2005). Therefore, any increase in the fine sediment fraction of their habitat may cause avoidance behaviour until such time that currents remove fine sediments from the seabed, although modelled deposition levels for fine sediments are expected to be highly localised and at very low levels (up to <5mm, in close proximity to activities with lower sediment deposition across the wider area).

8.8.4.16 Herring occur mostly in entirely pelagic habitats, but utilise benthic environments for spawning, and are known to prefer gravelly and coarse sand environments for this purpose, specifically around the southeast and northeast of the IoM, both close to and west and northwest of the Morgan Array Area (Coull *et al*., 1998). With respect to the effects of sediment deposition on herring spawning activity, it has been shown that herring eggs may be tolerant of very high levels of SSC (Mesieh *et al*., 1981; Kiorbe *et al*., 1981). Detrimental effects may be seen if smothering occurs and the deposited sediment is not removed by the currents (Birklund and Wijsmam, 2005), however this would be expected to occur quickly in this case (i.e. within a couple of tidal cycles), given the low levels of deposition expected. Furthermore, the limited amount of suitable sandy gravel sediments for herring spawning within the Morgan Array Area, with the majority of the sediment habitats being unsuitable (Figure 8.2), will likely limit the potential for effects of SSC on herring spawning. This is supported by the mapping of spawning grounds (as described in section 8.4.2), which shows the highest intensity of herring spawning within the IoM 12nm territorial waters, just outside and to the west of the Morgan Array Area, reducing any potential for impact of SSC.

8.8.4.17 Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of medium vulnerability, high recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be **medium**, which is supported by the relatively low proportions of suitable spawning grounds and primary habitat in the Morgan Array Area.

8.8.4.18 All other fish and shellfish ecology IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops*, king and queen scallop, and elasmobranch species, are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be **low**.

Diadromous species

8.8.4.19 Diadromous fish species known to occur in the area are also expected to have some tolerance to naturally high SSC, given their migration routes typically require them to travel through estuarine habitats, which have background SSC that are considerably higher than those expected in the offshore areas of the fish and shellfish ecology study area. As it is predicted that construction activities associated with the Morgan Generation Assets will produce temporary and short-lived increases in SSC, with levels well below those experienced in estuarine environments, it would be expected that any diadromous species should only be temporarily affected (if they are affected at all, based on the timing of the construction phase). Any negative effects on these species are likely to be short term behavioural effects, such as avoidance (Boubee, *et al*., 1996), or temporary slightly erratic alarmed swimming behaviour (Chiasson, 2011), and are not expected to create any significant barrier to migration to rivers or estuaries used by these species in the fish and shellfish ecology study area. However, these studies were laboratory based, and do not cover the species found within the fish and shellfish ecology study area, so the potential for other responses does exist, but these are unlikely, given the naturally highly turbid nature of estuarine environments that these species are adapted to traverse.

8.8.4.20 Diadromous fish species IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptors is therefore, considered to be **low.**

Significance of effect

Marine species

8.8.4.21 Overall, the magnitude of the impact is deemed to be low for the majority of fish and shellfish IEFs, and the sensitivity is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.4.22 Overall, the magnitude of the impact for herring is deemed to be low, and the sensitivity is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.4.23 Overall, the magnitude of the impact is deemed to be low and the sensitivity of the diadromous fish IEF receptors is considered to be low. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

8.8.4.24 Maintenance activities within the fish and shellfish ecology study area may lead to increases in SSC and associated sediment deposition over the expected 35 year operational lifetime of the Morgan Generation Assets. The MDS describes the repair of up to 8km of inter-array cable in one event every three years, and up to 20km of interconnector cable in three events every 10 years. The MDS also describes the reburial of 20km of inter-array cable in one event every five years, and 3km of interconnector cable in one event every five years.

8.8.4.25 The magnitude of the impacts would be a fraction of those quantified for the construction phase. The sediment plumes and sedimentation footprints would be dependent on which section of the cable is being repaired and the kind of sediment that the repairs took place in however, for the purposes of this assessment, the impacts of the operations and maintenance activities (i.e. cable repair and reburial) are predicted to be no greater than those for construction.

8.8.4.26 The impact is predicted to be of local spatial extent, short term duration, intermittent and of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **negligible**.

Sensitivity of receptor

Marine species

8.8.4.27 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.4.10 to paragraph 8.8.4.18), ranging from **low to medium** sensitivity, and these will equally apply in the operations and maintenance phase.

Diadromous species

8.8.4.28 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.4.19 to paragraph 8.8.4.20), with **low** sensitivity, and this will equally apply in the operations and maintenance phase.

Significance of effect

Marine species

8.8.4.29 Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of most fish IEFs is considered to be low to medium. The effect will, therefore, be of **negligible or minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.4.30 Overall, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

8.8.4.31 Decommissioning of the Morgan Generation Assets infrastructure may lead to increases in SSCs and associated sediment deposition. The MDS states that if scour protection, cable protection and the suction caisson foundations were to be removed this would result in an increase in SSC.

8.8.4.32 The decommissioning of scour protection, cable protection and foundations, it is assumed, would result in increases in suspended sediments and associated deposition that was no greater than what was produced during construction. For the purpose of this assessment, the impacts of decommissioning activities are therefore predicted to be no greater than those for construction. In actuality, the release of sediment in the decommissioning phase will be lower than the construction phase as it doesn't include activities such as seabed drilling and seabed preparation.

8.8.4.33 The impact is predicted to be of local spatial extent, short term duration (for the individual decommissioning activities), intermittent and of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

Marine species

8.8.4.34 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.4.10 to paragraph 8.8.4.18), ranging from **low to medium** sensitivity, and these will equally apply in the decommissioning phase.

Diadromous species

8.8.4.35 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.4.19 to paragraph 8.8.4.20), with **low** sensitivity, and this will equally apply in the decommissioning phase.

Significance of effect

Marine species

8.8.4.36 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low to medium. The effect will, therefore, be of **negligible or minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.4.37 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

8.8.5 Long term habitat loss

8.8.5.1 The construction, operations and maintenance and decommissioning activities on the generation of the Morgan Generation Assets development may lead to long term habitat loss. The MDS is represented by the installation and presence of foundations, scour protection, cable protection, and cable crossing protection, and is summarised in Table 8.14. While this assessment considers long term habitat loss, in reality the impact will be represented not by a loss of habitat, but rather a change in a sedimentary habitat and replacement with hard artificial substrates (i.e. 'Physical change to another seabed type', as defined by MarESA). While the habitat loss effects are considered in this section, the potential for colonisation of these hard substrates by fish and shellfish IEFs is considered in section 8.8.7 below.

Construction phase

Magnitude of impact

8.8.5.2 The presence of the Morgan Generation Assets infrastructure within the Fish and Shellfish Ecology study area will result in long term habitat loss. The MDS is for up to 1,509,530m^2 of long-term habitat loss due to the installation of suction bucket 4-legged jacket foundations for wind turbines and OSPs, associated scour protection, cable protection, and cable crossing protection (Table 8.14). This represents 0.47% of the Morgan Generation Assets boundary.

8.8.5.3 Foundations and associated scour protection may account for up to 755,890m^2 of long-term habitat loss. Foundation protection and associated scour protection will be required for up to all 68 wind turbines and four OSPs in the Morgan Array Area.

8.8.5.4 Cable protection may account for up to 620,000m^2 of long-term habitat loss. The MDS assumes up to 10% of the inter-array cables and 20% of the interconnector cables would require cable protection with a cable protection width of 10m. Additionally, cable crossing protection may result in up to 133,640m^2 of long-term habitat loss. Cable protection may be required for 67 crossings for the inter-array cable, and 10 crossings for the interconnector cable.

8.8.5.5 Long term subtidal habitat loss impacts will occur during the construction phase and will be continuous and irreversible throughout the 35-year operations and maintenance phase.

8.8.5.6 The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible during the operations and maintenance phase. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

Marine species

8.8.5.7 Fish and shellfish species that are reliant upon the presence of suitable sediment/habitat for their survival are typically more vulnerable to change depending on the availability of habitat within the wider geographical region. The seabed habitats removed by the installation of infrastructure within the Morgan Array Area will reduce the amount of suitable habitat and available food resources for fish and shellfish species and communities associated with the baseline sediments, however this area represents a low percentage compared with the extensive nature of fish and shellfish habitats (e.g. for spawning, nursery, feeding or overwintering) located within the fish and shellfish ecology study area.

8.8.5.8 As confirmed by the detailed baseline characterisation (see section 8.4.2), the fish and shellfish ecology study area coincides with fish spawning and nursery habitats including plaice, sole, lemon sole, herring, sprat, European hake, ling, whiting, cod, haddock *Melanogrammus aeglefinus*, sandeel, horse mackerel *Trachurus trachurus*, mackerel, *Nephrops*, and a range of elasmobranchs (Coull *et al*., 1998; Ellis *et al*., 2012; Aires *et al*., 2014; see Table 8.10 and volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR).

8.8.5.9 The fish species most vulnerable to long-term habitat loss include sandeel and herring, which are demersal spawning species (i.e. eggs are laid on the seabed), as these have specific habitat requirements for spawning (e.g. sandy sediments for sandeel and coarse, gravelly sediments for herring). Demersal-spawning elasmobranchs tend to have low intensity spawning grounds in the fish and shellfish ecology study area (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR) which extend well beyond the project boundaries, and thus are unlikely to be significantly impacted by long-term habitat loss. The fish and shellfish ecology study area is also located in the vicinity of known high and low intensity herring spawning habitat (see section 8.4.2). These occur primarily outside the Morgan Generation Assets boundaries and therefore will not be negatively affected directly by long term habitat loss form project infrastructure.

8.8.5.10 Sandeel also have specific habitat requirements throughout their juvenile and adult life history, as well as being demersal spawners, and loss of this specific type of habitat through construction and presence of infrastructure could represent an impact on this species. However, monitoring at Horns Rev I, located off the Danish coast, has indicated that the presence of operational wind farm structures has not led to significant adverse effects on sandeel populations in the long term (van Deurs *et al*., 2012; Stenberg *et al*., 2011). Initial results of a pre- to post-construction monitoring study have reported that in some areas of the Beatrice Offshore Wind Farm, located in the northwest of the North Sea, there was an increase in sandeel abundance (BOWL, 2021a). The findings of a single monitoring study are not able to categorically confirm the conclusion that offshore wind developments are beneficial to sandeel populations; however, it does provide additional evidence that there is no adverse effect on sandeel populations.

8.8.5.11 The fish and shellfish ecology study area also coincides with high intensity sandeel spawning habitat (Ellis *et al*., 2012) as confirmed by benthic site-specific surveys (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR for habitat distribution and suitability). The presence of offshore wind farm infrastructure will result in direct impacts on this habitat within the Morgan Array Area, though as detailed above the proportion of habitat affected within the Morgan Generation Assets is small, and this area is smaller still in the context of the known sandeel habitats (including spawning and nursery habitats) and the potential sandeel habitats in the fish and shellfish ecology study area.

8.8.5.12 Monitoring at Belgian offshore wind farms has reported that fish assemblages undergo no drastic changes due to the presence of offshore wind farms (Degraer *et al*., 2020). They reported slight, but significant increases in the density of some common soft sediment-associated fish species (common dragonet *Callionymus lyra*, solenette, lesser weever *Echiichthys vipera* and plaice) within the offshore wind farm (Degraer *et al*., 2020). There was also some evidence of increases in numbers of species associated with hard substrates, including crustaceans (including edible crab), sea bass and common squid *Alloteuthis subulata* (potentially an indication that foundations were being used for egg deposition; Degraer *et al*., 2020). The author noted that these effects were site specific and therefore may not necessarily be extrapolated to other offshore wind farms, although this does indicate the presence of offshore wind farm infrastructure does not lead to adverse, population wide effects. More specific to the Irish Sea, the three years post-construction survey of introduced structures in the Waleny Extension Wind Farm found the development of mussel and barnacle communities around introduced structures (CMACS, 2014). This represents a changed species composition compared to the previous sedimentary communities, but this is unlikely to be highly significant in terms of ecosystem function, with only a slight overall reduction in biodiversity noted during post-construction surveys, with a slowly recovering trend towards baseline community diversity noted.

8.8.5.13 The Morgan Array Area also directly overlaps grounds considered important to fishing and spawning of the commercially important queen and king scallop (see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR for full details on known habitat distribution and suitability). Construction has the potential to directly damage these fishing and spawning grounds, but the potential is known to exist for recovery and increased maturity of the overall population due to decreased fishing pressure following completion of construction, with no significant change in resilience (Raoux *et al*., 2019). Long-term loss of habitat directly around the cables and wind turbines represent only a very small proportion of habitat within the fish and shellfish ecology study area, and so are unlikely to cause significant impacts on the wider scallop populations.

8.8.5.14 *Nephrops* spawning and nursery habitat overlaps with the entirety of the Morgan Array Area, with wider spawning habitats of undetermined intensity throughout the fish and shellfish ecology study area. Long-term habitat loss is predicted to affect a small proportion of this habitat. Levels of impact on *Nephrops* offshore Irish Sea fishing grounds are known to be correlated directly to the intensity and frequency of the disturbance event (Ball *et al*., 2000). As the proportion of the Morgan Generation Assets affected by long term habitat loss is small and the proportion of *Nephrops* habitat available elsewhere in the fish and shellfish ecology study area is high, the overall impact of long-term habitat loss is likely to be low.

8.8.5.15 Most fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.8.5.16 King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of regional importance. The sensitivity of the receptor is therefore considered to be **low**.

8.8.5.17 European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be **medium**.

8.8.5.18 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be **medium**.

8.8.5.19 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally give a medium sensitivity. However, the sensitivity of herring to this impact is considered to be **low**, due to the wide availability of suitable spawning sediments and alternative herring spawning ground close to the Morgan Array Area.

Diadromous species

8.8.5.20 Diadromous fish species are highly mobile and therefore are generally able to avoid areas subject to long term subtidal habitat loss. Diadromous species that are likely to interact with the fish and shellfish ecology study area are only likely to do so by passing through the area during migrations to and from rivers located on the west coast of

England and Wales (e.g. those designated sites with diadromous fish species listed as qualifying features; see Table 8.10 and volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR). The habitats within the fish and shellfish ecology study area are not expected to be particularly important for diadromous fish species and therefore habitat loss during the construction and operations and maintenance phases of the Morgan Generation Assets is unlikely to cause any direct impact to diadromous fish species and would not affect migration to and from rivers.

8.8.5.21 Indirect impacts on diadromous fish species may occur due to impacts on prey species, for example sandeel population impacts affecting food supplies to sea trout. As outlined previously for marine species, the majority of large fish species would be able to avoid habitat loss effects due to their greater mobility and would recover into the areas affected following cessation of construction. Sandeel (and other less mobile prey species) would be affected by long term subtidal habitat loss, although recovery of this species is expected to occur quickly as the sediments recover following installation of infrastructure and adults recolonise and also via larval recolonisation of the sandy and gravelly sediments which dominate the fish and shellfish ecology study area. These sediments are known to recover quickly following cable installation (RPS, 2019).

8.8.5.22 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.8.5.23 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.24 For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.25 For European lobster and *Nephrops*, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.26 For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.27 For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.5.28 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low to medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

8.8.5.29 The impacts of long-term habitat loss are likely to be identical to those introduced during the construction phase of the Morgan Generation Assets, with the impacts predicted to be continuous over the 35 year operational period.

8.8.5.30 The impact is predicted to be of local spatial extent, long term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

Marine species

8.8.5.31 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.5.7 to paragraph 8.8.5.18), ranging from **low to medium** sensitivity, and these will equally apply in the operations and maintenance phase.

Diadromous species

8.8.5.32 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.4.17 to paragraph 8.8.4.19), with **low** sensitivity, and this will decrease in the operations and maintenance phase due to intermittent and short term nature of activities.

Significance of effect

Marine species

8.8.5.33 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.34 For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.35 For European lobster and *Nephrops*, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.36 For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.37 For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.5.38 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The overlap of the effect with these receptors will be very low, and will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

8.8.5.39 Decommissioning will involve leaving the introduced scour protection, cable protection, and cable crossing protection in place, representing up to 1,453,250m^2 of permanent subtidal habitat loss.

8.8.5.40 The impact is predicted to be of local spatial extent, permanent and irreversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

Marine species

8.8.5.41 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.5.7 to paragraph 8.8.5.18), ranging from **low to medium** sensitivity, and these will equally apply in the decommissioning phase.

Diadromous species

8.8.5.42 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.4.17 to paragraph 8.8.4.20), with **low** sensitivity, and this will equally apply in the decommissioning phase.

Significance of effect

Marine species

8.8.5.43 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.44 For king and queen scallop, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.45 For European lobster and *Nephrops*, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.46 For sandeel, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.5.47 For herring, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.5.48 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.6 EMFs from subsea electrical cabling

8.8.6.1 The operations and maintenance activities on the transmission assets of the Morgan Generation Assets may lead to impacts from EMFs emitted from subsea electrical cabling. The MDS is represented by the presence and operation of inter-array and interconnector cables and is summarised in Table 8.14.

Operations and maintenance phase

Magnitude of impact

8.8.6.2 EMF comprise both the electrical fields, measured in volts per metre (V/m), and the magnetic fields, measured in microtesla (μT) or milligauss (mG). Background measurements of the magnetic field are approximately 50μT (i.e. 500mG) for example in the North Sea and Irish Sea (Tasker *et al.*, 2010; Eirgrid, 2015). It is common practice to block the direct electrical field using conductive sheathing, meaning that the only EMFs that are emitted into the marine environment are the magnetic field and the resultant induced electrical field. It is generally considered impractical to assume that cables can be buried at depths that will reduce the magnitude of the magnetic field, and hence the sediment-sea water interface induced electrical field, to below that at which these fields could be detected by certain marine organisms on or close to the seabed (Gill *et al*., 2005; Gill et al., 2009). By burying a cable, the magnetic field at the seabed is reduced due to the distance between the cable and the seabed surface as a result of field decay with distance from the cable (CSA, 2019).

8.8.6.3 A variety of design and installation factors affect EMF levels in the vicinity of the cables. These include current flow, distance between cables, cable insulation, number of conductors, configuration of cable and burial depth. The flow of electricity associated with an alternating current (AC) cable changes direction (as per the frequency of the AC transmission) and creates a constantly varying electric field in the surrounding marine environment (Huang, 2005).

8.8.6.4 The strength of the magnetic field (and consequently, induced electrical fields) decreases rapidly horizontally and vertically with distance from source. A recent study conducted by CSA (2019) found that inter-array and offshore export cables buried between depths of 1m to 2m reduces the magnetic field at the seabed surface four-fold. For cables that are unburied and instead protected by thick concrete mattresses or rock berms, the field levels were found to be similar to buried cables.

8.8.6.5 CSA (2019) investigated the link relationship between voltage, current, and burial depth, the results of which are presented in Table 8.25 which shows the magnetic and induced electric field levels expected directly over the undersea power cables and at distance from the cable for varying cable types. Directly above the cable, EMF levels decrease with increased distance from the seafloor to 1m above the cable, while laterally away from the cable (i.e. at distances greater than 3m), the magnetic fields at the seafloor and at 1m above the seafloor are comparable.

Table 8.25: Typical magnetic field levels over AC undersea power cables (buried at target depth of 0.9-1.8m) from offshore wind energy projects (CSA, 2019).

Power Cable Type	Magnetic Field Levels (mG)			
	Directly Above Cable		3 to 7.5 m laterally away from cable	
	1 m above seafloor	At seafloor	1 m above seafloor	At seafloor
Inter-Array	5 to 15	20 to 65	<0.1 to 7	<0.1 to 10
Power Cable Type	Magnetic Field Levels (mG)			
	Directly Above Cable		3 to 7.5 m laterally away from cable	
	1 m above seafloor	At seafloor	1 m above seafloor	At seafloor
Inter-Array	0.1 to 1.2	1.0 to 1.7	0.01 to 0.9	0.01 to 1.1

8.8.6.6 During the operations and maintenance phase of the project there will be up to 500km cables of 66kV to 132kV inter-array cables, and up to 60km of 275kV HVAC interconnector cable (Table 8.14). The minimum burial depth for cables will be 0.5m, and the operations and maintenance phase is expected to last up to 35 years.

8.8.6.7 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility (when the cables are decommissioned). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of receptor

Marine species

8.8.6.8 Fish and shellfish species (particularly elasmobranchs) are able to detect applied or modified magnetic fields. Species for which there is evidence of a response to E and/or B fields include elasmobranchs (shark, skate and ray); plaice (Gill *et al*., 2005; CSA, 2019), and crustaceans such as crab and lobster (Scott *et al*., 2021). It can be inferred that the life functions supported by an electric haptic sense (Caputi *et al*., 2013) may include detection of prey, predators or conspecifics in the local environment (Pedraja *et al*., 2018) to assist with feeding, predator avoidance, and 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, Formicki *et al*., 2019).

8.8.6.9 Studies examining the effects of EMF from AC undersea power cables on fish behaviours have been conducted to determine the thresholds for detection and response to EMF. Table 8.26 provides an up-to-date summary of the scientific studies conducted to assess sensitivity of EMF on varying fish species.

Table 8.26: Relationship between geomagnetic field detection electrosensitivity, and the ability to detect 50/60-Hz AC fields in common marine fish and shellfish species (adapted from CSA, 2019).

Species Group	Detect Geomagnetic Field	Detect Electric Field	Evidence from Laboratory Studies of 50/60-Hz EMF from AC Power Cables	Evidence from Field Studies of AC Power Cables
Skate	Yes, multiple species (Normandeau *et al.*, 2011)	Yes, multiple species (Normandeau *et al.*, 2011)	No responses expected at 60 Hz (Kempster *et al.*, 2013)	No attraction at California AC cable sites operating at up to 914mG (Love *et al.*, 2016).
Flounder	Potentially, due to observed orientation behaviours (Metcalfe *et al.*, 1993)	Not tested	Not tested	No population-level effects, but some evidence of delayed cable crossing. It is unclear whether effect was due to cable EMF or prior sediment disturbance (Vattenfall, 2006).
Tuna and mackerel	Yes, for some species (Walker, 1984)	Not tested (Normandeau *et al.*, 2011)	Not tested	Some evidence of attraction of mackerel to monopile structure, but no effect from cables (Bouma, 2008).
Lobster and crab	Yes, for some lobster species (Lohmann *et al.*, 1995; Hutchison *et al.*, 2018)	Not tested (Normandeau *et al.*, 2011)	No effect at 800,000 µT (Ueno *et al.*, 1986)	Distribution unaffected by 60-Hz AC cable operating up to 800mG (Love *et al.*, 2017).

8.8.6.10 A number of field studies have observed behaviours of fish and other species around AC submarine cables in the USA (see citations in Table 8.26). Observations at three energized 35-kV AC undersea power cable sites off the coast of California that run from three offshore platforms to shore, which are unburied along much of the route, did not show that fish were repelled by or attracted to the cables (Love *et al*., 2016). A study investigating the effect of EMF on lesser sandeel larvae spatial distribution found that there was no effect on the larvae (Cresci *et al*., 2022), and a prior study concluded the same for herring (Cresci *et al*.,2020).

8.8.6.11 Elasmobranchs (i.e. shark, skate and ray) are known to be the most electro-receptive of all fish. These species possess specialised electro-receptors which enable them to detect very weak voltage gradients (down to 0.5 µV/m) in the environment naturally emitted from their prey (Gill *et al*., 2005). Both attraction and repulsion reactions to electrical fields have been observed in elasmobranch species. Spurdog, an elasmobranch species known to occur within the fish and shellfish ecology study area, avoided electrical fields at 10 µV/cm (Gill and Taylor, 2001), although it should be noted that this level (i.e. 10 µV/cm is equivalent to 1,000 µV/m) is considerably higher than levels associated with offshore electrical cables. 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 a greater searching effort when the cables were switched on (Gill *et al*., 2009). However, the responses were not predictable and did not always occur (Gill *et al*., 2009). In another study, EMF from 50/60-Hz AC sources appears undetectable in elasmobranchs. Kempster and Colin (2011) have noted the physiological capacity for detection of EMFs in basking shark, known to migrate through the fish and shellfish ecology study area, but no current evidence exists on specific impacts of EMFs of any strength on this species, apart from the likely detection capacity of a standard electrical field benchmark level of 1V/m (Wilding et al., 2020). More generally, Kempster *et al. (*2013) reported that small shark could not detect EMF produced at 20 Hz and above, and Hart and Collin (2015) found no significant repellent effect of a magnetic field of 14,800 G (1.4T) on shark catch rates, suggesting a low sensitivity to these fields.

8.8.6.12 Crustacea, including lobster and crab, have been shown to demonstrate a response to B fields, with the Caribbean spiny lobster *Panulirus argus* shown to use a magnetic map for navigation (CSA, 2019). EMF exposure has been shown to result in varying egg volumes for edible crab compared to controls. Exposed larvae were significantly smaller, but there were no statistically significant differences in hatched larval numbers, deformities, mortalities, or fitness (Scott, 2019). Exposure to EMF has also been shown to affect a variety of physiological processes within crustaceans. For example, Lee and Weis demonstrated that EMF exposure affected moulting in fiddler crab (*Uca pugilator* and *Uca pugnax*) (Lee and Weis, 1980). Several studies have also suggested that EMFs affect serotonin regulation which may affect the internal physiology of crustaceans potentially leading to behavioural changes, although such changes have not been reported (Atema and Cobb, 1980; Scrivener, 1971).

8.8.6.13 Crab movement and location inside large cages has been reported to be unaffected by proximity to energized AC undersea power cables off south California and in Puget Sound, indicating crab also were not attracted to or repelled by energized AC undersea power cables that were either buried or unburied (Love *et al*., 2016), and no significant change in distance or speed of travel over time when American lobster *Homarus americanus* were exposed to 53-65 μT (Hutchison *et al*., 2020). However, studies on the Dungeness crab and edible crab have reported behavioural changes during exposure to increased EMF and both species showed increased activity when compared to crab that were not exposed (Scott *et al*., 2018; Woodruff *et al*., 2012). Crab may also spend less time buried, which is normally a natural predator avoidance behaviour (Rosaria and Martin, 2010), and some species have been noted not to cross undersea cables (Love *et al*., 2017), potentially reducing habitats available for predation.

8.8.6.14 It is uncertain if other crustaceans including commercially important European lobster and *Nephrops* are able to respond to magnetic fields in this way. Limited research undertaken with the European lobster found no neurological response to magnetic field strengths considerably higher than those expected directly over an average buried power cable (Normandeau *et al*., 2011; Ueno *et al*., 1986). A field study by Hutchison *et al*. (2018) observed the behaviour of American lobster (a magneto-sensitive species) to direct current (DC) and AC fields from a buried cable and found that it did not cause a barrier to movement or migration, as both species were able to freely cross the cable route. However, lobster were observed to make more turns when near the energised cable. Adult lobster have been shown to spend a higher percentage of time within shelter when exposed to EMF. European lobster exposed to EMF have also been found to have a significant decrease in egg volume at later stages of egg development and more larval deformities (Scott, 2020).

8.8.6.15 Scott *et al*. (2020) presents a review of the existing papers on the impact of EMF on crustacean species. Of the papers reviewed by Scott *et al*. (2020), three studied EMF effects on fauna in the field, the rest were laboratory experiments which directly exposed the target fauna to EMF (Scott *et al*., 2020). These laboratory experiments, while giving us an indication of crustacean behaviour to EMF, may be less applicable in the context of subsea cables in the marine environment. Of the field experiments, one demonstrated that lobster have a magnetic compass by tethering lobster inside a magnetic coil (Lohmann *et al*., 1995), one focused on freshwater crayfish and put magnets within the crayfish hideouts (Tański *et al*., 2005), and the last one looked at shore crab at an offshore wind farm and found no adverse impact on the population. The two former papers may not be directly applicable to offshore wind farm subsea cables and the latter found no adverse impact on the population of shore crab from the offshore wind farm (Langhamer *et al*., 2016).

8.8.6.16 Further research by Scott *et al.* (2021) found that physiological and behavioural impacts on edible crab occurred at 500 μT and 1000 μT, causing disruption to the L-Lactate and D-Glucose circadian rhythm and altering Total Haemocyte Count, and also causing attraction to EMF exposed areas and reduced roaming time. However, these physiological and behavioural effects did not occur at 250 μT. Seeing as even in the event of an unburied cable the maximum magnetic field reported was 78.27 μT (Normandeau *et al.*, 2011), it can be assumed that the magnetic fields generated by the Morgan cables will be lower than 250 μT, and therefore will not present any adverse effects on edible crab. Harsanyi *et al*. (2022) noted that chronic exposure to EMF effects could lead to physiological deformities and reduced swimming test rates in lobster and edible crab larvae. However, these deformities were in response to EMF levels of 2,800 μT and therefore are considerably higher than EMF effects expected for buried cables. The report recommends burying of cables in order to reduce any potential impacts associated with high levels of EMF in line with the designed in mitigation outlined in Table 8.16.

8.8.6.17 In summary, the range over which these species can detect electric fields is limited to a scale of metres around electrical cables buried to a target depth of 0.9-1.8m (CSA, 2019). Pelagic species generally swim well above the seafloor and can be expected to rarely be exposed to the EMF at the lowest levels from AC undersea power cables buried in the seafloor, resulting in impacts that would therefore be localised and transient. Demersal species (e.g. elasmobranchs) that dwell on the bottom, will be closer to the undersea power cables and thus encounter higher EMF levels when near the cable. Demersal species and shellfish are also likely to be exposed for longer periods of time and may be largely constrained in terms of location. However, the rapid decay of the EMF with horizontal distance (Bochert and Zettler, 2006) (i.e. within metres) minimises the extent of potential impacts. Finally, fish that can detect the Earth's magnetic field are unlikely to be able to detect magnetic fields produced by 50/60-Hz AC power cables and therefore these species are unlikely to be affected in the field (CSA, 2019).

8.8.6.18 Most marine fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.8.6.19 Decapod crustaceans and elasmobranchs in the fish and shellfish ecology study area are deemed to be of medium vulnerability, high recoverability, and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

Diadromous species

8.8.6.20 EMFs may also interfere with the navigation of sensitive diadromous species. Species for which there is evidence of a response to E and/or B fields include river lamprey, sea lamprey, European eel, and Atlantic salmon (Gill *et al*., 2005; CSA, 2019). Effects of EMFs surrounding undersea cables on allis shad, twaite shad and European smelt are currently poorly researched, with recommendations made to investigate these potential effects in future (Gill, *et al*., 2012; Sinclair *et al*., 2017; noting that shad species are pelagic and therefore unlikely to interact with EMF from installed cables). Lamprey possess specialised ampullary electroreceptors that are sensitive to weak, low frequency electric fields (Bodznick and Northcutt, 1981; Bodznick and Preston, 1983), which are hypothesised to be used for prey-detection, although further research is required in this area (Tricas and Carlston, 2012). 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 (i.e. adults did not move) when stimulated with electrical fields of intensities of between 2.5 and 100 mV/m, with normal behaviour observed at electrical field intensities higher and lower than this range. It should be noted, however, that these levels are considerably higher than modelled induced electrical fields expected from AC subsea cables (see Table 8.25). There is currently no evidence of lamprey responses to magnetic B fields (Gill and Bartlett, 2010).

8.8.6.21 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; CSA, 2019). Mark and recapture experiments undertaken at the Nysted operational offshore wind farm showed that eel did cross the offshore export cable (Hvidt *et al*., 2003). Studies on European eel in the Baltic Sea have highlighted some limited effects of subsea cables (Westerberg and Lagenfelt, 2008), with evidence of direct detection of EMF through the lateral line of this species (Moore and Riley, 2009). The swimming speed during migration was shown to change in 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 (i.e. on average 40 minutes) would not be likely to influence fitness in a 7,000km migration, with little to no impact on migratory behaviour noted beyond 500m from wind farm development infrastructure (Ohman *et al*., 2007). Research in Sweden on the effects of a High Voltage Direct Current (HVDC) cable on the migration patterns of a range of fish species, including salmonids, failed to find any effect (Westerberg *et al*., 2007; Wilhelmsson *et al*., 2010). Research conducted at the Trans Bay cable, a DC undersea cable near San Francisco, California, found that migration success and survival of chinook salmon (*Oncorhynchus tshawytscha*) was not impacted by the cable. However, as with the Hutchison *et al*. (2018) study on lobster, behavioural changes were noted when these fish were near the cable (Kavet *et al*., 2016) with salmon appearing to remain around the cable for longer periods. These studies demonstrate that while DC undersea power cables can result in altered patterns of fish behaviour, these changes are temporary and do not interfere with migration success or population health.

8.8.6.22 Table 8.27 provides a summary of the scientific studies conducted to assess sensitivity of EMF on varying diadromous fish species.

Table 8.27: Relationship between geomagnetic field detection electrosensitivity, and the ability to detect 50/60-Hz AC fields in diadromous fish species (adapted from CSA, 2019).

Species Group	Detect Geomagnetic Field	Detect Electric Field	Evidence from Laboratory Studies of 50/60-Hz EMF from AC Power Cables	Evidence from Field Studies of AC Power Cables
American/European Eel	Yes, for multiple species (Normandeau *et al.*, 2011)	Mixed evidence (Normandeau *et al.*, 2011)	No effect of 950mG magnetic field at 50 Hz on swim behaviour or orientation (Orpwood *et al.*, 2015)	Unburied AC cable did not prevent migration of eel (Westerberg *et al.*, 2007).
Salmon	Yes, for multiple species (Yano *et al.*, 1997, Putman *et al.*, 2014)	Not tested (Normandeau *et al.*, 2011)	No effect of 950mG magnetic field at 50 Hz on swim behaviour (Armstrong *et al.*, 2015)	Not surveyed.

8.8.6.23 Diadromous fish IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.8.6.24 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of most fish and shellfish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.6.25 The magnitude of impact on decapod crustaceans and elasmobranch IEFs is considered to be low, and the sensitivity is also low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.8.6.26 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of diadromous IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.7 Colonisation of hard structures

8.8.7.1 The construction and operations and maintenance activities on the generation assets and rock protection around the transmission assets will lead to colonisation of hard surfaces with consequent effects on fish and shellfish populations. The MDS is represented by the wind turbines, scour protection, cable protection, and cable crossing protection, and is summarised in Table 8.14. These are likely to continue beyond the decommissioning phase of the project if infrastructure is left in situ post decommissioning (discussed in further detail below).

Construction, operations and maintenance and decommissioning phases

Magnitude of impact

8.8.7.2 The MDS is for up to 1,995,525m^2 of habitat creation due to the installation of suction bucket jacket foundations, associated scour protection and cable protection associated with inter-array cables and interconnector cables as well as their associated crossings in subtidal habitats (Table 8.14). This equates to 0.62% of the Morgan Generation Assets area. In reality, the suction caisson jacket foundations will have a lattice design rather than a solid surface, which would result in a smaller surface area than has been assumed for the MDS It is expected that the foundations and scour and cable protection will be colonised by epifaunal species already occurring within the area (e.g. tunicates, bryozoans, mussel and barnacles which are typical of temperate seas), which will likely attract increased abundances of demersal and pelagic fish species through predation behaviours.

8.8.7.3 Decommissioning will involve removal of wind turbine foundations and cables, leaving cable and scour protections *in situ* on the seafloor. This equates to up to 1,208,497m^2 of residual hard substrata after removal of the wind turbine foundations and cabling.

8.8.7.4 A review by Degraer *et al*. (2020) explained the process by which wind turbine foundations are colonised and the vertical zonation of species that can occur. In general biofouling communities on offshore installations are dominated by mussel species, macroalgae, and barnacles near the water surface. This essentially creates a new intertidal zone, with filter feeding arthropods at intermediate depths; and anemones in deeper locations (De Mesel *et al*., 2015). Colonisation by these species will likely represent an increase in biodiversity and a change compared to the situation if no hard substrates were present (Lindeboom *et al*., 2011).

8.8.7.5 The introduction of new hard substrate will represent a shift in the baseline conditions from soft substrate areas (i.e. muds, sands and gravels) to hard substrate in the areas where infrastructure is present. This may produce some potentially beneficial effects, for example the likely increase in biodiversity and individual abundance of reef species and total number of species over time, as observed at the monopile foundations installed at Lysekil research site (a test site for offshore wind-based research, north of Gothenburg, Sweden) (Bender *et al*., 2020). Additionally, the increased structural complexity of the substrate may provide refuge as well as increasing feeding opportunities for larger and more fish and shellfish mobile species (Langhamer and Wilhelmsson, 2009), with an expected increase in ecosystem carrying capacity (Andersson and Ohman, 2010). This effect can also be applied to jacket foundations, wherein a study by Lefaible *et al*. (2019) identified that jacket foundations had higher densities and species richness in closer vicinity to the wind turbines compared to a control and a monopile foundation. A study of gravity based foundations in the Belgian part of the North Sea by Mavraki *et al.* (2020), found that higher food web complexity was associated with zones of high accumulation of organic material, such as soft substrate or scour protection, suggesting potential reef effect benefits from the presence of the hard structures.

8.8.7.6 The reef effect may be enhanced by the deposition of fouling material on the seabed. An investigation conducted at the research platform Forschungsplattformen in Nord- und Ostsee 1 FINO 1 in the southwest German Bight in the North Sea reported that yearly, 878,000 single shell halves from blue mussel (*Mytilus edulis*) sink onto the seabed from the FINO 1 platform, thereby greatly extending the reef effects created by the construction of the offshore platform structure (Krone *et al*., 2013). Removal of marine growth from the regularly licenced wind turbine foundation cleaning and maintenance may also cause debris to fall within the vicinity of the wind turbine foundation. It is likely that seaweed/algal material would disperse into the water column, with heavier material (e.g. mussel) being deposited within 10m to 15m of the foundation. This material has the potential to change the prevailing sediment type in the immediate vicinity of the wind turbines, and therefore extending the reef effect. These processes have been noted to increase abundances of reef-related fish species around offshore wind farm structures (Bergstrom *et al*., 2013).

8.8.7.7 The attraction of fish and shellfish species to installed hard structures is supported by the first year's monitoring from Beatrice offshore wind farm (APEM, 2021) which noted fish and shellfish at the base of foundations although no biological material was recorded on the seabed. Material may be rapidly consumed by organisms or relocated due to tidal currents and further monitoring will be required to clarify if biological material builds up over time (APEM, 2021). Any additional effects up the food chain in relation to marine mammals (volume 2, chapter 9: Marine mammals of the PEIR) and ornithology (volume 2, chapter 10: Offshore ornithology of the PEIR) will be considered in their individual chapters.

8.8.7.8 The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible during the lifetime of the Morgan Generation Assets. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of receptor

Marine species

8.8.7.9 Hard substrate habitat created by the introduction of wind turbine 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), with more complex communities later likely attracted to the developing algal and suspension feeder communities as potential new sources of food (Karlsson *et al*., 2022). Continued colonisation has been seen for a number of years after the initial construction, until a stratified recolonised population is formed (Krone *et al*., 2013), subject to natural seasonal variability, but still representing a significant change from the baseline sedimentary environment (Kerckhof, *et al*., 2010). Feeding opportunities or the prospect of encountering other individuals in the newly introduced heterogenous environment (Langhamer, 2012) may attract fish aggregations from the surrounding areas, which may increase the carrying capacity of the area in the long term (Andersson and Öhman, 2010; Bohnsack, 1989).

8.8.7.10 The dominant natural substrate character of the fish and shellfish ecology study area (largely sandy gravel and gravelly sand) 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 typically high diversity 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), especially in the case of scour protection, which can up to double the number of crustaceans found near wind turbine foundations compared to wind turbines with no scour protection (Krone *et al*., 2017). Conversely, when placed on a soft seabed, as will occur in this case, 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 recolonisation, and the original soft-bottom population will be displaced (Desprez, 2000). This was observed in studies by Leonhard *et al*. (Danish Energy Agency, 2012) at the Horns Rev offshore wind farm, and Bergström *et al*. (2013) at the Lillgrund offshore wind farm, where an increase in fish species associated with reef structures was noted, and similar trends were seen in the Walney Extension three years post-construction colonisation study (CMACS, 2014).

8.8.7.11 Impacts on demersal fish and shellfish communities are varied, with the original sandy-bottom fish population near the Lillgrund offshore wind farm reported to be displaced by introduced hard substrate communities (Danish Energy Agency, 2012). However, a decrease in soft sediment species is contradictory to findings of Degraer *et al*. (2020) where an increase in density of soft sediment species was seen, although this increase may be related to reduced fishing pressure within the array. These increases may only be site-specific and cannot be extrapolated to applying to all introduced hard structures without further research. However, a recent review (Dunkley and Solandt, 2022) has found that rates of bottom-towed fishing has decreased by 77% in almost all investigated offshore wind farm sites, with associated protection of demersal and pelagic fish and shellfish populations. Further, a meta-analysis by Gill et al., (2021) found no evidence of negative impacts from offshore wind farm construction and associated hard structure introduction on a range of demersal and pelagic fish, with positive effects in terms of increased biomass and abundance noted for shellfish.

8.8.7.12 The longest monitoring programme conducted to date at the Lillgrund offshore wind farm in the Öresund Strait in south Sweden, showed no overall increase in fish numbers, although redistribution towards the foundations within the offshore wind farm area was noticed for some species (i.e. cod, 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. Overall, results from earlier studies reported in the scientific literature did not provide robust data (e.g. 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 recolonisation in a more quantitative manner (Bouma and Lengkeek, 2012; Krone *et al*., 2013), with hard substrates consistently increasing species richness in the long term, but changing species composition towards a shellfish-dominated hard substrate community, thus having an impact of local ecological function (Coolen, *et al*., 2020).

8.8.7.13 There is some uncertainty as to whether artificial reefs facilitate recruitment in the local population, or whether the effects are simply a result of concentrating biomass from surrounding areas (Inger *et al*., 2009). Linley *et al*. (2007) concluded that finfish species were likely to have a neutral to beneficial likelihood of benefitting, which is supported by evidence demonstrating that abundance of fish can be greater within the vicinity of wind turbine foundations than in the surrounding areas (Wilhelmsson *et al*., 2006a; Inger *et al*., 2009), with increases in species richness noted in some studies (Coolen *et al*., 2020). A number of studies on the effects of vertical structures and offshore wind farm structures on fish and benthic assemblages have been undertaken in the Baltic Sea (Wilhelmsson *et al*., 2006a; 2006b). These studies have shown evidence of increased abundances of small demersal fish species in the vicinity of structures, most likely due to the increase in abundance of epifaunal communities which increase the structural complexity of the habitat (e.g. mussel and barnacles *Cirripedia spp*.).

8.8.7.14 It was speculated that in true marine environments, such as the north Irish Sea, offshore wind farms may enhance local species richness and diversity, with small demersal species such as gobies or sandeel providing prey items for larger, commercially important species including cod (which have been recorded aggregating around vertical steel constructions in the North Sea; Wilhelmsson *et al*., 2006a), and other pelagic species, although only in the direct vicinity of the altered habitats (Andersson, 2011). Monitoring of fish populations in the vicinity of an offshore wind farm off the coast of the Netherlands indicated that the offshore wind farms acted as a refuge for at least part of the cod population (Lindeboom *et al*., 2011; Winter *et al*., 2010). Similarly, horse mackerel, mackerel, herring, and sprat have been found to utilise the new hard substrate for spawning, or predation on the newly developed community (Glarou *et al*., 2020).

8.8.7.15 In contrast, post construction fisheries surveys conducted in line with the Food and Environmental Protection Act (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, 2009; BOWind, 2008). These suggested that any effects, if seen, are likely to be highly localised and while of uncertain duration, the evidence suggests effects are not necessarily adverse, although uncertainty does exist surrounding this issue.

8.8.7.16 It is likely that the greatest potential for beneficial effects exist for crustacean species, such as crab and lobster, due to expansion of their natural habitats (Linley *et al*., 2007) and the creation of additional heterogenous hard substrate refuge areas. Where foundations and scour protection are placed within areas of sandy and coarse gravelly sediments, this will represent novel habitat and new potential sources of food in these areas and could potentially extend the habitat range of shellfish species such as edible crab, which strongly associate with wind farm foundations (Hooper and Austen, 2014). Post-construction monitoring surveys at the Horns Rev offshore wind farm in the North

Sea noted that the hard substrates were used as a hatchery or nursery grounds for several species and was particularly successful for edible crab (BioConsult, 2006). They concluded that crustacean larvae and juveniles rapidly invade the hard substrates from the breeding areas (BioConsult, 2006). As both crab and lobster are commercially exploited in the vicinity of the fish and shellfish ecology study area, there is potential for benefits to the fisheries, depending on the materials used in construction of the offshore wind farm.

8.8.7.17 Other shellfish species, such as mussel species, have the potential for great expansion of their normal habitat due to increased hard substrate in areas of sandy habitat. Krone *et al. (*2013) coined the term 'Mytilusation' to describe this mass biofouling process recorded at a platform in the German Bight, North Sea. It was found that over a three year period, almost the entire vertical surface of area of the platform piles had been colonised by three key species blue mussel, the amphipod *Jassa spp*. and anthozoans (mainly *Metridium senile*, the plumose anemone). These three species were observed to occur in depth-dependant bands, attracting pelagic fish species such as horse mackerel in large numbers. As discussed above, layers of shell detritus were visible at the base of the foundations due to the mussel populations above, and both velvet swimming crab and edible crab were recorded here, which shows potential benefits to these existing IEF species within the Morgan Array Area.

8.8.7.18 The colonisation of new habitats may also potentially lead to the introduction of INNS, which may have indirect adverse effects on shellfish populations as a result of competition. The site-specific benthic survey around the Morgan Generation Assets identified no INNS as being currently present. However, this dataset is limited and cannot be used to draw conclusions about the entire fish and shellfish ecology study area, with the potential for INNS to currently be present or be introduced during the course of the construction and operations and maintenance phases. There is little evidence of adverse effects on fish and shellfish IEFs resulting from colonisation of other offshore wind farms by INNS. The post construction monitoring report for the Barrow offshore wind farm demonstrated no evidence of INNS on or around the monopiles (EMU, 2008a), and a similar study of the Kentish Flats monopiles only identified slipper limpet *Crepidula fornicata* (EMU, 2008b). A study into the spread of INNS by wind farm hard substrate colonisation suggested the risk of this occurring was minor, and requires more research to fully understand, with implementation of precautionary built-in measures recommended to prevent spread where possible (Lasram *et al*., 2019). The impact of INNS on seabed habitats is further discussed and assessed in volume 2, chapter 7: Benthic subtidal ecology of the PEIR.

8.8.7.19 Marine fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, and local to national importance (recoverability is not relevant to this impact during the operations and maintenance phase). The sensitivity of the receptor is therefore, considered to be **low**.

Diadromous species

8.8.7.20 Diadromous species that are likely to interact with the fish and shellfish ecology study area are only likely to do so by passing through the area during migrations to and from rivers flowing into the east Irish Sea (i.e. on the west coast of England, southwest coast of Scotland and north coast of Wales), with these sites designated based on the presence of diadromous fish species (see section 8.4.3). In most cases, it is expected that diadromous fish are unlikely to utilise the increase in hard substrate within the fish and shellfish ecology study area for feeding or shelter opportunities as they are only likely to be in the vicinity when passing through during migration.

8.8.7.21 However, there is potential for impacts upon diadromous fish species resulting from increased predation by marine mammal species within offshore wind farms. Tagging of harbour seal *Phoca vitulina* and grey seal *Halichoerus grypus* around Dutch and UK windfarms provided significant evidence that the seal species were utilising wind farm sites as foraging habitats (Russell *et al*., 2014), specifically targeting introduced structures such as wind turbine foundations. However, a further study using similar methods concluded that there was no change in behaviour within the wind farm (McConnell *et al*., 2012), so it is not certain exactly to what extent seals utilise offshore wind developments overall. More site-specific data from the north Irish Sea has found that harbour porpoise and grey seal also utilise wind farm areas for feeding (Goold, 2008), suggesting a potential risk of foraging on diadromous species around the infrastructure within the Morgan Array Area. However, due to the small spatial and temporal overlaps between foraging behaviour and diadromous migrations, it is unlikely that this would result in significant increased predation on diadromous species. Research has shown that Atlantic salmon smolts spend little time in the coastal waters, and instead are very active swimmers in coastal waters, making their way to feeding grounds quickly (Gardiner *et al*., 2018a; Gardiner *et al*., 2018a; Newton *et al*., 2017; Newton *et al*., 2019; Newton *et al*., 2021; see volume 4, annex 8.1: Fish and shellfish ecology technical report of the PEIR for further detail on Atlantic salmon migration). Due to the evidence that Atlantic salmon tend not to forage in the coastal waters, it is unlikely that they will spend time foraging around wind turbine foundations and therefore are at low risk of impact from increased predation from seals and other predators.

8.8.7.22 Sea trout may be at higher risk of increased predation from seals than Atlantic salmon due to their higher usage of coastal environments. Sea trout are generalist, opportunistic feeders with their diet comprising mainly of fish, crustaceans, polychaetes and surface insects with the proportion of each of these prey categories varying dependent on season (Rikardsen *et al*., 2006; Knutsen *et al*., 2001). Due to the potential for increase in juvenile crustacean species and other shellfish species which are potential prey items from sea trout, it is possible that foraging sea trout may be attracted to the hard substrates introduced by installation of the Morgan Generation Assets. This attraction could in turn lead to increased predation of seal species upon sea trout species. However, there is little evidence at present documenting an increased abundance of sea trout around wind turbine foundations (increases in fish abundance tend to be hard bottom dwelling fish species), therefore the above effect of increased prey items attracting sea trout is only theoretical. Further, the Morgan Array Area is situated in an area of both low and high intensity sandeel spawning, and it is likely that sandeel will make up a considerable proportion of sea trout diet when in the marine environment (Svenning *et* al., 2005; Thorstad *et al.,* 2016*)*. Sandeel species are unlikely to be directly associated with introduced hard structures due to sandy habitat preferences (largely outside the Morgan Array Area). Therefore, sea trout may be less likely to be attracted to the increased prey availability colonised on hard substrates, given there is an existing abundance of prey species which are not associated with hard structure communities.

8.8.7.23 The low risk of effects on diadromous fish species extends to the freshwater pearl mussel, which has part of its life stage that is reliant on diadromous fish species including Atlantic salmon and sea trout, and the potential of impact on these species is low.

8.8.7.24 Sea lamprey are parasitic in their marine phase, feeding off larger fish and marine mammals (Hume, 2017). As such it is not expected that they will be particularly attracted to structures associated with offshore wind developments. However, this is not certain, as there is limited information available on the utilisation of the marine environment by sea lamprey.

8.8.7.25 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.8.7.26 Sea trout are deemed to be of medium vulnerability, high recoverability and national importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.8.7.27 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of all fish and shellfish IEFs is considered to be low. The effect will, therefore, be of **minor adverse** significance, at worst, which is not significant in EIA terms.

8.8.7.28 As outlined above, there is potential for beneficial effects to certain fish and shellfish IEFs, although there are uncertainties as to which species in particular would benefit and the significance of this positive effect.

Diadromous species

8.8.7.29 The magnitude of the impact is deemed to be low, and the sensitivity of all diadromous fish species is considered to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.8 Injury due to increased risk of collision with vessels

8.8.8.1 Guidance provided by National Oceanic and Atmospheric Administration (NOAA) has defined serious injury to basking shark and marine mammals as ‘any injury that will likely result in mortality’ (NMFS, 2005). NMFS clarified its definition of ‘serious injury’ in 2012 and stated their interpretation of the regulatory definition of serious injury as any injury that is ‘more likely than not’ to result in mortality, or any injury that presents a greater than 50% chance of death to the basking shark or marine mammal (NMFS, 2012; Helker *et al*., 2017). Non-serious injury is likely to result in short-term impacts and may also have long-term effects on health and lifespan.

8.8.8.2 Collisions of vessels with basking shark have the potential to result in both fatal and non-fatal injuries (Darling and Keogh, 1994), with these collisions being known to occur relatively frequently (Scott and Gisborne, 2006). The potential therefore exists for collisions with basking shark in any vessel activities throughout the lifetime of the Morgan Generation Assets.

Construction phase

Magnitude of impact

8.8.8.3 Vessel traffic associated with the Morgan Generation Assets has the potential to lead to an increase in vessel movements within the fish and shellfish ecology study area. This increase in vessel movement could lead to an increase in interactions between basking shark and vessels during offshore construction, with vessels travelling at higher speeds (>7m/s) pose a higher risk because of the potential for a stronger impact (Schoeman *et al*., 2020). Except for CTVs, vessels involved in the construction phase are likely to be travelling considerably slower than this, and all vessels will be required to follow a Project offshore Environmental Management Plan. The offshore Environmental Management Plan outlines instructions for vessel behaviour and vessel operators, including advice to operators to not deliberately approach basking shark and to avoid sudden changes in course or speed. Therefore, with the Morgan Generation Assets designed in measures in place, the risk of collision is anticipated to be reduced and would only be present for transiting vessels (as opposed to stationary).

8.8.8.4 Vessel traffic associated with the construction activities will result in an increase in vessel movements within the fish and shellfish ecology study area as up to 1,878 return trips by construction vessels may be made throughout the construction phase (Table 8.14). This could lead to an increase in interactions between basking shark and up to 63 construction vessels on site at any one time over the potential four-year construction period. A proportion of vessels involved in construction will be relatively small in size (e.g. tugs, vessels carrying ROVs, crew transfer vessels, dive boats, barges and RIBs) and due to good manoeuvrability able to move to avoid basking shark, when detected (Schoeman *et al*., 2020). Larger vessels with lower manoeuvrability may need larger distances to avoid an animal, however they will also be travelling at slower speeds and have more time to react when basking shark are detected. In addition, the noise emissions from vessels involved in the construction phase are likely to deter animals from the potential zone of impact. The vessel movements will be contained within the Morgan Array Area and will follow existing shipping routes to and from the ports.

8.8.8.5 The impact is predicted to be of local spatial extent, medium term duration, intermittent and, whilst the risk will only occur during vessel transits, the effect of collision on sensitive receptors is of medium to low reversibility (depending on the extent of injuries). It is predicted that the impact will affect the receptor directly. With designed-in measures in place the risk of collision will be reduced, however, given the potential for a collision to lead to injury the magnitude is, conservatively, considered to be **low**.

Sensitivity of receptor

8.8.8.6 Basking shark and other large animals are generally able to detect and avoid vessels, however, it is unclear why some individuals do not always move out of the path of an approaching vessel (Schoeman *et al*., 2020). It has been suggested that behaviours such as resting, foraging, nursing, and socialising could distract these animals from detecting the risk posed by vessels (Dukas, 2002), as well as their need to spend time near the surface for feeding (Pirotta *et al*., 2018). There can be consequences to a lack of response to disturbance, in terms of behavioural habituation that can result in decreased wariness of vessel traffic, which has the potential to result in an increased collision risk (Cates *et al*., 2017).

8.8.8.7 There have been 63 reports of vessel collisions with basking shark over a 21-year study period within the vicinity of the Irish Sea (Solandt and Chassion, 2013), although it is possible that mortality from vessel strikes is under-recorded (Van Waerebeek *et al*., 2007). Therefore, any predicted vessel collisions may be an underestimate of the true number within the fish and shellfish ecology study area. This should be considered in the context of the nearby IoM territorial waters, where the designated MNRs have been identified as an area of potential conservation importance for migrating basking sharks (Dolton *et al*., 2020). However, it should be noted that no basking shark were observed during 12 months of aerial surveys of the Morgan Array Area and as such, although they are known to occur in the area, there is no evidence to demonstrate that the Morgan Generation Assets is particularly important for basking shark, therefore reducing the potential for collision risk.

8.8.8.8 Individual basking shark tend to show distressed behaviour and avoidance tendencies when disturbed by vessels (Bloomfield and Solandt, 2008). If physical impact does occur, the injuries can potentially be significant, although long-term monitoring has noted successful healing of wounds from propellor injuries (Speedie *et al*., 2009) and ship collisions (Solandt and Chassion, 2013), with negative impacts only seen after repeated direct exposure to disturbance and damage (Kelly *et al*., 2004). Due to the implementation of an offshore Environmental Management Plan for all vessels, this repeated exposure and damage is unlikely to occur in this case, with any collisions unlikely to be lethal at the speeds most vessels are travelling.

8.8.8.9 The basking shark within the Morgan Fish and Shellfish Ecology Area are deemed to be of low vulnerability, medium recoverability, and international importance. The sensitivity of the receptor, therefore, is considered to be **medium**.

Significance of effect

8.8.8.10 The magnitude of the impact is deemed to be low, and the sensitivity of basking shark is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Operations and maintenance phase

Magnitude of impact

8.8.8.11 Vessel usage during operations and maintenance phase of the Morgan Generation Assets may lead to injury to basking shark due to collision with vessels. Vessel types which will be required during the operations and maintenance phase include those used during routine inspections, repairs and replacement of equipment, major component replacement, painting or other coatings, removal of marine growth, replacement of access ladders, and geophysical surveys (Table 8.14).

8.8.8.12 Any on-site activities will require vessel transit, with up to 16 vessels present at any one time, and a maximum licenced 1,970 vessel movements to and from the site per year, with most of these being CTVs. Over the predicted 35-year lifetime of the Morgan Generation Assets, this could lead to a maximum of 68,950 vessel movements overall, with each representing a collision risk to basking shark. However, implementation of the offshore Environmental Management Plan and any other designed-in measures will limit the risk of these collisions, and the decreased number of vessels on-site at any one time will likely reduce the risk further when compared to the construction activities.

8.8.8.13 The impact is predicted to be of local spatial extent, long term duration, intermittent, and of medium to low reversibility if collision occurs. It is predicted that the impact will affect the receptor directly. With designed-in measures in place, collision risk will be reduced, but the long-term duration of the operations and maintenance activities makes the magnitude of this impact **low**.

Sensitivity of receptor

8.8.8.14 The sensitivity of the basking shark can be found in the construction phase assessment (paragraph 8.8.8.6 to paragraph 8.8.8.10), with **medium** sensitivity, and this will equally apply in the operations and maintenance phase.

Significance of effect

8.8.8.15 The magnitude of the impact is deemed to be low, and the sensitivity of basking shark is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

8.8.8.16 Vessel movements during the decommissioning phase may potentially lead to collision risks with basking shark. Activities during this phase are expected to be a reversal of the construction phase, with similar or identical vessel numbers and movements as are already covered in the construction assessment.

8.8.8.17 The impact is predicted to be of local spatial extent, medium term duration, intermittent, and of medium to low reversibility if collision occurs. It is predicted that the impact will affect the receptor directly. With designed-in measures in place the risk of collision will be reduced, however, given the potential for a collision to lead to injury the magnitude is, conservatively, considered to be **low**.

Sensitivity of receptor

8.8.8.18 The sensitivity of the basking shark can be found in the construction phase assessment (paragraph 8.8.8.6 to paragraph 8.8.8.10), with **medium** sensitivity, and this will equally apply in the decommissioning phase.

Significance of effect

8.8.8.19 The magnitude of the impact is deemed to be low, and the sensitivity of basking shark is considered to be medium. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.8.9 Future monitoring

8.8.9.1 No fish and shellfish ecology monitoring to test the predictions made within the impact assessment is considered necessary at this stage.

8.9 Cumulative effect assessment methodology

8.9.1 Methodology

8.9.1.1 The CEA takes into account the impact associated with the Morgan Generation Assets together with other projects and plans. The projects and plans selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise (see volume 3, annex 5.1: Cumulative effects screening matrix of the PEIR). Each project has been considered on a case-by-case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

8.9.1.2 The fish and shellfish ecology CEA methodology has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. As part of the assessment, all projects and plans considered alongside the Morgan Generation Assets have been allocated into 'tiers' reflecting their current stage within the planning and development process, these are listed below. Broadly, the approach to identifying projects considered in the fish and shellfish ecology CEA is consistent with that taken for subtidal and intertidal ecology (i.e. screening projects to a range of 50km for additive effects) and physical processes (i.e. screening projects within two tidal excursions). However, for underwater noise during the construction phase, a larger buffer of 100km from the Morgan Generation Assets has been used to screen projects to account for the greater zone of influence associated with construction noise (specifically piling).

8.9.1.3 A tiered approach to the assessment has been adopted, as follows:

- Tier 1: the Morgan Generation Assets considered alongside projects which are or have:
  - Under construction
  - Permitted application
  - Submitted application
  - Those currently operational that were not operational when baseline data were collected.
- Tier 2: the Morgan Generation Assets considered alongside Tier 1 projects, as well as projects where:
  - Scoping report has been submitted and is in the public domain
- Tier 3: the Morgan Generation Assets considered alongside Tier 1 and Tier 2 projects, as well as projects where:
  - Scoping report has not been submitted and is not in the public domain
  - Identified in the relevant Development Plan
  - Identified in other plans and programmes.

8.9.1.4 This tiered approach is adopted to provide a clear assessment of the Morgan Generation Assets alongside other projects, plans and activities.

8.9.1.5 The specific projects, plans and activities scoped into the CEA, are outlined in Table 8.28 and shown in Figure 8.8.

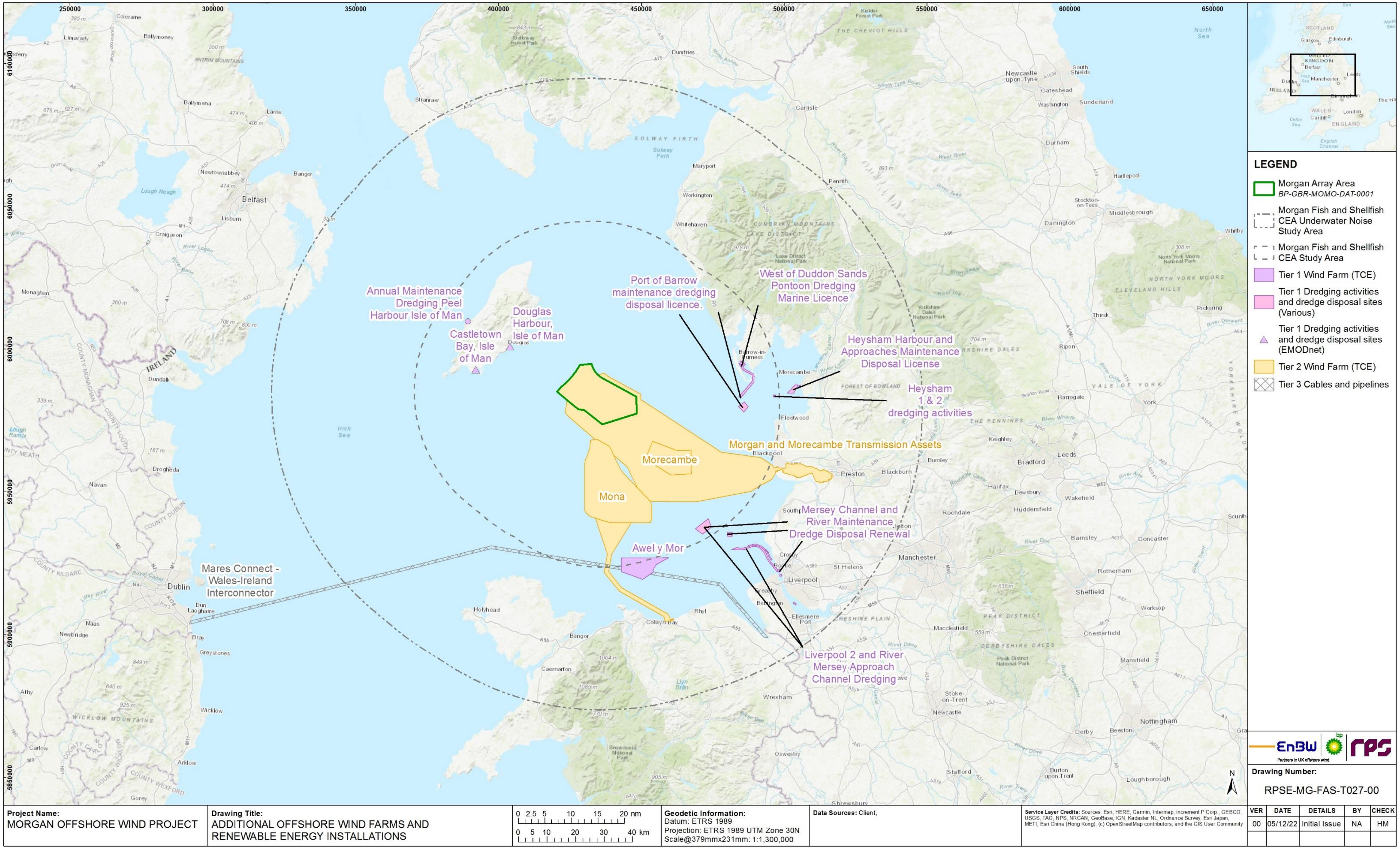
8.9.1.6 A number of the impacts considered for the Morgan Generation Assets alone, as outlined in Table 8.14 and section 8.8, have not been considered within the CEA due to the localised and temporally restricted nature of these impacts. These impacts include:

- Disturbance/remobilisation of sediment-bound contaminants in all phases
- Temporary habitat loss/disturbance – operations and maintenance phase
- Increase in suspended sediment concentrations and associated deposition – operations and maintenance phase.

Table 8.28: List of other projects, plans and activities considered within the CEA.

Project/Plan	Status	Distance from the Morgan array area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Morgan Generation Assets	**-**	**-**	**Base case (section 8.6.1) for comparison to other scoped in projects**	**Q1 2026 – Q4 2029**	**Q1 2030 – Q4 2065**	**-**
Tier 1-						
Offshore renewables projects						
Awel y Môr Offshore Wind Farm	Application Submitted	46.8	Up to 100MW (48 to 91 wind turbines)	2026 - 2030	2030 - 2055	The construction, operations and maintenance and decommissioning phases of this project will overlap with the construction and operations and maintenance of the Morgan Generation Assets.
Dredging activities and dredge disposal sites						
Douglas Harbour, Isle of Man	Operational	22.7	Dredging to deepen harbour channels and capital dredging in front of the proposed terminal to create a berth pocket.	n/a	2016 - 2031	Dredging and disposal activities associated with this project will overlap with the construction and operations and maintenance phases of the Morgan Generation Assets.
Castletown Bay, Isle of Man	Operational	29.46	Maintenance Harbour Dredging, 1995, Sea Disposal. Extracted amounts: 249 tonnes	n/a	2022-2037	Dredging and disposal activities associated with this project will overlap with the construction and operations and maintenance phases of the Morgan Generation Assets.
Port of Barrow maintenance dredging disposal licence (MLA/2015/00458/1)	Operational	35.9	Dredging is required to maintain the Port of Barrow and its approach channel at its advertised navigational depth for all vessels entering and leaving the port.	n/a	2016 -2026	Dredging and disposal activities associated with this project will overlap with the construction phase of the Morgan Generation Assets.
West of Duddon Sands Pontoon Dredging Marine Licence	Operational	38.4	Sedimentation can cause the pontoon edge adjacent to the harbour wall to be raised during spring low tides. The scope of the marine licence application covers dredging which will be required annually based on the current observed rates of accumulation.	n/a	2018 - 2028	The operations and maintenance activities associated with this project will overlap with the construction phase of the Morgan Generation Assets.
Annual Maintenance Dredging Peel Harbour Isle of Man	Operational	39.7	Capital harbour dredging, and maintenance dredging. Extracted amount: 400,000m^3 annually.	n/a	2022 - 2037	The operations and maintenance activities associated with this project will overlap with the construction and operations and maintenance phases of the Morgan Generation Assets.
Liverpool 2 and River Mersey Approach Channel Dredging	Operational	44.5	Marine licence for a new ferry terminal and associated infrastructure. Infill of dock area of 20,000m^3 for West waterloo dock and 4,000m^3 for Princes half-tide dock.	n/a	2019-2028	The operations and maintenance activities associated with this project will overlap with the construction phase of the Morgan Generation Assets.
Mersey channel and river maintenance dredge disposal renewal (MLA/2021/00202)	Operational	44.5	The Mersey Docks and Harbour Company Ltd, as the Harbour Authority for the Port of Liverpool has an obligation to dredge the approaches to Liverpool in order to maintain navigation into the Mersey Estuary for all river users.	n/a	2021 - 2031	Dredging and disposal activities associated with this project will overlap with the construction and operations and maintenance phases of the Morgan Generation Assets.
Heysham 1 & 2 dredging activities	Operational	47.8	Maintenance at cooling water outflows for nuclear power station. Dredging of up to 150,000m^3 silt and 6000,000m^3 sand. Disposal of up to 28,000m^3 per year.	n/a	2017 - 2027	The operations and maintenance activities associated with this project will overlap with the construction phase of the Morgan Generation Assets.
Heysham Harbour and Approaches Maintenance Disposal License	Operational	48.1	Dredging of up to 356,714m^3 of sand and 235,058m^3 of silt at Heysham Harbour, and up to 293,764m^3 of sand at Heysham Approaches. Disposal of silt and sand.	n/a	2017-2027	The operations and maintenance activities associated with this project will overlap with the

Project/Plan	Status	Distance from the Morgan array area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
						construction phase of the Morgan Generation Assets.
Tier 2-						
Offshore renewables projects						
Mona Offshore Wind Farm	Pre-application	5.5	1.5 GW (Up to 107 wind turbines)	2028 - 2029	2030 - 2065	The construction, operations and maintenance and decommissioning phases of this project will overlap with the construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets.
Morecambe Offshore Windfarm Generation Assets	Pre-application	11.2	12 -24MW (Up to 40 wind turbines)	2026 - 2028	2029 -2089	The construction, operations and maintenance and decommissioning phases of this project will overlap with the construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets.
Cables and pipelines						
Morgan and Morecambe Offshore Wind Farms Transmission Assets	Pre-application	11.24	Morgan and Morecambe Offshore Wind Farms Transmission Assets	2026 - 2028	2029 - 2064	Project construction phase overlaps with Morgan Generation Assets construction phase.
Tier 3-						
Cables and pipelines						
MaresConnect – Wales-Ireland Interconnector Cable	Permitted but not yet implemented	48.2	A proposed 750MW subsea and underground electricity interconnector system linking the existing electricity grids in Ireland and Great Britain.	N/A	N/A	This project will overlap with the construction and operations and maintenance phases of the Morgan Generation Assets.



The Awel y Môr agreement for lease area extends further to the west than the application boundary presented, however Awel y Môr Offshore Wind Farm Ltd. have decided to develop in the area presented

Figure 8.8: Other projects, plans and activities screened into the cumulative effects assessment.

8.9.2 Maximum design scenario

8.9.2.1 The MDSs identified in Table 8.29 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative effects presented and assessed in this section have been selected from the Project Design Envelope provided in volume 1, chapter 3: Project description of the PEIR as well as the information available on other projects and plans, in order to inform a 'maximum design scenario'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g. different wind turbine layout), to that assessed here, be taken forward in the final design scheme.

Table 8.29: Maximum design scenario considered for the assessment of potential cumulative effects on fish and shellfish ecology.

[a] C=construction, O=operations and maintenance, D=decommissioning

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Temporary habitat loss/disturbance	✓	×	×	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** • Offshore Wind Farm projects: – Awel y Môr Offshore Wind Farm construction phase. • Dredging projects: – Port of Barrow maintenance dredging disposal licence – West of Duddon Sands pontoon dredging marine licence – Annual maintenance dredging Peel Harbour IoM – Mersey channel and river maintenance dredge disposal renewal – Douglas Harbour, IoM – Castletown Bay, IoM – Heysham 1 and 2 dredging activities – Heysham Harbour and Approaches Maintenance Disposal Licence – Liverpool 2 and River Mersey approach channel dredging. **Tier 2** • Offshore Wind Farm projects: – Morecambe Offshore Windfarm Generation Assets construction and operation and maintenance phases – Mona Offshore Wind Farm construction phase. • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase). **Tier 3** • Cables and pipelines: – MaresConnect – Wales-Ireland Interconnector Cable.	These projects all involve activities which will result in temporary habitat disturbance/loss which may coincide with the construction, operations and maintenance, and decommissioning phases for the Morgan Generation Assets contributing to the impact upon fish and shellfish IEFs cumulatively with the Morgan Generation Assets.
	×	×	✓	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** There are no tier 1 projects operational in this phase of the Morgan Generation Assets. **Tier 2** • Offshore wind farm projects: – Mona Offshore Wind Farm decommissioning phase – Morecambe Offshore Windfarm Generation Assets operation and maintenance phase. • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase).	

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Underwater noise impacting fish and shellfish receptors	✓	×	×	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** • Offshore wind farm projects: – Awel y Môr Offshore Wind Farm. **Tier 2** • Offshore wind farm projects: – Mona Offshore Wind Farm – Morecambe Offshore Windfarm Generation Assets – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase). **Tier 3** • No tier 3 projects are predicted have been identified as interacting cumulatively with the Morgan Generation Assets for this impact, due to a lack of piling in all Tier 3 projects.	These projects all involve activities which will result in underwater noise which may coincide with the construction phase for the Morgan Generation Assets contributing to the impact upon fish and shellfish IEFs cumulatively with the Morgan Generation Assets. These justifications broadly align with those noted in the CEA of volume 2, chapter 7: Benthic subtidal ecology of the PEIR.
Increased SSCs and associated sediment deposition	✓	×	×	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** • Offshore Wind Farm projects: – Awel y Môr Offshore Wind Farm construction phase. • Dredging projects: – Port of Barrow maintenance dredging disposal licence – West of Duddon Sands pontoon dredging marine licence – Annual maintenance dredging Peel Harbour IoM – Mersey channel and river maintenance dredge disposal renewal – Douglas Harbour, IoM – Castletown Bay, IoM – Heysham 1 and 2 dredging activities – Heysham Harbour and Approaches Maintenance Disposal Licence – Liverpool 2 and River Mersey approach channel dredging. **Tier 2** • Offshore Wind Farm projects: – Morecambe Offshore Windfarm Generation Assets construction and operation and maintenance phases – Mona Offshore Wind Farm construction phase. • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase) **Tier 3** • Cables and pipelines: – MaresConnect – Wales-Ireland Interconnector Cable.	These projects all involve activities which will result in increased SSC and sediment deposition which may coincide with the construction, operations and maintenance, and decommissioning phases for the Morgan Offshore Wind Project contributing to the impact upon fish and shellfish IEFs cumulatively with the Morgan Offshore Wind Project.

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
	×	×	✓	**Tier 1** • Use of Walney Extension pontoon/jetty dredging and disposal site **Tier 2** • Mona Offshore Wind Project residual structures • Morecambe Offshore Windfarm residual structures.	
Long term habitat loss.	✓	✓	×	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** • Offshore wind farm projects: – Awel y Môr Offshore Wind Farm. **Tier 2** • Offshore wind farm projects: – Mona Offshore Wind Farm – Morecambe Offshore Windfarm Generation Assets • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase). **Tier 3** • Cables and pipelines: – MaresConnect – Wales-Ireland Interconnector Cable.	These projects will all result in the installation of hard structures on the seabed which will lead to long term habitat loss within the CEA benthic subtidal ecology study area meaning they may also affect habitats that the Morgan Generation Assets will also affect.
	×	×	✓	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** No tier 1 projects are predicted to overlap with the decommissioning phase of the Morgan Generation Assets. **Tier 2** • Offshore wind farm projects: – Morecambe Offshore Windfarm Generation Assets – Mona Offshore Wind Farm. • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase).	

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Electromagnetic Fields (EMF) from subsea electrical cabling.	×	✓	×	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** • Offshore wind farm projects: – Awel y Môr Offshore Wind Farm. **Tier 2** • Offshore wind farm projects: – Mona Offshore Wind Farm – Morecambe Offshore Windfarm Generation Assets – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase). **Tier 3** • Cables/pipelines: – MaresConnect Wales-Ireland Interconnector Cable.	These projects all involve activities which will result in EMF emissions which may coincide with the operations and maintenance phase for the Morgan Generation Assets, contributing to this impact upon fish and shellfish IEFs cumulatively with the Morgan Generation Assets.
Colonisation of hard structures	✓	✓	×	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** • Offshore wind farm projects: – Awel y Môr Offshore Wind Farm. **Tier 2** • Offshore wind farm projects: – Mona Offshore Wind Farm – Morecambe Offshore Windfarm Generation Assets. • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase). **Tier 3** • Cables/pipelines: – MaresConnect – Wales-Ireland Interconnector Cable.	These projects will all result in the installation of hard structures on the seabed which could be colonised by new communities which may coincide with the construction, operations and maintenance, and decommissioning phase for the Morgan Generation Assets, contributing to this impact upon fish and shellfish IEFs cumulatively with the Morgan Generation Assets.
	×	×	✓	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** There are no tier 1 projects operational in this phase of the Morgan Generation Assets. **Tier 2** • Offshore wind farm projects: – Mona Offshore Wind Farm decommissioning phase – Morecambe Offshore Windfarm Generation Assets operation and maintenance phase. • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase).	

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Injury due to increased risk of collision with vessels (basking shark only)	✓	✓	×	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** • Offshore Wind Farm projects: – Awel y Môr Offshore Wind Farm construction phase • Dredging projects: – Port of Barrow maintenance dredging disposal licence – West of Duddon Sands pontoon dredging marine licence – Annual maintenance dredging Peel Harbour IoM – Mersey channel and river maintenance dredge disposal renewal – Douglas Harbour, IoM – Castletown Bay, IoM – Heysham 1 and 2 dredging activities – Heysham Harbour and Approaches Maintenance Disposal Licence – Liverpool 2 and River Mersey approach channel dredging. **Tier 2** • Offshore Wind Farm projects: – Morecambe Offshore Windfarm Generation Assets construction and operation and maintenance phases – Mona Offshore Wind Farm construction phase • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase). **Tier 3** • Cables and pipelines: – MaresConnect – Wales-Ireland Interconnector Cable.	These projects all involve activities which will result in increased vessel traffic that may collide with basking shark, which may coincide with the construction, operations and maintenance, and decommissioning phases for the Morgan Generation Assets, contributing to the impact on this fish IEF cumulatively with the Morgan Generation Assets.

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
	×	×	✓	MDS as described for the Morgan Generation Assets (Table 8.14) assessed cumulatively with the following other projects/plans: **Tier 1** • Offshore Wind Farm projects: – Awel y Môr Offshore Wind Farm construction phase • Dredging projects: – Port of Barrow maintenance dredging disposal licence – West of Duddon Sands pontoon dredging marine licence – Annual maintenance dredging Peel Harbour IoM – Mersey channel and river maintenance dredge disposal renewal – Douglas Harbour, IoM – Castletown Bay, IoM – Heysham 1 and 2 dredging activities – Heysham Harbour and Approaches Maintenance Disposal Licence – Liverpool 2 and River Mersey approach channel dredging. **Tier 2** • Offshore Wind Farm projects: – Morecambe Offshore Windfarm Generation Assets construction and operation and maintenance phases – Mona Offshore Wind Farm construction phase • Cables and pipelines: – Morgan and Morecambe Offshore Wind Farms Transmission Assets (scoping search area construction phase).	

8.10 Cumulative effects assessment

8.10.1.1 A description of the significance of cumulative effects upon fish and shellfish ecology receptors arising from each identified impact is given below.

8.10.2 Temporary subtidal habitat loss

8.10.2.1 There is the potential for cumulative temporary habitat loss as a result of construction and decommissioning activities associated with the Morgan Generation Assets and other offshore wind farms (i.e. from cable burial, jack-up activities, anchor placements and seabed preparation), dredging activities; aggregate extraction activities and cables and pipelines (see Table 8.14). For the purposes of this PEIR, this additive impact has been assessed within the cumulative fish and shellfish ecology study area, defined as the area within a 50km buffer of the Morgan Generation Assets, and a 100km buffer for underwater noise, using the tiered approach outlined above. The 50km buffer area captures a fair representation of potentially impacted fish and shellfish IEFs within the cumulative fish and shellfish ecology study area in proximity to the Morgan Generation Assets. The potential effects of this impact alone were assessed for this project in section 8.8.2.

8.10.2.2 Almost all plans/projects/activities screened into the assessment for cumulative effects from temporary habitat loss/disturbance are either on-going activities (i.e. licensed and application aggregate extraction areas) or other offshore wind farms which are consented, submitted or under construction (i.e. tier 1). Three tier 2 projects have been identified within the cumulative fish and shellfish ecology study area (i.e. Morecambe Offshore Wind Farm, Mona Offshore Wind Project, and the Morgan and Morecambe Offshore Wind Farms Transmission Assets), and one tier 3 project has been identified (i.e. MaresConnect Wales-Ireland Interconnector Cable).

Tier 1

Construction phase

Magnitude of impact

8.10.2.3 Predicted cumulative temporary habitat loss and disturbance from each of the tier 1 plans, projects, and activities is presented in Table 8.30 together with a breakdown of the sources of this data from the relevant Environmental Statements, marine licences, and reports, and any assumptions made where necessary information was not presented in these. Table 8.30 shows that for all projects, plans, and activities in the tier 1 assessment, the cumulative temporary habitat loss/disturbance is estimated at up to 100.06km^2 (including the Morgan Generation Assets).

8.10.2.4 The maximum total temporary habitat loss and disturbance associated with the Awel y Môr Wind Farm construction phase within the cumulative fish and shellfish ecology study area is 9.93km^2. The values of temporary habitat loss for Morgan Generation Assets are very significantly larger than for this tier 1 project, as the Morgan Generation Assets assessment includes habitat affected as a result of seabed preparation and all of the construction activities while the Awel y Môr Offshore Wind Farm has less associated construction work.

8.10.2.5 Temporary habitat loss/disturbance from tier 1 dredge and disposal activities is likely to result in intermittent disturbance throughout the licenced period resulting in the disturbance of approximately 4.22km^2 of seabed spread over the construction period and potentially beyond (Table 8.30). There are also a number of dredge licences without readily available environmental information (i.e. Castletown Bay, IoM, Douglas Harbour, IoM, Walney Extension pontoon/jetty dredging and disposal, Heysham 1 and 2, and Heysham Harbour (Figure 8.8)). The dredging activities are however of a small scale and likely to be intermittent throughout the Morgan Generation Assets construction phase affecting relatively small areas in comparison with the Morgan Generation Assets.

Table 8.30: Cumulative temporary habitat loss for the Morgan Generation Assets construction phase and other tier 1 plans, projects, and activities in the cumulative fish and shellfish ecology study area.

Project	Predicted temporary habitat disturbance/loss (km^2)	Component parts of temporary habitat disturbance/loss	Source
Morgan Generation Assets	87.36	See Table 8.14	n/a
Offshore renewables			
Awel y Môr Offshore Wind Farm	Construction: 9.93	Temporary habitat disturbance/loss may result from: • Jack up events • Anchoring • Intertidal horizontal directional drilling (HDD).	RWE (2022)
Dredging activities and dredge disposal sites			
Port of Barrow maintenance dredging disposal licence.	0.01	Temporary habitat disturbance/loss may result from: • Dredging of silt, sand and gravel. The values provided for this project represent the area of the project as not temporary habitat disturbance/loss values were provided.	Associated British Ports (2016)
Liverpool Marina Maintenance Dredging - sustainable relocation of dredged material to the River Mersey	No official figure given.	Temporary habitat disturbance/loss may result from: • Dredging.	Anthony D Bates Partnership LLP (2020)

Project	Predicted temporary habitat disturbance/loss (km^2)	Component parts of temporary habitat disturbance/loss	Source
Liverpool 2 and River Mersey approach channel dredging	3.71	Temporary habitat disturbance/loss may result from: • Dredging of silt. The values provided for this project represent the area of the project as not temporary habitat disturbance/loss values were provided.	Royal Haskoning (2012)
Mersey channel and river maintenance dredge disposal renewal	0.5	Temporary habitat disturbance/loss may result from: • Dredging of silt and sand.	Royal Haskoning (2018)
Total	100.06		

8.10.2.6 The cumulative effect is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.2.7 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone in paragraph 8.8.2.12 to paragraph 8.8.2.33.

8.10.2.8 Most fish and shellfish ecology IEFs in the Morgan Fish and Shellfish Ecology Study Area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.2.9 King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of regional importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.2.10 European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be **medium**.

8.10.2.11 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be **medium**.

8.10.2.12 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally give a medium to high sensitivity. However, the sensitivity of herring to this impact is considered to be **low**, due to the limited suitable spawning sediments overlapping directly with the Morgan Array Area and the core herring spawning ground being located outside and to the northwest of the fish and shellfish ecology study area.

Diadromous species

8.10.2.13 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone in paragraph 8.8.2.34 to paragraph 8.8.2.368.8.2.36.

8.10.2.14 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **negligible**.

Significance of effect

Marine species

8.10.2.15 For most fish and shellfish ecology IEFs in the Morgan Fish and Shellfish Ecology Study Area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.16 For king and queen scallop, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.17 For European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.18 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.19 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.2.20 For the diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Tier 2

Construction phase

Magnitude of impact

8.10.2.21 The tier 2 Mona Offshore Wind Project, Morecambe Offshore Wind Farms, and Morgan and Morecambe Offshore Wind Farms Transmission Assets within the cumulative fish and shellfish ecology study area are likely to create temporary habitat disturbance/loss. For the Mona Offshore Wind Project temporary habitat disturbance/loss is likely to result from site preparation activities in advance of installation activities, cable installation activities (including UXO detonation, pre-cabling seabed clearance and anchor placements), and placement of spud-can legs from jack-up operations. The temporary habitat disturbance/loss predicted to result from the Mona Offshore Wind Project is up to 130,151,192m^2 (bp/EnBW, 2023) and is approximately double that arising from the Morgan Generation Assets. However, overall, this does not represent a large area compared to the wider fish and shellfish ecology study area.

8.10.2.22 No publicly available information was available, at the time of writing, which quantifies the extent of temporary habitat disturbance/loss associated with the Morecambe Offshore Wind Farm or the Morgan and Morecambe Offshore Wind Farms Transmission Assets and so these are not represented in the cumulative tier 2 total.

8.10.2.23 The indicative capacity of the Morecambe Offshore Wind Farm (Table 8.28) is however smaller than the Morgan Generation Assets and therefore the scale of the temporary habitat disturbance/loss associated with the tier 2 project may be less than that associated with the Morgan Generation Assets.

8.10.2.24 The cumulative effect is predicted to be of regional spatial extent, medium term duration (i.e. the construction phase for the Morgan Generation Assets is up to four years), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.2.25 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone in paragraph 8.8.2.12 to paragraph 8.8.2.33.

8.10.2.26 Most fish and shellfish ecology IEFs in the Morgan Fish and Shellfish Ecology Study Area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.2.27 King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of regional importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.2.28 European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be **medium**.

8.10.2.29 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be **medium**.

8.10.2.30 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally give a medium to high sensitivity. However, the sensitivity of herring to this impact is considered to be **low**, due to the limited suitable spawning sediments overlapping directly with the Morgan Array Area and the core herring spawning ground being located outside and to the northwest of the fish and shellfish ecology study area.

Diadromous species

8.10.2.31 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone in paragraph 8.8.2.34 to paragraph 8.8.2.36.

8.10.2.32 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **negligible**.

Significance of effect

Marine species

8.10.2.33 For most fish and shellfish ecology IEFs in the Morgan Fish and Shellfish Ecology Study Area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.34 For king and queen scallop, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.35 For European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.36 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.37 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.2.38 For the diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

8.10.2.39 The decommissioning phases of the Mona Offshore Wind Project, Morecambe Offshore Wind Farm, and Morgan and Morecambe Offshore Wind Farms Transmission Assets will likely have temporal overlap with the decommissioning of the Morgan Generation Assets. The expected magnitude of temporary habitat loss will be less than the construction phase, due to the leaving in place of scour protection, and cable protection. Temporary habitat loss will mostly therefore occur from spud-can jack-up legs, with 910,800m^2 of this associated with the Mona Offshore Wind Project, which will be similar in size to the Morgan Generation Assets.

8.10.2.40 Limited public information is currently available for the Morecambe Offshore Wind Farm or Morgan and Morecambe Offshore Wind Farms Transmission Assets regarding temporary habitat loss or disturbance, but the smaller indicative capacity of these projects than the Morgan Generation Assets (Table 8.28) suggests a lower level of potential impact in terms of temporary habitat loss.

8.10.2.41 The cumulative effect is predicted to be of regional spatial extent, medium term duration (i.e. the duration of the Mona decommissioning phase), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

8.10.2.42 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone in paragraph 8.8.2.12 to paragraph 8.8.2.33, ranging from **negligible** to **medium**, and these will apply equally in the decommissioning phase.

Significance of effect

Marine species

8.10.2.43 For most fish and shellfish ecology IEFs in the Morgan Fish and Shellfish Ecology Study Area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.44 For king and queen scallop, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.45 For European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.46 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.47 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.2.48 For the diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Tier 3

Construction phase

Magnitude of impact

8.10.2.49 The proposed construction of the MaresConnect Wales-Ireland Interconnector Cable will likely overlap with the construction phase of the Morgan Generation Assets, leading to a potential cumulative impact. As this project is only at the proposal stage, no specifications are publicly available currently and therefore all assessment scores associated with this project are subject to review when this information is published. The anticipated construction timeline is not currently publicly available (MaresConnect, 2022). The laying and burying of the cable will likely follow standard jet trenching and cable protection installation, although technical specifications will only be released at later development stages.

8.10.2.50 The cumulative effect is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.2.51 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone in paragraph 8.8.2.12 to paragraph 8.8.2.33.

8.10.2.52 Most fish and shellfish ecology IEFs in the Mona Fish and Shellfish Ecology Study Area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.2.53 King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of regional importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.2.54 European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be **medium**.

8.10.2.55 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be **medium**.

8.10.2.56 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally give a medium to high sensitivity. However, the sensitivity of herring to this impact is considered to be **low**, due to the limited suitable spawning sediments overlapping directly with the Morgan Array Area and the core herring spawning ground being located outside and to the northwest of the fish and shellfish ecology study area.

Diadromous species

8.10.2.57 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone in paragraph 8.8.2.34 to paragraph 8.8.2.36.

8.10.2.58 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **negligible**.

Significance of effect

Marine species

8.10.2.59 For most fish and shellfish ecology IEFs in the Mona Fish and Shellfish Ecology Study Area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.60 For king and queen scallop, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.61 For European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.62 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.2.63 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.2.64 For the diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

8.10.3 Underwater noise impacting fish and shellfish receptors

Tier 1

Construction phase

Magnitude of impact

8.10.3.1 The construction phases of the Awel y Môr Offshore Wind Farm will have temporal and spatial overlap with the Morgan Generation Assets in terms of construction noise (specifically piling and UXO clearance), potentially resulting in a cumulative impact. The assessment of noise impacts associated with the Morgan Generation Assets alone has been presented above (section 8.8.3), with a medium magnitude identified based on a range of technical specifications and noise modelling outputs.

8.10.3.2 For the Awel y Môr, maximum hammer piling energy of up to 5,000kJ is planned for monopiles, with up to 50 of these monopiles being installed over up to a maximum 74-day period (single vessel), with a maximum duration of 896 hours of piling expected. When considered cumulatively with the Morgan Generation Assets this would equate to up to 144 days and 1,561 hours of piling over construction phases of several years (i.e. four and three years for Morgan Generation Assets and Awel y Môr, respectively).

8.10.3.3 Noise modelling undertaken for the Awel y Môr project indicated similar patterns as those for the Morgan Generation Assets, with injury and mortality from noise produced within the Awel y Môr Array Area to ranges of up to 1,300m for group 1 fish, 6,300m for group 2 fish, and 8,600m calculated for group 3 fish, if modelled as static receptors (RWE, 2021a). In all cases, modelling the fish as fleeing receptors highly significantly reduced mortality distances, down to <100m even for group 3 fish. Injury distances were calculated to reach out to up to 12,000m for group 3 static receptors, with this again reducing to 120m when fish were modelled as fleeing receptors, with similar patterns for all other groups of fish.

8.10.3.4 As with the Morgan Generation Assets, mitigation including soft starts will reduce the risk of injury and mortality to many fish and shellfish receptors. With respect to behavioural effects the Awel y Môr project indicated behavioural effects to similar ranges as those predicted for the Morgan Generation Assets, with behavioural effects expected to a range of approximately up to tens of kilometres from the piling location at the maximum hammer energies. The Awel y Môr assessment predicted that effects of minor adverse significance on cod, sandeel, and all groups of fish due to the limited overlap with spawning and nursery habitats and the intermittent and reversible nature of the effect on fish behaviour. For herring, there was no overlap between noise contours from Awel y Môr and key spawning habitats for this species in the Irish Sea. Diadromous fish species were not examined separately for the Awel y Môr Offshore Wind Farm, but evidence did indicate for fish motivated by strong biological drivers, as would be the case for diadromous fish on their spawning migrations, the significance was minor adverse.

8.10.3.5 The cumulative effect is predicted to be of regional spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.3.6 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Offshore Wind Project alone.

8.10.3.7 Most marine fish IEFs species, including elasmobranch species, in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.10.3.8 Sprat, cod and sandeel are deemed to be of medium vulnerability, high recoverability and regional to national importance. The sensitivity of the receptor is therefore, considered to be **medium**.

8.10.3.9 Herring are deemed to be of high vulnerability, high recoverability and national importance. The sensitivity of the receptor is therefore, considered to be **medium**.

8.10.3.10 All shellfish IEFs, including European lobster, *Nephrops*, edible crab, and king and queen scallop, are deemed to be of low vulnerability, high recoverability and local to regional importance. The sensitivity of the receptor is therefore, considered to be **low**.

Diadromous species

8.10.3.11 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Offshore Wind Project alone.

8.10.3.12 Most diadromous fish species IEFs in the Mona Fish and Shellfish Ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.10.3.13 Allis shad and twaite shad are deemed to be of medium vulnerability, high recoverability, and national importance. The sensitivity of the receptor is therefore considered to be **medium**.

Significance of effect

Marine species

8.10.3.14 For most fish and shellfish ecology IEFs in the fish and shellfish ecology study area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.3.15 For sprat, cod, and sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. As noted for the Morgan alone assessment, this is due to the short term, intermittent nature of the impact (both alone and cumulatively), the relatively small proportion of spawning habitats affected at any one time (given the broadscale nature of these habitats) and that effects would only occur if piling occurs during the peak spawning periods for these species.

8.10.3.16 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. This is because the Awel y Môr offshore wind farm is located a greater distance from herring spawning grounds in the Irish Sea than the Morgan Offshore Wind Project and would therefore not represent a significantly increased risk to herring spawning. As noted in section 8.8.3, there is a residual risk of significant effects on herring spawning for the Morgan Offshore Wind Project, if piling occurs during the herring spawning period, however further measures are currently being investigated by the project to minimise this risk.

8.10.3.17 For all shellfish IEFS, including king and queen scallop, European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.3.18 For most diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.3.19 For allis shad and twaite shad, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms, as piling from both wind farms was not predicted to result in disruption to migration of diadromous fish species undertaking migration activities for spawning.

Tier 2

Construction phase

Magnitude of impact

8.10.3.20 The construction phases of the Mona Offshore Wind Project, the Morecambe Offshore Wind Farm, and the Morgan and Morecambe Offshore Wind Farms Transmission Assets will have temporal and spatial overlap with the Morgan Generation Assets in terms of construction noise, potentially resulting in a cumulative impact. The assessment of noise impacts associated with the Morgan Generation Assets alone has been presented above (section 8.8.3), with a medium magnitude identified based on a range of technical specifications and noise modelling outputs.

8.10.3.21 For the Mona Offshore Wind Project, noise modelling indicated similar patterns as those for the Morgan Generation Assets, with injury and mortality from noise produced within the Mona Array Area to ranges of up to 1,085m for group 1 fish, 2,090m for group 2 fish, and 2,880m calculated for group 3 fish, if modelled as static receptors (RWE, 2021a). In all cases, modelling the fish as fleeing receptors highly significantly reduced mortality distances, down to <100m even for group 3 fish. Injury distances were calculated to reach out to up to 4,400m for group 3 and 4 static receptors, with this again reducing to <100m in all cases when fish were modelled as fleeing receptors, with similar patterns for all other groups of fish.

8.10.3.22 As with the Morgan Generation Assets, mitigation including soft starts will reduce the risk of injury and mortality to many fish and shellfish receptors. With respect to behavioural effects the Awel y Môr project indicated behavioural effects to similar ranges as those predicted for the Morgan Generation Assets, with behavioural effects expected to a range of approximately up to tens of kilometres from the piling location at the maximum hammer energies. The Awel y Môr assessment predicted that effects of minor adverse significance on cod, sandeel, and all groups of fish due to the limited overlap with spawning and nursery habitats and the intermittent and reversible nature of the effect on fish behaviour. For herring, there was no overlap between noise contours from Awel y Môr and key spawning habitats for this species in the Irish Sea. Diadromous fish species were not examined separately for the Awel y Môr Offshore Wind Farm, but evidence did indicate for fish motivated by strong biological drivers, as would be the case for diadromous fish on their spawning migrations, the significance was minor adverse.

8.10.3.23 Currently, no information is publicly available for the noise modelling and construction parameters of the Morecambe Offshore Wind Farm, although it is expected this will be similar in scale to the Morgan and Mona Offshore Wind Projects.

8.10.3.24 The cumulative effect is predicted to be of regional spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.3.25 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone.

8.10.3.26 Most marine fish IEFs species, including elasmobranch species, in the Mona Fish and Shellfish Ecology study area are deemed to be of low vulnerability, high recoverability and local to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.10.3.27 Sprat, cod and sandeel are deemed to be of medium vulnerability, high recoverability and regional to national importance. The sensitivity of the receptor is therefore, considered to be **medium**.

8.10.3.28 Herring are deemed to be of high vulnerability, high recoverability and national importance. The sensitivity of the receptor is therefore, considered to be **medium**.

8.10.3.29 All shellfish IEFs, including European lobster, *Nephrops*, edible crab, and king and queen scallop, are deemed to be of low vulnerability, high recoverability and local to regional importance. The sensitivity of the receptor is therefore, considered to be **low**.

Diadromous species

8.10.3.30 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone.

8.10.3.31 Most diadromous fish species IEFs in the Mona Fish and Shellfish Ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be low.

8.10.3.32 Allis shad and twaite shad are deemed to be of medium vulnerability, high recoverability, and national importance. The sensitivity of the receptor is therefore considered to be **medium**.

Significance of effect

Marine species

8.10.3.33 For most fish and shellfish ecology IEFs in the Mona Fish and Shellfish Ecology Study Area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.3.34 For sprat, cod, and sandeel, the magnitude of the cumulative impact is deemed to be medium, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.3.35 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered medium. The cumulative effect would therefore be of **minor adverse** significance, which is not significant in EIA terms. Cumulatively, other nearby projects are unlikely to contribute to this impact due to their distance from the known spawning grounds. As noted in section 8.8.3, there is a residual risk of significant effects on herring spawning for the Morgan Offshore Wind Project, if piling occurs during the herring spawning period, however further measures are currently being investigated by the project to minimise this risk.

8.10.3.36 For all shellfish IEFS, including king and queen scallop, European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.3.37 For most diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.3.38 For allis shad and twaite shad, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is significant in EIA terms, as piling from all Tier 2 wind farms are not predicted to result in disruption to migration of diadromous fish species.

8.10.4 Increased SSCs and associated sediment deposition

8.10.4.1 Increased suspended sediment concentrations and associated sediment deposition is expected to occur in relation to the construction and decommissioning phases of the Morgan Generation Assets, which was assessed for this impact alone in section 8.8.3.1. This may occur alongside the construction of the Tier 1 Awel y Môr Offshore Wind Farm; the operational activities of nearby dredging and dredge disposal activities, and one aggregate extraction and disposal site (see Table 8.28). Three tier 2 offshore wind farms have been identified within the Fish and Shellfish Ecology study area (Morecambe Offshore Wind Farm, Mona Offshore Wind Project, and the Morgan and Morecambe Offshore Wind Farms Transmission Assets) while one tier 3 project, the MaresConnect Wales-Ireland Interconnector Cable, has been identified.

Tier 1

Construction phase

Magnitude of impact

8.10.4.2 The magnitude of the increase in SSC arising from seabed preparation involving sandwave clearance, the installation of the wind turbines, OSP foundations and cables, has been assessed as low for the Morgan Generation Assets alone, as described in section 8.8.3.1. The greatest impacts are due to potential sandwave clearance activities within the fish and shellfish ecology study area.

8.10.4.3 Coinciding with the construction phase of the Morgan Generation Assets is the proposed development of Awel y Môr Offshore Wind Farm. Construction activities may result in increased suspended sediment concentration; however, these activities would be of limited spatial extent and frequency and are unlikely to interact with sediment plumes from the Morgan Offshore Array Area.

8.10.4.4 The cumulative impact assessment also considers sea disposal of dredged material at licenced dredging activity and disposal sites, including the Mersey channel and river maintenance dredge disposal renewal; Heysham Harbour dredging; West of Duddon Sands pontoon/jetty dredging and disposal; the Peel Harbour Maintenance Dredging; the Heysham 1 and 2 dredging activities; the Douglas Harbour and Castletown Bay dredging in the IoM, and the Port of Barrow maintenance dredging disposal (Table 8.28). If the dredge material dumping coincided with construction activities at the Morgan Generation Assets, both resultant plumes would be advected on the tidal currents, they would travel in parallel, and not towards one another, and are thus unlikely to significantly interact.

8.10.4.5 The cumulative effect is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.4.6 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.4.7 Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, and the proximity of herring spawning grounds to the Morgan Array Area, herring is deemed to be of medium vulnerability, high recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be **medium**.

8.10.4.8 All other fish and shellfish ecology IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops*, king and queen scallop, and elasmobranch species, are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be **low**.

Diadromous species

8.10.4.9 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.4.10 Diadromous fish species IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptors is therefore, considered to be **low.**

Significance of effect

Marine species

8.10.4.11 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.4.12 For all other fish and shellfish ecology species IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops*, king and queen scallop, and elasmobranch species, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.4.13 For diadromous fish species IEFs in the fish and shellfish ecology study area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be **low**. The cumulative effect will, therefore, be of minor adverse significance, which is not significant in EIA terms.

Tier 2

Construction phase

Magnitude of impact

8.10.4.14 For the tier 2 Mona Offshore Wind Project increased SSC and sediment deposition is likely to result from site preparation activities in advance of installation activities including sandwave and debris clearance, drilling for foundation installation, and cable installation and burial activities. The increases in SSC and sediment deposition predicted to result from the Mona Offshore Wind Project are similar to those reported for the Morgan Generation Assets with the displacement of up to 33,072,196m^3 of total spoil volume. This could potentially result in SSC increases of up to 1000mg/l during the sediment dumping immediately near the sediment release site, although this would be highly localised and would return to background levels within three days. Otherwise, average SSC increases would reach <300mg/l for foundation installation, but only within 100m of the site, with significant advection and sedimentation to natural backgrounds levels across the 20km tidal excursion within a short time period. Plumes from multiple concurrent foundation installation activities were modelled as having concentrations of <1mg/l if they met, which is not significant compared to background levels and natural variation.

8.10.4.15 No publicly available information was available, at the time of writing, which quantifies the extent of increased SSC and sediment deposition associated with the Morecambe Offshore Wind Farm or the Morgan and Morecambe Offshore Wind Farms Transmission Assets, although they can reasonably be expected to be similar to those associated with the Morgan Generation Assets.

8.10.4.16 The cumulative effect is predicted to be of regional spatial extent, medium term duration (i.e. the construction phase for the Morgan Generation Assets is up to three years), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.4.17 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.4.18 Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, and the proximity of herring spawning grounds to the Morgan Array Area, herring is deemed to be of medium vulnerability, high recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be **medium**.

8.10.4.19 All other fish and shellfish ecology IEFs in the Mona Fish and Shellfish Ecology study area, including sandeel, *Nephrops*, king and queen scallop, and elasmobranch species, are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be **low**.

Diadromous species

8.10.4.20 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.4.21 Diadromous fish species IEFs in the Mona Fish and Shellfish Ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptors is therefore, considered to be **low.**

Significance of effect

Marine species

8.10.4.22 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.4.23 For all other fish and shellfish ecology species IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops*, king and queen scallop, and elasmobranch species, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.4.24 For diadromous fish species IEFs in the fish and shellfish ecology study area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

8.10.4.25 The decommissioning phases of the Mona Offshore Wind Project, Morecambe Offshore Wind Farm and the Morgan and Morecambe Offshore Wind Farms Transmission Assets could have the potential to overlap temporally with the decommissioning of the Morgan Generation Assets. The expected magnitude of increased SSC and sediment deposition will be less than the construction phase, due to the leaving in place of cables, scour protection, and cable protection, with no associated sediment clearance or drilling required.

8.10.4.26 No public information is currently available for the Morecambe Offshore Wind Farm or the Morgan and Morecambe Offshore Wind Farms Transmission Assets, although they can reasonably be expected to be similar to those associated with the Morgan Generation Assets.

8.10.4.27 The cumulative effect is predicted to be of regional spatial extent, medium term duration (i.e. the duration of the Morgan decommissioning phase), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.4.28 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment, ranging from **low to medium** sensitivity, and these will equally apply in the decommissioning phase.

Diadromous species

8.10.4.29 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment with **low** sensitivity, and this will equally apply in the decommissioning phase.

Significance of effect

Marine species

8.10.4.30 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.4.31 For all other fish and shellfish ecology species IEFs in the Mona Fish and Shellfish Ecology study area, including sandeel, *Nephrops*, king and queen scallop, and elasmobranch species, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

For diadromous fish species IEFs in the Mona Fish and Shellfish Ecology study area, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Tier 3

Construction phase

Magnitude of impact

8.10.4.32 The proposed construction of the MaresConnect Wales-Ireland Interconnector Cable has a low potential to overlap with the construction phase of the Morgan Generation Assets, with the MaresConnect Interconnector Cable being 48.2km from the Mona Offshore Array Area. However, the likely jet trenching activities for the laying and burying of the cables for both projects could run concurrently and interaction of SSC plumes on spring tide events may occur. The concentration of suspended sediment will reduce significantly moving further from the activity with levels of less, with the distance between the projects causing the potential overlap of resultant plumes to be most likely be negligible.

8.10.4.33 The cumulative effect is predicted to be of regional spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly, although at a very low level due to the distances involved. The magnitude is, therefore, considered to be **negligible**.

Sensitivity of the receptor

Marine species

8.10.4.34 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.4.35 Based on the increase in sensitivity of herring eggs to the smothering effects of increased sediment deposition, and the proximity of herring spawning grounds to the Morgan Array Area, herring is deemed to be of medium vulnerability, high recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be **medium**.

8.10.4.36 All other fish and shellfish ecology IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops*, king and queen scallop, and elasmobranch species, are deemed to be of low to medium vulnerability, high recoverability and local to national importance. The sensitivity of these IEFs is therefore considered to be **low**.

Diadromous species

8.10.4.37 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.4.38 Diadromous fish species IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptors is therefore, considered to be **low.**

Significance of effect

Marine species

8.10.4.39 For herring, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.4.40 For all other fish and shellfish ecology species IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops*, king and queen scallop, and elasmobranch species, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.4.41 For diadromous fish species IEFs in the fish and shellfish ecology study area, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5 Long term habitat loss

8.10.5.1 Cumulative long term habitat loss is predicted to occur as a result of the presence of the Mona Offshore Wind Project, which was assessed for this impact alone in section 8.8.5, alongside all other tier 1 offshore wind farms which are consented, submitted or under construction within the cumulative fish and shellfish ecology study area (see Table 8.28). Long term habitat loss may result from the physical presence of foundations, scour protection and cable protection. Three tier 2 projects including offshore wind farms and the Morgan and Morecambe Offshore Wind Farms Transmission Assets have been identified within the cumulative fish and shellfish ecology study area (Morecambe Offshore Wind Farm and Morgan Generation Assets) while one tier 3 project, the MaresConnect Wales-Ireland Interconnector Cable, has been identified.

Tier 1

Construction and operations and maintenance phases

Magnitude of impact

8.10.5.2 The planned construction of the tier 1 Awel y Môr Offshore Wind Farm will introduce up to 1.07km^2 of permanent hard structures, which will remain in place during the 25-year operations and maintenance phase and will be left permanently in place following the decommissioning phase but was not expected to cause any significant impact (RWE, 2021a). This will act alongside the 2.28km^2 of hard structures introduced by the Morgan Generation Assets to represent a potential cumulative long term habitat loss of up to approximately 3.35km^2.

8.10.5.3 The cumulative effect is predicted to be of regional spatial extent, long term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.5.4 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.5.5 Most fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.5.6 King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of regional importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.5.7 European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be **medium**.

8.10.5.8 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be **medium**.

8.10.5.9 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally give a medium sensitivity. However, the sensitivity of herring to this impact is considered to be **low**, due to the wide availability of suitable spawning sediments and alternative herring spawning ground close to the Morgan Array Area.

Diadromous species

8.10.5.10 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.5.11 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.10.5.12 For most fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.13 For king and queen scallop, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.14 For European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.15 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.16 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.5.17 For the diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

<u>Tier 2</u>

Construction and operations and maintenance phases

Magnitude of impact

8.10.5.18 The maximum total long term habitat loss for which information is publicly available will be associated with the tier 2 Mona Offshore Wind Project. For the Mona Offshore Wind Project long term habitat loss is likely to result mostly from foundation structures and associated scour protection, and under any cable protection required. The long-term habitat loss predicted to result from the Mona Offshore Wind Project is up to 2.36km^2 (bp/EnBW, 2023) and is therefore similar to that arising from the Morgan Offshore Wind Project. This will act cumulatively with the Morgan Generation Assets and the Awel y Môr Offshore Wind Farm to cause long term habitat loss of up to 6.97km^2.

8.10.5.19 Limited publicly available information was available, at the time of writing, which quantifies the extent of long-term habitat loss associated with the Morecambe Offshore Wind Farm or Morgan and Morecambe Offshore Wind Farms Transmission Assets and so this is not represented in the cumulative tier 2 total.

8.10.5.20 The indicative capacity of the Morecambe Offshore Wind Farm (Table 8.28) is however smaller than the Morgan Generation Assets and therefore the scale of the long-term habitat loss associated with the tier 2 project may be less than that associated with the Morgan Generation Assets. For reference, based on the proposed 40 wind turbine generators at the Morecambe Offshore Windfarm Generation Assets, and the use of gravity base foundations (foundation diameter of 65m; excluding seabed levelling), the potential area of long-term habitat loss based on the presence of wind turbine generator foundations only is 0.13km^2. This value does not include any associated scour and cable protection, or offshore substations, due to the lack of available information, but will be slightly higher with these elements accounted for. For the Morgan Generation Assets, the area associated with wind turbine foundations and scour protection assessed in the alone assessment equates to 0.75km^2 based on 68 four-legged suction bucket foundations, for context, indicating the differing spatial scales.

8.10.5.21 The cumulative effect is predicted to be of regional spatial extent, long term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.5.22 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Offshore Wind Project alone.

8.10.5.23 Most fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.5.24 King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of regional importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.5.25 European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be **medium**.

8.10.5.26 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be **medium**.

8.10.5.27 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally give a medium sensitivity. However, the sensitivity of herring to this impact is considered to be **low**, due to the wide availability of suitable spawning sediments and alternative herring spawning ground close to the Morgan Array Area.

Diadromous species

8.10.5.28 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Offshore Wind Project alone.

8.10.5.29 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is, therefore, considered to be **low**.

Significance of effect

Marine species

8.10.5.30 For most fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.31 For king and queen scallop, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.32 For European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.33 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.34 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.5.35 For the diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

8.10.5.36 The decommissioning phases of the Mona Offshore Wind Project, Morecambe Offshore Wind Farm, and Morgan and Morecambe Offshore Wind Farms Transmission Assets could have the potential to have temporal overlap with the decommissioning of the Morgan Generation Assets. The expected magnitude of long term habitat loss will be similar to the construction phase, due to the leaving in place of scour protection, and cable protection. Permanent habitat loss will mostly therefore occur due to the presence of these structures. Within these projects, up to 0.91km^2 of this temporary habitat loss will be associated with the Mona Offshore Wind Project, which is larger in size than the Morgan Generation Assets, but still represents a low level of impact compared to the entire fish and shellfish ecology study area.

8.10.5.37 As outlined above, no public information is currently available for the Morecambe Offshore Wind Farm or Morgan and Morecambe Offshore Wind Farms Transmission Assets, but their smaller indicative capacity than the Morgan Generation Assets (Table 8.28) suggests a lower level of potential impact in terms of permanent habitat loss.

8.10.5.38 The cumulative effect is predicted to be of regional spatial extent, permanent (i.e. structures will remain in-situ post decommissioning), continuous and irreversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.5.39 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.5.7 to paragraph 8.8.5.18), ranging from **low to medium** sensitivity, and these will equally apply in the decommissioning phase.

Diadromous species

8.10.5.40 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 8.8.4.17 to paragraph 8.8.4.19), with **low** sensitivity, and this will equally apply in the decommissioning phase.

Significance of effect

Marine species

8.10.5.41 For most fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.42 For king and queen scallop, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.43 For European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.44 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.45 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.5.46 For the diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

<u>Tier 3</u>

Construction and operations and maintenance phases

Magnitude of impact

8.10.5.47 The proposed construction of the MaresConnect Wales-Ireland Interconnector Cable will potentially overlap with the construction phase and operations and maintenance phases of the Morgan Generation Assets, leading to a potential cumulative impact. Specifically, the installation of electrical cables is likely to involve introduction of cable protection which will represent long term habitat loss. The exact specifications of the cable protection are not currently known, although the overlap and thus cumulative impact between this and tier 2 projects is expected to be minor to negligible, given the large distance between the projects.

8.10.5.48 The cumulative effect is predicted to be of regional spatial extent, long term duration, continuous and low reversibility to irreversible, if left in place. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.5.49 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.5.50 Most fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.5.51 King and queen scallop are deemed to be of medium vulnerability, high recoverability, and of regional importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.5.52 European lobster and *Nephrops* are deemed to be of high vulnerability, medium to high recoverability and of regional importance. The sensitivity of these fish and shellfish IEFs is therefore considered to be **medium**.

8.10.5.53 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance. The sensitivity of sandeel is therefore considered to be **medium**.

8.10.5.54 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, which would normally give a medium sensitivity. However, the sensitivity of herring to this impact is considered to be **low**, due to the wide availability of suitable spawning sediments and alternative herring spawning ground close to the Morgan Array Area.

Diadromous species

8.10.5.55 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.5.56 Diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is, therefore, considered to be **low**.

Significance of effect

Marine species

8.10.5.57 For most fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.58 For king and queen scallop, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.59 For European lobster and *Nephrops*, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.60 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.5.61 For herring, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.5.62 For the diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

8.10.6 EMFs from subsea electrical cabling

8.10.6.1 The operation of the subsea cabling laid and buried as part of the Morgan Generation Assets will produce electromagnetic fields, with potential impacts on fish and shellfish receptors within the Morgan Array Area. This could have impacts cumulatively with the operations and maintenance phases of the tier 1 Awel y Môr Offshore Wind Farm; the tier 2 Mona Offshore Wind Farm, Morecambe Offshore Wind Farm, and Morgan and Morecambe Offshore Wind Farms Transmission Assets, and the tier 3 MaresConnect Wales-Ireland Interconnector Cable.

<u>Tier 1</u>

Operations and maintenance phase

Magnitude of impact

8.10.6.2 The maximum EMF impacts associated with the tier 1 Awel y Môr Offshore Wind Farm within the CEA will originate from the project's inter-array, interconnector, and offshore export cables, which have the potential for creating a cumulative impact with the inter-array and interconnector cables of the Morgan Generation Assets. For the Awel y Môr Offshore Wind Farm this is likely to result from the operation of the 145km of inter-array cables, and 81.3km of export cables (RWE, 2021a). The minimum burial depth for cables for Awel y Môr is planned to be 1m, likely limiting EMFs to the range of up to 10m from the cable, in line with the predictions for the Morgan Generation Assets as discussed in section 8.8.6 above. (Table 8.28).

8.10.6.3 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility (when the cables are decommissioned). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.6.4 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Offshore Wind Project alone.

8.10.6.5 Most marine fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.6.6 Decapod crustaceans and elasmobranchs in the Mona Fish and Shellfish Ecology study area are deemed to be of medium vulnerability, high recoverability, and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

Diadromous species

8.10.6.7 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Offshore Wind Project alone.

8.10.6.8 Diadromous fish IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.10.6.9 For most marine fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.6.10 For decapod crustaceans and elasmobranchs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.6.11 For diadromous fish IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

<u>Tier 2</u>

Operations and maintenance phase

Magnitude of impact

8.10.6.12 The maximum EMF impacts associated with the tier 2 projects within the cumulative fish and shellfish ecology study area will originate from the inter-array, interconnector, and offshore export cables of the Mona Offshore Wind Project and the Morecambe

Offshore Wind Farm, and the Morgan and Morecambe Offshore Wind Farms Transmission Assets. For the Mona Offshore Wind Project this is likely to result from the operation of up to 500km of 66kV to 132kV inter-array cables, 50km of 275kV HVAC interconnector cable, and up to 360km of 275kV HVAC offshore export cables. The minimum burial depth for cables will be 0.5m, likely limiting EMFs to the range of metres from the cable, with impacts expected to be similar to the Morgan Generation Assets, due to the similar sizes and extents of the projects (bp/EnBW, 2023).

8.10.6.13 The extent of EMFs associated with the Morgan and Morecambe Offshore Wind Farms Transmission Assets are approximately quantified for the current early stage of development of this project. The scoping report indicates the use of up to 80km of 66kV to 132kV HVAC inter-array and interconnector cables, and up to 580km of export cables, with all cables buried to an expected depth of 1m.

8.10.6.14 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility (when the cables are decommissioned). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.6.15 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.6.16 Most marine fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.6.17 Decapod crustaceans and elasmobranchs in the fish and shellfish ecology study area are deemed to be of medium vulnerability, high recoverability, and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

Diadromous species

8.10.6.18 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.6.19 Diadromous fish IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.10.6.20 For most marine fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.6.21 For decapod crustaceans and elasmobranchs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.6.22 For diadromous fish IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Tier 3

Operations and maintenance phase

Magnitude of impact

8.10.6.23 The proposed operation of the MaresConnect Wales-Ireland Interconnector Cable will temporally overlap with the operations and maintenance phase of the Morgan Generation Assets, resulting in a potential cumulative impact. Specifically, the MaresConnect Wales-Ireland Interconnector Cable is expected to continuously produce EMFs during operation, although exact specifications are not currently publicly available. However, the overall potential cumulative impact is expected to be small and limited to directly around the cable, with very little to no overlap between it and the Morgan Generation Assets.

8.10.6.24 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility (when the cables are decommissioned). It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **negligible**.

Sensitivity of the receptor

Marine species

8.10.6.25 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.6.26 Most marine fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

8.10.6.27 Decapod crustaceans and elasmobranchs in the fish and shellfish ecology study area are deemed to be of medium vulnerability, high recoverability, and local to national importance. The sensitivity of the receptor is therefore considered to be **low**.

Diadromous species

8.10.6.28 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.6.29 Diadromous fish IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.10.6.30 For most marine fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.6.31 For decapod crustaceans and elasmobranchs, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.6.32 For diadromous fish IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be negligible. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.7 Colonisation of hard structures

8.10.7.1 The introduction of hard structures into areas of predominantly soft sediments has the potential to alter community composition and biodiversity within the cumulative fish and shellfish ecology study area. Colonisation of hard substrates will occur over time, beginning in the construction phase and continuing through the operations and maintenance and decommissioning phases, with this impact assessed alone for the Morgan Generation Assets in section 8.8.7. Cumulative impacts may occur through the introduction of other projects within the cumulative fish and shellfish ecology study area. Specifically, the tier 1 Awel y Môr Offshore Wind Farm; the tier 2 Mona Offshore Wind Project, Morecambe Offshore Wind Farm, and Morgan and Morecambe Offshore Wind Farms Transmission Assets, and the tier 3 MaresConnect Wales-Ireland Interconnector Cable represent areas of introduced hard structures, in terms of foundations, scour protection, and cable protection.

<u>Tier 1</u>

Construction and operations and maintenance phases

Magnitude of impact

8.10.7.2 The Awel y Môr Offshore Wind Farm construction phase is planned to overlap temporally with the Morgan Generation Assets construction phase and could result in a cumulative impact. This will represent the introduction of up to 3.06km^2 of new hard structures for potential colonisation, including foundations, scour protection, and cable protection structures, involving up to 1.07km^2 for Awel y Môr, and 1.99km^2 for the Morgan Generation Assets. The temporal overlap between tier 1 projects will likely result in cumulative impacts.

8.10.7.3 The cumulative effect is predicted to be of regional spatial extent, medium to long term duration (i.e. the construction and operations and maintenance phases), continuous and low reversibility. It is predicted that the impact will affect the receptor directly. However, due to the relatively small area of new hard structures introduced during this phase, compared to the wider cumulative fish and shellfish ecology study area, the magnitude is therefore considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.7.4 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.7.5 Marine fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, and local to national importance (recoverability is not relevant to this impact during the operations and maintenance phase). The sensitivity of the receptor is therefore, considered to be **low**.

Diadromous species

8.10.7.6 Most diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.10.7.7 Sea trout are deemed to be of medium vulnerability, high recoverability and national importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.10.7.8 For marine fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.7.9 For most diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.7.10 For sea trout, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

<u>Tier 2</u>

Construction and operations and maintenance phases

Magnitude of impact

8.10.7.11 The Mona Offshore Wind Project, Morecambe Offshore Wind Farm, and Morgan and Morecambe Offshore Wind Farms Transmission Assets will increase the introduced hard structure area available for colonisation, with potential cumulative impacts on the

Fish and Shellfish Ecology IEFs within the cumulative fish and shellfish ecology study area. Within these, the Mona Offshore Wind Project is the only one with technical specifications publicly available currently. The introduction of foundation structures and associated scour protection, and any cable protection required, will likely leading to an increase in colonisation of these surfaces. The available area for colonisation predicted to result from the Mona Generation Assets is up to 2,854,062m^2 (bp/EnBW, 2023) and is therefore similar to that arising from the Morgan Offshore Wind Project.

8.10.7.12 No publicly available information was available, at the time of writing, which quantifies the extent of area available for colonisation of hard structures associated with the Morecambe Offshore Wind Farm or the Morgan and Morecambe Offshore Wind Farms Transmission Assets and so this is not represented in the cumulative tier 2 total.

8.10.7.13 The indicative capacity of these two projects (Table 8.28) are however smaller than the Morgan Generation Assets and therefore the scale of the impacts associated with these tier 2 projects may be less than that associated with the Morgan Generation Assets.

8.10.7.14 The cumulative effect is predicted to be of regional spatial extent, long term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.7.15 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.7.16 Marine fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, and local to national importance (recoverability is not relevant to this impact during the operations and maintenance phase). The sensitivity of the receptor is therefore, considered to be **low**.

Diadromous species

8.10.7.17 Most diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.10.7.18 Sea trout are deemed to be of medium vulnerability, high recoverability and national importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.10.7.19 For marine fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.7.20 For most diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.7.21 For sea trout, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

8.10.7.22 The decommissioning phases of the Mona Offshore Wind Project, Morecambe Offshore Wind Farm, and Morgan and Morecambe Offshore Wind Farms Transmission Assets may have temporal overlap with the decommissioning of the Morgan Generation Assets. The expected magnitude of the colonisation of hard structures will be similar to the previous phases, due to the leaving in place of scour protection, and cable protection. Colonisation of hard structures will mostly therefore occur due to the presence of these structures.

8.10.7.23 No public information is currently available for the Morecambe Offshore Wind Farm or Morgan and Morecambe Offshore Wind Farms Transmission Assets, but their smaller indicative capacities than the Morgan Generation Assets (Table 8.28) suggests a potentially lower level of potential impact.

8.10.7.24 The cumulative effect is predicted to be of regional spatial extent, permanent (i.e. hard structures will remain in-situ post decommissioning), continuous and irreversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

Marine species

8.10.7.25 The sensitivity of marine fish and shellfish IEFs to this impact can be found in the construction and operations and maintenance phases (paragraph 8.8.7.9 to paragraph 8.8.7.19), with **low** sensitivity, and these are expected to apply after the decommissioning phase equally.

Diadromous species

8.10.7.26 The sensitivity of diadromous fish and shellfish IEFs to this impact can be found in the construction and operations and maintenance phases (paragraph 8.8.7.20 to paragraph 8.8.7.26), with **low** sensitivity, and these are expected to apply during the decommissioning phase equally.

Significance of effect

Marine species

8.10.7.27 For marine fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.7.28 For most diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.7.29 For sea trout, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Tier 3

Construction and operations and maintenance phases

Magnitude of impact

8.10.7.30 The proposed construction of the MaresConnect Wales-Ireland Interconnector Cable will likely overlap with the construction phase of the Morgan Generation Assets, leading to a potential cumulative impact. Specifically, the installation of electrical cables is likely to include introduction of cable protection which will act as a potential site for colonisation by hard structure communities. Although no exact specifications are publicly available for the area for potential colonisation, it is expected that the cable protection will only represent a small increase of introduced hard structures proportional to the entire cumulative fish and shellfish ecology study area, and so will have only a minor cumulative impact.

8.10.7.31 The cumulative effect is predicted to be of regional spatial extent, long term duration, continuous and low reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is, therefore, considered to be **negligible**.

Sensitivity of the receptor

Marine species

8.10.7.32 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Morgan Generation Assets alone.

8.10.7.33 Marine fish and shellfish ecology IEFs in the fish and shellfish ecology study area are deemed to be of low vulnerability, and local to national importance (recoverability is not relevant to this impact during the operations and maintenance phase). The sensitivity of the receptor is therefore, considered to be **low**.

Diadromous species

8.10.7.34 Most diadromous fish species are deemed to be of low vulnerability, high recoverability and national to international importance. The sensitivity of the receptor is therefore, considered to be **low**.

8.10.7.35 Sea trout are deemed to be of medium vulnerability, high recoverability and national importance. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

Marine species

8.10.7.36 For marine fish and shellfish ecology IEFs, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Diadromous species

8.10.7.37 For most diadromous fish species IEFs, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.7.38 For sea trout, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.10.8 Injury due to increased risk of collision with vessels (basking shark only)

8.10.8.1 Increased levels of vessel activity related to the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets will likely represent an increased risk of collision with basking shark, with this impact assessed alone in section 8.8.8. This could have cumulative impacts with the vessels involved in activities associated with the tier 1 Awel y Môr Offshore Wind Farm, dredging and dredge disposal, and aggregate extraction and disposal within the cumulative fish and shellfish ecology study area. These could also have cumulative impacts with the tier 2 Mona Offshore Wind Project, Morecambe Offshore Wind Farm, and Morgan and Morecambe Offshore Wind Farms Transmission Assets, and the tier 3 MaresConnect Wales-Ireland Interconnector Cable, which will involve increased vessel activity in every phase over their proposed lifetimes.

Tier 1

All phases

Magnitude of impact

8.10.8.2 The construction phase of the Awel y Môr Offshore Wind Farm is expected to overlap temporally with the construction phase of the Morgan Generation Assets, potentially resulting in a cumulative impact. Specifically, the construction activities of the Awel y Môr Offshore Wind Farm will involve increasing vessel numbers in the vicinity overall, but analysis of existing heavy background vessel traffic suggests this rise will not be significant (RWE, 2021b).

8.10.8.3 During the operations and maintenance phase the number of vessels associated with both tier 1 wind farms (Morgan and Awel y Môr) will be lower than during the construction phase, and therefore risks of collision to basking shark will similarly reduce.

8.10.8.4 Other projects that could cumulatively impact basking shark through increased risk of vessel collision include a range of small scale and spatially widely distributed dredging and disposal activities (Table 8.28). As these activities will involve a low number of vessels at once, many of which are moving slowly, and widely spatially distributed throughout the cumulative fish and shellfish ecology study area, the level of cumulative impact is expected to be low.

8.10.8.5 The cumulative effect is predicted to be of regional spatial extent, long term duration (i.e. all phases of the tier 1 projects), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

8.10.8.6 The basking shark sensitivity to this impact within the fish and shellfish ecology study area has been assessed previously.

8.10.8.7 The basking shark within the Mona Fish and Shellfish Ecology Area are deemed to be of low vulnerability, medium recoverability, and international importance. The sensitivity of the receptor, therefore, is considered to be **medium**.

Significance of effect

8.10.8.8 For basking shark, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Tier 2

All phases

Magnitude of impact

8.10.8.9 The number of vessels undertaking construction activities in the Morgan Fish and Shellfish study area will overlap temporally and act to have a cumulative impact with the construction of the Mona Offshore Wind Project, the Morecambe Offshore Wind Farm, and the Morgan and Morecambe Offshore Wind Farms Transmission Assets. Based on currently publicly available information concerning the Mona Offshore Wind Project, examined in detail in volume 2, chapter 8: Fish and shellfish ecology chapter of the PEIR, this will increase construction vessel numbers to a maximum of 91 construction vessels at any one time, and is therefore similar to the Morgan Offshore Wind Project.

8.10.8.10 At the time of writing, no public information was available for the Morecambe Offshore Wind Farm or the Morgan and Morecambe Offshore Wind Farms Transmission Assets. However, given the smaller indicative capacity of these projects compared to the Morgan Generation Assets (Table 8.28), it is expected that the number of construction vessels will be similar or smaller, and so the risk of collision with basking shark will not significantly increase.

8.10.8.11 During the operations and maintenance phase the number of vessels associated with all tier 2 projects will be expected to be lower than during the construction phase, and therefore risks of collision to basking shark will similarly reduce.

8.10.8.12 The cumulative effect is predicted to be of regional spatial extent, long term duration (all phases of the tier 2 projects), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

8.10.8.13 The basking shark sensitivity to this impact within the fish and shellfish ecology study area has been assessed previously.

8.10.8.14 The basking shark within the Morgan Fish and Shellfish Ecology Area are deemed to be of low vulnerability, medium recoverability, and international importance. The sensitivity of the receptor, therefore, is considered to be **medium**.

Significance of effect

8.10.8.15 For basking shark, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

Tier 3

All phases

Magnitude of impact

8.10.8.16 The number of vessels undertaking construction or maintenance activities on the MaresConnect Wales-Ireland Interconnector Cable will overlap temporally with the Morgan Generation Assets and potentially act to cause a cumulative impact. Specifically, this will increase construction vessel numbers, although the total number at any one time is not currently publicly available (vessels involved in maintenance of this project are expected to be minimal). This will represent an increased risk of collision with basking shark but compared to the overall area available for basking shark, the potential spatial area of impact is low and therefore the risk of collision will similarly be low.

8.10.8.17 The cumulative effect is predicted to be of regional spatial extent, medium term duration (all phases of the tier 3 projects), intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

Sensitivity of the receptor

8.10.8.18 The basking shark sensitivity to this impact within the fish and shellfish ecology study area has been assessed previously.

8.10.8.19 The basking shark within the Morgan Fish and Shellfish Ecology Area are deemed to be of low vulnerability, medium recoverability, and international importance. The sensitivity of the receptor, therefore, is considered to be **medium**.

Significance of effect

8.10.8.20 For basking shark, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be medium. The cumulative effect is, therefore, considered to be of **minor adverse** significance, which is not significant in EIA terms.

8.11 Transboundary effects

8.11.1.1 A screening of transboundary impacts has been carried out and any potential for significant transboundary effects with regard to fish and shellfish ecology from the Morgan Generation Assets upon the interests of other states has been assessed as part of this PEIR. The potential transboundary impacts assessed within volume 3, annex 5.2: Transboundary impacts screening of the PEIR are summarised below.

8.11.1.2 As set out above, the majority of impacts on fish and shellfish IEF receptors will be restricted to the within the Morgan Array Area and the immediate surrounding areas. Exceptions to this are impacts from underwater noise, and the impacts of increased suspended sediment concentrations and associated sediment deposition, which have the potential to extend into IoM waters.

8.11.1.3 Underwater noise impacting fish and shellfish receptors has a magnitude deemed to be low and the sensitivity of the receptors to this impact is considered to be low to medium. Effects of underwater noise on fish and shellfish receptors are not predicted to extend beyond UK and IoM waters.

8.11.1.4 Increased SSCs and associated sediment deposition has a magnitude deemed to be low, and the sensitivity of the receptors is considered to be low to medium, with the significance therefore being negligible to minor adverse. However, the identified tidal excursion of 20km means that any increased SSC is likely to settle out before crossing any international boundaries, suggesting this impact is unlikely to have any significant transboundary effect.

8.11.1.5 Based on the above assessment, no significant transboundary effects on fish and shellfish IEFs are predicted as a result of the Morgan Generation Assets.

8.12 Inter-related effects

8.12.1.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the Morgan Generation Assets (construction, operations and maintenance, and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three phases (e.g. subsea noise effects from piling, operational wind turbines, vessels and decommissioning)
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on fish and shellfish ecology, such as temporary habitat loss; underwater noise; increased SSCs and sediment deposition; long term habitat loss; EMF from subsea cabling; colonisation of hard structure, and disturbance or remobilisation of sediment-bound contaminants may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects may be short term, temporary or transient effects, or incorporate longer term effects.

8.12.1.2 A description of the likely interactive effects arising from the Morgan Generation Assets on fish and shellfish ecology is provided in volume 2, chapter 19: Inter-related effects (offshore) of the PEIR.

8.12.1.3 Table 8.31 lists the inter-related effects (project lifetime effects) that are predicted to arise during the construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets, and also the inter-related effects (receptor-led effects) that are predicted to arise for fish and shellfish receptors.

Table 8.31: Summary of likely significant inter-related effects on the environment for individual effects occurring across the construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets and from multiple effects interacting across all phases (receptor-led effects).

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of impact	Phase[a]			Likely significant inter-related effects	Significance
	C	O	D		
Temporary and long term habitat loss/disturbance.	✓	✓	✓	When subtidal habitat loss (temporary and long term) is considered additively across all phases of the project, the total area of habitat affected is larger than for the individual project stages. However, similar habitats are widespread across the Fish and Shellfish ecology study area and the wider Irish Sea and the impact will therefore be proportionally small in this context. During the operations and maintenance phase, most of the disturbance will be highly localised, and the habitats affected are predicted to recover quickly following completion of maintenance activities with fish and shellfish IEFs recovering into the affected areas. Also, many operations and maintenance activities will be located in the same areas affected during construction (e.g. jack up operations adjacent to wind turbines, or reburial of exposed cables). Decommissioning will also be impacting the same locations, to a lesser degree than during construction. Therefore, across the project lifetime, the effects on fish and shellfish IEFs 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.	Minor adverse

Description of impact	Phase[a]			Likely significant inter-related effects	Significance
	C	O	D		
Underwater noise impacting fish and shellfish receptors	✓	×	×	The impact of underwater noise from piling will only arise during the construction phase and as such there will be no interaction effects across the project phases.	Minor adverse
Increased SSCs and associated sediment deposition	✓	✓	✓	The majority of the seabed disturbance (resulting in highest SSC/deposition) will occur during the construction and decommissioning phases, with minor increases in SSC/deposition during the operations and maintenance phase. IEFs and associated spawning/nursery habitats potentially affected by increased SSC and deposition will recover quickly following impact exposure such that there will be no inter-related effects across the construction, operations and maintenance and decommissioning phases. Therefore, across the project lifetime, the effects on fish and shellfish IEFs 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.	Minor adverse
Electromagnetic Fields (EMF) from subsea electrical cabling.	×	✓	×	This effect will only arise during the operations and maintenance phase and as such there will be no interaction effects across the project phases.	Minor adverse
Colonisation of hard structures	✓	✓	✓	This impact will occur throughout all phases of the Morgan Generation Assets, with the expected development of hard substrate communities throughout the lifetime of the infrastructure. These communities will differ from the surrounding sedimentary biotopes but are unlikely to represent a significant decrease in biodiversity. Also, much of the hard infrastructure is expected to be left in place following decommissioning (except wind turbine and OSP foundations), and this will provide long-term stability to any communities which form. Therefore, across the project lifetime, the effects on fish and shellfish IEFs 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.	Minor adverse
Disturbance/remobilisation of sediment-bound contaminants	✓	✓	✓	This impact is expected to occur in all project phases. However, it is unlikely to have any additive effects due to the modelling and literature suggesting re-sedimentation to negligible concentrations within a few tidal cycles, which will not cause any significant combined impact across phases greater than what has been assessed for each individual phase.	Minor adverse
Injury due to increased risk of collision with vessels (basking shark only)	✓	✓	✓	This impact is unlikely to have any additive effect across the three phases of the Morgan Generation Assets, due to the implementation of a designed-in project-specific offshore Environmental Management Plan to be followed by every vessel engaged in the project to avoid collisions where possible. Should any collisions occur, the impact will be limited to that phase of activity, and evidence exists to suggest long-term survivability of basking shark in the event of collisions.	Minor adverse
Receptor-led effects					
Potential exists for spatial and temporal interactions between habitat loss or disturbance, underwater noise, increased SSC/deposition, colonisation of hard substrates, EMF effects, disturbance and remobilisation of sediment-bound contaminants, and injury to basking shark from vessel collisions during the lifetime of the Morgan Generation Assets. Based on current understanding, and expert knowledge, the greatest scope for potential interaction impacts is predicted to arise through the interaction of habitat loss (temporary and long term), increased SSC, underwater noise from piling during the construction phase, and EMF effects during the operations and maintenance phase. These individual impacts were assigned a significance of negligible to minor adverse as standalone impacts and although potential combined impacts may arise, it is important to recognise that some of the activities potentially resulting in combined effects are mutually exclusive. For example, most effects associated with an increase in SSC/deposition will arise from seabed preparation and sandwave clearance works installation of the Morgan inter-array and interconnector cables, whereas most noise effects will arise from foundation piling undertaken at a different time. In addition, these impacts will be temporary and reversable following cessation of construction or decommissioning, with fish and shellfish communities expected to recover into wind farm areas. Furthermore, underwater noise from piling operations is predicted to result in the displacement of mobile fish from areas around foundations which in turn will mean that these species will not be exposed to the greatest predicted increases in SSC. Any potential behavioural effects as a result of EMF would be likely to occur over the same area as habitat loss/change effects (i.e. within metres of the cable) and therefore habitat loss effects would not be additive to EMF effects. There may be localised changes in fish and shellfish communities in the areas affected by long term habitat loss, due to potential changes in substrate type and foraging opportunities, and potential behavioural effects associated with EMF. Any shifts in baseline assemblage will be limited to these areas and, therefore, effects of greater significance than the individual impacts in isolation (i.e. negligible to moderate) are not predicted. Overall, the evidence presented in section 8.8 indicates that impacts on fish and shellfish receptors from construction operations (particularly piling) are temporary and reversible and that fish and shellfish communities are not significantly adversely affected by the presence of operational wind farms (see section 8.8.7) and therefore additive effects across impacts and phases are not expected to occur.					

8.13 Summary of impacts, mitigation measures and monitoring

8.13.1.1 Information on fish and shellfish ecology within the fish and shellfish ecology study area was collected through desktop review, with improved coverage of published literature ensured through stakeholder consultation, and incorporation of some site-specific data opportunistically collected during site surveys.

- Table 8.32 presents a summary of the potential impacts, measures adopted as part of the project and residual effects in respect to fish and shellfish ecology. The impacts assessed include temporary habitat loss/disturbance; underwater noise impacting fish and shellfish receptors; increased SSCs and associated sediment deposition; long term habitat loss; EMF from subsea electrical cabling; colonisation of hard structures; and injury due to increased risk of collision with vessels. Overall, it is concluded that there will be no significant effects impacting fish and shellfish receptors. There is potential for herring to be subject to moderate adverse effects from underwater noise, should piling occur during the known spawning period for this species. No mitigation is required based upon the assessment outcomes; however, mitigation options are currently being investigated to minimise risks of significant impacts if piling occurs during the herring spawning season.

- Table 8.33 presents a summary of the potential cumulative impacts, mitigation measures and residual effects. The cumulative impacts assessed include temporary habitat loss/disturbance; underwater noise impacting fish and shellfish receptors; increased SSCs and associated sediment deposition; long term habitat loss; EMF from subsea electrical cabling; colonisation of hard structures, and injury due to increased risk of collision with vessels (basking shark only). Overall, it is concluded that there will be no significant cumulative effects from the Morgan Generation Assets alongside other projects/plans.
- Potential transboundary impacts have been identified in regard to effects of the Morgan Generation Assets in relation to underwater noise impacting fish and shellfish receptors, however no significant transboundary effects on this receptor group are predicted to occur.

Table 8.32: Summary of potential environmental effects, mitigation and monitoring.

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of effect	Phase[a] C	Phase[a] O	Phase[a] D	Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Temporary habitat loss/disturbance	✓	✓	✓	Development of, and adherence to, an offshore Environmental Management Plan throughout all phases, and actions to reduce potential for introduction of INNS.	C: Low O: Low D: Low	C: Marine – Low to medium Diadromous- Negligible O: Marine – Low to medium Diadromous - Negligible D: Marine – Low to medium Diadromous - Negligible	C: Marine - Minor adverse Diadromous - Negligible O: Marine – Minor adverse Diadromous - Negligible D: Marine – Minor adverse Diadromous - Negligible	Not required	C: Marine - Minor adverse Diadromous - Negligible O: Marine – Minor adverse Diadromous - Negligible D: Marine – Minor adverse Diadromous - Negligible	None proposed
Underwater noise impacting fish and shellfish receptors	✓	×	✓	Implementation of piling soft-start and ramp-up measures. This measure will minimise the risk of injury to fish species in the immediate vicinity of piling activities, allowing individuals to flee the area before noise levels reach a level at which injury may occur.	C: Medium	C: Marine – Low to medium Diadromous – Low to medium	C: Marine – Minor adverse Diadromous- Minor adverse	Not required, however further mitigation is currently being investigated to minimise risks of significant impacts if piling occurs during the herring spawning season.	C: Marine – Minor adverse Diadromous- Minor adverse	None proposed at this stage
Increased suspended sediment concentrations (SSCs) and associated sediment deposition	✓	✓	✓	Development of, and adherence to, an offshore Environmental Management Plan.	C: Low O: Negligible D: Low	C: Marine – Low to medium Diadromous- Low O: Marine – Low to medium Diadromous - Low D: Marine – Low to medium Diadromous - Low	C: Marine – Minor adverse Diadromous - Negligible O: Marine – Negligible or minor adverse Diadromous - Negligible D: Marine – Negligible or minor adverse Diadromous - Negligible	Not required	C: Marine – Minor adverse Diadromous - Negligible O: Marine – Negligible or minor adverse Diadromous - Negligible D: Marine – Negligible or minor adverse Diadromous - Negligible	None proposed

Description of effect	Phase[a]			Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
	C	O	D							
Long term habitat loss.	✓	✓	✓	Development of, and adherence to, an offshore Environmental Management Plan throughout all phases; actions to reduce potential for introduction of INNS, and development and adherence to a CSIP.	C: Low O: Low D: Low	C: Marine – Low to medium Diadromous - Low O: Marine – Low to medium Diadromous - Low D: Marine – Low to medium Diadromous - Low	C: Marine – Minor adverse Diadromous – Minor adverse O: Marine – Minor adverse Diadromous – Negligible to minor adverse D: Marine – Minor adverse Diadromous – Minor adverse	Not required	C: Marine – Minor adverse Diadromous – Minor adverse O: Marine – Minor adverse Diadromous – Negligible to minor adverse D: Marine – Minor adverse Diadromous – Minor adverse	None proposed
Electromagnetic Fields (EMF) from subsea electrical cabling.	×	✓	×	Development and adherence to a CSIP. All electrical cables will be buried to depths of at least 0.5m as informed by a CBRA. While burial of cables will not reduce the strength of EMF, it does increase the distance between cables and fish and shellfish receptors, thereby potentially reducing the effect on those receptors.	O: Low	O: Marine – Low Diadromous - Low	O: Marine – Minor adverse Diadromous – Minor adverse	Not required	O: Marine – Minor adverse Diadromous – Minor adverse	None proposed
Colonisation of hard structures	✓	✓	✓	Development of, and adherence to, an offshore Environmental Management Plan throughout all phases, and actions to reduce potential for introduction of INNS.	C: Low O: Low D: Low	C: Marine – Low Diadromous - Low O: Marine – Low Diadromous - Low D: Marine – Low Diadromous - Low	C: Marine –Minor adverse Diadromous – Minor adverse O: Marine – Minor adverse Diadromous – Minor adverse D: Marine – Minor adverse Diadromous – Minor adverse	Not required	C: Marine –Minor adverse Diadromous – Minor adverse O: Marine – Minor adverse Diadromous – Minor adverse D: Marine – Minor adverse Diadromous – Minor adverse	None proposed
Injury due to increased risk of collision with vessels	✓	✓	✓	An offshore Environmental Management Plan will be issued to all Project vessel operators, requiring them to: • Not deliberately approach basking shark • Keep vessel speed to a minimum; and • Avoid abrupt changes in course or speed should basking shark approach the vessel. The offshore Environmental Management Plan will be adhered to at all times.	C: Low O: Low D: Low	C: Marine – Medium O: Marine – Medium D: Marine - Medium	C: Marine – Minor adverse O: Marine – Minor adverse D: Marine – Minor adverse	Not required	C: Marine – Minor adverse O: Marine – Minor adverse D: Marine – Minor adverse	None proposed

Table 8.33: Summary of potential cumulative environmental effects, mitigation and monitoring.

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of effect	Phase[a] C	O	D	Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Temporary habitat loss/disturbance	✓	✓	✓	Development of, and adherence to, an offshore Environmental Management Plan throughout all phases, and actions to reduce potential for introduction of INNS.	C: Low O: Low D: Low	C: Marine – Low to medium Diadromous- Negligible O: Marine – Low to medium Diadromous - Negligible D: Marine – Low to medium Diadromous - Negligible	C: Marine - Minor adverse Diadromous - Negligible O: Marine – Minor adverse Diadromous - Negligible D: Marine – Minor adverse Diadromous - Negligible	Not required	C: Marine - Minor adverse Diadromous - Negligible O: Marine – Minor adverse Diadromous - Negligible D: Marine – Minor adverse Diadromous - Negligible	None proposed
Underwater noise impacting fish and shellfish receptors	✓	×	✓	Implementation of piling soft-start and ramp-up measures. This measure will minimise the risk of injury to fish species in the immediate vicinity of piling activities, allowing individuals to flee the area before noise levels reach a level at which injury may occur.	C: Medium	C: Marine – Low to medium Diadromous – Low to medium	C: Marine – Minor adverse Diadromous- Minor adverse	Not required, however further mitigation is currently being investigated to minimise risks of significant impacts if piling occurs during the herring spawning season.	C: Marine – Minor adverse Diadromous- Minor adverse	None proposed
Increased suspended sediment concentrations (SSCs) and associated sediment deposition	✓	✓	✓	Development of, and adherence to, an offshore Environmental Management Plan.	C: Low O: Negligible D: Low	C: Marine – Low to medium Diadromous- Low O: Marine – Low to medium Diadromous - Low D: Marine – Low to medium Diadromous - Low	C: Marine – Minor adverse Diadromous - Negligible O: Marine – Negligible or minor adverse Diadromous - Negligible D: Marine – Negligible or minor adverse Diadromous - Negligible	Not required	C: Marine – Minor adverse Diadromous - Negligible O: Marine – Negligible or minor adverse Diadromous - Negligible D: Marine – Negligible or minor adverse Diadromous - Negligible	None proposed

Description of effect	Phase[a] C	O	D	Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Long term habitat loss.	✓	✓	✓	Development of, and adherence to, an offshore Environmental Management Plan throughout all phases; actions to reduce potential for introduction of INNS, and development and adherence to a CSIP.	C: Low O: Low D: Low	C: Marine – Low to medium Diadromous - Low O: Marine – Low to medium Diadromous - Low D: Marine – Low to medium Diadromous - Low	C: Marine – Minor adverse Diadromous – Minor adverse O: Marine – Minor adverse Diadromous – Negligible to minor adverse D: Marine – Minor adverse Diadromous – Minor adverse	Not required	C: Marine – Minor adverse Diadromous – Minor adverse O: Marine – Minor adverse Diadromous – Negligible to minor adverse D: Marine – Minor adverse Diadromous – Minor adverse	None proposed
Electromagnetic Fields (EMF) from subsea electrical cabling.	×	✓	×	Development and adherence to a CSIP. All electrical cables will be buried to depths of at least 0.5m as informed by a CBRA. While burial of cables will not reduce the strength of EMF, it does increase the distance between cables and fish and shellfish receptors, thereby potentially reducing the effect on those receptors.	O: Low	O: Marine – Low Diadromous - Low	O: Marine – Minor adverse Diadromous – Minor adverse	Not required	O: Marine – Minor adverse Diadromous – Minor adverse	None proposed
Colonisation of hard structures	✓	✓	✓	Development of, and adherence to, an offshore Environmental Management Plan throughout all phases, and actions to reduce potential for introduction of INNS.	C: Low O: Low D: Low	C: Marine – Low Diadromous - Low O: Marine – Low Diadromous - Low D: Marine – Low Diadromous - Low	C: Marine –Minor adverse Diadromous – Minor adverse O: Marine – Minor adverse Diadromous – Minor adverse D: Marine – Minor adverse Diadromous – Minor adverse	Not required	C: Marine –Minor adverse Diadromous – Minor adverse O: Marine – Minor adverse Diadromous – Minor adverse D: Marine – Minor adverse Diadromous – Minor adverse	None proposed
Injury due to increased risk of collision with vessels	✓	✓	✓	An offshore Environmental Management Plan will be issued to all Project vessel operators, requiring them to: • Not deliberately approach basking shark • Keep vessel speed to a minimum; and • Avoid abrupt changes in course or speed should basking shark approach the vessel. The offshore Environmental Management Plan will be adhered to at all times.	C: Low O: Low D: Low	C: Marine – Medium O: Marine – Medium D: Marine - Medium	C: Marine – Minor adverse O: Marine – Minor adverse D: Marine – Minor adverse	Not required	C: Marine – Minor adverse O: Marine – Minor adverse D: Marine – Minor adverse	None proposed

8.14 Next steps

8.14.1.1 As outlined in section -89646752.481.-89646752, to date, only the site-specific surveys within the Morgan Array Area have been completed and were available to inform this chapter for the purposes of the PEIR. Further site-specific surveys were undertaken in the summer of 2022 to include the ZOI around the Morgan Array Area. The baseline description and impact assessments in this chapter will therefore be updated with this additional data for the final Environmental Statement.

8.15 References

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