# MONA OFFSHORE WIND PROJECT

## Environmental Statement

### Volume 2, Chapter 3:Fish and shellfish ecology

Document Number: MOCNS-J3303-RPS-10041

Document Reference: F2.3

APFP Regulations: 5(2)(a)

February 2024

F01

Image of an offshore wind farm

www.morganandmona.com/en

## Document status

| Version | Purpose of document | Authored by | Reviewed by | Approved by | Review date |
|---|---|---|---|---|---|
| F01 | Application | RPS | Mona Offshore Wind Ltd | Mona Offshore Wind Ltd | Feb 2024 |

**Prepared by:**

**RPS**

**Prepared for:**

**Mona Offshore Wind Limited.**

# Contents

# Tables

# Figures

# Glossary

| Term | Meaning |
|---|---|
| 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. |
| Environmental Impact Assessment | The process of identifying and assessing the significant effects likely to arise from a project. This requires consideration of the likely changes to the environment, where these arise as a consequence of a project, through comparison with the existing and projected future baseline conditions. |
| Evidence Plan | The Evidence Plan is a mechanism to agree upfront what information the Applicant needs to supply to the Planning Inspectorate as part of the Development Consent Order (DCO) applications for the Mona Offshore Wind Project. |
| 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 Mona Offshore Wind Project. |
| K-strategist | Relatively slow-growing organisms which invest greater resources into raising a small number of offspring. |
| Masking | Masking occurs when sound emissions interfere with a marine animal's ability to hear a sound of interest. |
| 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 |
| AL (AL1, AL2) | Action Level (Action Level 1, Action Level 2) |
| BNG | Biodiversity Net Gain |
| CBRA | Cable Burial Risk Assessment |
| CCS | Carbon Capture and Storage |
| CEA | Cumulative Effects Assessment |
| CIEEM | Chartered Institute of Ecology and Environmental Management |
| CMACS | Centre for Marine and Coastal Studies Ltd |
| CMS | Construction Method Statement |

| Acronym | Description |
|---|---|
| COWRIE | Collaborative Offshore Wind Research into the Environment |
| CSIP | Cable Specification and Installation Plan |
| CSQG | Canadian Sediment Quality Guideline |
| CTV | Crew Transfer Vehicle |
| DC | Direct Current |
| DCO | Development Consent Order |
| DDV | Drop Down Video |
| EcIA | Ecological Impact Assessment |
| EIA | Environmental Impact Assessment |
| EMF | Electromagnetic Fields |
| EMODnet | European Marine Observation and Data Network |
| EMU | Ecological Marine Unit |
| EWG | Expert Working Group |
| HRA | Habitat Regulations Assessment |
| HVAC | High Voltage Alternation Current |
| ICES | International Council for the Exploration of the Sea |
| IEF | Important Ecological Features |
| IEMA | Institute of Environmental Management and Assessment |
| IMO | International Maritime Organisation |
| INNS | Invasive Non-Native Species |
| IoM | Isle of Man |
| ISAA | Information to Support Appropriate Assessment |
| IUCN | International Union for Conservation of Nature |
| JNCC | Joint Nature Conservation Committee |
| MarESA | Marine Evidence Based Environmental Sensitivity Assessment |
| MarLIN | Marine Life Information Network |
| MARPOL | International Convention for the Prevention of Pollution from Ships |
| MCZ | Marine Conservation Zone |
| MHWS | Mean High Water Springs |
| MMO | Marine Management Organisation |
| MNR | Marine Nature Reserve |
| MPA | Marine Protected Area |
| MPCP | Marine Pollution Contingency Plan |
| NBN | National Biodiversity Network |
| NEQ | Net Explosive Quantity |

| Acronym | Description |
|---|---|
| NINEL | Northern Ireland Herring Larvae Survey |
| NMFS | National Marine Fisheries Service |
| NPS | National Policy Statement |
| NRW | Natural Resources Wales |
| NSIPs | Nationally Significant Infrastructure Projects |
| OSP | Offshore Substation Platform |
| OSPAR | Oslo Paris Convention for the Protection of the Marine Environment of the North-East Atlantic |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PCB | Polychlorinated Biphenyl |
| PDE | Project Design Envelope |
| PEIR | Preliminary Environmental Information Report |
| PSA | Particle Size Analysis |
| PTS | Permanent Threshold Shift |
| RMS | Root-Mean-Square |
| SAC | Special Area of Conservation |
| SSSI | Site of Special Scientific Interest |
| SNCB | Statutory Nature Conservation Bodies |
| SOV | Service Operation Vehicle |
| SPA | Special Protected Area |
| SPI | Species of Principal Importance |
| SPM | Suspended Particulate Matter |
| SSC | Suspended Sediment Concentration |
| TEL | Threshold Effect Level |
| TTS | Temporary Threshold Shift |
| UXO | Unexploded Ordnance |
| ZoI | Zone of Influence |

# Units

| Unit | Description |
|---|---|
| % | Percentage |
| mm | Millimetres |
| cm | Centimetres |
| m | Metres |
| km | Kilometres |

| Unit | Description |
|---|---|
| nm | Nautical miles |
| $m^2$ | Square metres |
| $km^2$ | Square kilometres |
| $m^3$ | Cubed metres |
| m/h | Metres per hour |
| m/s | Metres per second |
| mg/l | Milligrams per litre |
| kg | Kilograms |
| µg/g | Micrograms per gram |
| kV | Kilovolts |
| V/m | Volts per metre |
| MW | Megawatts |
| GW | Gigawatts |
| GWh | Gigawatt hours |
| µT | Microtesla |
| mG | Milligauss |
| G | Gauss |
| kJ | Kilojoules |
| Hz | Hertz |
| kHz | Kilohertz |
| dB | Decibels |
| µPa | Micropascals |
| ˚C | Degrees Celsius |

# 3 Fish and shellfish ecology

## 3.1 Introduction

### 3.1.1 Overview

3.1.1.1 This chapter of the Environmental Statement presents the assessment of the potential impact of the Mona Offshore Wind Project on fish and shellfish ecology. Specifically, this chapter considers the potential impact of the Mona Offshore Wind Project seaward of Mean High Water Springs (MHWS) during the construction, operations and maintenance and decommissioning phases.

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

- Volume 2, Chapter 1: Physical processes of the Environmental Statement
- Volume 2, Chapter 2: Benthic subtidal and intertidal ecology of the Environmental Statement
- Volume 2, Chapter 4: Marine mammals of the Environmental Statement.

3.1.1.3 This chapter also draws upon information contained within:

- Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement
- Volume 6, Annex 1.1: Physical processes technical report of the Environmental Statement
- Volume 6, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the Environmental Statement
- Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement
- Volume 6, Annex 4.1: Marine mammals technical report of the Environmental Statement
- Volume 6, Annex 6.1: Commercial fisheries technical report of the Environmental Statement.

## 3.2 Legislative and policy context

### 3.2.1 Legislation

3.2.1.1 The policy context for the Mona Offshore Wind Project is set out in Volume 1, Chapter 2: Policy and legislative context of the Environmental Statement. The policy and legislation set out below is the most relevant to fish and shellfish ecology.

#### Habitats Regulations

3.2.1.2 The Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (collectively known as the 'Habitats Regulations') require the assessment of significant effects on internationally important nature conservation sites, including the following:

- Special Areas of Conservation (SACs) or candidate SACs
- Special Protection Areas (SPAs) or potential SPAs
- Sites of Community Importance
- Ramsar sites.

3.2.1.3 These designated sites have been given full consideration in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and are given further consideration within this chapter where the impacts are assessed as likely to have an effect.

#### Marine and Coastal Access Act 2009

3.2.1.4 Parts three and four of the Marine and Coastal Access Act 2009 introduced a new marine planning and licensing system for overseeing the marine environment and a requirement to obtain a marine licence for certain activities and works at sea. Section 149A of the Planning Act 2008 allows applicants for development consent to apply for 'deemed marine licences' as part of the consenting process.

3.2.1.5 Part five of the Marine and Coastal Access Act 2009 enables the designation of Marine Conservation Zones (MCZs) in England and Wales as well as UK offshore areas. Consideration of MCZs is required for any marine licence application or an application for development consent which includes a deemed marine licence.

3.2.1.6 The potentially impacted designated sites have been given full consideration in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement as well as in the MCZ Assessment and are given further consideration within this chapter where the impacts are deemed likely to have an effect.

#### Environment Act 2021

3.2.1.7 The Environment Act 2021 sets out targets, plans and policies for environmental protection in England. Schedule 15 of the Environment Act 2021 sets out provisions for Biodiversity Net Gain (BNG) in respect of nationally significant infrastructure projects (NSIPs) and amends the Planning Act 2008. These provisions are not yet in force but propose to include the requirement for the production of BNG statements for NSIPs. In response to the recent consultation on the requirements of the Environment Act 2021, the Government has stated that it intends to produce a draft BNG statement for NSIPs and intends to consult with the industry on this (Department for Environment, Food and Rural Affairs (Defra), 2023). The stated intention is for the requirements of the Environment Act 2021 in relation to biodiversity to be implemented no later than 2025, which will temporally overlap with the ongoing development of the Mona

Offshore Wind Project. The approach taken for the Mona Offshore Wind Project regarding biodiversity enhancement is outlined in the Biodiversity benefit and green infrastructure statement (Document Reference J7).

3.2.1.8 This Act does not however apply to works occurring within Welsh inshore waters, where instead a separate marine licence is required from Natural Resources Wales (NRW), such as the Mona Offshore Wind Project.

#### Environment (Wales) Act 2016

3.2.1.9 The Environment (Wales) Act 2016 sets out targets, plans and policies for environmental protection in Wales. Section 6 of the Environment (Wales) Act 2016 requiring all public authorities, when carrying out their functions in Wales, to seek to “maintain and enhance biodiversity” where it is within the proper exercise of their functions. In doing so, public authorities must also seek to “promote the resilience of ecosystems”. Welsh Government now requires strategic action to safeguard ecological networks and secure biodiversity enhancement. The approach taken for the Mona Offshore Wind Project regarding biodiversity enhancement is outlined in the Biodiversity benefit and green infrastructure statement (Document Reference J7).

### 3.2.2 Planning policy context

3.2.2.1 The Mona Offshore Wind Project will be located in Welsh offshore waters (beyond 12 nm from the Welsh coast) and Welsh inshore waters, with both the offshore and onshore infrastructure located wholly within Wales. As set out in Volume 1, Chapter 1: Introduction of the Environmental Statement, as the Mona Offshore Wind Project is an offshore generating station with a capacity of greater than 350 MW located in Welsh waters, it is a NSIP as defined by Section 15(3) of the Planning Act 2008 (the 2008 Act). As such, there is a requirement to submit an application for a Development Consent Order (DCO) to the Planning Inspectorate to be decided by the Secretary of State for the Department for Energy Security and Net Zero.

### 3.2.3 National Policy Statements

3.2.3.1 There are currently six energy National Policy Statements (NPSs), two of which contain policy relevant to offshore wind development and the Mona Offshore Wind Project, specifically:

- Overarching NPS for Energy (NPS EN-1) which sets out the UK Government’s policy for the delivery of major energy infrastructure (Department for Energy Security & Net Zero, 2024a).
- NPS for Renewable Energy Infrastructure (NPS EN-3) (Department for Energy Security & Net Zero, 2024b).

3.2.3.2 NPS EN-1 and NPS EN-3 include guidance on what matters are to be considered in the assessment. These are summarised in Table 3.1 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 3.2.

**Table 3.1: Summary of the NPS EN-1 and NPS EN-3 provisions relevant to fish and shellfish ecology.**

| Summary of NPS EN-1 and EN-3 provision | How and where considered in the chapter |
|---|---|
| **NPS EN-1** | |
| [NPS EN-1, paragraph 4.1.5] In considering any proposed development, in particular when weighing its adverse impacts against its benefits, the Secretary of State should take into account:<br>• Its potential benefits including its contribution to meeting the need for energy infrastructure, job creation, reduction of geographical disparities, environmental enhancements, and any long-term or wider benefits<br>• Its potential adverse impacts, including on the environment, and including any long-term and cumulative adverse impacts, as well as any measures to avoid, reduce, mitigate or compensate for any adverse impacts, following the mitigation hierarchy.<br>In addition, in exercising functions in relation to Wales, the Secretary of State should act in accordance with duties placed upon public authorities, including Ministers of the Crown, by Section 6 of the Environment (Wales) Act 201691 and seek to maintain and enhance biodiversity, and in so doing promote the resilience of ecosystems, so far as consistent with the proper exercise of the Secretary of State's functions. | The existing ecology is laid out in the baseline environment (section 3.4), with all relevant information used to inform the associated assessment of significant effects on this baseline (section 3.9). This can be used to allow weighing of impacts and benefits in the decision-making process. |
| [NPS EN-1, paragraph 4.1.6] In this context, the Secretary of State should take into account environmental, social and economic benefits and adverse impacts, at national, regional and local levels. These may be identified in this NPS, the relevant technology specific NPS, in the application or elsewhere (including in local impact reports, marine plans, and other material considerations as outlined in Section 1.1). | Nearby designated sites, and their associated habitats and species of principal importance (SPI), have been identified in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and are listed in section 3.5.2, with the identified Important Ecological Features (IEFs) listed in section 3.5.3. These can be used in accounting for national, regional, and local impacts of these projects. |
| [NPS EN-1, paragraph 4.1.11] The energy NPSs have taken account of the National Planning Policy Framework (NPPF), the Planning Practice Guidance (PPG) for England, and Planning Policy Wales and Technical Advice Notes (TANs) for Wales, where appropriate. | All guidance and policy frameworks in relation to fish and shellfish ecology have been identified in section 3.2 and complied with throughout. |
| [NPS EN-1, paragraph 4.3.3] The Regulations require an assessment of the likely significant effects of the proposed project on the environment, covering the direct effects and any indirect, secondary, cumulative, transboundary, short, medium, and long-term, permanent and temporary, positive and negative effects at all stages of the project, and also of the measures envisaged for avoiding or mitigating significant adverse effects. | The impacts on fish and shellfish ecology have been assessed in section 3.9, with all other impacts assessed throughout the chapters. |
| [NPS EN-1, paragraph 4.3.4] To consider the potential effects, including benefits, of a proposal for a project, the applicant must set out information on the likely significant environmental, social and economic effects of the development, and show how any likely significant negative effects would be avoided, reduced, mitigated or compensated for, following the mitigation hierarchy. This information could include matters such as employment, equality, biodiversity net gain, community cohesion, health and well-being. | The impacts on fish and shellfish ecology have been assessed in section 3.9, with all other impacts assessed throughout the chapters, with mitigation measures identified in section 3.8. |

| Summary of NPS EN-1 and EN-3 provision | How and where considered in the chapter |
|---|---|
| [NPS EN-1, paragraph 4.2.5] 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 3.9) examines the impacts of all stages of the project on the environmental factors, and specifically the fish and shellfish ecology receptors, impacted by the Mona Offshore Wind Project. |
| [NPS EN-1, paragraph 4.2.10] The applicant must provide information proportionate to the scale of the project, ensuring the information is sufficient to meet the requirements of the Environmental Impact Assessment (EIA) Regulations | Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement; the baseline (section 3.5); Maximum Design Scenario (MDS) (section 3.7.1), and assessment of impacts (section 3.9) sections examine the scale of potential impacts on the fish and shellfish ecology receptors. |
| [NPS EN-1, paragraph 4.2.12] Where some details are still to be finalised, the Environmental Statement should, to the best of the applicant's knowledge, assess the likely worst-case environmental, social and economic effects of the proposed development to ensure that the impacts of the project as it may be constructed have been properly assessed. | The MDS outlined in section 3.7.1 provides the calculated maximum design scenario impacts on fish and shellfish ecology. |
| [NPS EN-1, paragraphs 4.5.8 - 4.5.9] Applicants for a development consent order must take account of any relevant Marine Plans and are expected to complete a Marine Plan assessment as part of their project development, using this information to support an application for development consent.<br>Applicants are encouraged to refer to Marine Plans at an early stage, such as in preapplication, to inform project planning, for example to avoid less favourable locations as a result of other uses or environmental constraints. | All relevant Marine Plans and guidelines are outlined in section 3.2, with compliance to relevant fish and shellfish ecology clauses highlighted. |
| [NPS EN-1, paragraphs 4.6.6 and 4.6.9] Energy NSIP proposals, whether onshore or offshore, should seek opportunities to contribute to and enhance the natural environment by providing net gains for biodiversity, or the wider environment where possible.<br>In Wales, applicants should consider the guidance set out in Section 6.4 of Planning Policy Wales and the relevant policies in the Wales National Marine Plan. | The Welsh National Marine Plan policy has been examined in relation to fish and shellfish ecology receptors in section 3.2.5.<br>The Biodiversity benefit and green infrastructure statement (Document Reference J7) outlines the approach of the Mona Offshore Wind Project to biodiversity enhancement. |
| [NPS EN-1, paragraph 4.10.5] In certain circumstances, measures implemented to ensure a scheme can adapt to climate change may give rise to additional impacts, for example as a result of protecting against flood risk, there may be consequential impacts on coastal change. In preparing measures to support climate change adaptation applicants should take reasonable steps to maximise the use of nature-based solutions alongside other conventional techniques. | The potential future impact of climate change on fish and shellfish ecology is examined in the future baseline scenario (section 3.5.4). |
| [NPS EN-1, paragraphs 4.12.5 and 4.12.7] Applicants should consult the Marine Management Organisation (MMO) (or Natural Resources Wales (NRW) in Wales) on energy NSIP projects which would affect, or would be likely to affect, any relevant marine areas as defined in the Planning Act 2008 (as amended by section 23 of the Marine and Coastal Access Act 2009). Applicants are encouraged to consider the relevant marine plans in advance of consulting the MMO for England or the relevant policy teams at the Welsh government.<br>Applicants should make early contact with relevant regulators, including the Environment Agency or NRW and the MMO, to | The consultation process is outlined in section 3.3 of this chapter, including any communications with the Marine Management Organisation (MMO), the Environment Agency and NRW. |

| Summary of NPS EN-1 and EN-3 provision | How and where considered in the chapter |
|---|---|
| discuss their requirements for Environmental Protections and other consents. | |
| [NPS EN-1, paragraph 5.4.17] Where the development is subject to EIA the applicant should ensure that the ES clearly sets out any effects on internationally, nationally, and locally designated sites of ecological or geological conservation importance (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats. | Designated sites are set out in section 3.5.2, with IEFs defined in section 3.5.3 based on their conservation, ecological and commercial importance. The impact assessment (section 3.9) has been undertaken to consider the effects of each project on these IEFs. |
| [NPS EN-1, paragraph 5.4.19] 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 3.9), with designed in mitigation measures (section 3.8) proposed to reduce impacts where possible. |
| [NPS EN-1, paragraph 5.4.22] The design of energy NSIP proposals will need to consider the movement of mobile/migratory species such as birds, fish and marine and terrestrial mammals and their potential to interact with infrastructure. | Diadromous and migratory fish species have been identified as IEFs in section 3.5.3 and are considered in each relevant impact assessment in section 3.9. |
| [NPS EN-1, paragraph 5.4.23] Energy projects will need to ensure vessels used by the project follow existing regulations and guidelines to manage ballast water. | Vessels will operate under a Code of Conduct and will adhere to an Invasive Non-Native Species (INNS) management plan at all times, as detailed in section 3.8. |
| [NPS EN-1, paragraph 5.4.35] Applicants should include appropriate avoidance, mitigation, compensation and enhancement measures as an integral part of the proposed development.<br>In particular, the applicant should demonstrate that:<br>• During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works<br>• The timing of construction has been planned to avoid or limit disturbance<br>• 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<br>• Habitats will, where practicable, be restored after construction works have finished<br>• Opportunities will be taken to enhance existing habitats rather than replace them, and where practicable, create new habitats of value within the site landscaping proposals. Where habitat creation is required as mitigation, compensation, or enhancement the location and quality will be of key importance. In this regard habitat creation should be focused on areas where the most ecological and ecosystems benefits can be realised. | 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 in the construction, operation and maintenance and decommissioning phases (Table 3.18 and section 3.7.1). Also, to reduce impacts where possible, mitigation measures have been defined in section 3.8. |
| [NPS EN-1, paragraph 5.4.36] Applicants should produce and implement a Biodiversity Management Strategy as part of their development proposals. This could include provision for biodiversity awareness training to employees and contractors so as to avoid unnecessary adverse impacts on biodiversity during the construction and operation stages. | Any specific mitigation measures to minimise disturbance or damage to habitats and biodiversity have been identified and justified (<br>Table 3.19). |

<table>
<tr><th>Summary of NPS EN-1 and EN-3 provision</th><th>How and where considered in the chapter</th></tr>
<tr><td>[NPS EN-1, paragraph 5.6.10] Where relevant, applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures.</td><td>The potential impacts of suspended sediment concentrations have been modelled, with their impacts on fish and shellfish ecology receptors assessed in section 3.9.4.</td></tr>
<tr><td>[NPS EN-1, paragraph 5.12.6] Where noise impacts are likely to arise from the proposed development, the applicant should include the following in the noise assessment:<ul><li>A description of the noise generating aspects of the development proposal leading to noise impacts, including the identification of any distinctive tonal, impulsive, low frequency or temporal characteristics of the noise</li><li>Identification of noise sensitive receptors and noise sensitive areas that may be affected</li><li>The characteristics of the existing noise environment</li><li>A prediction of how the noise environment will change with the proposed development<ul><li>In the shorter term, such as during the construction period</li><li>In the longer term, during the operating life of the infrastructure</li><li>At particular times of the day, evening and night (and weekends) as appropriate, and at different times of year</li></ul></li><li>An assessment of the effect of predicted changes in the noise environment on any noise-sensitive receptors, including an assessment of any likely impact on health and well-being where appropriate, and noise-sensitive areas</li><li>If likely to cause disturbance, an assessment of the effect of underwater or subterranean noise</li><li>Measures to be employed in mitigating the effects of noise using best available techniques to reduce noise impacts.</li></ul></td><td>The sources of sound impacts have been identified in the MDS in section 3.7.1, and the impacts on fish and shellfish ecology receptors have been assessed alone in section 3.9.3, and cumulatively in section 3.11. Specific mitigation measures, including soft-starts for piling to reduce this impact, have been identified and discussed in section 3.8.</td></tr>
<tr><td>[NPS EN-1, paragraphs 5.12.11 – 5.12.12] In the marine environment, applicants should consider noise impacts on protected species, both at the individual project level and in-combination with other marine activities.<br><br>Applicants should submit a detailed impact assessment and mitigation plan as part of any development plan, including the use of noise mitigation and noise abatement technologies during construction and operation.</td><td>All relevant protected fish and shellfish ecology receptors which could be impacted by sound have been identified in section 3.5.3, and assessed in section 3.9.3 alone, and cumulatively in section 3.11. Mitigation measures to reduce this impact, including soft-starts for piling activities, have been identified and discussed in section 3.8. In addition, the project plans to develop an Underwater sound management strategy post-consent and in discussion with stakeholders to support reduction of the impact magnitude associated with underwater sound from piling. An Outline underwater sound management strategy (Document Reference J16) will be provided with the Application.</td></tr>
<tr><td colspan="2">NPS EN-3</td></tr>
<tr><td>[NPS EN-3, paragraphs 2.6.1 – 2.6.3] Where details are still to be finalised applicants should explain in the application which elements of the proposal have yet to be finalised, and the reason why this is the case.<br><br>Where flexibility is sought in the consent as a result, applicants should, to the best of their knowledge, assess the likely worst-case environmental, social and economic effects of the</td><td>The possible maximum magnitude of impacts on fish and shellfish ecology receptors have been identified in the MDS in section 3.7.1, based on the Project Design Envelope (PDE).</td></tr>
</table>

| Summary of NPS EN-1 and EN-3 provision | How and where considered in the chapter |
|---|---|
| proposed development to ensure that the impacts of the project as it may be constructed have been properly assessed.<br>Full guidance on how applicants and the Secretary of State should manage flexibility is set out in Section 4.3 of EN-1. | |
| [NPS EN-3, paragraphs 2.8.32 – 2.8.33] 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.<br>Whilst the technical suitability of the foundation design is not in itself a matter for the Secretary of State, the Secretary of State will need to be satisfied that the foundations will not have an unacceptable adverse effect on marine biodiversity, the physical environment or marine heritage assets. | Potential impacts from the range of possible foundation design parameters are addressed in the MDS calculation (section 3.7.1), with the levels of impact on ecologically important fish and shellfish receptors assessed in the assessment of significant effects (section 3.9). |
| [NPS EN-3, paragraph 2.8.48] Applicants are encouraged to work collaboratively with those other developers and sea users on co-existence/co-location opportunities, shared mitigation, compensation and monitoring where appropriate. Where applicable, the creation of statements of common ground between developers is recommended. Work is ongoing between government and industry to support effective collaboration and to find solutions to facilitate to greater co-existence/co-location. | Relevant developers have been consulted where appropriate. Other stakeholders have been consulted prior to application directly and through the expert working groups, as outlined in section 3.3. A range of fishers operating within the vicinity of the projects have been consulted on potential impacts and mitigation strategies. |
| [NPS EN-3, paragraph 2.8.52 – 2.8.53] Given the scale of offshore wind deployment required to meet 2030 and 2050 ambitions, applicants will need to give close consideration to impacts on MPAs, either alone or in combination, in addition to mitigation measures and/or compensation (both individually and in combination with other plans or projects) which may be needed to approve their projects.<br>It is likely that these may include proactive measures to reduce the impact of deployment e.g. micrositing of cable routes to avoid vulnerable habitats, alternatives piling or trenching techniques, noise abatement technology, collision avoidance methods or compensation for habitat loss. | Potentially impacted nearby designated sites have been identified in section 3.4.5 and are assessed throughout the chapter. Mitigation measures to minimise impacts on these designated sites have been identified and discussed in section 3.8. |
| [NPS EN-3, paragraph 2.8.98 and 2.8.101] Applicants should have regard to the specific ecological and biodiversity considerations that pertain to proposed offshore renewable energy infrastructure developments, namely:<br>• Fish (see Section 2.8.250 of this NPS)<br>• Intertidal and subtidal seabed habitats and species (see Section 2.8.233 of this NPS)<br>• Marine mammals (see Section 2.8.237 of this NPS)<br>• Birds (see Section 2.8.240 of this NPS)<br>• Wider ecosystem impacts and interactions.<br>Applicants must undertake a detailed assessment of the offshore ecological, biodiversity and physical impacts of their proposed development, for all phases of the lifespan of that development, in accordance with the appropriate policy for offshore wind farm EIAs, Habitat Regulations Assessments (HRAs) and MCZ assessments (See Sections 4.2 and 5.4 of EN-1). | The existing ecology and biodiversity of the projects fish and shellfish ecology study area has been examined in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and the baseline assessment (section 3.5). Any changes expected have been identified in the MDS calculation (section 3.7.1), with the levels of impact on fish and shellfish receptors assessed in the assessment of significant effects (section 3.9). |
| [NPS EN-3, paragraphs 2.11.39 – 2.11.40] Applicants need to consider environmental and biodiversity net gain as set out in Section 4.5 of EN-1 and the Environment Act 2021. | Both potential negative and positive effects on fish and shellfish ecology have been considered in the impact assessment presented in section 3.9. |

| Summary of NPS EN-1 and EN-3 provision | How and where considered in the chapter |
|---|---|
| Applicants should assess the potential of their proposed development to have net positive effects on marine ecology and biodiversity, as well as negative effects. | |
| [NPS EN-3, paragraphs 2.8.104 – 2.8.106] Applicants should consult at an early stage of pre-application with relevant statutory consultees, as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options should be undertaken.<br>In developing proposals applicants must refer to the best practice advice provided by the Offshore Wind Enabling Action Programme.<br>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. | Consultation has been undertaken through the Benthic Ecology, Fish and Shellfish Ecology and Physical Processes Expert Working Group (EWG) as detailed in section 3.3.<br>The impact assessment (section 3.9) has been undertaken taking into account published post-construction monitoring from offshore wind farms in the UK and overseas and all relevant guidance identified in section 3.4.1. Where required based upon the assessment outcomes to ensure impacts are managed, appropriate post-construction monitoring will be considered for the Mona Offshore Wind Project. |
| [NPS EN-3, paragraphs 2.8.150 – 2.8.151] The applicant should identify fish species that are the most likely receptors of impacts with respect to:<br>• Spawning grounds<br>• Nursery grounds<br>• Feeding grounds<br>• Over-wintering areas for crustaceans<br>• Migration routes<br>• Protected sites.<br>Applicant assessments should identify the potential implications of underwater noise from construction and unexploded ordnance including, where possible, implications of predicted construction and soft start noise levels in relation to mortality, permanent threshold shift (PTS), temporary threshold shift (TTS) and disturbance, and addressing both sound pressure and particle motion) and Electromagnetic Fields (EMF) on sensitive fish species. | Important habitats for fish and shellfish, including spawning, nursery and migration routes have been considered in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and summarised in section 3.4. Effects on these, including sound and EMF impacts, have been assessed in section 3.9. |
| [NPS EN-3, paragraphs 2.8.200 – 2.8.203] Applicants should engage with interested parties in the potentially affected offshore sectors early in the pre-application phase of the proposed offshore wind farm, with an aim to resolve as many issues as possible prior to the submission of an application. (see paragraphs 2.8.56 and 2.8.273/4 and 2.8.267 of this NPS for further guidance).<br>Such stakeholder engagement should continue throughout the life of the development including construction, operation and decommissioning phases where necessary.<br>As many offshore industries are regulated by government, the relevant Secretary of State should also be a consultee where necessary.<br>Such engagement should be taken to ensure that solutions are sought that allow offshore wind farms and other uses of the sea to co-exist successfully. | Relevant stakeholders have been consulted prior to application, and the expert working groups, as outlined in section 3.3. A range of fishers operating within the vicinity of the projects have been consulted on potential impacts and mitigation strategies. |
| [NPS EN-3, paragraphs 2.8.213 – 2.8.216] Applicants must always employ the mitigation hierarchy, in particular to avoid as far as is possible the need to find compensatory measures for coastal, inshore and offshore developments affecting HRA sites | Mitigation measures to reduce impacts on fish and shellfish receptors have been identified in section 3.8. |

| Summary of NPS EN-1 and EN-3 provision | How and where considered in the chapter |
|---|---|
| and/or MCZs. It is essential that applicants involve Statutory Nature Conservation Bodies (SNCBs) and Defra as early as possible in the planning process to enable discussions of what is and isn't a significant and/or adverse effect, subsequent implications, and if required, mitigation and/or compensation.<br>At the earliest possible stage, alternative ways of working and use of technology should be employed to avoid environmental impacts. Where impacts cannot be avoided, measures to reduce and mitigate impacts should be employed, for example using trenching techniques or noise abatement technology.<br>Applicants should undertake a review of up-to-date research and all potential avoidance, reduction and mitigation options presented for all receptors.<br>Only once all feasible alternatives and mitigation measures have been employed, should applicants explore possible compensatory measures to make good any remaining significant adverse effects to site integrity. | Relevant SNCBs and other stakeholders have been consulted prior to application, and the expert working groups, as outlined in section 3.3. A range of fishers operating within the vicinity of the projects have been consulted on potential impacts and mitigation strategies. |
| [NPS EN-3, paragraphs 2.8.221 – 2.8.223] Applicants are advised to develop an ecological monitoring programme to monitor impacts during the pre-construction, construction and operational phases to identify the actual impacts caused by the project and compare them to what was predicted in the EIA/HRA.<br>Should impacts be greater than those predicted, an adaptive management process may need to be implemented and additional mitigation required, to ensure that so far as possible the effects are brought back within the range of those predicted.<br>Monitoring should be of sufficient standard to inform future decision-making. Increasing the understanding of the efficacy of alternatives and mitigation will deliver greater certainty on applicant requirements. | Mitigation measures are in place to reduce the significance of impacts where possible, as outlined in section 3.8. Recommendations for any potential future monitoring, where appropriate, are outlined in section 3.11.9. |
| [EN-3, 2.8.245 – 2.8.247] EMF in the water column during operation, is in the form of electric and magnetic fields, which are reduced by use of armoured cables for inter array and export cables.<br>Burial of the cable increases the physical distance between the maximum EMF intensity and sensitive species. However, what constitutes sufficient depth to reduce impact will depend on the geology of the seabed.<br>It is unknown whether exposure to multiple cables and larger capacity cables may have a cumulative impact on sensitive species. It is therefore important to monitor EMF emissions which may provide the evidence to inform future EIAs. | Cable burial and any cable protection specifications have been examined in the MDS (section 3.7.1), with specific impacts of EMFs assessed in section 3.9.6. |
| [EN-3, 2.8.261 – 2.8.262] Detailed discussions between the applicant for the offshore wind farm and the relevant consultees should have progressed as far as reasonably possible prior to the submission of an application. As such, appropriate mitigation should be included in any application, and ideally agreed between relevant parties.<br>In some circumstances, the Secretary of State may wish to consider the potential to use requirements involving arbitration as a means of resolving how adverse impacts on other commercial activities will be addressed. | Relevant SNCBs and other stakeholders have been consulted prior to application, and the expert working groups, as outlined in section 3.3. A range of fishers operating within the vicinity of the projects have been consulted on potential impacts and mitigation strategies. |

**Table 3.2: 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 chapter |
|---|---|
| **NPS EN-1** | |
| [NPS EN-1, paragraph 5.4.2] The Government's biodiversity strategy aim is to halt overall biodiversity loss in England by 2030 and then reverse loss by 2042, support healthy well-functioning ecosystems and establish coherent ecological networks, with more and better places for nature for the benefit of wildlife and people. This aim needs to be viewed in the context of the challenge presented by climate change. Healthy, naturally functioning ecosystems and coherent ecological networks will be more resilient and adaptable to climate change effects. Failure to address this challenge will result in significant adverse impact on biodiversity and the ecosystem services it provides. | The conservation status of habitats and species is considered throughout this chapter, with the baseline 3.5.3), and assessment of significant effects (section 3.9) examining this in detail.<br>The Biodiversity benefit and green infrastructure statement (Document Reference J7) outlines the approach of the Mona Offshore Wind Project to biodiversity enhancement.<br>The potential future impact of climate change is examined in the future baseline scenario (section 3.5.4). |
| [NPS EN-1, paragraph 5.4.42] 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, impact should be mitigated and as a last resort, appropriate compensation measures should be sought. | Mitigation is broadly assessed in the measures adopted as part of the Mona Offshore Wind Project (section 3.8), and where appropriate in each impact assessment if the impact was deemed to be moderate or above. |
| [NPS EN-1, paragraph 5.4.48] 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, have been identified in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and are listed in section 3.6.3, with the identified IEFs listed in section 3.5.3. |
| **NPS EN-3** | |
| [NPS EN-3, paragraph 2.11.53] The Secretary of State should consider the effects of a proposed development 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 3.4), with all relevant information used to inform the associated assessment of significant effects on this baseline (section 3.9). |

### 3.2.4 Welsh National Marine Plan

3.2.4.1 The fish and shellfish ecology impact assessment has been made with consideration to the specific policies set out in the Welsh National Marine Plan (Welsh Government, 2019). Key provisions are set out in Table 3.3 along with details as to how these have been addressed within the assessment.

**Table 3.3: Summary of Welsh National Marine Plan policy in relation to fish and shellfish ecology.**

| Policy | Key provisions | How and where considered in the chapter |
|---|---|---|
| ENV_01: Resilient marine ecosystems. | Proposals should demonstrate how potential impacts on marine ecosystems have been taken into consideration and should, in order of preference: | Potential impacts on fish and shellfish ecology receptors have been identified in the key parameters for assessment (section 3.7). Mitigation |

| Policy | Key provisions | How and where considered in the chapter |
|---|---|---|
| | • Avoid adverse impacts<br>• Minimise impacts where they cannot be avoided<br>• Mitigate impacts where they cannot be minimised.<br>If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding.<br>Proposals that contribute to the protection, restoration and/or enhancement of marine ecosystems are encouraged. | measures have been outlined in section 3.8, and each impact has been comprehensively assessed based on the best available information and literature in section 3.9. |
| ENV_02: Marine Protected Areas (MPA) | Proposals should demonstrate how they:<br>• Avoid adverse impacts on individual Marine Protected Areas (MPAs) and the coherence of the network as a whole<br>• Have regard to the measures to manage MPAs<br>• Avoid adverse impacts on designated sites that are not part of the MPA network. | All relevant nearby MPAs and designated sites were identified through desktop review and stakeholder consultation and are examined in the designated sites section 3.6.3. The potential impacts on these designated sites are considered in section 3.9 and for features of MCZs and SACs within the MCZ Screening and Information to Support Appropriate Assessment (section 3.6). |
| ENV_05: Underwater noise | Proposals should demonstrate that they have considered man-made noise impacts on the marine environment and, in order of preference:<br>• Avoid adverse impacts<br>• Minimise impacts where they cannot be avoided<br>• Mitigate impacts where they cannot be minimised.<br>If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. | This potential impact has been considered through specific modelling in Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, with the findings assessed in the context of fish and shellfish ecology receptors in the underwater impacts section 3.9.3. |
| ENV_07: Fish Species and Habitats | Proposals potentially affecting important feeding, breeding (including spawning & nursery) and migration areas or habitats for key fish and shellfish species of commercial or ecological importance should demonstrate how they, in order of preference:<br>• Avoid adverse impacts on those areas<br>• Minimise adverse impacts where they cannot be avoided<br>• Mitigate adverse impacts where they cannot be minimised.<br>If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. | Important feeding, breeding, and migration areas have been identified in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and have been summarised in the baseline environment section 3.4. The level of potential impacts on these areas have been assessed in section 3.9, with measures adopted broadly to prevent significant impacts identified in section 3.8. |
| GOV_01: Cumulative effects | Proposals should demonstrate that they have assessed potential cumulative effects and should, in order of preference:<br>• Avoid adverse effects<br>• Minimise effects where they cannot be avoided | The potential for cumulative impacts in relation to other nearby offshore projects has been identified and examined in section 3.11. |

| Policy | Key provisions | How and where considered in the chapter |
|---|---|---|
| | • Mitigate effects where they cannot be minimised.<br>If significant adverse effects cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. Proposals that contribute to positive cumulative effects are encouraged. | |

### 3.2.5 Planning Policy Wales

3.2.5.1 Planning Policy Wales (Welsh Government, 2021) (PPW) sets out the land use planning policies of the Welsh Government. The objective is to ensure the planning system contributes towards sustainable development and improves the social, economic, environmental and cultural wellbeing of Wales. Those sections of particular relevance to fish and shellfish ecology are set out in Table 3.4.

**Table 3.4: Planning Policy Wales.**

| Summary of PPW Provision | How and where considered in the Environmental Statement |
|---|---|
| [Paragraph 6.4.4] It is important that biodiversity and resilience considerations are taken into account at an early stage in both development plan preparation and when proposing or considering development proposals. | The existing biodiversity surrounding the Mona Offshore Wind Project has been detailed in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and has been summarised in section 3.4. |
| [Paragraph 6.4.15] Statutorily designated sites (including Sites of Special Scientific Interest (SSSIs), SACs, SPAs, Ramsar sites, and formally proposed but not yet designated sites [paragraphs 6.4.16-19]) must be protected from damage and deterioration, with their important features conserved and enhanced by appropriate management. | All nearby designated sites with relevant fish and shellfish receptors which could be impacted by the Mona Offshore Wind Project have been identified in section 3.5.2, and have been assessed alone where relevant in section 3.9, and cumulatively in section 3.11. |
| [Paragraph 6.4.22] Any applications submitting a planning application must conform with any statutory species protections provisions affecting the site of the development. | Relevant protected fish and shellfish species have been identified and listed as IEFs in section 3.5.3, and have been assessed where there could be a significant impact. |

### 3.2.6 North West Inshore and North West Offshore Coast Marine Plans

3.2.6.1 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, due to the fish and shellfish ecology study area overlapping this region (MMO, 2021). Key provisions are set out in Table 3.5 along with details as to how these have been addressed within the assessment.

**Table 3.5: North-West Inshore and North-West Offshore Marine Plan policies of relevance to fish and shellfish ecology.**

| Policy | Key provisions | How and where considered in the chapter |
|---|---|---|
| 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 6, annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement; the baseline (section 3.5) and assessed in detail in Section 3.9. |
| 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. | MPAs with fish and shellfish features have been identified in section 3.4.5. Assessment of impacts on features of these sites, where relevant, are presented in section 3.9, with site specific assessments presented in section 3.5.2, and section 8.10 of Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement. |
| 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 6, Annex 8.1: Fish and shellfish ecology technical report of the Environmental Statement presents a detailed characterisation of the fish and shellfish ecology in the fish and shellfish ecology study area, which is summarised in section 3.5.3. Assessment of impacts, with consideration of mitigation measures, on these receptors is presented in section 3.9. |
| 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 INNS has been highlighted and considered in section 3.8, dealing with measures adopted as part of the Mona Offshore Wind Project, with justifications given. These are also considered in the impact assessment section 3.9. |

| Policy | Key provisions | How and where considered in the chapter |
|---|---|---|
| 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 sound during all phases of the development, as detailed in section 3.9.3, as well as the whole of section 3.9 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 sound resulting from the construction, operations and maintenance, and decommissioning phases have been considered in the sound impact assessment (section 3.9.3). |
| 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 3.11). |
| 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 3.12) and inter-related effects (section 3.13) sections. |

## 3.3 Consultation

### 3.3.1 Overview

3.3.1.1 A summary of the key topics raised during consultation activities undertaken to date specific to fish and shellfish ecology is presented in Table 3.6 below, together with how these topics have been considered in the production of this Environmental Statement chapter. Further detail is presented within Volume 6, Annex 3.1: Fish and shellfish technical report of the Environmental Statement.

### 3.3.2 Evidence plan

3.3.2.1 The purpose of the Evidence Plan process is to agree the information the Mona Offshore Wind Project needs to supply to the Secretary of State, as part of a DCO application for Mona Offshore Wind Project. The Evidence Plan seeks to ensure compliance with the HRA and EIA. The development and monitoring of the Evidence

Plan and its subsequent progress is being undertaken by the Evidence Plan Steering Group. The Steering Group comprises the Planning Inspectorate, the Applicant, NRW, Natural England, the Joint Nature Conservation Committee (JNCC) and the MMO as the key regulatory and SNCBs. To inform the EIA and HRA process during the pre-application stage of the Mona Offshore Wind Project, 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 Preliminary Environmental Information Report (PEIR) in February 2022 and November 2022. In addition to the Evidence Plan process, consultation was also undertaken in June 2021 with NRW, Natural England and the JNCC with regards to the subtidal benthic ecology survey scope, which included consideration for fish and shellfish ecology (particularly herring spawning and sandeel substrate suitability assessment.

3.3.2.2 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 Mona Offshore Wind Project. A summary of discussions and key topics raised is set out in Table 3.6 below. The second EWG meeting (November 2022) updated stakeholders on progress with the PEIR, including raising current potential significant impacts from underwater sound and other impacts to allow discussion of potential mitigation measures.

3.3.2.3 The third EWG meeting (March 2023) was held during the PEIR finalisation process and dealt primarily with the Morgan Offshore Wind Project Generation Assets for fish and shellfish receptors. However, advice was sought on the suitability of the 135 dB $SEL_{ss}$ (single strike Sound Exposure Level) metric as a behavioural threshold for underwater sound impacts on herring spawning grounds for both the Morgan and Mona Offshore Wind Projects. This sound level is presented on all relevant sound contour figures at the request of the MMO and has been discussed throughout the text alongside other relevant thresholds. Otherwise, this EWG dealt with presenting updated baselines for herring, sandeel and scallops as was previously requested following EWG02.

3.3.2.4 The fourth EWG meeting (July 2023) followed the conclusion of the statutory Section 42 consultation period, with responses from a wide range of stakeholders received and given consideration. Responses related to fish and shellfish ecology involved requests for incorporation of more recent datasets into the baseline characterisation; the presentation of herring and sandeel density data as aggregated heat maps, and the expansion of the queen and king scallop fisheries baseline and assessments by using local knowledge and data. This and a range of recommendations on appropriate underwater sound impact thresholds will be incorporated into this Environmental Statement.

3.3.2.5 The fifth EWG meeting occurred in October 2023, but focused mainly on updated benthic ecology assessments and did not encompass any fish and shellfish ecology elements.

3.3.2.6 The sixth EWG meeting was undertaken in December 2023, where updated assessment details for the impact of underwater sound affecting fish and shellfish receptors were presented. The meeting was attended by the MMO, Cefas, NRW, Natural England, the JNCC, the Isle of Man Government, The Wildlife Trust and North Wales Wildlife Trust. Discussion relating to fish and shellfish ecology surrounded effects from underwater sound during the construction phase from piling. A summary of key feedback received and proposed actions were presented regarding impacts of underwater sound on herring and cod, along with updated modelling outputs based upon the refined project design and maximum design scenario.

**Table 3.6: Summary of key consultation topics raised during consultation activities undertaken for the Mona Offshore Wind Project relevant to fish and shellfish ecology.**

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement. |
| 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and baseline (section 3.5), and cod sensitivity has been given consideration throughout the impact assessment (section 3.9) including underwater sound. |
| February 2022 | Cefas – First Evidence Plan Expert Working Group | Elasmobranchs (e.g. basking shark) around the Isle of Man (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 3.5), with sensitivities examined in relation to possible impacts in the sound impact assessment section (section 3.9.3). |
| 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 MCZs and SACs within the fish and shellfish ecology study area have been examined in detail in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement, 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 sound impact assessment (section 3.9.3). |
| February 2022 | Natural Resources Wales – First Evidence Plan Expert Working Group | The Zone of Influence 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 | Comment was noted and a wider ZoI has been used for the underwater sound assessment. Effects of underwater sound on fish and shellfish receptors is presented in section 3.9.3. |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| | | excursion therefore impacts may go beyond that definition of the ZoI. | |
| 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement. |
| 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 sound impact assessment (section 3.9.3). |
| 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 3.4), with details given in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement. |
| February 2022 | Natural Resources Wales – First Evidence Plan Expert Working Group | Bangor University and the IoM government have undertaken surveys for scallop which may provide a useful data source. | Examined in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement for all relevant IEFs and included in the baseline (section 3.4) of this chapter. |
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | Ensure that any species protected under the IoM Wildlife Act 1990 – specifically, basking shark – are given appropriate consideration in the assessment. Also, the Man Marine Nature Reserve and a range of IoM-specific legislation and agreements should be fully considered. | Basking shark, and other relevant legislation and species of interest, have been considered in the baseline (section 3.4), as IEFs (section 3.5.3), and where appropriate in the assessment of significant effects (section 3.9). |
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | Ensure that appropriate consideration is given to designated marine protected sites and their associated species, particularly those protected under Manx law or identified and threatened or declining by the Marine Environment of the North-East Atlantic (OSPAR) Convention. Included within this are king and queen scallop, which are protected in most Marine Nature Reserves (MNRs) around the IoM. | Designated sites within IoM territorial waters, and their associated habitats and species of principal importance, have been identified in Volume 6: Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and are listed in section 3.6.3, with the identified IEFs listed in section 3.5.3. |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | Trans-boundary impacts on Manx seascapes, fisheries, and fish populations should be fully considered where relevant, with particular reference to Bangor University studies examining king and queen scallop grounds specifically. | The impact assessment considered all potential impacts on fish and shellfish receptors, including those within IoM territorial waters (section 3.9). |
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | The IoM government draws attention to the Manx Marine Environmental Assessment and a range of other reports and studies specifically dealing with the IoM region, and requests that these are incorporated into the fish and shellfish assessments where applicable. | The Manx Marine Environmental Assessment and Bangor University studies have been incorporated into Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement, and in the baseline (section 3.4). |
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | The IoM government recommends that consideration is given to monitoring local shellfish stocks, pre- and post-construction, and potentially including the long-term effects on larval settlement and recruitment processes. | The impacts on shellfish populations have been examined in the assessment of significant effects (section 3.9), with recommendations given for future shellfish stock and effect monitoring (section 3.9.9). |
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | The IoM government recommends the scoping in of the potential impact of particle motion and noise on fish and shellfish, with the recommendation of more data collection to justify scoping this in or out. This recommendation includes monitoring of turbine operational noise. | The potential impacts of particle motion and sound have been assessed in section 3.9.3, with specifically provided references incorporated where relevant. |
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | The straight-line west boundary of the study area does not follow jurisdictional or ecological boundaries and should be updated to follow IoM territorial waters. | This change to the fish and shellfish ecology study area was made throughout the chapter and has been presented in the baseline (section 3.4). |
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | No apparent consideration has been given to shellfish in relation to spawning and nursery grounds. | Shellfish spawning and nursery grounds have been identified and characterised in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and are presented here in the baseline (section 3.4). |
| June 2022 | Isle of Man Government, Department of Infrastructure – Scoping Opinion | Note the existence of the Douglas Bay statutory herring spawning closure regulated under Manx law, which closes grounds to the southeast of the IoM to herring fishing between 21 September and 5 November. | The comment is acknowledged, and this information has been incorporated into the baseline characterisation (Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement). |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| June 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 turbine generators that are of representative size for the Mona offshore wind farm. | This potential impact has been scoped out based on site specific sound information, including modelling of sound emissions from the proposed wind turbines and effects on fish and shellfish receptors (section 3.9.3). |
| June 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. | This has been examined in the underwater sound impact assessment (section 3.9.3). |
| June 2022 | Natural Resources Wales – Scoping Opinion | With regards to Fish and Shellfish, NRW (A) advise consideration of: Twaite Shad, European Smelt, River Lamprey and Sea Lamprey under Diadromous fish. | These species have been included as IEFs (section 3.5.3) and are examined throughout the assessment of significant effects (section 3.9). |
| June 2022 | Natural Resources Wales – Scoping Opinion | With regards to Fish and Shellfish, NRW (A) advise consideration of the potential for piling noise to disrupt spawning activity for cod and other hearing species. | Cod and other relevant hearing species are included as IEFs in the Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and baseline (section 3.5), and cod sensitivity has been given consideration throughout the impact assessment (section 3.9) including underwater sound. |
| June 2022 | Natural Resources Wales – Scoping Opinion | With regards to Fish and Shellfish, NRW (A) advise consideration of the inclusion of other species such as Whiting in the assessment of key prey species. | This species has been included as IEFs (section 3.5.3) and is examined throughout the assessment of significant effects (section 3.9). |
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) disagree that the impacts to invertebrates due to EMF can be scoped out at this stage. There is some evidence that EMFs affect crustacea behavioural patterns. These should be reviewed and assessed (where appropriate) as part of the Environmental Statement. | Electromagnetic field effects on fish and shellfish receptors (including crustacea) are examined in detail in the relevant assessment of significant effects (section 3.9.6). |
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) advise that the NIRAS Consulting Ltd. Screening principles as used by The Crown Estate, are adopted to incorporate Annex II migratory fish features, using a stepwise approach to assess nearby European sites for diadromous fish species. | All relevant screening principles and designated sites and species have been considered in section 3.6.3, with the identified IEFs listed in section 3.5.3 and in the Information to Support Appropriate Assessment (ISAA) (Document Reference E.1). |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) recommend the incorporation of a range of up-to-date references and data sources on fish spawning grounds and pressures. | Full details of the baseline characterisation incorporating these references are presented in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement. |
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) note that collision with vessels is scoped in as a potential impact to marine mammals and advise that basking sharks, as large marine animals, would also be at risk from collisions, and should therefore be included in the quantitative assessments done for marine mammals. | This was scoped in for basking shark for this chapter and for marine mammals within Volume 6, Annex 4.1: Marine mammals technical report of the Environmental Statement and has been assessed for the potential for injury due to vessel collisions (section 3.9.9). |
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) agree with the assumption that all diadromous fish have the potential to occur in the ecological study area as outlined in Section 4.2.4.12 (Part 2)/ Section 4.2.4.13 (Part 3) Diadromous fish species, however given the diversity in species, life stages and behaviour within the diadromous fish group, NRW (A) do not consider that meaningful seasonal key migration periods can be defined. | Potential migration periods of diadromous species have been examined in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and are examined as a separate receptor in each of the assessments of significant effects (section 3.9) to account for any uncertainty. |
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) would welcome further information on how the report on impacts to herring from piling operations will be considered – is the intention to produce heat maps of spawning activity? | Data from Northern Ireland Herring Larvae Survey (NINEL) herring spawning surveys has been mapped alongside known spawning grounds in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement and are described in the baseline (section 3.4). |
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) advise that inclusion of marine fish listed as Priority Species under Section 7 of Environment (Wales) Act (2016) should also be considered as present within the area, and should be included, (e.g. Sandeel, Herring and various Elasmobranchs). In addition, Crawfish *Palinurus elephas* should also be included. | Protection under Section 7 of the Environment (Wales) Act 2016 has been considered in the baseline assessment (section 3.4), and in identification of IEFs (section 3.5.3). |
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) would welcome further consultation on which species will be considered in each broad ecological receptor group. | This information has been presented in the baseline (section 3.4). |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) advise that both temporal and spatial construction noise cumulative effects are considered, such as disturbance to spawning activities over consecutive spawning seasons, from construction of several projects. | This has been examined in the underwater sound impact assessment (section 3.9.3). Mitigation to reduce impacts on sensitive fish species are detailed in section 3.8. Development of an Underwater sound management strategy is planned post-consent, to define measures to reduce the magnitude of underwater sound thereby reducing the residual impact significance for cod and herring. An Outline underwater sound management strategy (Document Reference J16) is provided with the Application. Potential impacts from other projects in the area have also been considered in the cumulative impacts assessment (section 3.11). |
| June 2022 | Natural Resources Wales – Scoping Opinion | NRW (A) do not agree that contaminated sediments should be scoped out of the project assessment for the array area for fish and shellfish receptors, with 2021 survey results reported where relevant and compared against Cefas action levels (AL). | This impact has been scoped in and is examined in the relevant assessment of significant impacts (section 3.9.8). |
| June 2022 | The Planning Inspectorate – Scoping Opinion | To scope out accidental pollution resulting from all phases of the Proposed Development, 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 3.8, including reference to management plans which will be secured through requirements within the DCO or as conditions through the marine licences. |
| June 2022 | The Planning Inspectorate – Scoping Opinion | In the absence of evidence that the proposed turbines would have comparable noise outputs to 2011 to 2014 studies showing negligible impact from wind turbine operations and maintenance phases, the Inspectorate does not agree operational noise can be scoped out of the Environmental Statement. | This impact has been scoped out based on site specific sound information, including modelling of sound emissions from the proposed wind turbines and effects on fish and shellfish receptors (section 3.9.3). |
| June 2022 | The Planning Inspectorate – Scoping Opinion | Although sediment contaminants have been found to be low in the area historically, at this stage and in the absence of the results of further ongoing sampling, the Inspectorate does not agree to scope out the release of | The potential impacts of resuspension of sediment-bound contaminants in all phases of the generation and transmission assets on fish and |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| | | sediment-bound contaminants in regard to the generation assets. The Environmental Statement should include an assessment of the effects on fish and shellfish ecology from the release of sediment-bound contaminants, where likely significant effects could occur. | shellfish receptors has been assessed in section 3.9.8. |
| June 2022 | The Planning Inspectorate – Scoping Opinion | The Inspectorate considers that activities during operations and maintenance work such as the use of jack-up barges have the potential to generate underwater noise and vibration. 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. | This impact has been scoped out based on site specific sound information, including modelling of sound emissions from the vessels during all phases and effects on fish and shellfish receptors as detailed in section 3.9.3. |
| June 2022 | The Planning Inspectorate – Scoping Opinion | No site-specific fish and shellfish surveys are proposed. None of the nearby projects used in the desktop data review spatially overlap with the Proposed Development and a number of datasets proposed to be used to inform the baseline are more than 10 years old. The Applicant should ensure that the baseline data used in the Environmental Statement assessments are sufficiently up to date to provide a robust baseline. | 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 6, Annex 6.1: Commercial fisheries technical report of the Environmental Statement). |
| June 2022 | The Planning Inspectorate – Scoping Opinion | If only existing data is to be used, the Environmental Statement should provide evidence to justify that it constitutes a robust characterisation of the receiving environment, with reference to the date, seasonal period and geographic coverage of the data. Use of existing data should be done in agreement with consultees. | As per the above response, with seasonal period and geographic coverage presented in Volume 6, Annex 3.1: Fish and shellfish technical report of the Environmental Statement, and the baseline assessment (section 3.5). |
| June 2022 | The Planning Inspectorate – Scoping Opinion | Multiple references are made to fish and shellfish species of principal importance in England under the NERC Act 2006. The Applicant should ensure that relevant Welsh | Protection under Section 7 of the Environment (Wales) Act 2016 has been considered in the |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| | | legislation is referred to within the Environmental Statement, and that marine fish listed as a Priority Species under Section 7 of Environment (Wales) Act 2016 are included. | baseline assessment (section 3.5), and in identification of IEFs (section 3.5.3). |
| June 2022 | The Planning Inspectorate – Scoping Opinion | The Proposed Development overlaps with high intensity spawning areas for several fish species, including cod which are a hearing species. The potential for piling noise to disrupt spawning activity for cod and other hearing species should be assessed. | The baseline of spawning habitats for commercially and ecologically important fish and shellfish species is presented in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement, with underwater sound impacts considered in section 3.9.3. |
| June 2022 | The Planning Inspectorate – Scoping Opinion | The Applicant should give consideration to controlling the time of the proposed construction and/ or operational activities to avoid key and sensitive periods to species, such as fish spawning seasons and fish migration periods. Where this is not considered necessary or feasible, this should be justified in the Environmental Statement. | The spawning seasons of commercially and ecologically important fish and shellfish species is presented in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement, with underwater sound impacts considered in section 3.9.3. This includes consideration of mitigation to reduce effects on fish and shellfish receptors. |
| 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 3.9). |
| June 2022 | The Planning Inspectorate – Scoping Opinion | 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 3.9. |
| June 2022 | The Planning Inspectorate – Scoping Opinion | 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 3.9.9). |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| March 2023 | Cefas – Expert Working Group 3 | Cefas recommend that the 135 dB $SEL_{ss}$ (SEL single strike) threshold be used in assessing the sensitivity of herring to underwater noise, based on currently available evidence. | This recommendation has been carried forward and caveated based on the limitations of the original study this threshold was derived from and is presented in sound contours in section 3.9.3 and assessed throughout the text alongside other standard behavioural thresholds. |
| March 2023 | NRW – Expert Working Group 3 | NRW recommend that the diadromous fish migration patterns and timings are approached with more caution, as most findings on diadromous fish are from coastal areas and the Mona Offshore Wind Project is relatively far offshore, therefore increasing uncertainty about the temporal and spatial overlap of migration periods within the study area. | The assessment of diadromous species migration patterns and periods has been caveated to explain this uncertainty in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement. This has been carried through to all diadromous species impact assessments in this chapter. |
| June 2023 | Isle of Man Government, NFFO and WFA – Section 42 consultation | Questions were raised about the suitability of using the potentially outdated Coull *et al*. (1998) and Ellis *et al*. (2012) sources to characterise fish and shellfish spawning grounds within the fish and shellfish ecology study area, with the recommendation to use more recent references. | These sources have been used extensively throughout and have been checked against recent literature and long-term studies in the baseline environment (section 3.5) to confirm they remain up to date and representative of current fish and shellfish population distributions. |
| June 2023 | Isle of Man Government, West Coast Sea Products Ltd – Section 42 consultation | Queries were raised about the current characterisation of the queen and king scallop fisheries, with recommendations to expand this characterisation with more up-to-date sources and local knowledge. | The baseline for these species has been expanded to include more recent sources from Bangor University and published literature in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement, and has been included in the baseline in section 3.5 and throughout the assessment. |
| June 2023 | MMO – Section 42 consultation | The MMO has requested that the herring and sandeel suitability assessments include heat maps following the MarineSpace methodology, with ‘prime’ and ‘sub-prime’ suitability also being changed to follow more relevant guidance. | The existing suitability has been changed to ‘preferred’, ‘marginal’ and ‘unsuitable’ to align with the categories derived from EMODnet seabed substrates data, but heat mapping for each year was deemed to be unsuitable due to low data values and density. Instead, as agreed with the EWG during EWG meeting 4, a 10-year aggregated dataset was mapped, with this presented in Volume 6, Annex 3.1: Fish and |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| | | | shellfish ecology technical report of the Environmental Statement. |
| July 2023 | Cefas, NRW | Acknowledgment of the limitations of the 135 dB $SEL_{ss}$ (SEL single strike), but request to keep in as a conservative threshold to ensure all potential impacts from noise are fully investigated. | This threshold has been included in the assessment in section 3.9.3 alongside all other thresholds, with explanations of its limitations and benefits. |
| July 2023 | Isle of Man Government – Expert Working Group 4 | Asked for clarification on whether projects used for the cumulative assessment were all publicly available, and how the Isle of Man Offshore Windfarm could be incorporated into the Environmental Statement. | All projects examined in the cumulative effects assessment in section 3.11 utilise publicly available information from published Environmental Statements (and associated documents), scoping reports and applications, including for the Ørsted Mooir Vannin Offshore Windfarm, which recently published their Scoping Report (Ørsted, 2023).. |
| July 2023 | NRW – Expert Working Group 4 | Yearly herring spawning heat maps will not be required if the interpretation of available information is adequate within the technical report and chapter. | The herring spawning grounds have been characterised in Volume 6, Annex 3.1: Fish and shellfish ecology of the Environmental Statement, and a 10-year aggregated heat map has been produced to further characterise the spawning grounds to best inform the assessment. Data from the OneBenthic tool (Cooper and Martinez, 2017) has also been examined and mapped for herring and sandeel suitability, to increase the reliability of the findings of the assessment. |
| December 2023 | NRW – Expert Working Group 6 | Asked for clarification as to why $SEL_{ss}$ is modelled instead of $SEL_{cum}$ | Both $SEL_{ss}$ and $SEL_{cum}$ are modelled, with full details provided within Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement. Modelling data is also presented as contour plots for $SEL_{ss}$, $SPL_{pk}$ and $SEL_{cum}$ (mortality, recoverable injury and TTS only) in the underwater sound impact assessment in section 3.9.3. |
| December 2023 | Isle of Man Government – Expert Working Group 6 | Asked for clarification as to whether we had received additional advice on the larval phases of herring post spawning and how these will be impacted by sound? | The underwater sound impact assessment in section 3.9.3 includes fish eggs and larvae (static) mortality ranges, which are outlined both in a table and fully in text in the chapter. They don’t |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| | | | specifically relate to herring eggs and larvae, but are considered applicable. The herring larval data used to inform important spawning grounds for assessment of impacts from underwater sound in section 3.9.3 was provided by the Agri-food and Bioscience Institute (ICES, 2022a). |
| December 2023 | Cefas and NRW – Expert Working Group 6 | Cefas asked for confirmation as to whether a potential scenario for concurrent piling at Mona and Morgan Generation Assets at the same time has been modelled to inform cumulative impact assessment.<br>NRW asked if we have considered increased areas of ensonification and the presence of multiple areas of ensonification in the cumulative impact assessment. | It is possible that Mona and Morgan Generation Assets may undertake piling within the same time period, however based upon the low likelihood of both projects incurring hammer blows at the same moment, no modelling has been undertaken to investigate concurrent piling across the two projects. Full details of the underwater sound modelling undertaken is available within Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, with relevant information presented within the underwater sound impact assessment in section 3.9.3 for Mona Offshore Wind Project. The potential for increased areas of ensonification and potential presence of multiple areas of ensonification has been qualitatively considered within the cumulative effects assessment for underwater sound presented in section 3.11.3.<br>Development of an Underwater sound management strategy is planned post-consent, to define measures to reduce the magnitude of underwater sound thereby reducing the residual impact significance for cod and herring. An outline strategy (Document Reference J16) is provided with the Application. |
| December 2023 | Cefas – Expert Working Group 6 | In response to the post-meeting MMO requst to stakeholders to confirm whether the Underwater sound management strategy is an acceptable approach to manage underwater sound impacts, Cefas raised the following:<br>• The Applicant's suggestion of an Underwater sound management strategy is welcome given the potential | Final underwater sound modelling is fully detailed in Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, with relevant information presented within the underwater sound impact assessment in section 3.9.3 for the Mona Offshore Wind Project. No further underwater sound modelling is proposed. |

| Date | Consultee and type of response | Topics raised | Response to issue raised and/or where considered in this chapter |
|---|---|---|---|
| | | impacts of underwater noise to herring and cod. This is also appropriate given the need to manage cumulative impacts of underwater sound produced by multiple projects in the region. Any measures that may reduce these impacts, such as reduced number of foundations and/or hammer energies would be welcome. | The extent of impact on herring and cod spawning grounds is fully assessed within the underwater sound impact assessment in section 3.9.3 for the Mona Offshore Wind Project and in section 3.11.3 cumulatively with other projects and plans. |
| | | • However, it should be noted that the final underwater sound scenarios/modelling needs to be presented in the Environmental Statement so that full extent of noise disturbance at the herring and cod spawning grounds can be understood and appropriate mitigation measures can be applied (where applicable). Mitigation for cod and herring from underwater noise should be agreed at the time of consent, rather than post-consent and should be agreed before any Underwater sound management strategy is accepted. | An Outline underwater sound management strategy (Document Reference J16) is provided within the Application with the full strategy to be developed post-consent with input from relevant stakeholders to finalise the appropriate mitigation measures to manage the effects from underwater sound during construction on herring and cod. |

## 3.4 Baseline methodology

### 3.4.1 Relevant guidance

3.4.1.1 A number of guidance documents have been considered when compiling the baseline.

3.4.1.2 The OSPAR guidance on Environmental Considerations for Offshore Wind Farm Development has a primary aim to provide scientific guidance to those involved with the gathering, interpretation and presentation of data within an Environmental Impact Assessment (EIA) as part of the consents application process in England and Wales (OSPAR, 2008). In this chapter this guidance has informed the baseline characterisation focus for fish and shellfish ecology, such as spawning and nursery grounds, and incorporation of International Union for Conservation of Nature (IUCN) Red List information for key species when defining IEFs.

3.4.1.3 The identification of sensitive and protected habitats is a key feature of this chapter; these include mapped spawning and nursery grounds, particularly for those species which are highly substrate specific. Key information sources used to guide the identification of mapped spawning and nursery grounds which overlap the Mona Offshore Wind Project include Coull *et al.* (1998) and Ellis *et al.* (2012).

### 3.4.2 Scope of the assessment

3.4.2.1 The scope of this Environmental Statement has been developed in consultation with relevant statutory and non-statutory consultees as detailed in Table 3.6. This consultation process involved the scoping opinion, a number of regular EWGs, the development of an Evidence Plan Steering Group and the statutory Section 42 consultation period. The consultation added detail to the range of potential impacts which could effect fish and shellfish ecology receptors, taking into account local and national views about adequate coverage of important species within the fish and shellfish ecology study area.

3.4.2.2 Taking into account the scoping and consultation process, Table 3.7 summarises the topics considered as part of this assessment.

**Table 3.7: Topics considered within this assessment.**

| Activity | Potential effects scoped into the assessment |
|---|---|
| **Construction phase** | |
| Jack-up events, cable installation, sandwave clearance deposition, anchor placements, existing disused cable removal | Temporary habitat loss/disturbance<br>Underwater sound during the construction phase impacting fish and shellfish receptors<br>Increased suspended sediment concentrations (SSCs) and associated sediment deposition<br>Long term habitat loss<br>Introduction of artificial structures and colonisation of hard structures<br>Disturbance/remobilisation of sediment-bound contaminants<br>Injury due to increased risk of collision with vessels (basking shark only) |
| Piling for offshore wind turbines foundations, offshore substation platforms (OSPs), geophysical site investigation surveys, Unexploded Ordnance (UXO) clearance | |
| Vessel traffic and other sound-producing activities | |
| Sandwave clearance, foundation installation and cable installation | |
| Foundations (wind turbines and OSPs) and scour protection, cable protection and cable crossing protection | |
| Vessel movements | |

| Activity | Potential effects scoped into the assessment |
|---|---|
| **Operation and maintenance** | |
| Jack-ups at wind turbines and OSPs | Temporary habitat loss/disturbance |
| Vessel traffic and other sound-producing activities | Increased suspended sediment concentrations (SSCs) and associated sediment deposition |
| Repair and reburial of cables | Long term habitat loss |
| Foundations and scour protection, cable protection and cable crossing protection | Electromagnetic Fields (EMFs) from subsea electrical cabling |
| | Introduction of artificial structures and colonisation of hard structures |
| Presence of cables | Disturbance/remobilisation of sediment-bound contaminants |
| Vessel movements | Injury due to increased risk of collision with vessels (basking shark only) |
| **Decommissioning** | |
| Jack-up events, cable removal, anchor placements | Temporary habitat loss/disturbance |
| Vessel traffic and other sound-producing activities | Increased suspended sediment concentrations (SSCs) and associated sediment deposition |
| Suction caissons removal, cables removal | Long term habitat loss |
| Scour and cable protection left *in situ* | Introduction of artificial structures and colonisation of hard structures |
| Vessel movements | Disturbance/remobilisation of sediment-bound contaminants |
| | Injury due to increased risk of collision with vessels (basking shark only) |

3.4.2.3 Effects which are not considered likely to be significant have been scoped out of the assessment. A summary of the effects scoped out, together with the justification for scoping them out and whether the approach has been agreed with key stakeholders through either scoping or consultation is presented in Table 3.8.

**Table 3.8: 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 through the marine licences (e.g. Offshore Environmental Management Plan, including a MPCP). These plans include planning for accidental spills, address all potential contaminant releases and include key emergency contact details. It also sets 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 an event did occur, the magnitude of this will be minimised through measures such as the implementation of an MPCP. This approach was agreed during the scoping phase with stakeholders through EWGs and the Scoping Opinion. 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. | Sound generated by operational wind turbines is of a very low frequency and low sound pressure level (Andersson, 2011). Studies have found that sound levels are only high enough to possibly cause a behavioural reaction within metres from a wind turbine (Wahlberg and Westerberg, 2005; Sigray and Andersson, 2011; Vandendriessche *et al.*, 2015) and therefore such levels are not considered to have potentially significant effects on fish and shellfish receptors. Further studies have |

| Potential impact | Justification |
|---|---|
| | shown increases in fish abundance surrounding operational wind turbines, supporting the suggestion that behavioural effects are apparent at very close range (Van Hal *et al.*, 2017). The MMO (MMO, 2014) review of post-consent monitoring at offshore wind farms found that available data on the operational wind turbine sound, from the UK and abroad, in general showed that sound levels from operational wind turbines are low and the spatial extent of the potential impact of the operational sound 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 5, Annex 3.1: Underwater sound technical report of the Environmental Statement for further detail. This approach was agreed in the scoping phase and reaffirmed during consultation during EWGs as part of the Evidence Plan Process. 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 sound, 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 5, Annex 3.1: Underwater sound technical report of the Environmental Statement for further detail. This approach was agreed during the scoping phase with stakeholders through EWGs and the Scoping Opinion. 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. |

### 3.4.3 Fish and shellfish ecology study area

3.4.3.1 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 3.1, as agreed with stakeholders through consultation (see section 3.3):

- The Mona Fish and Shellfish Ecology study area covers the east Irish Sea, extending from MHWS west from the Mull of Galloway in Scotland to the west tip of Anglesey, following the territorial waters 12 nm limit of the Isle of Man (IoM), based on consultation with the EWG and all relevant stakeholders. 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 sound over a wider area) associated with the Mona Offshore Wind Project on the identified receptors.

3.4.3.2 The Mona fish and shellfish ecology study area (hereafter referred to as the 'fish and shellfish ecology study area') includes 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 2: Benthic subtidal and intertidal ecology of the Environmental Statement.

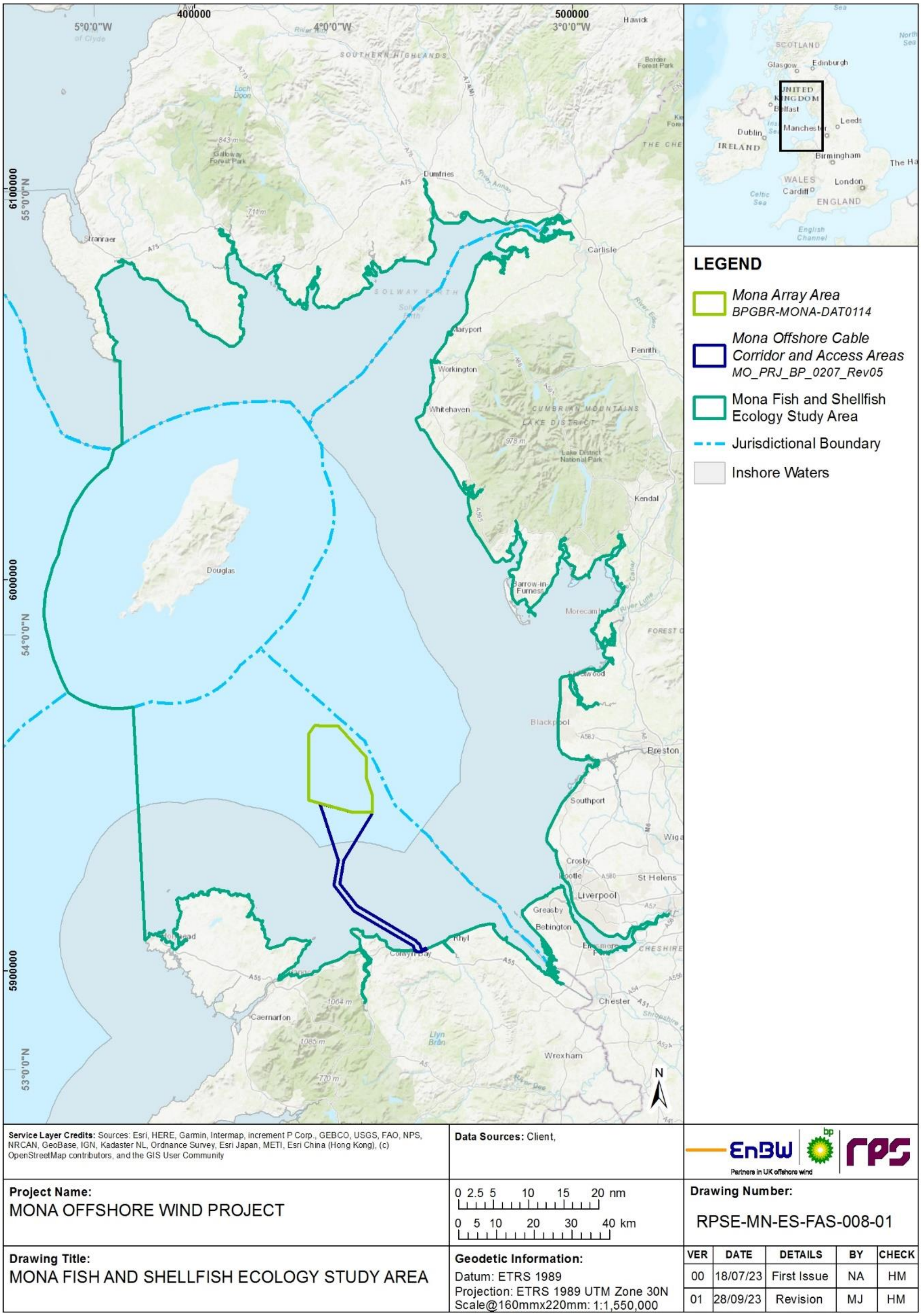



**Figure 3.1: Mona fish and shellfish ecology study area.**

### 3.4.4 Desktop study

3.4.4.1 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 3.9 below, with full details presented in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement.

**Table 3.9: Summary of key desktop reports.**

| Title | Source | Year | Author |
|---|---|---|---|
| Manx Basking Shark Watch, 1987 to 2022 | Manx Whale and Dolphin Watch | 1987 to 2022 | Manx Whale and Dolphin Watch |
| Fisheries Sensitivity Maps in British Waters | United Kingdom Offshore Operators Association Ltd. | 1998 | Coull *et al*. |
| Rhyl Flats Offshore Wind Farm, Fish and Fisheries Baseline Study, 2002 to 2006 | Marine Data Exchange | 2002, 2005, 2006a | Coastal Fisheries Conservation and Management (COWL, 2002; Centre for Marine and Coastal Studies Ltd. (CMACS), 2005, 2006a) |
| Effects of climate variability on basking shark abundance off southwest Britain | Fisheries Oceanography | 2005 | Cotton *et al*. |
| Walney and West of Duddon Sands Offshore Wind Farms, Baseline Benthic Survey – Epifaunal Beam Trawl Results | Marine Data Exchange | 2005 | Titan Environmental Surveys Ltd. |
| Herring larvae surveys of the north Irish Sea 1993 to 2021 | The Agri-Food and Biosciences Institute | 2006 to 2022 | Agri-Food and Biosciences Institute (ICES, 2006; Dickey-Collas *et al*., 2010; ICES, 2022b) |
| Burbo Bank Offshore Wind Farm, Pre-construction Commercial Fish Survey (2 m Beam Trawl) | Marine Data Exchange | 2006b, c | 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 | 2009a | Brown and May Marine Ltd. |
| Ormonde Offshore Wind Farm Pre-Construction Juvenile & Adult Fish Survey | Marine Data Exchange | 2009b, c | 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 |
| Rhiannon Wind Farm Round 3 Autumn Fish Trawl Survey | Marine Data Exchange | 2010, 2013 | CMACS |

| Title | Source | Year | Author |
|---|---|---|---|
| Burbo Bank Extension Offshore wind farm: Adult and Juvenile Fish Characterisation Survey | Marine Data Exchange | 2011a, b | Brown and May Marine Ltd. |
| Gwynt y Mor Offshore Wind Farm, Pre-construction Baseline Beam Trawl Data | Marine Data Exchange | 2011 | CMACS |
| Ormonde Offshore Wind Farm, Adult and Juvenile Fish and Epi-benthic Post-construction Survey, 2012 to 2014 | Marine Data Exchange | 2012a, 2014 | Brown and May Marine Ltd. |
| 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 | 2013a | Brown and May Marine Ltd. |
| Welsh waters scallop survey – Cardigan Bay to Liverpool Bay July-August 2013 | Bangor University | 2013 | Lambert *et al.* |
| Celtic Array – Rhiannon wind farm preliminary environmental information chapter 10: fish and shellfish ecology | Marine Data Exchange | 2013 | Celtic Array Ltd. |
| Updating Fisheries Sensitivity Maps in British Waters | Scottish Marine and Freshwater Science Report | 2014 | Aires *et al.* |
| ICES Celtic Seas ecoregion fisheries overview | Summary of commercial fisheries in the Celtic Sea | 2018a, b | ICES |
| Manx Marine Environmental Assessment | IoM Government – Fisheries Division | 2018 | Howe *et al*. |
| IoM scallop surveys, 1992 to 2022 | Bangor University – Sustainable Fisheries IoM | 2022 | Bangor University Sustainable Fisheries and Aquaculture Group |
| Welsh Waters Scallop Surveys and Stock Assessment | Bangor University | 2019 | Delargy *et al*. |
| ICES scallop assessment working group | ICES | 2019c | ICES |
| Bass and Ray Ecology in Liverpool Bay | Bangor University Sustainable Fisheries and Aquaculture Group. | 2020 | Moore *et al.* |
| Annual Fisheries Science Report | Bangor University Sustainable Fisheries and Aquaculture Group | 2021 | Jenkins *et al.* |
| Spawning and nursery grounds of forage fish in Welsh and surrounding waters | Cefas | 2021 | Campanella and van der Kooij |
| UK Sea Fisheries Annual Statistics Report | MMO | 2022 | MMO |
| SeaLifeBase | https://www.sealifebase.ca/ | 2022 | Palomares and Pauly |

| Title | Source | Year | Author |
|---|---|---|---|
| Northern Irish Ground Fish Trawl Survey, data reviewed for years 2012 to 2022 | ICES | 2022a | ICES |
| ICES working group on surveys on ichthyoplankton in the North Sea and adjacent seas | ICES | 2022b | ICES |
| Awel y Môr Offshore Wind Farm. Category 6: Environmental Statement | Awel y Môr Offshore Wind Farm Ltd. | 2022 | RWE Renewables UK |
| National Biodiversity Network (NBN) Atlas | NBN Atlas | 2023 | NBN Atlas |
| Marine Recorder Public UK Snapshot | JNCC | 2023 | JNCC |
| JNCC MPA Mapper | JNCC | 2023 | JNCC |
| Cefas OneBenthic Application | Cefas | 2023 | Cefas |
| Morecambe Offshore Windfarm Generation Assets PEIR Volume 1 Chapter 10: Fish and shellfish ecology of the Environmental Statement | Morecambe Offshore Windfarm Ltd | 2023 | Morecambe Offshore Windfarm Ltd |
| Morgan Offshore Wind Project Generation Assets PEIR Volume 2 Chapter 8: Fish and shellfish ecology of the Environmental Statement | Morgan Offshore Wind Ltd | 2023 | Morgan Offshore Wind Ltd |
| Marine Life Information Network (MarLIN) | MarLIN | 2023 | Tyler Walters *et al*. |
| 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 |

### 3.4.5 Identification of designated sites

3.4.5.1 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 Mona Offshore Wind Project 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 Mona Offshore Wind Project – specifically the Mona Array Area, and the Mona Offshore Cable Corridor and Access Areas

– Sites and associated qualifying interests were located within the potential ZoI for impacts associated with the Mona Offshore Wind Project

– 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 Mona Offshore Wind Project and/or the ZoI of impacts associated with the development.

### 3.4.6 Site specific surveys

3.4.6.1 In order to inform this chapter, site-specific surveys were undertaken, as agreed with the members of the Benthic Ecology, Fish and Shellfish and Physical Processes EWG (see Table 3.6 for further details). A summary of the surveys undertaken to inform the fish and shellfish ecology impact assessment is outlined in Table 3.10 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 surveys also provided opportunistic fish and shellfish records which have been extracted from the survey data to inform the baseline characterisation.

**Table 3.10: Summary of site-specific survey data.**

| Title | Extent of survey | Overview of survey | Survey contractor | Date | Reference to further information |
|---|---|---|---|---|---|
| Benthic Subtidal Survey | Mona Offshore Windfarm Array Area | Grab samples, visual survey outputs (Drop Down Video (DDV) sampling) and laboratory testing | Gardline Ltd. | 2021 | Gardline Ltd., 2022 |
| Benthic Subtidal Survey | Mona Offshore Cable Corridors and Access Areas, and Array Area ZoI. | Grab samples, visual survey outputs (DDV sampling) and laboratory testing | Gardline Ltd. | 2022 | Gardline Ltd., 2023 |

## 3.5 Baseline environment

### 3.5.1 Overview

3.5.1.1 The baseline environment has been described in detail within Volume 6, Annex 3.1: Fish and shellfish ecology of the Environmental Statement. The fish and shellfish ecology receptors that could be potentially impacted by the Mona Offshore Wind Project have been determined by the desktop review of available data and information as detailed in Table 3.9, and through use of fish and shellfish ecology data from site-specific surveys, as detailed in Table 3.10 (see Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement 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.

3.5.1.2 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*, thornback ray *Raja clavata* and angel shark *Squatina squatina*.
- 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)
- Shellfish species – king scallop, queen scallop, European lobster *Homarus gammarus*, edible crab *Cancer pagurus*, velvet swimming crab *Necora puber*, squid Loliginidae spp. and Ommastrephidae spp., common whelk *Buccinum undatum* and *Nephrops*.

3.5.1.3 The spawning and nursery habitats present in the fish and shellfish ecology study area are summarised in Table 3.11, and are based on Ellis *et al*. (2012) and Coull *et al*. (1998) with the seasonality of each species covered in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement. 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). These areas of spawning were reassessed by more recent surveys and summarised in Campanella and van der Kooij (2021), which found similar distributions for all investigated species and therefore supports the use of Coull *et al*. (1998) and Ellis *et al*. (2012). Further detail on nursery and spawning grounds is presented in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement.

3.5.1.4 The sensitivities of herring and sandeel to offshore wind energy development (including underwater sound and seabed disturbance), elasmobranch species of interest, and the economic importance of king and queen scallop in the IoM territorial waters are examined within this baseline. Specifically, a summary of the baseline characterisation for these four species/groups, as presented in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement, has been included in the following section.

**Table 3.11: Key species with spawning and nursery grounds overlapping the Mona Offshore Array Area and Mona Offshore Cable and Access Areas Route (Coull *et al.*, 1998 and Ellis *et al.*, 2012).**

| Common Name | Species Name | Spawning | Nursery |
|---|---|---|---|
| Anglerfish | *Lophius piscatorius* | | ✓ |
| Cod | *Gadus morhua* | ✓ | ✓ |
| Herring | *Clupea harengus* | | ✓ |
| Horse Mackerel | *Trachurus trachurus* | ✓ | |
| Lemon Sole | *Microstomus kitt* | ✓ | ✓ |
| King scallop | *Pecten maximus* | | ✓ |
| Ling | *Molva molva* | ✓ | |
| Mackerel | *Scomber scombrus* | ✓ | ✓ |
| *Nephrops* | *Nephrops norvegicus* | ✓ | ✓ |
| Plaice | *Pleuronectes platessa* | ✓ | ✓ |
| Queen scallop | *Aequipecten opercularis* | | ✓ |
| Sandeel | 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

3.5.1.5 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 sound. Herring spawning grounds have been identified by Coull *et al*. (1998) as being present within the fish and shellfish ecology study area. Data presented by Coull *et al*. (1998) is broad scale, and therefore confidence in, and resolution of, data showing 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).

3.5.1.6 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 <10 mm (in line with standard International Herring Larvae Survey (ICES, 2020) 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 3.5.5), the NINEL data is most useful as an indicator of spatial distribution of spawning grounds and does not give an indication of the size of the herring spawning population.

3.5.1.7 The larval densities were mapped and compared to the spatial distribution of spawning grounds presented in the Coull *et al*. (1998) data and the Particle Size Analysis (PSA) data from the site-specific benthic surveys within and around the Mona Array Area (outlined in section 3.4.6, shown in Figure 3.2). This PSA data, when presented alongside European Marine Observation and Data Network (EMODnet) seabed substrate data in Figure 3.2, was used to assess habitat suitability for herring spawning, in line with standard preference categories from Reach *et al*. (2013). This data demonstrated overlaps between the spawning ground datasets identified from site-specific surveys and those identified in Coull *et al*. (1998), with year-to-year variability in preferred spawning locations accounted for by the relatively high resolution and consistency of the data collection process. Specifically, the Coull *et al*. (1998), and the NINEL datasets showed significant spawning areas to the northwest of the Mona Array Area, and to the north, east and northeast of the IoM. The most suitable spawning grounds were located entirely outside of the Mona Array Area, which is further supported by results from detailed site-specific survey PSA data (see Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement for full results). This site-specific survey data found that the majority of the Mona Array Area and Mona Offshore Cable Corridor and Access Areas comprised unsuitable sediment for herring spawning, with only small patches of marginal habitat in the south east section of the Mona Array Area, and four stations pertaining to preferred habitats within the south of the Mona Offshore Cable Corridor and Access Areas (Figure 3.2). This process was applied to data from other surveys in the fish and shellfish ecology study area collated in the Cefas OneBenthic tool, to give a broader characterisation of sediment suitability for herring spawning, with most sampled stations being deemed unsuitable throughout, as further detailed in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement.

### Sandeel

3.5.1.8 Sandeel high and low intensity spawning grounds have been identified by Ellis *et al*. (2012) as 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 indicate any differences based on seasonal population changes.

3.5.1.9 Figure 3.3 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement for further details). Areas with no shading in Figure 3.3 represent unsuitable spawning habitat, whilst the PSA results were categorised into unsuitable, marginal and preferred sandeel habitat, based on mud and sand ratios in grab samples, as defined by Latto *et al*. (2013), and are presented as such within the figure. This process was applied to data from other surveys in the fish and shellfish ecology study area collated in the Cefas OneBenthic tool, to give a broader characterisation of sediment suitability for sandeel spawning, with a pattern of preferred habitats being present on gravelly sand and sandy gravel, as further detailed in Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement.

3.5.1.10 The site-specific surveys and EMODnet seabed substrate data show overall good alignment within the Mona Array Area, with most stations classed as unsuitable habitat. A number of stations in the west and south of the Mona Array Area represented marginal and preferred habitats. Site-specific surveys performed for the benthic baseline characterisation confirmed the presence of only two sandeel within the Mona Array Area, although these were only opportunistic catches from apparatus not designed for sandeel sampling, and therefore cannot be used to inform overall abundance without further studies to specifically sample sandeel. EMODnet data indicates that the Mona Offshore Cable Corridor and Access Areas is situated entirely within high intensity sandeel spawning grounds, with substrates mainly comprising gravelly sand and (gravelly) sand, which are preferred sandeel habitats. This was confirmed by the site-specific data PSA results, which indicated that most stations within the Mona Offshore Cable Corridor and Access Areas were classified as preferred habitat for sandeel spawning.

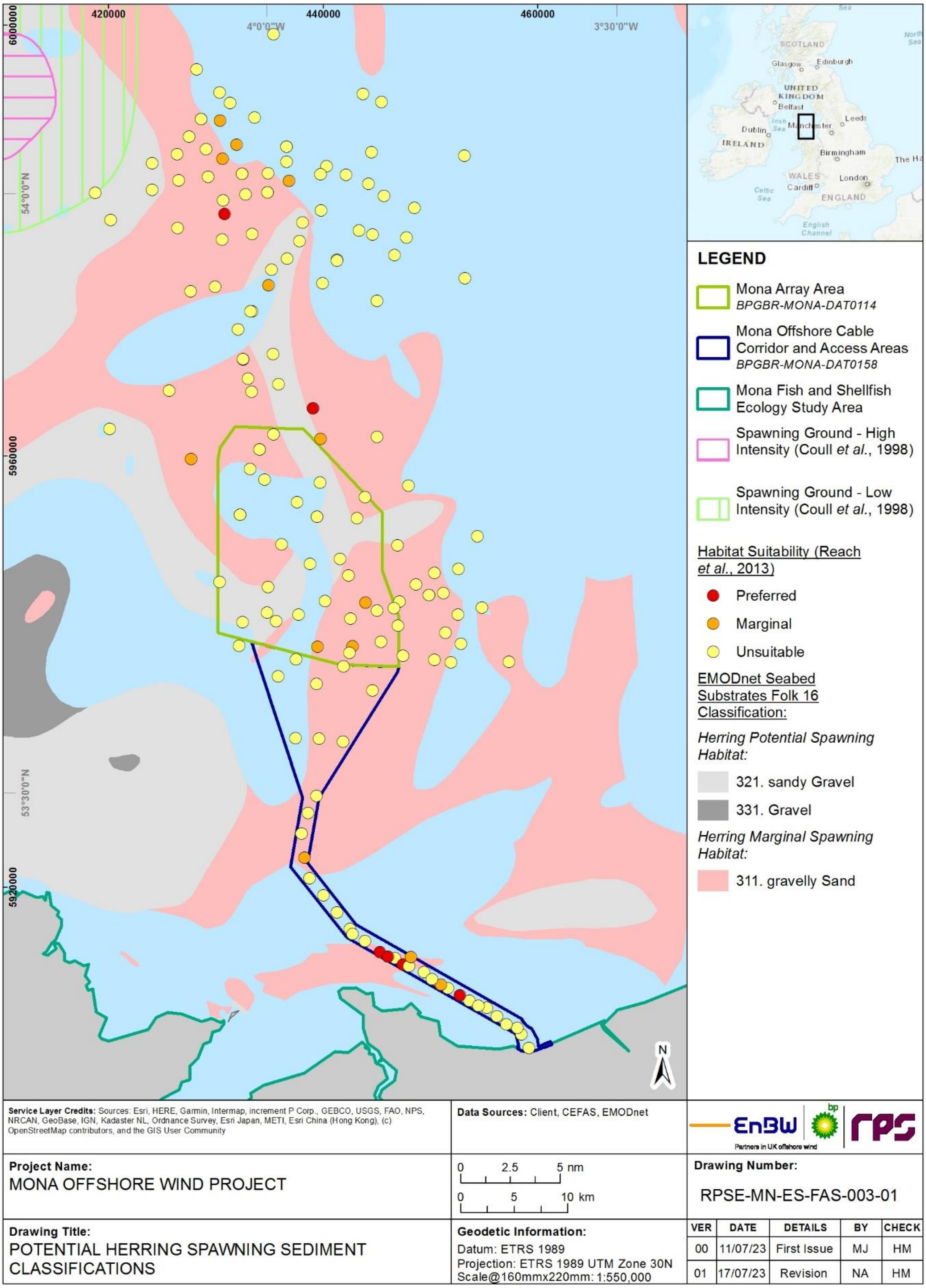



**Figure 3.2: Herring spawning habitat preference classifications from EMODnet and site-specific survey data.**

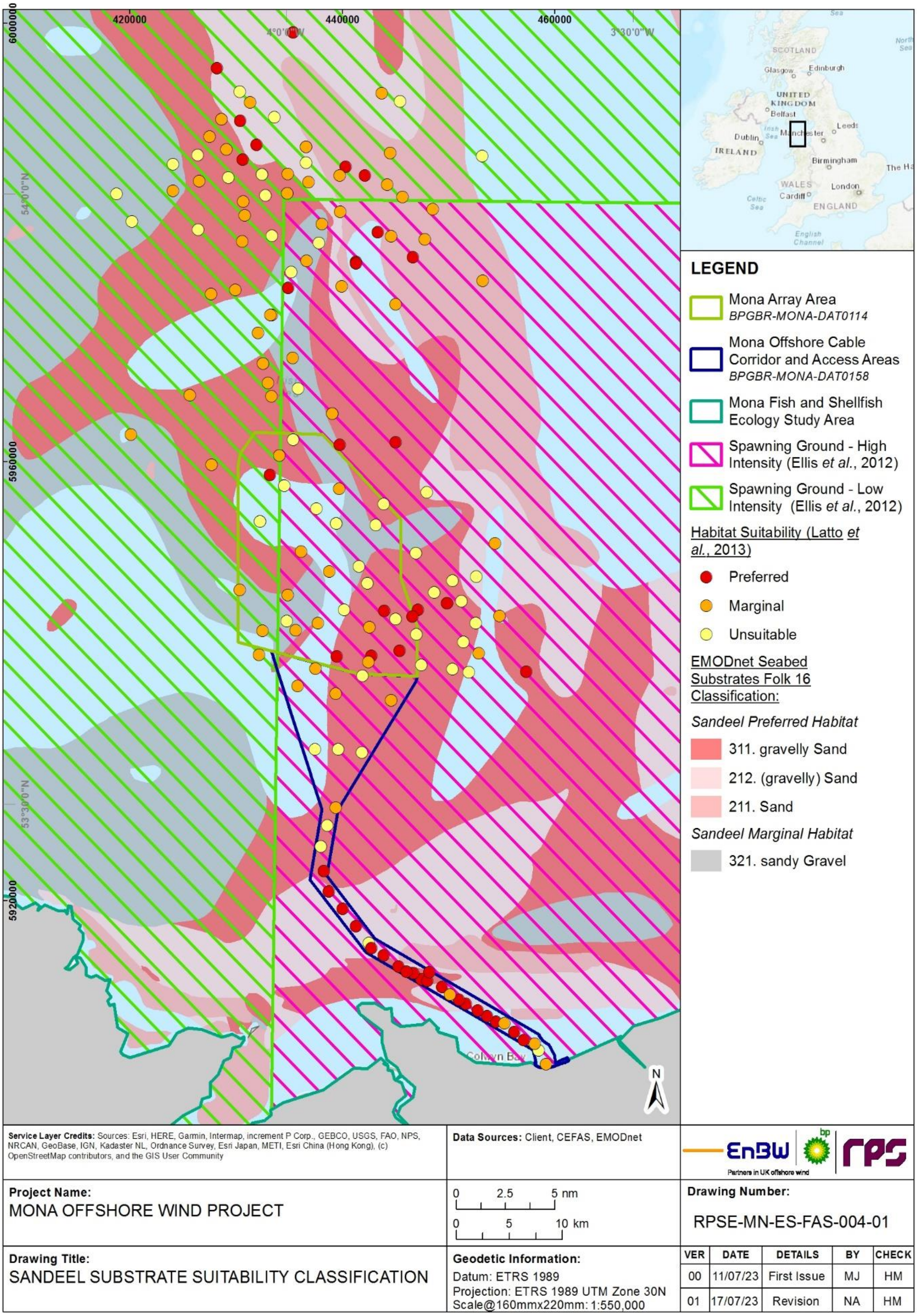



**Figure 3.3: Sandeel habitat suitability and spawning ground intensity based on Coull *et al*. (1998) and Ellis *et al*. (2012).**

## Elasmobranchs

3.5.1.11 A range of elasmobranch species are known to occur within the Irish Sea, such as the spotted and thornback rays. Inshore Fisheries and Conservation Authority 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 elasmobranch 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 *et al*., 1996), and in deep offshore waters for the cuckoo ray (Moriarty *et al*., 2015), potentially overlapping with the fish and shellfish ecology study area. Also, angel shark are known to have a preference for shallow coastal and continental shelf soft sediment habitats for feeding (Lawson *et al*., 2019), and a small group of up to 100 individuals are known to feed in the south west of the fish and shellfish ecology study area intermittently during the spring and summer months (Barker *et al*., 2022).

3.5.1.12 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 to 200 m 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 1057 km 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 6, Annex 4.1: Marine mammals technical report of the Environmental Statement, 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 to 200 m (Doherty *et al*., 2017), and therefore could be present within the Mona Array Area, where depths average <50 m. Evidence exists of their regular migration in small numbers through the area near to the Mona Offshore Wind Project (Shark Trust, 2022; Manx Whale and Dolphin Watch, 2023).

## King and Queen Scallop

3.5.1.13 King and queen scallop both show preferences for clean firm sand, fine or sandy gravel, and are found in high densities on muddy sand (Marshall and Wilson, 2008, Carter, 2008). High levels of commercial fishing for king scallop have been recorded within the wider fish and shellfish ecology study area (ICES, 2020), and for queen scallop in the middle of the Mona Array Area, as examined in detail with relevant mapping from fisheries data in Volume 6, Annex 6.1: Commercial fisheries technical report of the Environmental Statement. Areas within the wider fish and shellfish ecology study area are considered important spawning grounds for queen scallop, contributing to the highly fished area located within the Mona Offshore Array. In addition, queen scallop have been reported by Bloor *et al*. (2019) to be found in densities of 1 to 11 individuals per 100 $m^2$ within IoM territorial waters northwest of the Mona Array Area, with potential for overlap between these areas due to the relative mobility of queen scallop in the summer months (see Volume 6, Annex 6.1: Commercial fisheries technical report of the Environmental Statement for additional information).

3.5.1.14 King and queen scallop are the most important fisheries by sale values in Manx waters, around the IoM (Murray *et al*., 2009; Duncan and Emmerson, 2018). However, since 2011, the stock assessment within the Manx waters indicates a decreasing trend of queen scallop biomass which is also illustrated by lower commercial landings (ICES, 2019).

### 3.5.2 Designated sites

3.5.2.1 Designated sites identified for the fish and shellfish ecology chapter are described below in Table 3.12.

**Table 3.12: Designated sites and relevant qualifying fish and shellfish ecology interests.**

* Note that references to scallops within Table 3.12 are collectively to the species within the family Pectinidae, and do not reflect a specific genus or species within this group. References within the same table to sandeel refer to the family Ammodytidae and do not reflect a specific genus or species within this group.

| Designated Site | Closest Distance from the Mona Offshore Wind Project (km) | Relevant Features of Interest |
|---|---|---|
| Dee Estuary SAC/Aber Dyfrdwy SAC | 34.51 | • Sea lamprey<br>• River lamprey |
| Little Ness MNR | 40.66 | • Basking shark<br>• European eel<br>• Scallops*<br>• Whelk |
| Langness MNR | 40.94 | • European eel<br>• Basking shark<br>• Lobster nursery ground<br>• Cod spawning and nursery ground |
| Douglas Bay MNR | 42.66 | • European eel<br>• Scallops*<br>• Whelk |
| Laxey Bay MNR | 44.4 | • Atlantic salmon<br>• European eel<br>• Sea trout<br>• Scallops*<br>• Whelk |
| Ribble Estuary MCZ | 48.39 | • Sparling |
| Baie ny Carrickey MNR | 49.94 | • European eel<br>• Basking shark<br>• Spiny lobster (Paniluridae sp.) |
| Ramsey Bay MNR | 51.95 | • European eel<br>• European bass nursery<br>• Sandeel*<br>• Scallops*<br>• Whelk |

| Designated Site | Closest Distance from the Mona Offshore Wind Project (km) | Relevant Features of Interest |
|---|---|---|
| Wyre Lune MCZ | 52.61 | • Sparling |
| Calf of Man and Wart Bank MNR | 53.26 | • European eel<br>• Basking shark<br>• Sandeel*<br>• Spiny lobster |
| Port Erin Bay MNR | 56.60 | • Basking shark<br>• Plaice nursery |
| Niarbyl Bay MNR | 57.46 | • Basking shark |
| River Dee and Bala Lake/Afon Dyfrdwy a Llyn Tegid SAC | 59.13 | • Sea lamprey<br>• River lamprey<br>• Atlantic salmon<br>• Brook lamprey |
| West Coast MNR | 60.71 | • European eel<br>• Basking shark<br>• Sandeel*<br>• European bass nursery<br>• Scallops*<br>• Whelk |
| River Ehen SAC | 83.01 | • Atlantic salmon<br>• Freshwater pearl mussel |
| River Derwent and Bassenthwaite Lake SAC | 95.06 | • Sea lamprey<br>• River lamprey<br>• Atlantic salmon<br>• Brook lamprey |
| Solway Firth SAC | 109.46 | • Sea lamprey<br>• River lamprey |
| Solway Firth MCZ | 122.71 | • Sparling |

### 3.5.3 Important ecological features

3.5.3.1 IEFs are habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Mona Offshore Wind Project. 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, as defined under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006. Table 3.13 details the criteria used for determining IEFs and Table 3.14 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 3.14).

**Table 3.13: Defining criteria for IEFs (adapted from CIEEM, 2018).**

| Value of IEF | Defining criteria |
|---|---|
| International | Internationally designated sites.<br>Species protected under international law (i.e. species listed as qualifying interests of SACs under Annex II of the EU Habitats and Species Directive). |
| National | Nationally designated sites.<br>Species protected under national law.<br>Annex II species which are not listed as qualifying interests of SACs in the fish and shellfish ecology study area.<br>OSPAR List of Threatened or Declining Species, and IUCN Red List species that have nationally important populations within the Mona Offshore Wind Project, particularly in the context of species/habitat that may be rare or threatened in English and Welsh waters.<br>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.<br>Species that have spawning or nursery areas within or in the immediate vicinity of the Mona Offshore Wind Project 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 Mona Offshore Wind Project (i.e. are locally widespread or abundant).<br>Priority habitats and species (SPIs) have been deemed features characteristic of the English and Welsh marine environment.<br>Species that are of commercial value to the fisheries which operate within the Mona Offshore Wind Projects.<br>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 Mona Offshore Wind Project.<br>Species that have spawning or nursery areas within the Mona Offshore Wind Project 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 Mona Offshore Wind Project). |

| Value of IEF | Defining criteria |
|---|---|
| Local | Species that are of commercial importance but do not form a key component of the fish assemblages within the Mona Offshore Wind Project (e.g. they may be exploited in deeper waters outside the Mona Offshore Wind Project).<br>The spawning/nursery area for the species are outside the Mona Offshore Wind Project.<br>The species is common throughout English and Welsh waters but forms a component of the fish assemblages in the Mona Offshore Wind Project. |

**Table 3.14: IEF species and representative groups within the Mona Offshore Wind Project.**

| IEF | Specific name/ representative species | Importance | Justification |
|---|---|---|---|
| **Marine Fish IEFS** | | | |
| Plaice | *Pleuronectes platessa* | Regional | Listed as a Species of Principal Importance.<br>High intensity spawning and low intensity nursery grounds identified throughout the Mona Offshore Wind Project.<br>Plaice is an important commercial species throughout the fish and shellfish ecology study area, Mona Offshore Wind Project and within the surrounding east Irish Sea. |
| Lemon Sole | *Microstomus kitt* | Local | Spawning and nursery grounds are undetermined and unspecified within the fish and shellfish ecology study area, Mona Offshore Wind Project and wider east Irish Sea. It is an important and abundant commercial fish species, but not in the immediate vicinity of the Mona Array Area and in the wider east Irish Sea. |
| Dover sole | *Solea solea* | Regional | Listed as a SPI.<br>High intensity spawning and nursery grounds identified throughout the fish and shellfish ecology study area and Mona Offshore Wind Project.<br>Dover sole is an important commercial species throughout the fish and shellfish ecology study area, Mona Offshore Wind Project and within the surrounding east Irish Sea. |
| 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 fish and shellfish ecology study area.<br>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.<br>High intensity spawning and nursery grounds are present throughout the fish and shellfish ecology study area.<br>It is an important commercial fish species, but not in the immediate vicinity of the Mona Array Area and in the wider east Irish Sea, following collapse of the stock and subsequent poor recovery rates. |

| IEF | Specific name/ representative species | Importance | Justification |
|---|---|---|---|
| Whiting | *Merlangius merlangus* | Regional | Listed as a SPI.<br>Low intensity spawning and high intensity nursery grounds identified throughout the fish and shellfish ecology study area.<br>Whiting is an important commercial species throughout the Mona Array Area and within the surrounding east Irish Sea. |
| Other demersal species | | Local to regional | Species including anglerfish *Lophius piscatorius,* ling *Molva molva*, European hake *Merluccius merluccius* and European seabass *Dicentrarchus labrax* are common throughout English and Welsh waters and are likely to be in the fish and shellfish ecology study area. The first three listed species are also Species of Principal Importance.<br>They are important commercial species, but not in the immediate vicinity of the Mona Array Area and in the east Irish Sea. |
| Sandeel species | Ammodytidae spp. | Regional | 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.<br>Sandeel are important prey species for fish, birds and marine mammals.<br>High intensity spawning grounds and low intensity nursery grounds are present throughout the fish and shellfish ecology study area.<br>Identified as likely to be present in the fish and shellfish ecology study area and Mona Offshore Wind Project based on historic data and habitat preference.<br>Raitt's sandeel *Ammodytes marinus* is listed as a Species of Principal Importance. |
| Herring | *Clupea harengus* | National | Listed as a SPI.<br>Low intensity spawning grounds present immediately outside of the Mona Array Area and within the fish and shellfish ecology study area. High intensity nursery grounds present within the fish and shellfish ecology study area. Although herring spawning grounds do not directly overlap the Mona Array Area, this specific area of the Irish Sea has been denoted as key spawning habitat for the species.<br>Herring is an important commercial species, but not in the immediate vicinity of the Mona Array Area or in the wider east Irish Sea. |
| Mackerel | *Scomber scombrus* | Regional | Listed as a SPI.<br>Important prey species for larger fish, birds and marine mammals.<br>Low intensity spawning and nursery grounds throughout the fish and shellfish ecology study area and the wider east Irish Sea.<br>Mackerel is an important commercial species, but not in the immediate vicinity of the Mona Array Area or in the wider east Irish Sea. |

| IEF | Specific name/ representative species | Importance | Justification |
|---|---|---|---|
| Sprat | *Sprattus sprattus* | Regional | Important prey species for larger fish, birds and marine mammals.<br>Unspecified intensity spawning and nursery grounds within the fish and shellfish ecology study area.<br>Sprat is an important commercial species, but not in the immediate vicinity of the Mona Array Area or in the wider east Irish Sea. |
| Basking Shark | *Cetorhinus maximus* | International | 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 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 1981.<br>Basking shark are likely to be present in low abundances, if present at all, near the IoM and in proximity to the Mona Array Area.<br>Listed as a SPI. |
| Tope | *Galeorhinus galeus* | Regional | Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework.<br>Low intensity nursery grounds within the fish and shellfish ecology study area.<br>Listed as a SPI. |
| Spurdog | *Squalus acanthias* | Regional | Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework.<br>High intensity nursery grounds within the fish and shellfish ecology study area.<br>Listed as a SPI. |
| Rays | Rajidae spp. | Regional | Ray species include spotted ray, and thornback ray.<br>These species either have low intensity nursery grounds and/or no known spawning grounds within the Mona Array Area. |
| **Shellfish IEF Species** | | | |
| Edible crab | *Cancer pagurus* | Regional | Commercially important species. Identified as being likely to be present within the fish and shellfish ecology study area and Mona Offshore Wind Project. |
| Norway lobster | *Nephrops norvegicus* | Regional | Commercially important species. Identified as being likely to be present within the fish and shellfish ecology study area and Mona Offshore Wind Project. |
| European lobster | *Homarus gammarus* | Regional | Commercially important species. Identified as being likely to be present within the fish and shellfish ecology study area and Mona Offshore Wind Project. |
| King Scallop | *Pecten maximus* | Regional | Commercially important species. Identified as being present within the fish and shellfish ecology study area and Mona Offshore Wind Project. |
| Queen Scallop | *Aequipecten opercularis* | Regional | Commercially important species. Identified as being present within the fish and shellfish ecology study area and Mona Offshore Wind Project. |

| IEF | Specific name/ representative species | Importance | Justification |
|---|---|---|---|
| Velvet swimming crab | *Necora puber* | Local | Commercially important species. Identified as being likely to be present within the fish and shellfish ecology study area and Mona Offshore Wind Project. |
| Other shellfish | | Local | Other shellfish including, but not limited to, swimming crab, spider crab (*Maja brachydactyla*), shrimp and cockles have been identified as being likely to occur within the fish and shellfish ecology study area.<br>These are all important commercial species, but not in the immediate vicinity of the Mona Array Area or in the wider east Irish Sea. |
| **Diadromous Fish IEF Species** | | | |
| Sea trout | *Salmo trutta* | National | Listed as a SPI.<br>Listed as a species of Least Concern by the IUCN Red List. Listed as a Convention for the Protection of the OSPAR threatened/declining species.<br>Likely to migrate through the fish and shellfish ecology study area. Not a feature of any designated sites in the vicinity of the Mona Offshore Wind Project. |
| European eel | *Anguilla anguilla* | National | Listed as a SPI.<br>Listed as Critically Endangered by the IUCN Red List. Listed as an OSPAR threatened/declining species.<br>Likely to migrate through the Mona Offshore Wind Project. This species is a qualifying feature of multiple MNRs in the vicinity of the Mona Offshore Wind Project. |
| Sea lamprey | *Petromyzon marinus* | International | Listed as a SPI.<br>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 fish and shellfish ecology study area.<br>Likely to migrate through the fish and shellfish ecology study area. |
| River lamprey | *Lampetra fluviatilis* | International | Listed as a SPI.<br>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 fish and shellfish ecology study area.<br>Likely to migrate through the Mona Offshore Wind Project, although only in coastal/estuarine areas nearer the Mona Offshore Cable Corridor and Access Areas. |
| Twaite shad | *Alosa fallax* | National | Listed as a SPI.<br>Listed as a species of Least Concern by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Annex II species.<br>Likely to migrate through the fish and shellfish ecology study area. |

| IEF | Specific name/ representative species | Importance | Justification |
|---|---|---|---|
| Allis shad | *Alosa alosa* | National | Listed as a SPI.<br>Listed as a species of Least Concern by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Annex II species.<br>Likely to migrate through the fish and shellfish ecology study area. |
| Atlantic salmon | *Salmo salar* | International | Listed as a SPI.<br>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 fish and shellfish ecology study area.<br>Likely to migrate through the fish and shellfish ecology study area. |
| Sparling/ European smelt | *Osmerus eperlanus* | National | Listed as a SPI.<br>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 fish and shellfish ecology study area.<br>Likely to migrate through the fish and shellfish ecology study area, although only in coastal/estuarine areas, nearer the Mona Offshore Cable Corridor and Access Areas. |
| Freshwater pearl mussel | *Margaritifera margaritifera* | International | Listed in Annexes II and V of the EU Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (The Habitats Directive) and Annex III of the Bern Convention. Listed as Endangered on the IUCN Red List, and as an SPI.<br>Annex II species and listed as qualifying features of a number of SACs in the vicinity of the fish and shellfish ecology study area. |

### 3.5.4 Future baseline scenario

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

3.5.4.2 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 Mona Offshore Wind Project 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 Mona Offshore Wind Project.

3.5.4.3 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*., 2019).

3.5.4.4 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 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).

3.5.4.5 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 Mona Offshore Wind Project development should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment.

### 3.5.5 Data limitations

3.5.5.1 The data sources used in this chapter are detailed in Table 3.9 and Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement. This largely comprises a desk-based assessment of the Mona fish and shellfish ecology 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.

3.5.5.2 Site-specific surveys were carried out for benthic ecology requirements (Volume 2, Chapter 2: Benthic subtidal and intertidal ecology of the Environmental Statement) and were used to determine suitable herring habitats and the presence of sandeel individuals and to confirm presence of suitable sandeel habitats in line with EMODnet data within the Mona 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 Environmental Statement. Recent modelling based on collated survey data in the Welsh and surrounding waters (including the IoM territorial waters; Campanella and van der Kooij, 2021) provides up-to-date evidence to support the distribution of the previously identified spawning and nursery grounds for a range of foraging species, with any slight changes in mapped species distribution likely being due to natural interannual variation. Broadly, these studies all describe the same patterns of spawning and nursery habitat within the fish and shellfish ecology study area, and thus the maps available from Coull *et al*. (1998) and Ellis *et al*. (2012) data can be considered reliable and of continued relevance.

3.5.5.3 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement 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 6, Annex 3.1: Fish and shellfish technical report of the Environmental Statement and should not represent a significant impact on the predictability of the Environmental Statement.

## 3.6 Impact assessment methodology

### 3.6.1 Overview

3.6.1.1 The fish and shellfish ecology impact assessment has followed the methodology set out in Volume 1, Chapter 5: EIA methodology of the Environmental Statement. 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 Ecological Impact Assessment (EcIA) in the UK and Ireland (CIEEM, 2019; updated in 2022)
- 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, 2016)
- 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 (Judd, 2012)
- Marine Evidence-based Sensitivity Assessment – A Guide (Tyler-Walters *et al*., 2023).

3.6.1.2 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 (the 2017 EIA Regulations) (relevant to the DCO application)
- The Marine Works (Environmental Impact Assessment Regulations) 2007 (the 2007 EIA Regulations) (relevant to the marine licence application to NRW)
- The Planning Act 2008 (relevant to the DCO application)
- The Marine and Coastal Access Act 2009 (relevant to the marine licence application to NRW).

### 3.6.2 Impact assessment criteria

3.6.2.1 The criteria for determining the significance of effects is 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 Environmental Statement.

3.6.2.2 The criteria for defining magnitude in this chapter are outlined in Table 3.15 below.

**Table 3.15: 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) |

3.6.2.3 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.

3.6.2.4 The sensitivities of fish and shellfish IEFs presented within this chapter of the Environmental Statement 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 3.5.3 and as presented in Table 3.14 for the fish and shellfish IEFs considered in this assessment.

3.6.2.5 The criteria for defining sensitivity in this chapter are outlined in Table 3.16 below.

**Table 3.16: 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. |
| Medium | Nationally and internationally important receptors with medium vulnerability and medium recoverability.<br>Regionally important receptors with medium to high vulnerability and low recoverability.<br>Locally important receptors with high vulnerability and no ability to recover. |
| Low | Nationally and internationally important receptors with low vulnerability and high recoverability.<br>Regionally important receptors with low vulnerability and medium to high recoverability.<br>Locally important receptors with medium to high vulnerability and low recoverability. |
| Negligible | Locally important receptors with low vulnerability and medium to high recoverability.<br>Receptor is not vulnerable to impacts regardless of value/importance. |

3.6.2.6 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 3.17. Where a range of significance of effect is presented in Table 3.17, the final assessment for each effect is based upon expert judgement, with a clear justification provided in the impact assessment.

3.6.2.7 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 3.17: Matrix used for the assessment of the significance of the effect.**

| Sensitivity of Receptor | Magnitude of Impact | | | |
|---|---|---|---|---|
| | **Negligible** | **Low** | **Medium** | **High** |
| **Negligible** | Negligible | Negligible or Minor | Negligible or Minor | Minor |
| **Low** | Negligible or Minor | Negligible or Minor | Minor | Minor or Moderate |
| **Medium** | Negligible or Minor | Minor | Moderate | Moderate or Major |
| **High** | Minor | Minor or Moderate | Moderate or Major | Major |
| **Very High** | Minor | Moderate or Major | Major | Major |

### 3.6.3 Designated sites

3.6.3.1 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 3.5.2 of this chapter. 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 Mona Offshore Wind Project on the designated sites is contained within the MCZ Assessment. With respect to nationally and locally designated sites, where these sites fall within the boundaries of an internationally designated site (e.g. 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).

3.6.3.2 The ISAA has been prepared (Document Reference E.1) in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (Planning Inspectorate, 2022) and will be submitted as part of the Application for Development Consent.

## 3.7 Key parameters for assessment

### 3.7.1 Maximum design scenario

3.7.1.1 The MDSs identified in Table 3.18 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 Environmental Statement. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the PDE (e.g. different infrastructure layout), to that assessed here be taken forward in the final design scheme.

**Table 3.18: Maximum design scenario considered for the assessment of potential impacts on fish and shellfish ecology.**

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

| Potential impact | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| Temporary habitat loss/disturbance. | ✓ | ✓ | ✓ | **Construction phase**<br>Up to 60,512,833 m² of subtidal habitat loss/disturbance in total across the Mona Array Area and Mona Offshore Cable Corridor.<br>Maximum duration of the offshore construction phase is up to four years.<br>Mona Array Area:<br>Up to 48,784,483 m² of temporary habitat loss/disturbance in the Mona Array Area comprising:<br>• Jack-up events: up to 816,000 m² of disturbance from the use of jack-up vessels during foundation installation, with up to four jack-up events at each of 96 wind turbine (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<br>• Sandwave clearance for foundations: up to 923,839 m² of habitat disturbance associated with sandwave clearance comprising:<br>– 826,440 m² of sandwave clearance associated with seabed preparation for wind turbine foundations<br>– 97,399 m² of sandwave clearance associated with seabed preparation for OSP foundations.<br>• Cable installation (including sandwave clearance and pre-lay preparation): up to 19,050,000 m² of disturbance comprising:<br>– Inter-array cables: up to 16,250,000 m² disturbance from installation of up to 325 km of inter-array cables (assumes 50% requires boulder clearance with a 20 m width of disturbance and 60% requires sandwave clearance with an 80 m width of disturbance)<br>– Interconnector cables: up to 2,800,000 m² disturbance from installation of up to 50 km of interconnector cables (assumes 40% requires boulder clearance with a 20 m width of disturbance and 60% requires sandwave clearance with an 80 m width of disturbance).<br>• Sandwave clearance material deposition: Up to 26,074,994 m² of habitat disturbance associated with the deposition of sandwave clearance material comprising: | **Construction phase:**<br>Maximum footprint which would be affected during the construction, operations and maintenance and decommissioning phases, with the scenarios and methods chosen for assessment based on them producing the maximum design scenario compared to other proposed methods and infrastructure.<br>The MDS assumes that the width of disturbance for sandwave and pre-lay preparation (boulder and debris clearance) also includes subsequent burial.<br>Pre-lay preparation is likely to be required across all inter-array, interconnector and export cables. 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, 40% of interconnector, and 20% of export cables will be subject to pre-lay preparation only.<br>It is anticipated that the sandwaves requiring clearance in the Mona Array Area are likely to be in the range 15 m 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 SSC” 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 0.5 m height. The MDS assumes temporary loss of benthic habitat is beneath this. |

| Potential impact | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | – 16,833,242 $m^2$ (from deposition of 8,416,621 $m^3$) of sandwave clearance material associated with seabed preparation for wind turbine and OSP foundations<br>– 8,377,752 $m^2$ (from deposition of 4,188,876 $m^3$) of sandwave clearance material associated with seabed preparation for inter-array cables<br>– 1,268,082 $m^2$ (from deposition of 634,041 $m^3$) of sandwave clearance material associated with seabed preparation for OSP foundations<br>• Existing disused cable removal: Up to 920,000 $m^2$ from the removal of 46 km of disused cables<br>• UXO removal: clearance of up to 23 UXOs within the Mona Array Area and Mona Offshore Cable Corridor ranging from 25 kg up to 907 kg with 130 kg the most likely (common) maximum.<br><u>Mona Offshore Cable Corridor:</u><br>Up to 11,728,000 $m^2$ of temporary habitat loss/disturbance in the Mona Offshore Cable Corridor comprising:<br>• Export cable installation (including sandwave clearance and pre-lay preparation): up to 8,640,000 $m^2$ of disturbance resulting from installation of up to 360 km of export cables (assumes 80% requires boulder clearance with a 20 m width of disturbance and 20% requires sandwave clearance with a 40 m width of disturbance)<br>• Sandwave clearance material deposition: up to 3,008,000 $m^2$ of habitat disturbance from deposition of 1,504,000 $m^3$ of sandwave clearance material associated with sandwave clearance for export cables<br>• Anchor placements: up to 80,000 $m^2$ of habitat disturbance from a 100 $m^2$ anchor placement event every 500 m during offshore export cable installation within the nearshore area (10 km for each of the four export cables)<br>• UXO removal: clearance of up to 23 UXOs within the Mona Array Area or Mona Offshore Cable Corridor ranging from 25 kg up to 907 kg with 130 kg the most likely (common) maximum.<br><br>**Operations and maintenance phase**<br>Up to 17,402,800 $m^2$ of temporary subtidal habitat disturbance in total across the Mona Array Area and Mona Offshore Cable Corridor. | The actual disturbance width for cable installation is likely to be considerably less.<br>**Operations and maintenance phase:**<br>The MDS for habitat disturbance associated with export cable maintenance includes repairs/reburial of subtidal cables.<br>**Decommissioning phase:**<br>Parameters for decommissioning will be significantly lower than for the construction phase as sandwave clearance and pre-lay preparation will not be required in advance of cable removal and cable protection and scour protection will be left *in situ*.<br>The MDS assumes the complete removal of all wind turbine and OSP foundations and cables; piles will be cut below the seabed. |

| Potential impact | Phase[a] | | | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | C | O | D | | |
| | | | | Operational phase up to 35 years.<br>Mona Array Area:<br>Up to 10,822,800 m² of temporary habitat disturbance in the Mona Array Area comprising:<br>• Up to 1,822,800 m² of temporary habitat disturbance due to jack-ups at wind turbines and OSPs over the lifetime of the Mona Offshore Wind Project for the following:<br>– Up to 840 major component replacements (one every four years for each location) for wind turbines<br>– 12 major component replacements (three over the lifetime per OSP) for OSPs<br>– Four access ladder replacements and four modifications to/replacement of J-tubes for wind turbines<br>– Four access ladder replacements and four modifications to/replacement of J-tubes for OSPs<br>• Up to 5,200,000 m² of temporary habitat disturbance due to inter-array cable maintenance associated with:<br>– 2,800,000 m² from seven reburial events (one every five years) affecting up to 20,000 m per reburial event<br>– 2,400,000 m² from 12 repair events (one every three years) affecting up to 10,000 m per cable repair events<br>– Assuming 20 m width seabed disturbance for repair and remedial burial<br>• Up to 3,800,000 m² of temporary habitat disturbance due to interconnector cable maintenance:<br>– 280,000 m² from seven reburial events (one every five years) affecting up to 2,000 m per reburial event<br>– 3,520,000 m² from 11 repair events (three every 10 years) affecting up to 16,000 m of cable per repair event<br>– Assuming 20 m width seabed disturbance for repair and remedial burial.<br>Mona Offshore Cable Corridor:<br>Up to 6,580,000 m² of temporary habitat disturbance in the Mona Offshore Cable Corridor comprising: | |

| Potential impact | Phase[a] | | | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | C | O | D | | |
| | | | | • Subtidal export cable maintenance:<br>– 4,480,000 m² from 14 repair events (two repairs every five years) for each of the four export cables (i.e. 56 repair events in total) affecting up to 4 km per cable per repair event (i.e. 16 km for all four cables)<br>– 2,100,000 m² from seven reburial events (one event every five years) s affecting up to 15 km of cable per reburial event<br>– Assuming 20 m width seabed disturbance for repair and remedial burial.<br>**Decommissioning phase**<br>Temporary subtidal habitat loss/disturbance due to:<br>• Cable removal: temporary habitat disturbance from the removal of 325 km of inter-array cables, 50 km of interconnector cables and 360 km of offshore export cables<br>• Anchor placements: temporary habitat disturbance from anchor placements during cable removal<br>• Jack-up events: temporary habitat disturbance from the use of jack-up vessels during foundation removal.<br>• | |
| Underwater sound during the construction phase impacting fish and shellfish receptors | ✓ | × | × | **Construction phase**<br>• Wind turbines :<br>– Installation of up to 64 wind turbine foundations with four-legged jacket foundations (256 piles, diameter of each pile = 3.8 m) installed by impact piling; plus<br>– Gravity base foundations: up to 32 gravity base foundations with 10 requiring piling for ground strengthening purposes, leading to up to 150 piles, with 15 piles per foundation (maximum diameter of 4 m per pile)<br>• OSPs: installation of four OSPs with foundations consisting of four-legged jacket foundations, with three piles per leg (48 piles, maximum diameter of 3.5 m per pile) installed by impact piling<br>• Maximum hammer energy of up to 4,400 kJ<br>• Up to two vessels piling concurrently with a maximum hammer energy of 3,000 kJ each (minimum distance 1.4 km, maximum distance 15 km, between piling vessels) | For 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.<br>Minimum spacing between concurrent piling represents the highest risk of injury to fish and shellfish as sound from adjacent foundations could combine to produce a greater radius of effect compared to a single piling event.<br>Number of OSPs (four) chosen for examination in MDS due to having largest hammer energy.<br>For jacket foundations and gravity base foundations 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. . |

| Potential impact | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | • Maximum of up to 4.5 hours of piling per pile for with a cumulative total of up to 1,818 hours across wind turbine foundations (jackets and gravity base foundations) and OSP foundations, with a maximum of one foundation (four piles) per day.<br>• Consecutive piling of two foundations (eight piles) using a maximum of two vessels over each 24-hour period<br>• Four piles installed per 24 hours per vessel = 114 days (64 days for wind turbine foundations, 37.5 days for gravity base foundations, 12 days for OSP foundation piles) for a single vessel (maximum temporal) or 57 days for two vessels (maximum spatial)<br>• Total piling phase (foundation installation) of up to two years within a four-year construction programme.<br>Geophysical site investigation:<br>• Geophysical site investigation activities will include the following activities:<br>– Multibeam echosounder<br>– Side Scan Sonar<br>– Single Beam Echosounder<br>– Sub-Bottom Profilers<br>– Ultra High Resolution Seismic.<br>For further detail regarding geophysical sound sources and levels, see Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement.<br>UXO:<br>• Clearance of up to 23 UXOs (estimated) within the Mona Array Area or Offshore Cable Corridor<br>• A range of UXO sizes assessed from 25 kg up to 907 kg with 130 kg the most likely (common) maximum<br>• For high order detonation donor charges of 1.2 kg (most common) and 3.5 kg (single barracuda blast charge)<br>• Up to 0.5 kg Net Explosive Quantity (NEQ) clearance shot for neutralisation of residual explosive material at each location<br>• Clearance during daylight hours only.<br>MDS is for high order clearance but assessment also considered: | Consecutive piling is assumed to install a maximum of eight piles over a maximum period of 24 hours.<br>Range of geophysical and geotechnical activities likely to be undertaken using equipment typically employed for these types of surveys. . |

| Potential impact | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | • Low order clearance charge size of 0.08 kg<br>• Low yield clearance configurations of 0.75 kg charges (up to 4 x 0.75 kg). | |
| Increased suspended sediment concentrations (SSCs) and associated sediment deposition | ✓ | ✓ | ✓ | **Construction phase:**<br>Site preparation:<br>Sandwave clearance:<br>• Activities undertaken over an approximate 12-month duration within the wider four year construction programme<br>• Wind turbines and OSP foundations: the MDS assumes sandwave clearance for wind turbine foundations and that clearance is required at up to 50% of locations. Spoil volume per location has been calculated on the basis of 34 locations supporting the largest suction bucket four-legged jacket foundation with an associated base diameter of 205 m piled to an average depth of 7.5 m. This equates to a total spoil volume of 8,416,621 $m^3$ and a volume of 247,548 $m^3$ per location<br>• Inter-array cables: sandwave clearance along 163 km of cable length, with a width of 80 m, to an average depth of 3.0 m. Total spoil volume of 4,188,876 $m^3$<br>• Interconnector cables: sandwave clearance along 30 km of cable length, with a width of 80 m, to an average depth of 5.1 m. Total spoil volume of 432,000 $m^3$<br>• Offshore export cables: sandwave clearance along 72 km of export cable, with a width of 40 m, to an average depth of 5.1 m. Total spoil volume of 1,504,000 $m^3$<br>• Removal of up to 46 km of disused cables.<br>Foundation installation:<br>• Undertaken over an approximate 12-month duration<br>• Wind turbines:<br>– installation of 45 three legged jacket piles of 5.5 m diameter, drilled to a depth of 75 m at a rate of up to 1.78 m/h, with maximum spoil volume of 2,107 $m^3$ per pile<br>• installation of 23 conical gravity base foundations with a caisson diameter of 37 m and a sea surface diameter 15 m. Installation requires dredging of a maximum area of 32,761 $m^2$ to a maximum depth of 10 m OSPs: installation of one OSP with six legs with three piles per leg, each 5.5 m drilled to a depth of | **Construction phase**<br>Site preparation:<br>The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the 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 be in the range up to 15 m in height. In all cases the material cleared from the sandwave will be sidecast in close proximity in order that the sediment is readily available for supply for sandwave recovery by natural physical processes. The exception to this will be if a small proportion of the material is used for ballast within the foundation structure (see foundation installation below)<br>Site clearance activities may be undertaken using a range of techniques, with the suction hopper dredger calculated to result in the greatest increase in suspended sediment and largest plume extent as material is released near the water surface during the relocation of material. In reality plough dredging may be implemented however the volume of material brought into suspension would be reduced as material is ploughed along the bed.<br>Boulder clearance activities will result in minimal increases in suspended sediment concentrations and have therefore not been considered in the assessment.<br>Foundation installation: |

| Potential impact | Phase[a] | | | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | C | O | D | | |
| | | | | 75 m at a rate of up to 1.78 m/h, with maximum spoil volume of 2,107 $m^3$ per pile<br>• Two drilled piles installed concurrently at adjacent sites.<br>Cable installation:<br>• Inter-array cables: Installation via trenching of up to 325 km of cable, with a trench width of up to 3 m and a depth of up to 6 m. Total spoil volume of 2,925,000 $m^3$. Installed over a period of approximately 12 months<br>• Interconnector cables: installation via trenching of up to 50 km of cable, with a trench width of up to 3 m and a depth of up to 3 m. Total spoil volume of 225,000 $m^3$. Installed over a period of approximately four months<br>• Offshore export cables: installation via trenching of up to 360 km of cable, with a trench width of up to 3 m and a depth of up to 3 m. Total spoil volume of 1,620,000 $m^3$. Installed over a period of 15 months<br>• Intertidal export cable: installation via trenchless techniques with punch out location offshore of MLWS.<br>**Operations and maintenance phase:**<br>• Project lifetime of 35 years<br>• Inter-array cables: repair of up 10 km of cable in one event every three years. Reburial of up to 20 km of cable in one event every five years<br>• Interconnector cables: repair of up to 16 km of cable in each of three events every 10 years. Reburial of up to 2 km of cable in one event every five years<br>• Export cables: repair of up to 32 km of subtidal cable in eight events every five years. Reburial of up to 15 km of subtidal cable in one event every five years.<br>**Decommissioning phase:**<br>• If cables and scour/cable protection are removed the SSC increases temporarily. Similarly, if suction caissons are removed using the overpressure to release them then SSC will be temporarily increased. | The dredging and site preparation associated with conical gravity base foundations may involve the use of up to 7,000 $m^3$ of this material as ballast within the structure. The remaining material will be sidecast in close proximity to be available within the sediment cell for transport and sandwave regeneration.<br>Installation of foundations via augured (drilled) operations results in the release of the largest volume of sediment unrestrained through the water column. The greatest volume of sediment disturbance by drilling at individual locations is associated with the largest diameter pile for wind turbines. It is noted that it is unlikely that drilling would be required to the full depth and the most likely scenario is that piles would be driven, with no drilling required. This would give rise to minimal increases in SSC, however the most arduous scenario has been assessed as the MDS.<br>The maximum number of three legged jacket pile foundations to be installed for the largest wind turbine generators is 45 out of an array of 68 wind turbine generators. Therefore, for the holistic approach of SSC assessment the remaining 23 foundations are conical gravity based foundations with associated dredging activities.<br>The selected OSP scenario represents the greatest volume of sediment to be released for a drilling event.<br>The greatest drilling rate associated with the largest pile diameter represents the maximum level of increase in suspended sediment concentrations.<br>Cable installation: |

| Potential impact | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | | Cable routes inevitably include a variety of seabed material and in some areas 3 m depth may not be achieved or may be of a coarser nature which settles in the vicinity of the cable route. The maximum burial depth of 6 m for inter-array cables would only be required at locations where significant seabed/sandwave mobility is identified. The assessment therefore considers the upper bound in terms of suspended sediment and dispersion potential.<br>Cables may be buried by ploughing, trenching or jetting with trenching or jetting mobilising the greatest volume of material to increase suspended sediment concentrations.<br>**Operation and maintenance phase**<br>The greatest foreseeable number of cable reburial and repair events is considered to the MDS for sediment dispersion.<br>**Decommissioning phase**<br>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.<br>The MDS assumes the complete removal of all wind turbine and OSP foundations and cables; piles will be cut below the seabed. |
| Long term habitat loss. | ✓ | ✓ | ✓ | **Construction and operations and maintenance phase**<br>Up to 2,192,412 m² of long-term habitat loss over the lifetime of the Mona Offshore Wind Project associated with the following:<br>• Presence of foundations and scour protection: up to 760,452 m² of habitat loss comprising: | Largest wind turbine and OSP foundation type and associated scour protection, maximum length of cables and cable protection resulting in maximum extent of habitat loss.<br>MDS for decommissioning (and permanent habitat loss following decommissioning) assumes removal of only the foundations, if any additional |

| Potential impact | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | – Wind turbines: up to 735,488 m² from the presence of up to 68 wind turbine foundations on suction bucket four-legged jacket foundations with associated scour protection<br>– OSPs: up to 24,964 m² from four OSPs on suction bucket jacket foundations with associated scour protection<br>• Presence of cable protection: up to 1,145,000 m² of habitat loss comprising:<br>– Inter-array cable protection: 325,000 m² associated with up to 10% of 325 km of inter-array cables requiring cable protection (10 m width of cable protection).<br>– Interconnector cable protection: 100,000 m² for up to 20% of 50 km of interconnector cables requiring cable protection (10 m width of cable protection)<br>– Export cable protection: 720,000 m² for up to 20% of 360 km of export cables requiring cable protection (10 m width of cable protection)<br>• Presence of cable crossing protection: up to 435,960 m² of habitat loss comprising:<br>– Cable protection for cable crossings for inter-array cables: 192,960 m² from 67 cable crossings (each up to 60 m in length and 36 m in width)<br>– Cable protection for cable crossings for interconnector cables: 10,000 m² from 10 cable crossings (each up to 50 m in length and 20 m in width)<br>– Cable protection for cable crossings for offshore export cables: 144,000 m² from, and 24 crossings (each up to 50 m in length and 30 m in width)<br>Operations and maintenance phase up to 35 years.<br><br>**Decommissioning phase**<br>• Up to 2,135,276 m² of permanent subtidal habitat loss due to scour and cable protection left in situ post decommissioning. | infrastructure is decommissioned, this will result in a reduced area of permanent habitat loss.<br>Maximum amount of cable and scour protection resulting in the largest area of infrastructure to be left in situ after decommissioning. |
| Electromagnetic Fields (EMF) from subsea electrical cabling. | × | ✓ | × | **Operations and maintenance phase:**<br>Presence of inter-array, interconnector and offshore export cables:<br>• Inter-array cables: up to 325 km of inter-array cables of 66 kV or 132kV<br>• Interconnector cables: up to 50 km of 275 kV High Voltage Alternating Current (HVAC) cables | Maximum length of cables across the array area and offshore export cable route and minimum burial depth (the greater the burial depth, the more the EMF is attenuated). |

| Potential impact | Phase[a] | | | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | C | O | D | | |
| | | | | • Offshore export cables: up to 360 km of 275 kV HVAC cables<br>• Minimum burial depth 0.5 m<br>• The MDS assumes up to 10% of inter-array cables, 20% of interconnector cables, and 20% of export cables may require cable protection<br>• Cable protection: cables will also require cable protection at asset crossings (up to 67 crossings for inter-array cables, 10 crossings for interconnector cables and up to 24 crossings for offshore export cables)<br>• Operations and maintenance phase of up to 35 years. | |
| Introduction of artificial structures and colonisation of hard structures | × | ✓ | × | **Operations and maintenance phase:**<br>Long term habitat creation of up to 2,685,616 m² due to:<br>Mona Array Area<br>• Wind turbines and OSPs: Presence of up to 68 wind turbines and four OSPs on suction bucket jacket foundations<br>• Scour protection: Presence of scour protection for wind turbine foundations and OSP foundations<br>• Cable protection: Presence of cable protection associated with up to 10% of 325 km of inter-array cables and 20% of the 50 km of interconnector cables<br>• Cable crossing protection: Presence of cable protection for cable crossings, 67 cable crossings for inter-array cables (each up to 80 m in length and 36 m in width) and 10 cable crossings for interconnector cables (each up to 50 m in length and 20 m in width).<br><br>Mona Offshore Cable Corridor and Access Areas<br>• Wind turbines and OSPs: Presence of up to 68 wind turbines and four OSPs on suction bucket jacket foundations<br>• Scour protection: Presence of scour protection for wind turbine foundations and OSP foundations<br>• Cable protection: Presence of cable protection associated with up to 20% of the 360 km of offshore export cables | 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 can involve the use of a combination of steel armour wire, burial, rock dump mattresses with rock berm and protection material, and rock/grout 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.<br>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. |

| Potential impact | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | • Cable crossing protection: Presence of cable protection for cable crossings, 24 cable crossings for each of the four offshore export cables (each up to 50 m in length and 30 m in width)<br>Operational phase up to 35 years. | |
| Disturbance/ remobilisation of sediment-bound contaminants | ✓ | × | ✓ | **Construction phase:**<br>• The MDS as described above for increased SSC and associated deposition during the construction phase.<br>**Decommissioning phase:**<br>• The MDS as described above for increased SSC and associated deposition during the decommissioning phase. | The justification for the disturbance/remobilisation of sediment-bound contaminants MDS is the same as for the increased SSC and associated deposition impact above, as this MDS results in the release of the largest volume of sediment and associated contaminants. |
| Injury due to increased risk of collision with vessels (basking shark only) | ✓ | ✓ | ✓ | **Construction phase**<br>**Vessels**<br>• Up to a total of 86 construction vessels on site at any one time (22 main installation and support vessels, eight tug/anchor handlers, 13 cable lay installation and support vessels, two guard vessels, eight survey vessels, 12 seabed preparation vessels, 14 crew transfer vessels (CTVs), three scour protection installation vessels and four cable protection installation vessels)<br>• Up to 2,055 installation vessel movements (return trips) during construction (521 main installation and support vessels, 74 tug/anchor handlers, 96 cable lay installation and support vessels, 68 guard vessel, 35 survey vessels, 43 seabed preparation vessels, 1,155 CTVs, 41 scour protection installation vessels and 22 cable protection installation vessels)<br>• Maximum offshore construction duration of up to 4 years.<br>**Operations and Maintenance Phase**<br>• Up to a total of 21 operations and maintenance vessels on site at any one time (six CTVs/workboats, three jack-up vessels, four cable repair vessels, four service operation vessels (SOV) or similar and four excavators/backhoe dredgers)<br>• Up to 849 operations and maintenance vessel movements (return trips) each year (730 CTVs/workboats, 25 jack-up vessels, eight cable repair vessels, 78 SOV or similar and eight excavators/backhoe dredgers)<br>• Operations and maintenance lifetime of up to 35 years. | 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 Mona Offshore Wind Project. This represents the broadest range of vessel types and movements, and therefore greatest potential for collision risk. |

| Potential impact | Phase[a] | | | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | C | O | D | | |
| | | | | **Decommissioning Phase**<br>• Vessels used for a range of decommissioning activities such as removal of foundations, cables and cable protection<br>• Sound from vessels assumed to be as per vessel activity described for construction phase above. | |

## 3.8 Measures adopted as part of the Mona Offshore Wind Project

3.8.1.1 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 of the Mona Offshore Wind Project 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 potentially 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).

3.8.1.2 A number of measures (primary and tertiary) have been adopted as part of the Mona Offshore Wind Project to reduce the potential for impacts on fish and shellfish ecology. These are outlined in Table 3.19 below. As there is a secured commitment to implementing these measures for the Mona Offshore Wind Project, they have been considered in the assessment presented in section 3.9 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

3.8.1.3 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 3.9 below.

3.8.1.4 The Mona Offshore Wind Project design has changed from the PEIR to the Environmental Statement including a reduction in the number of wind turbines from 107 to 96. The number of wind turbines has been reduced by approximately 10% subsequently reducing the number of foundations that require piling. Monopile foundations (as presented in the PEIR) have also been removed from the Project Design Envelope (PDE), and pin piles only have been considered in the Environmental Statement. As such, the maximum hammer energy of 5,500 kJ (presented in the PEIR for monopiles) has not been taken forward to the Environmental Statement. A proportion of hammer energy is converted into waterborne acoustic energy going into the water column and large hammer energies may result in increased peak sound levels received by fish. As such, the removal of monopile foundations and the maximum hammer energy of 5,500 kJ from the design envelope has reduced the range at which instantaneous injury, mortality and behavioural effects could occur to fish from received $SPL_{pk}$.

## Table 3.19: Measures adopted as part of the Mona Offshore Wind Project.

| Measures adopted as part of the Mona Offshore Wind Project | Justification | How the measure will be secured |
|---|---|---|
| **Primary measures: Measures included as part of the project design** | | |
| Development of and adherence to a Marine Mammal Mitigation Protocol (MMMP), based on the Outline MMMP (Document Reference J21) that requires implementation of an initiation stage of a piling soft start and ramp-up. | This measure will minimise the likelihood of injury from elevated underwater sound to marine mammal and some fish species in the immediate vicinity of piling operations, allowing reactive individuals to move away from the area before sound levels reach a level at which injury may occur. | MMMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |
| Development of and adherence to a MMMP (to be developed in accordance with the Outline MMMP (Document Reference J21)) which sets a maximum separation limit of 15 km for concurrent piling. | Commitments made around maximum separation during concurrent piling will minimise the likelihood of disturbance to marine mammal and fish species in the immediate vicinity of piling operations, by limiting the ensonified area during concurrent piling.<br>Where piling occurs concurrently a maximum separation distance of 15 km is used to limit the ensonified area as there is greater overlap when closer together. | MMMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |
| Development of and adherence to a MMMP (to be developed in accordance with the Outline MMMP (Document Reference J21)) which sets a minimum separation limit of 1.4 km for concurrent piling. | Commitments made around minimum separation during concurrent piling will minimise the likelihood of injury to marine mammal and fish species in the immediate vicinity of piling operations, by limiting the spatial overlap of areas of ensonification during concurrent piling.<br>Where piling occurs concurrently, a minimum separation distance of 1.4 km is used to minimise the potential for effects due to direct overlap of concurrent piling. | MMMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |
| Development of and adherence to a MMMP (to be developed in accordance with the Outline MMMP (Document Reference J21)) which sets the limit on maximum hammer energy used during concurrent piling at 3,000 kJ and during the single event piling at 4,400kJ. | Commitments made around concurrent piling will minimise the likelihood of injury to marine mammal and fish species in the immediate vicinity of piling operations, by reducing the ensonified area during concurrent piling. | MMMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |
| Development and adherence to a MMMP (to be developed in accordance with the Outline MMMP (Document Reference J21) that requires implementation of a mitigation hierarchy with regard to UXO clearance that follows:<br>• Avoid UXO<br>• Clear UXO with low order techniques<br>• Clear UXO with high order techniques.<br>Low order techniques or avoidance of confirmed UXO are not always possible and are dependent upon the individual situations surrounding each UXO. | Low order techniques generate less underwater sound than high order techniques and therefore present a lower risk to sound-sensitive receptors such as marine mammals and fish during UXO clearance. Noting the position statement from statutory authorities on UXO clearance (UK Government, 2022), the option to clear UXOs with low order techniques has been considered as a potential primary mitigation measure as part of this assessment.<br>Note, however, that low order techniques are not always possible and are dependent upon the individual situations | MMMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |

| Measures adopted as part of the Mona Offshore Wind Project | Justification | How the measure will be secured |
|---|---|---|
| | surrounding each UXO. Given that it is possible that high order detonation may be used, the Outline MMMP includes mitigation to reduce the likelihood of injury from UXO clearance. Please see below.<br>The Outline underwater sound management strategy (Document Reference J16) includes potential further mitigation options, should the measures in the MMMP (Document Reference J21) not reduce impacts, such that there will be no residual significant effect from the project. | |
| Development and adherence to an Offshore Construction method statement (CMS) including Cable Specification and Installation Plan (CSIP) which will include cable burial where possible and cable protection. | To minimise potential impact from the cables and removal of cables a commitment to bury cables where possible has been made in accordance with the specific policies set out in the Welsh Marine Plan (Welsh Government, 2019) and additionally the North West Inshore and North West Offshore Coast Marine Plans (MMO, 2021).<br>The Applicant recognises that the best form of cable protection is achieved through cable burial to the required depths, according to the results of a Cable Burial Risk Assessment and Burial Assessment Study, which will be included within the CSIP.<br>The burial methodology should select the appropriate tools to endeavour to achieve burial to the required depth of lowering in a single pass, seeking to avoid burial methods that require multiple passes with a burial tool in order to achieve lowering of the cable.<br>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. | Offshore CMS secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence as a condition. |
| Development and adherence to an Offshore CMS which includes a CSIP which require material arising from drilling and/or sandwave clearance to be deposited in close proximity to the works. | To retain material within the sediment cell and maintain sediment transport regimes. | The Offshore CMS is secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |
| **Tertiary measures: Measures required to meet legislative requirements, or adopted standard industry practice** | | |
| Development of and adherence to a MMMP, which will be developed in accordance with the Outline MMMP (Document Reference J21) included as part of the application. | The implementation of an approved MMMP will mitigate for the risk of physical or permanent auditory injury to marine mammals within a pre-defined ‘mitigation zone’ for each activity. The | MMMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured |

| Measures adopted as part of the Mona Offshore Wind Project | Justification | How the measure will be secured |
|---|---|---|
| The Outline MMMP (Document Reference J21) present appropriate mitigation for activities that could potentially lead to injurious effects on marine mammals including: piling, UXO clearance and some types of geophysical activities.<br>Piling: for the purpose of developing the MMMP (Document Reference J21) as an annex of the Underwater sound management strategy (Document Reference J16), a mitigation zone will be defined based on the maximum predicted injury range from the dual metric sound modelling for the maximum spatial scenario (pin piles) and across all marine mammal species. The Outline MMMP (Document Reference J21) sets out the measures to apply in advance of and during piling activity including the use of:<br>• Marine Mammal Observers (MMOs)<br>• Passive Acoustic Monitoring (PAM)<br>• Acoustic Deterrent Devices (ADD)<br>Therefore following the latest JNCC guidance (JNCC, 2010a).<br>UXO clearance: Measures including visual and acoustic monitoring, the use of an ADD and soft start charges will be applied to deter animals from the mitigation zone as defined by sound modelling for the largest possible UXO following the latest JNCC guidance (JNCC, 2010b).<br>Geophysical surveys: Mitigation for injury during high resolution geophysical surveys using a sub-bottom profiler from a conventional vessel will involve the use of MMOs and PAM to ensure that the risk of injury over the defined mitigation zone is reduced in line with JNCC guidance (JNCC, 2017). Soft start is not possible for some SBP equipment but will be applied for other high resolution surveys where possible. Note also, some multi-beam surveys in shallow waters (<200 m) are not subject to the development of and adherence requirements of mitigation. | mitigation zone is determined considering the largest injury zone across all species for each relevant activity. The use of an approved MMMP will also minimise the potential for collision risk, or potential injury to, marine mammals and other marine megafauna (e.g. basking shark). The MMMP will include visual and acoustic monitoring as a minimum over the defined mitigation zones to ensure animals are clear before the activity commences. Additional measures to deter animals from injury risk zones may be applied in some instances (e.g. ADDs or soft start charges).<br>The MMMP will be developed on the basis of the most recent published statutory guidance and in consultation with key stakeholders.<br>Benefits derived from the MMMP are also expected to apply to some fish species. | within the standalone NRW marine licence. |
| Development of, and adherence to, an Offshore Environmental Management Plan (EMP).<br>The Offshore EMP will include development of a 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 Mona Offshore Wind Project development. | Offshore EMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |

| Measures adopted as part of the Mona Offshore Wind Project | Justification | How the measure will be secured |
|---|---|---|
| The Offshore EMP will include actions to minimise INNS, including a biosecurity plan to limit 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. | Offshore EMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |
| Offshore EMP will be issued to all Project vessel operators, requiring them to:<br>• not deliberately approach basking sharks and other marine megafauna<br>• keep vessel speed to a minimum where deemed to be appropriate<br>• avoid abrupt changes in course or speed should basking sharks or other marine megafauna approach the vessel, where appropriate and possible taking into account all technical considerations.<br>Codes of Conduct will be adhered to at all times. | To minimise the potential for collision risk, or potential injury to, basking shark and other marine megafauna. | Offshore EMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |
| Development of and adherence to an offshore EMP that will include a MPCP which will include planning for accidental spills, address all potential contaminant releases and include key emergency details. | To ensure that the potential for release of pollutants during construction, operations and maintenance, and decommissioning phases are minimised. These will likely include designated areas for refuelling where spillages can be easily contained, storage of chemicals in secure designated areas in line with appropriate regulations and guidelines, double skinning of pipes and takes containing hazardous substances, and storage of these substances in impenetrable bunds. The MPCP will ensure that in the unlikely event that a pollution event occurs, that plans are in place to respond quickly and effectively to ensure any spillage is minimised and potential effects on the environment are ideally avoided or minimised.<br>Implementation of these measures will ensure that accidental release of contaminants from vessels will be avoided or minimised, thus providing protection for marine life across all phases of the Mona Offshore Wind Project. | Offshore EMP secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |
| Development of and adherence to a Decommissioning Programme in accordance with the Energy Act 2004.<br>A Decommissioning Programme is required under the provisions of the Energy Act 2004 and this must be | The aim of this plan is to adhere to the existing UK legislation and guidance. Overall, this will ensure the legacy of the Mona Offshore Wind Project will result in the minimum amount of long-term disturbance to the environment. | Decommissioning Programme secured as a requirement in Schedule 2 of the draft DCO and is a requirement of the Energy Act 2004. |

| Measures adopted as part of the Mona Offshore Wind Project | Justification | How the measure will be secured |
|---|---|---|
| approved by the Secretary of State before works commence. | While this measure has been committed to as part of the Mona Offshore Wind Project, the MDS for the decommissioning phase has been considered in each of the relevant impact assessments presented in section 3.9. | |
| Development of and adherence to an Underwater sound management strategy (Document Reference J16) that includes consideration of Noise Abatement Systems (NAS) as part of mitigation options. A commitment to considering Noise Abatement Systems (NAS) as part of mitigation options in the Underwater sound management strategy, which will be developed in accordance with the Outline underwater sound management strategy (Document Reference J16), will be made as part of a stepped strategy post consent and following the mitigation hierarchy - avoid, reduce, mitigate. | To mitigate for the likelihood of physical or permanent auditory injury or behavioural impacts to fish and marine mammals. | Underwater sound management strategy secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. |

## 3.9 Assessment of significant effects

### 3.9.1 Overview

3.9.1.1 The impacts of the construction, operations and maintenance, and decommissioning phases of the Mona Offshore Wind Project have been assessed on fish and shellfish ecology. The potential impacts arising from the construction, operations and maintenance and decommissioning phases of the Mona Offshore Wind Project are listed in Table 3.18, along with the MDS against which each impact has been assessed.

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

### 3.9.2 Temporary habitat loss/disturbance

3.9.2.1 The construction, operations and maintenance, and decommissioning activities on the wind turbine foundations, OSP foundations, inter-array and offshore export cables may lead to temporary habitat loss/disturbance. The MDS is represented by jack-up events, cable installation, sandwave clearance, anchor placement and cable repairs, and is summarised in Table 3.18.

#### Construction phase

#### Magnitude of impact

3.9.2.2 The installation of the Mona Offshore Wind Project infrastructure within the fish and shellfish ecology study area will lead to temporary habitat loss/disturbance. The MDS accounts for up to 60,512,833 $m^2$ of temporary habitat loss/disturbance during the construction phase (Table 3.18). This equates to approximately 13.18% of the area within the Mona Offshore Wind Project boundary overall, although only a small proportion of this will be impacted at any one time.

3.9.2.3 Jack-up events for the installation of the foundations for the wind turbines and OSPs will result in up to 816,000 $m^2$ of temporary habitat loss/disturbance. Four jack-up events will be necessary for each of the 96 wind turbines as well as two jack-up events for each of the four OSPs.

3.9.2.4 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 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 Mona 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 year three 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).

3.9.2.5 Cable installation (including pre-lay preparation such as boulder and sandwave clearance) of inter-array, interconnector and offshore export cables may result in up to 27,690,000 $m^2$ of temporary habitat loss/disturbance. The components of this activity include the installation of up to 325 km of inter-array cable, up to 50 km of interconnector cable as well as 360 km of offshore export cable (assuming 100% of the cable is buried). Seabed preparation activities are expected to be required for inter-array cables, interconnector cables and offshore export cables and for the purpose of the MDS, boulder clearance has been expected to occur for up to 50% of inter-array cables, 40% of interconnector cables, and 20% of offshore export cables. Sandwave clearance is expected to be required for up to 50% of inter-array cables, 60% of interconnector cables and 80% of offshore export cables.

3.9.2.6 Sandwave clearance and deposition may result in up to 30,006,833 $m^2$ of temporary habitat loss/disturbance as a result of the deposition of 14,541,497 $m^3$ 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 0.5 m 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.

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

3.9.2.8 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).

3.9.2.9 The maximum duration of the offshore construction phase for the Mona Offshore Wind Project 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.

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

3.9.2.11 The magnitude of impact on herring and sandeel, due to their ecological and commercial importance, are considered in terms of direct impact from the infrastructure in the broader context of potential spawning and habitation grounds within the fish and shellfish ecology study area.

3.9.2.12 For herring, only a small number of sampled stations within the Mona Offshore Wind Project boundary are deemed to be marginal or preferred spawning substrates, largely grouped within the nearshore area of the Mona Offshore Cable Corridor and Access Areas away from any mapped or known spawning grounds. The majority of stations throughout the rest of the Mona Offshore Wind Project were composed of unsuitable sediment types for herring spawning due to elevated mud content above the threshold of 5% (Reach *et al.*, 2013). In the context of the fish and shellfish ecology study area, this represents a very small proportion of preferred sediment, and the Mona Offshore Wind Project does not overlap with any recorded important herring spawning or nursery grounds (Coull *et al*., 1998). Therefore, for herring, the magnitude is considered to be **negligible**.

3.9.2.13 For sandeel, a greater number of sampling stations within the Mona Offshore Wind Project boundary are deemed to be of marginal or preferred substrata, with a cluster of preferred stations located along the Mona Offshore Cable Corridor and Access Areas. In terms of overlap with sandeel spawning grounds, 83.5% of the Mona Offshore Wind Project overlaps high intensity sandeel spawning ground and 16.5% overlaps low intensity spawning ground. It is acknowledged that these percentages refer to overlap with mapped spawning grounds, which do not represent a hard boundary and are subject to change over time; these percentages are provided as purely contextual information to support the assessment. In the context of the regional fish and shellfish ecology study area, which is almost entirely encompassed by low and high intensity sandeel spawning grounds, this represents a proportionally small area of disturbance to potential spawning habitats; equating to 7.8% of high intensity spawning grounds and 0.6% of low intensity spawning grounds within the fish and shellfish ecology area. On the basis of the widespread nature of mapped spawning and habitation grounds for sandeel, and the comparatively small footprint of temporary habitat loss and/or disturbance associated with the Mona Offshore Wind Project the magnitude is considered to be **low**.

## Sensitivity of receptor

### Marine species

3.9.2.14 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 (egg bearing) female lobster released 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 others (Campbell and Stasko,1985; Comeau and Savoie, 2002).

3.9.2.15 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 2: Benthic subtidal and intertidal ecology of the Environmental Statement) 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement 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 6, Annex 2.1: Benthic subtidal and intertidal ecology technical report of the Environmental Statement), 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 4: Marine mammals of the Environmental Statement, and Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement, respectively.

3.9.2.16 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 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.

3.9.2.17 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 6 km following habitat disturbance (Lambert *et al.*, 2014), which applies to some species of interest within the fish and shellfish ecology study area (see Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement 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 to 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

3.9.2.18 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 up to a maximum of 59,512,833 $m^2$, such as during cable laying and seabed preparation. While the total habitat loss/disturbance footprint represents a moderate proportion of the area within the Mona Offshore Wind Project boundary (i.e. 13.4%), 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 and the hydrodynamic regime within the eat Irish Sea (RPS, 2019). Following this recovery of sediments, recovery of associated communities is also expected (see Volume 2, Chapter 2: Benthic subtidal and intertidal ecology of the Environmental Statement) including shellfish populations moving back into these impacted areas.

3.9.2.19 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 6: Commercial fisheries chapter of the Environmental Statement). 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). With increased size and age of queen scallop individuals were found to be able to travel increased distances in response to a disturbance event (Schmidt *et al*., 2008), although repeated disturbances of up to four events within 28 days has been found to significantly decrease reaction times to disturbances (Laming *et al*., 2013). It has been documented that king scallop have been able to move up to 30 m 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 adjacent areas.

3.9.2.20 Both king and queen scallop tend to occur in aggregations, as their larval distribution is reliant on relatively unpredictable hydrodynamics (Brand, 1991, Delargy, 2019). As both king and queen scallop are expected to continue spawning outside of the project boundaries, and within unimpacted areas of the fish and shellfish ecology study area, and suitable habitat for settlement will remain after recovery following cessation of construction, it is predicted that king scallop will continue to be recruited into the Mona Array Area. Therefore, king 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 king scallop have a high recovery potential (i.e. recovery within months, with full recovery in a small number of years).

3.9.2.21 This reported recovery potential differed between king and queen scallop, with king scallop found to recover to their population carrying capacity within less than three years following temporary habitat loss in areas both closed and open to fishing (Kaiser *et al*., 2018). For queen scallop however, numbers of individuals remained consistent pre- and post-disturbance, with full recovery noted by the first re-sampling one-year post-disturbance. These relatively rapid recovery times are known to be broadly typical of soft sediment epifauna following disturbance events resulting in temporary habitat loss such as trawling or dredging (Hiddink *et al*., 2017). Based on these relatively rapid recovery times into recently disturbed habitats, commercially important queen and king scallop populations are expected to show resilience to temporary habitat loss and/or disturbance (Dignan *et al*., 2014). Queen and king scallop are protected under IoM management schemes, wherein queen scallop are protected against unlicenced towed gear fishing under IoM bylaws (SD 2018/0186 – IoM Government, 2018), and king scallop are protected by a range of measures, such as the IoM King Scallop Long-Term Management Plan 2021 (Isle of Man Government, 2021), which specified alterations to fishing rights and technical specifications of dredges and tow-bars to minimise damage where possible. These measures have the potential to combine with natural resilience to temporary habitat disturbance to aid in the protection of these commercially important scallop populations.

3.9.2.22 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. Scallop species were also assessed in this study to be slow-growing K-strategists that invest greater resources into raising a smaller number of offspring compared to R-strategists that use their resources to produce a greater number of offspring. The K-strategist scallop species were most well established in equilibrium environments, although the equilibrium environment required for their colonisation and growth is likely to be developed relatively rapidly, within three years for king scallop and within approximately eight to 10 years for queen scallop. (Kaiser *et al*., 2018). 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 2: Benthic subtidal and intertidal ecology of the Environmental Statement), 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.

3.9.2.23 Construction activities (including cable installation) within the fish and shellfish ecology study area may also impact on spawning and nursery habitats for *Nephrops*, as these areas overlap (Coull *et al.,* 1998) with the northwest of the fish and shellfish ecology study area (Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement), although this overlap is relatively small, and any impact is likely to be limited. Larval settlement will also increase the rate of recovery in an area (Phua *et al*., 2002), with the presence of *Nephrops* spawning and nursery habitats in the vicinity of the fish and shellfish ecology study area (see Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement) potentially increasing the rate of recovery in disturbed areas.

3.9.2.24 A recent study undertaken by Roach *et al*. (2018) 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 turbine foundations 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**

3.9.2.25 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 sediment (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 pelagic elasmobranch species. Spotted ray (and other ray species), which spawn in demersal habitats, have low intensity spawning grounds overlapping the Mona Array Area (Ellis *et al*., 2012), and this species has 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

3.9.2.26 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement). Therefore, any significant seabed disturbance activities carried out during spawning periods may result in mortality of eggs and reduced 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.

3.9.2.27 However, the Mona 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 Mona Array Area. While sandeel spawning habitat is expected to be present along parts of the Mona Offshore Cable Corridor and Access Areas (where sediments are suitable) the proportion of these habitats affected is predicted to be relatively small, given the abundance of similar substrate types and the extensive nature of fish spawning grounds across the wider fish and shellfish ecology study area.

3.9.2.28 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.

3.9.2.29 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 28 km. 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement).

3.9.2.30 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 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.

3.9.2.31 Infrastructure installation will not occur simultaneously across the full Mona Offshore Wind Project 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.

3.9.2.32 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 4: Marine mammals of the Environmental Statement and Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.

3.9.2.33 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**.

3.9.2.34 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**.

3.9.2.35 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**.

3.9.2.36 Sandeel are deemed to be of high vulnerability, high recoverability and of regional importance, and preferred sediment types for spawning and habitation are present within the Mona Offshore Wind Project. The sensitivity of sandeel is therefore considered to be **high**.

3.9.2.37 Herring are deemed to be of high vulnerability, medium recoverability and of national importance, although there is limited suitable substrate for herring spawning with the Mona Offshore Wind Project. The sensitivity of herring to this impact is therefore considered to be **high**.

**Diadromous species**

3.9.2.38 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement). 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.

3.9.2.39 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).

3.9.2.40 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 Mona Array Area likely highly 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

3.9.2.41 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.

3.9.2.42 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.

3.9.2.43 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.

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

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

#### Diadromous species

3.9.2.46 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.

## Operations and maintenance phase

### Magnitude of impact

3.9.2.47 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 17,402,800 $m^2$ of temporary habitat loss/disturbance within this phase (Table 3.18). This equates to a small proportion (3.6%) of the area within the Mona Offshore Wind Project Array Area boundary. 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 this 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.

3.9.2.48 The activities which contribute to temporary habitat loss/disturbance in this phase may include up to 1,822,800 $m^2$ attributed to jack-up events at wind turbines and OSPs over the 35-year lifetime of the Mona Offshore Wind Project. This temporary habitat loss/disturbance is the result of up to 840 major component replacements (one every four years for each location) for wind turbines, and 12 major component replacements (three over the lifetime per 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.

3.9.2.49 Inter-array cable, interconnector cable and offshore export cable repairs and remedial burial may also contribute up to 15,580,000 $m^2$ of temporary habitat loss/disturbance. For inter-array cables this value accounts for up to 20 km for reburial events every five years and up to 10 km for cable repair events every three years (assuming 20 m width seabed disturbance). For interconnector cables this value accounts for up to 2 km for reburial events with one event every five years and up to 16 km of cable in each of three events every 10 years for repair events (assuming 20 m width seabed disturbance). For the offshore export cables this value accounts for the repair of up to 32 km of cable in eight events every five years and reburial of up to 15 km of cable in one event every five years.

3.9.2.50 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, OSP interconnector and offshore export 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 at a much lower magnitude.

3.9.2.51 As in the construction phase, sandeel and herring are assessed based on their potential spawning ground overlap with the Mona Offshore Wind Project in the wider context of spawning grounds within the fish and shellfish ecology study area. The criteria remain the same as in the construction phase, and therefore the magnitude for sandeel is considered to be **low** and the magnitude for herring is considered to be **negligible**.

3.9.2.52 For other marine and diadromous IEFs, 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

3.9.2.53 The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction phase assessment (paragraph 3.9.2.14 to paragraph 3.9.2.40), ranging from **negligible to high** sensitivity, and these will equally apply in the operations and maintenance phase.

### Significance of effect

#### Marine species

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

3.9.2.55 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.

3.9.2.56 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.

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

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

#### Diadromous species

3.9.2.59 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

3.9.2.60 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 96 wind turbine foundations (two jack-up events for wind turbines and two jack-up events for the foundations), and two jack-up events at each of four OSP. The parameters for decommissioning will be significantly lower than for the construction phase as cable protection and scour protection are assumed to be left *in situ*.

3.9.2.61 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 3.9.2.2 to 3.9.2.11. 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.

3.9.2.62 As in the construction phase, sandeel and herring are assessed based on their potential spawning ground overlap with the Mona Offshore Wind Project in the wider context of spawning grounds within the fish and shellfish ecology study area. The criteria remain the same as in the construction phase, and therefore the magnitude for sandeel is considered to be **low**, and the magnitude for herring is considered to be **negligible**.

3.9.2.63 For the remaining marine and diadromous species IEFs, 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

3.9.2.64 The sensitivity of the fish and shellfish IEFs, for both marine and diadromous species, can be found in the construction phase assessment (paragraph 3.9.2.14 to paragraph 3.9.2.40), ranging from **negligible to high** sensitivity, and these will equally apply in the decommissioning stage.

### Significance of effect

#### Marine species

3.9.2.65 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.

3.9.2.66 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.

3.9.2.67 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.

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

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

#### Diadromous species

3.9.2.70 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.

## 3.9.3 Underwater sound impacting fish and shellfish receptors

3.9.3.1 The construction and decommissioning of the transmission and generation assets is likely to lead to underwater sound impacting fish and shellfish receptors. The MDS is represented by the installation of pin piles for the wind turbine and the OSP foundations and is summarised in Table 3.18.

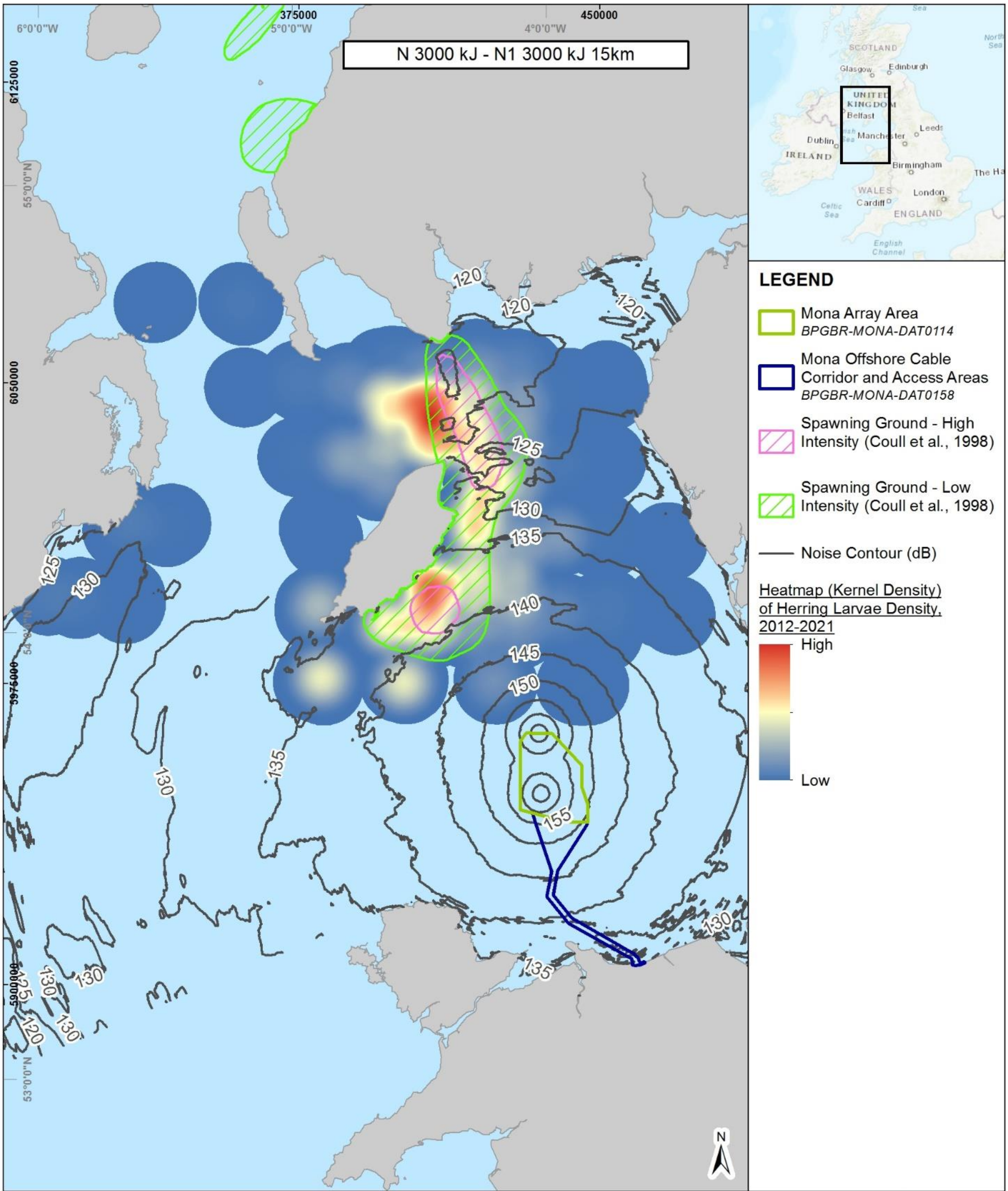
## Construction phase

### Magnitude of impact

3.9.3.2 The installation of foundations within the Mona Array Area may lead to injury and/or disturbance to fish and shellfish species due to underwater sound during pile driving. The MDS considers the greatest effect from underwater sound on fish and shellfish IEFs, considering the greatest hammer energy for pin pile installation. A maximum hammer energy of up to 4,400 kJ for pin piles was modelled, associated with installation of the OSPs.

3.9.3.3 The pin piling activities are represented by the installation of up to 64 pin-piled 4-legged jacket foundations with four piles per leg (up to 256 piles total) for wind turbines, 32 pin-piled foundations with up to 10 requiring piling, leading to up to 150 piles, with 15 piles per foundation (maximum diameter of 4 m per pile) and four 4-legged jacket foundations with three piles per leg (48 piles) for the OSPs, with each pile installed via impact piling. Pin pile installation will take place over a period of an average 4.5 hours per pile for both wind turbine and OSP foundations, with up to two vessels piling concurrently, giving rise to a maximum cumulative total of 1,152 hours of piling for the wind turbine foundations, and up to 216 hours of piling for OSPs, with a total of 1,368 hours of pin piling activity overall. For each wind turbine and OSP foundation, there will be a total of four piles inserted per day, with up to a maximum of 24 hours of piling per day. Overall, pin piling for the wind turbine and OSP foundations will equal 114 days for a single vessel (temporal maximum, with 64 wind turbines, 12 days for OSP foundation installation, and 37.5 for potential gravity base foundations), or 57 days for two vessels (spatial maximum), out of a maximum two years of foundation installation within a four-year construction programme.

3.9.3.4 The piling activities are assessed based upon the installation of up to 64 wind turbine foundations and four OSPs, using up to two vessels concurrently with a minimum distance of 1.4 km and a maximum of 15 km between vessels. Based on the underwater sound modelling, the MDS involves the assessment of a pin piling at a single location (i.e. consecutive piling) with a maximum hammer energy of 4,400 kJ. These numbers of wind turbine and OSP piles have been chosen based on maximum hammer energy compared to other lower energy installation scenarios, to best examine the maximum distance associated with sound impacts using modelled underwater sound contours. Other consecutive and concurrent piling scenarios with lower hammer energy values of 3,000 kJ and different spatial distributions were also modelled, and impact ranges are presented in Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, but the assessed scenario was chosen due to this representing the maximum potential impact from underwater sound on fish and shellfish receptors. It should be noted that the concurrent piling scenario with a maximum hammer energy of 3,000 kJ was modelled to impact a smaller area overall that piling of a single OSP foundation using a higher hammer energy. Concurrent piling modelling demonstrated that sound level values in terms of a dB metric are not mathematically additive, with a typical increase of just approximately 3 dB when adding together two equal sound levels (e.g. 10 dB + 10 dB = approximately 13 dB, not 20 dB). An example showing concurrent piling at the north modelled location, based on hammer energies of 4,400 kJ and 3,000 kJ is shown in Figure 3.4




| | | |
|---|---|---|
| **Service Layer Credits:** Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community | **Data Sources:** Client, NINEL, CEFAS, Seiche | EnBW bp Partners in UK offshore wind · rps |
| **Project Name:** MONA OFFSHORE WIND PROJECT | 0 5 10 20 nm<br>0 10 20 40 km | **Drawing Number:** RPSE-MN-ES-FAS-039-00 |
| **Drawing Title:** HERRING SPAWNING GROUNDS AND AGGREGATED HERRING LARVAL DENSITY (2012-2021) HEAT MAP BASED ON KERNEL DENSITY ESTIMATION WITH SUBSEA SOUND (SELCUM; 5DB CONTOURS; N PILING LOCATION) | **Geodetic Information:**<br>Datum: ETRS 1989<br>Projection: ETRS 1989 UTM Zone 30N<br>Scale@160mmx220mm: 1:1,600,000 | |

| VER | DATE | DETAILS | BY | CHECK |
|---|---|---|---|---|
| 00 | 22/09/23 | First Issue | NA | LS |

**Figure 3.4: Herring spawning grounds and aggregated ten-year NINEL larval densities (2012 to 2021; larvae/m$^2$) with subsea 5 dB sound SEL$_{cum}$ contours for concurrent pin piling at 3,000 kJ hammer energy at the north location.**

3.9.3.5 Sound impacts within this assessment are measured using the Peak Sound Pressure Level ($SPL_{pk}$), Cumulative Sound Exposure Level ($SEL_{cum}$) metrics. $SPL_{pk}$ refers to the overall Root-Mean-Square (RMS) maximum amplitude of a sound averaged over a specified time period, while $SEL_{cum}$ corresponds to the $SPL_{pk}$ of a continuous sound impulse with a time duration of one second and the same acoustic energy as the sound impulse. These two measures can be used to refer to the same sound event and are presented using approximations of both metrics for clarity throughout where relevant to the assessment.

3.9.3.6 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 site investigation surveys are completed within the Mona 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 907 kg for the Mona Offshore Wind Project, cleared by either low order or high order techniques (see Table 3.18). Many UXO may be left *in situ* and micro-sited around to avoid the need to undertake clearance. Detonation of UXO would represent a short term (i.e. seconds) increase in underwater sound (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.

3.9.3.7 To understand the magnitude of underwater sound emissions from piling and UXO clearance during construction activity, underwater sound modelling has been undertaken considering the key parameters summarised above. Full details of the modelling undertaken are presented in Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement.

3.9.3.8 Piling activities were modelled for pin pile foundations at three locations within the Mona Array Area taking into account the varying bathymetry and sediment type across the model areas (see Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement). Underwater sound modelling included the use of ‘soft start’ mitigation to reduce the potential for injury effects (as set out in Table 3.19). Soft start and ramp up processes were included within the modelling as this is considered to reflect the most realistic scenario, as these measures will be required to be implemented to provide mitigation for marine mammals during all piling operations. Whilst there is limited information available regarding the efficacy of these measures for fish (and shellfish) receptors, it is anticipated that some fish will benefit from the reduction in decibel levels and sound impacts giving rise to lower levels of barotrauma or disturbance from the implementation of these measures and some will not. The implications of the modelling for fish and shellfish injury and behaviour are outlined in the following sensitivity section.

3.9.3.9 All other underwater sound sources including cable installation and foundation drilling are non-percussive and will result in much lower sound 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 underwater sound sources see Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement; these are not considered further herein as the effect on fish and shellfish receptors is considered to be negligible.

3.9.3.10 The pre-construction geophysical surveys, using any of the available techniques outlined in Table 3.18, 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 behavioural impacts to low or negligible levels.

3.9.3.11 The impact of underwater sound on most fish and shellfish receptors during the construction phase is predicted to be of regional spatial extent, relatively short term duration, intermittent and of high reversibility, with the soundscape returning to near-baseline conditions upon completion of construction activities. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low**.

3.9.3.12 Cod high and low intensity spawning grounds are located across almost the entire fish and shellfish ecology study area. Underwater sound at levels with potential to cause behavioural effects (approximately 160 dB re 1 µPa $SPL_{pk}$) from piling using a 4,400 kJ hammer energy is expected to travel across approximately 21.64% of mapped high intensity cod spawning ground, and a relatively small proportion of low intensity cod spawning ground in the context of both the regional fish and shellfish ecology study area and the wider Irish Sea which is widely used for spawning by this species (Figure 3.5). Whilst the percentage overlap with the mapped high intensity spawning ground is moderate based on a maximum hammer energy of 4,400 kJ, the proportion of the total area available for cod spawning is much lower. It is acknowledged that spawning grounds are not fixed boundaries, and spawning does not occur at an equal density across the mapped grounds, with variation inside and outside mapped grounds annually and throughout the spawning season, therefore percentage overlaps with spawning grounds must be interpreted with caution. These are therefore used to advise the assessment of magnitude where appropriate, alongside key factors including expert judgement and project design parameters, but do not underpin the assessment for sensitivity or significance.

3.9.3.13 For cod, the impact of underwater sound during the construction phase is predicted to be of regional spatial, relatively short-term duration (with spawning of cod occurring from January to April), intermittent and of high reversibility, with the soundscape returning to baseline conditions (in terms of piling sound) upon completion of construction activities. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **low** during the cod spawning season, based upon the wide extent of spawning habitat otherwise available within the Irish Sea for this species (Ellis *et al*., 2012). Outside of the spawning season, the magnitude of impact to cod is considered **negligible**.

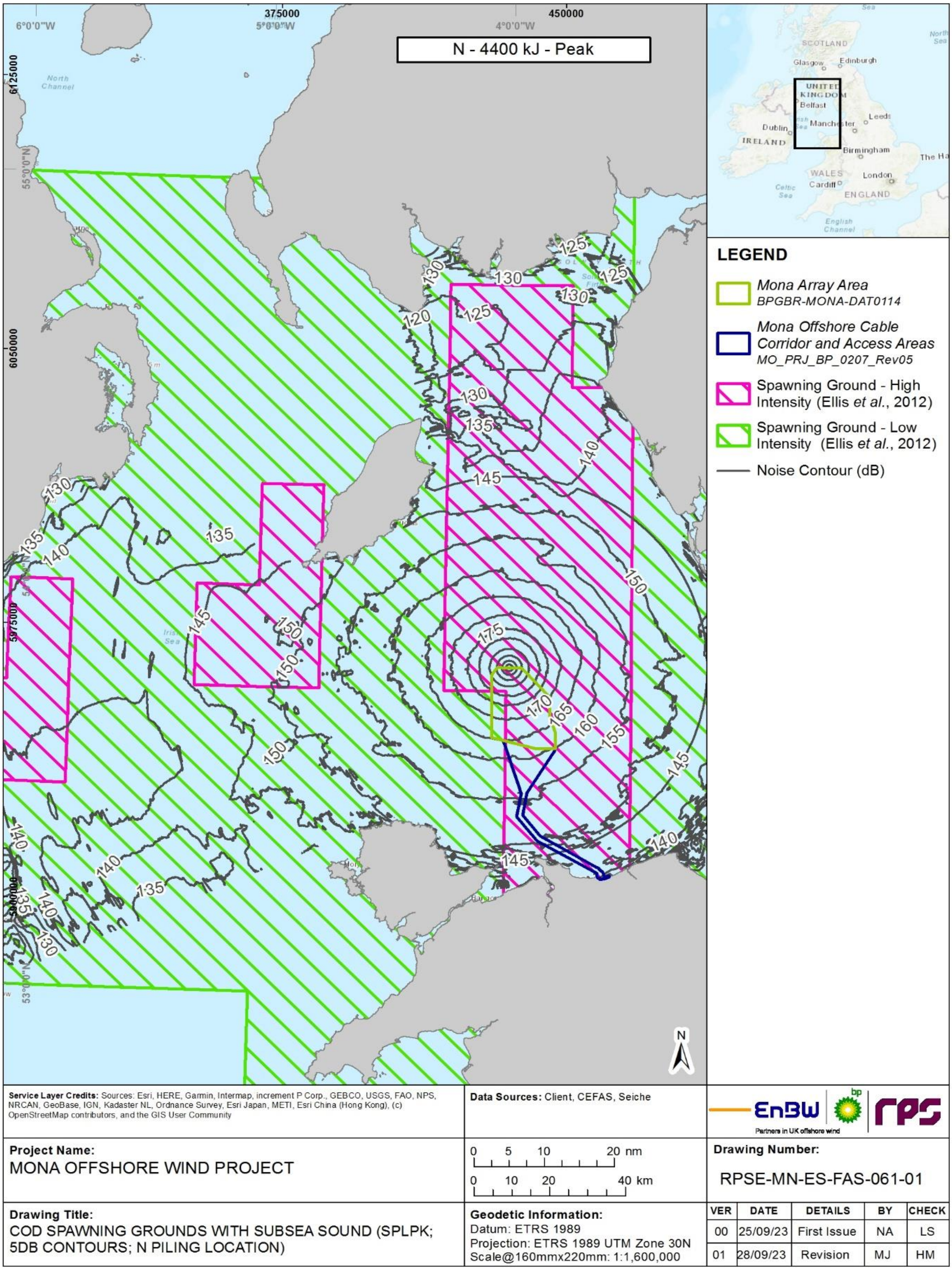



**Figure 3.5: Cod spawning grounds with subsea 5 dB sound $SPL_{pk}$ contours for pin piling at 4,400 kJ hammer energy at north location.**

3.9.3.14 Discrete high and low intensity mapped herring spawning grounds are located off the east coast of the IoM at Douglas Bank. Underwater sound at levels with potential to cause effects to herring (approximately 135dB $SEL_{ss}$ or approximately 160dB $SPL_{pk}$) from pile driving using a maximum hammer energy of 4,400 kJ overlap with these mapped grounds; the former encompasses both high and medium intensity mapped spawning ground (27.52% and 53.16% respectively), and the latter metric just crosses the southeast limit of low intensity mapped spawning ground.

3.9.3.15 For herring, the impact of underwater sound during the construction phase is predicted to be of regional spatial extent (however, overlapping with mapped high and low intensity spawning ground), relatively short-term duration (noting that spawning of Manx herring consistently occurs over a three to four week period from late September; Dickey-Collas *et al.*, 2001), intermittent and of high reversibility, with the soundscape returning to near-baseline conditions upon completion of construction activities. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **medium** during the herring spawning season as described above, and **negligible** outside of this period.

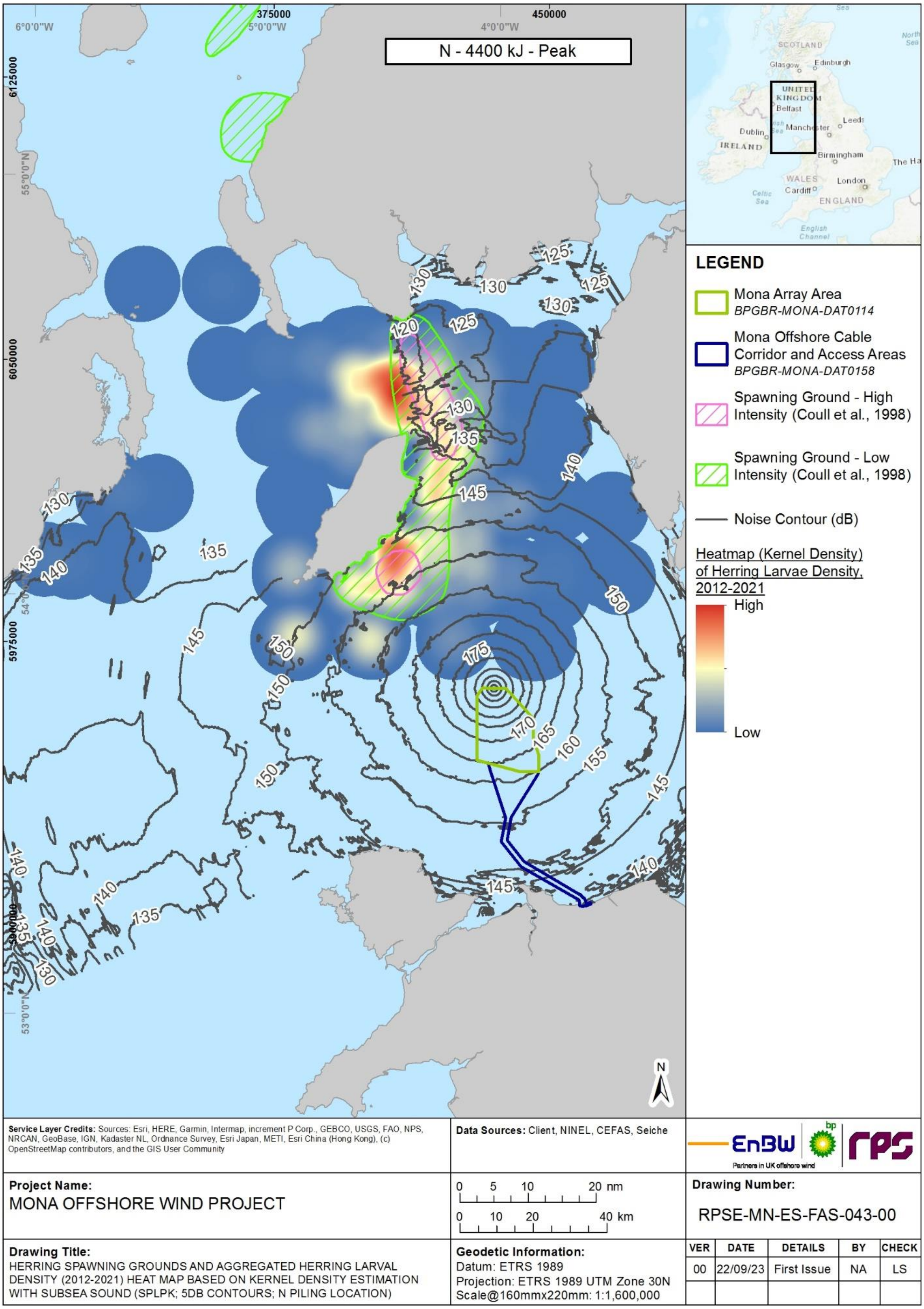
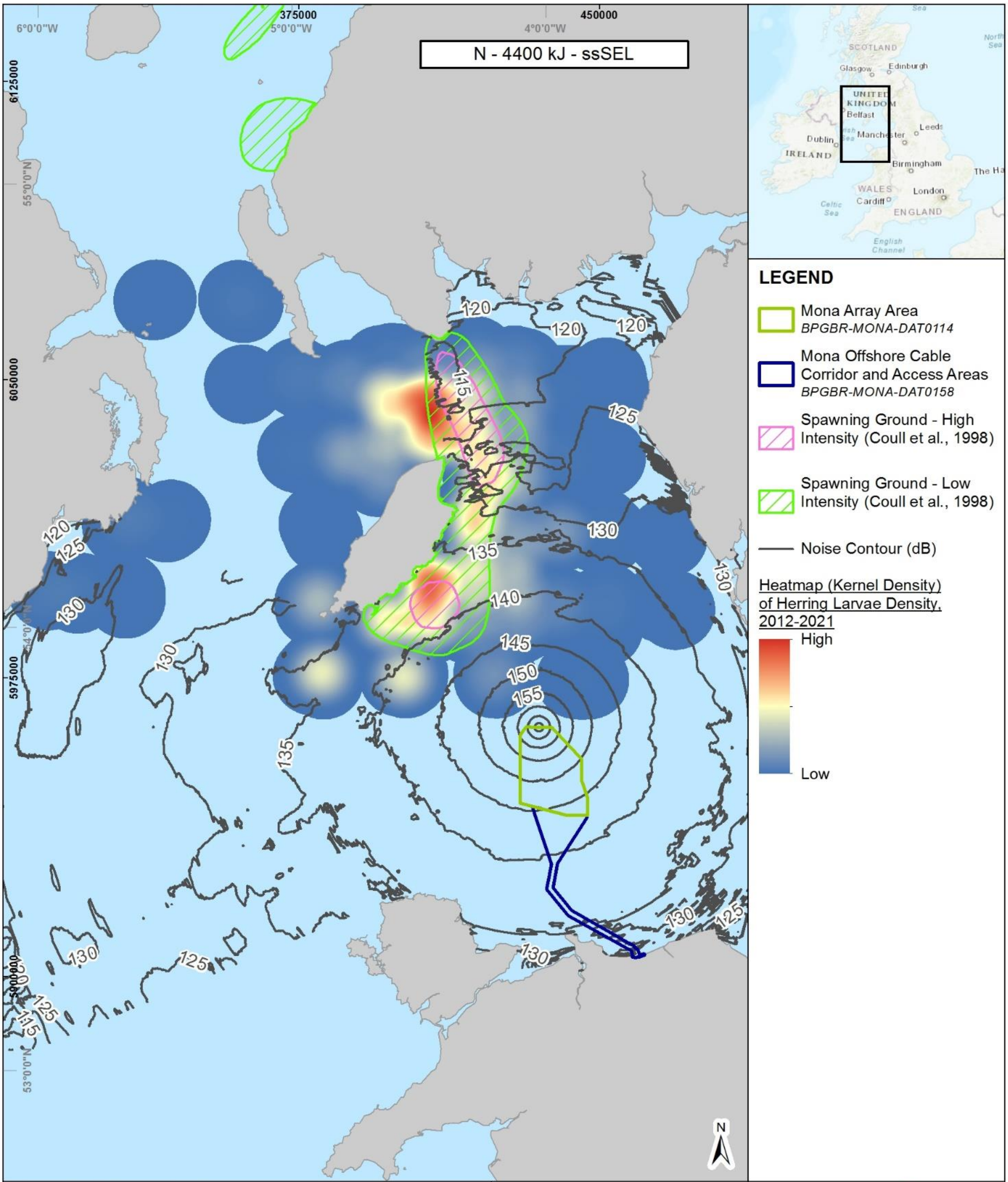



**Figure 3.6: Herring spawning grounds and aggregated ten-year NINEL larval densities (2012 to 2021; larvae/m²) with subsea 5 dB sound $SPL_{pk}$ single strike contours for pin piling at 4,400 kJ hammer energy at the north location.**




**Service Layer Credits:** Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

**Data Sources:** Client, NINEL, CEFAS, Seiche

**Project Name:**
MONA OFFSHORE WIND PROJECT

0 5 10 20 nm
0 10 20 40 km

**Drawing Number:**
RPSE-MN-ES-FAS-044-00

**Drawing Title:**
HERRING SPAWNING GROUNDS AND AGGREGATED HERRING LARVAL DENSITY (2012-2021) HEAT MAP BASED ON KERNEL DENSITY ESTIMATION WITH SUBSEA SOUND (SELSS; 5DB CONTOURS; N PILING LOCATION)

**Geodetic Information:**
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,600,000

| VER | DATE | DETAILS | BY | CHECK |
|---|---|---|---|---|
| 00 | 22/09/23 | First Issue | NA | LS |

**Figure 3.7: Herring spawning grounds and aggregated ten-year NINEL larval densities (2012 to 2021; larvae/m²) with subsea 5 dB sound SEL$_{ss}$ contours for pin piling at 4,400 kJ hammer energy at north location.**

### Sensitivity of receptor

3.9.3.16 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.

3.9.3.17 Underwater sound 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 sound on fish species (see Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement). 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, sandeel). 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 500 Hz
- 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.

3.9.3.18 Relatively few studies have been conducted on impacts of underwater sound on invertebrates, including crustacean species, and little is known about the effects of anthropogenic underwater sound 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 conservative estimates for shellfish species (risk of behavioural effects are discussed further below for shellfish).

3.9.3.19 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 below.

#### Piling – mortality and injury

3.9.3.20 Table 3.20 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 sound on fish.

**Table 3.20: 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 (i.e. 10s of metres), intermediate (i.e. 100s of metres), and far field (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]<br>(*Intermediate*) Low<br>(*Far*) Low |
| | | Peak, dB re 1 μPa | >207 | |

3.9.3.21 The full results of the underwater sound modelling are presented in Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement. To inform this assessment, Table 3.21 displays the predicted mortality and injury ranges for each defined group of fish associated with the installation of one 5.5 m diameter pin pile for the OSP at with a hammer energy of 4,400 kJ, using the $SPL_{pk}$ metric. Further, the predicted mortality and injury ranges using the $SEL_{cum}$ metric are given fish are modelled as both receptors moving away from the sound source in Table 3.22 (therefore excluding stationary receptors), and as static receptors in Table 3.23. The potential sound impacts of installing a pin pile with a hammer energy of 3,000 kJ were also modelled for all the same parameters as the 4,400 kJ piling scenario, but this single pin pile at 4,400 kJ scenario resulted in the greatest realistic predicted mortality and injury ranges and therefore forms the focus of the assessment and the spatial MDS.

3.9.3.22 The content of Table 3.21 is taken directly from Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, Table 1.34.

**Table 3.21: Fish mortality and injury ranges for single pin pile installation at 4,400 kJ based on the $SPL_{pk}$ 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 | 46 | 223 |
| | Recoverable injury | 213 | 46 | 223 |
| Group 2 Fish: Swim bladder not involved in hearing (particle motion detection) | Mortality | 207 | 83 | 404 |
| | Recoverable injury | 207 | 83 | 404 |
| Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection) | Mortality | 207 | 83 | 404 |
| | Recoverable injury | 207 | 83 | 404 |
| Sea turtles | Mortality | 207 | 83 | 404 |
| Fish eggs and larvae | Mortality | 207 | 83 | 404 |

3.9.3.23 Note that the content of Table 3.22 is taken directly from Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, Table 1.32; information regarding TTS ranges is presented herein in Table 3.24.

**Table 3.22: Fish mortality and injury ranges for single pin pile installation at 4,400 kJ based on $SEL_{cum}$ for fish moving away from the sound source (N/E – threshold not exceeded).**

| Hearing group | Response | Threshold (SEL, dB re 1 µPa$^2$s) | 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 | 66 |
| Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection) | Mortality | 207 | N/E |
| | Recoverable injury | 203 | 66 |

3.9.3.24 The content of Table 3.23 is taken directly from Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, Table 1.33; information regarding TTS ranges is presented herein in Table 3.25.

**Table 3.23: Fish mortality and injury ranges for single pin pile installation at 4,400 kJ based on $SEL_{cum}$ 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 | 369 |
| | Recoverable injury | 216 | 556 |
| Group 2 Fish: Swim bladder not involved in hearing (particle motion detection) | Mortality | 210 | 1,260 |
| | Recoverable injury | 203 | 3,180 |
| Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection) | Mortality | 207 | 1,890 |
| | Recoverable injury | 203 | 3,180 |
| Fish eggs and larvae | Mortality | 210 | 1,260 |

3.9.3.25 For $SPL_{pk}$, when piling energy is at its maximum (i.e. 4,400 kJ), mortality and recoverable injury to fish may occur within a maximum of 404 m of the piling activity (smaller ranges for less sensitive Group 1 fish species, and higher ranges for the more sensitive Groups 2 to 4 species; Table 3.21). The potential for mortality or mortal injury to fish eggs would also occur at distances of up to 404 m (Table 3.21), with a low to moderate risk of recoverable injury to eggs and larvae within the range of hundreds of metres (see Table 3.20 for qualitative criteria) based on the maximum decibel levels expected from piling activities. It should be noted that these ranges are the maximum ranges for the maximum hammer energy (4,400 kJ), and it is unlikely that injury will occur to all fish groups in this range due to the implementation of soft starts during piling operations (Table 3.19), which will allow some fish to move away from the areas of highest sound levels before they reach a level that would cause an injury. The injury ranges based on the first strike for soft start initiation will be smaller than those maximum ranges presented (i.e. with a maximum of 83 m, depending on the fish species group considered, as detailed in Table 3.21).

3.9.3.26 Stationary or passive fish eggs and larvae are predicted to be exposed to SEL values associated with mortality impacts at distances up to 1,260 m (Table 3.23). This close range will limit the proportion of fish eggs and larvae exposed to potential mortality from pin piling sound emissions at any given time.

3.9.3.27 For $SEL_{cum}$, mortality and injury ranges were calculated for piling activities wherein fish are modelled as both receptors moving away from the source and as static receptors. These mortality and injury ranges indicate that when fish are modelled as receptors moving away from the sound source with the implementation of soft start initiation, the mortality injury ranges are considerably smaller than those predicted for $SPL_{pk}$. Specifically, the mortality thresholds were not exceeded for any of the Group 1 to 4 fish. The injury recoverability ranges were exceeded for the more sensitive Group 2 to 4 fish, with ranges of 66 m in these cases (Table 3.22).

3.9.3.28 When fish were modelled as static receptors using the $SEL_{cum}$ metric (Table 3.23), ranges for recoverable injury and mortality were significantly higher than for when fish were modelled as receptors moving away from the sound source. Specifically, this modelling showed a maximum mortality range of up to 1,890 m in Group 3 and 4 fish, and a recoverable injury range of up to 3,180 m for Group 2 to 4 fish, and lower ranges for Group 1 species and fish eggs and larvae.

3.9.3.29 The injury ranges presented indicate that injury may occur out to ranges of hundreds of metres for $SPL_{pk}$ (up to 404 m for Group 2 to 4 fish, and fish eggs and larvae, as detailed in Table 3.21). However, in reality, the risk of fish injury overall will be considerably lower due to the hammer energies used 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 3.21. The expected behaviour of some species of fish moving away from the area affected when exposed to high levels of sound and the soft start procedure, modelled and presented in Table 3.22, mean that it is likely that reactive fish will have sufficient time to vacate the areas where injury may occur prior to sound levels reaching a level causing mortality, with only recoverable injury predicted for group 2 and 3 fish out to 66 m. If the fish were to remain in the area and not have any behavioural response to the piling sound, therefore being considered as static receptors, the potential range for both mortality and recoverable injury would be much greater. This range could potentially extend out to thousands of metres from the piling sound source, with this precautionary modelling approach shown in Table 3.23.

3.9.3.30 Other than mortality and recoverable injury, the TTS level of impact was modelled on each group of fish, with this being defined as a temporary reduction in hearing sensitivity caused by exposure to intense sound. Normal hearing ability returns following cessation of the sound 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.

3.9.3.31 In assessing the potential for TTS impacts, modelling was carried out on the single 4,400 kJ and concurrent 3,000 kJ piling scenarios, with the single 4,400 kJ piling scenario causing the largest potential impact in all cases. For this assessment, the single piling scenario ranges are presented alongside the smaller concurrent piling scenario for comparison and as evidence of the larger impact of the single piling scenario.

3.9.3.32 Table 3.24 shows the predicted ranges of effect for TTS for all fish groups modelled as receptors moving away from the sound source which may occur as a result of piling for one pin pile at a maximum hammer energy of 4,400 kJ. In this single piling scenario, when fish are modelled as moving away from the sound source, TTS is predicted to occur to a maximum range of 15,800 m from piling operations for all groups of fish, with the Group 1 basking shark having a smaller TTS range of 12,200 m.

3.9.3.33 Table 3.24 shows the TTS ranges predicted for fish species modelled as static receptors for the same parameters, with maximum ranges of 19,800 m from piling operations.

3.9.3.34 Note that the content Table 3.24 is taken directly from Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, Table 1.32 and Table 1.42.

**Table 3.24: TTS ranges for fish moving away from the sound source due to single 4,400 kJ and concurrent 3,000 kJ pin pile installation based on the Cumulative SEL Metric.**

| Hearing group | Response | Threshold (SEL, dB re 1 μPa$^2$s) | 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 | 15,800 [12,200] | 14,100 [10,620] |
| Group 2 Fish: Swim bladder not involved in hearing (particle motion detection) | TTS | 186 | 15,800 | 14,100 |
| Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection) | TTS | 186 | 15,800 | 14,100 |

3.9.3.35 Note that the content of Table 3.25 is taken directly from Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, Table 1.33 and Table 1.43.

**Table 3.25: TTS ranges for static fish due to single 4,400 kJ and concurrent 3,000 kJ pin pile Installation based on the Cumulative SEL Metric.**

| Hearing group | Response | Threshold (SEL, dB re 1 μPa$^2$s) | Range (m) – singe piling | Range (m) – concurrent piling |
|---|---|---|---|---|
| Group 1 Fish: No swim bladder (particle motion detection) | TTS | 186 | 19,800 | 18,100 |
| Group 2 Fish: Swim bladder not involved in hearing (particle motion detection) | TTS | 186 | 19,800 | 18,100 |
| Group 3 and 4 Fish: Swim bladder involved in hearing (primarily pressure detection) | TTS | 186 | 19,800 | 18,100 |

3.9.3.36 TTS, recoverable injury and mortality ranges are presented in (showing mapped herring spawning grounds) and Figure 3.9(showing mapped cod spawning grounds) for moving group 3 and 4 fish and in Figure 3.10 (herring) and Figure 3.11 (cod) for static group 3 and 4 fish based upon single piling at the north modelled location, with a hammer energy of 4,400 kJ ($SEL_{cum}$).

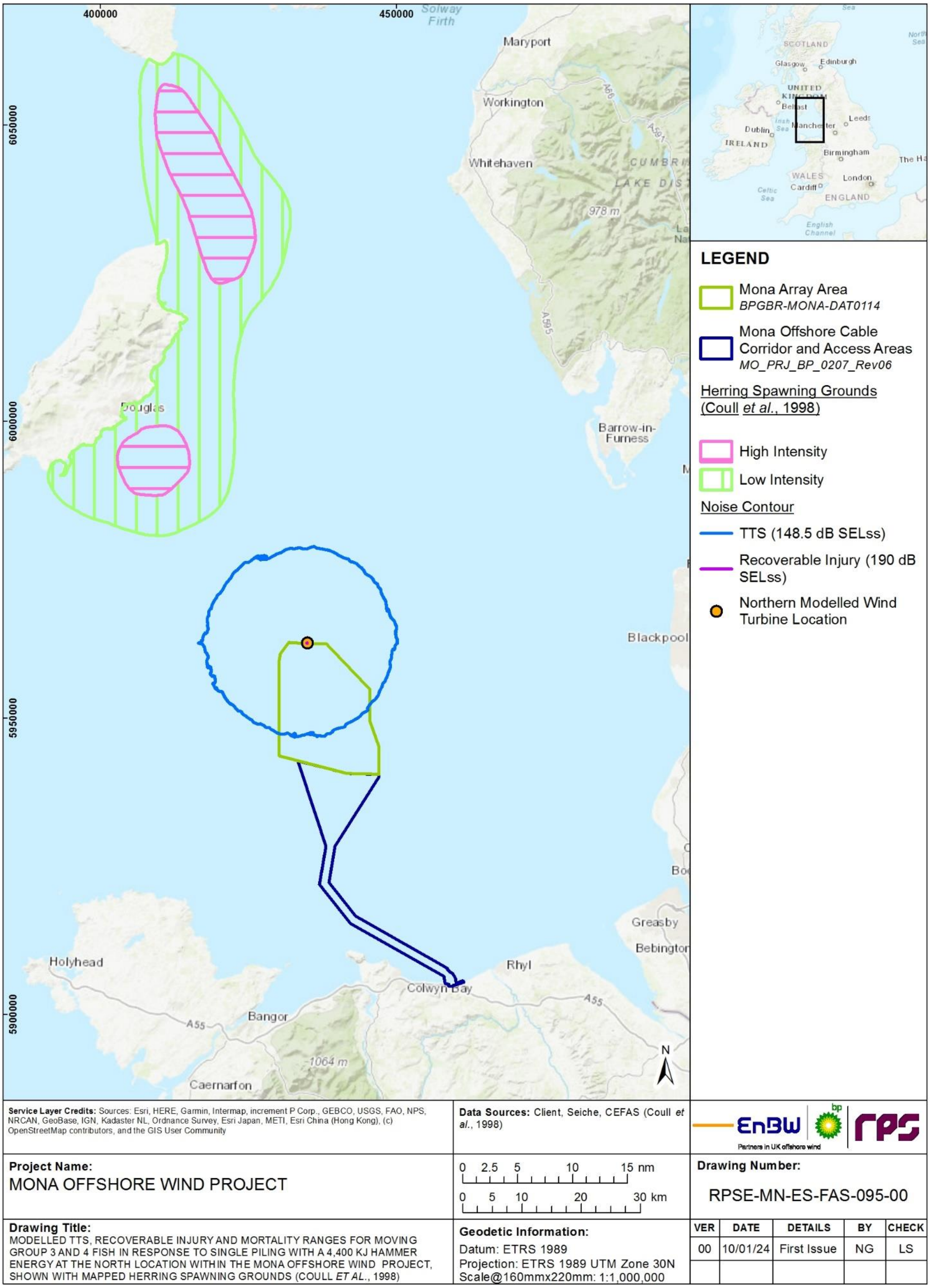



**Figure 3.8: Modelled TTS, recoverable injury and mortality ranges for moving group 3 and 4 fish in response to single piling with a 4,400 kJ hammer energy at the north location within the Mona Offshore Wind Project, shown with mapped herring spawning grounds (Coull *et al*., 1998).**

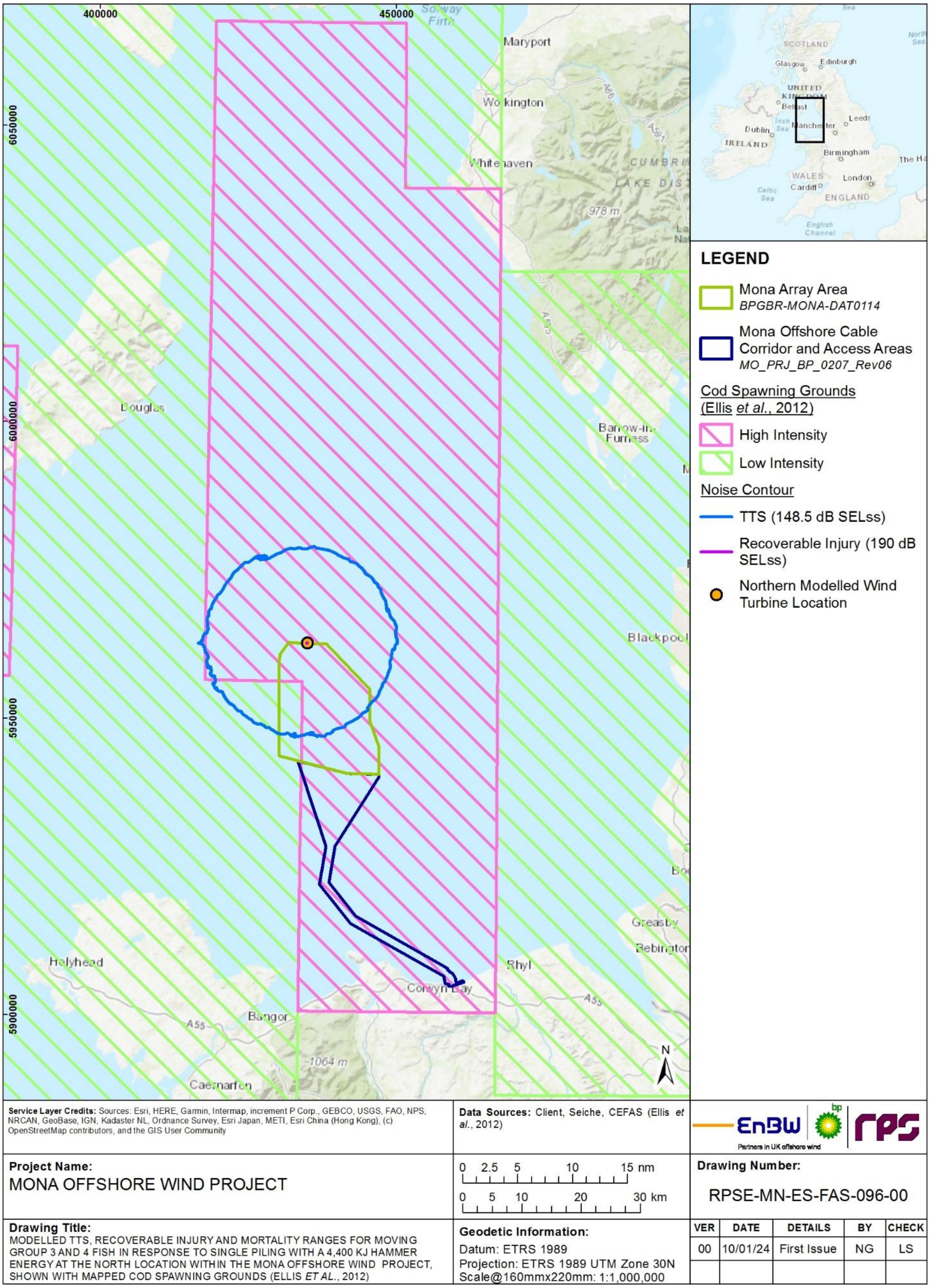
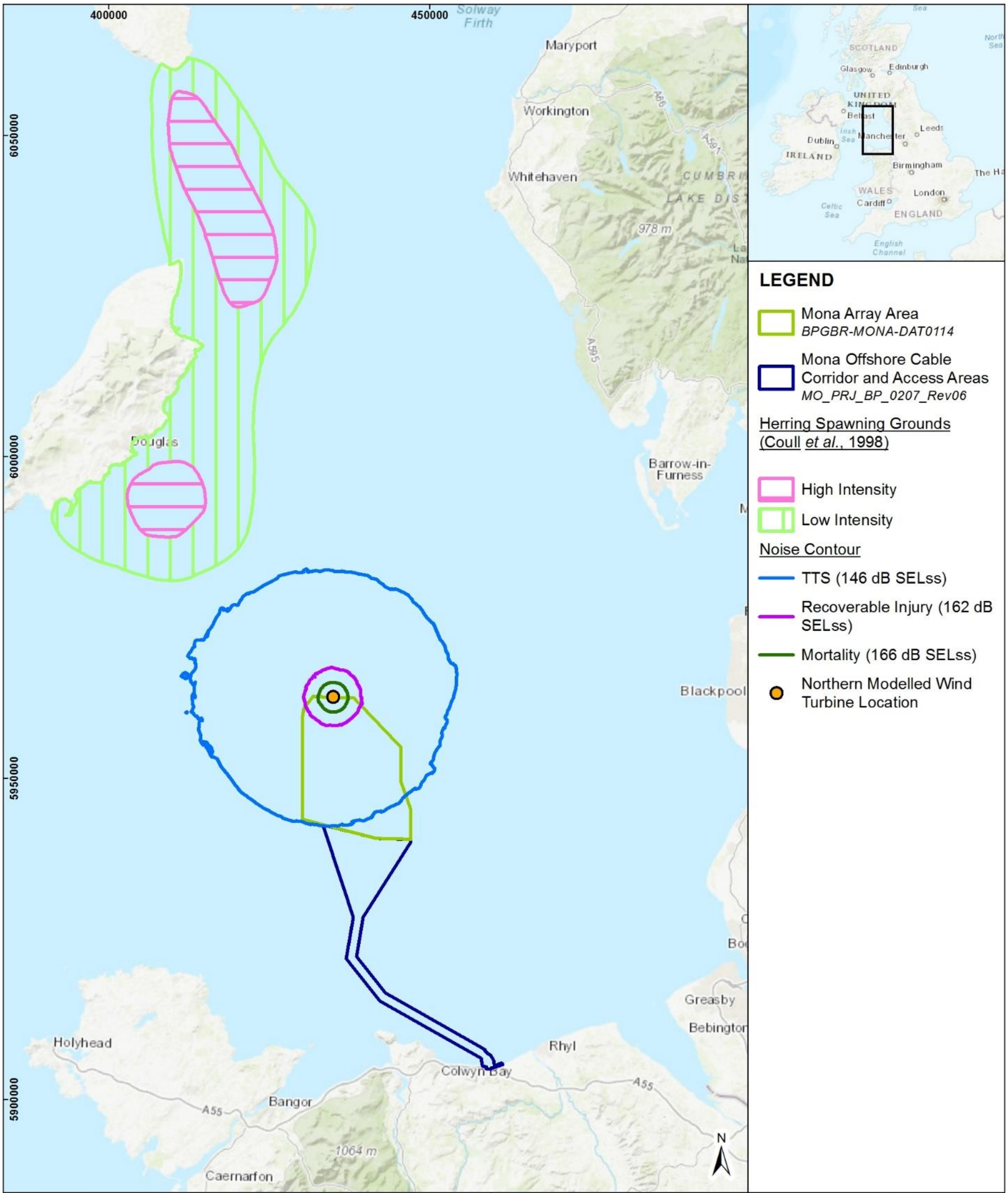



**Figure 3.9: Modelled TTS, recoverable injury and mortality ranges for moving group 3 and 4 fish in response to single piling with a 4,400 kJ hammer energy at the north location within the Mona Offshore Wind Project, shown with mapped cod spawning grounds (Ellis *et al*., 2012).**




**Service Layer Credits:** Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

**Data Sources:** Client, Seiche, CEFAS (Coull *et al.*, 1998)

**Project Name:** MONA OFFSHORE WIND PROJECT

Scale: 0 2.5 5 10 15 nm; 0 5 10 20 30 km

**Drawing Number:** RPSE-MN-ES-FAS-093-00

**Drawing Title:** MODELLED TTS, RECOVERABLE INJURY AND MORTALITY RANGES FOR STATIC GROUP 3 AND 4 FISH IN RESPONSE TO SINGLE PILING WITH A 4,400 KJ HAMMER ENERGY AT THE NORTH LOCATION WITHIN THE MONA OFFSHORE WIND PROJECT, SHOWN WITH MAPPED HERRING SPAWNING GROUNDS (COULL *ET AL.*, 1998)

**Geodetic Information:**
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:1,000,000

| VER | DATE | DETAILS | BY | CHECK |
|---|---|---|---|---|
| 00 | 10/01/24 | First Issue | NG | LS |

**Figure 3.10: Modelled TTS, recoverable injury and mortality ranges for static group 3 and 4 fish in response to single piling with a 4,400 kJ hammer energy at the north location within the Mona Offshore Wind Project, shown with mapped herring spawning grounds (Coull *et al*., 1998).**

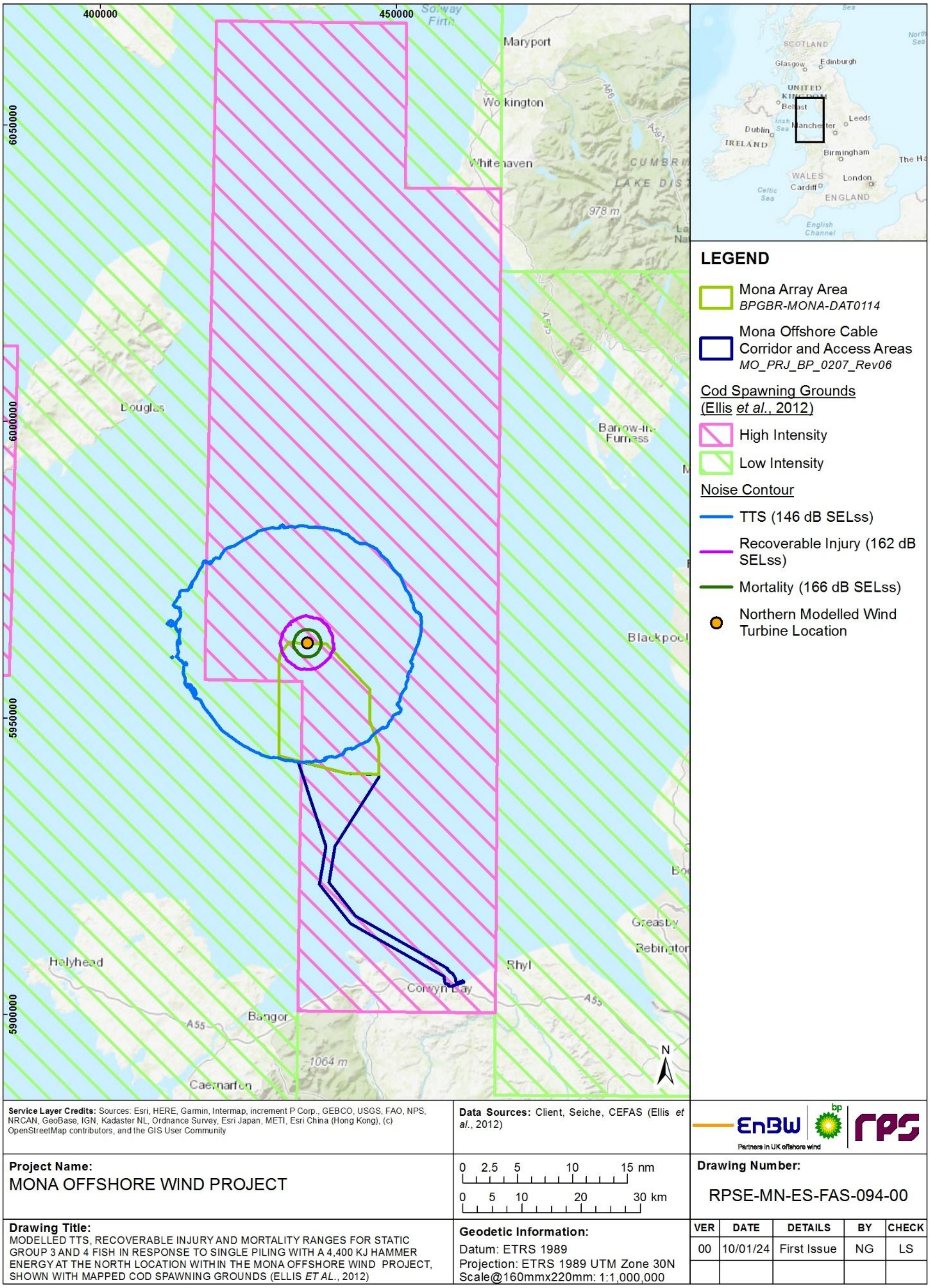



**Figure 3.11: Modelled TTS, recoverable injury and mortality ranges for static group 3 and 4 fish in response to single piling with a 4,400 kJ hammer energy at the north location within the Mona Offshore Wind Project, shown with mapped cod spawning grounds (Ellis *et al*., 2012)**

### UXO clearance

3.9.3.37 Underwater sound modelling has also been completed for underwater sound associated with UXO clearance and detonation. Modelling was undertaken for a range of orders of detonation, from a realistic worse case high order detonation to low order detonations (e.g. deflagration and clearance shots) to be used as mitigation to minimise sound levels. Table 3.26 details the injury ranges for fish of all groups in relation to various orders of detonation (see Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement for full details on UXO modelling assumptions and factors). For the purposes of this assessment, it has been assumed that the MDS will be clearance of UXO with a NEQ of 907 kg cleared by either low order or high order techniques.

3.9.3.38 Note that the content of Table 3.26 is taken directly from Volume 5, Annex 3.1: Underwater sound technical report of the Environmental Statement, Table 1.27 and Table 1.28.

**Table 3.26: Injury Ranges for all Fish Groups Relating to Varying Orders of Detonation**

| Detonation size (kg) | PTS range (m) | |
|---|---|---|
| | Fish Lower Range | Fish Higher Range |
| Low Order and Low Yield Detonations | | |
| 0.08 (donor charge) | 44 | 27 |
| 0.5 (clearing shot) | 81 | 49 |
| 0.75 (x2) | 117 | 70 |
| 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 |

### Behaviour of marine fish in response to sound

3.9.3.39 Fish species responses to construction-related underwater sound 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 sound 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).

3.9.3.40 Any potential short-term sound 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 sound 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 sound 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 3.27 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 3.27: Potential Risk for the Onset of Behavioural Effects in Fish from Piling (Popper *et al*., 2014)[a].**

[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).

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

3.9.3.41 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*., 2014). 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 sound (Popper *et al*., 2014) and, as indicated in Table 3.27, the risk of behavioural effects in the intermediate and far fields are therefore greater for these species.

3.9.3.42 Group 1 elasmobranch species do not possess a swim bladder, and thus will be most impacted by particle motion, with evidence of startle and moving away from the sound source responses to piling sounds a minimum of 20 to 30 dB re 1 μPa above background conditions due to increased particle motion (Casper *et al*., 2012). It is likely that the designed-in soft start procedure will allow some individuals near the sound source to avoid injury by moving away from 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.

3.9.3.43 A number of studies have examined the behavioural effects of the sound pressure component of impulsive sound (including piling and seismic surveys using airgun sound sources) on fish species. Seismic surveys are being used in this assessment as a general contextual proxy for piling, and are not being used in any stage of the Mona Offshore Wind Project activities, and so the findings should be interpreted with caution. A study by Pearson *et al*. (1994) on the effects of geophysical survey sound 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 sound 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 sound levels exceeding 147 to 151 dB re 1 µPa SEL in every case, although these responses were also temporary and returned to baseline behavioural conditions shortly thereafter.

3.9.3.44 Application of the abovementioned studies to wild fish should be interpreted with caution due to inherent differences in reactions expected between caged versus free-roaming fish, and through the use of seismic airgun impulse sound as a caveated proxy for pile-driving activities. Seismic airguns are unable to be used as a proxy for UXO clearance, as they use a highly repetitive impulsive sound source, whereas UXO clearance is likely to comprise singular, or a small series of blasts of gradually increasing sound levels with associated shockwaves (where high order techniques are used), therefore the real-world impacts between the two are likely to differ. Differences also apply between seismic airguns and pile driving, in terms of overall sound exposure levels and frequencies. However specific studies relating to the impacts of UXO clearance and pile driving on fish and shellfish receptors are limited and thus a proxy is used to support the evidence base for assessment.

3.9.3.45 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, sound modelling was undertaken for $SPL_{pk}$for single and concurrent scenarios around the Mona Array Area (i.e. these sound contours are presented and discussed below relative to spawning habitats for key species in the fish and shellfish ecology study area. The contours show $SPL_{pk}$ associated with the greatest hammer energy for a single pin pile. Based on the studies summarised above, it can be expected that behavioural effects could be expected within the 160 dB re 1 µPa $SPL_{pk}$ contours, noting that this is likely to be conservative given McCauley *et al*. (2000) noted behavioural effects on a range of species at approximately 168 dB 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 sound (Popper *et al*., 2014). It is unlikely that the maximum hammer energy of 4,400 kJ would be used in most piling activities, potentially reducing the range of the sound contours. These ranges and the results discussed below broadly align with qualitative thresholds for behavioural effects on fish as set out in Table 3.27, 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

**Behaviour, injury and mortality – herring**

3.9.3.46 Herring are known to be particularly sensitive to underwater sound (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 northeast of the Mona Array Area, directly southeast and northeast of the IoM, with seabed sediments within the Mona Array Area and Mona Offshore Cable Corridor and Access Areas shown to be largely unsuitable for herring spawning (see Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement). Sound contours shown in Figure 3.12 indicate that there is minimal overlap between the herring spawning grounds and the 160 dB re 1 μPa $SPL_{pk}$ sound contour, even at the north-most piling location for a single pile at a maximum hammer energy of 4,400 kJ (there will be no overlap of this sound contour with the spawning grounds for the majority of piling locations further south within the Mona Array Area). Significant but reversible diving reactions have been noted for sounds up to 168 dB re 1 μPa SPL based on sonar sound sources (Doksaeter *et al*., 2012), which is above the 160 dB threshold suggested above and therefore this has no overlap with the spawning grounds from this piling location and hammer energy scenario.

3.9.3.47 To ensure a precautionary approach is taken for this sensitive species, it was recommended by the MMO during the Benthic Ecology, Fish and Shellfish and Physical Processes EWG that a threshold of 135 dB re 1μPa$^2$ $SEL_{ss}$ is used to assess potential sound impacts on 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 sound level were identified in sprat and mackerel in a naturally quiet coastal environment where fish were not habituated to vessel sound 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 sound 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 $SPL_{pk}$ 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 3.7 presents sound contours for $SEL_{ss}$ for the maximum hammer energy associated with pin pile installation and indicates that, based on a threshold of 135dB re 1μPa$^2$ $SEL_{ss}$, up to 38.73% of combined high and low intensity herring spawning ground could be affected for piling at the north modelled piling location. When comparing this to the 3,000 kJ hammer energy which will be the applied maximum at 75% of jacket locations and for 100% of gravity based foundations, up to 31.48% and 0% of combined high and low intensity spawning ground could be affected, based on the $SEL_{ss}$ (Figure 3.12) and $SPL_{pk}$ metrics (Figure 3.13), respectively. The assessment is based upon the MDS of 4,400 kJ hammer energy; however it is useful to highlight the difference in percentage overlap associated with the lower maximum hammer energy. However as noted above, any effects of piling will be temporary and intermittent (i.e. 114 days over a two year piling phase) and any potential behavioural effects on herring would only occur if piling occurs at locations within range of the herring spawning grounds/high density larval records within the herring spawning season (late September for three to four weeks; Dickey-Collas *et al.*, 2001)

3.9.3.48 However, if herring are within an area due to acting under other biological drivers, the disruption caused by underwater sound may be non-significant. This was found in an investigation into the impact of impulsive seismic air gun surveys on feeding herring schools, which found a slight but not significant reduction in swimming speed when exposed to the sound impact (Peña *et al*., 2013). The findings of this survey indicated that feeding herring did not display avoidance responses to seismic sound sources, even when the vessel came into close proximity to herring. This indicated an awareness of and response to impulsive anthropogenic sound, which would be expected in response to piling, but not a significant response when fish were highly motivated to remain within an area – in this case during feeding, but potentially also in spawning. Another example is from a spawning herring survey undertaken whilst piling was occurring at the Gunfleet Sands offshore wind farm within the relatively enclosed environment of the Thames estuary. Aggregations of spawning herring were caught within 10 to 15 km of active piling on the spawning grounds at Eagle Bank and Colne Bar, thus indicating that spawning was not entirely disrupted by piling at Gunfleet Sands offshore wind farm. This study suggests that herring's biological driver to use these grounds to spawn may have overridden the potential behavioural effects of percussive piling sound on herring (Brown and May Marine Ltd, 2009d). Increased tolerance (and decreased sensitivity) to underwater sound may occur for some fish and shellfish during key life history stages, such as spawning or migration, although further research is required on spawning success when exposed to sound for full conclusions to be drawn.

3.9.3.49 For comparison to the single pin piling scenario, and in response to stakeholder requests, Figure 3.14 presents sound contours for the $SEL_{cum}$ metric for concurrent piling at the maximum hammer energy of 3,000 kJ associated with pin pile installation at the north location. This figure indicates that, based on a threshold of 135 dB re 1 $\mu Pa^2$ $SEL_{cum}$, approximately the same area of herring high and low intensity spawning grounds will be impacted as in the $SEL_{ss}$ at 3,000 kJ hammer energy single piling scenario (Figure 3.12 also presents this data with the heat-mapped NINEL herring larval densities, based on 10 years of aggregated data). In either case, any effects of piling will be temporary and intermittent (i.e. 114 days over a two year piling phase), and any potential behavioural 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).

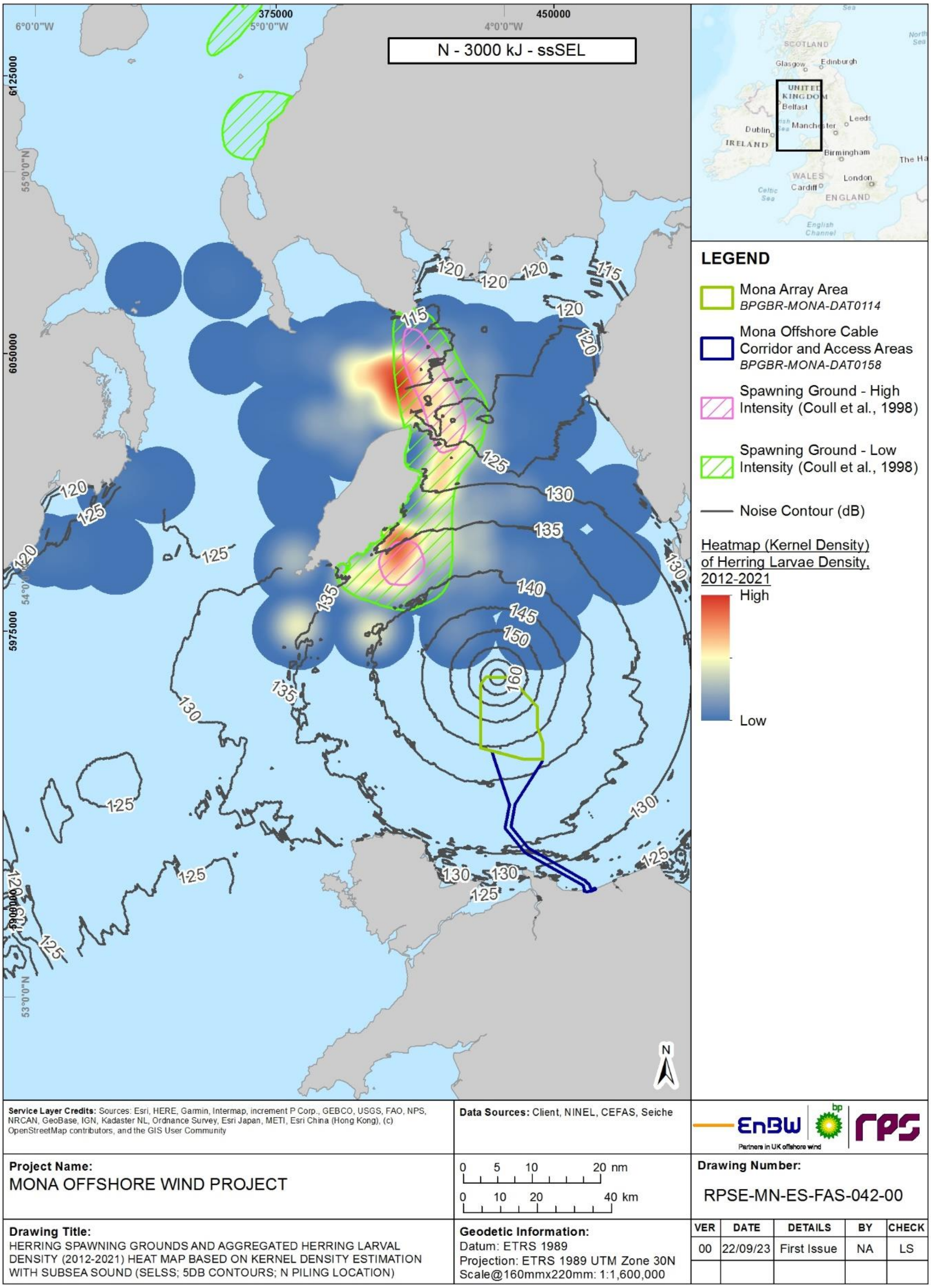



**Figure 3.12: Herring spawning grounds and aggregated larval density (larvae/m$^2$; 2012 to 2021) with subsea 5 dB sound SEL$_{ss}$ contours for pin piling at 3,000 kJ hammer energy at the north location.**

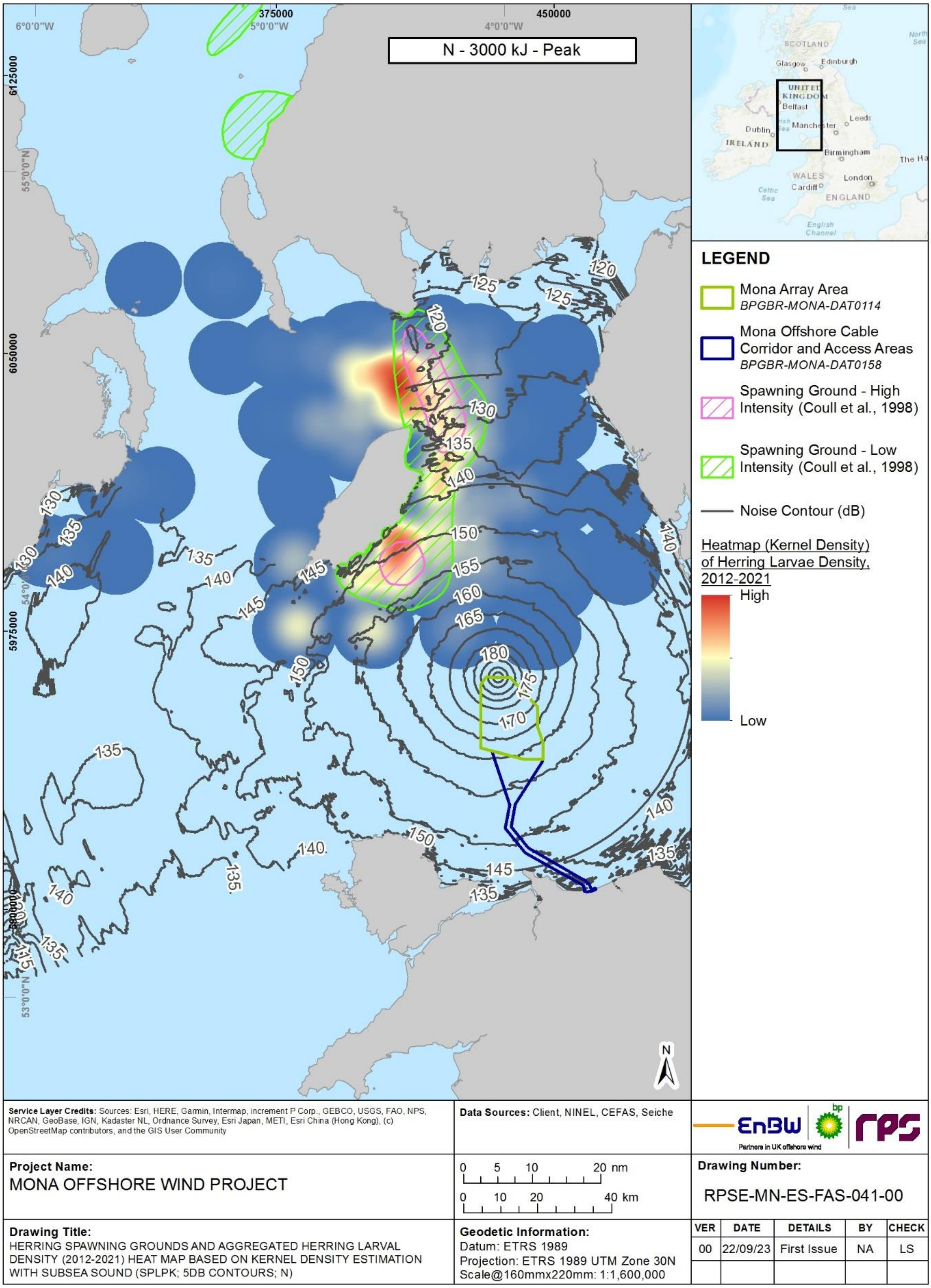



**Figure 3.13: Herring spawning grounds and aggregated larval density (larvae/m²; 2012 to 2021) with subsea 5 dB sound $SPL_{pk}$ contours for pin piling at 3,000 kJ hammer energy at the north location.**

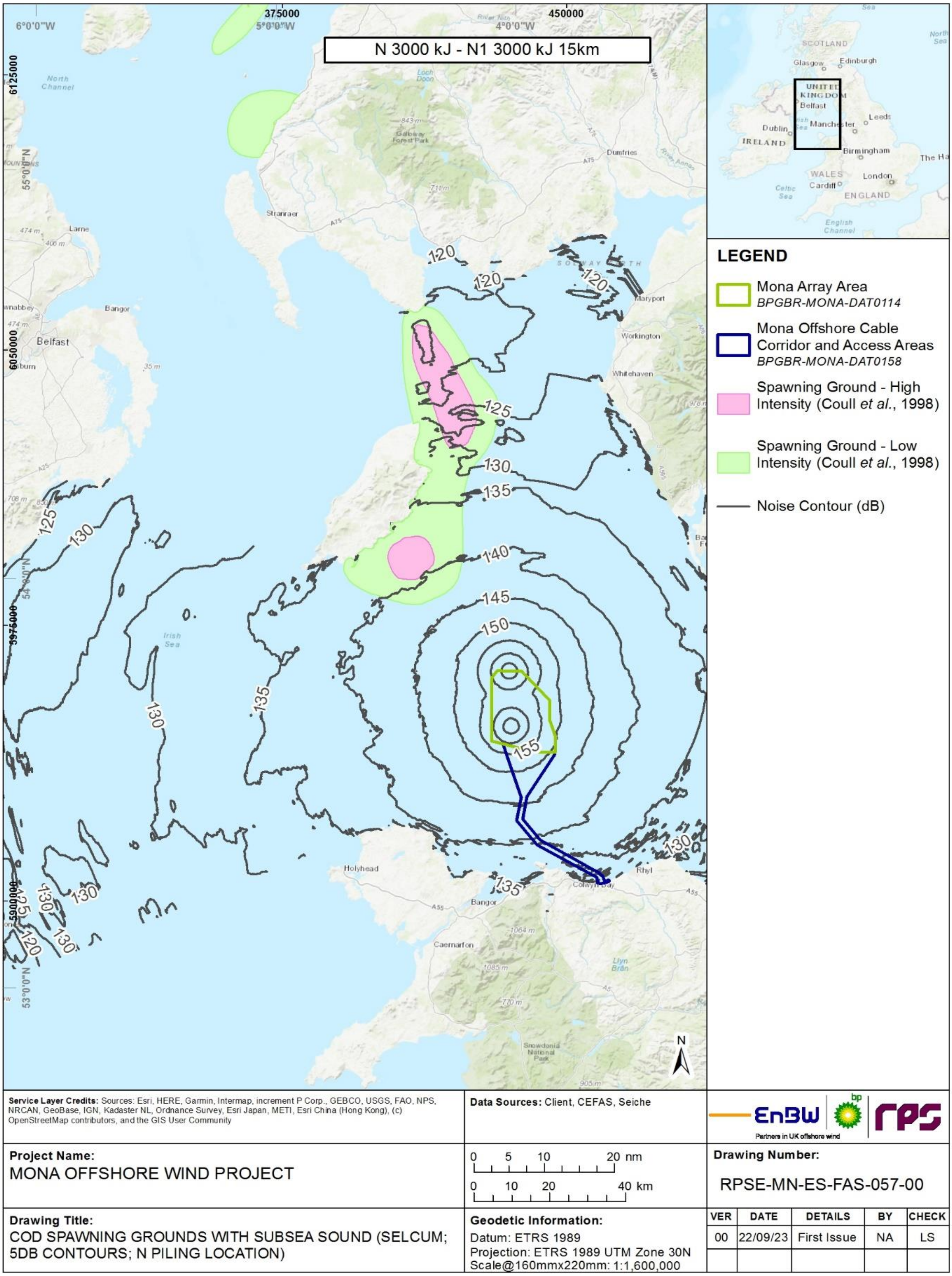



**Figure 3.14: Herring spawning grounds with subsea 5 dB sound $SEL_{cum}$ contours for concurrent 3,000 kJ hammer energy pin piling at the north location.**

### Behaviour, injury and mortality – Cod

3.9.3.50 A number of studies have examined the behavioural effects of the sound pressure component of impulsive sound (including piling operations and seismic airgun surveys) on commercially important fish species such as Group 3 cod. Mueller-Blenkle et al. (2010) measured behavioural responses of cod and sole (Solea solea) 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 SPLpk for cod and 144 dB to 156 dB re 1 μPa SPLpk for sole. However, these thresholds should not be interpreted as the level at which an avoidance reaction will be elicited, as the study was not able to show this.

3.9.3.51 More recent modelling work on cod has shown an expected decrease in population growth rates in response to loud piling sound (Soudijn *et al*., 2020), due to a decrease in food intake and an increase in energy expenditure as part of an avoidance response to modelled sound energy impacts. However, this model was noted in the study to likely underestimate cod fecundity due to underestimation of feeding rates or overestimations of the energetic or reproduction costs of cod, and this, combined with the short-term nature of the sound impact from piling (i.e. up to 114 days of piling over a two year piling phase), suggests that long-term population-level effects are unlikely to occur within the fish and shellfish ecology study area. Cod spawning behaviour was also monitored pre- and post-construction (which included piling operations) at the Beatrice wind farm site (BOWL, 2021b) and it was concluded that there was no change in the presence of cod spawning between pre- and post-construction surveys, with the caveat that spawning intensity was found to be low across both surveys. From these studies, it can be inferred that sound 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.

3.9.3.52 Figure 3.5 shows the overlap between sound contours from the north pin piling location at a maximum hammer energy of 4,400 kJ relative to known cod spawning and nursery habitat (Ellis *et al*., 2012) for $SPL_{pk}$. It should be noted that these habitats are broadscale, with no specific evidence of spawning occurring throughout the entire highlighted blocks, and therefore based on this slight uncertainty the assessments have been precautionary. This indicates that piling at the north location at this hammer energy has a 19.87% overlap with the high intensity spawning grounds, with the 160 dB re 1µPa $SPL_{pk}$ contours directly overlapping these grounds. When compared with piling at 3,000 kJ hammer energy (Figure 3.15; which is the maximum energy that will apply at 75% of jacket locations, and for 100% of gravity base foundations), up to 15.93% of high intensity cod spawning habitat may be subject to behavioural effects. When considered in the context of the mapped spawning habitat available for cod within both the fish and shellfish ecology study area and the wider Irish Sea, both these values represent only a small proportion of habitat which would be subject to behavioural effects during piling.

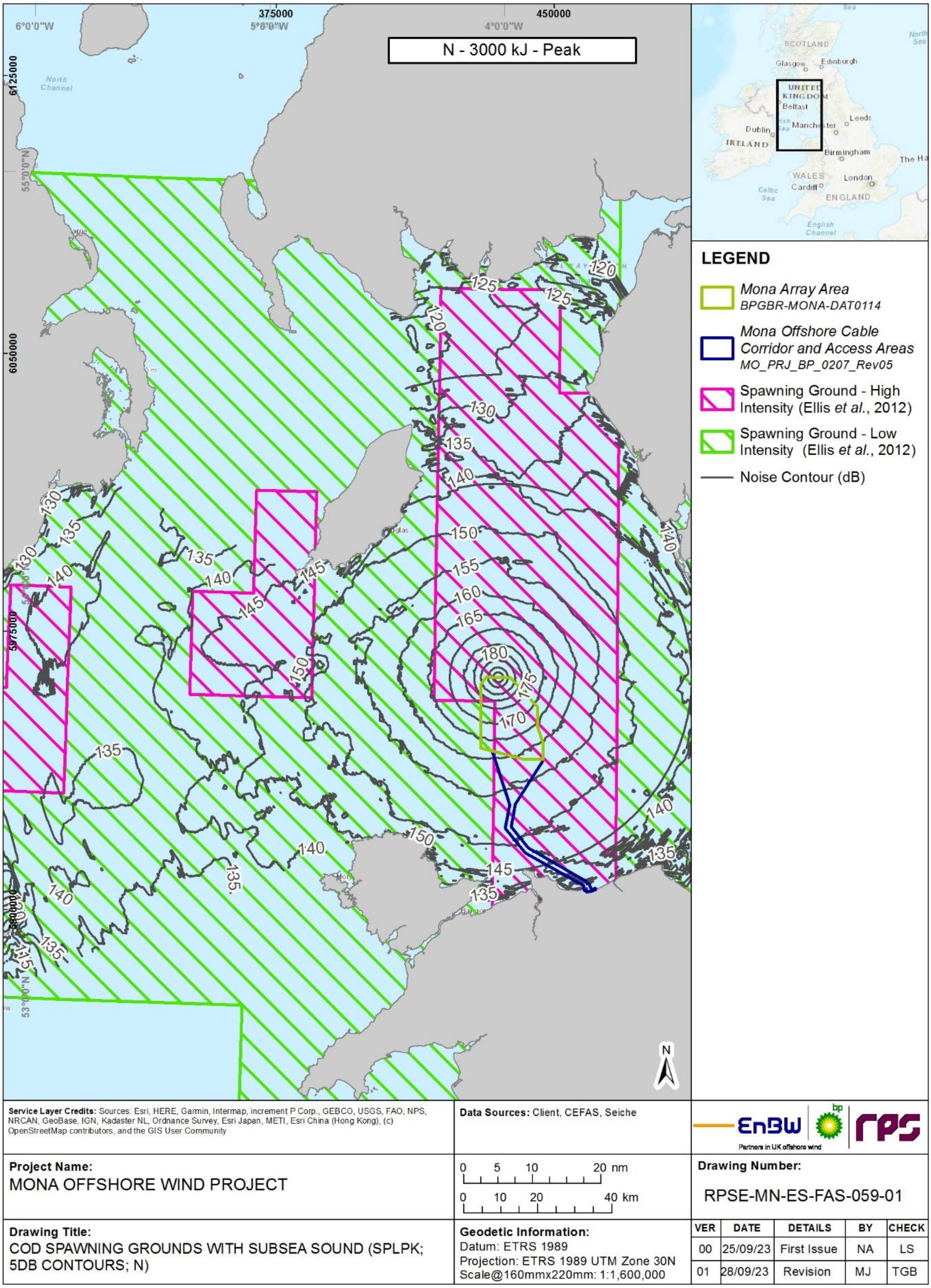



**Figure 3.15: Cod spawning grounds with subsea 5 dB sound $SPL_{pk}$ contours for pin piling at 3,000 kJ hammer energy at the north modelled location.**

**Mortality and injury – fish eggs and larvae**

3.9.3.53 Effects on fish eggs and larvae are expected to be limited with only a low level of impacts anticipated which are limited in extent (relative to the wide-ranging nature of spawning and nursery habitats of the variety of species present within the fish and shellfish ecology study area) and with high recoverability expected where impacts do occur (Bolle *et al*., 2016). It is known that fish larvae tend to have low sensitivity to impulsive piling sound up to 210 dB re 1 μPa SPL (Bolle *et al*., 2016). Although evidence exists of sound 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 sound up to 216 dB re 1 μPa $SEL_{cum}$ (Bolle *et al*., 2014).

**Mortality and injury – other marine fish species**

3.9.3.54 A range of other marine fish species are identified as IEFs within the fish and shellfish ecology study area (section 3.5.3), and these also have the potential to be impacted by the sound generated by piling activities. However, the relative proportion of these habitats affected by piling operations at any one time 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 Mona Offshore Wind Project, potentially limiting the impacts of the piling sound. It should also be noted that for all marine fish species, behavioural responses to underwater sound are highly dependent on a number of factors, such as species, sex, age, condition, life history state and other environmental stressors to which the affected individuals have been exposed.

3.9.3.55 For group 1 sandeel species in the fish and shellfish ecology study area, previous modelling has indicated a possible temporary reduction by up to approximately 20% in Group 1 sandeel populations in areas affected by piling sound (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.

3.9.3.56 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**.

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

3.9.3.58 Cod are deemed to be of high vulnerability, medium recoverability in the context of the Irish Sea stock, and regional importance, with overlap of sound contours from pile driving with both mapped high and low intensity spawning grounds. The sensitivity of the receptor is therefore, considered to be **high**.

3.9.3.59 Herring are deemed to be of high vulnerability, high recoverability and national importance, with strong reactions noted to relatively low levels of sound due to their hearing physiology. The sensitivity of the receptor is therefore, considered to be **high**. It should be noted however, that evidence exists to suggest that biological drivers (i.e. those related to spawning) may override such responses to underwater sound, suggesting a potential lower sensitivity when highly motivated to continue or undertake a particular activity (Brown and May Marine, 2009d; Peña *et al*., 2013 ).

### Behaviour, injury and mortality – diadromous species

3.9.3.60 As with fully marine species, diadromous fish species within close proximity to piling operations may experience injury or mortality. However as diadromous fish species are highly mobile and tend 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 3.19), allowing individuals in close proximity to piling to move away from the ensonified area, further reduces the likelihood of injury and mortality on diadromous species.

3.9.3.61 Diadromous fish species may experience behavioural effects in response to piling sound, including a startle response, disruption of feeding, or avoidance of an area, and these behavioural responses may occur within a range of hundreds of metres to several kilometres from piling operations. The distance and level of impact depends on the species and their relative sensitivities to underwater sound; 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 (Popper *et al*., 2014).

3.9.3.62 The Group 1 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). Specifically, lamprey species were found to exhibit only a slight swimming speed increase and a small decrease in resting behaviour when exposed to continuous low frequency sound of 50 to 200 Hz (Mickle *et al*., 2019), suggesting a relatively low vulnerability to sound impacts overall. The sound modelling outputs (including sound contours) discussed within this assessment indicated that piling related underwater sound would result in behavioural responses of many fish species at the 160 dB re 1 µPa $SPL_{pk}$ sound level, which is likely to be highly precautionary for lamprey due to their low sensitivity to sound. These 160 dB re 1 µPa $SPL_{pk}$ sound level were expected to be present only in the immediate vicinity of the Mona Array Area and would not extend close to the coasts of north Wales or northwest England, thereby limiting potential impacts on migrating lamprey species. Further, the sound impacts will be short-term and intermittent in nature during the construction phase (i.e. piling occurring over approximately 114 days over a two year piling phase). As such, there is negligible risk of disruption to migration of lamprey.

3.9.3.63 The Group 2 Atlantic salmon responses to sound impacts have been investigated, with research from Harding *et al.* (2016) failing to produce physiological or behavioural responses in Atlantic salmon when subjected to sounds similar to piling. However, the sound levels tested were estimated at <160 dB re 1 µPa RMS ($SPL_{pk}$, or approximately <135 to 140 dB re 1 $\mu Pa^2 s$ $SEL_{cum}$), 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 also 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 sound levels, it would be expected that avoidance reactions would occur, thus avoiding injury effects. As with Group 1 lamprey, the behavioural response contour of 160 dB re 1 µPa $SPL_{pk}$ is not likely to reach the coasts of north Wales or northwest England, therefore limiting potential impacts to around the Mona Array Area. As the sound impacts will be short-term and intermittent in nature during the construction phase (i.e. piling occurring over approximately 114 days over a two year piling phase) there is low risk of disruption to migration of these species if their migration and spawning periods are considered within the scheduling of construction operations. The low risk of effects on migration of Atlantic salmon and sea trout also extends to the freshwater pearl mussel, as part of its life stage is reliant on diadromous fish species including Atlantic salmon and sea trout.

3.9.3.64 The Group 2 smelt have the potential to be impacted by sound, 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 3.5.2. However, this species is largely restricted to coastal and estuarine habitats and the extent of the sound contours modelled show no significant overlap with coastal areas of north Wales or northwest England. Further, evidence from a port sound study indicated that smelt are able to habituate to repeated sound impacts with no significant loss of ecological function (Jarv *et al*., 2015). As the piling sound 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.

3.9.3.65 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 adults migrating towards the sea, with there being no significant impact expected on these 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 sound (Simpson *et al*., 2014), but with recovery noted when the sound source was removed. Based on this potential for recovery, the small overlap of sound contours with coastal areas, and the relatively short migration period of eels through the affected zones, it is predicted that any impact to European eel will be minor.

3.9.3.66 The highly sensitive Group 4 shad species (i.e. allis and twaite shad), like herring, are known to be sensitive to underwater sound, particularly ultrasonic tones, with both shad species found to be able to detect ultrasonic tones of 171 dB re: 1 μPa $SPL_{pk}$ at a distance of up to 187 m (Mann *et al*., 1998). Evasive behaviours were commonly seen in direct response to ultrasonic stimuli (Platcha and Popper, 2003). Due to this sensitivity and evasive response, it is unlikely that shad species will remain in the vicinity of construction activities for a long enough period to cause significant harm, which will be further minimised by the utilisation the soft-start procedure during piling activities. Disruption to migration may occur in the immediate vicinity of the Mona Array Area during piling activities, but these will be short term and intermittent, and the sound levels which could cause a behavioural response are unlikely to extend to the coastlines from any of the piling scenarios modelled. Shad would have the highest potential to be affected if piling occurred during the migratory period for these species, which occurs over spring up until June, and peaks in April and May for both species (Acolas *et al*., 2004). As such, there is low risk of disruption to migration of these species.

3.9.3.67 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**.

3.9.3.68 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 **high**.

### Behaviour, injury and mortality – shellfish species

3.9.3.69 As information on the impact of underwater sound 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 sound (e.g. the vibration of the water molecules which results in the pressure wave) and ground borne vibration (Popper *et al*., 2001). Sound is detected more as particle motion through stimulation of sensory setae within statoliths (Carroll *et al*., 2017), although crustaceans also have other mechanoreceptor systems which could be capable of detecting vibration. Broadly, evidence exists of crustaceans being sensitive to sounds of frequency <1 kHz (Budelmann, 1992). It has also been reported that the sound wave signature of piling sound 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.

3.9.3.70 Scott *et al*. (2020) reviewed the existing published literature on the influence of anthropogenic sound and vibration and on crustaceans, including IEF species. The review concluded that some literature sources identified behaviour and physiology effects on crustaceans from anthropogenic sound, however, there were several that showed no effect. The paper notes that to date no effect or influence of sound 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 sound on mortality, immediate or delayed (Scott *et al*., 2020).

3.9.3.71 Of the shellfish IEF species within the fish and shellfish ecology study area, decapod crustaceans such as European lobster, edible crab, and *Nephrops* are believed to be physiologically resilient to sound as they lack gas filled spaces within their bodies (Popper *et al*., 2001). To date, no lethal effects of underwater sound have been described for edible crab, European lobster or *Nephrops*. Sub-lethal physiological effects have been reported among *Nephrops* and related species, with a reduction in burying, bioregulation and locomotion behaviour in response to simulated shipping and construction sound (Solan *et al*., 2016), although simulated shipping sound had no effect on the physiology of *Nephrops.* Caution should be applied in the application of laboratory study (i.e. those within a controlled environment) results to wild fish and shellfish species, due to inherent variance in reactions in such differing conditions. Laboratory studies provide a useful reference to potential reactions and effects, but cannot fully simulate real-world scenarios. However, given the scarcity of published literature on the subject, these studies are considered valid reference points to support assessment.

3.9.3.72 Sub-lethal physiological effects have been identified from impulsive sound sources including bruised hepatopancreas and ovaries in snow crab exposed to seismic survey sound emissions (at unspecified SPL) (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.

3.9.3.73 Another study on brown shrimp found elevated $SPL_{pk}$ sound levels 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 sound (e.g. movement and anti-predation behaviour). In contrast to *Nephrops*, increased movement has been seen in these species in response to simulated shipping sound 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 fish and shellfish ecology study area, this research provides useful context for the sub-lethal effects from sound impacts which the shellfish IEF species will likely similarly be exposed to. It should be noted that many of the previous studies were laboratory-based, which could potentially reduce the reliability of their results when compared or applied to a real-world piling scenario, but this evidence is still useful for understanding possible impacts on shellfish species within the vicinity of the Mona Array Area.

3.9.3.74 Behavioural impacts have been noted in the giant scallop *Placopecten magellanicus*, with piling sound travelling through the seabed out to 50 m 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 Mona Array Area, given the relatively small proportion of the overall scallop population in the fish and shellfish ecology study area potentially affected by this impact.

3.9.3.75 Other than piling and vessel sound, shellfish will likely be exposed to pre-construction geophysical surveys within the Mona Array Area and Mona Offshore Cable Corridor and Access Areas. In evaluating this impact, a report by Christian *et al*. (2013) found no significant difference between acute effects of seismic airgun exposure upon caged adult snow crabs *Chionoecetes opilio* in comparison with those in control cages with no exposure to seismic pulses – these pulses are a similar impulsive high amplitude sound source to piling; >189 dB re 1 µPa $SPL_{pk}$ @ 1 m (which may be used in the pre-construction phase surveys). 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, which 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). Similarly, lobsters show the same trend eight months following exposure (Day *et al*., 2016), suggesting a low vulnerability and high recoverability to this sound source.

3.9.3.76 Regarding shellfish eggs and larvae, there is no direct evidence to suggest they are at risk of direct harm from high amplitude anthropogenic underwater sound such as piling (Edmonds *et al*., 2016). Evidence exists of underwater sound 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 sound 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 sound impacts. Similar to scallop larvae, exposure to sound 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.

3.9.3.77 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.

3.9.3.78 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

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

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

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

3.9.3.82 For herring, the magnitude of the impact is deemed to be medium, and the sensitivity of herring is considered to be high. The effect will, therefore, be of **moderate adverse** significance during the herring spawning season, which is significant in EIA terms. This is due to the hearing sensitivity of herring, coupled with the presence of discrete high and low intensity spawning grounds within range of underwater sound levels which may give rise to an effect. Even though these spawning grounds have relatively small amounts of overlap with sound contours from piling, the precautionary approach adopted for this assessment still indicates a potential moderate adverse effect when piling at locations in the north of the Mona Array Area using the maximum modelled hammer energy.

3.9.3.83 For most diadromous fish species, the magnitude of the impact is deemed to be low, and the sensitivity of diadromous IEFs are considered to be 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.

3.9.3.84 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. The short term, intermittent nature of the impact and the relatively small proportion of spawning habitats affected at any one time will only cause this to be significant if the piling activities occur during the peak migration period for this species, which could be accounted for in future piling activity scheduling.

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

### Further mitigation and residual effects

3.9.3.86 The project alone assessment predicts potentially significant effects to herring as a result of underwater sound generated by piling during the herring spawning period (late September for three to four weeks; Dickey-Collas *et al*., 2001). mitigation is secured through the Underwater sound management strategy (Document Reference J16) which is secured in the deemed marine licence. This strategy establishes a process of investigating options to manage underwater sound levels in consultation with the licensing authority and SNCBs and agreeing, prior to construction of those works which would lead to underwater sound impacts, which mitigation measures will be implemented to reduce impacts such that there will be no residual significant effect.

## 3.9.4 Increased suspended sediment concentrations (SSCs) and associated sediment deposition

3.9.4.1 Increases of SSC and associated deposition are predicted to occur during the construction and decommissioning phases as a result of the installation/removal of foundations, sandwave clearance activities and the installation of inter-array, interconnector, and export cables. Increases in suspended sediments and associated sediment deposition are also predicted to occur during the operations and maintenance phase due to inter-array, OSP interconnector, and export cable repair and reburial events. Volume 6, Annex 1.1: Physical processes technical report of the Environmental Statement provides a full description of the physical assessment, including numerical modelling used to inform the predictions made with respect to increases in suspended sediment and subsequent deposition. The MDS for this impact is outlined in Table 3.18.

3.9.4.2 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. 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 30 mg/l. Based on the data provided within this study, the SPM within the area of the Mona Offshore Wind Project has been estimated to range from approximately 0.9 mg/l to 3 mg/l between 1998 to 2005.

### Construction phase

### Magnitude of impact

3.9.4.3 For the purposes of this assessment, the following activities have been considered (see Table 3.18):

- Seabed preparation (sandwave, boulder and debris clearance)
- Drilling for foundation installation
- Installation of array, interconnector, and offshore export cables.

3.9.4.4 Increases in SSCs by sandwave clearance, cable installation, and foundation installation were modelled in Volume 6, Annex 1.1: Physical processes technical report of the Environmental Statement, based on the MDS parameters provided in Table 3.18.

3.9.4.5 Seabed clearance activities may be undertaken using a range of techniques and the use of a suction hopper dredger will result in the greatest increase in SSCs and largest plume extent as material is released near the water surface during disposal. Modelling simulated the use of a suction hopper dredger with a phasing representative of the scale of the sandwaves; dredging and then depositing material within the Mona Offshore Cable Corridor and Access Areas as it progressed along the route. The MDS for the inter-array and interconnector cables sandwave clearance also accounts for up to an 80 m wide corridor for 50% of the inter-array cables and for 40% of the interconnector cables.

3.9.4.6 Sandwave clearance may be required at up to 50% of the potential locations for suction bucket foundations and both sandwave clearance and dredging may be required for the installation of gravity base foundations. For the largest conical gravity bases the maximum dredging area per foundation may be 32,761 $m^2$ whilst the average area is 14,641 $m^2$, similarly the maximum dredging depth may be 10 m with an average depth of 3 m.

3.9.4.7 It is proposed that a small proportion of the dredged material from site preparation( 7,000 $m^3$ per foundation) is to be sequestered as ballast within the gravity base foundations. Within the Mona Array Area the seabed sediment is comprised largely of medium to coarse sand, as described in Volume 2, Chapter 1: Physical processes of the Environmental Statement, and is therefore suited to augment with rock infill to provide ballast. This material represents a depth of approximately 95 cm below the slab foundation and scour protection extent and <8% of the seabed preparation volume. At the site of each of the largest wind turbine gravity base foundations an average of 41,337 $m^3$ of gravel may be placed to underlie the installation. Therefore, although the sequestered material will be removed from the sediment budget, the sediment in question represents a smaller volume than that occupied by the gravity base foundation within the seabed and the installation processes will not result in a void which could potentially interrupt transport processes by intercepting sediment. This is fully assessed within Volume 2, Chapter 1: Physical processes of the Environmental Statement.

3.9.4.8 The dredging phase plumes (less than 50 mg/l) are predicted to be smaller than the plumes generated during disposal (1,000 mg/l), although the plume is expected to be most extensive when the deposited material is redistributed on successive tides, with average levels of less than 500 mg/l in the Mona Array Area. Sedimentation of deposited material in the Mona Offshore Cable Corridor and Access Areas is focussed within 100 m of the site of release with a maximum thickness of 0.5 to 1 m, whilst the finer sediment fractions are distributed in the vicinity at much smaller thicknesses of 5 to 10 mm. The dispersion of the released material is predicted to continue on successive tides. One day following cessation of clearance operations in the Mona Array Area results in approximately 1 m thickness of deposited material at the site of release on average. Sedimentation of 30 mm occurs at the trench site, with sediment thickness reducing moving away from the trench but remaining in the sediment cell and retained in the sediment transport system.

3.9.4.9 The MDS used for modelling for foundation installation assumes that up to 45 wind turbine foundations with three-legged jacket piles (5.5 m diameter) will be installed via drilling; the remaining 23 wind turbine foundations will be installed with suction bucket or gravity base foundations. The MDS for OSP foundation installation is based upon one six-legged jacket OSP, with three 5.5 m diameter pin piles per leg installed via drilling. Modelling also included concurrent drilling at two adjacent locations. Modelling was based upon larger 16 m diameter piles, with generates plumes of less than 50 mg/l SSC, therefore the smaller 5.5 m diameter piles would be expected to generate lower SSCs. SSCs within the plume would be localised, persisting only for a matter of days and within the plume envelope are expected to be less than 1 mg/l a short distance from the discharge location. Following cessation of drilling, turbidity levels reduce within a few hours, however some of the sediment fines released become re-suspended during successive tides as they are redistributed, but turbidity levels remain low overall. Beyond the immediate drilling location, the sedimentation is expected to be less than 1 mm thickness, therefore indiscernible from the surrounding sediments. SSCs are expected to return to baseline conditions with a couple of tidal cycles, although Spring tides following the works may lead to mobilisation and redistribution of unconsolidated deposits, incorporating the material into the existing tidal regime.

3.9.4.10 Modelling of suspended sediments associated with concurrent foundation installation in the northeast of the Mona Array Area showed the plume related directly to the sediment releases and was predicted to have an average concentration of less than 10 mg/l at the sites, that reduced rapidly with distance from the two discharge locations. Where the plumes converge concentrations were expected to be less than 1 mg/l. In the southeast of the site, the stronger currents and finer materials lead to a greater proportion of the material being held in suspension. The peak concentrations for the installation, and up to three days later, in the southeast of the Mona Array Area are approximately 50 mg/l, while average values are typically less than one fifth of this concentration. In the central north of the site average SSCs are 50 mg/l where the plumes coalesce. This is similar to the unmerged values as the plumes are travelling in concert with the tide (and not towards one another) and at the point that the plume reaches the adjacent discharge it is highly dispersed.

3.9.4.11 Sediments deposited on slack tide in the northeast of the Mona Array Area are expected to be resuspended on subsequent tides. Typically, this plume concentration will be less than 10 mg/l, and this reduces as distance from the site increases due to natural sediment dispersal. In the southeast of the Mona Array Area material also settled out on the slack tide and is expected to be re-suspended in subsequent tides, with the concentration of sediment resuspended being related to increasing current speed. In the central north of the Mona Array Area, the concentration at the centre of the plume envelope peak is expected to be approximately 50 mg/l. Three days after installation, sediment concentrations are expected to reduce, with sedimentation and resuspension occurring dependent on the current speed and tidal cycle. Peak concentrations in a resuspension event at this point are likely to reach a maximum of less than 30 mg/l, compared to average concentrations of a maximum of 3 mg/l in the area normally.

3.9.4.12 In the northeast of the Mona Array Area, the greatest sedimentation thicknesses occur at the drilling site, with very localised values of approximately 300 mm. This corresponds to the immediate settlement of coarser material fractions, the lower neap current speed in this area, and also the portion of work undertaken on slack tide. The coarser material is expected to remain at the drill site whilst the finer sand fraction will migrate to the east on the residual current, but with low deposition thicknesses of less than 1 mm due to the limited volume of material released overall. The naturally highly dispersive nature of spring tidal currents, coupled with the finer material in the southeast of the Mona Array Area, will result in the material being dispersed eastwards following the end of the installation. The resulting sedimentation thicknesses from the two drilling activities will be <0.1 mm, and this settlement will most likely be imperceptible when compared to background sediment transport activity. The suspended sediment will most likely be entrained into existing native material sand ripples.

3.9.4.13 As with the northeast of the Mona Array Area, the coarser material in the central north of the Mona Array Area will be retained at the site of the installation with a similar maximum sedimentation thickness of 300 mm. However, the material carried to the east on the residual current will be twice the thickness of the northeast location at approximately 3 mm. Once again, the formulation of sand ripples is evident. As noted previously, this is native material from the sediment cells and would be entrained into the baseline sediment transport patterns.

3.9.4.14 The MDS for the installation of inter-array cables and interconnector cables assumes installation via trenching. Trenches are expected to have a width of 3 m and a maximum depth of 6 m (Table 3.18). For the inter-array cable installation, peak plume concentrations occur at around 500 mg/l at the release site with the sediment settling during slack water and becoming resuspended in the form of an amalgamated plume. Sedimentation of 30 mm thickness occurs at the trench site, with sediment thicknesses reducing with increased distance from the trench. Sedimentation of 30 mm occurs at the trench site, with sediment thickness reducing moving away from the trench but remaining in the sediment cell and retained in the sediment transport system. The greatest area of increased SSC, extending approximately 20 km from the site (i.e. one tidal excursion), is associated with re-mobilisation of the deposited material on subsequent tides, with SSC ranging between 1,000 mg/l and 0.3 mg/l.

3.9.4.15 For offshore export cable installation, the modelled SSC along the route ranged between 50 mg/l and 1,000 mg/l with the highest levels identified at the source of the sediment release in the shallowest water. Modelling outputs predicted an average SSC of less than 300 mg/l along the offshore export cable route, falling to background levels on the slack tide. Tidal patterns indicate that although the released material migrates both east and west through settling and resuspension processes on successive tides, the sedimentation level is small (typically less than 0.5 mm thickness), and the greatest levels of deposition occur along the trenching route as coarser material settles. The maximum SSC during the dredging phase of the export cable installation was predicted to be 30 mg/l.

3.9.4.16 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 **low**.

### Sensitivity of receptor

#### Marine species

3.9.4.17 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement).

3.9.4.18 The north Irish Sea experiences regular temporary increases in SSC, linked heavily to interannual changes in 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 <5 mg/l, but this can increase to over 100 mg/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.

3.9.4.19 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 1,000 mg/l predicted in the inter-array cables and interconnector cables sandwave clearance and offshore export cable trenching 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 300 mg/l. These levels are unlikely to affect the development of most eggs and larvae.

3.9.4.20 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.

3.9.4.21 Queen scallop have the potential to suffer 74.1 to 88.9% mortality following continual burial under less than 5 cm of sediment for two to four consecutive days (Hendrick *et al*., 2016). Emergence success was found to be lowest from burial beneath finer sediment fractions to this depth, and no emergence was found from the 5 cm or 7 cm tested burial depths over any time period (Hendrick *et al*., 2016). This indicates a high intolerance to high levels of sedimentation over relatively short time periods, with burial for longer than two days increasing mortality highly significantly. Sedimentation of greater than 5 cm thickness is expected in the immediate vicinity of the construction activities on the first day following cessation of construction encompassing a very small area around the source (see Volume 2, Chapter 1: Physical processes of the Environmental Statement for average sedimentation figures), which has the potential to lead to mortality to queen scallop present, based upon laboratory results from Hendrick *et al.* (2016). Sediment is expected to dissipate to background levels for the area by the action of tidal cycles within approximately two days following the cessation of construction, which will reduce the potential for mortality of individuals.

3.9.4.22 The Hendrick *et al.* (2016) study was laboratory-based, with any sediment removed after the set investigated time period and then mortality checked by measurement of shell gape one minute following direct disturbance. Therefore, the mortality and emergence values might be overestimates compared to a real-world scenario, where buried queen scallop would only survive if they were able to emerge on their own typically within two days, or via hydrodynamic redistribution of deposited materials, which is expected within this time frame. Therefore, as a precautionary approach, it should be considered that any sedimentation of greater than 5 cm thickness would lead to no emergence and likely full mortality within the footprint of sedimentation, and any burial under sedimentation thicknesses of up to at least approximately 5 cm will significantly increase mortality if queen scallop individuals have not emerged in under two days.

3.9.4.23 King and queen scallop both have high intensity spawning grounds almost fully overlapping the Mona Array Area and are considered relatively mobile and are expected to avoid active events causing increases in SSC. This potential avoidance behaviour is less prevalent in juvenile king scallop when undergoing burial events, where burial from up to 5 cm of sediment deposition can reduce growth rates, potentially having impacts on future spawning times (Szostek, *et al*., 2013). However, the relatively low level of SSC and associated deposition, and the large area available outside of the immediate construction footprint for spawning, is unlikely to impact king scallop at a population level in the short or long term.

3.9.4.24 It has been found that for both species, survival is strongly linked to the ability to emerge from sediment (Last *et al*., 2011, Hendrick *et al*., 2016). Evidence exists that indicates that individuals of 1 mm in length have the potential to detach from the substrate in the event of disturbance, followed by recession into local sediments where possible, and where not possible this can lead to potential dispersal by currents and water turbulence (Minchin, 1992). Based on the findings of these studies, it is possible that juveniles and larvae of both species within the fish and shellfish ecology study area have the potential to survive short term increases in SSC and associated deposition. High levels of sedimentation are unlikely to occur outside of the immediate construction footprint at the Mona Offshore Wind Project based on the modelling presented in Volume 6, Annex 1.1: Physical processes technical report of the Environmental Statement (see average sedimentation figures), but king and queen scallop should be considered in the context of being intolerant of burial under sediment for extended time periods.

3.9.4.25 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 north of the Mona Array Area) is however 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 fish and shellfish ecology study area.

3.9.4.26 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 Mona Offshore Wind Project, 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 preferred high energy habitat and spawning environment within the Irish Sea (MarineSpace Ltd, 2013). Therefore, effects on sandeel spawning activity 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 (5 to 10mm of deposition, in close proximity to activities with lower sediment deposition across the wider area).

3.9.4.27 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 far northeast of the Mona 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 (Messieh *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 very limited amount of marginal or preferred sandy gravel sediments for herring spawning within the Mona Array Area, with the majority of the sediments assessed as unsuitable (Figure 3.2), 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 3.5), which shows high intensity herring spawning within the IoM 12 nm territorial waters, outside of the Mona Array Area Mona Offshore Cable Corridor and Access Areas, and the extent of plumes and sedimentation from the physical processes modelling at the north piling location (see Volume 2, Chapter 1: Physical processes of the Environmental Statement) which do not extend far beyond the array, and in an east to west orientation, thereby reducing any potential for impacts of SSC on herring.

3.9.4.28 Based on the sensitivity of herring eggs to the smothering effects of sediment deposition, herring is deemed to be of medium vulnerability, medium recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be **medium**.

3.9.4.29 Based on their intolerance to smothering, queen and king scallop are deemed to be of medium vulnerability, medium recoverability and of national importance; the sensitivity of these receptors is therefore considered **medium**. Queen scallop are considered of slightly higher vulnerability than king scallop to this impact, however overall, the sensitivity of both species is considered medium.

3.9.4.30 All other fish and shellfish ecology IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops*, 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

3.9.4.31 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 SSCs 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 Mona Offshore

Wind Project 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 the estuarine environments that these species are adapted to traverse.

3.9.4.32 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

3.9.4.33 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.

3.9.4.34 For king and queen scallop and herring, the magnitude of the impact 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

3.9.4.35 Overall, the magnitude of the impact is deemed to be low, and the sensitivity of the 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

3.9.4.36 Maintenance activities within the fish and shellfish ecology study area may lead to increases in SSC and associated sediment deposition over the operational lifetime of the Mona Offshore Wind Project. The MDS describes the repair of 10 km of inter-array cable in one event every three years, 16 km of interconnector cable in three events every 10 years and 32 km of offshore export cable every five years. The MDS also describes the reburial of 20 km of inter-array cable in one event every five years, 2 km of interconnector cable in one event every five years, 15 km of subtidal offshore export cable in one event every five years and up to 1.6 km of intertidal cable every five years.

3.9.4.37 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.

3.9.4.38 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

3.9.4.39 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.4.4 to paragraph 3.9.4.30), ranging from **low to medium** sensitivity, and these will equally apply in the operations and maintenance phase.

#### Diadromous species

3.9.4.40 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.4.31 to paragraph 3.9.4.32), with **low** sensitivity, and this will equally apply in the operations and maintenance phase.

### Significance of effect

#### Marine species

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

3.9.4.42 For king and queen scallop and herring, the magnitude of the impact is deemed to be negligible 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

3.9.4.43 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

### Magnitude of impact

3.9.4.44 Decommissioning of the Mona Offshore Wind Project 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.

3.9.4.45 The decommissioning of scour protection, cable protection, foundations, inter-array, interconnector and export cables, it is assumed, would result in increases in suspended sediments and associated deposition that were 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.

3.9.4.46 The impact is predicted to be of local spatial extent, short term duration (for the individual maintenance 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

3.9.4.47 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.4.4 to paragraph 3.9.4.30), ranging from **low to medium** sensitivity, and these will equally apply in the decommissioning phase.

#### Diadromous species

3.9.4.48 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.4.31 to paragraph 3.9.4.32), with **low** sensitivity, and this will equally apply in the decommissioning phase.

### Significance of effect

#### Marine species

3.9.4.49 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.

3.9.4.50 For king and queen scallop and herring, the magnitude of the impact 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

3.9.4.51 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.

## 3.9.5 Long term habitat loss

3.9.5.1 The construction, operations and maintenance and decommissioning activities on the generation and transmission assets of the Mona Offshore Wind Project 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 3.18. 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 3.9.7 below.

### Construction and operations and maintenance phases

### Magnitude of impact

3.9.5.2 The presence of the Mona Offshore Wind Project infrastructure within the fish and shellfish ecology study area will result in long term habitat loss. The MDS is for up to 2,192,412 m$^2$ of long-term habitat loss due to the installation of suction bucket jacket foundations and associated scour protection and cable protection associated with wind turbines and all types of cable (Table 3.18). This represents 0.52% of the area within the Mona Offshore Wind Project boundary.

3.9.5.3 Foundation and scour protection may account for up to 760,452 $m^2$ of long-term habitat loss. Foundation protection and associated scour protection will be required for up to 68 wind turbine foundations and four OSPs in the Mona Array Area.

3.9.5.4 Cable protection may account for up to 1,145,000 $m^2$ of long-term habitat loss. The MDS assumes up to 10% of 325 km of the inter-array cables, 20% of 50 km of the interconnector cables and 20 % of 360 km of the offshore export cables would require cable protection with a width of 10 m. Additionally cable crossing protection may result in 346,960 $m^2$ of long-term habitat loss. Cable protection may be required for 67 crossings for the inter-array cable, 10 crossings for the interconnector cable and 24 crossings for the offshore export cable.

3.9.5.5 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.

3.9.5.6 The fish and shellfish ecology study area encompasses areas of high and low intensity spawning ground for herring, although these are located outside of the Mona Offshore Wind Project, in the area of Douglas Bank within the IoM territorial waters. Further, the substrates within the Mona Array Area and along the Mona Offshore Cable Corridor and Access Areas showed limited observations of suitable substrate for herring spawning, with a small number of stations representing preferred substrata in the inshore half of the Offshore Export Cable. It's worth noting that this area is not in the vicinity of any mapped or reported herring spawning grounds.

3.9.5.7 Due to the absence of any overlap with mapped or reported herring spawning grounds, and the highly limited extent of substrate suitable for herring spawning, along with the highly localised spatial extent of the impact, it is predicted that this impact will not affect the receptor and the magnitude is therefore considered to be **negligible**.

3.9.5.8 In relation all other fish and shellfish ecology IEFs, 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

3.9.5.9 Fish and shellfish species that are reliant upon the presence of suitable sediment and 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 Mona 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.

3.9.5.10 As confirmed by the detailed baseline characterisation (see section 3.5), 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 3.14 and Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement).

3.9.5.11 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement) which extend well beyond the project boundaries, and thus are unlikely to be significantly impacted by long-term habitat loss. As previously discussed, the fish and shellfish ecology study area encompasses mapped high and low intensity herring spawning habitat in the area of Douglas Bank off the coast of the IoM (see section 3.5). These occur outside the Mona Offshore Wind Project boundaries and therefore will not be negatively affected by long term habitat loss from project infrastructure.

3.9.5.12 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 to suggest there are limited adverse effects on sandeel populations.

3.9.5.13 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 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement for habitat distribution and suitability). The presence of offshore wind farm infrastructure will result in direct impacts on this habitat within the Mona Array Area and Mona Offshore Cable Corridor and Access Areas, though as detailed above the proportion of habitat affected within the Mona Offshore Wind Project 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.

3.9.5.14 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), Atlantic cod, 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 Walney Extension Wind Farm found the development of mussel and barnacle communities around introduced structures (CMACS, 2014a). 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.

3.9.5.15 The Mona Array Area also directly overlaps grounds considered important to fishing and spawning of the commercially important queen and king scallop (see Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement 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 potential for decreased fishing pressure following completion of construction in some areas, with no significant change in resilience (Raoux *et al*., 2019), although some level of fishing activity is expected to continue during the operation and maintenance phase. 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.

3.9.5.16 *Nephrops* spawning habitat intersects slightly with the northeast of the Mona 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 Mona Offshore Wind Project affected by long term habitat loss is small and the proportion of *Nephrops* habitat overlapping the project boundaries are similarly small, the overall impact of long-term habitat loss is likely to be low.

3.9.5.17 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**.

3.9.5.18 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**.

3.9.5.19 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**.

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

3.9.5.21 Herring are deemed to be of high vulnerability, medium recoverability and of national importance; the sensitivity of herring is therefore considered **medium**.

#### Diadromous species

3.9.5.22 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 (e.g. those designated sites with diadromous fish species listed as qualifying features; see Table 3.14 and Volume 6, Annex 3.1: Fish and shellfish ecology technical report of the Environmental Statement). 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 Mona Offshore Wind Project is unlikely to cause any direct impact to diadromous fish species and would not affect migration to and from rivers.

3.9.5.23 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 sediments which dominate the fish and shellfish ecology study area. These sediments are known to recover quickly following cable installation (RPS, 2019).

3.9.5.24 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

3.9.5.25 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.

3.9.5.26 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.

3.9.5.27 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.

3.9.5.28 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.

3.9.5.29 For herring, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. Negligible significance is applied due to the absence of mapped spawning grounds and presence of highly limited substrate suitable for herring spawning within the footprint of long-term habitat loss. This suggests that the area of the Mona Offshore Wind Project is not important for spawning herring.

### Diadromous species

3.9.5.30 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.

## Decommissioning

### Magnitude of impact

3.9.5.31 Decommissioning will involve leaving the introduced scour protection, cable protection, and cable crossing protection in place, representing up to 2,195,276 $m^2$ of permanent subtidal habitat loss. Evidence exists to suggest recovery of habitats and species post-decommissioning could occur, based upon removal of all introduced infrastructure, but a precautionary approach of assessing this as permanent habitat loss has been adopted following stakeholder feedback. As such this assessment should be considered conservative.

3.9.5.32 Due to the absence of any overlap with mapped or reported herring spawning grounds, and the highly limited extent of substrate suitable for herring spawning, along with the highly localised spatial extent of the impact, it is predicted that this impact will not affect the receptor and the magnitude is therefore considered to be **negligible**.

3.9.5.33 For all other fish and shellfish ecology IEFs, 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

3.9.5.34 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.5.9 to paragraph 3.9.5.20), ranging from **low to medium** sensitivity, and these will equally apply in the decommissioning phase.

#### Diadromous species

3.9.5.35 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.4.28 to paragraph 3.9.4.31), with **low** sensitivity, and this will equally apply in the decommissioning phase.

### Significance of effect

#### Marine species

3.9.5.36 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.

3.9.5.37 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.

3.9.5.38 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.

3.9.5.39 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.

3.9.5.40 For herring, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. Negligible significance is applied due to the absence of mapped spawning grounds and presence of highly limited substrate suitable for herring spawning within the footprint of long-term habitat loss.

**Diadromous species**

3.9.5.41 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.

## 3.9.6 Electromagnetic Fields (EMFs) from subsea electrical cabling

3.9.6.1 The operations and maintenance activities on the transmission assets of the Mona Offshore Wind Project may lead to impacts from EMFs emitted from subsea electrical cabling. The MDS is represented by the presence and operation of inter-array, interconnector and offshore export cables and is summarised in Table 3.18.

### Operations and maintenance phase

### Magnitude of impact

3.9.6.2 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 50 µT (i.e. 500 mG) 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).

3.9.6.3 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 (proposed for the Mona Offshore Cable Corridor and Access Areas) changes direction (as per the frequency of the AC transmission) and creates a constantly varying electric field in the surrounding marine environment (Huang, 2005), which can be contained with a metallic screen or sheath.

3.9.6.4 The strength of the magnetic field (and consequently, induced electrical fields) decreases rapidly radially with distance from the source according to the inverse power law. A recent study conducted by CSA (2019) found that inter-array and offshore export cables buried between depths of 1 m to 2 m 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.

3.9.6.5 CSA (2019) investigated the link relationship between voltage, current, and burial depth, the results of which are presented in Table 3.28 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 1 m above the cable, while laterally away from the cable (i.e. at distances greater than 3 m), the magnetic fields at the seafloor and at 1 m above the seafloor are comparable.

**Table 3.28: Typical magnetic field levels over AC undersea power cables (buried at target depth of 0.9 to 1.8m) from offshore wind energy projects (CSA, 2019).**

| Power Cable Type buried at 0.9 m | 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 |
| Export Cable | 10 to 40 | 20 to 165 | <0.1 to 12 | 1 to 15 |
| **Power Cable Type buried at 1.8 m** | **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 |
| Export Cable | 0.2 to 2.0 | 1.9 to 3.7 | 0.02 to 1.1 | 0.04 to 1.3 |

3.9.6.6 During the operations and maintenance phase of the project there will be up to 325 km of 66 kV inter-array cables, up to 50 km of 275 kV HVAC interconnector cable and up to 360 km of 275 kV HVAC offshore export cables (Table 3.18). The minimum expected burial depth for cables will be 0.5 m, and the operations and maintenance phase is expected to last up to 35 years.

3.9.6.7 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

3.9.6.8 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).

3.9.6.9 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 3.29 provides an up-to-date summary of the scientific studies conducted to assess sensitivity of EMF on varying fish species.

**Table 3.29: 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 914 mG (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 and Langkeek, 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 800 mG (Love *et al*., 2017). |

3.9.6.10 A number of field studies have observed behaviours of fish and other species around AC submarine cables in the USA (see citations in Table 3.29). 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).

3.9.6.11 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 Mona Offshore Wind Project fish and shellfish ecology 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 1 V/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 (1.4 T) on shark catch rates, suggesting a low sensitivity to these fields.

3.9.6.12 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).

3.9.6.13 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 to 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.

3.9.6.14 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).

3.9.6.15 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).

3.9.6.16 Further research by Scott *et al.* (2021) found that physiological and behavioural impacts on edible crab occurred at 500 μT and 1,000 μT. For context, Earth's magnetic field averages 50 μT; Earth's iron core provides its own fluctuations over time, and solar flares also cause EMF impacts. Comparatively, EMFs created from cables could be considered insignificant. The Scott *et al.* (2021) study, found that EMFs caused disruption to the L-Lactate and D-Glucose circadian rhythm and altering Total Haemocyte Count in edible crab, and also caused specimens to be attracted 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 78.3 μT (Normandeau *et al.*, 2011), it can be assumed that the magnetic fields generated by the Mona offshore export 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 3.19.

3.9.6.17 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 to 1.8 m (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).

3.9.6.18 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**.

3.9.6.19 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

3.9.6.20 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*., 2020; 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 3.28). There is currently no evidence of lamprey responses to magnetic B fields (Gill and Bartlett, 2010).

3.9.6.21 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 7,000 km migration, with little to no impact on migratory behaviour noted beyond 500 m from wind farm development infrastructure (Ohman *et al*., 2007). Research in Sweden on the effects of a High Voltage Direct Current 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.

3.9.6.22 Table 3.30 provides a summary of the scientific studies conducted to assess sensitivity of EMF on varying diadromous fish species.

**Table 3.30: Relationship between geomagnetic field detection electro sensitivity, 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 950 mG 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 950 mG magnetic field at 50 Hz on swim behaviour (Armstrong *et al.*, 2015) | Not surveyed. |

3.9.6.23 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

3.9.6.24 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.

3.9.6.25 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

3.9.6.26 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.

## 3.9.7 Introduction of artificial structures and colonisation of hard structures

3.9.7.1 The construction and operations and maintenance activities on the generation assets and rock protection around the transmission assets will lead to the introduction of artificial structures and 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 3.18. 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).

## Operations and maintenance phase

### Magnitude of impact

3.9.7.2 The MDS is for up to 2,685,616 $m^2$ of habitat creation due to the installation of suction bucket jacket foundations (or gravity base foundations, if used in construction, although they have not been considered further due to their maximum design scenario being lower than the current present scenario), associated scour protection and cable protection associated with inter-array cables, interconnector and offshore export cables as well as their associated crossings in only subtidal habitats (Table 3.18). This equates to 0.65% of the area within the Mona Offshore Wind Farm boundary. This value however is likely an over estimation of habitat creation as it has been calculated assuming the foundations were a solid structure. The suction bucket jacket foundations will likely 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.

3.9.7.3 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).

3.9.7.4 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.

3.9.7.5 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 turbine foundation cleaning and maintenance may also cause debris to fall within the vicinity of the turbine foundation. It is likely that seaweed/algal material would disperse into the water column, with heavier material (e.g. mussel) being deposited within 10 m to 15 m of the foundation. This material has the potential to change the prevailing sediment type in the immediate vicinity of the wind turbine foundations, 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).

3.9.7.6 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 4: Marine mammals of the Environmental Statement) and ornithology (Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement) will be considered in their individual chapters.

3.9.7.7 The impact is predicted to be of local spatial extent, long term duration, continuous and irreversible during the lifetime of the Mona Offshore Wind Project. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

## Sensitivity of receptor

### Marine species

3.9.7.8 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).

3.9.7.9 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 turbine foundations compared to wind turbine foundations 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, 2013) 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, 2014b).

3.9.7.10 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, 2013). 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.

3.9.7.11 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).

3.9.7.12 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.).

3.9.7.13 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).

3.9.7.14 In contrast, post construction fisheries surveys conducted in line with the Food and Environmental Protection Act 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.

3.9.7.15 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.

3.9.7.16 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 the plumose anemone, *Metridium senile*). 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 Mona Array Area.

3.9.7.17 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 surveys around the Mona Array Area 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 2: Benthic subtidal and intertidal ecology of the Environmental Statement.

3.9.7.18 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

3.9.7.19 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 3.5.2). 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.

3.9.7.20 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 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 Mona 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 6, Annex 3.1: Fish and shellfish ecology technical chapter of the Environmental Statement 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.

3.9.7.21 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 Mona Offshore Wind Project. 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 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 Mona Array Area is situated in an area of 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 associated with turbine structures due to sandy habitat preferences (largely outside the Mona Array Area) and therefore sea trout may be less likely to be attracted to increased prey availability colonised on hard substrates, when there is an abundance of prey species which is not associated with the installation of hard substrate.

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

3.9.7.23 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.

3.9.7.24 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**.

3.9.7.25 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

3.9.7.26 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.

3.9.7.27 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

3.9.7.28 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.

### 3.9.8 Disturbance/remobilisation of sediment-bound contaminants

3.9.8.1 The construction, operations and maintenance, and decommissioning activities on the generation and transmission assets of the Mona Offshore Wind Project may lead to disturbance or remobilisation of sediment-bound contaminants such as metals, hydrocarbons, and organic pollutants. The MDS is represented by sandwave clearance, cable installation, cable repair, and any infrastructure removal activities and is summarised in Table 3.18.

3.9.8.1 The relevant MarESA pressures and benchmarks used to inform this impact assessment are described here.

- Transitional elements and organometal contamination: Exposure of marine species or habitat to one or more relevant contaminants via uncontrolled releases or incidental spills. The increase in transition elements levels compared to natural background concentrations are most likely due to their input from land/riverine sources, by air or directly at sea
- Hydrocarbon and Polycyclic Aromatic Hydrocarbons (PAH) contamination: Exposure of marine species or habitats to one or more relevant hydrocarbon contaminants via uncontrolled releases or incidental spills. Increases in the levels of these compounds are compared with natural background concentrations
- Synthetic compound contamination: Exposure of marine species or habitats to one or more relevant synthetic contaminants via uncontrolled releases or incidental spills. Increases in the levels of these compounds are compared with natural background concentrations.

#### Construction phase

#### Magnitude of impact

3.9.8.2 The installation of the Mona Offshore Wind Project infrastructure will likely lead to remobilisation of sediment-bound contaminants. Sediment grab samples from the Mona Array Area were analysed for contaminants including heavy metals, polychlorinated biphenyls (PCBs), and PAHs. The full results of this sediment chemistry analysis are detailed in Volume 6, Annex 2.1: Benthic ecology technical report of the Environmental Statement. The concentrations of the heavy metals, PAHs and PCBs was compared to the corresponding Cefas Action Levels 1 and 2 (AL1 and AL2) and the Canadian Threshold Effect Level (TEL) and probable effect levels. Within the Mona Array Area one site in the southwest exceeded the Cefas AL1 limit and Canadian TEL for Arsenic, and one site exceeded Cefas AL1 for cadmium within the Mona Array Area, but both were below Cefas AL2. Concentrations of PAHs and PCBs in all samples were found to be under AL1 and the Canadian Sediment Quality Guidelines (CSQGs).

3.9.8.3 The total area that is likely to be disturbed by construction activities, and therefore the potential volume of material disturbed, resulting in the potential release of sediment bound contaminants is set out in section 3.9.2. While the area affected is relatively large, the proportion of this area affected at any one time will only be a fraction of this overall total for the construction phase. The MDS is for 1,504,000 $m^3$ of spoil from export cable sandwave clearance (over a period of 12 months; noting sandwaves will be comprised of mobile sands with minimal fine sediments), 1,782 $m^3$ of spoil from the OSP foundation installation, up to 247,548 $m^3$ of spoil from wind turbine foundation installation, 1,620,000 $m^3$ for export cable installation (over a period of 15 months) and

2,925,000 $m^3$ for inter-array cable installation (over a period of 12 months) (Table 3.18).

3.9.8.4 Following disturbance as a result of construction activities, the majority of re-suspended sediments are expected to be deposited in the immediate vicinity of the works (for further detail on deposition see section 3.9.3.1.). The release of contaminants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and currents, and therefore increased bioavailability resulting in significant adverse eco-toxicological effects are not expected.

3.9.8.5 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 **low**.

## Sensitivity of receptor

### Marine species

3.9.8.6 The disturbance/remobilisation of sediment-bound contaminants has the potential to affect IEFs primarily within and in the vicinity of the Mona Array Area and Mona Offshore Cable Corridor and Access Areas. Generally, residues in water are less likely to be a long-term concern because of photo-degeneration and dilution to below biological significant concentrations, causing sediment-bound contaminants to be most impactful. Tolerance to heavy metals varies depending on species, and tolerance tends to be low for most groups of IEF species. For example, the capacity of bivalves, such as king and queen scallop, which have limited mobility to avoid this impact, to accumulate heavy metals exceeding background environmental levels, in their tissues is well known, resulting in sub-lethal effects (Aberkali and Trueman, 1985). The only heavy metal of concern within the subtidal area of the Mona Offshore Wind Project is non-anthropogenically introduced arsenic, which is present in levels lower than those typical of deep-sea sediments (typically 40 µg/g) (Neal *et al*., 1979). The most common bioavailable organoarsenic compound, arsenobetaine is not reported as having significant toxic impacts on fish and shellfish species if ingested (Neff, 1997), which is already highly unlikely in this situation. As such, the local fish and shellfish communities have developed in an environment of existing low levels of contamination, so any release of contaminants from construction activities is not likely to significantly increase bioavailability beyond natural levels. Suchanek (1993) reviewed the effects of oil on bivalves. Generally, contact with oil causes an increase in energy expenditure and a decrease in feeding rate, resulting in less energy available for growth and reproduction.

3.9.8.7 Studies on PCBs largely demonstrate they are highly toxic and can undergo biomagnification within food webs to have significant impacts on fish species such as sprat and herring (Vuorinen *et al*., 2002, Burreau *et al*., 2006). PCBs are also known to contaminate various shellfish species including scallop (Marsden and Cranford, 2016), as well as edible crab and velvet swimming crab (Bodin *et al*., 2007a). Crustacean species have been found to be able to metabolise PCBs (Bodin *et al*., 2007b), suggesting even low level PCB contamination will not have a significant impact on these species. Biomagnification within the food web can expose elasmobranchs, including but not limited to basking shark to this contaminant (Boldrocchi *et al*., 2022), with the potential for negative metabolic impacts if exposed for long periods of time (Tiktak *et al*., 2020). However, as there is no PCB concentration above AL1 within the Mona Array Area or Mona Offshore Cable Corridor and Access Areas, and these species are highly migratory, they are unlikely to be exposed to any short-term remobilisation of very low-level contaminants within the Mona Array Area.

3.9.8.8 The effects of remobilised sediment-bound PAHs are well understood, with significant negative impacts noted on sandeel hatching success and survival (Bunn *et al*., 2000), and a wide literature exists concerning other impacts on the identified marine IEFs. However, as all PAH concentrations were under AL1 and both CSQGs, this impact with have little to no effect on any species present.

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

3.9.8.10 Sandeel are deemed to be of medium vulnerability to PAHs specifically, medium recoverability, and regional importance. This would normally give a sensitivity of medium, but the lack of significant levels of PAHs in the Mona Array Area gives the receptor a sensitivity of **low**.

3.9.8.11 All other fish and shellfish IEFs 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**.

#### Diadromous species

3.9.8.12 Diadromous species will likely only be present within the fish and shellfish ecology study area when migrating to or from rivers flowing into the east Irish Sea. Therefore, the possibility for temporal and spatial overlap of these species and the very short-term remobilisation of sediment-bound contaminants, which will likely resettle within a small number of tidal cycles, is very low. Also, it is known that many diadromous species are exposed naturally to levels of PCBs, such as in trout (Atuma *et al*., 1993), sea lamprey (Madenjian *et al*., 2013), European eels (Bressa *et al*., 1997), and Atlantic salmon (Zitko, 1974). Similarly, bioaccumulation of heavy organometals has been noted on trout gills (Tkachenko *et al*., 2019), alongside a range of other low levels of natural exposure in other IEF species. Given this acclimation to natural contaminants, with no significant detriments to health or spawning noted at low levels, it is therefore likely that this impact will have little impact on diadromous species during construction.

3.9.8.13 All diadromous IEF 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

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

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

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

**Diadromous species**

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

## Decommissioning

### Magnitude of impact

3.9.8.18 Decommissioning could potentially involve the removal of scour protection or cable protection, or removal of suction caissons using overpressure, which would increase SSC overall in the area, with related remobilisation of sediment-bound contaminants. However, these will again be significantly below the amount remobilised during construction and will thus likely be below AL or CSQG thresholds.

3.9.8.19 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 indirectly. The magnitude is therefore considered to be **negligible** adverse.

### Sensitivity of receptor

**Marine species**

3.9.8.20 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.8.6 to paragraph 3.9.8.11) with low sensitivity, and these will equally apply in the decommissioning phase.

**Diadromous species**

3.9.8.21 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.8.12 to paragraph 3.9.8.13), with low sensitivity, and these will equally apply in the decommissioning phase.

### Significance of effect

3.9.8.22 The magnitude of the impact is deemed to be negligible, and the sensitivity of king and queen scallop are considered to be low. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

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

3.9.8.24 The magnitude of the impact is deemed to be negligible, and the sensitivity of all other IEFs is considered to be low. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

**Diadromous species**

3.9.8.25 The magnitude of the impact is deemed to be negligible, and the sensitivity of diadromous species is considered to be low. The effect will, therefore, be on **negligible** significance, which is not significant in EIA terms.

### 3.9.9 Injury due to increased risk of collision with vessels

3.9.9.1 Guidance provided by National Oceanic and Atmospheric Administration has defined serious injury to basking shark and marine mammals as 'any injury that will likely result in mortality' (National Marine Fisheries Service (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.

3.9.9.2 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 Mona Offshore Wind Project.

#### <u>Construction phase</u>

#### Magnitude of impact

3.9.9.3 Vessel traffic associated with the Mona Offshore Wind Project 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 (>7 m/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 Code of Conduct. The Code of Conduct 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 Mona Offshore Wind Project 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).

3.9.9.4 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 2,055 return trips by construction vessels may be made throughout the construction phase (Table 3.18). This could lead to an increase in interactions between basking shark and vessels, with up to 86 construction vessels on site at any one time over the maximum 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 sound emissions from vessels involved in the construction phase are likely to deter animals from the potential zone of impact.

3.9.9.5 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

3.9.9.6 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), and their need to spend time near the surface for breathing or basking activities (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).

3.9.9.7 There have been 63 reports of vessel collisions with basking shark over a 21-year study period (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), and they are known to migrate through this area; in typically under ten sightings per month are reported consistently throughout each year (Manx Whale and Dolphin Watch, 2023). However, it should be noted that no basking shark were observed during 24 months of aerial surveys of the Mona Array Area and as such, although they are known to occur in the area, there is no evidence to demonstrate that the Mona Offshore Wind Project is particularly important for basking shark, therefore reducing the potential for collision risk.

3.9.9.8 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 a Code of Conduct 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.

3.9.9.9 The basking shark within the fish and shellfish ecology study 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

3.9.9.10 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

3.9.9.11 Vessel usage during operations and maintenance phase of the Mona Offshore Wind Project may lead to injury to marine mammals 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 3.18).

3.9.9.12 Any on-site activities will require vessel transit, with up to 21 vessels present at any one time, and a maximum licenced 849 vessel movements to and from the site per year, with most of these being CTVs. Over the predicted 35-year lifetime of the Mona Offshore Wind Project, this could lead to a maximum of 29,715 vessel movements overall, with each representing a collision risk to basking shark. However, implementation of the Code of Conduct 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.

3.9.9.13 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

3.9.9.14 The sensitivity of the basking shark can be found in the construction phase assessment (paragraph 3.9.9.6 to paragraph 3.9.9.9), with **medium** sensitivity, and this will equally apply in the operations and maintenance phase.

### Significance of effect

3.9.9.15 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

### Magnitude of impact

3.9.9.16 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.

3.9.9.17 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

3.9.9.18 The sensitivity of the basking shark can be found in the construction phase assessment (paragraph 3.9.9.6 to paragraph 3.9.9.9), with **medium** sensitivity, and this will equally apply in the decommissioning phase.

### Significance of effect

3.9.9.19 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.

### 3.9.10 Future monitoring

3.9.10.1 No fish and shellfish ecology monitoring to test the predictions made within the impact assessment is considered necessary.

## 3.10 Cumulative effect assessment methodology

### 3.10.1 Methodology

3.10.1.1 The CEA takes into account the impact associated with the Mona Offshore Wind Project 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 5, Annex 5.1: Cumulative effects screening matrix of the Environmental Statement). 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.

3.10.1.2 The fish and shellfish ecology CEA methodology has followed the methodology set out in Volume 1, Chapter 5: EIA methodology of the Environmental Statement. As part of the assessment, all projects and plans considered alongside the Mona Offshore Wind Project 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 benthic subtidal and intertidal ecology (i.e. screening projects to a range of 50 km for additive effects) and physical processes (i.e. screening projects within two tidal excursions). However, for underwater sound during the construction phase, a larger buffer of 100 km from the Mona Offshore Wind Project has been used to screen projects to account for the greater zone of influence associated with construction sound (specifically piling).

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

- Tier 1: the Mona Offshore Wind Project 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, and/or those that are already operational but have an ongoing impact
- Tier 2: the Mona Offshore Wind Project considered alongside Tier 1 projects, as well as projects where:
  - Scoping report has been submitted and is in the public domain
- Tier 3: the Mona Offshore Wind Project considered alongside Tier 1 and Tier 2 projects, 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.

3.10.1.4 This tiered approach is adopted to provide a clear assessment of the Mona Offshore Wind Project alongside other projects, plans and activities. The assessment approach involves Tier 1 projects being considered alongside the Mona Offshore Wind Project, Tier 2 projects being assessed including Tier 1 projects and the Mona Offshore Wind Project, and Tier 3 being based on less definitive qualitative parameters due to the limited nature of information available for this Tier.

3.10.1.5 The specific projects, plans and activities scoped into the CEA, are outlined in Table 3.31 and shown in Figure 3.16. This list may be updated as the applications for new projects throughout the fish and shellfish study area become available, such as the scoping report of the Mooir Vannin Offshore Windfarm.

3.10.1.6 A number of the impacts considered for the Mona Offshore Wind Project alone, as outlined in Table 3.18 and section 3.9, 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 3.31: List of other projects, plans and activities considered within the CEA.**

1: 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.

| Project/plan | Status | Distance from the Mona array area (km) | Distance from the Mona offshore/onshore cable corridor (km) | Description of project/plan | Dates of construction (if applicable) | Dates of operation (if applicable) | Overlap with the Mona Offshore Wind Project |
|---|---|---|---|---|---|---|---|
| **Tier 1** | | | | | | | |
| **Offshore renewables** | | | | | | | |
| Awel y Môr Offshore Wind Farm[1] | Consented | 13.52 | 3.60 | Up to 50 wind turbines | 2026 to 2030 | 2030 to 2055 | The construction, operations and maintenance and decommissioning phases of this project will overlap with the construction and operations and maintenance of the Mona Offshore Wind Project. |
| **Dredging activities and dredge disposal sites** | | | | | | | |
| Liverpool 2 and River Mersey approach channel dredging (MLA/2018/00536/8) | Operational | 22.1 | 22.44 | Capital dredging in front of the proposed terminal to create a berth pocket. | n/a | 2019 to 2028 | Dredging and disposal activities associated with this project will overlap with the construction phase of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| Mersey channel and river maintenance | Operational | 22.1 | 22.53 | The Mersey Docks and Harbour Company Ltd, as the Harbour Authority for | n/a | 2021 to 2031 | Dredging and disposal activities associated with this |

| Project/plan | Status | Distance from the Mona array area (km) | Distance from the Mona offshore/onshore cable corridor (km) | Description of project/plan | Dates of construction (if applicable) | Dates of operation (if applicable) | Overlap with the Mona Offshore Wind Project |
|---|---|---|---|---|---|---|---|
| dredge disposal renewal (MLA/2021/00202) | | | | 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. | | | project will overlap with the construction and operations and maintenance phases of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| Conwy River | Operational | 35.2 | 7.70 | Dredging, no further information given. | n/a | 2022 to 2037 | Dredging and disposal activities associated with this project will overlap with the construction and operations and maintenance phases of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| Douglas Harbour, IoM | Operational | 43.1 | 67.0 | Dredging to deepen harbour channels and capital dredging in front of the proposed terminal to create a berth pocket. | n/a | 2016 to 2031 | Dredging and disposal activities associated with this project will overlap with the construction and operations and maintenance phases of the Mona Offshore |

| Project/plan | Status | Distance from the Mona array area (km) | Distance from the Mona offshore/onshore cable corridor (km) | Description of project/plan | Dates of construction (if applicable) | Dates of operation (if applicable) | Overlap with the Mona Offshore Wind Project |
|---|---|---|---|---|---|---|---|
| | | | | | | | Wind Project, and all phases in terms of vessel movements. |
| Walney Extension pontoon/jetty dredging and disposal (MLA/2018/00403) | Operational | 46.0 | 55.28 | Twice yearly dredging campaigns over the next 10 years at each of the two dredge locations. | n/a | 2019 to 2029 | Dredging and disposal activities associated with this project overlaps with the construction phase of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| Castletown Bay, IoM | Operational | 47.6 | 64.42 | Dredging to deepen harbour channels. | n/a | 2022 to 2037 | Dredging and disposal activities associated with this project will overlap with the construction and operations and maintenance phases of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| Port of Barrow maintenance dredging disposal licence | Operational | 48.1 | 58.07 | Dredging is required to maintain the Port of Barrow and its approach channel at its advertised navigational depth for all | n/a | 2016 to 2026 | Dredging and disposal activities associated with this project will overlap with the |

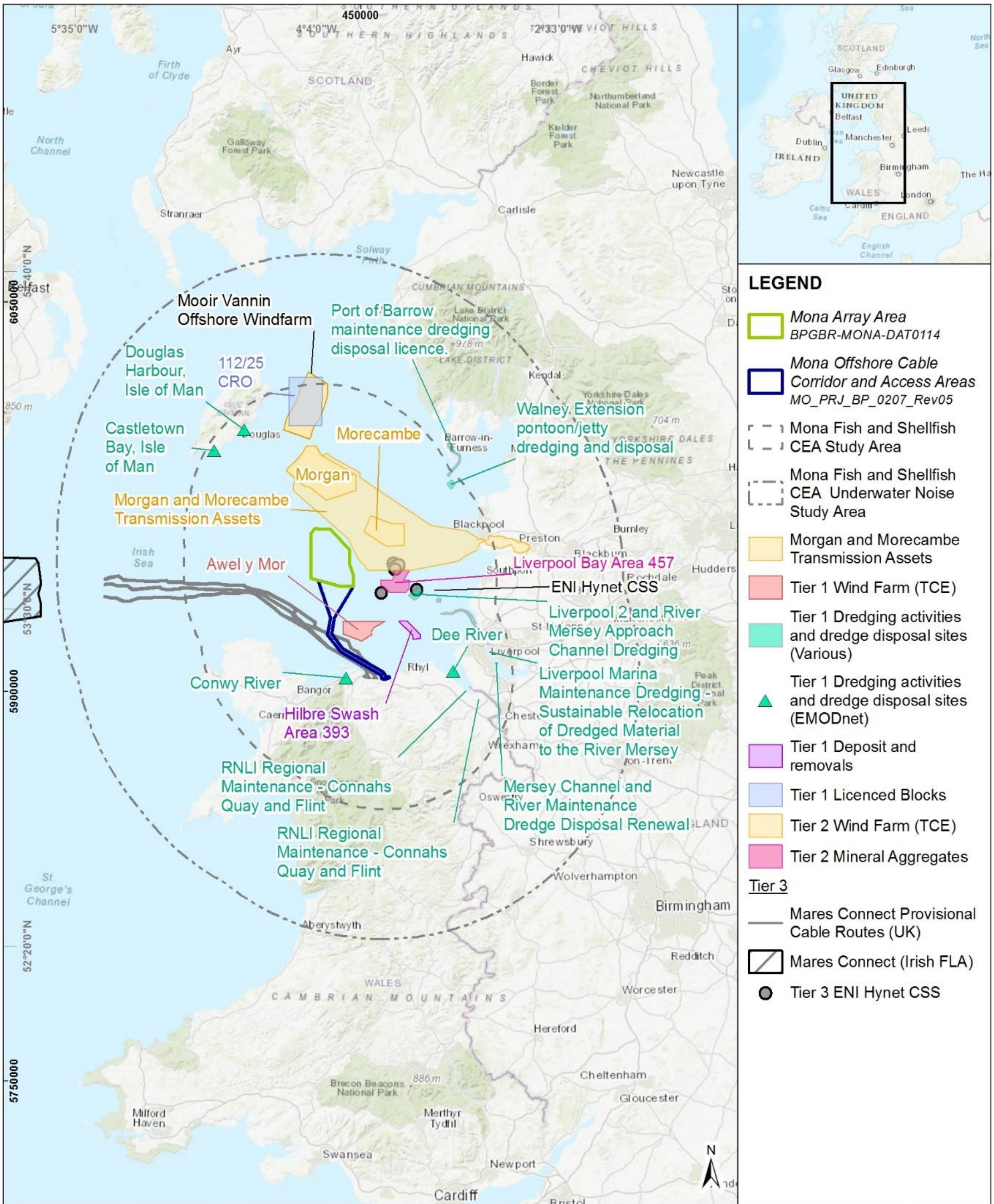
| Project/plan | Status | Distance from the Mona array area (km) | Distance from the Mona offshore/onshore cable corridor (km) | Description of project/plan | Dates of construction (if applicable) | Dates of operation (if applicable) | Overlap with the Mona Offshore Wind Project |
|---|---|---|---|---|---|---|---|
| (MLA/2015/00458/ 1) | | | | vessels entering and leaving the port. | | | construction phase of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| Dee River | Operational | 51.3 | 26.71 | Dredging, no further information given. | n/a | 2022 to 2037 | Dredging and disposal activities associated with this project will overlap with the construction and operations and maintenance phases of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| Liverpool Marina Maintenance Dredging - sustainable relocation of dredged material to the River Mersey (MLA/2020/00492) | Operational | 59.5 | 41.48 | Annual campaigns of maintenance dredging over the next ten years using small hydraulic dredger. | n/a | 2021 to 2030 | Dredging and disposal activities associated with this project will overlap with the construction and operations and maintenance phase of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |

| Project/plan | Status | Distance from the Mona array area (km) | Distance from the Mona offshore/onshore cable corridor (km) | Description of project/plan | Dates of construction (if applicable) | Dates of operation (if applicable) | Overlap with the Mona Offshore Wind Project |
|---|---|---|---|---|---|---|---|
| RNLI Regional Maintenance (MLA/2015/00016) | Operational | 59.9 | 31.76 | Low impact maintenance works to RNLI operated lifeboat stations and associated slipways, berths and other infrastructure. | n/a | 2019 to 2029 | Dredging and disposal activities associated with this project will overlap with the construction phase of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| **Deposit and removals** | | | | | | | |
| Hilbre Swash (NRW) (Marine aggregate extraction area number 392/393) | Operational | 22.4 | 17.20 | Licence to extract up to 12 million tonnes of aggregate (mainly sand) over 15 years. | n/a | 2015 to 2029 | Aggregate extraction activities associated with this project will overlap with the construction phase of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| **Other works – oil and gas** | | | | | | | |
| Isle of Man Crogga Licence: 112/25 | Operational | 33.92 | 61.60 | Block reference 112/25. Within IoM territorial waters. 266 km$^2$ offshore the northeast coast of the IoM. | n/a | 2017 to 2048 | Drill appraisal well operations will overlap with the construction of the Mona Offshore Wind Project, and all phases in terms |

| Project/plan | Status | Distance from the Mona array area (km) | Distance from the Mona offshore/onshore cable corridor (km) | Description of project/plan | Dates of construction (if applicable) | Dates of operation (if applicable) | Overlap with the Mona Offshore Wind Project |
|---|---|---|---|---|---|---|---|
| | | | | | | | of vessel movements. |
| **Tier 2** | | | | | | | |
| **Offshore Renewables Projects** | | | | | | | |
| Morgan Offshore Wind Farm | Pre-application | 5.52 | 32.93 | Up to 96 wind turbines | 2026 to 2028 | 2029 to 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 Mona Offshore Wind Project. |
| Morecambe Offshore Windfarm Generation Assets | Pre-application | 8.9 | 21.53 | Up to 40 wind turbines | 2026 to 2028 | 2029 to 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 Mona Offshore Wind Project. |

| Project/plan | Status | Distance from the Mona array area (km) | Distance from the Mona offshore/onshore cable corridor (km) | Description of project/plan | Dates of construction (if applicable) | Dates of operation (if applicable) | Overlap with the Mona Offshore Wind Project |
|---|---|---|---|---|---|---|---|
| Mooir Vannin Offshore Windfarm | Pre-application | 34.5 | 59.9 | Orsted have signed an agreement for lease to develop a 700 MW (annual output 3000 GWh) wind farm on the east coast and have undertaken initial surveys since 2016. | 2030 to 2032 | 2032 onwards | The operation and maintenance phase of this project is anticipated to overlap with the operation and maintenance phase of the Mona Offshore Wind Project. |
| **Oil and gas** | | | | | | | |
| ENI HyNet Carbon Capture and Storage (CCS) | Pre-application | 12.1 | 9.52 | CCS project in the east Irish Sea. Works will include installation of a new Douglas CCS platform and work on the existing Hamilton, Hamilton North and Lennox wellhead platforms. | 2024 to mid 2020s | Mid 2020s | The construction and operations and maintenance phases of this project may overlap with the construction, operations and maintenance and decommissioning phases of the Mona Offshore Wind Project. |
| **Cables and pipelines** | | | | | | | |
| Morgan and Morecambe Offshore Wind Farms Transmission Assets | Pre- application | 8.9 | 21.53 | Morgan and Morecambe Offshore Wind Farms Transmission Assets | 2026 to 2028 | 2029 to 2064 | Project construction phase overlaps with Mona Offshore Wind Farm construction phase. |

| Project/plan | Status | Distance from the Mona array area (km) | Distance from the Mona offshore/onshore cable corridor (km) | Description of project/plan | Dates of construction (if applicable) | Dates of operation (if applicable) | Overlap with the Mona Offshore Wind Project |
|---|---|---|---|---|---|---|---|
| **Deposit and removals** | | | | | | | |
| Liverpool Bay Area 457 | Pre-application | 10.99 | 11.01 | Westminster Gravels will be renewing their aggregate extraction licence in Area 457 in Liverpool Bay. Their Environmental Statement is planned to be submitted in 2024. Proposed extraction of 18 million tonnes of aggregate (mainly sand and fine sediment) over 15 years. | N/A | Unknown | Aggregate extraction activities associated with this project will overlap with the construction and operations and maintenance phases of the Mona Offshore Wind Project, and all phases in terms of vessel movements. |
| **Tier 3** | | | | | | | |
| **Cables and pipelines** | | | | | | | |
| MaresConnect – Wales-Ireland Interconnector Cable | Electricity licence from Ofgem, but no scoping report at this stage | 16.4 | 0.0 | A proposed 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 Mona Offshore Wind Project. |




**Service Layer Credits:** Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

**Data Sources:** Client, TCE, NRW, Lle Wales GeoPortal, NRW Survey Application P2578_R6143_Rev1, Departmnet of Housing Local Government and Heritage Forshore Application FS007635, NSTA, ENI

**Project Name:**
MONA OFFSHORE WIND PROJECT

0 5 10 20 30 nm
0 5 10 20 30 40 50 60 70 km

**Drawing Number:**
RPSE-MN-ES-FAS-038-04

**Drawing Title:**
OTHER PROJECTS, PLANS AND ACTIVITIES SCREENED INTO THE CUMULATIVE EFFECTS ASSESSMENT

**Geodetic Information:**
Datum: ETRS 1989
Projection: ETRS 1989 UTM Zone 30N
Scale@160mmx220mm: 1:2,500,000

| VER | DATE | DETAILS | BY | CHECK |
|---|---|---|---|---|
| 00 | 11/08/23 | First Issue | MJ | HM |
| 04 | 21/11/23 | Revision | NA | HM |

**Figure 3.16: Other projects, plans and activities screened into the cumulative effects assessment.**

### 3.10.2 Maximum design scenario

3.10.2.1 The MDSs identified in Table 3.32 have been selected as those having the potential to result in the maximum potential effect on an identified receptor or receptor group. The cumulative effects presented and assessed in this section have been selected from the PDE provided in Volume 1, Chapter 3: Project description of the Environmental Statement as well as the information available on other projects and plans, in order to inform a 'MDS'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the PDE (e.g. different turbine layout), to that assessed here, be taken forward in the final design scheme.

**Table 3.32: 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 Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Offshore Wind Farm projects:<br>– Awel y Môr Offshore Wind Farm construction phase<br>• Dredging projects:<br>– Walney Extension pontoon/jetty dredging and disposal<br>– Port of Barrow maintenance dredging disposal licence<br>– Liverpool Marina Maintenance Dredging<br>– Liverpool 2 and River Mersey approach channel dredging<br>– Mersey channel and river maintenance dredge disposal renewal<br>– Castletown Bay, IoM<br>– Douglas Harbour, IoM<br>– Conwy River<br>– Dee River<br>– RNLI Regional Maintenance<br>• Aggregates extraction activities:<br>– Hilbre Swash aggregate extraction<br>**Tier 2**<br>• Offshore Wind Farm projects:<br>– Morecambe Offshore Windfarm Generation Assets construction and operations and maintenance phases<br>– Morgan Offshore Wind Farm construction phase<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets<br>– ENI HyNet CCS project | These projects all involve activities which will result in temporary habitat disturbance/loss which may coincide with the construction and decommissioning phases for the Mona Offshore Wind Project contributing to the impact upon fish and shellfish IEFs cumulatively with the Mona Offshore Wind Project. |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | • Aggregates extraction activities:<br>– Liverpool Bay Area 457<br>**Tier 3**<br>• Cables and pipelines:<br>– MaresConnect – Wales-Ireland Interconnector Cable | |
| | × | × | ✓ | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>No tier 1 projects are predicted to overlap with the decommissioning phase of the Mona Offshore Wind Project.<br>**Tier 2**<br>• Offshore Wind Farm projects:<br>– Morgan Offshore Wind Farm decommissioning phase<br>– Morecambe Offshore Windfarm Generation Assets<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets<br>**Tier 3**<br>No tier 3 projects are predicted to overlap with the decommissioning phase of the Mona Offshore Wind Project. | |

| Potential cumulative effect | Phase[a] | | | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | C | O | D | | |
| Underwater sound impacting fish and shellfish receptors | ✓ | × | × | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Offshore wind farm projects:<br>– Awel y Môr Offshore Wind Farm<br>**Tier 2**<br>• Offshore wind farm projects:<br>– Morgan Offshore Wind Farm<br>– Morecambe Offshore Windfarm Generation Assets<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets<br>– ENI HyNet CCS project<br>**Tier 3**<br>No tier 3 projects are predicted to overlap with the construction phase of the Mona Offshore Wind Project. | These projects all involve activities which will result in underwater sound which may coincide with the construction phase for the Mona Offshore Wind Project contributing to the impact upon fish and shellfish IEFs cumulatively with the Mona Offshore Wind Project. These justifications broadly align with those noted in the CEA of Volume 2, Chapter 2: Benthic subtidal and intertidal ecology of the Environmental Statement. |
| Increased suspended sediment concentrations (SSCs) and associated sediment deposition | ✓ | × | × | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Offshore Wind Farm projects:<br>– Awel y Môr Offshore Wind Farm construction phase<br>• Dredging projects:<br>– Walney Extension pontoon/jetty dredging and disposal<br>– Port of Barrow maintenance dredging disposal licence<br>– Liverpool Marina Maintenance Dredging<br>– Liverpool 2 and River Mersey approach channel dredging<br>– Mersey channel and river maintenance dredge disposal renewal<br>– Castletown Bay, IoM<br>– Douglas Harbour, IoM<br>– Conwy River | These projects all involve activities which will result in increased SSC and sediment deposition which may coincide with the construction and decommissioning phases for the Mona Offshore Wind Project contributing to the impact upon fish and shellfish IEFs cumulatively with the Mona Offshore Wind Project. |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | – Dee River<br>– RNLI Regional Maintenance.<br>• Aggregate extraction activities:<br>– Hilbre Swash aggregate extraction<br>**Tier 2**<br>• Offshore Wind Farm projects:<br>– Morecambe Offshore Windfarm Generation Assets construction and operations and maintenance phases<br>– Morgan Offshore Wind Farm construction phase<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets.<br>– ENI HyNet CCS project<br>• Aggregates extraction activities:<br>– Liverpool Bay Area 457<br>**Tier 3**<br>• Cables and pipelines:<br>– MaresConnect – Wales-Ireland Interconnector Cable.<br>– | |
| | × | × | ✓ | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>No tier 1 projects are predicted to overlap with the decommissioning phase of the Mona Offshore Wind Project.<br>**Tier 2**<br>• Offshore Wind Farm projects:<br>– Morgan Offshore Wind Farm decommissioning phase<br>– Morecambe Offshore Windfarm Generation Assets<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets. | |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | **Tier 3**<br>No tier 3 projects are predicted to overlap with the decommissioning phase of the Mona Offshore Wind Project. | |
| Long term habitat loss. | ✓ | ✓ | × | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Offshore wind farm projects:<br>– Awel y Môr Offshore Wind Farm.<br>**Tier 2**<br>• Offshore wind farm projects:<br>– Morgan Offshore Wind Farm<br>– Morecambe Offshore Windfarm Generation Assets<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets.<br>– ENI HyNet CCS project<br>– Mooir Vannin Offshore Windfarm<br>**Tier 3**<br>• Cables/pipelines:<br>– MaresConnect Wales-Ireland Interconnector Cable.<br>– | These projects all involve activities resulting in the installation of hard structures on the seabed that could cause long term habitat loss which may coincide with the construction, operations and maintenance, and decommissioning phases for the Mona Offshore Wind Project, contributing to this impact upon fish and shellfish IEFs cumulatively with the Mona Offshore Wind Project. |
| | × | × | ✓ | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>No tier 1 projects are predicted to overlap with the decommissioning phase of the Mona Offshore Wind Project.<br>**Tier 2**<br>• Offshore Wind Farm projects:<br>– Morgan Offshore Wind Farm decommissioning phase | |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | – Morecambe Offshore Windfarm Generation Assets<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets<br>– ENI HyNet CCS project<br>**Tier 3**<br>• No tier 3 projects are predicted to overlap with the decommissioning phase of the Mona Offshore Wind Project. O | |
| Electromagnetic Fields (EMF) from subsea electrical cabling. | × | ✓ | × | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Offshore wind farm projects:<br>– Awel y Môr Offshore Wind Farm<br>**Tier 2**<br>• Offshore wind farm projects:<br>– Morgan Offshore Wind Farm<br>– Morecambe Offshore Windfarm Generation Assets<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets<br>– Mooir Vannin Offhore Windfarm.<br>**Tier 3**<br>• Cables/pipelines:<br>– 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 Mona Offshore Wind Project, contributing to this impact upon fish and shellfish IEFs cumulatively with the Mona Offshore Wind Project. |
| Introduction and colonisation of hard structures | ✓ | ✓ | × | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>• Offshore wind farm projects:<br>– Awel y Môr Offshore Wind Farm.<br>**Tier 2**<br>• Offshore wind farm projects: | 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 Mona Offshore Wind Farm, contributing to this impact upon |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | – Morgan Offshore Wind Farm<br>– Morecambe Offshore Windfarm Generation Assets<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets<br>– ENI HyNet CCS project<br>– Mooir Vannin Offshore Windfarm.<br>**Tier 3**<br>• Cables/pipelines:<br>– MaresConnect Wales-Ireland Interconnector Cable. | fish and shellfish IEFs cumulatively with the Mona Offshore Wind Project. |
| | × | × | ✓ | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans:<br>**Tier 1**<br>No tier 1 projects are predicted to overlap with the decommissioning phase of the Mona Offshore Wind Project.<br>**Tier 2**<br>• Offshore Wind Farm projects:<br>– Morgan Offshore Wind Farm decommissioning phase<br>– Morecambe Offshore Windfarm Generation Assets<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets<br>– ENI HyNet CCS project.<br>**Tier 3**<br>No tier 3 projects are predicted to overlap with the decommissioning phase of the Mona Offshore Wind Project. | |
| Injury due to increased risk of collision with vessels (basking shark only) | ✓ | ✓ | ✓ | MDS as described for the Mona Offshore Wind Project (Table 3.18) assessed cumulatively with the following other projects/plans in all phases:<br>**Tier 1**<br>• Offshore Wind Farm projects:<br>– Awel y Môr Offshore Wind Farm construction phase.<br>• Dredging projects: | 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 Mona Offshore Wind Project, contributing to the impact on |

| Potential cumulative effect | Phase[a] C | O | D | Maximum Design Scenario | Justification |
|---|---|---|---|---|---|
| | | | | – Walney Extension pontoon/jetty dredging and disposal<br>– Port of Barrow maintenance dredging disposal licence<br>– Liverpool Marina Maintenance Dredging<br>– Liverpool 2 and River Mersey approach channel dredging<br>– Mersey channel and river maintenance dredge disposal renewal<br>– Castletown Bay, IoM<br>– Douglas Harbour, IoM<br>– Conwy River<br>– Dee River<br>– RNLI Regional Maintenance.<br>• Aggregate extraction activities:<br>– Hilbre Swash aggregate extraction<br>• Oil and gas works<br>– Isle of Man Crogga Licence: 112/25<br>**Tier 2**<br>• Offshore Wind Farm projects:<br>– Morecambe Offshore Windfarm Generation Assets construction and operations and maintenance phases<br>– Morgan Offshore Wind Farm construction phase<br>– Morgan and Morecambe Offshore Wind Farms Transmission Assets.<br>– ENI HyNet CCS project<br>– Mooir Vannin Offshore Windfarm<br>• Aggregates extraction activities:<br>– Liverpool Bay Area 457<br>**Tier 3**<br>• Cables and pipelines:<br>– MaresConnect – Wales-Ireland Interconnector Cable.<br>– | this fish IEF cumulatively with the Mona Offshore Wind Project. |

# 3.11 Cumulative effects assessment

## 3.11.1 Overview

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

## 3.11.2 Temporary subtidal habitat loss/disturbance

3.11.2.1 There is the potential for cumulative temporary habitat loss as a result of construction and decommissioning activities associated with the Mona Offshore Wind Project 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 3.32). For the purposes of this Environmental Statement, this additive impact has been assessed within the cumulative fish and shellfish ecology study area, defined as the area within a 50 km buffer of the Mona Offshore Wind Project, and a 100 km buffer for underwater sound, using the tiered approach outlined above. The 50 km buffer area captures a fair representation of potentially impacted fish and shellfish IEFs within the Mona cumulative fish and shellfish ecology study area in proximity to the Mona Offshore Wind Project. The potential effects of this impact alone were assessed for this project in section 3.9.2.

3.11.2.2 Almost all plans, projects and 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). Five tier 2 projects have been identified within the cumulative fish and shellfish ecology study area (i.e. Morecambe Offshore Windfarm Generation Assets, Morgan Offshore Wind Project Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, ENI HyNet CCS and Liverpool Bay Area 457 aggregates extraction), and one tier 3 projects have been identified (i.e. MaresConnect Wales-Ireland Interconnector Cable).

### Tier 1

### Construction phase

### Magnitude of impact

3.11.2.3 Predicted cumulative temporary habitat loss and disturbance from each of the tier 1 plans, projects and activities is presented in Table 3.33 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 3.33 shows that for all projects, plans, and activities in the tier 1 assessment, the cumulative temporary habitat loss/disturbance is estimated at 96.51 km$^2$ (including the Mona Offshore Wind Project).

3.11.2.4 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 10.02 km$^2$. The values of temporary habitat loss for the Mona Offshore Wind Project are significantly larger than for this tier 1 project, as the Mona Offshore Wind Project assessment includes a larger area of habitat affected as a result of seabed preparation and all of the associated construction activities.

3.11.2.5 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 4.22 km$^2$ of seabed spread over the construction period and potentially beyond (Table 3.33). There are also a number of dredge licences without readily available environmental information (i.e. Castletown Bay, IoM; Douglas Harbour, IoM; Conwy River; Dee River; Walney Extension pontoon/jetty dredging and disposal, and RNLI Regional Maintenance (Figure 3.16)). The dredging is however of a small scale and likely to be intermittent throughout the Mona Offshore Wind Project construction phase affecting relatively small areas in comparison with the Mona Offshore Wind Project.

3.11.2.6 For licensed aggregate deposits and removal, the maximum total temporary habitat loss/disturbance is estimated at approximately 21.76 km$^2$ (Table 3.33). This figure is associated with aggregate extraction at the Hilbre Swash site, which is licenced for the next 15 years. It is unlikely that the whole site will be active at once therefore the impact associated with aggregate extraction at this site will be spread over the full length of the licence therefore resulting in longer-term low-level disturbance; the value presented in Table 3.33 is therefore a considerable overestimate.

3.11.2.7 For the cables scoped into the cumulative assessment, the two projects listed in Table 3.33 had specific published predicted temporary habitat loss data available. The magnitude of these activities is likely to be minimal, with little to no direct overlap with the Mona Offshore Wind Project.

**Table 3.33: Cumulative temporary habitat loss for the Mona Offshore Wind Project 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 |
|---|---|---|---|
| Mona Offshore Wind Project | 60.51 | See Table 3.18 | n/a |
| **Offshore renewables** | | | |
| Awel y Môr Offshore Wind Farm | Construction: 10.02 | Temporary habitat disturbance/loss may result from:<br>• Jack up events<br>• Anchoring<br>• Sandwave clearance<br>• Intertidal Horizontal Directional Drilling. | RWE (2022) |
| **Dredging activities and dredge disposal sites** | | | |
| Port of Barrow maintenance dredging disposal licence. | 0.01 | Temporary habitat disturbance/loss may result from:<br>• Dredging of silt, sand and gravel.<br>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) |

| Project | Predicted temporary habitat disturbance/loss (km$^2$) | Component parts of temporary habitat disturbance/loss | Source |
|---|---|---|---|
| Liverpool Marina Maintenance Dredging – sustainable relocation of dredged material to the River Mersey | No official figure given. | Temporary habitat disturbance/loss may result from:<br>• Dredging. | Anthony D Bates Partnership LLP (2020) |
| Liverpool 2 and River Mersey approach channel dredging | 3.71 | Temporary habitat disturbance/loss may result from:<br>• Dredging of silt.<br>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:<br>• Dredging of silt and sand. | Royal Haskoning (2018) |
| **Deposit and removals** | | | |
| Hilbre Swash | 21.76 | Temporary habitat disturbance/loss may result from:<br>• Aggregate extraction (mainly sand).<br>The values provided for this project represent the area of the project as no temporary habitat disturbance/loss values were provided. | NRW (2013) |
| **Total** | 96.51 | | |

3.11.2.8 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** for most fish and shellfish ecology IEFs.

3.11.2.9 For herring, due to the absence of mapped or reported spawning grounds and minimal proportion of suitable substrates for herring spawning within the Mona Offshore Wind Project, the magnitude is considered to be **negligible** as the receptor is not expected to be perceptibly affected by the impact.

3.11.2.10 For sandeel, due to the presence of mapped high and low intensity spawning grounds within the entire region, and the site-specific survey findings of preferred sediment for sandeel habitation and spawning within the Mona Offshore Wind Project, the magnitude is considered to be **low**. The cumulative effect is predicted to be regional spatial extent, medium term duration, intermittent and of high reversibility.

## Sensitivity of the receptor

### Marine species

3.11.2.11 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraph 3.9.2.14 to paragraph 3.9.2.37.

3.11.2.12 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**.

3.11.2.13 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**.

3.11.2.14 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**.

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

3.11.2.16 Herring are deemed to be of high vulnerability, medium recoverability and of national importance. The sensitivity of herring to this impact is therefore considered to be **high**.

### Diadromous species

3.11.2.17 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraph 3.9.2.38 to paragraph 3.9.2.40.

3.11.2.18 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

3.11.2.19 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.

3.11.2.20 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.

3.11.2.21 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.

3.11.2.22 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be high. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. Minor adverse significance is considered appropriate given the wide-ranging habitat for this species, encompassing the entire fish and shellfish ecology study area and the reported recoverability of sandeel to temporary habitat loss and disturbance.

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

**Diadromous species**

3.11.2.24 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 **negligible** significance, which is not significant in EIA terms.

## Tier 2

## Construction phase

### Magnitude of impact

3.11.2.25 The tier 2 Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Windfarm Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, and ENI HyNet CCS project within the cumulative fish and shellfish ecology study area are likely to create temporary habitat disturbance/loss. For the Morgan Offshore Wind Project Generation Assets 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 Morgan Offshore Wind Project Generation Assets is up to 85.54 $km^2$ (Morgan Offshore Wind Ltd., 2023) and is therefore similar to, and slightly larger than, that arising from the Mona Offshore Wind Project.

3.11.2.26 For the Morecambe Offshore Windfarm Generation Assets temporary habitat disturbance/loss is likely to result from site preparation activities in advance of foundation 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 Morecambe Offshore Windfarm Generation Assets is up to 3.46 $km^2$ (Morecambe Offshore Windfarm Ltd., 2023).

3.11.2.27 For the Morgan and Morecambe Offshore Wind Farms Transmission Assets, temporary habitat disturbance/loss is likely to result from jack-up events, cable installation, sandwave clearance, anchor placement and cable removals. The temporary habitat disturbance/loss predicted to result from the Morgan and Morecambe Offshore Wind Farms Transmission Assets is up to 64.03 $km^2$, thus being similar to the Mona Offshore Wind Project.

3.11.2.28 For the ENI HyNet CCS project, the activities will involve construction of offshore platforms, offshore carbon dioxide injection wells, offshore pipelines and offshore power and fibre optic cables, with a licenced area of 576.82 $km^2$ (ENI, 2023). The temporary habitat loss associated with these construction activities will be short term and intermittent in small areas over an 18 month period and are unlikely to represent a significant increase in temporary habitat loss cumulatively.

3.11.2.29 The Liverpool Bay Area 457 aggregate and disposal project will also likely have temporal overlap with the construction phase of the Mona Offshore Wind Project. The aggregate extraction is licenced to occur within an area of up to 64.8 $km^2$ (MarineSpace, 2023), although the actual extraction activities will be short term and intermittent, with recovery expected in this area following aggregate extraction. The licenced extraction activities will be up to 18 megatons over a 15 year period, with a maximum extraction rate of 1.2 megatons per year, representing a relatively small area of temporary habitat loss overall. Further, aggregates projects in English waters undertake monitoring by applying the Cefas OneBenthic M-test (or Mahalanobis test) tool under the Marine Aggregates Application, based on the Regional Seabed Monitoring Programme (Cooper and Martinez, 2017). This requires sediment sample data to be uploaded into the M-test tool, which then advises, based upon the substrate classification from the baseline data, whether there is sufficiently similar sediment remaining to allow for recolonisation by the existing faunal assemblage. Where samples fail the M-test, additional investigation is required by the licence holder.

3.11.2.30 For most fish and shellfish ecology IEFs the cumulative effect is predicted to be of regional spatial extent, medium term duration (i.e. the construction phase for the Mona Offshore Wind Project 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**.

3.11.2.31 For herring, due to the absence of mapped or reported spawning grounds and minimal proportion of suitable substrates for herring spawning within the Mona Offshore Wind Project, the magnitude is considered to be **negligible** as the receptor is not expected to be perceptibly affected by the impact.

3.11.2.32 For sandeel, due to the presence of mapped high and low intensity spawning grounds within the entire region, and the site-specific survey findings of preferred sediment for sandeel habitation and spawning within the Mona Offshore Wind Project, the magnitude is considered to be **low**. The cumulative effect is predicted to be regional spatial extent, medium term duration, intermittent and of high reversibility.

## Sensitivity of the receptor

### Marine species

3.11.2.33 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraph 3.9.2.14 to paragraph 3.9.2.37.

3.11.2.34 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**.

3.11.2.35 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**.

3.11.2.36 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**.

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

3.11.2.38 Herring are deemed to be of high vulnerability, medium recoverability and of national importance. The sensitivity of herring to this impact is therefore considered to be **high**.

**Diadromous species**

3.11.2.39 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraph 3.9.2.40.

3.11.2.40 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**

3.11.2.41 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.

3.11.2.42 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.

3.11.2.43 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.

3.11.2.44 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be high. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. Minor adverse significance is considered appropriate given the wide-ranging habitat for this species, encompassing the entire fish and shellfish ecology study area and the reported recoverability of sandeel to temporary habitat loss and disturbance.

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

**Diadromous species**

3.11.2.46 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 **negligible** significance, which is not significant in EIA terms.

## Decommissioning phase

### Magnitude of impact

3.11.2.47 The decommissioning phases of the Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Windfarm Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, and ENI HyNet CCS project will likely have temporal overlap with the decommissioning of the Mona Offshore Wind Farm. 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 0.47 $km^2$ of this associated with the Morgan Offshore Wind Project Generation Assets (Morgan

Offshore Wind Ltd., 2023), which will be similar in size to the Mona Offshore Wind Project.

3.11.2.48 For the Morgan and Morecambe Offshore Wind Farms Transmission Assets, decommissioning activities are anticipated to involve the removal of up to 60 km of interconnector cables, and up to 610 km of offshore export cables. This will have a potential impact up to the magnitude for the installation of these during the construction phase and will be much lower overall due to the lack of sandwave clearance or pre-lay preparation required.

3.11.2.49 For the ENI HyNet CCS project, the activities involved in decommissioning of offshore infrastructure is likely to involve the removal of development infrastructure using similar strategies to the construction, including the use of jack-up vessels and drill rig spud deployments. It is unlikely these will represent a significant increase in temporary habitat loss and are likely to be smaller in magnitude than the construction phase.

3.11.2.50 For the Morecambe Offshore Windfarm: Generation Assets, the predicted temporary habitat loss/disturbance the construction phase is estimated at 3.56 $km^2$. This includes the installation of wind turbines, OSPs and inter-array and interconnector cables for the Morecambe Offshore Windfarm: Generation Assets as well as jack-up events (Morecambe Offshore Windfarm Ltd., 2023).

3.11.2.51 For most fish and shellfish ecology IEFs 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 of high reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low**.

3.11.2.52 For herring, due to the absence of mapped or reported spawning grounds and minimal proportion of suitable substrates for herring spawning within the Mona Offshore Wind Project, the magnitude is considered to be **negligible** as the receptor is not expected to be perceptibly affected by the impact.

3.11.2.53 For sandeel, due to the presence of mapped high and low intensity spawning grounds within the entire region, and the site-specific survey findings of preferred sediment for sandeel habitation and spawning within the Mona Offshore Wind Project, the magnitude is considered to be **low**. The cumulative effect is predicted to be regional spatial extent, medium term duration, intermittent and of high reversibility.

## Sensitivity of the receptor

### Marine species

3.11.2.54 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraph 3.9.2.14 to paragraph 3.9.2.37.

3.11.2.55 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**.

3.11.2.56 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**.

3.11.2.57 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**.

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

3.11.2.59 Herring are deemed to be of high vulnerability, medium recoverability and of national importance. The sensitivity of herring to this impact is therefore considered to be **high**.

#### Diadromous species

3.11.2.60 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraph 3.9.2.40.

3.11.2.61 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

3.11.2.62 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.

3.11.2.63 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.

3.11.2.64 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.

3.11.2.65 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be high. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. Minor adverse significance is considered appropriate given the wide-ranging habitat for this species, encompassing the entire fish and shellfish ecology study area and the reported recoverability of sandeel to temporary habitat loss and disturbance.

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

#### Diadromous species

3.11.2.67 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 **negligible** significance, which is not significant in EIA terms.

## Tier 3

## Construction phase

### Magnitude of impact

3.11.2.68 The proposed construction of the MaresConnect Wales-Ireland Interconnector Cable will likely overlap with the construction phase of the Mona Offshore Wind Project, leading to a potential cumulative impact. As this project is only at the proposal stage, no specifications are publicly available currently. The anticipated construction timeline is not currently publicly available for the MaresConnect (MaresConnect, 2023). The laying and burying of the MaresConnect cable will likely follow standard jet trenching and cable protection installation, although technical specifications will only be released at later development stages.

3.11.2.69 For most fish and shellfish ecology IEFs 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**.

3.11.2.70 For herring, due to the absence of mapped or reported spawning grounds and minimal proportion of suitable substrates for herring spawning within the Mona Offshore Wind Project, the magnitude is considered to be **negligible** as the receptor is not expected to be perceptibly affected by the impact. Impacts may occur due to the up to 100 wind turbines expected to be constructed for the Isle of Man Offshore Wind Farm, however due to the Mona Offshore Wind Project not being considered important for herring spawning, no cumulative effect including Mona Offshore Wind Project is expected to occur.

3.11.2.71 For sandeel, due to the presence of mapped high and low intensity spawning grounds within the entire region, and the site-specific survey findings of preferred sediment for sandeel habitation and spawning within the Mona Offshore Wind Project, the magnitude is considered to be **low**. The cumulative effect is predicted to be regional spatial extent, medium term duration, intermittent and of high reversibility.

### Sensitivity of the receptor

**Marine species**

3.11.2.72 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraph 3.9.2.14 to paragraph 3.9.2.37.

3.11.2.73 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**.

3.11.2.74 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**.

3.11.2.75 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**.

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

3.11.2.77 Herring are deemed to be of high vulnerability, medium recoverability and of national importance. The sensitivity of herring to this impact is therefore considered to be **high**.

**Diadromous species**

3.11.2.78 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraph 0 to paragraph 3.9.2.40.

3.11.2.79 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**

3.11.2.80 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.

3.11.2.81 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.

3.11.2.82 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.

3.11.2.83 For sandeel, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be high. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. Minor adverse significance is considered appropriate given the wide-ranging habitat for this species, encompassing the entire fish and shellfish ecology study area and the reported recoverability of sandeel to temporary habitat loss and disturbance.

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

**Diadromous species**

3.11.2.85 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 **negligible** significance, which is not significant in EIA terms.

### 3.11.3 Underwater sound impacting fish and shellfish receptors

3.11.3.1 There is the potential for cumulative impacts from underwater sound generation as a result of construction phase of the Mona Offshore Wind Project and other offshore wind farms (i.e. pile driving and UXO clearance; see Table 3.32). For the purposes of this Environmental Statement, this additive impact has been assessed within the cumulative fish and shellfish ecology study area for underwater sound, defined as the area within a 100 km buffer of the Mona Offshore Wind Project, using the tiered approach outlined above. The 100 km buffer area captures a fair representation of potentially impacted fish and shellfish IEFs within the Mona cumulative fish and shellfish ecology study area in proximity to the Mona Offshore Wind Project in relation to underwater sound effects. The potential effects of this impact alone were assessed for this project in section 3.9.2.

3.11.3.2 All plans, projects and activities screened into the assessment for cumulative effects from underwater sound are other offshore wind farms which are consented, or pre-application. One tier 1 project has been identified (Awel y Môr Offshore Wind Farm), four tier 2 projects (Morecambe Offshore Windfarm Generation Assets, Morgan Offshore Wind Project Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, ENI HyNet CCS), and one tier 3 project (Isle of Man Offshore Wind Farm).

**Tier 1**

**Construction phase**

### Magnitude of impact

3.11.3.3 The construction phases of the Awel y Môr Offshore Wind Farm will have temporal and spatial overlap with the Mona Offshore Wind Farm in terms of construction sound (specifically piling and UXO clearance), potentially resulting in a cumulative impact. The assessment of sound impacts associated with the Mona Offshore Wind Farm alone has been presented above (section 3.9.3), with a low magnitude identified based on a range of technical specifications and sound modelling outputs.

3.11.3.4 For the Awel y Môr, maximum hammer piling energy of up to 5,000 kJ 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 Mona Offshore Wind Project this would equate to up to 188 days and 2,048 hours of piling over construction phases of several years (i.e. four and three years for Mona and Awel y Môr, respectively). The Awel y Môr figures are expected to be further refined and reduced in future as the engineering progresses, likely taking less construction time than the Mona Offshore Wind Farm.

3.11.3.5 Sound modelling undertaken for the Awel y Môr project indicated similar patterns as those for the Mona Offshore Wind Project, with injury and mortality to ranges of up to 1.3 km for group 1 fish, 6.3 km for group 2 fish, and 8.6 km calculated for group 3 fish, if modelled as static receptors (RWE, 2022). In all cases, modelling the fish as receptors moving away from the sound source highly significantly reduced mortality distances, down to <100 m even for group 3 fish. Injury distances were calculated to reach out to up to 12.0 km for group 3 static receptors, with this again reducing to up to 120 m when fish were modelled as receptors moving away from the sound source, with similar patterns for all other groups of fish.

3.11.3.6 As with the Mona Offshore Wind Project, 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 Mona Offshore Wind Project, with behavioural effects expected to a range of 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 sound 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.

3.11.3.7 For most fish and shellfish ecology IEFs 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**.

3.11.3.8 Awel y Môr and the Mona Offshore Wind Project sit across areas of mapped high and low intensity cod spawning ground. Underwater sound levels from the two projects cumulatively are expected to increase if piling were to occur concurrently at the two projects, due to the larger maximum hammer energy proposed for Awel y Môr. Cumulatively, the underwater sound contours at levels which may cause behavioural effects from the two projects overlap with moderate areas of mapped high and low intensity cod spawning grounds, if piling were to occur concurrently between January and April, when cod are reported to spawn. For cod, the cumulative effect is predicted to be of regional spatial extent although with a moderate degree of overlap with the available spawning grounds, short term duration, intermittent and of high reversibility, with the soundscape expected to return to near baseline conditions upon cessation of construction. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **medium**.

3.11.3.9 Cumulative underwater sound levels from Awel y Môr and the Mona Offshore Wind Project at levels which may cause behavioural effects may overlap with mapped high and low intensity herring spawning grounds located off the east coast of the IoM at Douglas Bank. Cumulatively, these underwater sound levels may overlap with small areas of mapped high and low intensity spawning grounds if piling were to occur concurrently in September and October when this particular herring stock are reported to spawn. For herring, the cumulative effect is predicted to be of regional spatial extent although with a small degree of overlap with the available spawning grounds, short term duration, intermittent and of high reversibility, with the soundscape expected to return to near baseline conditions upon cessation of construction. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **medium.**

### Sensitivity of the receptor

#### Marine species

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

3.11.3.11 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**.

3.11.3.12 Cod are deemed to be of medium vulnerability, medium recoverability and regional importance, with high overlap between high intensity spawning grounds and response-causing sound contours. The sensitivity of the receptor is therefore considered to be **high**.

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

3.11.3.14 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**

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

3.11.3.16 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**.

3.11.3.17 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 **medium**.

### Significance of effect

**Marine species**

3.11.3.18 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.

3.11.3.19 For cod, the magnitude of the impact is deemed to be medium, and the sensitivity is considered high. The effect will be of **moderate adverse** significance, which is significant in EIA terms. This significance is due to the relatively large overlap between high intensity spawning grounds and areas which may be subject to underwater sound levels in excess of 160 dB $SPL_{pk}$, which may elicit behavioural responses, and the extended area of ensonification associated with multiple projects undergoing construction, reducing the area available for spawning regionally.

3.11.3.20 For herring, the magnitude of the impact is deemed to be medium, and the sensitivity of herring is considered to be high. The effect will, therefore, be of **moderate adverse** significance, which is not significant in EIA terms. This is consistent with the alone assessment for Mona Offshore Wind Project because the Awel y Môr offshore wind farm is located a greater distance from herring spawning grounds in the Irish Sea than the Mona Offshore Wind Project and would therefore not represent an increased risk to herring spawning.

3.11.3.21 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**

3.11.3.22 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 will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

3.11.3.23 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 to be medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms. This is based upon piling from both wind farms not predicted to be concurrent or result in major disruption to movement of diadromous fish species undertaking migration activities for spawning.

## Tier 2

## Construction phase

### Magnitude of impact

3.11.3.24 The construction phases of the Morgan Offshore Wind Project Generation Assets, the Morecambe Offshore Windfarm Generation Assets, and the Morgan and Morecambe Offshore Wind Farms Transmission Assets will have temporal and spatial overlap with the Mona Offshore Wind Farm in terms of construction sound, potentially resulting in a cumulative impact. The assessment of sound impacts associated with the Mona Offshore Wind Farm alone has been presented above (section 3.9.3), with a medium magnitude identified based on a range of technical specifications and sound modelling outputs.

3.11.3.25 For the Morgan Offshore Wind Farm, sound modelling indicated similar patterns as those for the Mona Offshore Wind Project, with mortality from sound produced within the Morgan Array Area to ranges of up to 745 m for group 1 fish, 2.12 km for group 2 fish, and 2.98 km for group 3 and 4 fish, if modelled as static receptors (Morgan Offshore Wind Ltd., 2023). In all cases, modelling the fish as receptors moving away from the sound source highly significantly reduced mortality distances, down to <100 m even for group 3 fish. Injury distances were calculated to reach out to up to 4.76 km for group 2 to 4 static receptors, with this again reducing to <100 m in all cases when fish were modelled as receptors moving away from the sound source, with similar patterns for all other groups of fish.

3.11.3.26 For the Morecambe Offshore Windfarm Generation Assets, sound modelling indicated similar patterns as those for the Mona Offshore Wind Project, with injury and mortality from sound produced within the Morecambe Offshore Windfarm Generation Assets for a single monopile (maximum hammer energy of 5,000 kJ to ranges of up to 830 m for group 1 fish, 2.9 km for group 2 fish and 3.3 km calculated for group 3 fish, if modelled as static receptors (Morecambe Offshore Windfarm Ltd., 2023). Injury distances were calculated to reach out to up to 6.7 km for group 2 static receptors with similar patterns for all other groups of fish.

3.11.3.27 For the Morgan and Morecambe Offshore Wind Farms Transmission Assets, sound modelling also indicated similar patterns to the Mona Offshore Wind Project, wherein peak sound pressure levels when piling energy is at its maximum (i.e., 5,500 kJ) has been modelled to cause mortality and recoverable injury to fish within a maximum of 648 m of the piling activity. When fish are modelled as moving 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 2.02 km. When fish were modelled as static receptors, mortality and recoverable injury ranges were significantly higher than for both $SPL_{pk}$ and $SEL_{cum}$ when fish are modelled as receptors moving away from the source, with a maximum mortality range of up to 2.8 km in group 3 and 4 fish and a recoverable injury range of up to 4.34 km.

3.11.3.28 For most fish and shellfish ecology IEFs, 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**.

3.11.3.29 The tier 1 project, tier 2 projects and the Mona Offshore Wind Project sit across areas of mapped high and low intensity cod spawning ground. Cumulatively, the underwater sound contours at levels which may cause behavioural effects from the tier 1 and tier 2 projects overlap with moderate areas of mapped high and low intensity cod spawning grounds, if piling were to occur concurrently between January and April, when cod are reported to spawn. For cod, the cumulative effect is predicted to be of regional spatial extent although with a moderate degree of overlap with the available spawning grounds, short term duration, intermittent and of high reversibility, with the soundscape expected to return to near baseline conditions upon cessation of construction. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **medium**.

3.11.3.30 Cumulative underwater sound levels from the tier 1 and tier 2 projects and the Mona Offshore Wind Project at levels which may cause behavioural effects may overlap with mapped high and low intensity herring spawning grounds located off the east coast of the IoM at Douglas Bank. Cumulatively, these underwater sound levels may overlap with moderate areas of mapped high and low intensity spawning grounds if piling were to occur concurrently in September and October when this particular herring stock are reported to spawn. For herring, the cumulative effect is predicted to be of regional spatial extent although with a moderate degree of overlap with the available spawning grounds, short term duration, intermittent and of high reversibility, with the soundscape expected to return to near baseline conditions upon cessation of construction. It is predicted that the impact will affect the receptor directly. The magnitude is therefore considered to be **medium.**

## Sensitivity of the receptor

### Marine species

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

3.11.3.32 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**.

3.11.3.33 Cod are deemed to be of medium vulnerability, medium recoverability and regional importance, with moderate overlap between high intensity spawning grounds and response-causing sound contours. The sensitivity of the receptor is therefore, considered to be **high**.

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

3.11.3.35 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

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

3.11.3.37 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**.

3.11.3.38 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**

3.11.3.39 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.

3.11.3.40 For cod, the magnitude of the impact is deemed to be medium, and the sensitivity is considered high. The effect will be of **moderate adverse** significance, which is significant in EIA terms. This significance is due to the moderate overlap between high intensity spawning grounds and potential response-causing sound contours, and the increased ensonification area associated with multiple projects, reducing the area available for spawning within the region.

3.11.3.41 For herring, the magnitude of the impact is deemed to be medium, and the sensitivity of herring is considered to be high. The effect will, therefore, be of **moderate adverse** significance, which is significant in EIA terms. This is due to moderate overlap between high intensity spawning grounds and potential response-causing sound contours, and the sensitivity of herring to underwater sound physiologically.

3.11.3.42 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**

3.11.3.43 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 will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

3.11.3.44 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 to be medium. As such, it is likely the impact will be **minor adverse**, which is not significant in EIA terms.

## Tier 3

3.11.3.45 No relevant Tier 3 projects are expected to overlap with the construction phase of the Mona Offshore Wind Project.

**Further mitigation measures**

3.11.3.46 The cumulative impact assessment of elevated underwater sound from piling concludes a potentially significant effect in EIA terms for herring and cod during their respective spawning seasons. The project alone assessment also concluded a significant effect to herring during the herring spawning season, but not to cod, due to the wide availability of cod spawning habitat outside of the area of impact, however the Mona Offshore Wind Project may contribute to a cumulative impact in the context of other plans and projects within the region.

3.11.3.47 The assessment of cumulative effects from other plans and projects is based upon the respective maximum design scenarios presented in publicly available assessments for each project and/or plan alone. This assessment does not consider any further mitigation or reduced/refined project design envelopes for other Tier 1 and/or Tier 2 projects that may be implemented post consent. However it is understood that if other projects are consented, it is reasonable to assume that they will each implement appropriate measures such that any significant effect is reduced to a non-significant level. Although this assessment cannot conclude based upon this assumption, a significant cumulative impact is considered unlikely for this reason.

3.11.3.48 Post consent, following a refined project design envelope and programme clarity, the Underwater sound management strategy (Document Reference J16) will investigate options to manage underwater sound levels (such as NAS, temporal and spatial piling restrictions, piling methods, soft start) in order to reduce the magnitude for the project alone, and minimise the project's contribution to any cumulative effect. The project has prepared an Outline underwater sound management strategy (Document Reference J16) which is secured in the deemed marine licence in Schedule 14 of the draft DCO.

3.11.3.49 In this case, further mitigation options may be applied to reduce the magnitude for herring and cod during their respective spawning seasons. The Underwater sound management strategy (Document Reference J16) will be developed in consultation with the licensing authority and SNCBs, and agreed, prior to construction, those mitigation measures which may be implemented to reduce the magntitude of impact from the project alone.

## 3.11.4 Increased suspended sediment concentrations (SSCs) and associated sediment deposition

3.11.4.1 Increased suspended sediment concentrations and associated sediment deposition is expected to occur in relation to the construction and decommissioning phases of the Mona Offshore Wind Project, which was assessed for this impact alone in section 3.9.3.1. 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 at Hilbre Swash (see Table 3.31). Five tier 2 projects have been identified within the Fish and Shellfish Ecology study area (Morecambe Offshore Windfarm Generation Assets, Morgan Offshore Wind Project Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, the ENI HyNet CCS project, Liverpool Bay Area 457 aggregates extraction site) while two tier 3 projects, the MaresConnect Wales-Ireland Interconnector Cable and Isle of Man Offshore Wind Farm, have been identified.

### Tier 1

### Construction phase

### Magnitude of impact

3.11.4.2 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 Mona Offshore Wind Project alone, as described in section 3.9.3.1. The maximum design scenario and associated largest impacts are due to potential sandwave clearance activities within the fish and shellfish ecology study area.

3.11.4.3 Coinciding with the construction phase of the Mona Offshore Wind Project 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 Mona Offshore Array Area. However, the Mona Offshore Cable Corridor and Access Areas runs adjacent to Awel y Môr array area and interaction of SSC plumes on spring tide events may occur should trenching activities be undertaken simultaneously, although this is unlikely. SSC plumes from the Mona Offshore Cable Corridor and Access Areas would most likely reach background levels through natural sediment depositional processes before overlapping with the Awel y Môr array area, when travelling on the flood tide as they would run in parallel. If the plumes did overlap due to local tidal and current conditions, SSCs could increase by up to approximately 2 mg/l within the area of overlap, according to the respective technical reports of each of these projects, which is not significant compared to background conditions.

3.11.4.4 The cumulative impact assessment also encompasses aggregate extraction at both Hilbre Swash licensed areas located within 14.5 km of the Mona array area and 17.2 km of the Mona Offshore Cable Corridor and Access Areas. Resultant plumes from the disposal of dredged material and extraction of aggregate would be advected on the tidal current running in parallel and not coincide.

3.11.4.5 Similarly, the cumulative impact assessment considers sea disposal of dredged material at the Conwy River disposal site, located 33.9 km and 7.7 km from the Mona Array Area and Mona Offshore Cable Corridor and Access Areas respectively. If the offshore cable installation and dredge material dumping coincided, both resultant plumes would be advected on the tidal currents, they would travel in parallel, and not towards one another, and are unlikely to interact if offshore cable installation coincides with the use of the licensed sea disposal site. The same interaction applies to other licenced dredging activity and disposal sites, including the Mersey channel and river maintenance dredge disposal renewal; the Walney Extension pontoon/jetty dredging and disposal, the Dee River project; the RNLI Regional Maintenance Dredging; the Liverpool Marina Maintenance Dredging; the Douglas Harbour and Castletown Bay dredging in the IoM, and the Port of Barrow maintenance dredging disposal (Table 3.31).

3.11.4.6 The cumulative effect 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 **low**.

### Sensitivity of the receptor

#### Marine species

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

3.11.4.8 Based on the sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of medium vulnerability, medium recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be **medium**.

3.11.4.9 Based on their intolerance to smothering for extended periods, king and queen scallop are deemed to be of medium vulnerability, medium recoverability and of national importance; the sensitivity of these receptors is therefore considered **medium**.

3.11.4.10 All other fish and shellfish ecology IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops* 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**

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

3.11.4.12 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**

3.11.4.13 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.

3.11.4.14 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 medium. The cumulative effect will therefore be of **minor adverse** significance, which is not significant in EIA terms.

3.11.4.15 For all other fish and shellfish ecology species IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops* 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**

3.11.4.16 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

3.11.4.17 For the Morgan Offshore Wind Project Generation Assets 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 Morgan Offshore Wind Project Generation Assets are relatively similar to those reported for Mona Offshore Wind Project with the displacement of up to 21,540,241 $m^3$ of total spoil volume. This could potentially result in SSC increases of up to 3000 mg/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 <500 mg/l for foundation installation, but only within 100 m of the site, with significant advection and sedimentation to natural backgrounds levels across the 20 km tidal excursion within a short time period. Plumes from multiple concurrent foundation installation activities were modelled as having concentrations of <50 mg/l if they met, which is not even expected given modelled tidal advection in the area. Although this is significant compared to background levels, it is not significant in the context of natural variation in the wider Irish Sea.

3.11.4.18 For the tier 2 Morecambe Offshore Windfarm Generation Assets, 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. This involves the potential for sediment plume and deposition overlap during construction activities with the Morgan and Morecambe Offshore Wind Farms Transmission Assets. The increases in SSC and sediment deposition predicted to result from the Morecambe Offshore Windfarm Generation Assets are much lower than those reported for the Morgan and Morecambe Offshore Wind Farms Transmission Assets with the displacement of up to 1,238,700 $m^3$ of total spoil volume.

3.11.4.19 The site preparation of the construction phase of the Morgan and Mona Offshore Wind Farms Transmission Assets accounts for up to 10,447,489 $m^3$ of sandwave clearance, up to 72,320 $m^3$ of spoil from foundation installation, and up to 3,015,000 $m^3$ of spoil from cable installation. These increases are similar in magnitude to the Mona Offshore Wind Project and are unlikely to cause any significant cumulative impacts overall.

3.11.4.20 For the ENI HyNet CCS project, increased SSC and sediment deposition is likely to result from subsea pipeline and cable installation and refurbishment, which could cause increases in SSCs and deposition to cause smothering effects on nearby fish and shellfish receptors. However, the magnitude of these activities is likely to be low due to the size of the project compared to the surrounding renewable offshore projects.

3.11.4.21 The dredging and aggregate extraction activities expected to arise in the Liverpool Bay Area 457 are likely to cause increases in SSC, although it is likely this will be significantly smaller in area and volume compared to nearby projects. The scoping report (MarineSpace, 2023) for this project indicates that the licenced extraction activities will be up to 18 megatons over a 15-year period, with a maximum extraction rate of 1.2 megatons per year, much of which will be disposed of on-site. This disposal will cause local increases in SSC and deposition, but these are unlikely to be significant compared to nearby projects over the time scale licenced.

3.11.4.22 The cumulative effect is predicted to be of regional spatial extent, medium term duration (i.e. the construction phase for the Mona Offshore Wind Project 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

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

3.11.4.24 Based on the sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of medium vulnerability, medium recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be **medium**.

3.11.4.25 Based on their intolerance to smothering for extended periods, king and queen scallop are deemed to be of medium vulnerability, medium recoverability and of national importance; the sensitivity of these receptors is therefore considered **medium**.

3.11.4.26 All other fish and shellfish ecology IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops* 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

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

3.11.4.28 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

3.11.4.29 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.

3.11.4.30 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 medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

3.11.4.31 For all other fish and shellfish ecology species IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops* 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

3.11.4.32 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

3.11.4.33 The decommissioning phases of the Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Windfarm Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets could have the potential to overlap temporally with the decommissioning of the Mona Offshore Wind Farm. The expected magnitude of increased SSC and sediment deposition associated with the decommissioning of these projects are expected to be less than the construction phase, even if scour protection and cable protection are removed, due to no associated sediment clearance or drilling required. This represents a lower number of activities and reduced levels of seabed disturbance, and therefore this is not expected to significantly increase the cumulative impact.

3.11.4.34 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

#### Marine species

3.11.4.35 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

3.11.4.36 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

3.11.4.37 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.

3.11.4.38 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 medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

3.11.4.39 For all other fish and shellfish ecology species IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops* 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

3.11.4.40 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 3

## Construction phase

### Magnitude of impact

3.11.4.41 The proposed construction of the MaresConnect Wales-Ireland Interconnector Cable has the potential to overlap with the construction phase of the Mona Offshore Wind Project, with the MaresConnect Interconnector Cable being 14.7 km from the Mona Offshore Array Area and overlapping with the Mona Offshore Cable Corridor and Access Areas respectively, leading to a potential cumulative impact. Specifically, the likely jet trenching activities for the laying and burying of the cables for both projects will run concurrently and interaction of SSC plumes on spring tide events may occur. However, as with the Mona Offshore Wind Project, it is expected that the concentration of suspended sediment would reduce significantly quickly with distance from the activity and therefore the potential overlap of resultant plumes would be low.

3.11.4.42 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

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

3.11.4.44 Based on the sensitivity of herring eggs to the smothering effects of increased sediment deposition, herring is deemed to be of medium vulnerability, medium recoverability and of national importance, and therefore the sensitivity of this receptor is considered to be **medium**.

3.11.4.45 Based on their intolerance to smothering for extended periods, king and queen scallop are deemed to be of medium vulnerability, medium recoverability and of national importance; the sensitivity of these receptors is therefore considered **medium**.

3.11.4.46 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

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

3.11.4.48 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

3.11.4.49 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.

3.11.4.50 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 medium. The cumulative effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

3.11.4.51 For all other fish and shellfish ecology species IEFs in the fish and shellfish ecology study area, including sandeel, *Nephrops* 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**

3.11.4.52 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.

### 3.11.5 Long term habitat loss

3.11.5.1 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 3.9.5, 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 3.31). Long term habitat loss may result from the physical presence of foundations, scour protection and cable protection. Four 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 Windfarm Generation Assets, Morgan Offshore Wind Project Generation Assets and Mooir Vannin Offshore Wind Project) 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

3.11.5.2 The planned construction of the tier 1 Awel y Môr Offshore Wind Farm will introduce up to 1.07 km$^2$ 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, 2022). This will act alongside the 2.25 km$^2$ of hard structures introduced by the Mona Offshore Wind Project to represent a potential cumulative long term habitat loss of up to approximately 3.32 km$^2$.

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

3.11.5.4 For herring, due to the absence of any overlap of Mona Offshore Wind Project with mapped or reported herring spawning grounds, and the highly limited extent of substrate suitable for herring spawning, along with the highly localised spatial extent of the impact, it is predicted that Mona Offshore Wind Project will not affect the receptor or contribute to a cumulative effect and the magnitude is therefore considered to be **negligible**.

## Sensitivity of the receptor

### Marine species

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

3.11.5.6 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**.

3.11.5.7 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**.

3.11.5.8 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**.

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

3.11.5.10 Herring are deemed to be of high vulnerability, medium recoverability and of national importance; the sensitivity of herring is therefore considered **medium**.

### Diadromous species

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

3.11.5.12 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

3.11.5.13 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.

3.11.5.14 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.

3.11.5.15 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.

3.11.5.16 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.

3.11.5.17 For herring, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. Negligible significance is applied due to the absence of mapped spawning grounds and presence of highly limited substrate suitable for herring spawning within the footprint of long-term habitat loss. This suggests that the area of the Mona Offshore Wind Project is not important for spawning herring therefore Mona Offshore Wind Project is not expected to contribute to a cumulative effect with other projects.

**Diadromous species**

3.11.5.18 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.

## Tier 2

## Construction and operations and maintenance phases

### Magnitude of impact

3.11.5.19 The maximum total long term habitat loss for which information is publicly available will be associated with the tier 2 Morgan Offshore Wind Project Generation Assets. For the Morgan Offshore Wind Project Generation Assets long term habitat loss is likely to result from foundation structures and associated scour protection, and under any cable protection required. The long-term habitat loss predicted to result from the Morgan Offshore Wind Project Generation Assets is up to 1.52 $km^2$ (Morgan Offshore Wind Ltd., 2023) and is therefore smaller than that arising from the Mona Offshore Wind Project.

3.11.5.20 For the Morecambe Offshore Windfarm Generation Assets, the predicted long term habitat loss during the construction and operations and maintenance phase would equate to up to 0.46 $km^2$, with any long term habitat loss likely to arise under foundation structures and associated scour protection, and under any cable protection required (Morecambe Offshore Windfarm Ltd., 2023).

3.11.5.21 For the Morgan and Morecambe Offshore Wind Farms Transmission Assets, the predicted cumulative long term habitat loss during the construction and operations and maintenance phase would equate to up to 1.53 $km^2$, with any long term habitat loss likely to arise under OSP foundation structures and associated scour protection, and under any cable protection required (Morecambe Offshore Windfarm Ltd and Morgan Offshore Wind Ltd, 2023).

3.11.5.22 For the ENI HyNet CCS project, long term habitat loss is predicted to arise from construction of offshore platforms, offshore carbon dioxide injection wells, offshore pipelines and offshore power and fibre optic cables, with a licenced area of 576.82 $km^2$ (ENI, 2023). Although this licenced area is relatively large, the amount of habitat lost due to installation of infrastructure will be relatively low overall compared to habitat otherwise available otherwise in the fish and shellfish ecology study area.

3.11.5.23 The operation and maintenance phase of the Mooir Vannin Offshore Windfarm will temporally overlap with the operation and maintenance phase of the Mona Offshore Wind Project. Potential for long-term habitat loss will take the form of introduced hard substrata such as fixed bottom wind turbine monopile, monopod suction jacket, suction bucket jacket, piled jack and gravity base foundations of up to 18 m diameter at the seabed, scour protection and cable protection. Scour and cable protection would likely represent a permanent loss of habitat, as would typically be decommissioned in situ.

3.11.5.24 For most fish and shellfish ecology IEFs 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**.

3.11.5.25 For herring, due to the absence of any overlap of Mona Offshore Wind Project with mapped or reported herring spawning grounds, and the highly limited extent of substrate suitable for herring spawning, along with the highly localised spatial extent of the impact, it is predicted that Mona Offshore Wind Project will not affect the receptor or contribute to a cumulative effect and the magnitude is therefore considered to be **negligible**.

## Sensitivity of the receptor

### Marine species

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

3.11.5.27 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**.

3.11.5.28 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**.

3.11.5.29 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**.

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

3.11.5.31 Herring are deemed to be of high vulnerability, medium recoverability and of national importance; the sensitivity of herring is therefore considered **medium**.

### Diadromous species

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

3.11.5.33 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

3.11.5.34 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.

3.11.5.35 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.

3.11.5.36 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.

3.11.5.37 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.

3.11.5.38 For herring, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. Negligible significance is applied due to the absence of mapped spawning grounds and presence of highly limited substrate suitable for herring spawning within the footprint of long-term habitat loss. This suggests that the area of the Mona Offshore Wind Project is not important for spawning herring therefore Mona Offshore Wind Project is not expected to contribute to a cumulative effect with other projects.

#### Diadromous species

3.11.5.39 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

3.11.5.40 The decommissioning phases of the Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Windfarm Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, and ENI HyNet CCS project could have the potential to have temporal overlap with the decommissioning of the Mona Offshore Wind Farm. 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 1.46 $km^2$ of this temporary habitat loss will be associated with the Morgan Offshore Wind Project Generation Assets, which will be similar in size to the Mona Offshore Wind Project.

3.11.5.41 For the Morecambe Offshore Windfarm Generation Assets, the potential cumulative permanent habitat loss during the decommissioning phase would equate to up to 0.46 $km^2$, with no long-term habitat loss likely to arise. This is assumed to be the same as the long-term habitat loss estimate on the basis that it is currently unknown whether structures associated with the project would be removed at the point of decommissioning.

3.11.5.42 For the Morgan and Morecambe Offshore Wind Farms Transmission Assets, the predicted cumulative permanent habitat loss/alteration during the decommissioning phase would equate to up to 1.52 $km^2$, with any long-term habitat loss likely to arise under associated scour protection, and under any cable protection required (Morecambe Offshore Windfarm Ltd and Morgan Offshore Wind Ltd, 2023).

3.11.5.43 For the ENI HyNet CCS project, long term habitat loss is predicted to arise from the same new infrastructure and rock armour and protection being left in place at the end of the lifetime of the project, although again this is unlikely to represent a significant increase in lost habitat.

3.11.5.44 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**.

3.11.5.45 For herring, due to the absence of any overlap of Mona Offshore Wind Project with mapped or reported herring spawning grounds, and the highly limited extent of substrate suitable for herring spawning, along with the highly localised spatial extent of the impact, it is predicted that Mona Offshore Wind Project will not affect the receptor or contribute to a cumulative effect and the magnitude is therefore considered to be **negligible**.

## Sensitivity of the receptor

### Marine species

3.11.5.46 The sensitivity of the marine fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.5.9 to paragraph 3.9.5.20), ranging from **low to medium** sensitivity, and these will equally apply in the decommissioning phase.

### Diadromous species

3.11.5.47 The sensitivity of the diadromous fish and shellfish IEFs can be found in the construction phase assessment (paragraph 3.9.4.28 to paragraph 3.9.4.32), with **low** sensitivity, and this will equally apply in the decommissioning phase.

## Significance of effect

### Marine species

3.11.5.48 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.

3.11.5.49 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.

3.11.5.50 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.

3.11.5.51 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.

3.11.5.52 For herring, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. Negligible significance is applied due to the absence of mapped spawning grounds and presence of highly limited substrate suitable for herring spawning within the footprint of long-term habitat loss. This suggests that the area of the Mona Offshore Wind Project is not important for spawning herring therefore Mona Offshore Wind Project is not expected to contribute to a cumulative effect with other projects.

**Diadromous species**

3.11.5.53 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.

## Tier 3

### Construction, operations and maintenance and decommissioning phases

### Magnitude of impact

3.11.5.54 The proposed construction of the MaresConnect Wales-Ireland Interconnector Cable will overlap with the construction phase and/or operations and maintenance phases of the Mona Offshore Wind Project, 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 planned to be used are not currently publicly available, although the overlap and thus cumulative impact between this and tier 2 projects is expected to be minor.

3.11.5.55 For most fish and shellfish ecology IEFs 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**.

3.11.5.56 For herring, due to the absence of any overlap of Mona Offshore Wind Project with mapped or reported herring spawning grounds, and the highly limited extent of substrate suitable for herring spawning, along with the highly localised spatial extent of the impact, it is predicted that Mona Offshore Wind Project will not affect the receptor or contribute to a cumulative effect and the magnitude is therefore considered to be **negligible**.

### Sensitivity of the receptor

**Marine species**

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

3.11.5.58 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**.

3.11.5.59 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**.

3.11.5.60 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**.

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

3.11.5.62 Herring are deemed to be of high vulnerability, medium recoverability and of national importance; the sensitivity of herring is therefore considered **medium**.

**Diadromous species**

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

3.11.5.64 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**

3.11.5.65 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.

3.11.5.66 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.

3.11.5.67 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.

3.11.5.68 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.

3.11.5.69 For herring, the magnitude of the impact is deemed to be negligible, and the sensitivity of the receptor is considered to be medium. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. Negligible significance is applied due to the absence of mapped spawning grounds and presence of highly limited substrate suitable for herring spawning within the footprint of long-term habitat loss. This suggests that the area of the Mona Offshore Wind Project is not important for spawning herring therefore Mona Offshore Wind Project is not expected to contribute to a cumulative effect with other projects.

**Diadromous species**

3.11.5.70 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.

## 3.11.6 Electromagnetic Fields (EMF) from subsea electrical cabling

3.11.6.1 The operation of the subsea cabling laid and buried as part of the Mona Offshore Wind Project transmission assets will produce electromagnetic fields, with potential impacts on fish and shellfish receptors within the Mona Offshore Cable Corridor and Access

Areas and Mona 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 Morgan Offshore Wind Farm, Morecambe Offshore Windfarm Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets and Mooir Vannin Offshore Windfarm and the tier 3 MaresConnect Wales-Ireland Interconnector Cable.

## Tier 1

## Operations and maintenance phase

### Magnitude of impact

3.11.6.2 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 cables of the Mona Offshore Wind Project. For the Awel y Môr Offshore Wind Farm this is likely to result from the operation of the 145 km of inter-array cables, and 81.3 km of export cables (RWE, 2022). The minimum burial depth for cables for Awel y Môr is planned to be 1 m, likely limiting EMFs to the range of up to 10 m from the cable, broadly in line with the predictions for the Mona Offshore Wind Project as discussed in section 3.9.6 above (Table 3.31).

3.11.6.3 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

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

3.11.6.5 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**.

3.11.6.6 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

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

3.11.6.8 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

3.11.6.9 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.

3.11.6.10 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**

3.11.6.11 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.

## Tier 2

## Operations and maintenance phase

### Magnitude of impact

3.11.6.12 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 and interconnector cables of the Morgan Offshore Wind Project Generation Assets, the Morecambe Offshore Windfarm Generation Assets, the Morgan and Morecambe Offshore Wind Farms Transmission Assets and the Mooir Vannin Offshore Windfarm.

3.11.6.13 For the Morgan Offshore Wind Project Generation Assets this is likely to result from the operation of the 450 km and 500 km of 66 kV to 132 kV inter-array cables respectively, and up to 60 km of 275 kV HVAC interconnector cable. The minimum burial depth for cables will be 0.5 m, likely limiting EMFs to the range of metres from the cable, with impacts expected to be similar to the Mona Offshore Wind Project, due to the similar sizes and extents of the projects (Morgan Offshore Wind Ltd, 2023).

3.11.6.14 For the Morecambe Offshore Windfarm, the maximum EMF impacts will originate from the inter-array and interconnector cables. This is likely to result from the operation of up to 110 km of up to 132 kV inter-array cables and 10 km of up to 132 kV platform link cables. The minimum burial depth for cables will be between 0.5 m and 3 m with a target of burial depth of 1.5 m.

3.11.6.15 For the Morgan and Morecambe Offshore Wind Farms Transmission Assets, there will be up to 60 km of 275 kV HVAC interconnector cable and up to 610 km cables of 220 kV or 275 kV HVAC offshore export cables. The minimum burial depth for cables will be 0.5 m.

3.11.6.16 The operation and maintenance phases of the Mooir Vannin Offshore Windfarm will temporally overlap with the operation and maintenance phase of the Mona Offshore Wind Project, resulting in a potential cumulative impact. EMFs are expected to be emitted from export and other subsea cables, however the cable specifications and therefore the likely EMF emissions are not yet known except that transmission will involve both AC and DC. Cables are likely to be buried or positioned under cable protection to minimise EMF emissions, therefore the cumulative effects are expected to be small, and spatially localised to the immediate vicinity of the cables. Little to no direct overlap in EMF emissions is expected with the Mona Offshore Wind Project.

3.11.6.17 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

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

3.11.6.19 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**.

3.11.6.20 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

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

3.11.6.22 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

3.11.6.23 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.

3.11.6.24 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

3.11.6.25 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

3.11.6.26 The proposed operation of the MaresConnect Wales-Ireland Interconnector Cable will temporally overlap with the operations and maintenance phase of the Mona Offshore Wind Project, resulting in a 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 overlap between it and the Mona Offshore Wind Project.

3.11.6.27 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

3.11.6.28 The sensitivity of the marine species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraphs 3.9.6.8 to 3.9.6.19.

3.11.6.29 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**.

3.11.6.30 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

3.11.6.31 The sensitivity of diadromous species IEFs to this impact is described previously for the construction phase of the Mona Offshore Wind Project alone in paragraphs 3.9.6.20 to 3.9.6.23.

3.11.6.32 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

3.11.6.33 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.

3.11.6.34 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

3.11.6.35 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.

## 3.11.7 Introduction and colonisation of hard structures

3.11.7.1 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 Mona Offshore Wind Project in section 3.9.7. Specifically, the tier 1 Awel y Môr Offshore Wind Farm; the tier 2 Mona Offshore Wind Project, Morecambe Offshore Windfarm Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, ENI Hynet CCS project and Mooir Vannin Offshore Windfarm and the tier 3 MaresConnect Wales-Ireland Interconnector Cable represent areas of introduced hard structures, in terms of foundations, scour protection, and cable protection.

### Tier 1

### Construction and operations and maintenance phases

### Magnitude of impact

3.11.7.2 The Awel y Môr Offshore Wind Farm construction phase is planned to overlap temporally with the Mona Offshore Wind Project construction phase and could result in a cumulative impact. This will represent the introduction of up to 3.32 $km^2$ of new hard structures for potential colonisation, including foundations, scour protection, and cable protection structures (1.07 $km^2$ for Awel y Môr, and 2.25 $km^2$ for the Mona Offshore Wind Project). The temporal overlap between tier 1 projects will result in cumulative impacts related to introduction of similar new hard structures and effects on fish and shellfish IEFs.

3.11.7.3 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

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

3.11.7.5 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

3.11.7.6 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**.

3.11.7.7 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

3.11.7.8 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

3.11.7.9 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.

3.11.7.10 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.

## Tier 2

### Construction and operations and maintenance phases

### Magnitude of impact

3.11.7.11 The Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Windfarm Generation Assets, and Morgan and Morecambe Offshore Wind Farms Transmission Assets, ENI HyNet CCS project and Mooir Vannin Offshore Windfarm 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. 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.

3.11.7.12 The available area for colonisation predicted to result from the Morgan Offshore Wind Project Generation Assets is up to 1.99 $km^2$ (Morgan Offshore Wind Ltd., 2023) and is therefore similar to that arising from the Mona Offshore Wind Project.

3.11.7.13 The available area for colonisation predicted to result from the Morecambe Offshore Windfarm Generation Assets, based on the seabed area occupied by infrastructure, is up to 0.46 $km^2$, and is therefore smaller than the Mona Offshore Wind Project.

3.11.7.14 The available area for colonisation predicted to result from the Morgan and Morecambe Offshore Wind Farms Transmission Assets, based on the seabed area occupied by infrastructure, is up to 1.53 $km^2$, and is therefore similar to that arising from the Mona Offshore Wind Project.

3.11.7.15 The available area for colonisation predicted to result from the ENI HyNet CCS project, based on the seabed area occupied by infrastructure, is not fully quantified, but will involve construction of offshore platforms, offshore carbon dioxide injection wells, offshore pipelines and offshore power and fibre optic cables, with a licenced area of 576.82 $km^2$ (ENI, 2023). The actual hard structures in place will be much smaller than this area, and thus will represent a low magnitude overall.

3.11.7.16 The operation and maintenance phase of the Mooir Vannin Offshore Windfarm will temporally overlap with the operation and maintenance phase of the Mona Offshore Wind Project, resulting in a potential cumulative impact. Potential for introduced hard substrata will include fixed bottom foundations (monopiles, monopod suction jacket, suction bucket jacket, piled jacket and gravity base options) and also take the form of wind turbine ancillaries, scour protection and cable protection. It is expected that these structures will only represent a small increase of introduced hard substrata proportional to the entire cumulative study area and so will have only a minor cumulative impact.

3.11.7.17 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

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

3.11.7.19 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

3.11.7.20 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**.

3.11.7.21 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

3.11.7.22 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

3.11.7.23 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.

3.11.7.24 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

3.11.7.25 The decommissioning phases of the Morgan Offshore Wind Project Generation Assets, Morecambe Offshore Windfarm Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, and ENI HyNet CCS project may have temporal overlap with the decommissioning of the Mona Offshore Wind Farm. 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.

3.11.7.26 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

3.11.7.27 The sensitivity of marine fish and shellfish IEFs to this impact can be found in the construction and operations and maintenance phases (paragraph 3.9.7.8 to paragraph 3.9.7.18), with **low** sensitivity, and these are expected to apply after the decommissioning phase equally.

#### Diadromous species

3.11.7.28 The sensitivity of diadromous fish and shellfish IEFs to this impact can be found in the construction and operations and maintenance phases (paragraph 3.9.7.19 to paragraph 3.9.7.25), with **low** sensitivity, and these are expected to apply during the decommissioning phase equally.

### Significance of effect

#### Marine species

3.11.7.29 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

3.11.7.30 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.

3.11.7.31 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

3.11.7.32 The proposed construction of the MaresConnect Wales-Ireland Interconnector Cable will likely overlap with the construction phase of the Mona Offshore Wind Project, 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.

3.11.7.33 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**

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

3.11.7.35 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**

3.11.7.36 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**.

3.11.7.37 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**

3.11.7.38 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**

3.11.7.39 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.

3.11.7.40 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.

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

3.11.8.1 Increased levels of vessel activity related to the construction, operations and maintenance, and decommissioning phases of the Mona Offshore Wind Project will likely represent an increased risk of collision with basking shark, with this impact assessed alone in section 3.9.9. 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, aggregate extraction and disposal, and the Isle of Man Crogga Licence: 112/25 oil and gas activities 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 Windfarm Generation Assets, Morgan and Morecambe Offshore Wind Farms Transmission Assets, Liverpool Bay Area 457, ENI HyNet CCS project and Mooir Vannin Offshore Windfarm 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

3.11.8.2 The construction phase of the Awel y Môr Offshore Wind Farm is expected to overlap temporally with the construction phase of the Mona Offshore Wind Project, 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, 2022).

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

3.11.8.4 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 3.31), one regular marine aggregate extraction and disposal site at Hilbre Swash, and vessel activities associated with the Isle of Man Crogga Licence: 112/25 oil and gas works. 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.

3.11.8.5 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

3.11.8.6 The basking shark sensitivity to this impact within the fish and shellfish ecology study area has been assessed previously for the alone assessment in section 3.9.9.

3.11.8.7 The basking shark within the fish and shellfish ecology study 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

3.11.8.8 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

3.11.8.9 The number of vessels undertaking construction activities in the fish and shellfish ecology study area will overlap temporally and act to have a cumulative impact with the construction of the Morgan Offshore Wind Project Generation Assets, the Morecambe Offshore Windfarm Generation Assets, the Morgan and Morecambe Offshore Wind Farms Transmission Assets, ENI HyNet CCS project, Area 457 aggregates extraction and the Mooir Vannin Offshore Windfarm.

3.11.8.10 Based on current publicly available information concerning the Morgan Offshore Wind Project Generation Assets, this will increase construction vessel numbers to a maximum of 1,858 cumulatively for the Morgan Generation Assets and the Mona Offshore Wind Project, with up to 63 construction vessels on site at any one time. During the operations and maintenance phase the number of vessels is anticipated to be lower than during construction, and decommissioning will involve up to the same number as construction.

3.11.8.11 For the Morecambe Offshore Windfarm Generation Assets, this will increase construction vessel numbers to a maximum of 30 construction vessels at any one time and is lower than the maximum of 70 construction vessels expected at any one time for the Morgan and Morecambe Offshore Wind Farms Transmission Assets. Limited public information was available for the number of vessels on site during the operation and maintenance phase of the Morecambe Offshore Windfarm Generation Assets. However, the number of vessels associated with Morecambe Offshore Windfarm Generation Assets during the operation and maintenance phase will be lower than during the construction phase and therefore risks of collision to basking shark will similarly reduce. Vessel movements during decommissioning are expected to be a reversal of the construction phase, with similar or identical vessel numbers.

3.11.8.12 For the Morgan and Morecambe Offshore Wind Farms Transmission Assets, Vessel traffic associated with the construction activities will result in an increase in vessel movements within the study area as up to 740 return trips by construction vessels may be made throughout the construction phase, with up to 70 construction vessels on site at any one time. Any operations and maintenance activities will require vessel transit, with up to 19 vessels present at any one time within the Morgan and Morecambe Offshore Wind Farms Transmission Assets and a maximum licenced 1,155 vessel movements to and from the site per year, with most of these being CTVs. Over the predicted 35-year lifetime of the Morgan and Morecambe Offshore Wind Farms Transmission Assets, this could lead to a maximum of 40,425 vessel movements overall, with each representing a collision risk to basking shark. Vessel movements during decommissioning are expected to be a reversal of the construction phase, with similar or identical vessel numbers.

3.11.8.13 For the ENI HyNet CCS project, this will increase construction vessel numbers to a number which has not been fully quantified yet (ENI, 2023), but the construction activities are unlikely to represent a significant increase compared to the construction operations on surrounding offshore renewable projects.

3.11.8.14 The number of vessels undertaking dredging and aggregate extraction activities in Liverpool Bay Area 457 is currently not publicly available (MarineSpace, 2023), although the extraction activities will be undertaken with a small number of trailer suction hopper dredge vessels over a period of 15 years overall, and are unlikely to represent a significant increase in the number of vessels compared to heavy background traffic in the east Irish Sea.

3.11.8.15 The operation and maintenance phase of the Mooir Vannin Offshore Windfarm will temporally overlap with the operation and maintenance phase of the Mona Offshore Wind Project, resulting in a potential cumulative impact. This will increase vessel numbers during the operation and maintenance phase of the Mona Offshore Wind Project, however predicted vessel numbers are not currently available in the public domain. 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.

3.11.8.16 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

3.11.8.17 The basking shark sensitivity to this impact within the fish and shellfish ecology study area has been assessed previously in section 3.9.9.

3.11.8.18 The basking shark within the fish and shellfish ecology study 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

3.11.8.19 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

3.11.8.20 The number of vessels undertaking construction or maintenance activities on the MaresConnect Wales-Ireland Interconnector Cable will overlap temporally with the Mona Offshore Wind Project and 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.

3.11.8.21 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

3.11.8.22 The basking shark sensitivity to this impact within the fish and shellfish ecology study area has been assessed previously in section 3.9.9.

3.11.8.23 The basking shark within the 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

3.11.8.24 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.

### 3.11.9 Future monitoring

3.11.9.1 No future monitoring of fish and shellfish ecology is currently planned.

## 3.12 Transboundary effects

3.12.1.1 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 Mona Offshore Wind Project upon the interests of other states has been assessed as part of this Environmental Statement. The potential transboundary impacts assessed within Volume 5, Annex 5.2: Transboundary impacts screening of the Environmental Statement are summarised below.

3.12.1.2 As set out above, the majority of impacts on fish and shellfish IEF receptors will be restricted to the within the Mona Array Area and Mona Offshore Cable Corridor and Access Areas and the immediate surrounding areas. Exceptions to this are impacts from underwater sound, and the impacts of increased suspended sediment concentrations and associated sediment deposition.

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

3.12.1.4 Increased SSCs and associated sediment deposition has a magnitude deemed to be low, and the sensitivity of the receptors is considered low to medium, with the significance therefore being negligible to minor adverse. However, the identified tidal excursion of 20 km 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.

## 3.13 Inter-related effects

3.13.1.1 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 Mona Offshore Wind Project (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 sound 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 sound; increased SSCs and sediment deposition; long term habitat loss; EMF from subsea cabling; colonisation of hard structures, 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.

3.13.1.2 A description of the likely interactive effects arising from the Mona Offshore Wind Project on fish and shellfish ecology is provided in Volume 2, Chapter 11: Inter-related effects – offshore of the Environmental Statement.

## 3.14 Summary of impacts, mitigation measures and monitoring

3.14.1.1 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 site-specific data opportunistically collected during site investigation surveys.

- Table 3.34 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 sound impacting fish and shellfish receptors; increased SSCs and associated sediment deposition; long term habitat loss; EMF from subsea electrical cabling; introduction and colonisation of hard structures; disturbance/remobilisation of sediment-bound contaminants, and injury due to increased risk of collision with vessels. Overall, it is concluded that there will be potentially significant effects from the Mona Offshore Wind Project during the construction phase, precautionarily, for impacts to herring during the herring spawning season from underwater sound associated with piling (moderate adverse significance). It is proposed to manage and reduce the effect of this impact through establishment of an Underwater sound management strategy post-consent as mitigation (outline provided with the application, document reference J16). This strategy establishes a process of investigating options to manage underwater sound levels in consultation with the licensing authority and SNCBs and agreeing, prior to construction of those works which would lead to underwater sound impacts, which mitigation measures will be implemented to reduce impacts such that there will be no residual significant effect. The Underwater sound management strategy is secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence.

Therefore following implementation of this tertiary mitigation measure, there will be **no significant residual effects**.

- Table 3.35 presents a summary of the potential cumulative impacts, mitigation measures and residual effects. The cumulative impacts assessed include temporary habitat loss/disturbance; underwater sound 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 potentially significant cumulative effects from the Mona Offshore Wind Project alongside other projects/plans to herring and cod during their respective spawning seasons through the impact of underwater sound from piling (moderate adverse significance). Tertiary mitigation proposed for the project alone, based upon post-consent development of an Underwater sound management strategy (outline provided with the application, document reference J16), will also reduce any cumulative effect based upon reducing the magnitude of sound generated by the Mona Offshore Wind Project. The Underwater sound management strategy is secured within the deemed marine licence in Schedule 14 of the draft DCO and expected to be secured within the standalone NRW marine licence. Contribution to any cumulative effect from underwater sound during piling (and other relevant activities) by the Mona Offshore Wind Project will therefore not be significant. The assessment of cumulative effects from other plans and projects is based upon the respective MDSs presented in the Environmental Statements for tier 1 projects or PEIR for tier 2 projects. The assessment does not consider any further mitigation or reduced/refined project design envelopes for other tier 1 and/or tier 2 projects that may be implemented post-consent. However, it is understood that if other projects are consented, it is reasonable to assume that they will each implement appropriate measures such that any significant effect is reduced to a non-significant level. Although this assessment cannot conclude based upon this assumption, a significant cumulative impact is considered unlikely for this reason. **No residual significant cumulative effects** are expected to occur.
- **No potential significant transboundary impacts** have been identified in regard to effects of the Mona Offshore Wind Project.

**Table 3.34: Summary of potential environmental effects, mitigation and monitoring.**

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

| Description of impact | 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 EMP throughout all phases, and actions to reduce potential for introduction of INNS. | C: Negligible to Low<br>O: Negligible to Low<br>D: Negligible to Low | C: Marine - Low to High<br>Diadromous - Negligible<br>O: Marine - Low to High<br>Diadromous - Negligible<br>D: Marine - Low to High<br>Diadromous - Negligible | C: Marine - Minor adverse<br>Diadromous - Negligible<br>O: Marine - Minor adverse<br>Diadromous - Negligible<br>D: Marine - Minor adverse<br>Diadromous - Negligible | Not required | Negligible to Minor adverse | None proposed |
| Underwater sound impacting fish and shellfish receptors | ✓ | × | ✓ | Adherence to a MMMP, including 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 sound levels reach a level at which injury may occur. | C: Low to Medium | C: Marine - Low to High<br>Diadromous - Low to Medium | C: Marine - Minor adverse<br>Cod – Minor adverse<br>Herring - Moderate adverse<br>Diadromous - Minor adverse | Underwater sound management strategy (Document Reference J16) | Minor adverse | None proposed |
| Increased suspended sediment concentrations (SSCs) and associated sediment deposition | ✓ | ✓ | ✓ | Development of, and adherence to, an Offshore EMP and Offshore CMS. | C: Low<br>O: Negligible<br>D: Low | C: Marine - Low to Medium<br>Diadromous - Low<br>O: Marine - Low to Medium | C: Marine - Minor adverse<br>Diadromous - Negligible<br>O: Marine - Negligible to Minor adverse | Not required | Negligible to Minor adverse | None proposed |

| Description of impact | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Diadromous - Low<br>D: Marine - Low to medium<br>Diadromous - Low | Diadromous - Negligible<br>D: Marine - Minor adverse<br>Diadromous - Negligible | | | |
| Long term habitat loss. | ✓ | ✓ | ✓ | Development of, and adherence to, an Offshore EMP throughout all phases; actions to reduce potential for introduction of INNS, and development and adherence to an Offshore CMS including a CSIP. | C: Negligible to Low<br>O: Negligible to Low<br>D: Negligible to Low | C: Marine - Low to medium<br>Diadromous - Low<br>O: Marine - Low to medium<br>Diadromous - Low<br>D: Marine - Low to medium<br>Diadromous - Low | C: Marine - Negligible to Minor adverse<br>Diadromous - Minor adverse<br>O: Marine - Negligible to Minor adverse<br>Diadromous - Minor adverse<br>D: Marine - Negligible to Minor adverse<br>Diadromous - Minor adverse | Not required | Negligible to Minor adverse | None proposed |
| Electromagnetic Fields (EMF) from subsea electrical cabling. | × | ✓ | × | Development and adherence to an Offshore CMS including a CSIP. All electrical cables including inter-array, export, and inter-connector cables will be buried to depths of at least 0.5m, with cable protection used where cables are exposed, as informed by a cable burial risk assessment (CBRA). While burial of cables will not reduce the strength of EMF, it does increase the | O: Low | O: Marine - Low<br>Diadromous - Low | O: Marine - Minor adverse<br>Diadromous - Minor adverse | Not required | Minor adverse | None proposed |

| Description of impact | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | distance between cables and fish and shellfish receptors, thereby potentially reducing the effect on those receptors. | | | | | | |
| Introduction of artificial structures and colonisation of hard structures | ✓ | ✓ | ✓ | Development of, and adherence to, an Offshore EMP throughout all phases, and actions to reduce potential for introduction of INNS. | C: Low<br>O: Low<br>D: Low | C: Marine - Low<br>Diadromous - Low<br>O: Marine - Low<br>Diadromous - Low<br>D: Marine - Low<br>Diadromous - Low | C: Marine - Minor adverse<br>Diadromous - Minor adverse<br>O: Marine - Minor adverse<br>Diadromous - Minor adverse<br>D: Marine - Minor adverse<br>Diadromous - Minor adverse | Not required | Minor adverse | None proposed |
| Disturbance/remobilisation of sediment-bound contaminants | ✓ | ✓ | ✓ | Development of, and adherence to, an Offshore EMP. | C: Low<br>O: Negligible<br>D: Negligible | C: Marine - Low<br>Diadromous - Low<br>O: Marine - Low<br>Diadromous - Low<br>D: Marine - Low<br>Diadromous - Low | C: Marine - Minor adverse<br>Diadromous - Minor adverse<br>O: Marine - Negligible<br>Diadromous - Negligible<br>D: Marine - Negligible<br>Diadromous - Negligible | Not required | Negligible to Minor adverse | None proposed |
| Injury due to increased risk of collision with vessels | ✓ | ✓ | ✓ | Offshore EMP will be issued to all Project vessel operators, requiring them to: | C: Low<br>O: Low<br>D: Low | C: Marine - Medium<br>O: Marine - Medium | C: Marine - Minor adverse<br>O: Marine - Minor adverse | Not required | Minor adverse | None proposed |

| Description of impact | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | •not deliberately approach basking shark<br>•keep vessel speed to a minimum; and<br>•avoid abrupt changes in course or speed should basking shark approach the vessel.<br>Offshore EMP will be adhered to at all times. | | D: Marine - Medium | D: Marine - Minor adverse | | | |

**Table 3.35: 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tier 1** | | | | | | | | | | |
| Temporary habitat loss/disturbance | ✓ | × | × | Development of, and adherence to, an Offshore EMP throughout all phases, and actions to reduce potential for introduction of INNS. | C: Negligible to Low | C: Negligible to high | C: Negligible to minor adverse | Not required | Negligible to minor adverse | None proposed |
| Underwater sound impacting fish and shellfish receptors | ✓ | × | × | Adherence to a MMMP, including 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 sound levels reach a level at which injury may occur. | C: Low to Medium | C: Low to high | C: Minor adverse to Moderate adverse | Underwater Sound Management Strategy | Minor adverse | None proposed |
| Increased suspended sediment concentrations (SSCs) and associated sediment deposition | ✓ | × | × | Development of, and adherence to, an Offshore EMP. | C: Low | C: Low to medium | C: Minor adverse | Not required | Minor adverse | None proposed |
| Long term habitat loss | ✓ | ✓ | × | Development of, and adherence to, an Offshore EMP throughout all phases; actions to reduce potential for introduction of INNS, and development and adherence to an Offshore CMS including a CSIP. | C: Negligible to Low<br>O: Negligible to Low | C: Low to medium<br>O: Low to medium | C: Negligible to Minor adverse<br>O: Negligible to Minor adverse | Not required | Minor adverse | None proposed |
| Electromagnetic Fields (EMF) from | × | ✓ | × | Development and adherence to an Offshore CMS including a CSIP. All electrical cables including | O: Low | O: Low | O: Minor adverse | Not required | Minor adverse | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| subsea electrical cabling | | | | array, , export and inter-connector cables will be buried to depths of at least 0.5 m 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. | | | | | | |
| Introduction of artificial structures and colonisation of hard structures | ✓ | ✓ | × | Development of, and adherence to, an Offshore EMP throughout all phases, and actions to reduce potential for introduction of INNS. | C: Low<br>O: Low | C: Low<br>O: Low | C: Minor adverse<br>O: Minor adverse | Not required | Minor adverse | None proposed |
| Injury due to increased risk of collision with vessels (basking shark only) | ✓ | ✓ | ✓ | Offshore EMP will be issued to all Project vessel operators, requiring them to:<br>•not deliberately approach basking shark<br>•keep vessel speed to a minimum; and<br>•avoid abrupt changes in course or speed should basking shark approach the vessel.<br>Offshore EMP will be adhered to at all times. | C: Low<br>O: Low<br>D: Low | C: Medium<br>O: Medium<br>D: Medium | C: Minor adverse<br>O: Minor adverse<br>D: Minor adverse | Not required | Minor adverse | None proposed |
| **Tier 2** | | | | | | | | | | |
| Temporary habitat loss/disturbance | ✓ | × | ✓ | Development of, and adherence to, an Offshore EMP throughout all | C: Negligible to Low | C: Negligible to high | C: Negligible to minor adverse | Not required | Minor adverse | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | phases, and actions to reduce potential for introduction of INNS. | D: Negligible to Low | D: Negligible to high | D: Negligible to minor adverse | | | |
| Underwater sound impacting fish and shellfish receptors | ✓ | × | × | Adherence to a MMMP, including 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 sound levels reach a level at which injury may occur. | C: Low to Medium | C: Low to high | C: Minor adverse to Moderate adverse | Underwater sound management strategy (Document Reference J16) | Minor adverse | None proposed |
| Increased suspended sediment concentrations (SSCs) and associated sediment deposition | ✓ | × | ✓ | Development of, and adherence to, an Offshore EMP and Offshore CMS. | C: Low<br>D: Low | C: Low to medium<br>D: Low to medium | C: Minor adverse<br>D: Minor adverse | Not required | Minor adverse | None proposed |
| Long term habitat loss | ✓ | ✓ | ✓ | Development of, and adherence to, an Offshore EMP throughout all phases; actions to reduce potential for introduction of INNS, and development and adherence to an Offshore CMS including a CSIP. | C: Negligible to Low<br>O: Negligible to Low<br>D: Negligible to Low | C: Low to medium<br>O: Low to medium<br>D: Low to medium | C: Negligible to Minor adverse<br>O: Negligible to Minor adverse<br>D: Negligible to Minor adverse | Not required | Minor adverse | None proposed |
| Electromagnetic Fields (EMF) from subsea electrical cabling | × | ✓ | × | Development and adherence to an Offshore CMS including a CSIP. All electrical cables including array, , export and inter-connector cables will be buried to depths of at least 0.5 m 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 | O: Low | O: Low | O: Minor adverse | Not required | Minor adverse | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | shellfish receptors, thereby potentially reducing the effect on those receptors. | | | | | | |
| Introduction of artificial structures and colonisation of hard structures | ✓ | ✓ | ✓ | Development of, and adherence to, an Offshore EMP throughout all phases, and actions to reduce potential for introduction of INNS. | C: Low<br>O: Low<br>D: Low | C: Low<br>O: Low<br>D: Low | C: Minor adverse<br>O: Minor adverse<br>D: Minor adverse | Not required | Minor adverse | None proposed |
| Injury due to increased risk of collision with vessels (basking shark only) | ✓ | ✓ | ✓ | Offshore EMP will be issued to all Project vessel operators, requiring them to:<br>•not deliberately approach basking shark<br>•keep vessel speed to a minimum; and<br>•avoid abrupt changes in course or speed should basking shark approach the vessel.<br>Offshore EMP will be adhered to at all times. | C: Low<br>O: Low<br>D: Low | C: Medium<br>O: Medium<br>D: Medium | C: Minor adverse<br>O: Minor adverse<br>D: Minor adverse | Not required | Minor adverse | None proposed |
| **Tier 3** | | | | | | | | | | |
| Temporary habitat loss/disturbance | ✓ | × | × | Development of, and adherence to, an Offshore EMP throughout all phases, and actions to reduce potential for introduction of INNS. | C: Negligible to Low | C: Negligible to high | C: Negligible to minor adverse | Not required | Minor adverse | None proposed |
| Underwater sound impacting fish and shellfish receptors | ✓ | × | × | Adherence to a MMMP, including 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 | C: Low to Medium | C: Low to high | C: Minor adverse to Moderate adverse | Underwater sound management strategy (Document Reference J16) | Minor adverse | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | sound levels reach a level at which injury may occur. | | | | | | |
| Increased suspended sediment concentrations (SSCs) and associated sediment deposition | ✓ | × | × | Development of, and adherence to, an Offshore EMP and Offshore CMS. | C: Low | C: Low to medium | C: Minor adverse | Not required | Minor adverse | None proposed |
| Long term habitat loss | ✓ | ✓ | ✓ | Development of, and adherence to, an Offshore EMP throughout all phases; actions to reduce potential for introduction of INNS, and development and adherence to an Offshore CMS including a CSIP. | C: Negligible to Low<br>O: Negligible to Low<br>D: Negligible to Low | C: Low to medium<br>O: Low to medium<br>D: Low to medium | C: Negligible to Minor adverse<br>O: Negligible to Minor adverse<br>D: Negligible to Minor adverse | Not required | Minor adverse | None proposed |
| Electromagnetic Fields (EMF) from subsea electrical cabling | × | ✓ | × | Development and adherence to an Offshore CMS including a CSIP. All electrical cables including array, , export and inter-connector cables will be buried to depths of at least 0.5 m 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: Low | O: Minor adverse | Not required | Minor adverse | None proposed |
| Introduction of artificial structures and colonisation of hard structures | ✓ | ✓ | × | Development of, and adherence to, an Offshore EMP throughout all phases, and actions to reduce potential for introduction of INNS. | C: Low<br>O: Low | C: Low<br>O: Low | C: Minor adverse<br>O: Minor adverse | Not required | Minor adverse | 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Injury due to increased risk of collision with vessels (basking shark only) | ✓ | ✓ | ✓ | Offshore EMP will be issued to all Project vessel operators, requiring them to:<br>•not deliberately approach basking shark<br>•keep vessel speed to a minimum; and<br>•avoid abrupt changes in course or speed should basking shark approach the vessel.<br>Offshore EMP will be adhered to at all times. | C: Low<br>O: Low<br>D: Low | C: Medium<br>O: Medium<br>D: Medium | C: Minor adverse<br>O: Minor adverse<br>D: Minor adverse | Not required | Minor adverse | None proposed |

## 3.15 References

Aberkali, H.B. and Trueman, E.R. (1985) Effects of environmental stress on marine bivalve molluscs. Advances in Marine Biology, 22, 101-98.

Acolas, M.L., Anras, M.L.B., Veron, V., Jourdan, H., Sabatie, M.R., and Bagliniere, J.L. (2004) An assessment of the upstream migration and reproductive behaviour of allis shad (*Alosa alosa* L.) using acoustic tracking. ICES Journal of Marine Science, 61(8), 1291-1304. Available online: https://doi.org/10.1016/j.icesjms.2004.07.023. Accessed October 2023.

Agnalt, A.L., Kristiansen, T.S., and Jorstad, K.E. (2007) Growth, Reproductive Cycle and Movement of Berried European Lobsters (*Homarus gammarus*) in a Local Stock off Southwestern Norway. ICES Journal of Marine Sciences, 64, 288-97.

Aires, C., González-Irusta, J.M., and Watret, R. (2014) Updating Fisheries Sensitivity Maps in British Waters. Scottish Marine and Freshwater Science Vol 5 No 10. Edinburgh: Scottish Government, 88pp. DOI: 10.7489/1555-1.

Andersson, M.H. (2011) Offshore Wind Farms - Ecological Effects of Noise and Habitat Alteration on Fish. PhD Thesis, Department of Zoology, Stockholm University.

Andersson, M.H., Berggren, B., Wilhelmsson, D., and Öhman, M.C. (2009) Epibenthic Colonization of Concrete and Steel Pilings in a Cold-Temperate Embayment: A Field Experiment. Helgoland Marine Research, 63, 249–60.

Andersson, M.H., and Öhman, M. (2010) Fish and sessile assemblages associated with wind-turbine constructions in the Baltic Sea. Marine and Freshwater Research, 61, 642-50.

APEM (2021) Beatrice Offshore Wind Farm: Post Construction Benthic Monitoring Method Statement. Available online: https://marine.gov.scot/sites/default/files/apem_beatrice_owf_2020_post-construction_benthic_survey_methodology.pdf. Accessed October 2023.

Appleby, J.A., and Scarratt (1989) Physical effects of suspended solids on marine and estuarine fish and shellfish, with special reference to ocean dumping: a literature review. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1681.

Armstrong, J.D., Hunter, D.C., Fryer, R.J., Rycroft, P., and Orpwood, J.E. (2015) Behavioural responses of Atlantic salmon to mains frequency magnetic fields. Scottish Marine and Freshwater Science, 6(9).

Associated British Ports (2022) Barrow Channels Maintenance Dredge. Available online: https://www.abports.co.uk/media/d5ohcrbf/barrow-lntm-2022-23-maintenance-dredge-barrow-channel.pdf. Accessed October 2023.

Atema, J., and Cobb, J. S. (1980) Social behaviour in the biology and management of lobsters. 409–450.

Atuma, S.S., Andersson, O., Linder, C.E., and Hansson, L. (1993) Levels of some organochlorine compounds in sea trout (*Salmo trutta*) and whitefish (*Coregonus lavaretus*) from the Gulf of Bothnia. Health and Environmental Research Online, 23(2), 221-6, Technical Report, BIO.

Bagocius, D. (2015) Piling underwater noise impact on migrating salmon fishing during Lithuanian LNG terminal construction (Curonian Lagoon, Eastern Baltic Sea Coast). Marine Pollution Bulletin, 92(1-2), 45-51. Available online: https://doi.org/10.1016/j.marpolbul.2015.01.002. Accessed October 2023.

Ball, B.J., Fox, G., and Munday, B.W. (2000) Long- and short-term consequences of a *Nephrops* trawl fishery on the benthos and environment of the Irish Sea. ICES Journal of Marine Science, 57(5), 1315-20. Available online: https://doi.org/10.1006/jmsc.2000.0924. Accessed October 2023.

Barker, J., Davies, J., Goralczyk, M., Patel, S., O'Connor, J., Evans, J., Sharp, R., Gollock, M., Wood, F.R., Rosindell, J., Bartlett, C., Garner, B.J., Jones, D., Quigley, D., and Wray, B. (2022) The distribution, ecology and predicted habitat use of the Critically Endangered angelshark (*Squatina squatina*) in coastal waters of Wales and the central Irish Sea. Journal of Fish Biology, 101(3), pp. 640-58. Available online: https://doi.org/10.1111/jfb.15133. Accessed October 2023.

Bellman, M.A., Brinkmann, J., May, A., Wendt, T., Gerlach, S. and Remmers, P. (2020) Underwater noise during the impulse pile-driving procedure: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values. Supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium fur Umwelt, Naturschutz and nukleare Sicherheit (BMU)), FKZ UM16 881500. Commissioned and managed by the Federal Maritime and Hydrographic Agency (Bundesamt fur Seechifffahrt und Hydrographie (BSH)), Order No. 10036866. Edited by the itap GmbH.

Bender, A., Langhammer, O., and Sundberg, J. (2020) Colonisation of wave power foundations by mobile mega- and macrofauna – a 12 year study. Marine Environmental Research, 161, 105053, Available online: https://doi.org/10.1016/j.marenvres.2020.105053. Accessed October 2023.

Bentley J.W., Serpetti N., Fox C.J., Heymans J.J. and Reid D.G. (2020). Retrospective analysis of the influence of environmental drivers on commercial stocks and fishing opportunities in the Irish Sea. Fish and Oceanography, 295, 415–435.

Bergström, L., Sundqvist, F., and Bergström, U. (2013) Effects of an offshore wind farm on temporal and spatial patterns in the demersal fish community. Marine Ecology Progress Series 485, 11pp.

Berli, B.I., Gilbert, M.J.H., Ralph, A.L., Tierney, K.B., and Burkhardt-Holm, P. (2014) Acute exposure to a common suspended sediment affects the swimming performance and physiology of juvenile salmonids. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 176, 1-10, Available online: https://doi.org/10.1016/j.cbpa.2014.03.013. Accessed October 2023.

BioConsult (2006) Hydroacoustic Monitoring of Fish Communities at Offshore Wind Farms, Horns Rev Offshore Wind Farm, Annual Report 2005.

Birklund, J., and Wijsman, J. W. M. (2005) Aggregate Extraction: A Review on the Effects on Ecological Functions. Report Z3297/10 SAWDPIT Fith Framework Project no EVK3-CT-2001-00056. Available online: https://repository.tudelft.nl/islandora/object/uuid %3A11ee2c93-2dfd-429e-acd4-a079a0fa2552 Accessed October 2023.

Bisson, P.A., and Bilby, R.E. (1982) Avoidance of Suspended Sediment by Juvenile Coho Salmon. North American Journal of Fisheries Management, 2(4), pp. 371-4. Available online: https://doi.org/10.1577/1548-8659(1982)2<371:AOSSBJ>2.0.CO;2. Accessed October 2023.

Bloomfield, A., and Solandt, J.L. (2008) The Marine Conservation Society Basking Shark Watch 20-year report. Marine Conservation Society, Report.

Bloor, I.S.M., Emmerson, J. and Jenkins, S.R. (2019) Assessment of Queen Scallop stock status for the Isle of Man territorial sea 2019/2020. SFAG Report No. 1, 18pp.

Bochert, R., and Zettler, M.L. (2006) Effect of Electromagnetic Fields on Marine Organisms. In: Köller, J., Köppel, J., Peters, W. (eds) Offshore Wind Energy. Springer, Berlin, Heidelberg, 223-34. Available online: https://doi.org/10.1007/978-3-540-34677-7_14. Accessed October 2023.

Bodin, N., Abarnou, A., Le Guellec, A.M., Loizeau, V., and Philippon, L.X. (2007a) Organochlorinated contaminants in decapod crustaceans from the coasts of Brittany and Normandy (France). Chemosphere, 67(9), 536-47. Available online: https://doi.org/10.1016/j.chemosphere.2006.05.088. Accessed October 2023.

Bodin, N., Abarnou, A., Fraisse, D., Defour, S., Loizeau, V., Le Guellec, A.M., and Philippon, X. (2007b) PCB, PCDD/F and PBDE levels and profiles in crustaceans from the coastal waters of Brittany and Normandy (France). Marine Pollution Bulletin, 54(6), 657-68.

Bodznick, D. and Northcutt, R.G. (1981) Electroreception in Lampreys: Evidence that the Earliest Vertebrates were Electroreceptive. Science, 212, 465-67.

Bodznick, D. and Preston, D.G. (1983) Physiological Characterization of Electroreceptors in the Lampreys*. Ichthyomyzon uniscuspis* and *Petromyzon marinus*. Journal of Comparative Physiology 152, 209-17.

Bohnsack, J. A. (1989) Are High Densities of Fishes at Artificial Reefs the Result of Habitat Limitation or Behavioural Preference? B. Mar. Sci., 44(2), 631-45.

Boldrocchi, G., Spanu, D., Polesello, S., Walsecchi, S., Garibaldi, F., Lanteri, L., Ferrario, C., Monticelli, D., and Bettinetti, R. (2022) Legacy and emerging contaminants in the endangered filter feeder basking shark *Cetorhinus maximus*. Marine Pollution Bulletin, 176, 113466. Available online: https://doi.org/10.1016/j.marpolbul.2022.113466. Accessed October 2023

Bolle, L.J., de Jong, C., Blom, E., Wessels, P., van Damme, C., and Winter, H. (2014) Effect of pile-driving sound on the survival of fish larvae (Report No. C182/14). Report by IMARES - Wageningen UR.

Bolle, L.J., de Jong, C.A.F., Bierman, S.M., van Beek, P.J.G., Wessels, P.W., Blom, E., van Damme, C.J.G., Winter, H.V., and Dekeling, R.P.A. (2016) Effect of Pile-Driving Sounds on the Survival of Larval Fish. In: Popper, A., Hawkins, A. (eds) The Effects of Noise on Aquatic Life II. Advances in Experimental Medicine and Biology, 875, 91-100.

Boubee, J.A.T., Dean, T.L., West, D.W., and Barrier, R.F.G. (1996) Avoidance of suspended sediment by the juvenile migratory stage of six New Zealand native fish species. New Zealand Journal of Marine and Freshwater Research, 31(1), pp. 61-9. Available online: https://doi.org/10.1080/00288330.1997.9516745. Accessed October 2023

Bouma, S., and Lengkeek, W. (2008) Benthic communities on hard substrates within the first Dutch offshore wind farm (OWEZ). Algae 2011.

Bouma, S., and Lengkeek, W. (2012) Benthic communities on hard substrates of the offshore wind farm Egmond aan Zee (OWEZ). Noordzeewind, report number: OWEZ_R_266_T1_20120206_hard_substrate.

Bowers, D.G., Boudjelas, S., and Harker, G.E.L. (2010) The distribution of fine suspended sediments in the surface waters of the Irish Sea and its relation to tidal stirring. International Journal of Remote Sensing, 19(14), 2789-805: DOI: 10.1080/014311698214514.

BOWind (2008) Barrow Offshore Wind Farm Post Construction Monitoring Report. First annual report. 15 January 2008, 60pp.

BOWL (2021a) Beatrice Offshore Wind Farm Post-Construction Sandeel Survey–Technical Report.

BOWL (2021b) Beatrice Offshore Wind Farm Post-Construction Cod Spawning Survey – Technical Report.

Brand, A.R. (1991). Scallop ecology: Distributions and behaviour. In Scallops: biology, ecology and aquaculture (ed. S.E. Shumway), pp. 517-584. Amsterdam: Elsevier.

Bressa, G., Sisti, E., and Cime, F. (1997) PCBs and organochlorinated pesticides in eel (*Anguilla anguilla* L.) from the Po delta. Marine Chemistry, 58(3-4), 261-66. Available online: https://doi.org/10.1016/S0304-4203(97)00053-4. Accessed October 2023.

Brown and May Marine Ltd (2009a) Walney Offshore Wind Farm Pre-Construction Fish Survey.

Brown and May Marine Ltd (2009b) Ormonde Offshore Wind Farm Pre-Construction Juvenile & Adult Fish Survey. Spring 2009.

Brown and May Marine Ltd (2009c) Ormonde Offshore Wind Farm Pre-Construction Juvenile & Adult Fish Survey. Autumn 2009.

Brown and May Marine Ltd. (2009d) Gunfleet Sands Offshore Wind Farm Herring Spawning Survey 2009. Available online: https://www.marinedataexchange.co.uk/details/485/summary. Accessed June 2023.

Budelmann, B.U. (1992) Hearing in Crustacea. The Evolutionary Biology of Hearing, 131-139, DOI: 10.1007/978-1-4612-2784-7_9.

Bunn, N.A., Fox, C.J., and Webb, T. (2000) A Literature Review of Studies on Fish Egg Mortality: Implications for the Estimation of Spawning Stock Biomass by the Annual Egg Production Method. Cefas Science Series Technical Report No 111, 37pp.

Burreau, S., Zebuhr, Y., Broman, D., and Ishaq, R. (2006) Biomagnification of PBDEs and PCBs in food webs from the Baltic Sea and the northern Atlantic Ocean. Science of the Total Environment, 366(2-3), 659-72.

Campanella, F., and van der Kooij, J. (2021) Spawning and nursery grounds of forage fish in Welsh and surroundings waters. Cefas Project Report for RSPB, 65 pp.

Campbell, A., and Stasko, A. B. (1985) Movements of tagged American lobster, *Homarus americanus*, off southwestern Nova Scotia. Canadian Journal of Fisheries and Aquatic Sciences, 42, 229–38.

Caputi, A.A., Aguilera, P.A., Pereira, A.C., and Rodrigues-Cattaneo A. (2013) On the haptic nature of the active electric sense of fish. Brain Research, 1536, 27-43, Available online: https://doi.org/10.1016/j.brainres.2013.05.028. Accessed October 2023.

Carroll, A.G., Przeslawski, R., Duncan, A., Gunning, M., and Bruce, B. (2017) A critical review of the potential impacts of marine seismic surveys on fish & invertebrates. Marine Pollution Bulletin, 114(1), 9-24.

Carter, M.C. (2008) *Aequipecten opercularis* Queen scallop. In Tyler-Walters H. and Hiscock K. Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom. Available online: https://www.marlin.ac.uk/species/detail/1997. Accessed October 2023.

Casper, B.M., Halvorsen, M.B., and Popper, A.N. (2012) Are Sharks Even Bothered by a Noisy Environment? In: Popper, A.N., Hawkins, A. (eds) The Effects of Noise on Aquatic Life. Advances in Experimental Medicine and Biology, 730, 93-7. Available online: https://doi.org/10.1007/978-1-4419-7311-5_20. Accessed October 2023.

Cates, K., DeMaster, D. P., Brownell, R. L. Jr, Silber, G., Gende, S., *et al*. (2017). Strategic Plan to Mitigate the Impacts of Ship Strikes on Cetacean Populations: 2017-2020. IWC Strategic Plan to Mitigate Ship Strikes. Jersey: International Whaling Commission.

Cefas (2009) Strategic Review of Offshore Wind Farm Monitoring Data Associated with Food and Environmental Protection Act Licence Conditions. Project ME1117.

Cefas (2016). Suspended Sediment Climatologies around the UK. Report for the UK Department for Business, Energy & Industrial Strategy offshore energy Strategic Environmental Assessment programme. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/584621/CEFAS_2016_Suspended_Sediment_Climatologies_around_the_UK.pdf. Accessed October 2023.

Chiasson, A.G. (2011) The effects of suspended sediment on rainbow smelt (*Osmerus mordax*): A laboratory investigation. Canadian Journal of Zoology, 71(12), 2419-24, DOI:10.1139/z93-337.

Christian, J.R., Mathieu, A., Thomson, D.H., White, D., and Buchanan, R.A. (2013) Effect of Seismic Energy on Snow Crab (*Chionoecetes opilio*). Prepared for National Energy Board, Calgary, AB., File No. CAL-1-00364 (2003), 50pp.

Chung-Davidson., Y., Bryan, M.B., Teeter, J., Bedore, C.N., and Li, W. (2008) Neuroendocrine and Behavioural Responses to Weak Electric Fields in Adult Sea Lampreys (*Petromyzon marinus*). Hormones and Behaviour, 54(1), 34-40.

CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland. Chartered Institute of Ecology and Environmental Management. Available online: https://cieem.net/resource/guidelines-for-ecological-impact-assessment-ecia/. Accessed October 2023.

CIEEM (2022) Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater, Coastal and Marine, September 2018, Version 1.1 – Updated September 2019.

CMACS (2012) Walney Offshore Wind Farm Year 1 post-construction benthic monitoring technical survey report (2012 survey). Report to Walney Offshore Wind Farms (UK) Ltd/DONG Energy.

CMACS (2014a) Walney Offshore Wind Farm Year 3 post-construction benthic monitoring technical survey report (2014 survey). Report to Walney Offshore Wind Farms (UK) Ltd/DONG Energy.

CMACS (2014b) Walney I&II Offshore Wind Farms post-construction turbine foundation colonisation report (2014 survey). Report to Walney (UK) Offshore Wind Farms Ltd.

Comeau, M., and Savoie, F. (2002) Movement of American lobster (*Homarus americanus*) in the southwestern Gulf of St Lawrence. Fishery Bulletin US, 100, 181–192.

Coolen, J.W.P., van der Weide, B., Cuperus, J., Blomberg, M., Van Moorsel, G.W.N.M., Faasse, M.A., Bos, O.G., Degraer, S., and Lindeboom, H.J. (2020) Benthic biodiversity on old platforms, young wind farms, and rocky reefs. ICES Journal of Marine Science, 77(3), 1250-65. Available online: https://doi.org/10.1093/icesjms/fsy092. Accessed October 2023.

Cooper, K. and Martinez, R. (2017) OneBenthic M-Test Tool. Cefas. Available online: https://rconnect.cefas.co.uk/onebenthic_mtest/. Accessed October 2023.

Coull, K.A., Johnstone, R, and Rogers, S.I. (1998) Fisheries Sensitivity Maps in British Waters. United Kingdom Offshore Operators Association Ltd: Aberdeen.

Cresci, A., Allan, B.J.M., Shema, S.D., Skiftesvik, A.B., and Browman, H.I., (2020). Orientation behaviour and swimming speed of Atlantic herring larvae (*Clupea harengus*) in situ and in laboratory exposures to rotated artificial magnetic fields. J. Exp. Mar. Biol.Ecol. 526, 151358. Available online: https://doi.org/10.1016/j.jembe.2020.151358. Accessed October 2023.

Cresci, A., Perrichon, P., Durif, C.M., Sørhus, E., Johnsen, E., Bjelland, R., Larsen, T., Skiftesvik, A.B., and Browman, H.I. (2022). Magnetic fields generated by the DC cables of offshore wind farms have no effect on spatial distribution or swimming behaviour of lesser sandeel larvae (*Ammodytes marinus*). Marine Environmental Research, 176, p.105609.

CSA Ocean Sciences Inc. and Exponent (2019) Evaluation of Potential EMF Effects on Fish Species of Commercial or Recreational Fishing Importance in Southern New England. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Sterling, VA. OCS Study BOEM 2019-049. 59pp.

Danish Energy Agency (2013) Danish Offshore Wind. Key Environmental Issues - a Follow-up. The Environmental Group: The Danish Energy Agency, The Danish Nature Agency, DONG Energy and Vattenfall.

Darling, James, D. and Keogh, K.E. (1994) Observations of basking sharks, *Cetorhinus maximus*, in Clayoquot Sound. BC. Canadian Field-Naturalist, 108(2), 199-210.

Day, R.D., McCauley, R., Fitzgibbon, Q.P., and Semmens, J.M. (2016) Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries. Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, October. CC BY 3.0.

De Mesel I., Kerckhof F., Norro A., Rumes B., Degraer S. (2015). Succession and seasonal dynamics of the epifauna community on offshore wind farm foundations and their role as stepping stones for non-indigenous species. Hydrobiologia, 756: 37–50.

DEFRA (2023) Biodiversity Net Gain – Government response and summary of responses to consultation. Available online: https://www.gov.uk/government/consultations/consultation-on-biodiversity-net-gain-regulations-and-implementation/outcome/government-response-and-summary-of-responses. Accessed October 2023.

Degraer, S., Carey, D., Coolen, J., Hutchison, Z., Kerchof, F., Rumes, B., and Vanaverbeke, J. (2020) Offshore Wind Farm Artificial Reefs Affect Ecosystem Structure and Functioning: A Synthesis. Oceanography, 33(4), 48-57.

Delargy, A. (2019) Quantitative Methods for Producing Evidence to Support Sustainable King Scallop Management. Bangor University (United Kingdom).

Department for Energy Security & Net Zero (2024a) Overarching National Policy Statement for Energy (NPS EN-1). Available: https://assets.publishing.service.gov.uk/media/65a7864e96a5ec0013731a93/overarching-nps-for-energy-en1.pdf. Accessed February 2024.

Department for Energy Security & Net Zero (2024b) National Policy Statement for Renewable Energy Infrastructure (NPS EN-3). Available: https://assets.publishing.service.gov.uk/media/65a7889996a5ec000d731aba/nps-renewable-energy-infrastructure-en3.pdf. Accessed February 2024.

De Soto. A., N. Delorme, J. Atkins, S. Howard, J. Williams, and M. Johnson (2013) Anthropogenic noise causes body malformations and delays development in marine larvae. Sci. Reproduction, 3 (2013), p.2831.

Desprez, M. (2000) Physical and biological impact of marine aggregate extraction along the French coast of the eastern English Channel: short and long-term post-dredging restoration. ICES Journal of Marine Science 57, 1428-1438.

DFO (2004) Potential impacts of seismic energy on snow crab. DFO Can Sci Advis Sec. Habitat Status Report 2004/003, p.2.

Dickey-Collas, M., Nash, R. and Brown, J. (2001) The location of spawning of Irish Sea Herring (*Clupea harengus*). Journal of the Marine Biological Association of the UK, 81(04), pp. 713-14.

Dignan, S.P., Bloor, I.S.M, Murray, L.G., and Kaiser, M.J. (2014) Predicted impacts of proposed management measures in the Isle of Man queen scallop (*Aequipecten opercularis*) fishery to be introduced in the 2015 fishing season. Fisheries and Conservation Report No. 40, Bangor University, pp.11.

Doherty, P.D., Baxter, J.M., Gell, F.R., Godley, B.J., Graham, R.T., Hall, G., Hall, J., Hawkes, L.A., Henderson, S.M., Johnson, L. and Speedie, C. (2017) Long-term satellite tracking reveals variable seasonal migration strategies of basking sharks in the north-east Atlantic. Scientific reports, 7, 428-37.

Doksaeter, L., Handegard, N., Good, O., Vadsheim, P., and Nordlund, N. (2012) Behavior of captive herring exposed to naval sonar transmissions (1.0-1.6 kHz) throughout a yearly cycle. The Journal of the Acoustical Society of America, 131(2), 1632-42, DOI:10.1121/1.3675944.

Dolton, H.R., Gell, F.R., Hall, J., Hawkes, L.A., and Witt, M.J. (2020) Assessing the importance of Isle of Man waters for the basking short *Cetorhinus maximus*. Endangered Species Register, 41, 209-223. Available online:https://doi.org/10.3354/esr01018. Accessed October 2023.

Drinkwater, K.F. (2005) The response of Atlantic cod (Gadus morhua) to future climate change. ICES Journal of Marine Science, 62(7), 1327-1337. Available online: https://doi.org/10.1016/j.icesjms.2005.05.015. Accessed October 2023.

Dukas, R. (2002) Behavioural and ecological consequences of limited attention. Philos. T. R. Soc. B. 357, 1539–1547. doi: 10.1098/rstb.2002.10063.

Duncan P.F. and Emmerson J. (2018) Commercial Fisheries & Sea Angling. In: Manx Marine Environmental Assessment (2nd Ed.). Isle of Man Government. 71 pp.

Dunkley, F., and Solandt, J.L. (2022) Windfarms, fishing, and benthic recovery: Overlaps, risks and opportunities. Marine Policy, 145, 105262. Available online: https://doi.org/10.1016/j.marpol.2022.105262. Accessed October 2023.

Edmonds, N.J., Firmin, C.J., Goldsmith, D., Faulkner, R.C., and Wood, D.T. (2016). A review of crustacean sensitivity to high amplitude underwater noise: Data needs for effective risk assessment in relation to UK commercial species. Marine Pollution Bulletin, Volume 108, Issues 1–2, 5-11.

EGS (2011) Lynn and Inner Dowsing Offshore Wind Farms Post-Construction Survey Works Phase 2 – Benthic Ecology Survey Centrica Contract No. CREL/C/400012, Final Report. 184pp.

Eirgrid Group (2015) North-South 400 kV Interconnection Development Environmental Impact Statement Volume 3B. Available online: https://www.eirgridgroup.com/app-sites/nsip/docs/en/environmental-documents/volume-3b/main-doc/Volume %203B %20Chapter %208 %20Electric %20and %20Magnetic %20Fields %20(EMF).pdf, Accessed October 2023.

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. (2012). Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147, 56pp.

Ellis, J.R., Pawson, M.G. and Shackley, S.E. (1996) The comparative feeding ecology of six species of shark and four species of skate (Elasmobranchii) in the North-east Atlantic. Journal of the Marine Biological Association of the United Kingdom, 76, 89-106.

EMU (2004) Subsea Cable Decommissioning – A Limited Environmental Appraisal. Report commissioned by British Telecommunications plc, Cable and Wireless and AT&T, Report no. 04/J/01/06/0648/0415, available from UKCPC.

EMU (2008a) Barrow Offshore Wind Farm Monopile Ecological Survey. Report No. 08/J/1/03/1321/0825. Report prepared on behalf of Narrow Offshore Wind Ltd.

EMU (2008b) Kentish Flats Offshore Wind Farm Turbine Foundation Faunal Colonisation Diving Survey. Report No 08/J/1/03/1034/0839. Prepared on behalf of Kentish Flats Ltd.

ENI (2023) HyNet North West Liverpool Bay CCS Ltd HyNet Carbon Dioxide Transportation and Storage Project. Offshore EIA Scoping Report.

Fewtrell, J.L., and McCauley, R.D. (2012) Impact of air gun noise on the behaviour of marine fish and squid. Marine Pollution Bulletin, 64(5), 984-93. Available online: https://doi.org/10.1016/j.marpolbul.2012.02.009. Accessed October 2023.

Filiciotto, F., Vazzana, M., Celi, M., Maccarrone, V., Ceraulo, M., Buffa, G., Arizza, V., de Vincenzi, G., Rosario, G., Mazzola, S., and Buscaino, G. (2016). Underwater noise from boats: Measurement of its influence on the behaviour and biochemistry of the common prawn (*Palaemon serratus*, Pennant 1777). Journal of Experimental Marine Biology and Ecology. 478. 10.1016/j.jembe.2016.01.014.

Foden, J., Rogers, S.I., and Jones, A.P. (2009) Recovery rates of UK seabed habitats after cessation of aggregate extraction. Marine Ecology Progress Series, 390, 15-26, doi: 10.3354/meps08169.

Formicki, K., Korzelecka-Orkisz, A., and Tansk, A. (2019) Magnetoreception in fish. Journal of Fish Biology, 95(1), 73-91.

Gardiner, R., Main, R., Kynoch, R., Gilbey, J., and Davies, I. (2018a). A needle in the haystack? Seeking salmon smolt migration routes off the Scottish east coast using surface trawling and genetic assignment. Poster presentation to the MASTS Annual Science Meeting 31 October – 2 November 2018.

Gardiner, R., Main, R., Davies, I., Kynoch, R., Gilbey, J., Adams, C., and Newton M. (2018b). Recent investigations into the marine migration of salmon smolts in the context of marine renewable development. Conference Presentation. Environmental Interactions of Marine Renewables (EIMR) Conference, Kirkwall, 24-26 April 2018.

Gardline Limited (2022) Elizabeth Offshore Wind Farm Integrated Survey – Environmental Baseline Report. Gardline Report Ref 11602.E05.

Gardline Limited (2023) Morgan and Morecambe Offshore Wind Farms Integrated Survey – Environmental Baseline Survey Report Ref 11781.

Gill, A.B. and Taylor. H. (2001) The Potential of Electromagnetic Fields Generated by Cabling between Offshore Wind Turbines upon Elasmobranch Fishes. Report for the Countryside Council for Wales (CCW Science report No. 488), 60pp.

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. and Kimber, J.A. (2005) The Potential Effects of Electromagnetic Fields Generated by Sub-Sea Power Cables Associated with Offshore Wind Farm Developments on Electrically and Magnetically Sensitive Marine Organisms – A Review. COWRIE 1.5 Electromagnetic Fields Review.

Gill, A.B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. and Wearmouth, V. (2009) COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-Sensitive Fish Response to EM Emissions from Sub-Sea Electricity Cables of the Type used by the Offshore Renewable Energy Industry. COWRIE-EMF-1-06.

Gill, A.B., and Bartlett, M. (2010) Literature review on the potential effects of electromagnetic fields and subsea noise from marine renewable energy developments on Atlantic salmon, sea trout and European eel. Scottish Natural Heritage Commissioned Report No.401.

Gill, A.B., Bartlett, M., and Thomsen, F. (2012) Potential interactions between diadromous fishes of UK conservation importance and the electromagnetic fields and subsea noise from marine renewable energy developments. Journal of Fish Biology, 81, 664-695, doi:10.1111/J1095-8649.2012.03374.x..

Gill, A., Bremner, J., Blake, S., Fierens, L., Mynott, F., and Vanstaen, K. (2021) Effects of offshore wind farm construction and operation on commercial finish and commercial shellfish stocks and fisheries – Systematic evaluation of the literature. Cefas Project Report for Orsted Energy, 115pp.

Glarou, M., Zrust, M., and Svendsen, J.C. (2020) Using Artificial-Reef Knowledge to Enhance the Ecological Function of Offshore Wind Turbine Foundations: Implications for Fish Abundance and Diversity. Journal of Marine Science and Engineering, 8(5), 10.3390/jmse8050332.

Goold, J. (2008) Seasonal and spatial patterns of harbour porpoise and grey seal at a UK offshore wind farm site. Proceedings of the ASCOBANS/ECS workshop, Offshore Wind Farms and Marine Mammals: Impacts and Methodologies for Assessing Impacts, Special publication series no.49, 32-36.

Harding, H., Bruintjes, R., Radford, A. N., and Simpson, S. D., (2016). Measurement of Hearing in the Atlantic salmon (*Salmo salar*) using Auditory Evoked Potentials, and effects of Pile Driving Playback on salmon Behaviour and Physiology. Marine Scotland Science; Scottish Marine and Freshwater Science, 7, 46–47.

Harsanyi, P., Scott, K., Easton, B.A., de la Cruz Ortiz, G., Chapman, E.C., Piper, A.J., Rochas, C.M., and Lyndon, A.R., (2022) The Effects of Anthropogenic Electromagnetic Fields (EMF) on the Early Development of Two Commercially Important Crustaceans, European Lobster, *Homarus gammarus* (L.) and Edible Crab*, Cancer pagurus* (L.). Journal of Marine Science and Engineering, 10(5), p.564.

Hart, N.S., and Collin, S.P. (2015) Sharks senses and shark repellents. Integrative Zoology, 10 (1), 38-64. Available online: https://doi.org/10.1111/1749-4877.12095. Accessed October 2023.

Hawkins, A.D. (2009) The impact of pile driving upon fish. 5th International Conference on Bioacoustics 2009, Proceedings of the Institute of Acoustics.

Hawkins, A. D., Roberts, L., and Cheesman, S. (2014) Responses of free-living coastal pelagic fish to impulsive sounds, Journal of the Acoustic Society of America, 135, PP3101-3116.

Hawkins, A.D., and Popper, A.N. (2016) A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. ICES Journal of Marine Science, 74(3), 635-651.

Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. (2017) Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2011-2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-354,112 p.

Hendrick, V.J., Hutchison, Z.L., and Last, K.S. (2016) Sediment Burial Intolerance of Marine Macroinvertebrates. PLOS ONE, 26901775, https://doi.org/10.1371/journal.pone.0149114.

Hiddink, J.G., Jennings, S., Sciberras, M., Szostek, C.L., Hughes, K.M., Ellis, N., Rijnsdorp, A.D., McConnaughey, R.A., Mazor, T., Hilborn, R., Collie, J.S., Pitcher, C.R., Amoroso, R.O., Parma, A.M., Suuronen, P., and Kaiser, M.J. (2017) Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance. PNAS, 114(21), 8301-6. Available online: https://doi.org/10.1073/pnas.1618858114. Accessed October 2023.

Holland, G.J., Greenstreet, S.P.R., Gibb, I.M., Fraser, H.M., and Robertson, M.R., (2005) Identifying Sandeel *Ammodytes marinus* Sediment Habitat Preferences in the Marine Environment. Mar. Ecol. Prog. Ser., 303, 269-282.

Hooper, T., and Austen, M. (2014) The co-location of offshore windfarms and decapod fisheries in the UK: Constraints and opportunities. Marine Policy, 43, 295-300. Available online: https://doi.org/10.1016/j.marpol.2013.06.011. Accessed October 2023.

Howe V.L., Gell F.R., and Hanley, L.J. (2018) Subtidal Ecology. In: Manx Marine Environmental Assessment (2nd Ed). Isle of Man Government. 48pp.

Howell, T.R.W & Fraser, D.I., (1984) Observations on the dispersal and mortality of the scallop *Pecten maximus* (L.). ICES Council Meeting Papers, K:35.

Huang, Y. (2005) Electromagnetic Simulations of 135- kV Three phase Submarine Power Cables. Centre for Marine and Coastal Studies, Ltd. Prepared for Sweden Offshore.

Hume, J. (2017) A review of the geographic distribution, status and conservation of Scotland's lampreys. The Glasgow Naturalist. Volume 26, Part 4.

Hutchison, Z.L., Sigray, P., He, H., Gill, A.B., King, J., and Gibson, C. (2018) Electromagnetic Field (EMF) Impacts on Elasmobranch (shark, rays, and skates) and American Lobster Movement and Migration from Direct Current Cables. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2018-003.

Hutchison, Z.L., Gill, A.B., Sigray, P., He, H., and King, J.W. (2020) Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species. Scientific Reports, 10(4219).

Hvidt, C.B., Bech, M., and Klaustrup, M. (2003) Monitoring programme-status report 2003. Fish at the cable trace. Nysted offshore wind farm at Rødsand. Bioconsult.

ICES (2006) Report of the Herring Assessment Working Group South of 620 N (HAWG), 14-23 March, ICES Headquarters. ICES CM 2006/ACFM:20. 647pp.

ICES (2018a) Celtic Seas ecoregion – Fisheries overview, including mixed-fisheries considerations. Available: https://doi.org/10.17895/ices.pub.4640. Accessed October 2023.

ICES (2018b) Thornback ray (*Raja clavata*) in divisions 7.a, 7.f–g (Irish Sea, Bristol Channel, Celtic Sea North). ICES Advice on fishing opportunities, catch, and effort - Celtic Seas Ecoregion. Available online: https://doi.org/10.17895/ices.pub.4547. Accessed October 2023.

ICES (2019a) ICES stock assessment graphs for Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and divisions 3.a, 8.a-b, and 8.d. Available online: http://standardgraphs.ices.dk/ViewCharts.aspx?key=97630. Accessed October 2023.

ICES (2019b). Working Group on Elasmobranch Fishes (WGEF). ICES Scientific Reports. 1:25. 964 pp. Available online: http://doi.org/10.17895/ices.pub.5594. Accessed October 2023.

ICES (2019c) Scallop Assessment Working Group (WGSCALLOP). ICES Scientific Reports. 2:111. 57 pp. Available online: https://docslib.org/doc/10117260/ices-2019-scallop-assessment-working-group-wgscallop. Accessed April 2023.

ICES (2019d) ICES Stock Assessment graphs for Norway lobster (*Nephrops norvegicus*) in Division 7.a. [Online]. Available online: http://standardgraphs.ices.dk/ViewCharts.aspx?key=10212. Accessed October 2023.

ICES (2020) Scallop Assessment Working Group (WGSCALLOP). ICES Scientific Reports. 2:111. 57 pp. Available online: http://doi.org/10.17895/ices.pub.7626. Accessed October 2023.

ICES (2021a) Celtic Seas Ecoregion: Fisheries overview, including mixed-fisheries considerations, 30th November 2021.

ICES (2021b) International Bottom Trawl Survey Working Group (IBTSWG). ICES Scientific Reports. 3:69. 201 pp. Available online: https://doi.org/10.17895/ices.pub.8219. Accessed October 2023.

ICES (2022a) Working Group on Surveys on Ichthyoplankton in the North Sea and adjacent Seas (WGSINS; outputs from 2021 meeting) ICES Scientific Reports. 4:27. 47pp.

ICES (2022b) Fish trawl surveys. Biotic data in fish trawl surveys (DATRAS). 2012 to 2022 data from NIGFS. Available online: https://data.ices.dk/view-map. Accessed October 2023.

IEMA (2016) Environmental Impact Assessment. Guide to Delivering Quality Development. Available online: https://www.iema.net/download-document/7014. Accessed October 2023.

Inger, R., Attril, M.J., Bearhop, S., Broderick, A.C., Grecian, W.J., Hodgson, D.J., Mills, C., Sheehan, E., Votier, S.C., Witt, M.J., and Godley, B.J. (2009) Marine Renewable Energy: Potential Benefits to Biodiversity? An Urgent Call for Research. Journal of Applied Ecology, 46, 1145-1153.

International Council for the Exploration of the Sea (ICES) (2021) Celtic Seas Ecoregion: Fisheries overview, including mixed-fisheries considerations, 30th November 2021.

Isle of Man Government (2018) Manx Marine Nature Reserves Byelaw 1 2018. Statutory Document 2018/0186.

Isle of Man Government (2021) A Long-Term Management Plan for the Isle of Man King Scallop Fishery. Fisheries Division, Department of Environment, Food and Agriculture, Policy No. SF/LTMP/SCALLOP/1.0. Available online: https://www.gov.im/media/1376550/ltmp-10-260522.pdf. Accessed November 2023.

Jarv, L., Aps, R., Raid, T., and Jarvik, A. (2015) The impact of activities of the Port of Sillamäe, Gulf of Finland (Baltic Sea), on the adjacent fish communities in 2002–2014. 16th International Congress of the International Maritime Association of the Mediterranean, Conference Paper.

Jensen, H., Kristensen, P.S., and Hoffmann, E. (2004) Sandeels in the wind farm area at Horns Reef. Report to ELSAM, August 2004. Danish Institute for Fisheries Research, Charlottenlund.

Jensen, H., Rindorf, A., Wright, P.J. and Mosegaard, H. (2010) Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery. ICES Journal of Marine Science, 68(1), 42pp.

Jerko, H., Turunen-Rise, I., Enger, P.S., and Sand, O. (1989) Hearing in the eel (*Anguilla anguilla*). Journal of Comparative Physiology, 165, 455-9. Available online: https://doi.org/10.1007/BF00611234. Accessed October 2023.

Jezequel, Y., Cones, S., Jensen, F.H., Brewer, H., Collins, J., and Mooney, T.A. (2022) Pile driving repeatedly impacts the giant scallop (*Placopecten magellanicus*). Scientific Reports, 12:13580.

JNCC (2010a). Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. August 2010. Joint Nature Conservation Committee, Aberdeen, UK.

JNCC (2010b). JNCC guidelines for minimising the risk of injury to marine mammals from using explosives. Joint Nature Conservation Committee, Aberdeen, UK.

JNCC. (2017). JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys. Joint Nature Conservation Committee, Aberdeen, UK.

JNCC (2019) JNCC MPA Mapper. Online map resource. Available online: https://jncc.gov.uk/mpa-mapper/. Accessed October 2023.

Judd, A. (2012). Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects. Report by Centre for Environment Fisheries and Aquaculture Science (CEFAS).

Kaiser, M.J., Hormbrey, S., Booth, J.R., Hinz, H., and Hiddink, J.G. (2018) Recovery linked to life history of sessile epifauna following exclusion of towed mobile fishing gear. Journal of Applied Ecology, 55(3), 1060-70. Available online: https://doi.org/10.1111/1365-2664.13087. Accessed October 2023.

Karlsson, R., Tivefalth, M., Duranovic, I., Martinsson, S., Kjolhamar, A., and Murvoll, K.M. (2022) Artificial hard-substrate colonisation in the offshore Hywind Scotland Pilot Park. Wind Energy Science, 7, 801-814.

Kavet, R., Wyman, M.T., and Klimley, A.P. (2016). Modelling magnetic fields from a dc power cable buried beneath San Francisco Bay based on empirical measurements. PLoS One, 11(2), e0148543.

Kelly. C, Glegg, G.A. and Speedie, C.D. (2004). Management of marine wildlife disturbance. Ocean & Coastal Management, 47, 1-19.

Kempster, R., and Colin, S. (2011) Electrosensory pore distribution and feeding in the basking shark *Cetorhinus maximus* (Lamniformes: Cetorhinidae). Aquatic Biology, 12, 33-36. Available online: https://doi.org/10.3354/ab00328. Accessed October 2023.

Kempster, R.M., Hart, N.S., and Collin, S.P. (2013). Survival of the Stillest: Predator Avoidance in Shark Embryos. PLoS ONE 8(1), e52551.

Kerchof, F., Rumes, B., Norro, A., Jacques, T.G., and Degraer, S. (2010) Seasonal variation and vertical zonation of the marine biofouling on a concrete offshore windmill foundation on the Thornton Bank (southern North Sea). In: Degraer S, Brabant R, Rumes B, editors. Offshore wind farms in the Belgian part of the North Sea: Selected findings from the baseline and targeted monitoring. Brussels, Belgium: Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models; 27–37.

Kiorbe, T., Frantsen, E., Jensen, C.S., and Sorensen, G. (1981) Effects of suspended sediment on development and hatching of herring (*Clupea harengus*) eggs. Estuarine, Coastal and Shelf Science, 13(1), 107-11. Available online: https://doi.org/10.1016/S0302-3524(81)80109-0. Accessed October 2023.

Knutsen, J., Knutsen, H., Gjøsæter, J., and Jonsson, B. (2001). Food of anadromous brown trout at sea. Journal of Fish Biology, 59, 533 – 543, 10.1111/J1095-8649.2001.tb02359.x.

Krone, R., Dederer, G., Kanstinger, P., Kramer, P., Schneider, C., and Schmalenbach, I. (2017) Mobile demersal megafauna at common offshore wind turbine foundations in the German Bight (North Sea) two years after deployment - increased production rate of *Cancer pagurus*. Marine Environmental Research, 123, 53-61. Available online: https://doi.org/10.1016/j.marenvres.2016.11.011. Accessed October 2023.

Krone, R., Gutowa, L., Joschko, T.J., and Schröder, A. (2013) Epifauna dynamics at an offshore foundation Implications of future wind power farming in the North Sea. Marine Environmental Research, 85, 1-12.

Lagardère J.P., and Spérandio, M. (1981). Lagardère, Influence du niveau sonore de bruit ambiant sur la croissance de la crevett *Crangon crangon*. Resultats préliminaires Aquaculture, 24 (1981), 77-90.

Laming, S.R., Jenkins, S.R., and McCarthy, I.D. (2013) Repeatability of escape response performance in the queen scallop, *Aequipecten opercularis*. Journal of Experimental Biology, 216(17), 3264-72. Available online: https://doi.org/10.1242/jeb.080416. Accessed October 2023.

Langhamer, O. and Wilhelmsson, D. (2009). Colonisation of fish and crabs of wave energy foundations and the effects of manufactured holes - a field experiment. Marine environmental research, 68 4, 151-7.

Langhamer, O. (2012) Artificial Reef Effect in relation to Offshore Renewable Energy Conversion: State of the Art. The Scientific World Journal, Article ID 386713, 8pp. Available online: https://doi.org/10.1100/2012/386713. Accessed October 2023.

Langhamer, O., Holand, H., and Rosenqvist, G. (2016) Effects of an Offshore Wind Farm (OWF) on the common shore crab *Carcinus maenas*: Tagging pilot experiments in the Lillgrund Offshore Wind Farm (Sweden). PLoS One 11, 1–17.

Lamber, G.I., Jennings, S., Kaiser, M.J., Davies, T.W., and Hiddnik, J.G. (2014) Quantifying recovery rates and resilience of seabed habitats impacted by bottom fishing. Journal of Applied Ecology, 51(5), 1326-1336. Available online: https://doi.org/10.1111/1365-2664.12277. Accessed October 2023.

Lasram, F.B.R., Bourgougnon, N., Yolanda, D.A., Gillet, P., Le Loc'h, F., Masse, C., Nexer, M., Lejart, M., Quillien, N., and Taormina, B. (2019) Does the colonisation of offshore renewable energy farms facilitate the introduction and spread of non-indigenous species? CO M3T Bulletin no. 2, 52(16), 7, reference: 52036030.

Last, K.S., Hendrick, V.J., Beveridge, C.M., and Davies, A.J. (2011) Measuring the effects of suspended particulate matter and smother on the behaviour, growth and survival of key species found in areas associated with aggregate dredging. Marine Aggregate Levy Sustainability Fund, Project MEPF 08/P76.

Latto P.L., Reach I.S., Alexander D., Armstrong S., Backstrom J., Beagley E., Murphy K., Piper R. and Seiderer L.J. (2013) Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat. A Method Statement produced for BMAPA.

Lawson, J.M., Pollom, R.A., Gordon, C.A., Barker, J., Meyers, E.K.M., Zidowitz, H., Ellis, J.R., Bartoli, A., Morey, G., Fowler, S.L., Alvarado, D.J., Fordham, S.V., Sharp, R., Hood, A.R., and Dulvy, N.K. (2019) Extinction risk and conservation of critically endangered angel sharks in the Eastern Atlantic and Mediterranean Sea. ICES Journal of Marine Science, 77(1), pp. 12-29. Available online: https://doi.org/10.1093/icesjms/fsz222. Accessed October 2023.

Lee, P.H. and Weis, J.S. (1980) Effects of magnetic fields on regeneration in fiddler crabs. Biology Bulletin, 159, 681–691.

Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N., Bouma, S., Brasseur, S., Daan, R., Fijn, R.C. de Haan, D., Dirksen, S., van Hal, R., Hille Ris Lambers, R., ter Hofstede, R., Krijgsveld, K.L.,

Lefaible, N., L. Colson, U. Braeckman, and T. Moens. (2019). Evaluation of turbine-related impacts on macrobenthic communities within two offshore wind farms during the operational phase. Pp 47–64 in Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Marking a Decade of Monitoring, Research and Innovation.

Leopold, M. and Scheidat, M. (2011) Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation. Environmental Research Letters, 6, 035101, 13pp.

Linley, E.A.S., Wilding, T.A., Black, K., Hawkins, A.J.S. and Mangi S. (2007) Review of the Reef Effects of Offshore Wind Farm Structures and their Potential for Enhancement and Mitigation. Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department for Business, Enterprise and Regulatory Reform (BERR), Contract No: RFCA/005/0029P.

Lohmann, K.J., Pentcheff, N.D. Nevitt, G.A., Stetten, G.D., Zimmer-Faust, R.K., Jarrard, H.E., and Boles, L.C. (1995). Magnetic orientation of spiny lobsters in the ocean: experiments with undersea coil systems. Journal of Experimental Biology 198(2), 041-2,048.

Love, M.S., Nishimoto, M.M., Clark, S., and Bull, A.S. (2016). Renewable Energy in situ Power Cable Observation. U.S. Department of the Interior, Bureau of Ocean Energy Management, Pacific OCS Region, Camarillo, CA. OCS Study 2016-008. 86pp.

Love, M.S., Nishimoto, M.M., Clark, S., McCrea, M., and Bull, A.S. (2017) Assessing potential impacts of energized submarine power cables on crab harvests. Continental Shelf Research, 151(1), 23-29.

MacDonald, D.S., Little, M., Eno, N.C., and Hiscock, K. (1996) Disturbance of benthic species by fishing activities: a sensitivity index. Aquatic Conservation Marine and Freshwater Ecosystems, 6(4), 257-268. Available online: https://doi.org/10.1002/(SICI)1099-0755(199612)6:4<257::AID-AQC194>3.0.CO;2-7. Accessed October 2023.

Mackenzie, C.L., Ormondroyd, G.A., Curling, S.F., Ball, R.J., Whiteley, N.M., and Malham, S.K. (2014) Ocean Warming, More than Acidification, Reduces Shell Strength in a Commercial Shellfish Species during Food Limitation. PLoSONE https://doi.org/10.1371/journal.pone.0086764. Accessed October 2023.

Madenjian, C.P., Johnson, N.S., Binder, T.R., Rediske, R.R., and O'Keefe, J.P. (2013) Polychlorinated Biphenyl Concentrations and Activity of Sea Lamprey *Petromyzon marinus* Vary by Sex. Archives of Environmental Contamination and Toxicology, 65, 693-703. Available online: https://doi.org/10.1007/s00244-013-9936-y. Accessed October 2023.

MaresConnect (2023) Non-technical summary. Available online: https://maresconnect.ie/non-technical-summary/. Accessed September 2023.

MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd and Marine Ecological Surveys Ltd, (2013). Environmental Effect Pathways between Marine Aggregate Application Areas and Sandeel Habitat: Regional Cumulative Impact Assessments. A report for BMAPA.

MarineSpace Ltd (2023) Licence Area 457 Environmental Impact Assessment – Scoping Report. Report for Westminster Gravels Ltd.

Marsden, I.D., and Cranford, P.J. (2016) Chapter 13 - Scallops and Marine Contaminants. Developments in Aquaculture and Fisheries Science, 40, 567-584.

Marshall, C. and Wilson, E. (2008). Pecten maximus. Great scallop. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/speciesinformation.php?speciesID=4056. Accessed October 2023.

Mavraki, O., De Mesel, I., Degraer, S., Moens, T., and Vanaverbeke, J. (2020) Resource niches of co-occurring invertebrate species at an offshore wind turbine indicate a substantial degree of trophic plasticity. Frontiers in Marine Science, 7(379), 17pp., 10.3389/fmars.2020.00379.

McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M.N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J. and McCabe, K. (2000) Marine Seismic Surveys – A Study of Environmental Implications. Appea Journal, 692-707.

Mann, D.A., Lu, Z., Hastings, M.C., and Popper, A.N. (1998) Detection of ultrasonic tones and simulated dolphin echolocation clicks by a teleost fish, the American shad (*Alosa sapidissima*). The Journal of the Acoustical Society of America, 104(562).

Mann, D. A., Higgs, D., Tavolga, W., Souza, M.J., and Popper, A.N. (2001). Ultrasound detection by clupeiform fishes. The Journal of the Acoustical Society of America, 109, 3048–3054.

Manx Whale and Dolphin Watch (2023) Basking Sharks sightings data. Available online: https://www.mwdw.net/recent-basking-shark-sightings/. Accessed October 2023.

MarineSpace (2023) Licence Area 457 Environmental Impact Assessment – Scoping Report. MarineSpace Report.

Marshall, C.E. and Wilson, E. (2008). *Pecten maximus*. Great scallop. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [Online]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/speciesinformation.php?speciesID=4056. Accessed October 2023.

McConnell, B., Lonergan, and M., Dietz, R. (2012) Interactions between seals and offshore wind farms. The Crown Estate, 41 pp., ISBN: 978-1-906410-34-6.

Messieh, S.N., Wildish, D.J., and Peterson, R.H. (1981). Possible impact from dredging and soil disposal on the Miramichi Bay herring fishery. Can. Tech. Rep. Fish. Aquat. Sci., 1008, 33pp.

Metcalfe, J.D., Holford, B.H., and Arnold, G.P. (1993). Orientation of plaice (*Pleuronectes platessa*) in the open sea – evidence for the use of external directional clues. Marine Biology 117, 559-66.

Mickle, M.F., Miehls, S.M., Johnson, N.S., and Higgs, D.M. (2019) Hearing capabilities and behavioural response of sea lamprey (*Petromyzon marinus*) to low-frequency sounds. Canadian Journal of Fisheries and Aquatic Sciences, 76(9), 1541-8. Available online: https://doi.org/10.1139/cjfas-2018-0359. Accessed October 2023.

Minchin, D. (1992) Biological observations on young scallops, Pecten maximus. Journal of the Marine Biological Association of the United Kingdom, 72(4), 801-19.

MMO (2014) Review of post-consent offshore wind farm monitoring data associated with licence conditions. A report produced for the Marine Management Organisation, pp.194. MMO Project No. 1031. ISBN: 978-1-909452-24-4.

Moore, A.B., Bater, R., Lincoln, H., Robins, P., Simpson, S.J., Brewin, J., Cann, R., Chapman, T., Delargy, A., Heney, C. and Jones, M. (2020) Bass and ray ecology in Liverpool Bay. Fisheries Report 3. Bangor University Sustainable Fisheries and Aquaculture Group. Report to the MMO and NWIFCA. 60pp.

Moore, A., and Riley, W.D. (2009) Magnetic particles associated with the lateral line of the European eel *Anguilla anguilla*. Journal of Fish Biology, 74, 1629-34.

Morecambe Offshore Windfarm Ltd. (2023) Chapter 10: Fish and Shellfish Ecology. Morecambe Offshore Windfarm Generation Assets PEIR. Available online: https://bp-mmt.s3.eu-west-2.amazonaws.com/morecambe/Chapters/FLO-MOR-REP-0006-10+Chapter+10+Fish+and+Shellfish+Ecology.pdf. Accessed April 2023.

Morgan Offshore Wind Limited (2023) Morgan Offshore Wind Project Generation Assets PEIR. Volume 4, Annex 8.1: Fish and shellfish ecology technical report.

Morgan and Morecambe (Offshore Wind) Transmission Assets (2023) EIA Scoping Report, Part 2: Transmission assets. Rev04.

Moriarty, M., Greenstreet, S., Dransfeld, L., Shepard, S., Trenkel, V., and Reid, D. (2015) Variation in the abundance distribution of skate and ray species in the Celtic Seas. Presentation to Fisheries Society of the British Isles Annual Symposium 30th July, Plymouth University, UK.

Morley, E.L., Jones, G. and Radford, A.N. (2013) The importance of invertebrates when considering the impacts of anthropogenic noise. Proc. R. Soc. B, 281.

Morrison, F., Harvey, E., Franze, and Menden-Deuer, S. (2019) Storm-Induced Predator-Prey Decoupling Promotes Springtime Accumulation of North Atlantic Phytoplankton. Frontiers in Marine Science, Marine Ecosystem Ecology.

MMO (2021) North West Inshore and North West Offshore Marine Plan.

Mueller-Blenkle, C., Mcgregor, P., Gill, A.B., Andersson, M., Metcalfe, J., Bendall, V., Sigray, P., Wood, D., and Thomsen, F. (2010). Effects of pile-driving noise on the behaviour of marine fish. Published by Cefas on behalf of COWRIE Ltd.

Murray, L.G., Hinz, H. and Kaiser, M.J. (2009) Annual Marine Fisheries Research Report to DAFF 2007/2008. Fisheries & Conservation report, Bangor University 8.

Narita, D., Rehdanz, K., and Tol., R.S.J. (2012) Economic costs of ocean acidification: a look into the impacts on global shellfish production. Climatic Change, 113, 1049-63.

National Biodiversity Network (NBN) Atlas (2019) Available at: https://nbnatlas.org/. Accessed October 2023.

Neal, C., Elderfield, H., and Chester, R. (1979) Arsenic in sediment of the North Atlantic Ocean and the Eastern Mediterranean Sea. Marine Chemistry, 7(3), 207-10. Available online: https://doi.org/10.1016/0304-4203(79)90040-9. Accessed October 2023.

Neal, K.J., and Wilson, E. (2008) *Cancer pagurus* Edible crab. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom.

Nedwell, J., Turnpenny, A., Lovell, J.M., and Edwards, B. (2006) An investigation into the effects of underwater piling noise on salmonids. The Journal of the Acoustical Society of America, 120(5,1) 2550-4, DOI:10.1121/1.2335573.

Neff, J.M. (1997) Ecotoxicology of arsenic in the marine environment. Environmental Toxicology and Chemistry, 16(5), 917-927.

Newell, R.C., Seiderer, L.J., and Hitchcock, D.R. (1998) The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. Oceanography and Marine Biology, 36, 127-178.

Newton, M., Main, R. and Adams, C. (2017). Atlantic Salmon Salmo salar smolt movements in the Cromarty and Moray Firths, Scotland. LF000005-REP-1854, March 2017.

Newton, M. Honkanen, H. Lothian, A. and Adams, C (2019) The Moray Firth Tracking Project – Marine Migrations of Atlantic Salmon (Salmo salar) Smolts. Proceedings of the 2019 SAMARCH Project: International Salmonid Coastal and Marine Telemetry Workshop.

Newton, M., Barry, J., Lothian, A., Main, R. A., Honkanen, H., McKelvey, S. A., Thompson, P., Davies, I., Brockie, N., Stephen, A., O'Hara Murray, R., Gardiner, R., Campbell, L., Stainer, P., and Adams, C. (2021). Counterintuitive active directional swimming behaviour by Atlantic salmon during seaward migration in the coastal zone. ICES Journal of Marine Science, 78(5), 1730–1743. Available online: https://doi.org/10.1093/icesjms/fsab024. Accessed October 2023.

NMFS (2005) ‘Scoping Report for NMFS EIS for the National Acoustic Guidelines on Marine Mammals’. National Marine Fisheries Service.

NMFS (2012) National Marine Fisheries Service Policy Directive 02-238. Process for Distinguishing Serious from Non-Serious Injury of Marine Mammals.

Normandeau (Normandeau Associates, Inc.), Exponent Inc., T. Tricas, T. and Gill, A. (2011) Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA.OCS Study BOEMCSARE 2011-09.

NRW (2013) Marine aggregate extraction Area 392/393, known as Hilbre Swash, Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended), Regulation 22 – EIA Consent Decision. Available: https://cdn.cyfoethnaturiol.cymru/media/3217/eia-consent-decision-hilbre-swash.pdf?mode=pad&rnd=131469117293430000. Accessed October 2023.

Olbert, A.I., Dabrowski, T., Nash, S., and Hartnett, M. (2012) Regional modelling of the 21st century climate changes in the Irish Sea. Continental Shelf Research, 41, 48-60. Available online: https://doi.org/10.1016/j.csr.2012.04.003. Accessed October 2023.

Ohman, M.C., Sigray, P., and Westerberg, H. (2007). Offshore windmills and the effects of electromagnetic fields on fish. Ambio, 36, 630 – 633.

Orpwood, J.E., Fryer, R.J., Rycroft, P., and Armstrong, J.D. (2015) Effects of AC magnetic fields (MFs) on swimming activity in European eels *Anguilla anguilla*. Scottish Marine and Freshwater Science, 6(8), 1-22.

Ørsted (2023) Mooir Vannin Offshore Wind Farm Scoping Report. Available online: https://orstedcdn.azureedge.net/-/media/www/docs/corp/uk/im/scoping-report/mooir-vannin_scoping-report.pdf?rev=9c06c38674ff4cd7a28b13f5a1284f88&hash=7BE823F9CC4E02C50B7A9AB598B526FF. Accessed November 2023

OSPAR (2008) OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development. OSPAR Convention for the Protectioin of the Marine Environment of the North-East Atlantic, Report reference number 2008-3. Available online: www.vliz.be/imisdocs/publications/ocrd/224682.pdf. Accessed October 2023.

Parry, G.D., Heislers, S., Werner, G.F., Asplin, M.D., and Gason, A. (2002) Assessment of Environmental Effects of Seismic Testing on Scallop Fisheries in Bass Strait. Marine and Freshwater Resources Institute, Report Number 50, Marine and Freshwater Resources Institute: Queenscliff.

Parry, G.D. and Gason, A. (2006). The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia Fish. Res., 79, 272-284.

Payne, J.F., Andrews, C.A., Fancey, L.L., Cook, A.L., and Christian, J.R., (2007). Pilot study on the effects of seismic air gun noise on lobster (*Homarus americanus*). Canadian Technical Report of Fisheries and Aquatic Sciences No.2712V + 46.

Pearson, W.H., Skalski, J.R., Skulkin, S.D., and Malme, C.I. (1994). Effects of seismic energy releases on the survival and development of zoeal larvae of Dungeness crab (*Cancer magister*). Mar. Environ. Res., 38, 93-113.

Pedraja, F., Hofmann, V., Lucas, K.M., Young, C., Engelmann, J., and Lewis, J.E. (2018) Motion parallax in electric sensing. Proceedings of the National Academy of Sciences, 115(3), 573-577. Available online: https://doi.org/10.1073/pnas.1712380115. Accessed October 2023.

Pena, H., Handegard, N.O., and Ona, E. (2013) Feeding herring schools do not react to seismic air gun surveys. ICES Journal of Marine Science, 70(6), 1174-80. Available online: https://doi.org/10.1093/icesjms/fst079. Accessed October 2023.

Phua, C., van den Akker, S., Baretta, M., and van Dalfsen,, J. (2002) Ecological Effects of Sand Extraction in the North Sea. The North Sea Foundation.

Piper, A.T., White, P.R., Wright, R.M., Leighton, T.G., and Kemp, P.S. (2019) Response of seaward-migrating European eel (*Anguilla anguilla*) to an infrasound deterrent. Ecological Engineering, 127, 480-6. Available online:https://doi.org/10.1016/j.ecoleng.2018.12.001. Accessed October 2023.

Pirotta, V., Grech, A., Jonsen, I.D., Laurance, W.F., and Harcourt, R.G. (2018) Consequences of global shipping traffic for marine giants. Frontiers in Ecology and the Environment, 17(1), 39-47. Available online: https://doi.org/10.1002/fee.1987. Accessed October 2023.

Platcha, D.T.T., and Popper, A.N. (2003) Evasive responses of American shad (*Alosa sapidissima*) to ultrasonic stimuli. Acoustic Research Letters Online, 4(25). Available online: https://doi.org/10.1121/1.1558376. Accessed October 2023.

Planning Inspectorate (2018) Advice Note Nine: Rochdale Envelope. Version 3.

Planning Inspectorate (2019) Advice Note Seventeen: Cumulative effects assessment relevant to nationally significant infrastructure projects. Version 2.

Planning Inspectorate (2020a) Advice Note Seven: Environmental Impact Assessment: Process, Preliminary Environmental Information and Environmental Statements. Version 7.

Planning Inspectorate (2020b) Advice Note Twelve: Transboundary Impacts and Process. Version 6.

Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W.T., Gentry, R., Hal Vorsen, M.B., Lokkeborg, S., Rogers, P., Southall, B.L., Zeddies, D.G. and Tavolga, W.N. (2014) ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

Popper, A.N., and Hoxter, B. (1987) Sensory and non-sensory ciliated cells in the ear of the sea lamprey, *Petromyzon marinus*. Brain, Behavior and Evolution, 30, 43-61.

Popper, A.N. (2005) A review of hearing by sturgeon and lamprey. Report to US Army Corps of Engineers, Portland District.

Popper, A.N., Salmon, M. and Horch, K.W. (2001) Acoustic detection and communication by decapod crustaceans. Journal of Comparative Physiology A, 187 (2): 83-89.

Putman N.F., Jenkins E.S., Michielsens C.G.J., Noakes D.L.G. (2014) Geomagnetic imprinting predicts spatiotemporal variation in homing migration of pink and sockeye salmon. Journal of the Royal Society Interface, 11, pg.20140542.

Raoux, A., Lassalle, G., Pezy, J.P., Tecchio, S., Safi, G., Ernande, B., Maze, C., Le Loc'h, F., Lequesne, J., Girardin, V., Daubin, J.C., and Niquil, N. (2019) Measuring sensitivity of two OSPAR indicators for a coastal food web model under offshore wind farm construction. Ecological Indicators, 96(1), 728-738. Available online: https://doi.org/10.1016/j.ecolind.2018.07.014. Accessed October 2023.

Reach, I.S., Latto, P., Alexander, D., Armstrong, S., Backstrom, J., Beagley, E., Murphy, K., Piper, R. and Seiderer, L.J. (2013) Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas. A Method Statement produced for BMAPA.

RenewableUK (2013) Cumulative Impact Assessment Guidelines – Guiding Principles for Cumulative Impacts Assessment in Offshore Wind Farms. CIEEM report. Available online: https://tethys.pnnl.gov/sites/default/files/publications/Cumulative-Impact-Assessment-Guidelines.pdf. Accessed October 2023.

Rikardsen, A.H., Amundsen, P.A., Knudsen, R. and Sandring, S. (2006) Seasonal marine feeding and body condition of sea trout (*Salmo trutta*) at its northern distribution. ICES Journal of Marine Science, 63(3), 466–75.

Roach, M., Cohen, M., Forster, R., Revill, A.S., and Johnson, M. (2018) The effects of temporary exclusion of activity due to wind farm construction on a lobster (*Homarus gammarus*) fishery suggests a potential management approach. – ICES Journal of Marine Science, 75, 1416–1426.

Roberts, L., Cheesman, S., Elliott, M., and Breithaupt, T. (2016) Sensitivity of *Pagurus bernhardus* (L.) to substrate-borne vibration and anthropogenic noise. Journal of Experimental Marine Biology and Ecology, 474, 185–194.

Rosaria, J.C., and Martin, E.R. (2010) Behavioural changes in freshwater crab*, Barytelphusa cunicularis* after exposure to low frequency electromagnetic fields. World Journal of Fish Marine Science, 2, 487–494.

Rowley, A.F., Cross, M.E., Culloty, S.C., Lynch, S.A., Mackenzie, C.L., Morgan, E., O'Riordan, R.M., Robins, P.E., Smith, A.L., Thrupp, T.J., Vogan, C.L., Wootton, E.C., and Malham, S.K. (2014) The potential impact of climate change on the infectious diseases of commercially important shellfish populations in the Irish Sea—a review. ICES Journal of Marine Science, 71(4), 741-759. Available online: https://doi.org/10.1093/icesjms/fst234. Accessed October 2023.

Royal Haskoning (2012) Liverpool 2 and River Mersey Approach Channel Dredging Environmental Statement Non-Technical Summary. Available online: https://www.eib.org/attachments/pipeline/20120101_nts_en.pdf. Accessed October 2023.

Royal Haskoning (2018) Potential use of Site Y for disposal of maintenance dredge material from the Mersey Approach Channel Environmental Report.

RPS (2019) Review of Cable installation, protection, migration and habitat recoverability, The Crown Estate, Rev03.

Russell, D.J.F., Brasseur, S.M.J.M., Thompson, D., Hastie, G.D., Janik, V.M., Aarts, G., McClintock, B.T., Matthiopoulos, J., Moss, S.E.W., and McConnell, B. (2014) Marine mammals trace anthropogenic structures at sea. Current Biology, 24, R638–R639.

RWE (2022) Awel y Môr Offshore Wind Farm Preliminary Environmental Information Report Volume 2, Chapter 7: Marine Mammals. Environmental Statement chapter.

Sabatini, M., and Hill, J.M. (2008) *Nephrops norvegicus* Norway lobster. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: http://www.marlin.ac.uk/species/detail/1672. Accessed October 2023.

Sand, O., Enger, P.S., Karlsen, H.E., Knudsen, F., and Kvernstuen, T. (2000) Avoidance Responses to Infrasound in Downstream Migrating European Silver Eels, *Anguilla anguilla*. Environmental Biology of Fishes, 57, 327-36. Available online: https://doi.org/10.1023/A:1007575426155. Accessed October 2023.

Schmidt, M., Philipp, E.E.R., and Abele, D. (2008) Size and age-dependent changes of escape response to predator attack in the Queen scallop Aeuqipecten opercularis. Marine Biology Research, 4(6), p. 442-450. Available online: https://doi.org/10.1080/17451000802270346. Accessed October 2023.

Schoeman, R.P., Patterson-Abrolat, C., and Plon, S. (2020) A Global Review of Vessel Collisions with Marine Animals. Frontiers in Marine Science, Marine Conservation and Sustainability Review. Available online: https://doi.org/10.3389/fmars.2020.00292. Accessed October 2023.

Scott, W., and Gisborne, B. (2006) Basking Sharks: The Slaughter of BC's Gentle Giants. Vancouver, New Star Books. 88pp.

Scott, K., Harsanyi, P. & Lyndon, A. R. (2018) Understanding the effects of electromagnetic field emissions from Marine Renewable Energy Devices (MREDs) on the commercially important edible crab, *Cancer pagurus* (L.). Marine Pollution Bulletin, 131, 580–588.

Scott, K. (2019) Understanding the biology of two commercially important crustaceans in relation to fisheries and anthropogenic impacts. (Heriot-Watt University).

Scott, K., Piper, A.J.R. Chapman, E.C.N., and Rochas, C.M.V., (2020). Review of the effects of underwater sound, vibration and electromagnetic fields on crustaceans. Seafish Report.

Scott, K., Harsanyi, P., Easton, B.A.A., Piper, A.J.R., Rochas, C.M.V., and Lyndon, A.R. (2021) Exposure to Electromagnetic Fields (EMF) from Submarine Power Cables Can Trigger Strength-Dependent Behavioural and Physiological Responses in Edible Crab, *Cancer pagurus* (L.). Journal of Marine Science and Engineering, 9, 776.

Scrivener, J.C. (1971) Agonistic behaviour of the American lobster, *Homarus americanus*. (University of Victoria).

Serpetti, N., Benjamins, S., Brain, S., Collu, M., Harvey, B.J., Heymans, J.J., Hughes, A.D., Risch, D., Rosinski, S., Waggitt, J.J., and Wilson, B. (2021) Modeling Small Scale Impacts of Multi-Purpose Platforms: An Ecosystem Approach. Frontiers in Marine Science, Sec. Marine Ecosystem Ecology. Available online: https://doi.org/10.3389/fmars.2021.694013. Accessed October 2023.

Shark Trust (2022) Basking Shark Project – Hotspots and Sightings. Online report. Available online: https://www.sharktrust.org/Handlers/Download.ashx?IDMF=49e43478-8532-424c-9ca1-f2515d892dfd. Accessed October 2023.

Sigray, P., and Andersson, M. (2011). Particle Motion Measured at an Operation Wind Turbine in Relation to Hearing Sensitivity in Fish. The Journal of the Acoustical Society of America, 130, 200-7.

Simpson, S.D., Purser, J., and Radford, A.N. (2014) Anthropogenic noise compromises antipredator behaviour in European eels. Global Change Biology, 21(2), 586-93. Available online: https://doi.org/10.1111/gcb.12685. Accessed October 2023.

Sinclair, R., Lacey, C., Tyler-Walters, H., Sparling, C., and Tillin, H.M. (2020) Developing FeAST for mobile marine species. Scottish Natural Heritage Research Report No. 1175.

Skold, M., Goransson, P., Jonsson, P., Bastardie, F., Blomqvist, M., Agrenius, S., Hiddink, J.G., Nilsson, H.C., and Bartolino, V. (2018) Effects of chronic bottom trawling on soft-seafloor macrofauna in the Kattegat. Marine Ecology Progress Series, 586, 41-55,. Available online: https://doi.org/10.3354/meps12434. Accessed October 2023.

Solan, M., Hauton, C., Godbold, J.A., Wood, C.L., Leighton, T.G., and White, P. (2016) Anthropgenic sources of underwater sound can modify how sediment-dwelling invertebrates mediate ecosystem properties. Scientific Reports, 6, 20540.

Solandt, J.L., and Chassin, E. (2013) Marine Conservation Society Basking Shark Watch Overview of data from 2009 to 2013. Ross on Wye, UK: Marine Conservation Society, 6pp.

Soudijn, F.H., van Kooten, T., Slabbekoorn, H., and de Roos, A.M. (2020) Population-level effects of acoustic disturbance in Atlantic cod: a size-structured analysis based on energy budgets. Proceedings of the Royal Society of Biological Sciences, 287(1929). Available online: https://doi.org/10.1098/rspb.2020.0490. Accessed October 2023.

Speedie, C.D., Johnson, L.A., and Witt, M.J. (2009) Basking Shark Hotspots on the West Coast of Scotland: Key sites, threats and implications for conservation of the species. Scottish Natural Heritage, Inverness, Scotland, Commissioned Report No.339, 59pp. Available online: https://www.nature.scot/snh-commissioned-report-339-basking-shark-hotspots-west-coast-scotland. Accessed October 2023.

Speiser, D.I., and Johnsen, S. (2008). Scallops visually respond to the size and speed of virtual particles. Journal of Experimental Biology, 211, 2066-70.

Stanley, J.A., Radford, C.A., and Jeffs, A.G. (2012) Effects of Underwater Noise on Larval settlement. In: Popper, A.N., Hawkins, A. (eds) The Effects of Noise on Aquatic Life. Advances in Experimental Medicine and Biology, 730. Springer, New York, NY. Available online: https://doi.org/10.1007/978-1-4419-7311-5_84. Accessed October 2023.

Stanley, D.R., and Wilson, C.A. (1991) Factors affecting the abundance of selected fishes near oil and gas platforms in the Northern Gulf of Mexico. Fishery Bulletin, 89, 149-59.

Stenberg, C., Deurs, M.V., Støttrup, J., Mosegaard, H., Grome, T., Dinesen, G.E., Christensen, A., Jensen, H., Kaspersen, M., Berg, C.W., Leonhard, S.B., Skov, H., Pedersen, J., Hvidt, C.B., Klaustrup, M., Leonhard, S.B. (Ed.), Stenberg, C. (Ed.), and Støttrup, J. (Ed.) (2011) Effect of the Horns Rev 1 Offshore Wind Farm on Fish Communities, Follow-up Seven Years after Construction. DTU Aqua, DTU Aqua Report No. 246.

Suchanek, T.H. (1993) Oil impacts on marine invertebrate populations and communities. American Zoologist, 33, 510-523.

Svenning, M., Borgstrøm, R., Dehli, T.O, Moen, G., Barett, R., Pedersen, T., and Vader, W. (2005). The impact of marine fish predation on Atlantic salmon smolts (*Salmo salar*) in the Tana Estuary, North Norway, in the presence of an alternative prey, lesser sandeel (*Ammodytes marinus*). Fisheries Research. 00-00. 10.1016/j.fishres.2005.06.015.

Szostek, C.L., Davies, A.J., and Hinz, H. (2013) Effects of elevated levels of suspended particulate matter and burial on juvenile king scallops *Pecten maximus*. Marine Ecology Progress Series, 474 pp. 155-165, Available online: https://doi.org/10.3354/meps10088. Accessed October 2023.

Tański, A., Formicki, K., Śmietana, P., Sadowski, M. and Winnicki, A. (2005) Sheltering behaviour of spinycheek crayfish (*Orconectes limosus*) in the presence of an artificial magnetic field. Bull. Fr. La Pech. La Piscic. 376–377, 787–793.

Tasker, M., Amundin, M., Andre, M., Hawkins, A.D., Lang, W., Merck, T., Scholik-Schlomer, A., Teilmann, J., Thomsen, F., Werner, S., and Zakharia, M. (2010) Managing underwater noise in European waters: implementing the Marine Strategy Framework Directive. Advances in Experiment Medicine and Biology, 730, 583-5, doi: 10.1007/978-1-4419-7311-5_132.

Thorstad, E. Todd, C., Uglem, I., Bjørn, P., Gargan, P., Vollset, K., Halttunen, E., Kålås, S., Berg, M., and Finstad, B. (2016). Marine life of the sea trout. Marine Biology, 163.

Tiktak, G.P., Butcher, D., Lawrence, P.J., Norrey, J., Bradley, L., Shaw, K., Preziosi, R., and Megson, D. (2020) Are concentrations of pollutants in sharks, rays and skates (*Elasmobranchii*) a cause for concern? A systematic review. Marine Pollution Bulletin, 160, 111701. Available online: https://doi.org/10.1016/j.marpolbul.2020.111701. Accessed October 2023.

Tkachenko, H., Kurhaluk, N., Kasiyan, O., and Kaminski, P. (2019) Bioaccumulation of arsenic, chrome, manganese, and nickel in the gills of sea trout (*Salmo Trutta* M. *Trutta* L.) from the Southern Baltic Sea (Central Pomeranian region). Baltic Coastal Zone, 23, 65-80.

Tricas, T.C. and Carlson, B.A. (2012) Electroreceptors and magnetoreceptors. In: Cell Physiology Source Book: Essentials of Membrane Biophysics (N. Sperlakis, ed.), 4th ed. Academic Press, San Diego, 705-725.

Tyler-Walters, H., Tillin, H.M., d'Avack, E.A.S., Perry, F., and Stamp, T. (2023) Marine Evidence-based Sensitivity Assessment (MarESA) – Guidance Manual. Marine Life Information Network (MarLIN). Marine Biological Association of the UK, Plymouth, p. 170. Available online: https://www.marlin.ac.uk/assets/pdf/MarLIN-MarESA-Manual-Jun2023.pdf. Accessed October 2023.

Ueno, S., Lövsund, P., and Öberg, P.Å. (1986). Effect of time-varying magnetic fields on the action potential in lobster giant axon. Medical and Biological Engineering and Computing 24(5), 521-526.

UK Government (2022) Marine environment: unexploded ordnance clearance joint interim position statement. Policy Paper. Available online: https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement#:~:text=All%20aim%20to%20render%20UXOs,use%20is%20welcome%20and%20encouraged. Accessed December 2023.

Vandendriessche, S., Derweduwen, J. and Hostens, K. (2015) Equivocal effects of offshore wind farms in Belgium on soft substrate epibenthos and fish assemblages. Hydrobiologia. 756, 19–35.

Van Deurs, M., Grome, T.M., Kaspersen, M., Jensen, H., Stenberg, C., Sørensen, T.K., Støttrup, J., Warnar, T., and Mosegaar, H. (2012) Short and Long Term Effects of an Offshore Wind Farm on Three Species of Sandeel and their Sand Habitat. Marine Ecology Progress Series, 458, 169-180.

Van Hal, R., Griffioen, A.B. and van Keeken, O.A. (2017) Changes in fish communities on a small spatial scale, an effect of increased habitat complexity by an offshore wind farm. Marine Environmental Research. 126, 26–36.

Van Waerebeek, K., Baker, A.N., Félix, F., Gedamke, J., Iniguez, M., Sanino, G.P., et al. (2007) Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. Lat. Am. J. Aquat. Mamm. 6, 43–69. Doi: 10.5597/lajam00109.

Vattenfall, A., and Skov-og. N. (2006) Danish offshore wind-Key environmental issues (No. NEI-DK-4787). DONG Energy.

Vuorinen, P.J., Parmanne, R., Vartainen, T., Keinanen, M., Kiviranta, H., Kotovuori, O., and Halling, F. (2002) PCDD, PCDF, PCB and thiamine in Baltic herring (*Clupea harengus* L.) and sprat [*Sprattus sprattus* (L.)] as a background to the M74 syndrome of Baltic salmon (*Salmo salar* L.). ICES Journal of Marine Science, 59(3), 480-496. Available online: https://doi.org/10.1006/jmsc.2002.1200. Accessed October 2023.

Wahlberg, M. and Westerberg, H. (2005) Hearing in fish and their reactions to sounds from offshore wind farms. Marine Ecology Progress Series. 288, 295–309.

Wale, M.A., Simpson, S.D., and Radford, A.N. (2013) Size-dependent physiological responses of shore crabs to single and repeated playback of ship noise. Biology Letters, 9(2). Available online: https://doi.org/10.1098/rsbl.2012.1194. Accessed October 2023.

Wale, M.A., Briers, R.A., Hartl, M.G.J., Bryson, D., and Diele, K. (2019) From DNA to ecological performance: Effects of anthropogenic noise on a reef-building mussel. Science of the Total Environment, 689, 126-132, 10.1016/j.scitotenv.2019.06.380.

Walker, M.M. (1984) Learned magnetic field discrimination in yellowfin tuna, *Thunnus lbacares*. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 155(5), 673-9.

Welsh Government (2021) Planning Policy Wales. Policy document, Edition 11. Available online: https://www.gov.wales/sites/default/files/publications/2021-02/planning-policy-wales-edition-11_0.pdf. Accessed October 2023.

Westerberg, H., Langenfelt, I., Andersson, I., Wahlberg, M., and Sparrevik, E. (2007) Inverkan på fisk och fiske av SwePol Link - Fiskundersökningar 1999-2006 (in Swedish). Swedish Fisheries Agency.

Westerberg, H., and Langenfelt, I., (2008) Sub-sea power cables and the migration behaviour of the European eel. Fisheries Management and Ecology, 15, 369-75.

White, M., Gaffney, S., Bowers, D.G., and Bowyer, P. (2003) Interannual Variability in Irish Sea Turbidity and Relation to Wind Strength. Biology and Environment: Proceedings of the Royal Irish Academy, 10B(2), .83-90. Available online: https://www.jstor.org/stable/20500184. Accessed October 2023.

Wilber, D., and Clarke, D.G. (2001) Biological Effects of Suspended Sediments: A Review of Suspended Sediment Impacts on Fish and Shellfish With Relation to Dredging Activities in Estuaries. North American Journal of Fisheries Management, 21(4), 855-75, DOI:10.1577/1548-8675(2001)021<0855:BEOSSA>2.0.CO;2.

Wilding, C.M., Wilson, C.M., and Tyler-Walters, H. (2020) *Cetorhinus maximus* Basking shark. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available online: https://www.marlin.ac.uk/species/detail/1438. Accessed October 2023.

Wilhelmsson, D., Malm, T. and Ohman, M.C. (2006a) The Influence of Offshore Wind Power on Demersal Fish. ICES Journal of Marine Science 63, 775-84.

Wilhelmsson, D., Yahya, S.A.S. and Ohman, M.C. (2006b) Effects of high-relief structures on cold temperate fish assemblages: A field experiment. Marine Biology Research, 2006; 2, 136-47.

Wilhelmsson, D., Malm, T., Thompson, R., Tchou, J., Sarantakos, G., McCormick, N., Luitjens, S., Gullström, M., Patterson Edwards, J.K., Amir, O. and Dubi, A. (2010) Greening Blue Energy: Identifying and Managing the Biodiversity Risks and Opportunities of Offshore Renewable Energy. Edited by Gland, Switzerland: IUCN. 102pp.

Williams, R. Wright, A.J., Ashe, E., Blight, L.K., Bruintjes, R., Canessa, R., Clark, C.W., Cullis-Suskui, S., Dakin, D.T., Erbe, C., Hammonds, P.S., Merchant, N.D., O'Hara, P.D., Purser, J., Radford, A.N., Simpson, S.D., Thomas, L., and Wale, M.D. (2015). Impacts of anthropogenic noise on marine life: publication patterns, new discoveries, and future directions in research and management. Ocean Coastal Management, 115, 17-24.

Winter H.V., Aarts, G., and Van Keeken, O.A. (2010) Residence time and behaviour of sole and cod in the Offshore Wind Farm Egmond aan Zee (OWEZ) IMARES, Wageningen YR Report number: C038/10, 50pp.

Woodruff, D.L., Ward, J.A., Schultz, I.R., Cullinan, V.I., and Marshall, K.E. (2012) Effects of Electromagnetic Fields on Fish and Invertebrates Task 2.1.3: Effects on Aquatic Organisms Fiscal Year 2011 Progress Report. US Department of Energy.

Wright, P.J., Jensen, H., and Tuck, I. (2000). The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*. Journal of Sea Research 44, 243-256.

Wright, A.J., and Cosentino, A.M. (2015) JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys: We can do better. Marine Pollution Bulletin, 100(1), 231-9. Available online: https://doi.org/10.1016/j.marpolbul.2015.08.045. Accessed October 2023.

Yano, A., Ogura, M., Sato, A., Sakaki, Y., Shimizu, Y., Baba, N. and Nagasawa, K. (1997). Effect of modified magnetic field on the ocean migration of maturing chum salmon, *Oncorhynchus keta*. Marine Biology, 129, 523-530.

Zhou, W., Xu, X., Tu, X., and Chen, Y. (2016) Preliminary exploration for effects of sound stimulus on the movement behavior of *Litopenaeus vannamei*. in 2016 IEEE/OES China Ocean Acoustics Symposium, COA 2016 4–9 (IEEE, 2016). doi:10.1109/COA.2016.7535775.

Zitko, V. (1974) Uptake of chlorinated paraffins and PCB from suspended solids and food by juvenile Atlantic salmon. Bulletin of Environmental Contamination and Toxicology, 12, 406-412. Available online: https://doi.org/10.1007/BF01684974. Accessed October 2023.