RWE

Awel y Môr Offshore Wind Farm

Category 6: Environmental Statement

Volume 2, Chapter 6: Fish and Shellfish Ecology

Date: April 2022

Revision: B

Application Reference: 6.2.6

Pursuant to: APFP Regulation 5(2)(a)

REVISION	DATE	STATUS/ REASON FOR ISSUE	AUTHOR:	CHECKED BY:	APPROVED BY:
A	August 2021	PEIR	GoBe Consultants	RWE	RWE
B	March 2022	ES	GoBe Consultants	RWE	RWE

www.awelymor.cymru

RWE Renewables UK
Swindon Limited

Windmill Hill Business Park
Whitehill Way
Swindon
Wiltshire SN5 6PB
T +44 (0)8456 720 090
www.rwe.com

Registered office:
RWE Renewables UK
Swindon Limited Windmill
Hill Business Park Whitehill
Way
Swindon

Contents

Figures

Tables

Glossary of terms

TERM	DEFINITION
Demersal	Relating to the seabed and area close to it. Demersal spawning species are those which deposit eggs onto the seabed.
Elasmobranchs	Cartilaginous fishes such as sharks, rays, and skates.
Fish larvae	The developmental stage of fish which have hatched from the egg and receive nutrients from the yolk sac until the yolk is completely absorbed.

TERM	DEFINITION
Nursery habitat	Habitats where high numbers of juveniles of a species occur, having a greater level of productivity per unit area than other juvenile habitats.
Pelagic	Any part of the water column (i.e., the sea from surface to bottom sediments) that is not close to the seabed. Pelagic spawning species release their eggs into the upper layers of the sea.
Spawning	The release or deposition of eggs and sperm, usually into water, by aquatic animals.

Abbreviations and acronyms

TERM	DEFINITION
AyM	Awel y Môr
CEA	Cumulative Effects Assessment
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSIP	Cable Specification and Installation Plan
DCO	Development Consent Order
DEFA	Department of Environment, Food and Agriculture
EIA	Environmental Impact Assessment
ECC	Export Cable Corridor
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EMF	Electromagnetic Fields

TERM	DEFINITION
ES	Environmental Statement
ETG	Expert Topic Group
GBS	Gravity Based System
GES	Good Environmental Status
GyM	Gwynt y Môr offshore wind farm
HRA	Habitats Regulation Assessment
HDD	Horizontal Directional Drilling
JUVs	Jack-Up Vessels
LAT	Lowest Astronomical Tide
MCA	Marine and Coastguard Agency
MFE	Mass Flow Excavation
MHWS	Mean High Water Springs
MSFD	Marine Strategy Framework Directive
NIGFS	Northern Irish Ground Fish Survey
NPS	National Policy Statement
NW	North-west
NRW	Natural Resources Wales
NWGFS	Northwest Ground Fish Survey
OSP	Offshore Substation Platform
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Wind Farm
O&M	Operation and Maintenance

TERM	DEFINITION
PSA	Particle Size Analysis
PINS	Planning Inspectorate
PEIR	Preliminary Environmental Information Report
PELs	Probable Effect Levels
PEMP	Project Environment Management Plan
RIAA	Report to Inform Appropriate Assessment
SAC	Special Area of Conservation
SE	South-east
SEL_{cum}	Cumulative Sound Exposure Level
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
SPL_{peak}	Peak Sound Pressure Level
SSC	Suspended Sediment Concentrations
TELs	Threshold Effect Levels
THSD	Trailer Hopper Suction Dredger
TTS	Temporary Threshold Shift
UKBAP	UK Biodiversity Action Plan
UXO	Unexploded Ordnance
VER	Valued Ecological Receptor
WNMP	Welsh National Marine Plan
WTGs	Wind Turbine Generators
ZoI	Zone of Influence

Units

UNIT	DEFINITION
dB	Decibel
µPa	Micro pascal
m	metres
m^2	Square metre
m^3	Cubic metre
Mg/l	Milligrams per litre
nm	Nautical mile

6 Fish and Shellfish Ecology

6.1 Introduction

1 This chapter has been prepared by GoBe Consultants Ltd and assesses the potential effect on fish and shellfish ecology from the offshore works (including construction, operation and maintenance (O&M) and decommissioning) associated with Awel y Môr Offshore Wind Farm (hereafter referred to as AyM).

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

- Volume 2, Chapter 1: Offshore Project Description (application ref: 6.2.1);
- Volume 2, Chapter 2: Physical Processes (application ref: 6.2.2);
- Volume 2, Chapter 3: Marine Water and Sediment Quality (application ref: 6.2.3);
- Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology (application ref: 6.2.5);
- Volume 2, Chapter 9: Commercial and Recreational Fisheries (application ref: 6.2.8); and
- Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline (application ref: 6.4.6.1).

6.2 Statutory and policy context

3 This section identifies legislation and national and local policy of relevance to fish and shellfish ecology. The Marine Works (Environmental Impact Assessment) Regulations 2007 and the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (together referred to as 'the EIA Regulations'), Planning Act 2008 and the Environment (Wales) Act 2016 are considered along with the legislation relevant to fish and shellfish ecology.

4 The following section provides information regarding the legislative context surrounding the assessment of potential effects in relation to fish and shellfish ecology. Full details of all policy and legislation relevant to the AyM application are provided within Volume 1, Chapter 2: Policy and Legislation (application ref: 6.1.2). A summary of the current policy and legislation is provided below, the Applicant has ensured that the assessment adheres to the relevant Welsh legislation. The Environmental Assessments and Miscellaneous Planning (Amendment) (EU Exit) Regulations 2018 (made under the EU Withdrawal Act 2018 amended the domestic legislation which governs EIA as a result of the UK leaving the EU and ensures that the EIA Regulations continue to apply in substantially the same way.

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

- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017;
- The Marine Works (Environmental Impact Assessment) Regulations 2007;
- The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention; 1979);
- EU Council Directive 92/ 43/ EEC on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive');
- The Conservation of Habitats and Species Regulations 2017;
- The Environment (Wales) Act 2016;
- Marine and Coastal Access Act 2009; and
- The Wildlife and Countryside Act 1981.

6 Table 1 provides a summary of the key policy provisions of relevance to this assessment.

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

- The Overarching National Policy Statement (NPS) for Energy (NPS EN-1; Department for Energy and Climate Change (DECC), 2011a);

- The National Policy Statement for Renewable Energy Infrastructure (NPS EN-3, DECC, 2011b);
- National Policy Statement for Electricity Networks Infrastructure EN-5 (DECC, 2011c);
- Draft Overarching NPS EN-1 (DECC, 2021a);
- Renewable Energy Infrastructure draft NPS EN-3 (DECC, 2021b);
- The UK Marine Policy Statement (MPS; HM Government, 2011);
- The Welsh National Marine Plan (Welsh Government, 2019); and
- Future Wales – the National Plan 2040.

Table 1: Legislation and policy context.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
NPS EN-3	"Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed Offshore Wind Farm (OWF) and in accordance with the appropriate policy for OWF EIAs." (Paragraph 2.6.64 of NPS EN-3).	Construction, operation, maintenance and decommissioning phases of AyM have been assessed in sections 6.10 - 6.12.
	"Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate." (Paragraph 2.6.65 of NPS EN-3).	Consultation with relevant statutory and non-statutory stakeholders has been carried out from the early stages of AyM (see Table 4 for a summary of consultation with regard to fish and shellfish).
	"Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate." (Paragraph 2.6.66 of NPS EN-3).	Relevant data collected as part of post-construction monitoring from other OWF projects has informed the assessment of AyM (see sections 6.10 - 6.12).

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	"The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity." (Paragraph 2.6.67 of NPS EN-3).	The assessment methodology includes the provision for assessment of both positive and negative effects (Table 8)
	"The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it." (Paragraph 2.6.68 of NPS EN-3).	The potential effects on fish and shellfish ecology are presented within this chapter, with the assessment of effects presented within sections 6.10 - 6.12.
	"The designation of an area as a protected site (including HRA sites, MCZs and SSSIs) does not necessarily restrict the construction or operation of offshore wind farms in or near that area." (Paragraph 2.6.69 of NPS EN-3).	Designated sites within the region have been identified in section 6.7 as appropriate, and any potential impacts to features of the sites have been assessed in sections 6.10 - 6.12.
	"Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed" (Paragraph 2.6.70 of NPS EN-3).	Embedded mitigation relevant for the fish and shellfish ecology chapter is detailed in Table 11.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	"Ecological monitoring is likely to be appropriate during the construction and operational phases to identify the actual impact so that, where appropriate, adverse effects can then be mitigated and to enable further useful information to be published relevant to future projects." (Paragraph 2.6.71 of NPS EN-3).	The requirement for fish and shellfish monitoring has been considered within the impact assessment sections 6.10 - 6.12. In summary, no fish and shellfish monitoring for the construction, operation or decommissioning phases of AyM is considered necessary at this stage.
	"Where it is proposed that mitigation measures are applied to offshore export cables to reduce electromagnetic fields (EMF) the residual effects of EMF on sensitive species from cable infrastructure during operation are not likely to be significant. Once installed, operational EMF impacts are unlikely to be of sufficient range or strength to create a barrier to fish movement." (Paragraph 2.6.75 of NPS EN-3).	The impacts of EMF on fish and shellfish receptors have been considered in section 6.11.
	"EMF during operation may be mitigated by use of armoured cable for inter array and export cables which should be buried at a sufficient depth." (Paragraph 2.6.76 of NPS EN-3).	The impacts of EMF on fish and shellfish receptors have been considered in section 6.11 below.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	"During construction, 24 hour working practices may be employed so that the overall construction programme and the potential for impacts to fish communities are reduced in overall time." (Paragraph 2.6.77 of NPS EN-3).	AyM can confirm that 24 hour working practices will be employed for offshore construction works (Volume 2, Chapter 1 (application ref: 6.2.1)).
	"There is the potential for the construction and decommissioning phases, including activities occurring both above and below the seabed, to interact with seabed sediments and therefore have the potential to impact fish communities, migration routes, spawning activities and nursery areas of particular species. In addition, there are potential noise impacts, which could affect fish during construction and decommissioning and to a lesser extent during operation." (Paragraph 2.6.73 of NPS EN-3).	The potential effects on fish and shellfish ecology are presented within this chapter, with the assessment of effects presented within sections 6.10 - 6.12. Potential implications from underwater noise have been assessed in sections 6.10.1, 6.12.1 and 6.13.2.
	The applicant should identify fish species that are the most likely receptors of impacts with respect to: ● spawning grounds;	The key receptors of impacts are listed in Table 9. Consideration of receptors with regards to spawning grounds, nursery grounds, feeding grounds, over-wintering

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	● nursery grounds; ● feeding grounds; ● over-wintering areas for crustaceans; and ● migration routes. (Paragraph 2.6.74 of NPS EN-3).	areas and migration routes has been given, with those receptors of potential sensitivity to impacts from the development of AyM assessed within sections 6.10 - 6.12.
	The construction and operation of offshore wind farms can have both positive and negative effects on fish and shellfish stocks. (Paragraph 2.6.122 of NPS EN-3).	The effects on fish and shellfish stocks have been assessed in Volume 2, Chapter 9 (application ref: 6.2.9).
	"Effects of offshore wind farms can include temporary disturbance during the construction phase (including underwater noise) and ongoing disturbance during the operational phase and direct loss of habitat. Adverse effects can be on spawning, overwintering, nursery and feeding grounds and migratory pathways in the marine area. However, the presence of wind turbines can also have positive benefits to ecology and biodiversity." (Paragraph 2.6.63 of NPS EN-3).	The assessment methodology includes the provision for assessment of both positive and negative effects (Table 8). The potential effects on fish and shellfish ecology (inclusive of spawning, overwintering, nursery and feeding grounds and migratory pathways) are presented within this chapter, with the assessment of effects presented within sections 6.10 - 6.12.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
Draft NPS EN-3	"Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed Offshore Wind Farm (OWF) and in accordance with the appropriate policy for OWF EIAs Applicants will also need to consider environmental net gain as set out in the 25 Year Environment Plan." (Paragraph 2.24.5 of Draft NPS EN-3).	Construction, operation, maintenance and decommissioning phases of AyM have been assessed in sections 6.10 - 6.12.
	"Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate." (Paragraph 2.24.6 of Draft NPS EN-3).	Consultation with relevant statutory and non-statutory stakeholders has been carried out from the early stages of AyM (see Table 4 for a summary of consultation with regard to fish and shellfish).
	"Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWFs should be referred to where appropriate. Reference must be made to relevant scientific research and literature." (Paragraph 2.24.7 of Draft NPS EN-3).	Relevant data collected as part of post-construction monitoring from other OWF projects has informed the assessment of AyM (see sections 6.10 - 6.12.).

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	"The assessment should include the potential of the scheme to have both positive and negative effects on marine ecology and biodiversity." (Paragraph 2.24.8 of Draft NPS EN-3).	The assessment methodology includes the provision for assessment of both positive and negative effects (Table 8)
	"The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it." (Paragraph 2.24.18 of Draft NPS EN-3).	The potential effects on fish and shellfish ecology are presented within this chapter, with the assessment of effects presented within sections 6.10 - 6.12.
	"The designation of an area as a protected site (including HRA sites, MCZs and SSSIs) does not necessarily restrict the construction or operation of offshore wind farms in, near or through that area." (Paragraph 2.24.19 of Draft NPS EN-3).	Designated sites within the region have been identified in section 6.7 as appropriate, and any potential impacts to features of the sites have been assessed in sections 6.10 - 6.12.
	"Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed" (Paragraph 2.24.10 of Draft NPS EN-3).	Embedded mitigation relevant for the fish and shellfish ecology chapter is detailed in Table 11.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	"Ecological monitoring will be appropriate during the pre-construction, construction and operational phases to identify the actual impacts caused by the project and compare them to what was predicted in the EIA/HRA". (Paragraph 2.24.11 Draft NPS EN-3).	The requirement for fish and shellfish monitoring has been considered within the impact assessment sections 6.10 - 6.12. In summary, no fish and shellfish monitoring for the construction, operation or decommissioning phases of AyM is considered necessary at this stage.
	"Review of up-to-date research should be undertaken and all potential mitigation options presented. EMF in the water column during operation, is in the form of electric and magnetic fields, which are reduced by use of armoured cables for inter-array and export cables. Burial of the cable increases the physical distance between the maximum EMF intensity and sensitive species. However, what constitutes sufficient depth to reduce impact will depend on the geology of the seabed. It is unknown whether exposure to multiple cables and larger capacity cables may have a cumulative impact on sensitive species. Therefore monitoring EMF emissions	The impacts of EMF on fish and shellfish receptors have been considered in section 6.11 below.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	may provide the evidence to inform future EIAs". (Paragraph 2.26.4 of Draft NPS EN-3).	
	"The applicant should identify fish species that are the most likely receptors of impacts with respect to: • spawning grounds • nursery grounds • feeding grounds • over-wintering areas for crustaceans • migration routes • protected areas (e.g. HRA sites and MCZs)" (Paragraph 2.26.2 of Draft NPS EN-3).	The key receptors of impacts are listed in Table 9. Consideration of receptors with regards to spawning grounds, nursery grounds, feeding grounds, over-wintering areas, migration routes and protected areas has been given, with those receptors of potential sensitivity to impacts from the development of AyM assessed within sections 6.10 - 6.12.
	"The assessment should also identify potential implications of underwater noise from construction and unexploded ordnance (both sound pressure and particle motion) and EMF on sensitive fish species." (Paragraph 2.26.2 of Draft NPS EN-3).	Potential implications from underwater noise have been assessed in sections 6.10.1, 6.12.1 and 6.13.2. The impacts of EMF on fish and shellfish receptors have been considered in section 6.11.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
NPS EN-1	"Where the development is subject to EIA the applicant should ensure that the ES clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Infrastructure Planning Commission (IPC) consider thoroughly the potential effects of a proposed project." (Paragraph 5.3.3 of NPS EN-1).	The potential effects of AyM have been assessed in regard to international, national and local sites designated for ecological or geological features of conservation importance (see sections 6.10 - 6.12.). Direct or indirect effects on features of relevant Special Area of Conservation (SAC) and Special Protection Area (SPA) sites are also considered in the Habitats Regulations Assessment Screening Report and where relevant will be included in the Report to Inform Appropriate Assessment (RIAA) (application ref: 5.1).
	"Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance; those that are not, should be given a high degree of protection. Where a proposed development within or outside a SSSI is likely to have an adverse effect on a SSSI (either individually or together with other developments), development consent should not	Designated sites within the region have been identified in section 6.7 as appropriate, and any potential impacts to features of the sites have been assessed in sections 6.10 - 6.12.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	normally be granted. Where an adverse effect, after mitigation, on the site's notified special interest features is likely, an exception should only be made where the benefits (including need) of the development at this site clearly outweigh both the impacts on site features and on the broader network of SSSIs. The Secretary of State should use requirements and/or planning obligations to mitigate the harmful aspects of the development, and where possible, ensure the conservation and enhancement of the site's biodiversity or geological interest." (Paragraphs 5.3.10 and 5.3.11 of NPS EN-1).	
	"Marine Conservation Zones (MCZs) introduced under the Marine and Coastal Access Act (MCAA) 2009 are areas that have been designated for the purpose of conserving marine flora and fauna, marine habitat or features of geological or geomorphological interest. The Secretary of State is bound by the duties in relation to MCZs imposed by Sections 125 and 126 of the Marine and Coastal Access Act 2009." (Paragraph 5.3.12 and Paragraph 5.4.11 of NPS EN-1).	There are no MCZs which are considered to be at risk of effect from the construction, operation or decommissioning of AyM and as such, no further consideration of MCZs has been given.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	"Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the IPC should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate." (Paragraph 5.3.15 of NPS EN-1).	Designed-in measures to be adopted as part of the AyM project are presented in Table 11.
	"Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Secretary of State should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations." (Paragraph 5.3.17 of NPS EN-1).	All species receptors, including those of principal importance for the conservation of biodiversity in Wales are summarised in section 6.7 (full description in Volume 4, Annex 6.1 (application ref: 6.4.6.1)).
	"The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that:	Embedded measures to be adopted as part of the AyM project are presented in Table 11.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works; During construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements; Habitats will, where practicable, be restored after construction works have finished." (Paragraph 5.3.18 of NPS EN-1).	
Draft NPS EN-1	"Where the development is subject to EIA the applicant should ensure that the ES clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the	The potential effects of AyM have been assessed in regard to international, national and local sites designated for ecological or geological features of conservation importance (see sections 6.10 - 6.12.). Direct or indirect effects on features of relevant Special Area of Conservation (SAC) and Special Protection Area (SPA) sites are also considered in the Habitats Regulations

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	Infrastructure Planning Commission (IPC) consider thoroughly the potential effects of a proposed project." (Paragraph 5.4.3 of Draft NPS EN-1).	Assessment Screening Report and where relevant will be included in the Report to Inform Appropriate Assessment (RIAA) (5.1).
	"Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance; those that are not, should be given a high degree of protection. Most National Nature Reserves are notified as SSSIs. Development on land within or outside a SSSI, and which is likely to have an adverse effect on it (either individually or in combination with other developments), should not normally be permitted. The only exception is where the benefits (including need) of the development in the location proposed clearly outweigh both its likely impact on the features of the site that make it of special scientific interest, and any broader impacts on the national network of SSSIs. The Secretary of State should use requirements and/or planning obligations to mitigate the harmful aspects of the development and, where possible, to	Designated sites within the region have been identified in section 6.7 as appropriate, and any potential impacts to features of the sites have been assessed in sections 6.10 - 6.12.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	ensure the conservation and enhancement of the site's biodiversity or geological interest." (Paragraphs 5.4.9 and 5.4.10 of Draft NPS EN-1).	
	"Marine Conservation Zones (MCZs) introduced under the Marine and Coastal Access Act (MCAA) 2009 are areas that have been designated for the purpose of conserving marine flora and fauna, marine habitat or features of geological or geomorphological interest. The protected feature or features and the conservation objectives for the MCZ are stated in the designation order for the MCZ. The Secretary of State is bound by the duties in relation to MCZs imposed by Sections 125 and 126 of the Marine and Coastal Access Act 2009." (Paragraph 5.4.11 of Draft NPS EN-1).	There are no MCZs which are considered to be at risk of effect from the construction, operation or decommissioning of AyM and as such, no further consideration of MCZs has been given.
	"Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the IPC should maximise such opportunities in and around developments, using requirements or	Designed-in measures to be adopted as part of the AyM project are presented in Table 11.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	planning obligations where appropriate." (Paragraph 5.4.14 of Draft NPS EN-1).	
	"Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Secretary of State should ensure that these species and habitats are protected from the adverse effects of development by using requirements, planning obligations or licence conditions." (Paragraph 5.4.16 of Draft NPS EN-1).	All species receptors, including those of principal importance for the conservation of biodiversity in Wales are summarised in section 6.7 (full description in Volume 4, Annex 6.1 (application ref: 6.4.6.1)).
	"The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works; During construction and operation best practice will be followed to ensure that risk of disturbance or	Embedded measures to be adopted as part of the AyM project are presented in Table 11.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	damage to species or habitats is minimised, including as a consequence of transport access arrangements; Habitats will, where practicable, be restored after construction works have finished. mitigation measures should take into account existing habitats and should generally seek opportunities to enhance them, rather than replace them." (Paragraph 5.4.18 of Draft NPS EN-1).	

8 Guidance has been provided within the Marine Strategy Framework Directive (2008/56/EC) (MSFD), adopted in July 2008, which has been considered in this assessment. The MSFD is transposed for the whole of the UK by the Marine Strategy Regulations 2010, providing a UK-wide framework for meeting the requirements of the Directive. The relevance of the MSFD to AyM has been described in Volume 1, Chapter 2: Policy and Legislation (application ref: 6.1.2).

9 The overarching aim of the MSFD is to achieve 'Good Environmental Status' (GES) by 2020, across Europe's marine environment. Annex I of the MSFD identifies 11 high level qualitative descriptors for determining GES, with those relevant to the fish and shellfish ecology assessment for AyM outlined in Table 2, with a brief description of how and where these have been addressed in this assessment.

Table 2: Summary of the MSFDs high level descriptors of GES relevance to fish and shellfish ecology and consideration in the AyM assessment.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
MSFD	Descriptor 1 – Biological diversity: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	The effects on biological diversity have been described and considered within the assessment for AyM alone and the cumulative effects assessment (CEA) (sections 6.10- 6.13).
	Descriptor 2 – Non-indigenous species: non-indigenous species introduced by human activity are at levels that do not adversely alter the ecosystems.	The potential for effects associated with non-indigenous species of fish and shellfish ecology that may be attributable to the AyM project have been scoped out of the assessment as agreed through the Scoping Report (innogy, 2020).
	Descriptor 3 – Commercial species: The population of commercial fish species is healthy.	The effects on commercial fish and shellfish species have been described and considered within the assessment for AyM alone and in the CEA (sections 6.10 - 6.13).
	Descriptor 4 – Elements of marine food web: All elements of marine food webs, to the extent they	The effects on fish and shellfish ecology, inclusive of the interlinkages with

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.	interdependent ecological receptors described in other chapters is integral within this chapter and the wider ES with inter relationships described where appropriate.
	Descriptor 6 – Sea floor integrity: Sea floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	The effects on fish and shellfish ecology, inclusive of any risk to ecological integrity, has been described and considered within the assessment for AyM alone and the CEA assessment (sections 6.10 - 6.13).
	Descriptor 8 – Contaminants: Concentrations of contaminants are at levels not giving rise to pollution effects.	The effects of contaminants on fish and shellfish and species have been assessed in sections 6.10 - 6.13 as appropriate.
	Descriptor 9 – Contaminants in seafood: Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.	The effects of contaminants on fish and shellfish and species have been assessed in sections 6.10 - 6.13 as appropriate.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	Descriptor 10 – Marine litter: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	A Project Environmental Management and Plan (PEMP) will be produced prior to construction and followed to cover the construction and operation phases of AyM. The PEMP will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g., EA, Natural Resources Wales, and Maritime and Coastguard Agency (MCA)). A Decommissioning Plan will be developed to cover the decommissioning phase (Table 11).
	Descriptor 11 – Energy incl. underwater noise: introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	The effects of underwater noise on fish and shellfish have been assessed in sections 6.10 - 6.13.

6.2.1 Overview of Welsh Planning Policy

10 Planning Policy Wales sets out the land use planning policies of the Welsh Government, forming a strategic framework to guide development. The Planning Policy Wales documentation does not explicitly include a topic on fish and shellfish, with other relevant policy and guidance identified below.

11 The key local development plans to be considered in the development of the ES will be:

- Conwy County Borough Council local development plan;
- Flintshire County Council local development plan;
- Denbighshire County Council local development plan;
- The Anglesey and Gwynedd joint local development plan; and
- Future Wales: The National Plan 2040.

Welsh National Marine Plan

12 The Welsh National Marine Plan (WNMP) was published on 12 November 2019 and contains policy across a range of considerations (including nature conservation, sustainable use, seascape, and coastal communities and economic growth). The WNMP includes sector objectives for renewable energy to support decarbonisation of the Welsh economy and the use of marine renewable energy generation (including OWFs). Table 3 provides a summary of the key provisions of the WNMP of relevance to this assessment.

Table 3: WNMP policies of relevance to fish and shellfish ecology.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
Welsh National Marine Plan	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: a. avoid adverse impacts; and/or b. minimise impacts where they cannot be avoided; and/or c. mitigate impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. Proposals that contribute to the protection, restoration and/or enhancement of marine ecosystems are encouraged.	The potential impacts on fish and shellfish ecology have been assessed in sections 6.10 - 6.13. Consideration of the avoid, minimise and mitigate approach is given within the assessments as appropriate. Embedded mitigation measures are detailed within Table 11.
	ENV_02: Marine Protected Areas. Proposals should demonstrate how they:	Designated sites within the region have been identified in section 6.7 as appropriate, and any potential

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	avoid adverse impacts on individual Marine Protected Areas (MPAs) and the coherence of the network as a whole; have regard to the measures to manage MPAs; and avoid adverse impacts on designated sites that are not part of the MPA network.	impacts to features of the sites have been assessed in sections 6.10 - 6.13.
	ENV_02: Invasive non-native species. Proposals should demonstrate how they avoid or minimise the risk of introducing and spreading invasive non-native species. Where appropriate, proposals should include biosecurity measures to reduce the risk of introducing and spreading of invasive non-native species.	The risk of introducing and spreading non-native species will be minimized through the implementation of a PEMP, which will include a biosecurity plan.
	ENV_05: Underwater noise. Proposals should demonstrate that they have considered man-made noise impacts on the marine environment and, in order of preference: a. avoid adverse impacts; and/or	The effects of underwater noise on fish and shellfish have been assessed in sections 6.10 - 6.13.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	b. minimise impacts where they cannot be avoided; and/or c. mitigate impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding.	
	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: a. avoid adverse impacts on those areas; and/or b. minimise adverse impacts where they cannot be avoided; and/or c. mitigate adverse impacts where they cannot be minimised.	The potential effects on fish species and their habitats have been assessed in sections 6.10 - 6.13.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding.	

6.2.2 Underwater Noise Guidance

13 The assessment of potential effects from underwater noise has been carried out utilising the widely used and recognised criteria by Popper *et al*. (2014).

6.3 Consultation and scoping

14 Consultation is a key part of the DCO pre-application process. Consultation regarding fish and shellfish ecology has been undertaken with various statutory and non-statutory authorities, through the agreed Evidence Plan process (being used for the EIA process as well as for the Habitats Regulation Assessment (HRA)). A formal Scoping Opinion was sought from the SoS following submission of the Scoping Report (Innogy Renewables UK, 2020). The Scoping Opinion (PINS, 2020) was issued in July 2020 by PINS.

15 AyM's statutory consultation period under Section 42 of the Planning Act 2008 ran from 28 August to 11 October 2021, a period of six weeks. The PEIR was published as part of formal consultation which provided preliminary information on fish and shellfish ecology within Volume 2, Chapter 6: Fish and Shellfish Ecology (Application ref 6.2.6)

16 A summary of the responses relevant to the fish and shellfish ecology chapter in the Scoping Opinion are summarised in Table 4 below. This table also provides a summary of the key themes of the feedback received in relation to fish and shellfish ecology and outlines how the feedback has been considered in this ES chapter. A full list of all comments received during the formal consultation period and the response to those comments is provided in the Consultation Report (application ref: 5.1).

Table 4: Summary of consultation relating to Fish and Shellfish Ecology.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
July 2020 PINS Scoping Opinion	The Scoping Report does not provide sufficient evidence to support the scoping out of direct damage and disturbance to fish and shellfish receptors during construction and decommissioning. Accordingly, the ES should include an assessment of these matters where likely significant effects would occur. The Applicant should make effort to agree the approach to the assessment with relevant consultation bodies including NRW.	The impact assessment in sections 6.10 and 6.12 includes an assessment of direct damage and disturbance to fish and shellfish during construction and decommissioning. The approach to the assessment has been discussed with the Marine Ecology & Marine Mammals Expert Topic Group (ETG).
	The Scoping Report proposes to scope out accidental pollution resulting from construction and decommissioning of the Proposed Development. The Inspectorate	Accidental pollution impacts have been scoped out of the assessment. Table 11 details the embedded mitigation measures for AyM of relevance to fish and shellfish ecology, including the PEMP. These

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	agrees that this effect can be scoped out of the assessment. The ES should include details of the proposed mitigation measures to be included in the PEMP and constituent MPCP (as stated in paragraph 458 of the Scoping Report). The ES should also explain how such measures will be secured.	commitments are to be secured by conditions within the DCO and Marine Licences.
	The Inspectorate does not agree that impacts of EMF on fish and shellfish can be scoped out.	The impacts of EMF on fish and shellfish have been assessed within section 6.11 of this chapter.
	The Inspectorate does not agree that direct disturbance caused by operation and maintenance activities can be scoped out	The impacts of direct damage and disturbance during operation and maintenance activities have been assessed in section 6.11 of this chapter.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	The Inspectorate does not agree that cumulative impacts identified in paragraph 446 of the Scoping Report can be scoped out for the reasons provided at paragraph 3.3.3.	The relevant cumulative impacts have been included in the assessment of cumulative effects within section 6.13 of this chapter.
	The Scoping Report does not address potential impacts on fish feeding grounds or over-wintering areas for crustaceans. The ES should assess these impacts where significant effects are likely to occur.	During the impact assessment within the sections 6.10 - 6.13, consideration is given to effects on fish feeding grounds and over-wintering grounds as appropriate.
	The Inspectorate notes migratory fish species listed under paragraph 450 are also protected under legislation specified in paragraph 449 of the Scoping Report (e.g., Bern Convention, Habitats Directive, the Convention on International Trade in	The impact assessment in sections 6.10 - 6.13 below consider impacts to the relevant species as identified in the baseline characterisation which was agreed as sufficient with NRW via provision of a baseline characterisation report to the Marine Ecology & Marine Mammals ETG.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	Endangered Species of Wild Fauna and Flora (CITES) and UK Biodiversity Action Plan (UKBAP)). The assessment in the ES should also address species designated under UKBAP (e.g., smelt/sparling), Habitats Directive (e.g., salmon, sea trout, European eel) which are known to spawn in the rivers of North Wales, and UK Wildlife Countryside Act 1981 (e.g., critically endangered Angel Shark). The Applicant should make efforts to agree the approach to the assessment with relevant consultation bodies including NRW.	
July 2020 NRW Scoping Opinion	It is unclear from the text whether the listed data sources will be used to compile a list for species to be scoped into the assessment or	The fish and shellfish baseline as provided in Volume 4, Annex 6.1 (application ref: 6.4.6.1) has been agreed as sufficient for characterisation purposes (via the provision of the technical baseline to the Marine Ecology & Marine Mammals ETG in October 2020)

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	considered as Valued Ecological Receptors.	provides the full baseline for the project, including identification of the species considered in the assessment and considered as VERs.
	NRW do not consider the maps of marine fish spawning and nursery habitat sufficiently fine-scale or current to enable qualitative assessment of the special overlap with the development.	The fish and shellfish baseline as provided in Volume 4, Annex 6.1(application ref: 6.4.6.1) has been agreed as sufficient for characterisation purposes provides the full baseline for the project, including identification of the species considered in the assessment and considered as VERs.
	The applicant is advised that the protected species list needs amending to include, amongst others, S7 marine species.	The fish and shellfish baseline as provided in Volume 4, Annex 6.1(application ref: 6.4.6.1) has been agreed as sufficient for characterisation purposes provides the full baseline for the project, including identification of the species considered in the assessment and considered as VERs.
	NRW require further justification for screening out impacts due to EMF.	The impacts of EMF on fish and shellfish have been assessed within section 6.11 of this chapter.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
November 2020 ETG Meeting	Technical baseline discussions following receipt of comments from NRW. Desk study agreed as sufficient for characterisation of the AyM site with no site-specific surveys required.	Volume 4, Annex 4.1(application ref: 6.4.4.1) provides the full details of the baseline characterisation of the AyM which has been updated as discussed with the Marine Ecology & Marine Mammal ETG members. A summary of the Technical Baseline is provided in section 6.7 of this chapter.
November 2020 ETG Meeting NRW feedback on Fish & Shellfish technical baseline	NRW consider the evidence regarding salmon and sea trout migrations is anecdotal and therefore, potential impacts on these features should be scoped in.	Impacts to salmon and sea trout are considered throughout the assessment in sections 6.10 - 6.13 below.
	NRW agreed that the surveys and information presented in report is sufficient to define a list of baseline species, their distribution and use of habitat within the defined study area.	This is noted.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
March 2021 ETG Meeting	Confirmation given of inclusion of EMF and direct damage and disturbance into the assessment as requested through Scoping Opinions from PINS and NRW. Agreement on the principles of the MDS approach.	The impact assessment in sections 6.10 and 6.12 includes an assessment of direct damage and disturbance to fish and shellfish during construction and decommissioning. The impacts of EMF on fish and shellfish have been assessed within section 6.11 of this chapter.
October 2021 Section 42 Consultation NRW comment	NRW raised concern that some of the VERs (Valued Ecological Receptors) highlighted in Volume 4, Annex 4.1(application ref: 6.4.4.1) were not carried through to the chapter. NRW requested that rationale is provided as to why potential impacts to these species have not been addressed in the assessment.	The VERs highlighted in Volume 4, Annex 4.1(application ref: 6.4.4.1), have been tabulated in Table 9 of Section 6.3 of this chapter. Reference has been made to individual VERs throughout the assessments in sections 6.10 - 6.12.
October 2021	NRW noted that the approach used to present the temporal and spatial	Specific reference to the temporal and spatial MDS conclusions within the noise assessment in Section 6.10.1 has been added.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
Section 42 Consultation NRW comment	MDS in the assessment of noise impacts was not clear.	
October 2021 Section 42 Consultation NRW comment	NRW did not agree in all cases with the use of modelling outputs for fleeing receptors in the noise assessment, on the basis that the parameters to inform them (e.g., swim speed) were not necessarily realistic or conservative.	The swim speed of 1.5m/s used to inform the noise assessment on fleeing fish receptors was informed by the Hirata (1999) paper. The assessment (as presented in Section 6.10.1 of this chapter) included a consideration of fleeing and stationary receptors as part of the noise modelling. The approach is deemed to provide a conservative range within which impact may occur depending on individual fleeing speeds of fish receptors.
October 2021 Section 42 Consultation NRW comment	NRW requested clarification on how different vulnerability, recoverability and importance have been weighted or combined to produce sensitivity conclusions for receptors in the noise assessment.	Additional clarification on how the vulnerability, recoverability and importance of receptors are considered in order to determine their sensitivity to the impacts has been provided in Section 6.5.2. A clarification note was also provided to the consultee on 26 November 2021 (ETG Clarification Note: Fish

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
		Noise Sensitivity Weighting Justification. See Evidence Plan Report, application ref: 8.2).
October 2021 Section 42 Consultation NRW comment	NRW requested clarity on the overall piling period, as an inconsistency was noted between the Project Description and the Fish and Shellfish Chapter.	The overall piling period has been revised in accordance with Volume 2, Chapter 1: Offshore Project Description (application ref: 6.2.1).
October 2021 Section 42 Consultation NRW comment	NRW requested clarification on how spawning potential conclusions were reached, regarding potential noise impacts on sensitive receptors, including eggs and larvae.	Clarification on how the spawning potential conclusions were reached is provided in Section 6.10.1 of this chapter, and in the form of a clarification note, issued to the consultee on 26 November 2021(ETG Clarification Note: Fish Spawning Potential).
October 2021 Section 42 Consultation NRW comment	NRW agreed with the conclusions made regarding the potential for noise impacts on Group 2 receptors, inclusive of salon and sea trout.	This is noted.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
October 2021 Section 42 Consultation NRW comment	NRW stated they remain unclear on what area of fish VERs spawning grounds have been considered relevant in relation to the spatial and temporal MDS.	The areas of fish spawning grounds considered relevant to the spatial and temporal MDS have been provided through the calculation of the spawning potential of spawning receptors. Clarification on how the spawning potential conclusions were reached is provided in Section 6.10.1 of this chapter, and in the form of a clarification note, issued to the consultee on 26 November 2021(ETG Clarification Note: Fish Spawning Potential).
October 2021 Section 42 Consultation NRW comment	NRW stated they are unclear how the in-combination area of simultaneous piling at two locations has been considered, and how the temporal MDS of piling has been considered in the assessment.	The simultaneous piling of pin piles represents the spatial MDS in the noise assessment and has been assessed in Section 6.10.1 of this chapter. The temporal MDS of piling results from the sequential piling of pin piles and has been assessed in Section 6.10.1 of this chapter. Note the option for concurrent piling of monopiles has been removed as an embedded mitigation measure (see Table 11), in response to stakeholder

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
		concerns relating to the ecological effects of underwater noise.
October 2021 Section 42 Consultation NRW comment	NRW noted that the worst-case scenario for the installation of monopile foundations at both locations (in-combination area) for stationary receptors has not been assessed.	Based on revised noise modelling, the installation of two pin piles simultaneously at the same WTG location represents the spatial MDS (See Table 12 and Table 15). The sequential installation of pin pile foundations represents the temporal MDS. These scenarios are both assessed in Section 6.10.1 of this chapter.
October 2021 Section 42 Consultation NRW comment	NRW stated they do not agree with statements made around the migration pathways of sea trout and salmon regarding noise impacts from cofferdam installation but do agree that the low levels of potential noise from cofferdam piling means that the risk to fish receptors from the activities can be considered as low.	This noted.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
October 2021 Section 42 Consultation NRW comment	NRW stated that they were unable to agree or disagree with the conclusions made in the noise assessment on individual hearing groups, as well as the overall conclusion made. NRW suggested that in-combination effects of direct loss of fish, loss of eggs/larvae and disturbance may be higher than the individual components and requested that these are further discussed and evidenced in the assessment.	Further evidence has been provided on individual VERs in the noise assessment in Section 6.10.1 to support the conclusions made.
October 2021 Section 42 Consultation NRW comment	NRW noted the intention to fully assess the impacts of Unexploded ordnance (UXO) detonations as part of a marine licence application at a later stage of the project. NRW welcomed the use of mitigation methods such a bubble curtains and	This is noted.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	low order detonation to provide additional protection for fish and shellfish receptors.	
October 2021 Section 42 Consultation NRW comment	NWR agreed that the impact to fish from temporary increases in SSC and deposition are likely to be low, however request further clarity as to why only some VERs are assessed. NRW also requested further contextualisation for the loss of habitat for the receptors to support the conclusion.	The VERs identified in the Volume 4, Annex 6.1: Fish and Shellfish Ecology Technical Baseline (application ref: 6.4.6.1) have been addressed under the impact of temporary increases in SSC and deposition, with further reference made to the assessment of the impact on individual receptors.
October 2021 Section 42 Consultation NRW comment	NRW advised that it would be beneficial to aim to avoid the main migration periods of smolts and returning adult fish regarding potential noise impacts from HDD.	This topic was raised for discussion in the November 2021 ETG. See 'November 2021 ETG Meeting' entry within this table.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
October 2021 Section 42 Consultation NRW comment	NRW requested that the following amendments are made to the Fish and Shellfish Ecology Technical Baseline: • NRW advised that Atlantic salmon, Sea lamprey and River lamprey are all Annex II features of Habitats Directive sites within the study area for AyM and should therefore be assigned as of 'International Importance'. • NRW raised concerns that there is a lack of evidence for migration routes for salmon and sea trout and therefore the statements made in the report regarding the presence of salmon and sea trout in the AyM area are not supported by evidence.	The suggested amendments have been made to Volume 4, Annex 6.1 (application ref: 6.4.6.1).

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
October 2021 Section 42 Consultation Isle of Man Government comment	The Isle of Man Government acknowledged that specific reference to consultation with the Isle of Man Government has expanded the 'contextual area' for this topic and stated this this leads to greater confidence of consideration of interests.	This is noted.
	The Isle of man Government acknowledged that in the Preliminary Environmental Information Report Volume 1, Annex 3.2: Transboundary Screening report (application ref: 6.1.3.2) that the assessment of this topic 'is anticipated to focus on the Isle of Man and the Republic of Ireland, in addition to transboundary commercial interests considered	This is noted.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	through the Commercial Fisheries assessment in the EIA. The committee further acknowledged the explicit consideration of Manx interests and input in this Section.	
October 2021 Section 42 Consultation Isle of Man Government comment	The Isle of Man Government noted the relevance of ecological connectivity's between areas within the region, and the importance of larval distribution of scallops from north Wales into the wider Irish Sea.	This is noted.
October 2021 Section 42 Consultation Isle of Man Government comment	The Isle of Man Government recommended further consultation with Bangor University Fisheries and Conservation Science Group in this regard.	This is noted.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
October 2021 Section 42 Consultation Isle of Man Government comment	The Isle of man Government stated they seek reassurance that sufficient consideration of the potential impacts on sessile, commercially important fishery species has been given in regard to transboundary effects. The Isle of Man Government recommended that reports by Neil and Kaiser (2008) and Close (2014) are reviewed.	Additional consideration of the potential transboundary impacts on sessile, commercially important fishery species has been given in Section 6.15 of this chapter.
	The Wildlife Trusts state they do not agree with the assessment of 'medium' sensitivity assigned to herring for noise impacts and recommend that further mitigation is implemented.	AyM overlaps with herring nursery grounds but has no overlap with herring spawning grounds (See Figure 5). The closest herring spawning ground is located off the Isle of Man, out of range of any potential noise disturbance from piling operations.
October 2021 Section 42 Consultation	The Wildlife Trusts state they do not agree with the assessment of minor adverse significance for mortality	A commitment has been made by the Applicant for soft start piling to be used for all piling, no matter what time of the year. Suitable sediments being

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
comment from The Wildlife Trusts	and potential mortal injury, recoverable injury or behavioural impacts from noise. The Wildlife Trusts state that whilst they recognise that the AyM array area and cable route do not overlap with the Isle of Man herring spawning grounds, the site does overlap with key areas of habitat suitability for herring and identified herring nursery grounds. The Wildlife Trusts therefore advised that the precautionary principle is exercised, implementing softs, slow start piling year-round, and especially during the spawning season for herring stocks.	present does not indicate that spawning occurs in these areas, as sediment suitability is not the only factor that influences herring spawning. Therefore, additional weight has not been given to the presence of suitable habitats in the assessment of noise impacts on spawning herring, due to the desk-based review not finding any evidence of historic spawning grounds.
October 2021 Section 42 Consultation	The Wildlife Trusts state they are disappointed that fishing activities have been considered as part of the	The Applicant recognises this request, however as an existing activity commercial fishing is considered to form part of the baseline environment. This approach

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
comment from The Wildlife Trusts	baseline and has not been included within the Cumulative Effects Assessment (CEA).	is in accordance with the guidelines for undertaking cumulative effect assessment in offshore wind farms (Renewable UK, 2013).
November 2021 ETG Meeting	Discussion on feedback received during statutory consultation. Agreement on proposed restructuring of the chapter to ensure assessment conclusions on each VER are clearer. Agreement that a clarification note should be provided, giving further reasoning on how the sensitivity is weighted for receptors. Concerns were expressed by NRW about the qualitative impact assessment on spawning grounds. GoBe confirmed a clarification note would be provided on fish spawning potential calculations.	The chapter has been restructured to provide clearer impact assessment conclusions for each VER. A clarification note was provided to NRW on 26 November 2021 detailing the approach undertaken to determine the sensitivity weighting of individual receptors (ETG Clarification Note: Fish Noise Sensitivity Weighting Justification). A clarification note was provided to NRW on 26 November 2021 detailing the spawning potential calculations undertaken to inform the assessment (ETG Clarification Note: Fish Spawning Potential).

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	Further information was requested on concerns raised by NRW on HDD vibration impacts under the River Clwyd and the potential for effects on migratory salmon. Confirmation made that this was a concern raised by the onshore team, and that HDD was unlikely to be an issue for migratory salmon.	
December 2021 ETG Consultation	NRW raised concerns regarding the duration of the piling period and requested clarification on this in relation to spawning periods of fish receptors.	The Applicant clarified that MDS for piling duration amounts to a total of 896 hours of piling across the whole project within a three-year construction window. It is anticipated that piling will occur in a period no greater than 12 months in a three-year window. This clarification has also been added to Table 10, and Section 6.10.1 in the assessment of noise impacts on fish and shellfish VERs.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	NRW raised queries regarding the calculation of spawning potential for sandeel and sole. Specifically, NRW queried whether both high and low intensity spawning grounds were used to inform the assessment. Additionally, NRW raised concerns regarding the use of the sandeel spawning grounds extents across the Irish Sea, and requested that the potential for a smaller total spawning area (e.g. the northern Irish Sea) is assessed and considered in view of the reversibility of the stock, and the value of the species.	The Applicant confirms that areas of high intensity spawning grounds have been included within the assessment of spawning potential for the receptors. Regarding the use of reduced sandeel spawning grounds, the Applicant confirms that in the absence of specific sub-regional spawning grounds it is not possible to undertake revised spawning potential calculations, but in the use of high intensity spawning grounds, a precautionary approach has been taken.
	NRW raised queries regarding sensitivity weightings of fish receptors in relation to the noise assessment. NRW agreed that cod and whiting, as pelagic receptors should be	The Applicant agrees with this concern. Developing eggs and larvae have been assessed as stationary receptors, for receptors with spawning grounds in the vicinity of AyM in Section 6.10.1.

DATE AND CONSULTATION PHASE/ TYPE	CONSULTATION AND KEY ISSUES RAISED	SECTION WHERE COMMENT ADDRESSED
	regarded as fleeing receptors, but stated that developing eggs and juveniles should be assessed as stationary receptors.	
	Regarding the assessment of receptor sensitivities to impacts, NRW requested that differences between 'vulnerability' and 'recoverability' are further clarified in the ES, and specifically request that the resilience of receptor populations is considered further in the ES.	Further clarification on the assessment criteria for sensitivity has been included within the ES in Section 6.5.2, specific references to the assessment of receptors sensitivities to impacts has been included in Sections 6.10 - 6.13.

6.4 Scope and methodology

6.4.1 Study area

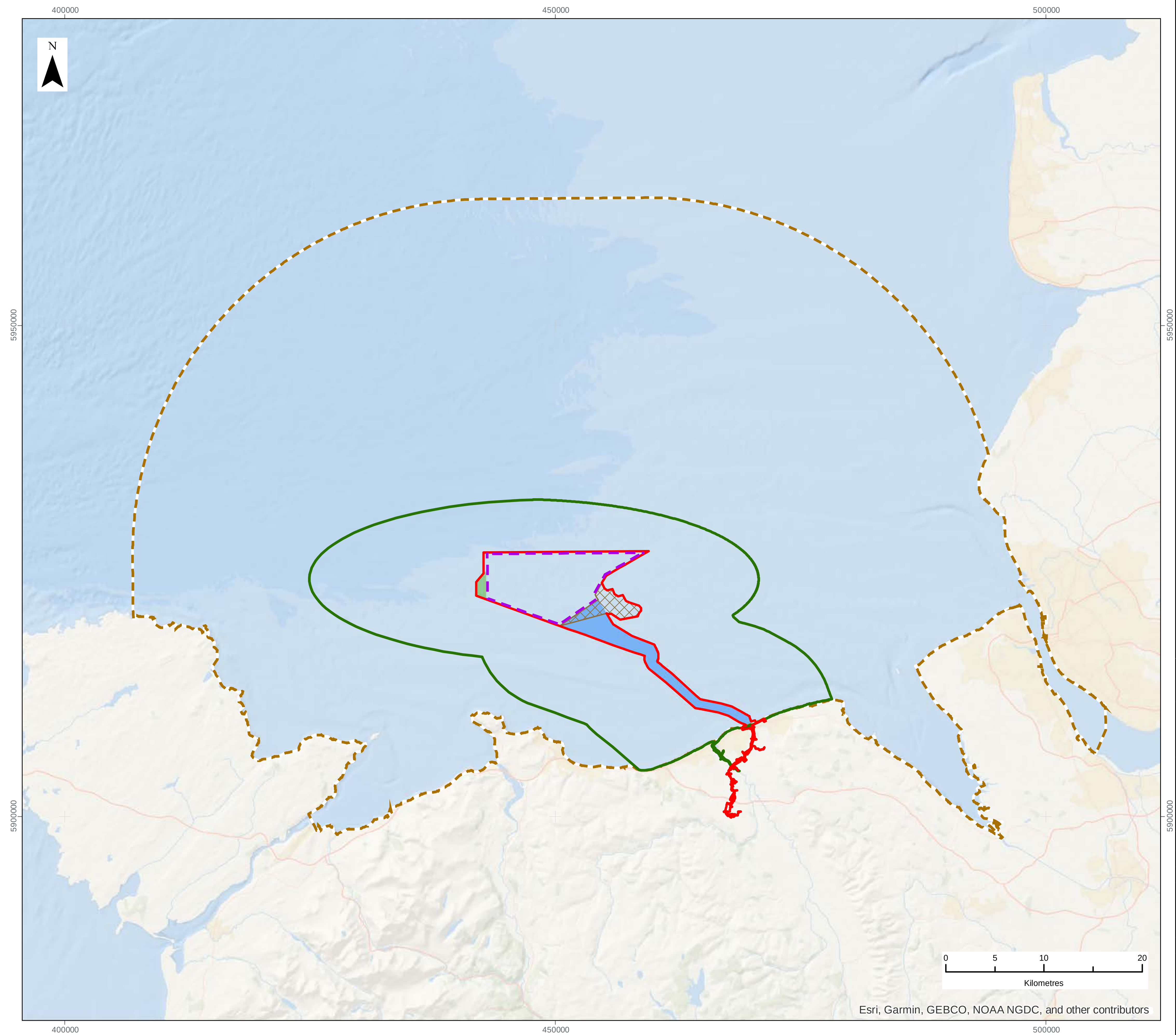
17 As fish are predominantly mobile, the study area used for characterisation of the proposed development is relatively broad, with an approximate extent between the mouth of the River Dee and the mouth of the Menai Strait, in the Irish Sea.

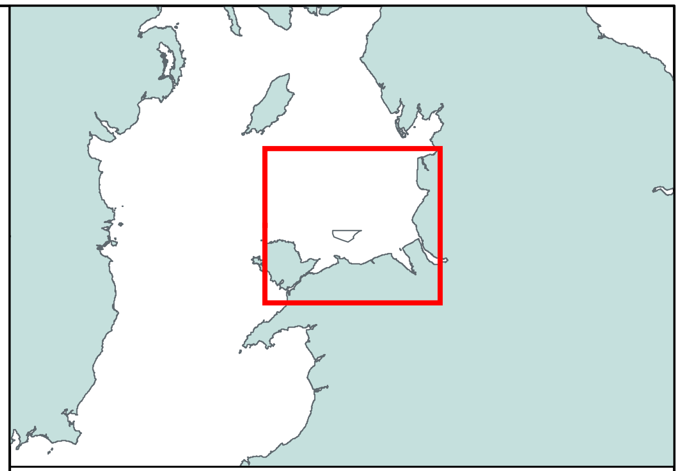
18 The fish and shellfish ecology study area is dynamic, in that it varies according to the nature of the impact being studied. The study areas have been derived according to expert judgement and include primarily (for direct impacts) the proposed wind farm array area and the more linear offshore ECC, beyond the array boundary, up to and including the intertidal zone, up to Mean High Water Springs (MHWS).

19 For those sedimentary impacts with a larger zone of influence (ZoI) that can extend to receptors beyond the direct footprint of the proposed development, for example increased Suspended Sediment Concentrations (SSCs), a wider study area has been defined based on the project specific hydrodynamic modelling undertaken (Volume 4, Annex 2.3: Physical Processes Modelling Results Report (application ref: 6.4.2.3)). The ZoI is presented in Figure 1 (Sedimentary ZoI). The ZoI for this assessment has been defined as an 8.5 km buffer around the offshore ECC which encapsulates the maximum extent of measurable plumes predicted by the modelling from activities within the ECC. An ellipse around the array (15 km study area) has been used to define the ZoI for the activities within the array, owing to the plumes generally moving in parallel relative to the coast in less disperse plumes. This ellipse encapsulates the maximum extent of measurable plumes predicted by the modelling. This study area is considered to be representative of the typical habitats found within the Irish Sea.

20 A 36 km study area for underwater noise impacts has been defined in accordance with outputs from the underwater noise modelling (Volume 4, Annex 6.2: Underwater Noise Technical Report (application ref: 6.4.6.2)).

21 Additionally, in response to consultation with the Isle of Man Department of Environment, Food and Agriculture (DEFA), a wider contextual area consisting of the northern Irish Sea has also been considered to give due regard to concerns raised in response to the Scoping Report. The extent of the wider area provides a regional context on fish and shellfish ecology but is not directly associated with a particular impact.





LEGEND

- Order Limits
- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- GyM Interlink Zone
- Sedimentary Zone of Influence
- Underwater Noise Zone of Influence

Data Source:

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

Fish and Shellfish Study Area

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	PN
2	03/03/2022	For Issue For ES	BPHB	AL

FIGURE NUMBER:

Figure 1

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:400,000	A3	WGS84	UTM30N

Fferm Wynt Alltraeth AWEL Y MÔR Offshore Wind Farm

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig1_Study_Area.mxd

6.4.3 Data sources

23 A detailed desktop review was carried out to establish the baseline of information available on fish and shellfish populations in the fish study area for AyM. Information was sought on fish and shellfish ecology in general and on spawning and nursery activity. The baseline characterisation utilises a broad combination of datasets and provides a robust temporal analysis and validation of the site-specific monitoring datasets and regional monitoring datasets. Of particular relevance to AyM is data available from Gwynt y Môr offshore wind farm (GyM). Table 5 details the data sources utilised in the baseline characterisation. Full details on the data sources and the utilisation of each data source is provided in Volume 4, Annex 6.1 (application ref 6.4.6.1).

Table 5: Data sources used for baseline characterisation.

DATA SOURCE	DATA UTILISATION
GyM baseline characterisation (CMACS, 2005a)	Used to provide information regarding the fish and shellfish ecology of the site.
Burbo Bank Extension Adult and Juvenile Fish Characterisation surveys (BMM, 2011)	
Annual FEPA Monitoring Report for North Hoyle OWF (Cefas, 2005)	
Rhyl Flats Offshore Wind Farm Beam Trawl Survey Report (CMACS, 2005b)	
British Geological Survey (BGS) Seabed Sediment datasets (Cefas, 2015)	PSA data presented to provide an indication on the location of suitable habitat and spawning grounds for sandeel and herring.
Broadscale Marine Habitat data (UKSeaMap, 2018, (published in 2019)).	Sediment data presented to provide an indication on the location of suitable habitat and

DATA SOURCE	DATA UTILISATION
	spawning grounds for sandeel and herring.
Northern Ireland Ground Fish Survey (NIGFS) (ICES, 2005-2018)	Used to inform locations of nursery grounds of sensitive receptors and to provide a temporal benchmark for analysis and validation of existing site-specific data.
North-West Groundfish Survey (Cefas, 2013)	
Fisheries Sensitivity Maps in British Waters (Coull *et al.*, 1998)	Used to provide information on likely spawning or nursery areas for commercial species.
Highly mobile fish species distributions in UK waters (Cefas, 2010)	Used to provide information on the distribution of highly mobile fish species within the region.
Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones) (Ellis *et al.*, 2010)	Provided information on fish spawning and nursery grounds.
Spawning and nursery grounds of selected fish species in UK waters. Scientific Series Technical Report (Ellis *et al.*, 2012)	
UK sea fisheries annual statistics report (MMO, 2018)	Used to provide information on commercially important fish species.
Landings statistics for the period 2012-2018 (MMO, 2018)	Used to inform the shellfish populations baseline, and to provide a temporal benchmark for analysis and validation of existing site-specific data.

DATA SOURCE	DATA UTILISATION
Agri-Food and Biosciences Institute (AFBI) Herring Acoustic Survey (2014)	Used to inform the herring population baseline.
AFBI annual scallop surveys (2019)	Used to inform the scallop population baseline.
Regional and national underwater noise monitoring campaigns and ES documents	GyM in particular for regional monitoring, and national ES chapters to identify the likely, precautionary, ZoI of construction phase underwater noise for the purposes of characterisation and study area definition
Additional data sources	
PSA data	Information from other aspects and chapters of the EIA will be cross-referred to.
Benthic habitats data from Benthic Ecology baseline characterisation	
Commercial Fisheries baseline characterisation	
International Bottom Trawl Survey (1965-2019)	These, together with additional data sources used in this report, will be used to provide a temporal benchmark for analysis and validation of existing site-specific data.
Irish Sea Annual Egg Production Method (AEPM) Plankton Survey (2000)	

24 Other studies undertaken as part of the AyM EIA have informed this chapter, specifically: Volume 2, Chapter 2: Physical Processes (application ref: 6.2.2); Volume 2, Chapter 3: Water Quality and Sediment Quality (application ref: 6.2.3); Volume 2, Chapter 4: Benthic Subtidal and Intertidal Ecology (application ref: 6.2.4); and Volume 2, Chapter 9: Commercial and Recreational Fisheries (application ref: 6.2.9).

6.5 Assessment criteria and assignment of significance

25 The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impacts. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts (see Volume 1, Chapter 3: Environmental Impact Assessment Methodology (application ref: 6.1.3)).

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

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

6.5.1 Magnitude of Impact

28 The magnitude of potential impacts is defined by a series of factors including the spatial extent of any interaction, the likelihood, duration, frequency and reversibility of a potential impact. The definitions of the levels of magnitude used in the assessment as shown in Table 6.

Table 6: Impact magnitude definitions.

MAGNITUDE	DEFINITION
High	The proposed development would result in a complete permanent change to baseline conditions and status of conservation features/ ecological functionality; or the proposed development would result in a change from baseline conditions that would affect the conservation status of the site or feature.
Medium	The feature's conservation status would not be affected, but the impact is likely to be significant in terms of

MAGNITUDE	DEFINITION
	ecological objectives or populations. If, in light of full information, it cannot be clearly demonstrated that the impact will not adversely affect the conservation objectives, then the impact should be assessed as high
Low	Minor change from the baseline but the impact is of limited temporal or physical extent.
Negligible	Discernible or barely discernible change from baseline conditions that results in a slight alteration to the key characteristics or features of a receptor.

6.5.2 Sensitivity of Receptors

29 The sensitivities of fish and shellfish receptors are defined by both their potential vulnerability to an impact from the proposed development, their recoverability, and the value or importance of the receptor. The following parameters are also taken into account:

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

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

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

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

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

- High value and importance: Internationally or nationally important (i.e., Annex II species listed as features of SACs and Section 7 species);
- Medium value and importance: Regionally important or internationally rare (i.e., MCZ/rMCZ features (species classified as features of conservation importance), or Species that are of commercial value to the fisheries which operate within the Irish Sea);
- Low value and importance: Locally important or nationally rare (i.e., species of commercial importance but do not form a key component of the fish assemblages within the AyM fish and shellfish study area); and
- Negligible value and importance: Not considered to be particularly important or rare.

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

35 The definitions of terms relating to the sensitivity of fish and shellfish ecology chapters are detailed in Table 7.

Table 7: Sensitivity of the VERs.

RECEPTOR SENSITIVITY	DESCRIPTION/ REASON
High	Nationally and internationally important receptors with high vulnerability and no ability for recovery.
Medium	Regionally important receptors with high vulnerability and no ability for recovery. Nationally and internationally important receptors with medium to high vulnerability and low to medium recoverability.
Low	Locally important receptors with medium to high vulnerability and low recoverability. Regionally important receptors with low vulnerability and medium recoverability. Nationally and internationally important receptors with low vulnerability and medium to high recoverability.
Negligible	Receptor is not vulnerable to impacts regardless of value/ importance. Locally important receptors with low vulnerability and medium to high recoverability.

6.5.3 Significance of Potential Effects

36 The matrix used for the assessment of the significance of potential effects is described in Table 8. The magnitude of the impact is correlated against the sensitivity of the receptor to provide a level of significance.

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

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

Table 8: Matrix to determine effect significance.

		SENSITIVITY			
		HIGH	MEDIUM	LOW	NEGLIGIBLE
ADVERSE MAGNITUDE	HIGH	Major	Major	Moderate	Minor
	MEDIUM	Major	Moderate	Minor	Negligible
	LOW	Moderate	Minor	Minor	Negligible
	NEGLIGIBLE	Minor	Minor	Negligible	Negligible
BENEFICIAL MAGNITUDE	NEGLIGIBLE	Minor	Minor	Negligible	Negligible
	LOW	Moderate	Minor	Minor	Negligible
	MEDIUM	Major	Moderate	Minor	Negligible
	HIGH	Major	Major	Moderate	Minor

Note: Effects of 'moderate' significance or greater are defined as significant with regard to the EIA Regulations.

6.6 Uncertainty and technical difficulties encountered

39 The description of spawning and nursery grounds is primarily based on the information presented in Ellis *et al*. (2012) and Coull *et al*. (1998) (where updates were not given in Ellis *et al*. (2012)). The limitations of these two sources of information is recognised. These publications provide an indication of the general location of spawning and nursery grounds are very broad, particularly in the context of the relatively small footprint of the AyM development. Similarly, the spawning times given in these publications represent the maximum duration of spawning on a species/stock basis. In some cases, the duration of spawning may be much more contracted, on a site-specific basis, than reported in Ellis *et al.* (2012) and Coull *et al.* (1998). Therefore, additional research publications have also been reviewed to provide site specific information.

40 Mobile species such as fish, exhibit varying spatial and temporal patterns. Site-specific surveys for GyM, North Hoyle, Rhyl Flats and Burbo Bank Extension were undertaken to provide semi-seasonal description of the fish and shellfish. These datasets represent snapshots of the fish and shellfish assemblage at the time of sampling and the fish and shellfish assemblages may vary considerably both seasonally and annually. With this in mind, the surveys conducted are considered sufficient and follow best practice.

6.7 Existing environment

6.7.1 Overview

41 A detailed characterisation of the fish and shellfish baseline environment is provided in Volume 4, Annex 6.1 (application ref: 6.4.6.1), with a summary provided here. This ES chapter should therefore be read alongside the detailed fish and shellfish characterisation annex. The baseline characterisation is informed by data collected across previous offshore wind farm projects.

42 Based on the data sources described, including surveys, a wide range of fish and shellfish species are expected to inhabit the study area, including Atlantic salmon (*Salmo salar*), Atlantic cod (*Gadus morhua*), whiting (*Merlangius merlangus*), plaice (*Pleuronectes platessa*), common sole (*Solea solea*), herring (*Clupea harengus*), mackerel (*Scomber scombrus*), lesser sandeel (*Ammodytes tobianus*), spotted ray (*Raja montagui*) and thornback ray (*Raja clavata*).

43 Otter trawls conducted as part of the North Irish Groundfish Survey (NIGFS) (ICES, 2010) across the Irish Sea, from 2005 to 2018, were dominated by whiting, haddock (*Melanogrammus aeglefinus*), small spotted catshark (*Scyliorhinus canicula*), plaice and herring. *Nephrops* (*Nephrops norvegicus*) were recorded in high abundances to the north of the site but were absent from the study area.

44 Beam trawls undertaken across the Irish Sea by Cefas in 1998 to inform the North-West Groundfish Survey (NWGFS) were dominated in plaice, sole, edible crab (*Cancer pagurus*), whiting, dab (*Limanda limanda*), common dragonet (*Callionymus lyra*), and pogge (*Agonus cataphractus*).

45 The characterising species recorded within site specific surveys for a number of local offshore wind farm projects (GyM, Burbo Bank Extension, North Hoyle, Rhyl Flats and Celtic Array) showed good agreement with the main species recorded within the more recent regional surveys, suggesting that monitoring data from GyM remains relevant for characterisation of the AyM site.

46 Data derived from Lockwood (2005) shows two distinct shellfish resources within the Irish Sea; a large scallop ground (*Pecten maximus, Aequipecten opercularis*) is located across the whole eastern Irish Sea, and a *Nephrops* resource is located to the north of Liverpool Bay, between the Isle of Man and the Cumbria coast. Shellfish abundances inshore appear to be dominated by cockles (*Cerastoderma edule*), brown crab (*Cancer pagurus*), lobsters (*Homarus Gammarus*), mussels (*Mytilus edulis*), shrimp (*Crangon crangon*) and whelk (*Buccinum caudatum*).

47 Current trends in the Irish Sea show a decrease in the biomass of queen scallop and king scallop, however recovery of king scallop stocks was observed in areas closed to commercial fishing (ICES, 2019).

48 Several species of fish and shellfish are known to either spawn or have nursery areas in relatively close proximity to, or potentially overlapping with the AyM study area (Coull *et al.,* 1998; Ellis *et al*., 2010). These spawning and nursery sites identified within and in proximity to AyM are presented in Figure 2 to Figure 6 below.

49 A number of species with 'high intensity' spawning overlap the AyM study area, including sandeel (Figure 6), plaice, sole and cod (Figure 2). Species with low intensity spawning grounds that cross the study area (as well as widely around the UK) include cod, sandeel, whiting, plaice, ling (*Molva molva*), mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*), hake (*Merluccius bilinearis*) and *Nephrops*. Following consultation with NRW, further consideration has been given to the high intensity herring spawning ground off the east coast of the Isle of Man (Coull *et al*, 1998).

50 Herring and sandeel are of particular relevance when considering impacts to spawning areas as they are demersal spawners and are inherently more sensitive to changes to seabed habitats. Site-specific PSA data have been collected for AyM, alongside data from GyM and broadscale sedimentary data to identify areas of potential spawning suitability for sandeel and herring (based on each species' preferred habitat types) (Figure 5 and Figure 6).

51 The Irish Sea provides important nursery ground habitat for a variety of fish species. For fish nursery grounds, the only species with 'high intensity' nursery grounds in the study area are spurdog (*Squalus spp.*), herring, cod, whiting and sole (Coull *et al*, 1998; Ellis *et al*, 2010). However, the high intensity nursery area for spurdog is primarily in the northern Irish Sea and extends across from the Solway Firth to the Irish coast outside of the primary study area.

52 The cod nursery grounds extend across the whole eastern Irish Sea and in a broader context along most of the North Sea coast. High intensity herring nursery grounds extend around the entire northern UK, and the North Sea coast.

53 Species with low intensity nursery areas that cross the study area (as well as widely around the UK) comprise of tope (*Galeorhinus galeus*), thornback ray, spotted ray, sandeel, mackerel, anglerfish (*Lophius piscatorius*) and plaice.

6.7.2 Species of Conservation Importance

54 Several species of conservation importance have been recorded within the region, with the legislation under which each species is designated varying.

55 Those species which are designated under the Habitats Regulations (among other legislation) are:

- Atlantic salmon;
- European eel (*Anguilla anguilla*);
- Allis shad (*Alosa alosa*);
- Twaite shad (*Alosa fallax*);
- River lamprey (*Lampetra fluviailis*); and
- Sea lamprey (Peteromyzon marinus).

56 Other species not protected under the Habitats Regulations are also present, with the following species designated under the Environment (Wales) Act 2016:

- Sea trout (*Salmo trutta*);
- Smelt (Osmerus eperlanus);
- Basking shark (*Cetorhinus maximus*); and
- Angel shark (Squatina squatina).

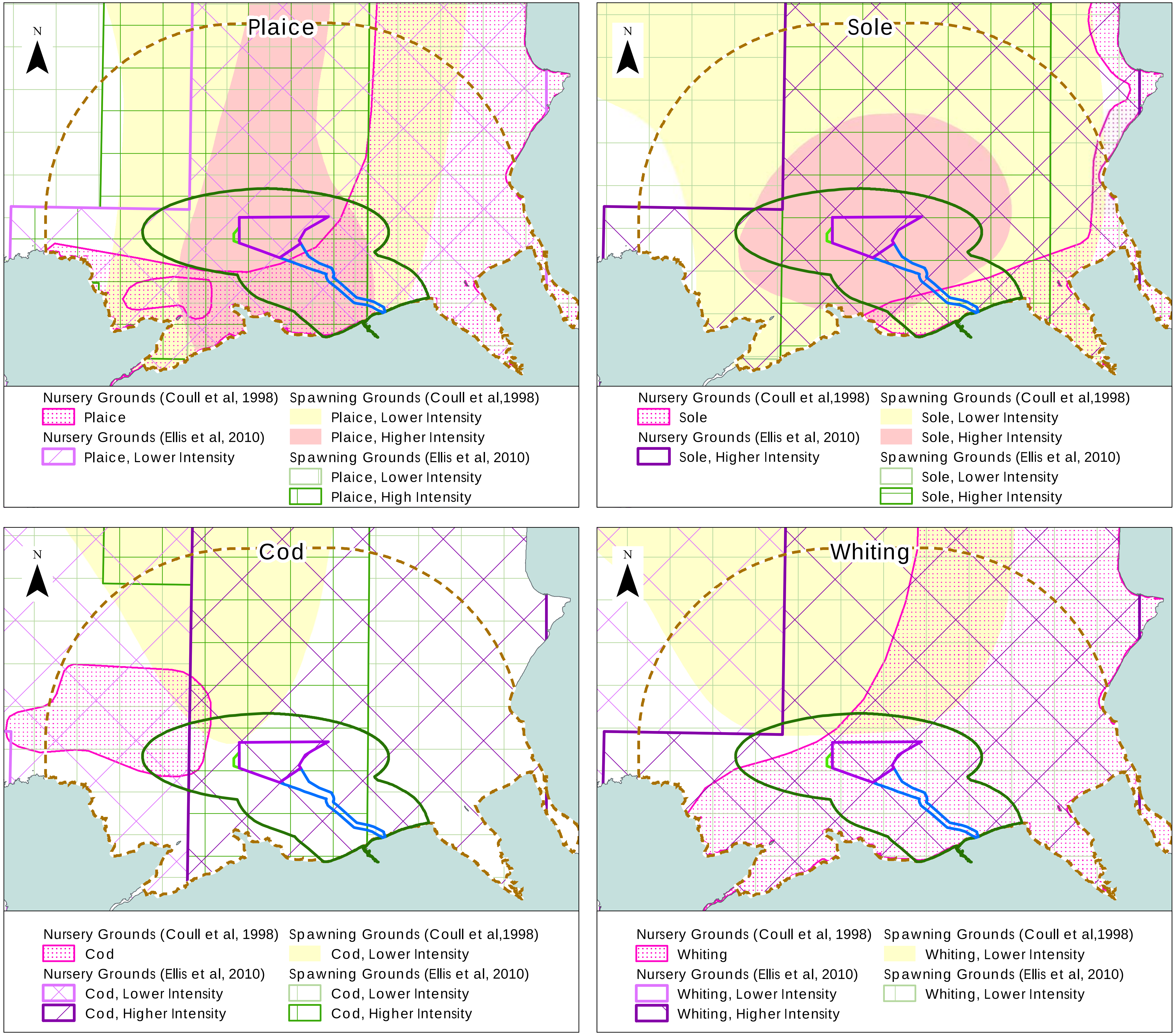
57 A number of the above species are features within designated sites. The relevant designated sites for the purposes of the ES are presented in Figure 7.

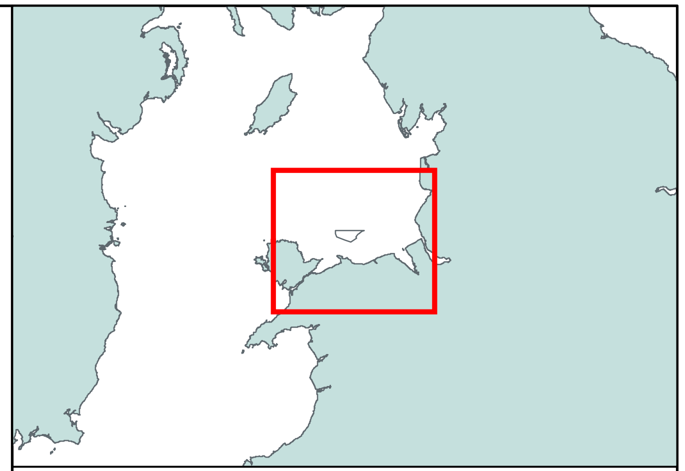
58 Following discussions with NRW, a number of additional designated sites within 100 km of AyM have also been considered within the Report to Inform Appropriate Assessment (RIAA) (Report 5.2: Report to Inform Appropriate Assessment), however, due to the distance to these sites, it is considered that there is not a potential pathway of effect to these sites for EIA purposes.

59 To summarise, Table 9 below details the Valued Ecological Receptors (VERs) identified within Volume 4, Annex 6.1(application ref: 6.4.6.1) to be brought forward into the assessment.

Table 9: Fish and Shellfish VERs.

VER GROUP	VERS
Demersal Fish	Cod, plaice, common sole, whiting, dab, thickback sole (*Microchirus variegatus*), flounder (*Platichthys flesus*), solenette (*Buglossidium luteum*), scaldfish (*Arnoglossus laterna*), common dragonet, anglerfish, pogge, sand goby (*Pomatoschistus minutus*) and poor cod (*Trisopterus minutus*).
Conservation Species	Atlantic salmon, sea trout, Allis shad, Twaite shad, river lamprey, sea lamprey, smelt and European eel.
Pelagic Fish	Sprat (*Sprattus sprattus*), mackerel, herring, hake, horse mackerel and haddock.
Benthopelagic Fish	Sandeel.
Shellfish	King scallop, queen scallop, common whelk, Nephrops, edible crab and common lobster
Elasmobranch	Spurdog, thornback ray, spotted ray, small spotted catshark, cuckoo ray (*Leucoraja naevus*), nursehound (*Scyliorhinus stellaris*), blonde ray (*Raja brachyura*), smoothhound (*Mustelus mustelus*) and basking shark.





LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Sedimentary Zone of Influence
- Underwater Noise Zone of Influence

0 10 20 40
Kilometres

Data Source:
Spawning and Nursery Grounds data from Centre for Environment, Fisheries and Aquaculture Science (Cefas)

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

Fish and shellfish spawning grounds

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	RM
2	24/01/2022	For Issue For ES	BPHB	AL

FIGURE NUMBER:

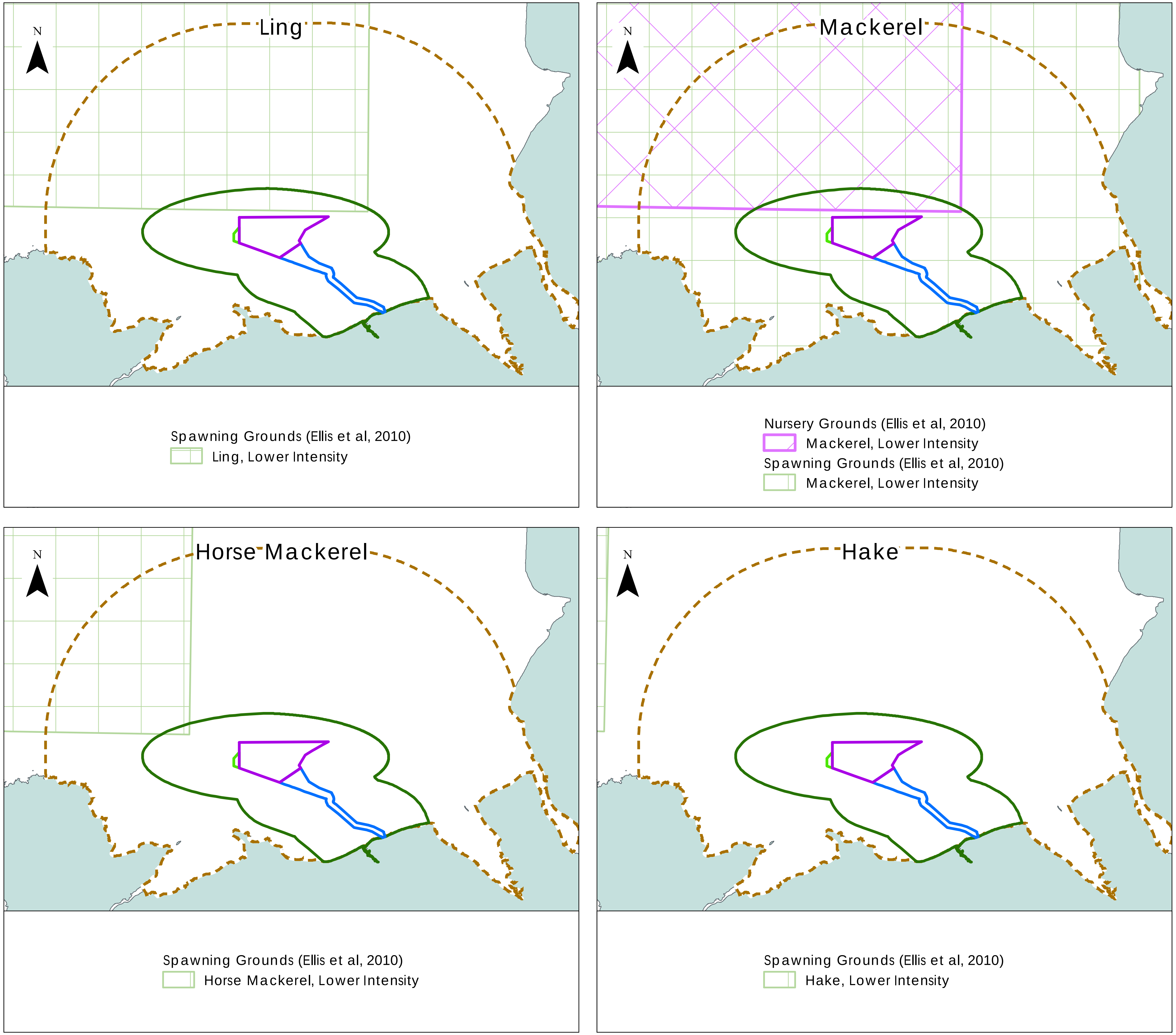
Figure 2

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:750,000	A3	WGS84	UTM30N

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

Service Layer Credits:

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig2_Spawning_Grounds_1.mxd



LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Sedimentary Zone of Influence
- Underwater Noise Zone of Influence

0 10 20 40
Kilometres

Data Source:
Spawning and Nursery Grounds data from Centre for Environment, Fisheries and Aquaculture Science (Cefas)

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

Fish and shellfish spawning grounds

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	RM
2	24/01/2022	For Issue For ES	BPHB	AL

FIGURE NUMBER:

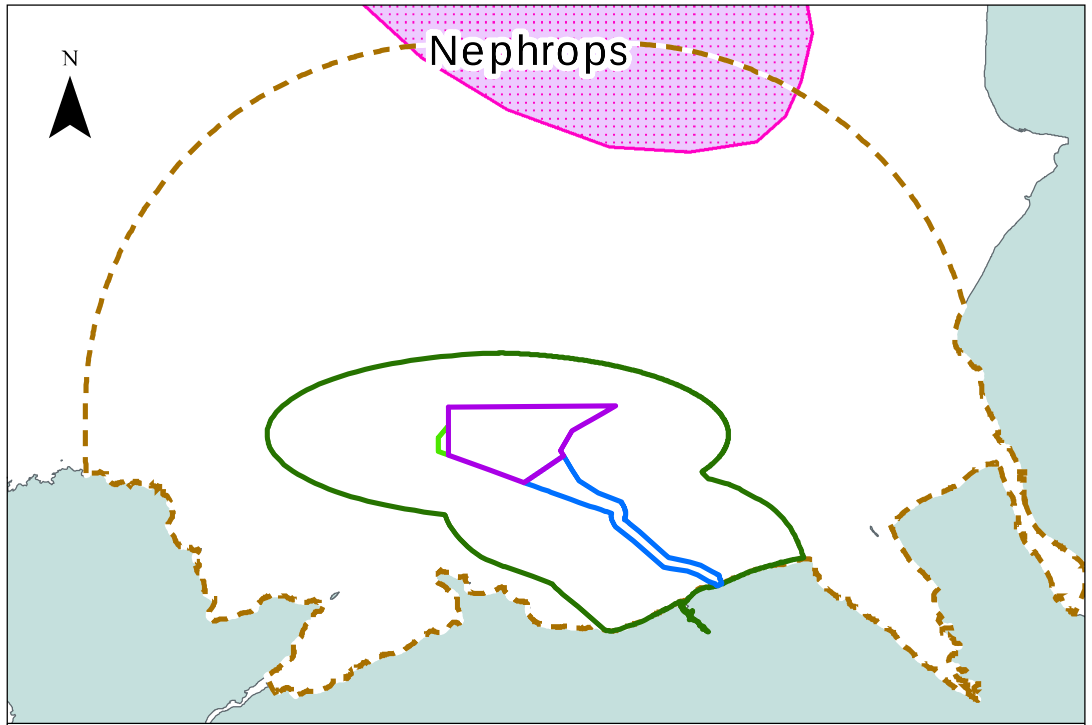
Figure 3

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:750,000	A3	WGS84	UTM30N

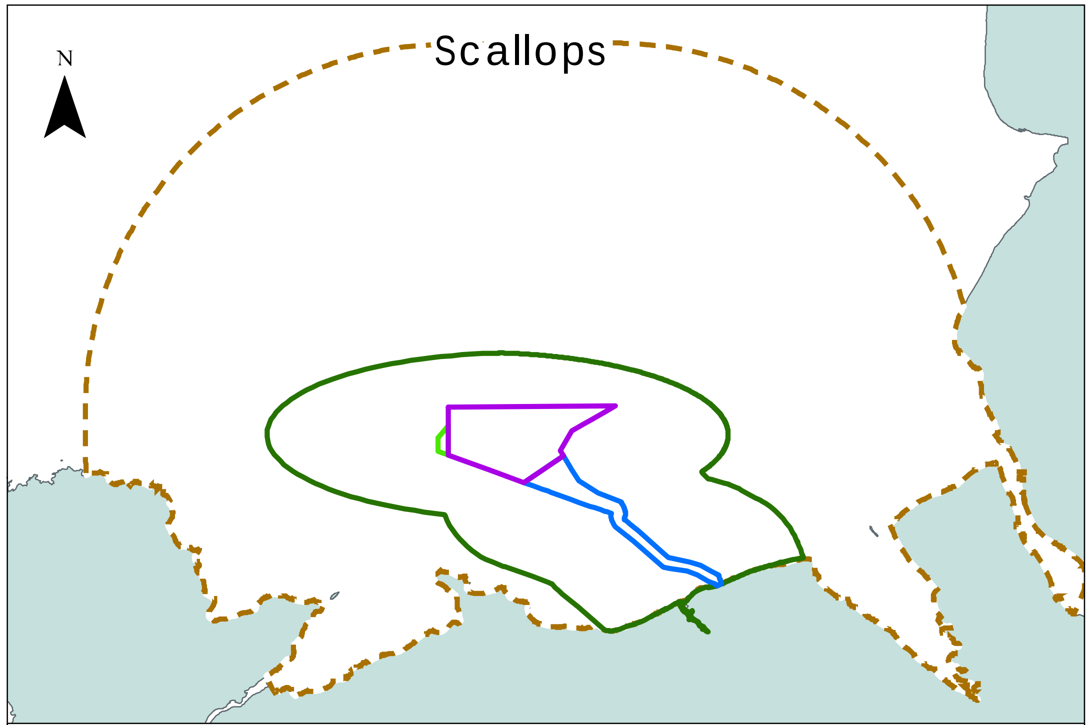
Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

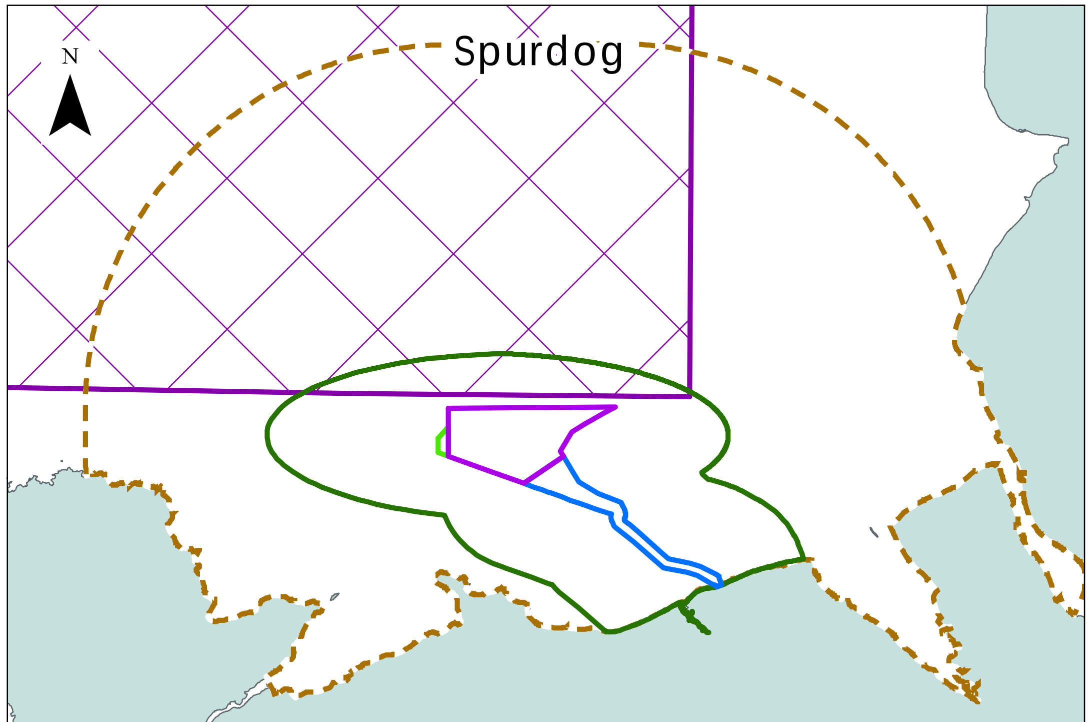
Service Layer Credits:

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig3_Spawning_Grounds_2.mxd

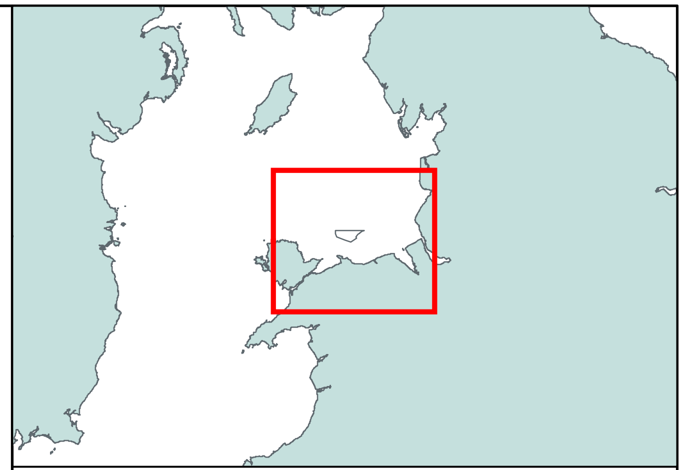


Nursery Grounds (Coull et al, 1998)
Nephrops
Spawning Grounds (Coull et al,1998)
Nephrops, Undetermined





Nursery Grounds (Ellis et al, 2010)
Spurdog, Higher Intensity



LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Sedimentary Zone of Influence
- Underwater Noise Zone of Influence

0 10 20 40
Kilometres

Data Source:
Spawning and Nursery Grounds data from Centre for Environment, Fisheries and Aquaculture Science (Cefas)

PROJECT TITLE:
AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:
Fish and shellfish spawning grounds

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	RM
2	24/01/2022	For Issue For ES	BPHB	AL

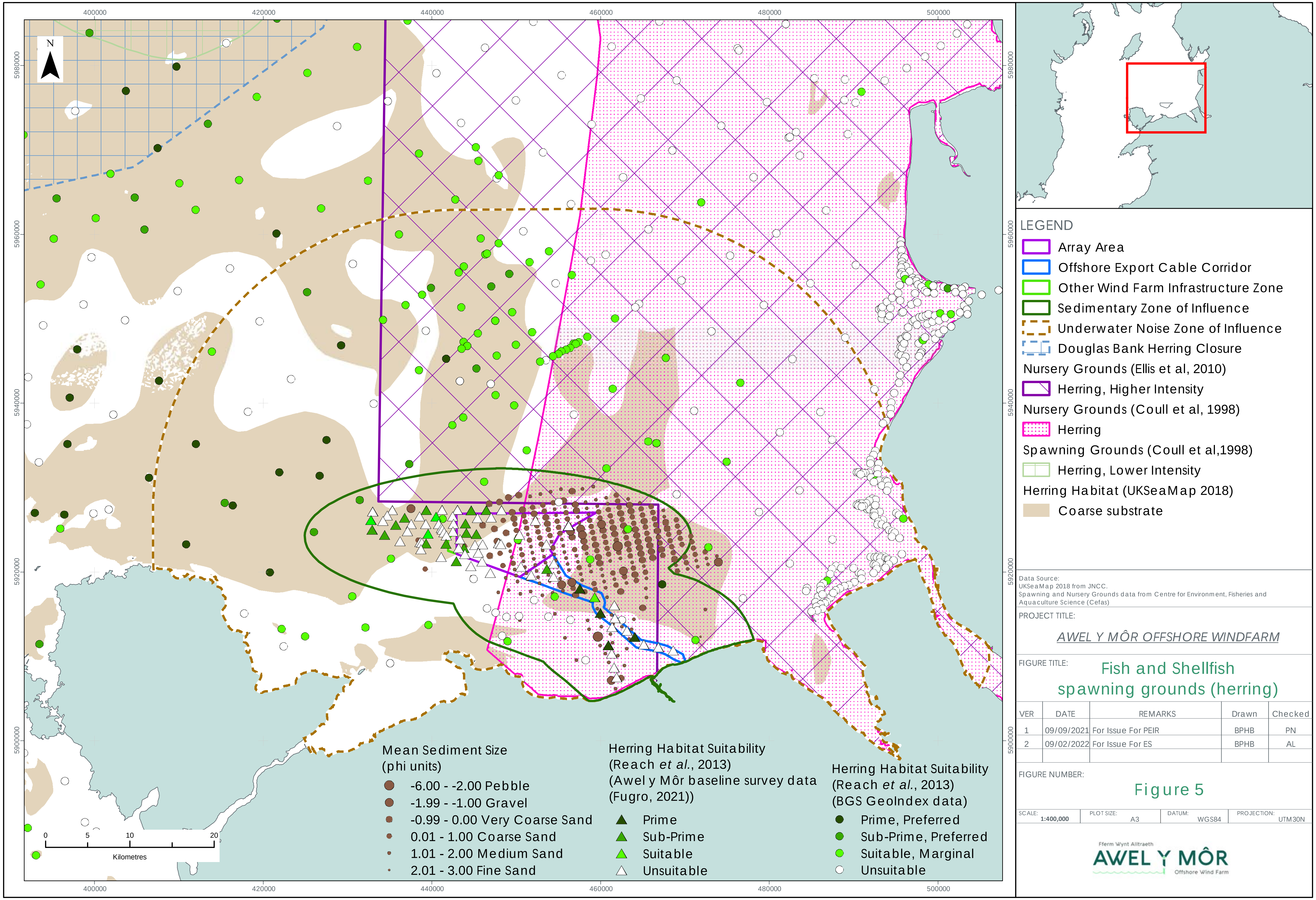
FIGURE NUMBER:
Figure 4

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:750,000	A3	WGS84	UTM30N

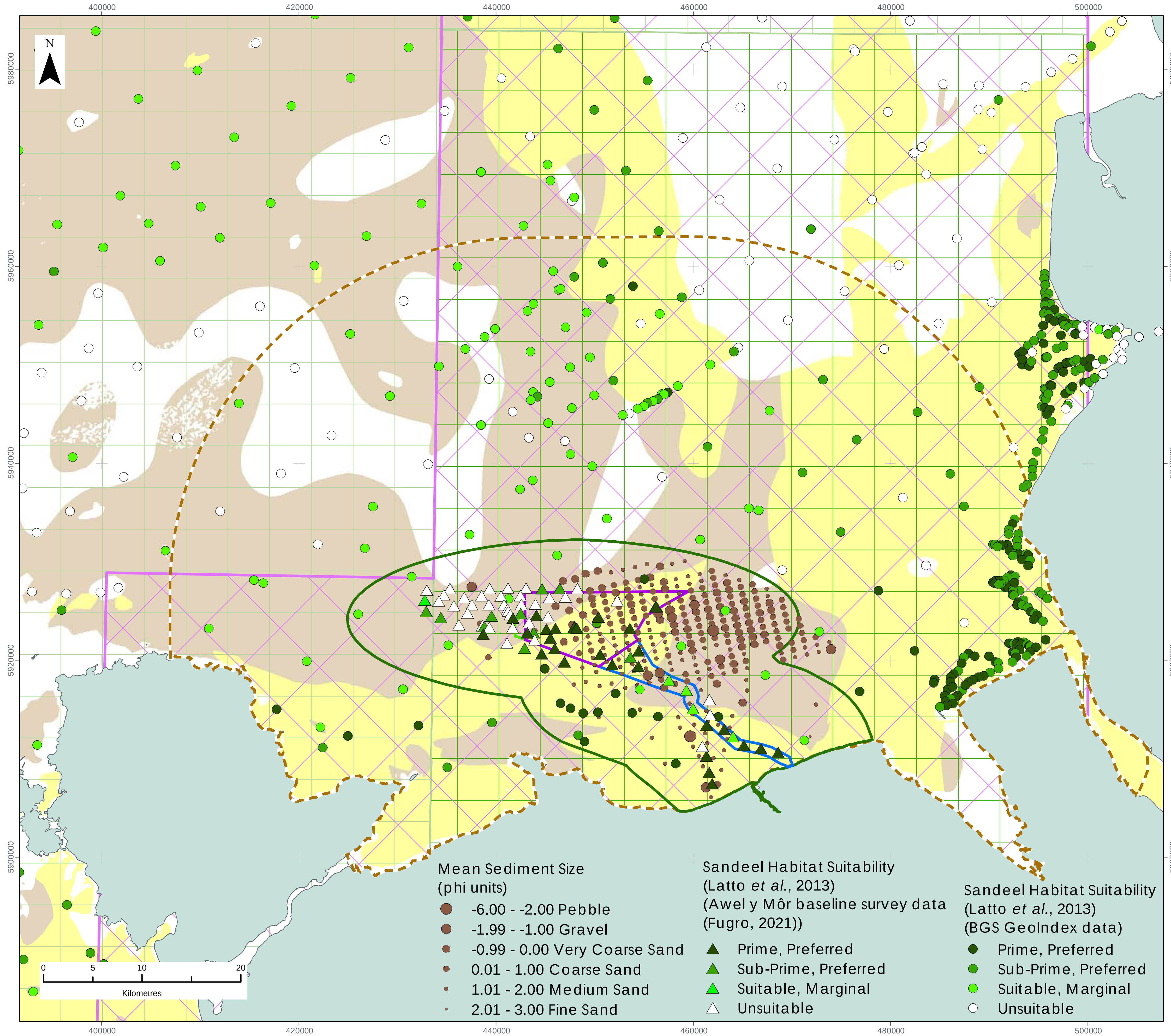
Fferm Wynt Alltraeth AWEL Y MÔR Offshore Wind Farm

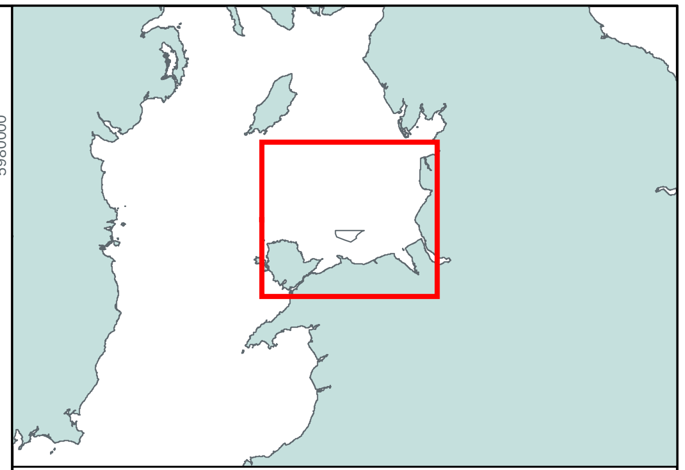
Service Layer Credits:

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig4_Spawning_Grounds_3.mxd



N
0 5 10 20
Kilometres
Mean Sediment Size
(phi units)
-6.00 - -2.00 Pebble
-1.99 - -1.00 Gravel
-0.99 - 0.00 Very Coarse Sand
0.01 - 1.00 Coarse Sand
1.01 - 2.00 Medium Sand
2.01 - 3.00 Fine Sand
Herring Habitat Suitability
(Reach et al., 2013)
(Awel y Môr baseline survey data
(Fugro, 2021))
Prime
Sub-Prime
Suitable
Unsuitable
Herring Habitat Suitability
(Reach et al., 2013)
(BGS GeoIndex data)
Prime, Preferred
Sub-Prime, Preferred
Suitable, Marginal
Unsuitable
LEGEND
Array Area
Offshore Export Cable Corridor
Other Wind Farm Infrastructure Zone
Sedimentary Zone of Influence
Underwater Noise Zone of Influence
Douglas Bank Herring Closure
Nursery Grounds (Ellis et al, 2010)
Herring, Higher Intensity
Nursery Grounds (Coull et al, 1998)
Herring
Spawning Grounds (Coull et al,1998)
Herring, Lower Intensity
Herring Habitat (UKSeaMap 2018)
Coarse substrate
Data Source:
UKSeaMap 2018 from JNCC.
Spawning and Nursery Grounds data from Centre for Environment, Fisheries and Aquaculture Science (Cefas)
PROJECT TITLE:
AWEL Y MÔR OFFSHORE WINDFARM
FIGURE TITLE:
Fish and Shellfish spawning grounds (herring)
VER | DATE | REMARKS | Drawn | Checked
1 | 09/09/2021 | For Issue For PEIR | BPHB | PN
2 | 09/02/2022 | For Issue For ES | BPHB | AL
FIGURE NUMBER:
Figure 5
SCALE: 1:400,000
PLOT SIZE: A3
DATUM: WGS84
PROJECTION: UTM30N





LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Sedimentary Zone of Influence
- Underwater Noise Zone of Influence

Nursery Grounds (Ellis et al, 2010)

- Sandeel, Lower Intensity

Spawning Grounds (Ellis et al, 2010)

- Sandeel, Lower Intensity
- Sandeel, Higher Intensity

Sandeel Habitat (UKSeaMap 2018)

- Coarse substrate
- Sand

Data Source:
UKSeaMap 2018 from JNCC.
Spawning and Nursery Grounds data from Centre for Environment, Fisheries and Aquaculture Science (Cefas)

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

Fish and Shellfish spawning grounds (sandeel)

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	PN
2	09/02/2022	For Issue For ES	BPHB	AL

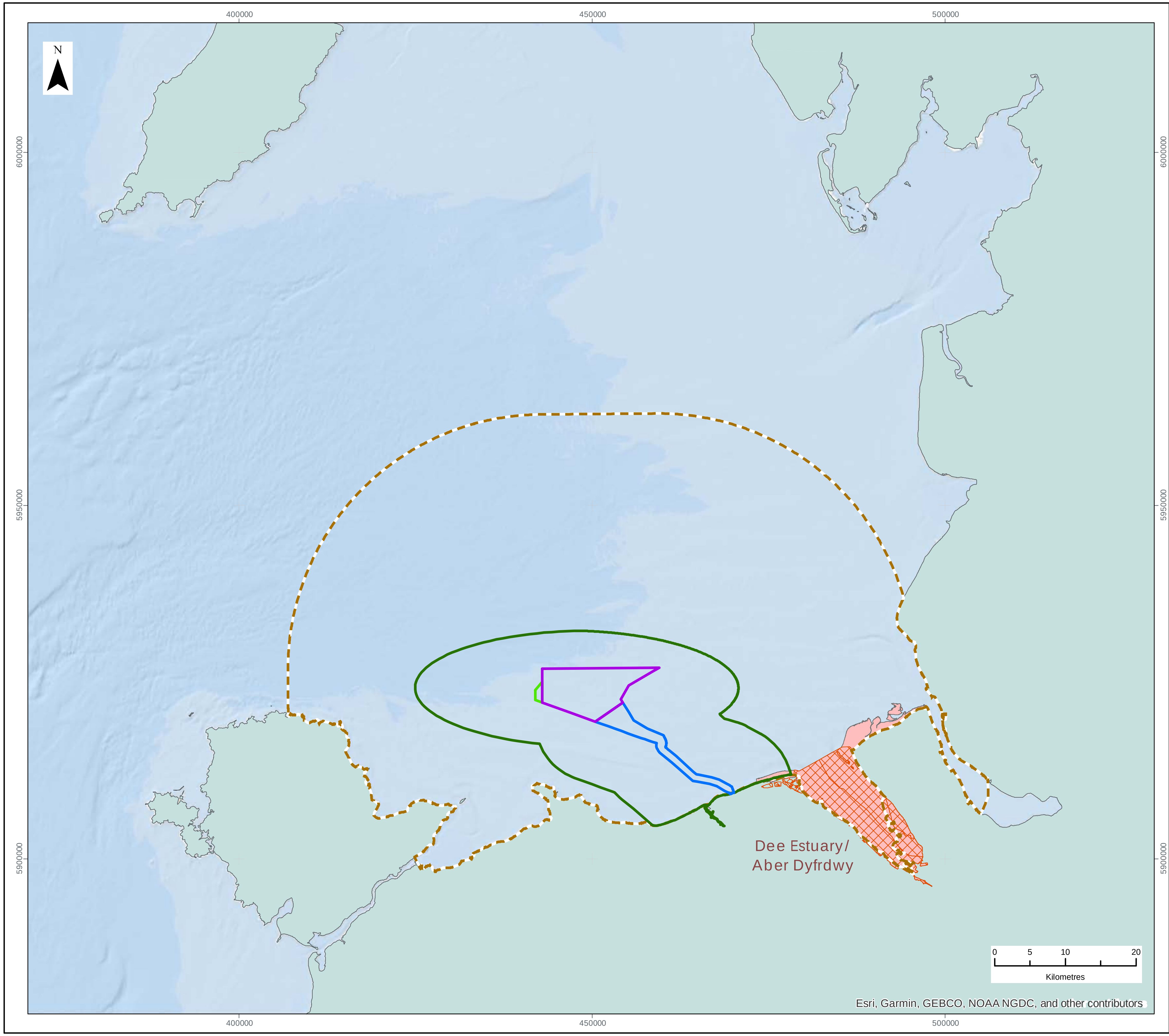
FIGURE NUMBER:

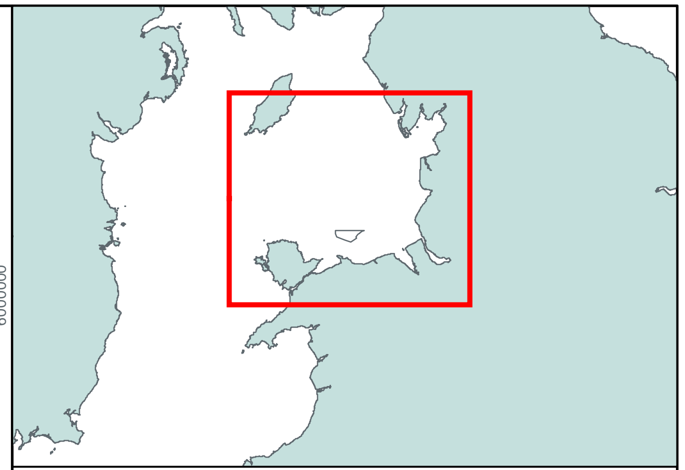
Figure 6

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:400,000	A3	WGS84	UTM30N

Fferm Wynt Alltraeth AWEL Y MÔR Offshore Wind Farm

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig6_Spawning_Grounds_Sandeel.mxd





LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Sedimentary Zone of Influence
- Underwater Noise Zone of Influence
- Special Area of Conservation
- Sites of Special Scientific Interest

Data Source:
SACs from JNCC, MCZs form Natural England
SSSIs from Natural England and NRW

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

Designated sites of relevance to fish & shellfish ecology

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	PN
2	24/01/2022	For Issue For ES	BPHB	AL

FIGURE NUMBER:

Figure 7

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:550,000	A3	WGS84	UTM30N

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig7_Designated_Sites.mxd

6.7.3 Evolution of the baseline

60 The current baseline description provides an accurate reflection of the current state of the existing environment. The indicative date for the start of construction is 2026, with an expected operational life of 25 years beginning by 2030, and therefore there exists the potential for the baseline to evolve between the time of assessment and point of impact. Outside of short-term or seasonal fluctuations, changes to the baseline in relation to fish and shellfish ecology usually occur over an extended period of time. Based on current information regarding reasonably foreseeable events over the next four years, the baseline is not anticipated to have fundamentally changed from its current state at the point in time when impacts occur. The baseline environment for operational/ decommissioning impacts is expected to evolve as described in the next section, with the additional consideration that any changes during the construction phase will have altered the baseline environment to a degree as set out in this chapter.

61 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 require that "an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge" is included within the ES (EIA Regulations, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of AyM (operational lifetime is anticipated to be 25 years), long-term trends mean that the condition of the baseline environment is expected to evolve. This section provides a qualitative description of the evolution of the baseline environment, on the assumption that AyM is not constructed, using available information and scientific knowledge of fish and shellfish ecology.

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

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

64 Climate change may influence fish distribution and abundance, affecting growth rates, recruitment, behaviour, survival and response to changes of other trophic levels. Within the Irish Sea, increased sea surface temperatures may lead to an increase in the relative abundance of species associated with more southerly areas. For example, data on herring and sardine *Sardina sp*. landings at ports in the English Channel showed that higher herring landings were correlated with colder winters, while warm winters were associated with large catches of sardine (Alheit and Hagen 1997).

65 One potential effect of increased sea surface temperatures is that some fish species will extend their distribution into deeper, colder waters. In these cases, however, habitat requirements are likely to become important, with some shallow water species having specific habitat requirements in shallow water areas which are not available in these deeper areas. For example, sandeel is less likely to be able to adapt to increasing temperatures as a result of its specific habitat requirements for coarse sandy sediment; declining recruitment in sandeel in parts of the UK has been correlated with increasing temperature (Heath *et al.,* 2012). Climate change may also affect key life history stages of fish and shellfish species, including the timing of spawning migrations (BEIS, 2016). However, climate change effects on marine fish populations are difficult to predict and the evidence is not easy to interpret and therefore it is difficult to make accurate estimations of the future baseline scenario for the entire lifetime of the AyM project (25 years).

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

67 There are indications that overfishing in UK waters is reducing to some degree. The recent International Council for the Exploration of the Sea (ICES) Celtic Seas Ecosystem Overview reported declines in fishing mortality estimates in recent years for shellfish, demersal and pelagic stock groups, with mean fishing mortality levels close to levels that produce maximum sustainable yield (ICES), 2021a). Should these improvements continue, this may not result in significant changes in the species assemblage in the Irish Sea fish and shellfish study area, although may result in increased abundances of the characterising species present in the area.

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

69 The AyM fish and shellfish baseline characterisation described in the preceding sections (and presented in detail in Volume 4, Annex 6.1 (application ref: 6.4.6.1)) represents a 'snapshot' of the fish and shellfish assemblages of the Irish Sea, within a gradual and continuously changing environment. Any changes that may occur during the lifetime of the project (i.e., construction, operation and decommissioning) should be considered in the context of the natural variability and other existing anthropogenic effects, including climate change and overfishing.

6.8 Key parameters for assessment

70 This section describes the MDS parameters on which the benthic and intertidal ecology assessment has been based. These are the parameters which are judged to give rise to the maximum levels of effect for the assessment undertaken, as set out in Volume 2, Chapter 1(application ref: 6.2.1). Should AyM be constructed to different parameters within the design envelope, then impacts would not be any greater than those set out in this ES using the MDS presented in Table 9

Table 10: Maximum Design Scenario.

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
CONSTRUCTION		
Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration	Spatial MDS - The concurrent piling of two pin piles at the same WTG location; - 50 WTGs on piled jacket foundations (four 3.5m diameter pin piles per jacket) – 200 pin piles; - Two OSP foundations (12 3.5 m diameter pins piles per jacket) – 24 pin piles; - Total of 224 pin piles; - Maximum hammer energy of 3,000kJ; - 4 hours piling duration per pile; - Eight pin piles installed per day; - Two piling vessels; and - 896 hours of piling, over 14 days Temporal MDS	For the array area, the spatial MDS results from the concurrent piling of pin piles for 50 WTGs, and two OSPs using 3,000 kJ hammer energy. This would result in the largest spatial noise impact at any given time. The temporal MDS for the array area would be associated with the installation of the maximum number of piles; the MDS would be the installation of 50 WTGs using piled jacket (WTG-type) foundations, and two OSPs on piled jackets (a total of 224 pin piles). Total of 896 hours of piling across the whole project within a three-year construction window (it is anticipated that piling will occur

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
	- 50 WTGs on piled jacket foundations (four 3.5m diameter pin piles per jacket) – 200 pin piles; - Two OSP foundations (12 3.5m diameter pins piles per jacket) – 24 pin piles; - Total of 224 pin piles - 4 hours piling duration per pile; - Maximum hammer energy of 3,000kJ; - Three pin piles installed per day; and - 896 hours of piling, over 74 days (single vessel). Monopile Foundations Piling Scenario - 34 monopile WTG foundations (15m diameter); - Two OSP monopile foundations (15m diameter); - 1 met mast monopile foundation (5m diameter); - Maximum hammer energy of 5,000kJ (3,000 kJ for the met mast); - 4.5 hour piling duration per pile; - 1 day per monopile;	in a period no greater than 12 months in a three-year window). It should be noted however, that whilst the spatial and temporal MDS are represented by the installation of pin piles, monopile foundations are still being considered by the project. As such, a scenario whereby monopile foundations are used has also been included within this table. The assessment within this chapter will only make reference to the spatial and temporal MDS, as the installation of monopile foundations do not represent a worst-case scenario in regard to fish and shellfish receptors.

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
	- 37 piling days (single vessel); and - 17 piling days (two vessels). HDD cofferdam sheet piling - Installation of sheet piles using percussive piling; - Maximum hammer energy of 300 kJ; and - In the shallow subtidal up to 1,000 m seaward of MHWS. UXO clearance: - Estimated 370 targets of which 52 may require investigation; - 10 UXO may require clearance (detonation or other method); - Up to 2 clearance events every 24 hours; and - Up to 10 detonations in 10 days	
Temporary increase in SSC and	Foundation seabed preparation:	The MDS for foundation installation results from the largest volume

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
sediment deposition Direct and indirect seabed disturbances leading to the release of sediment contaminants	- 50 WTGs x 2,500 m2 x small multi-leg gravity base structure (GBS) seabed preparation area x 4 m (depth) = 500,000 m3 - 2 x 21,600 m^2 GBS OSP jacket seabed preparation area x 4 m (depth) = 86,400 m^3 - Total volume from seabed prep = 500,000 m^3 + 86,400 m^3 = 586,400 m^3 Drill arisings from foundation installation: - 50 WTGS x 9,005 m^3 (drill arisings per small monopile) x up to 60% of locations may require drilling = 270,161 m^3 - 2 OSPs x 12,064 m^3 (drill arisings per OSP) = 24,127 m^3 - Total volume from drill arisings = 270,161 m^3 + 24,127 m^3 = 294,288 m^3 Seabed preparation for export cable installation: - Maximum volume of sediment disturbed from sandwave clearance in the offshore ECC: 6,281,000 m^3 Seabed preparation for inter-array cable installation:	suspended from seabed preparation and presents the worst-case for WTG installation. For cable installation, the MDS results from the greatest volume from sandwave clearance and installation. This also assumes the largest number of cables and the greatest burial depth.

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
	- Maximum volume of sediment disturbed from sandwave clearance in the array = 7,600,000 m^3; and - Material to be disposed of anywhere within the array area or within a nominated disposal area in close proximity. Inter-array cable installation: - Total length: 116 km; - Width: 18 m; - Depth: 4 m; and - Volume of disturbed during inter-array cable installation: 116 km x 18 m x 4 m x 0.5 (V-shaped trench) x 50% (material ejected from trench) = 2,089,854 m^3. Export cable installation: - Installation method: MFE; - Number of cables: 2; - Total length: 79.4 km in total; - Width: 18 m;	

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
	- Depth: 4 m; and - Volume: V-shaped trench x 50% material ejected from trench = 1,729,560 m^3. Horizontal directional drilling (HDD) exit pit excavation: - HDD pits will be between MHWS and 1,000 m seaward of MHWS; - Stage 1: Up to 3 HDD exit pits (10 m width x 75 m length x 2.5 m depth) excavated via backhoe dredger (or similar) with material side-cast for backfill. Note that three HDD pits have been included for contingency. Following duct installation, the pit may be secured by temporary rock bags or similar for up to 1.5 years; - Stage 2: Prior to cable installation, MFE will be used to remove loose sediment within the exit pits. Following cable installation, the HDD exit pits will be refilled using a backhoe dredger (or similar) with the previously side case material; - Maximum volume: 3 HDD exit pits x 10 m width x 75 length x 2.5 m depth x 2 (stages) = 11,250 m^3; and	

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
	- Release of a total of 18,117 m^3 of drill cuttings and drilling mud (bentonite) from three HDD ducts. Total volume of disturbed sediment for construction activities = **18,610,469 m^3**	
Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish arising from construction activities	Temporary habitat disturbance from jack-up vessels and anchor footprints: - 312 jack-up operations, with a maximum disturbance of 1,100 m^2 per operation would result = 0.343.2 km^2 in total. - Indicative impacted footprint for deployment of all anchors used during WTG, Offshore Substation Platform (OSP), met mast, topside and export cable installation = 0.464.4 km^2. - Temporary habitat disturbance from seabed preparation for inter-array cable installation: - 100% of the route may require boulder clearance; - Maximum area of seabed affected by sandwave clearance = 5.6 km^2; and	The temporary disturbance relates to seabed preparation for foundations and cables, jack up and anchoring operations, and cable installation. The footprint of infrastructure is assessed as a temporary impact in construction, and as a permanent impact in operation and maintenance (O&M). The MDS presents a precautionary approach to temporary habitat disturbance because it counts both the total footprint of seabed clearance as well as cable burial across both the array and offshore ECC areas. This approach

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
	- Material to be disposed of anywhere within the array area or within a nominated disposal area in close proximity. - Temporary habitat disturbance from inter-array cable installation using Mass Flow Excavation (MFE) = 2.09 km^2. - Temporary habitat disturbance from export array cable installation using MFE = 1.43 km^2. Temporary habitat disturbance from horizontal directional drilling (HDD) exit pit excavation within the intertidal: - HDD pits will be in either the intertidal or up to 1 km seaward of MHWS; - Stage 1: Up to 3 HDD exit pits (10 m width x 75 m length x 2.5 m depth) excavated via backhoe dredger (or similar) with material sidecast for backfill. Following duct installation the pit may be secured by temporary rock bags or similar for up to 1.5 years;	effectively counts the footprint of seabed habitat to be impacted by construction in the same area twice. However, this precautionary approach has been taken because there is some potential for recovery of habitats between the activities due to project timescales.

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
	- Stage 2: Following cable installation the HDD exit pits will be refilled using a backhoe dredger (or similar) with the previously side case material; and Total area = 2,250 m^2.	
Impacts on fishing pressure due to displacement	See commercial fisheries maximum design scenario presented in Volume 2, Chapter 8 (application ref: 6.2.8).	The scenarios presented in commercial fisheries provide for the greatest change in fishing pressure due to displacement from the construction area and therefore the greatest knock-on effect to fish and shellfish ecology.
OPERATION		
Long-term loss of habitat due to the presence of turbine foundations, scour protection and cable protection	WTGs: Turbine footprint with scour protection (based on 50 GBS foundations) = 570,209 m^2 OSPs:	The MDS is defined by the maximum area of seabed lost as a result of the placement of structures, scour protection, cable protection and cable crossings. The MDS also considers that scour

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
Increased hard substrate and structural complexity as a result of the introduction of turbine foundations, scour protection and cable protection	OSP footprint with scour protection (two monopile foundations) = 21,600 m^2 Met mast: Met mast footprint with scour protection = 855 m^2 Export cables: Maximum rock protection area for non-buried cables = 242,853 m^2 Cable crossings = 39,500 m^2 Inter-array cables: Maximum rock protection area for non-buried cables = 192,124 m^2 Total area of long-term habitat loss: 1.067 km^2.	protection is required for all foundations (including the met mast). Habitat loss from drilling and drill arisings is of a smaller magnitude than presence of project infrastructure.
Impacts on fishing pressure due to displacement	See commercial fisheries maximum design scenario presented in Volume 2, Chapter 8 (application ref: 6.2.8).	The scenarios presented in commercial fisheries provide for the greatest change in fishing pressure due to displacement from the construction area and therefore the greatest knock-on effect to fish and shellfish ecology.

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
EMF effects arising from cables during operational phase	Up to 116 km of inter-array cable connecting 50 WTGs producing a maximum field strength of 20 μT (microtesla) at a distance of around 1 m above the cable (seabed). Export cables and GyM interlink cables producing a magnetic field of less than 50 μT (and likely < 30 μT) 1 m above the export cable (seabed).	The maximum adverse scenario is associated with the use of 50 WTGs as this results in the greatest length of inter-array cable and export cables as this results in the longest total length of cable.
DECOMMISSIONING		
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Maximum levels of underwater noise during decommissioning would be from underwater cutting required to remove structures. This is much less than pile driving and therefore impacts would be less than as assessed during the construction phase/ piled foundations would likely be cut approximately 1 m below the seabed.	This would result in the maximum potential disturbance associated with noise associated with decommissioning activities including foundation decommissioning.
Temporary increase in SSC and	MDS is identical to (or less than) that of the construction phase.	MDS is assumed to be as per the construction phase, with all

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
sediment deposition		infrastructure removed in reverse-construction order. Buried cables are proposed to be left *in situ*, however this is to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time. The removal of cables is therefore still considered within the MDS.
Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish arising from construction activities	MDS is identical to (or less than) that of the construction phase.	MDS is assumed to be as per the construction phase, with all infrastructure removed in reverse-construction order. Buried cables are proposed to be left *in situ*, however this is to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time.

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
		The removal of cables is therefore still considered within the MDS.
Direct and indirect seabed disturbances leading to the release of sediment contaminants	MDS is identical to (or less than) that of the construction phase.	MDS is assumed to be as per the construction phase, with all infrastructure removed in reverse-construction order. Buried cables are proposed to be left *in situ*, however this is to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time. The removal of cables is therefore still considered within the MDS.
Impacts on fishing pressure due to displacement	MDS is identical to (or less than) that of the construction phase.	MDS is assumed to be as per the construction phase, with all infrastructure removed in reverse-construction order. Buried cables are proposed to be left *in situ*, however this is to be

POTENTIAL EFFECT	MAXIMUM ADVERSE SCENARIO ASSESSED	JUSTIFICATION
		determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time. The removal of cables is therefore still considered within the MDS.
CUMULATIVE EFFECTS		
Addressed in Cumulative Effects, Section 6.136.13.		

6.9 Mitigation measures

71 Mitigation measures that were identified and adopted as part of the evolution of the project design (embedded into the project design) and that are relevant to fish and shellfish ecology are listed in Table 11. The mitigation includes embedded measures, such as design changes, and applied mitigation which is subject to further study or approval of details; these include avoidance measures that will be informed by pre-construction surveys and necessary additional consents where relevant. The composite of embedded and applied mitigation measures apply to all parts of the AyM development works, including pre-construction, construction, O&M and decommissioning.

72 General mitigation measures, which would apply to all parts of the project, are set out first. Thereafter mitigation measures that would apply specifically to fish and shellfish issues associated with the array, offshore ECC and landfall, are described separately.

Table 11: Mitigation measures relating to fish and shellfish ecology.

PARAMETER	MITIGATION MEASURES
GENERAL	
Project design	The development boundary selection was made following a series of constraints analyses, with the array area and offshore ECC route selected to ensure the impacts on the environment and other marine users are minimised. Good design has continued to be applied throughout the development of AyM, with the final design representing a 53% reduction in the number of turbines considered when compared to the design put forward for Scoping (107 WTGs).
Project design	Good design has also continued to be applied in the context of concurrent piling being significantly reduced from the design proposed within the PEIR. The design in the PEIR considered a MDS of two distantly located piling operations occurring at the same time. The final design removed the option for simultaneous piling, expect in the case of adjacent (pin piles) piling operations to occur concurrently on the same foundation, therefore greatly reducing the potential underwater noise impact range.
Pollution prevention	A Project Environment Management Plan (PEMP) is proposed to be produced to ensure that the potential for contaminant release is strictly controlled. The PEMP will include a Marine Pollution Contingency Plan (MPCP) and will also incorporate plans to cover accidental spills, potential contaminant release and include key emergency contact details (e.g., NRW, Maritime Coastguard Agency and the project site coordinator). The PEMP will be secured as a condition in the Marine Licence.

PARAMETER	MITIGATION MEASURES
CONSTRUCTION	
Cable Specification and Installation Plan	Development of, and adherence to, a Cable Specification and Installation Plan (CSIP) post consent. The CSIP will set out appropriate cable burial depth in accordance with industry good practice, minimising the risk of cable exposure. The CSIP will also ensure that cable crossings are appropriately designed to mitigate environmental effects, these crossings will be agreed with relevant parties in advance of CSIP submission. The CSIP will include a detailed Cable Burial Risk Assessment (CBRA) to enable informed judgements regarding burial depth to maximise the chance of cables remaining buried whilst limiting the amount of sediment disturbance to that which is necessary. The CSIP will be secured as a condition in the Marine Licence.
Scour Protection Management Plan	Development of a Scour Protection Plan (SPP) which will set out the details of the protection where there is the potential for scour to develop around wind farm infrastructure, including turbine and substation/platform foundations and cables. The plan will be secured as a condition in the Marine Licence.
Project Design	The option for concurrent piling of monopiles has been removed as an embedded measure in response to stakeholder concerns relating to the ecological effects of underwater noise.
OPERATION	

PARAMETER	MITIGATION MEASURES
Project design	Where burial depth cannot be achieved, cable armouring will be implemented (e.g., mattressing, rock placement etc). The suitability of installing rock or mattresses for cable protection will be investigated, based on (inter alia) the seabed current data at the location of interest and the assessed risk of impact damage.
Project design	Development of a Scour Protection Management Plan (SPMP) which will consider the need for scour protection where there is the potential for scour to develop around wind farm infrastructure, including turbine and substation/ platform foundations and cables. The plan will be secured via a condition in the Marine Licence.
DECOMMISSIONING	
Decommissioning Plan	A Decommissioning Plan will be developed to cover the decommissioning phase as required under Chapter 3 of the Energy Act 2004. As the decommissioning phase will be a similar process to the construction phase but in reverse (i.e. increased project vessels on-site, partially deconstructed structures) the embedded mitigation measure will be similar to those for the construction phase. The Decommissioning Plan will be secured as a condition in the Marine Licence.

6.10 Environmental assessment: construction phase

73 The potential environmental impacts arising from the construction of AyM are listed in Table 10 along with the MDS against which each construction phase impact has been assessed. A description of the potential effect on fish and shellfish ecology receptors caused by each identified impact is given below.

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

Introduction

74 The assessment below focuses on underwater noise from pile-driving (pin piles) for the installation of foundations for offshore structures (i.e., WTGs and OSS), cable installation (including sheet impacts piling for cofferdams), vessel disturbance and UXO clearance. The installation of monopile foundations (although this scenario does not represent the temporal or spatial MDS) has also been considered.

75 To inform the assessment of potential impacts associated with underwater noise as a result of the installation of foundations, predictive underwater noise modelling has been undertaken for the relevant piling MDS, full details of which are presented in Volume 4, Annex 6.2 (application ref: 6.4.6.2). To inform the assessment of the potential impacts associated with underwater noise as a result of UXO clearance, a high-level consideration has been provided of the potential effects arising from UXO clearance below. It should be noted that UXO clearance will be consented under a separate Marine Licence and will therefore not be consented as part of the AyM consenting process, it is for this reason that a high-level review has been undertaken, drawing on site-specific experience gained at GyM.

Definition of Maximum Design Scenarios for underwater noise

76 The following provides further information on the definition of the MDS for underwater noise. As detailed in Table 10, several activities have the potential to introduce an effect receptor pathway for underwater noise. These can be broadly characterised as underwater noise associated with general seabed clearance, cable installation and vessel operations, underwater noise associated with foundation installation, and underwater noise associated with UXO specific seabed clearance.

MDS for general construction activities

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

MDS for foundation installation

78 The spatial and temporal MDS for underwater noise impacts from foundation installation (piling of pin piles) are defined according to a maximum scenario, i.e., the maximum design parameters that may be utilised during the construction of the proposed development. In this context it is important to note that the maximum hammer energies assumed in the MDS are likely to be highly precautionary and that in fact for many piling events, a lesser hammer energy will be required to complete the pile installation (they represent the upper limit of the equipment, rather than the likely energy that will be required to install any given foundation[i]).

79 The spatial MDS equates to the greatest area of effect from subsea noise at any one-time during piling which is considered to result from the concurrent installation of pin pile foundations at the north-west (NW) and south-east (SE) corners of the array (See Table 12).

80 The temporal MDS represents the longest duration of effects from subsea noise which is considered to result from the sequential installation of up to 224 pin piles in the array (See Table 12).

Table 12: Spatial and Temporal MDS for foundations installation.

PARAMETER	SPATIAL MDS	TEMPORAL MDS
Foundation type	Pin pile	Pin pile
Installation approach	Concurrent piling (two piling operations undertaken concurrently at the same WTG location)	Sequential piling.
Hammer energy (maximum)	3,000 kJ	3,000 kJ

[i] This level of detail will be informed by detailed ground investigations, foundation types and locations, and installation methodology, all of which is established post consent and detailed within the pre-construction plans that will be submitted for approval prior to commencement of works.

PARAMETER	SPATIAL MDS	TEMPORAL MDS
Maximum number of piles	224 (50 WTGs and two OSP on piled jacket foundations (pin piles))	224 (50 WTGs and two OSP on piled jacket foundations (pin piles))
Maximum piling duration (hours)	896 (4 hours per pin pile)	896 (4 hours per pin pile)

MDS for landfall works

81 As part of the landfall works, it may be necessary to install sheet piles to form a cofferdam for the trenchless installation techniques that includes but is not limited to Horizontal Directional Drilling (HDD). This cofferdam may be installed from MHWS out to 1,000 m seaward of MHWS, with installation using a percussive piling rig and a maximum hammer energy of 300 kJ.

MDS for seabed clearance activities

82 With regards the seabed clearance works associated with UXO, as detailed in Table 10, as part of the site preparation activities for AyM, UXO clearance may be required. Presence of UXO within the Order Limits can be managed in a number of ways: avoidance (through micrositing), non-destructive clearance through moving or removal of the UXO, or destructive clearance (i.e., in-situ detonation).

83 If required, destructive UXO clearance through detonation of the UXO can introduce a further underwater noise effect-receptor pathway that may result in an effect on noise sensitive receptors. Any UXO clearance would be completed within the AyM array area and ECC, as part of the pre-construction site preparatory works. Until detailed pre-construction surveys are undertaken across the AyM array area and ECC, the exact number of potential UXO which will need to be cleared is unknown. Based on evidence from the adjacent GyM project the level of UXO in the region is low. However, given the potential for the presence of UXO *in situ* detonation cannot be discounted at this stage, the Applicant has used its experience from the adjacent GyM wind farm to estimate the number of UXO that may require clearance. The MDS for UXO is therefore clearance of ten UXO via detonation.

84 Detonation of UXO would represent a short-term (i.e. seconds) increase in underwater noise (i.e. sound pressure levels and particle motion) and while noise levels will be elevated such that this may result in injury or behavioural effects on fish and shellfish species, UXO detonations are considered to have a lower likelihood of triggering a population level effect than that associated from piling operations, due to the significantly reduced temporal footprint that would arise from UXO operations. It is important to note that the Applicant is not applying for a Marine Licence for UXO clearance would be in parallel with the DCO application and therefore no formal assessment has been made; however high-level consideration has been provided to the potential effects arising from UXO clearance in paragraph 265 *et seq.* for completeness.

Receptor sensitivity and injury criteria for assessment

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

- Underwater noise associated with foundation installation.
  - Spatial MDS;
  - Temporal MDS;
- Underwater noise associated with cofferdam installation; and

- Underwater noise associated with UXO clearance.

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

87 For the purposes of the assessment, Volume 4, Annex 6.2 (application ref: 6.4.6.2) presents the results of modelling for a range of noise levels, representing the MDS for the installation of both monopiles and pin piles. The modelling results for cumulative sound exposure level (SEL_{cum}) provide outputs for both fleeing receptors (with the receptors fleeing from the source at a consistent rate of 1.5 ms^{-1}), and stationary receptors to account for spawning activity for more static demersal spawners such as sandeel or eggs and larvae.

Injury criteria

88 The fish receptors (VERs) within the AyM study area have been grouped into the Popper *et al*. (2014) categories (see Table 4 of Volume 4, Annex 6.2 (application ref: 6.4.6.2)) based on their hearing system, as outlined in Table 13 below. It is important to note that there are differences in impact thresholds for the different hearing groups.

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

Table 13: Hearing categories of fish receptors (Popper *et al*, 2014).

CATEGORY	VERS RELEVANT TO AYM
Group 1 (least sensitive)	Sandeel, common sole, thickback sole, flounder, dab, solenette, scaldfish, plaice, mackerel, elasmobranchs, river and sea lamprey
Group 2	Atlantic salmon, sea trout
Group 3 (most sensitive)	Herring, sprat, cod, ling*[ii], hake*, whiting, European eel*, allis and twaite shad, smelt*, haddock, horse mackerel*, common dragonet*, anglerfish*, pogge*, sand goby*, poor cod*

Table 14: Impact Threshold Criteria from Popper *et al*. (2014).

	IMPACT THRESHOLD NOISE LEVEL (DB RE 1 µPA SOUND PRESSURE LEVEL (SPL)/ DB RE 1 µPA² S SOUND EXPOSURE LEVEL (SEL))		
	MORTALITY AND POTENTIAL INJURY	RECOVERABLE INJURY	TTS
Group 1	219 dB SEL_{cum} 213 dB SPL_{peak}	216 dB SEL_{cum} 213 dB SPL_{peak}	>>186 dB SEL_{cum}
Group 2	210 dB SEL_{cum} 207 dB SPL_{peak}	203 dB SEL_{cum} 207 dB SPL_{peak}	>186 dB SEL_{cum}
Group 3	207 dB SEL_{cum} 207 dB SPL_{peak}	203 dB SEL_{cum} 207 dB SPL_{peak}	186 dB SEL_{cum}
Eggs and Larvae	210 dB SEL_{cum} 207 dB SPL_{peak}	N/A	N/A

[ii] *denotes uncertainty or lack of current knowledge with regard to the potential role of the swim bladder in hearing.

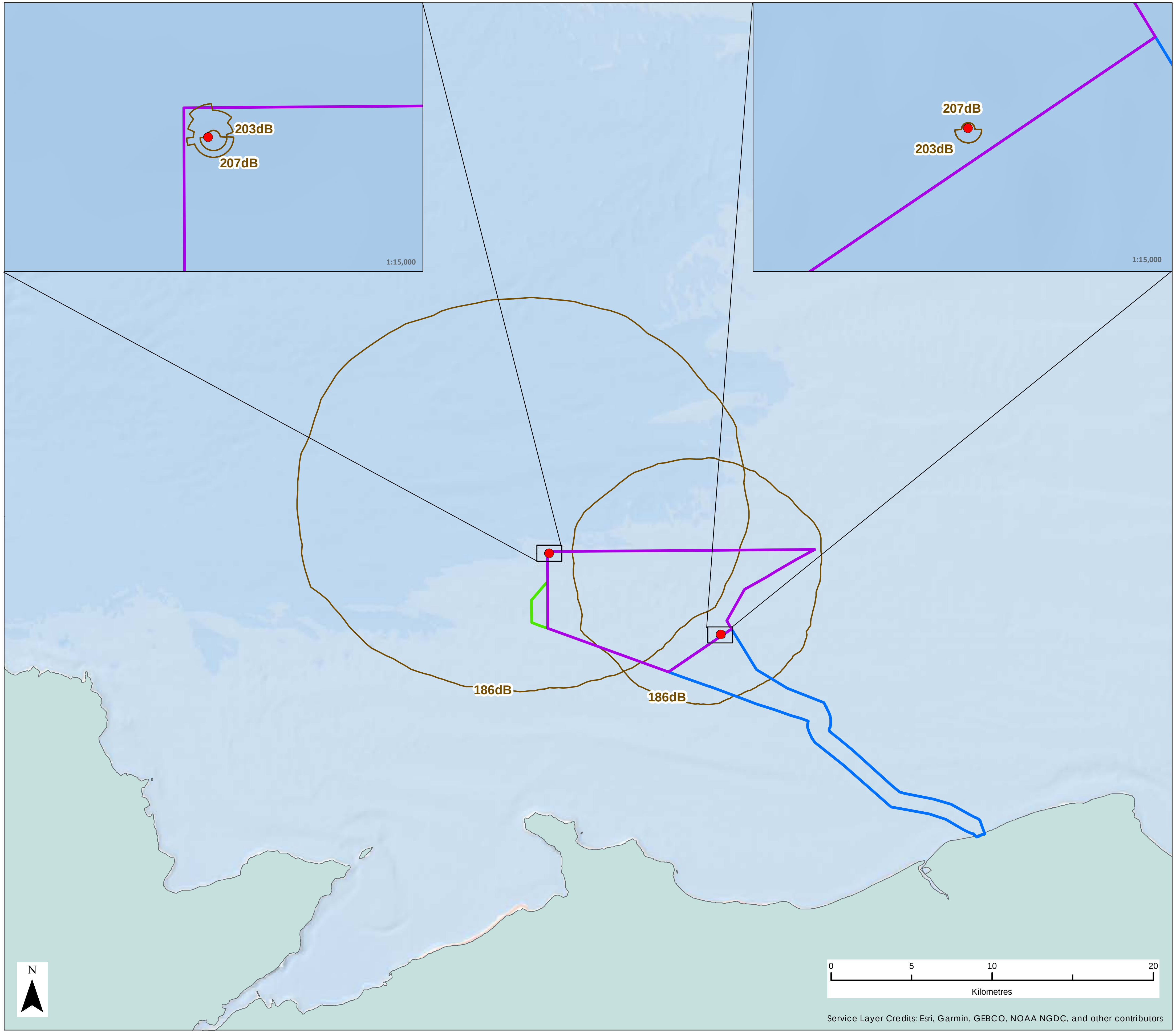
90 The noise modelling for injury ranges for fleeing and stationary fish is presented in the Underwater Noise Technical Report (Volume 4, Annex 6.2 (application ref: 6.4.6.2)), and referred to, as appropriate in the following assessments. Table 14 below summarises the results for each of the relevant criteria against each of the MDS under consideration.

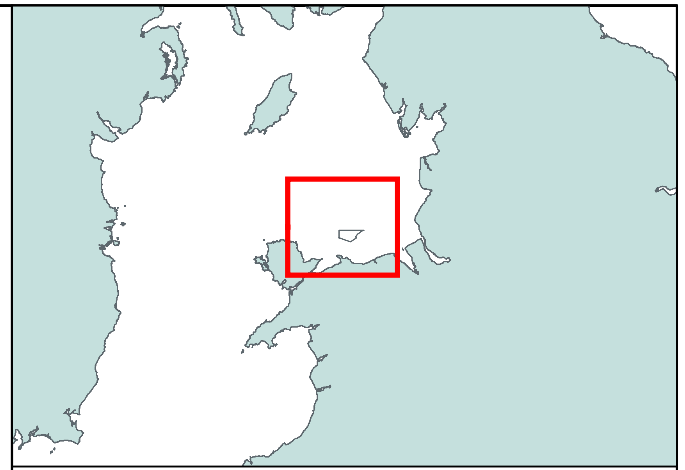
Table 15: Noise modelling results for injury ranges for fleeing and stationary receptors (Spatial and Temporal MDS).

RECEPTOR	CRITERIA	NOISE LEVEL (DB RE 1 µPA SOUND PRESSURE LEVEL (SPL)/ DB RE 1 µPA2 S SOUND EXPOSURE LEVEL (SEL))	SPATIAL MDS RANGE (SIMULTANEOUS PILING OF PIN PILES) (NW/SE)	TEMPORAL MDS RANGE (NW/SE) (SEQUENTIAL PILING OF PIN PILES) (NW/SE)
MORTALITY AND POTENTIALLY MORTAL INJURY				
Group 1 fish	SPL_{peak}	213	100/90	100/90
	SEL_{cum} (static)	219	2,000/1,500	1,300/980
	SEL_{cum} (fleeing)	219	<100/<100	<100/<100
Group 2 fish	SPL_{peak}	207	240/210	240/210
	SEL_{cum} (static)	210	6,300/4,500	4,500/3,200
	SEL_{cum} (fleeing)	210	<100/<100	<100/<100
Group 3 fish	SPL_{peak}	207	240/210	240/210
	SEL_{cum} (static)	207	8,600/6,200	6,300/4,500
	SEL_{cum} (fleeing)	207	<100/<100	<100<100

RECEPTOR	CRITERIA	NOISE LEVEL (DB RE 1 µPA SOUND PRESSURE LEVEL (SPL) / DB RE 1 µPA2 S SOUND EXPOSURE LEVEL (SEL))	SPATIAL MDS RANGE (SIMULTANEOUS PILING OF PIN PILES) (NW/SE)	TEMPORAL MDS RANGE (NW/SE) (SEQUENTIAL PILING OF PIN PILES) (NW/SE)
Eggs and larvae	SPL_{peak}	207	240/210	240/210
	SEL_{cum} (static)	210	6,300/4,500	4,500/3,200
RECOVERABLE INJURY				
Group 1 fish	SPL_{peak}	213	100/90	100/90
	SEL_{cum} (static)	216	3,000/2,200	2,000/1,500
	SEL_{cum} (fleeing)	216	<100/<100	<100/<100
Group 2 fish	SPL_{peak}	207	240/210	240/210
	SEL_{cum} (static)	203	12,000/9,000	9,500/6,800
	SEL_{cum} (fleeing)	203	120/<100	<100/<100
Group 3 fish	SPL_{peak}	207	240/210	240/210
	SEL_{cum} (static)	203	12,000/9,000	9,500/6,800

RECEPTOR	CRITERIA	NOISE LEVEL (DB RE 1 µPA SOUND PRESSURE LEVEL (SPL) / DB RE 1 µPA2 S SOUND EXPOSURE LEVEL (SEL))	SPATIAL MDS RANGE (SIMULTANEOUS PILING OF PIN PILES) (NW/SE)	TEMPORAL MDS RANGE (NW/SE) (SEQUENTIAL PILING OF PIN PILES) (NW/SE)
	SEL_{cum} (fleeing)	203	120/<100	<100/<100
TEMPORARY THRESHOLD SHIFT				
Group 1 fish	SEL_{cum} (static)	186	36,000/29,000	31,000/25,000
	SEL_{cum} (fleeing)	186	17,000/11,000	13,000/8,100
Group 2 fish	SEL_{cum} (static)	186	36,000/29,000	31,000/25,000
	SEL_{cum} (fleeing)	186	17,000/11,000	13,000/8,100
Group 3 fish	SEL_{cum} (static)	186	36,000/29,000	31,000/25,000
	SEL_{cum} (fleeing)	186	17,000/11,000	13,000/8,100





LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Noise Modelling Location
- Noise Modelling Contours

Data Source:

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

Spatial MDS for underwater noise (Fleeing)

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	PN
2	24/01/2022	For Issue For ES	BPHB	AL

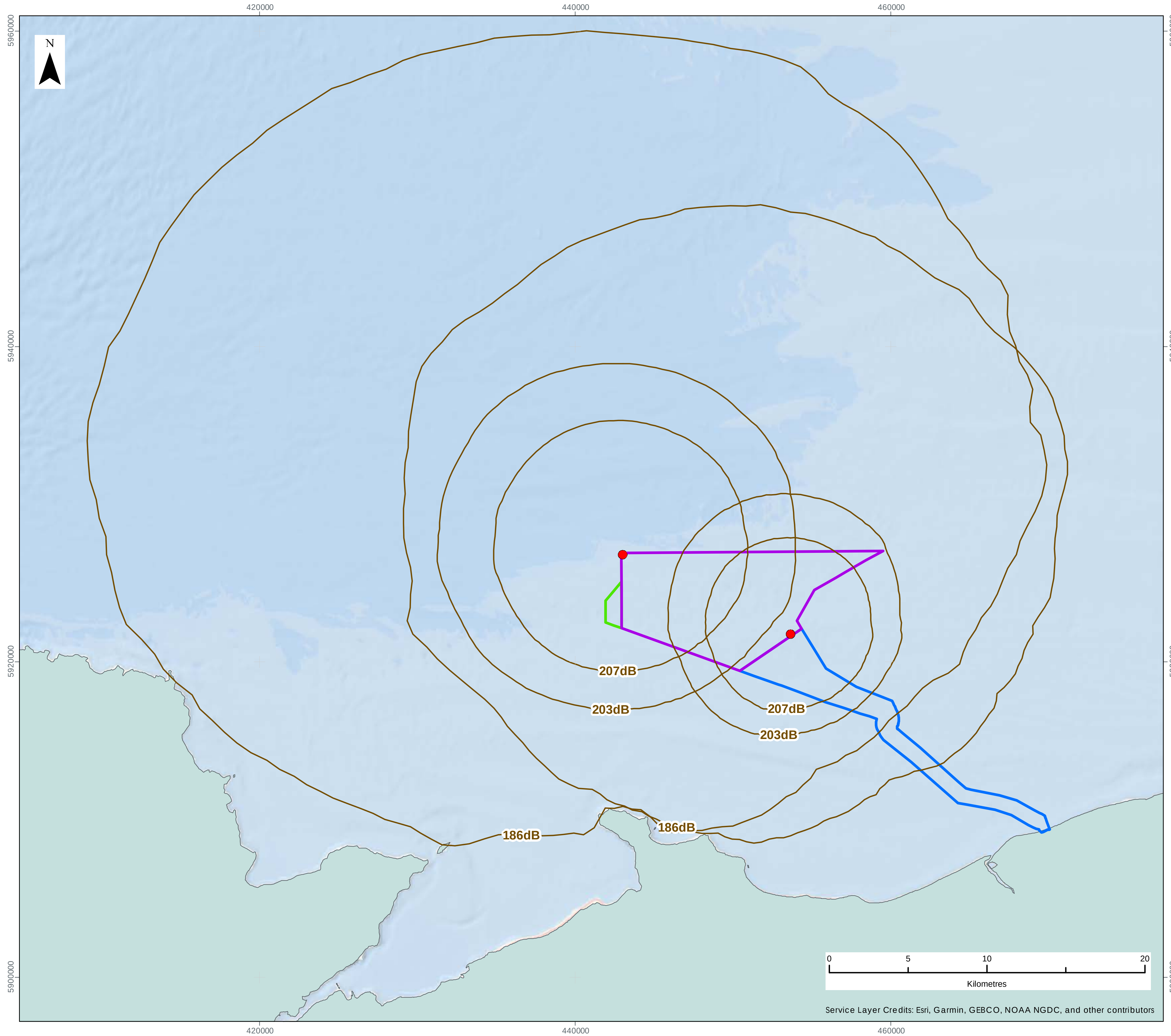
FIGURE NUMBER:

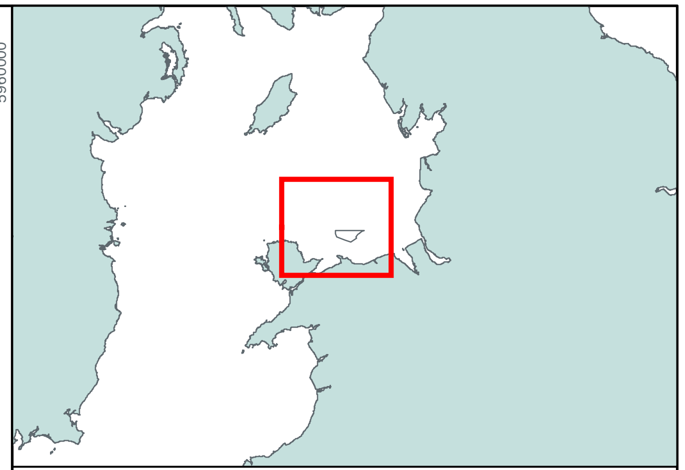
Figure 8

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:250,000	A3	WGS84	UTM30N

Fferm Wynt Alltraeth AWEL Y MÔR Offshore Wind Farm

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig8_Noise_Fleeing.mxd





LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Noise Modelling Location
- Noise Modelling Contours

Data Source:

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

Spatial MDS for underwater noise (Stationary)

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	PN
2	24/01/2022	For Issue For ES	BPHB	AL

FIGURE NUMBER:

Figure 9

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:250,000	A3	WGS84	UTM30N

Fferm Wynt Alltraeth AWEL Y MÔR Offshore Wind Farm

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig9_Noise_Stationary.mxd

Mortality and potential mortal injury

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

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

Group 1 VERS

Sensitivity

93 Group 1 VERs (mortality onset at >213 dB SPL_{peak} or >219 dB SEL_{cum}) lack a swim bladder and are therefore considered less sensitive to underwater noise (than other species). The specific sensitivity rating assigned to each VER, and associated justification is provided in Table 16 below.

Table 16: Group 1 VERs Sensitivity.

GROUP 1 VER	SENSITIVITY JUSTIFICATION
Sandeel	Low sensitivity. Sandeel spawning grounds (of low and high intensity) and suitable spawning habitats are widely distributed across the Irish Sea, and therefore noise impacts are anticipated to be small in the context of the wider environment. Sandeel are thought to be affected by vibration through the seabed, particularly when buried in the seabed during hibernation. Sandeel are considered stationary receptors due to their burrowing nature, substrate dependence and demersal spawning nature, sandeel are consequently thought to have limited ability to flee the affected area. Sandeel are anticipated to recover from noise impacts shortly after noise disturbance, with normal behaviours resuming (Hassel et al., 2004). On this basis, sandeel are considered to have medium recoverability to noise impacts. Sandeel are of national importance (Environment (Wales) Act 2016 Section 7 priority species).
Common sole, thickback sole, flounder, dab, solenette, scaldfish, plaice, mackerel,	Low sensitivity. These species lack a swim bladder and are of mobile nature and are therefore able to flee from noise disturbance.

GROUP 1 VER	SENSITIVITY JUSTIFICATION
elasmobranchs, river and sea lamprey	Based on their low vulnerability to noise impacts, and their mobile nature, these receptors are expected to recover quickly, returning to normal behaviours, and recolonising areas shortly after disturbance. Common sole, plaice and mackerel all have spawning grounds located across the AyM array area. Dab, mackerel, common sole and plaice are of national importance (Environment (Wales) Act 2016 Section 7 priority species). Mackerel and dab are of regional importance, being of commercial importance to the region. Elasmobranchs are of local to international importance. Sea lamprey and river lamprey are of international importance (designated under Appendix III of the Bern Convention, Annex II of the Habitats Directive, Schedule 5 of the Wildlife and Countryside Act 1981, and are Environment (Wales) Act 2016 Section 7 priority species). Thickback sole, flounder, Solenette and scaldfish are of local importance. Little or no commercial importance. Not listed under nature conservation legislation. Likely prey items for fish, bird and marine mammal species.

94 Group 1 receptors are deemed to be of low vulnerability, medium recoverability and local to international (i.e., lamprey) importance. The sensitivity of the Group 1 receptors to mortality and potential mortal injury from underwater noise is therefore considered to be **low**.

Magnitude of Impacts Resulting from the Spatial MDS

95 With regard to the spatial MDS (from the simultaneous installation of pin piles), the modelling results indicate that the maximum predicted range for mortality and potential mortal injury of stationary Group 1 receptors is up to 2,000 m from the piling locations. Noise impacts on fleeing Group 1 receptors are expected to be significantly less (<100 m) and within the immediate vicinity of the piling activity.

96 Spawning grounds for a number of Group 1 species around AyM (e.g. sole, sandeel, plaice and mackerel) are widely distributed across the Irish Sea and along the western UK and therefore in the context of the wider environment, the impacts from underwater noise are considered to be of local to regional scale (local for mortality and potential mortal injury based on the modelling results).

Magnitude of Impacts Resulting from the Temporal MDS

97 With regard to the temporal MDS (from the sequential installation of pin pile foundations), the modelling results indicate that the maximum predicted range for mortality and potential mortal injury of stationary Group 1 receptors is up to 1,300 m from the piling locations ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 1 receptors are expected to be significantly less (<100 m) and within the immediate vicinity of the piling activity.

Potential Impact on VER Spawning Potential

98 The potential impact from the temporal worst case on the spawning potential for receptors with spawning grounds overlapping AyM (sole, sandeel, mackerel and plaice) has been calculated for mortality and potential mortal injury.

99 Spawning potential is defined herein as the spatio-temporal component for spawning for a species which could be impacted. This is determined by multiplying the spawning period (t) by the spawning area (a), to give the spawning potential (S(pot).

$$t \times a = S(pot)$$

100 In doing so, this equation allows the calculation of the total spawning potential for each species which could be affected by noise impacts from AyM, when considering the temporal MDS.

101 The temporal MDS, or total piling time for the array, is 896 hours over a three-year construction period (it is anticipated that piling will occur in a period no greater than 12 months in a three-year window). The spawning period for the sensitive VERs is presented in Table 17. This is calculated through reference to the recognised spawning period(s) as follows:

- In the context of the annual sandeel spawning period (November to February (Ellis *et al*., 2012)) over three years (8,064 hours);
- For sole spawning period (from April to June) over three years (6,552 hours);
- For plaice spawning period (from Dec to March) over three years (8,640 hours); and
- For mackerel spawning period (from March to July) over three years (10,944 hours).

Table 17: VER Total Spawning Potential.

VER	SPAWNING PERIOD (T)	SPAWNING AREA (A)	VER SPAWNING POTENTIAL
Sole	6,552 hours	51,263 km^2	335,875,176 km^2hr
Sandeel	8,064 hours	55,284 km^2	445,810,176 km^2hr
Plaice	8,640 hours	36,584 km^2	316,085,760 km^2hr
Mackerel	10,944 hours	33,202 km^2	363,362,688 km^2hr

102 To determine the percentage of the spawning potential of each receptor affected by the piling, the spatial and temporal impacts from piling are taken into consideration.

103 As presented in Table 12, the temporal MDS from piling results from the piling of pin piles in the array, and results in a total piling time of 896 hours over a three-year construction period. As defined in Table 12, the spatial MDS for piling would result from the simultaneous piling of pin piles within the array. The spatial impact is presented as noise contours (See Figure 8 and Figure 9) that overlap the spawning grounds (see Figure 10 and Figure 11). By multiplying the total piling time by the area of VER spawning grounds affected, the 'affected spawning potential' is determined.

Table 18: VER Affected Spawning Potential.

VER	TOTAL PILING TIME	AREA OF SPAWNING GROUND AFFECTED	AFFECTED SPAWNING POTENTIAL
Sole (fleeing)	896 hours	0.002 km^2	1.759 km^2hr
Sandeel (static)	896 hours	4.81 km^2	4,310 km^2hr
Plaice (fleeing)	896 hours	0.002 km^2	1.759 km^2hr
Mackerel (fleeing)	896 hours	0.002 km^2	1.759 km^2hr

104 To determine the percentage of spawning potential affected by piling noise, the affected spawning potential is expressed as a percentage of the total spawning potential for each species.

Table 19: Percentage of Spawning Potential Affected.

VER	VER SPAWNING POTENTIAL	AFFECTED SPAWNING POTENTIAL	% OF SPAWNING POTENTIAL AFFECTED
Sole (fleeing)	335,875,176 km^2hr	1.76 km^2hr	0.000%

VER	VER SPAWNING POTENTIAL	AFFECTED SPAWNING POTENTIAL	% OF SPAWNING POTENTIAL AFFECTED
Sandeel (static)	445,810,176 km^2hr	4310.26 km^2hr	0.001%
Plaice (fleeing)	316,085,760 km^2hr	1.76 km^2hr	0.000%
Mackerel (fleeing)	363,362,688 km^2hr	1.76 km^2hr	0.000%

105 To conclude, using the Ellis *et al*. (2012) sole spawning ground extents for the Irish Sea, the potential impact on the spawning potential for sole from the temporal worst-case for AyM is 0.000%.

106 Using the sandeel spawning ground extents which overlap the Irish Sea, the potential impact on spawning potential for sandeel from the temporal worst-case for AyM is 0.001%.

107 Using the plaice spawning ground extents which overlap the Irish Sea, the potential impact on spawning potential for plaice from the temporal worst-case for AyM is 0.000%.

108 Using the mackerel spawning ground extents which overlap the Irish Sea, the potential impact on spawning potential for mackerel from the temporal worst-case for AyM is 0.000%.

109 It should be noted however this approach assumes that all piling will occur within the relevant spawning period which, based on the worst case of 896 hours over 37-74 days (dependent on the WTG model) is very unlikely. Given the broadscale nature of the spawning grounds, against the likely spatial extent of the spatial MDS and the duration of the temporal MDS, and the calculated impact on the identified species spawning potential, the impact magnitude for mortality and potential mortal injury is considered to be **low** (adverse) for both the spatial and temporal MDS.

Significance of Effect

110 Overall, the magnitude of the impact for Group 1 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 1 fish species which is not considered significant in EIA terms.

Group 2 VERs

Sensitivity

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

112 Group 2 species identified as of relevance to AyM are Atlantic salmon and sea trout. As Group 2 receptors, they are considered to be primarily sensitive to particle motion and so are likely to mainly sense underwater noise through movement of the water particles. The sensitivity rating assigned to each VER, and associated justification is provided in Table 20 below.

Table 20: Group 2 VERs Sensitivity.

GROUP 2 RECEPTOR	SENSITIVITY JUSTIFICATION
Atlantic salmon, sea trout	Low Sensitivity. These species are migratory and are therefore likely to be transient receptors within the site. They are considered to be mobile receptors, and able to flee from noise impacts. Based on their low vulnerability to noise impacts, and their mobile nature, these receptors are expected to recover quickly,

GROUP 2 RECEPTOR	SENSITIVITY JUSTIFICATION
	returning to normal behaviours, and recolonising areas shortly after disturbance. Atlantic salmon are of international importance (Designated under Annex III of the Bern convention and freshwater populations on Annexes II and V of the Habitats Directive. Atlantic salmon are a Section 7 priority species under the Environment (Wales) Act 2016). Sea trout are of national importance (Environment (Wales) Act 2016 Section 7 priority species).

113 Group 2 receptors are deemed to be of low vulnerability, medium recoverability and national to international importance. The sensitivity of the Group 2 receptors to mortality and potential mortal injury from underwater noise is therefore considered to be **low**.

Magnitude of Impacts Resulting from the Spatial MDS

114 With regards the spatial MDS from the simultaneous piling of pin piles, the impacts range for Group 2 receptors (assuming a fleeing receptor) are predicted to be <100 m from the NW and SE piling locations. Atlantic salmon and sea trout are thought to generally follow the coast, remaining within coastal waters rather than passing directly through the AyM site (as reviewed in the Fish and Shellfish Ecology Technical Baseline) and so are unlikely to be within range of any injurious effects from piling noise within the array area. Therefore, the magnitude of the impact to Group 2 receptors from the spatial MDS is considered to be **low** (adverse).

Magnitude of Impacts Resulting from the Temporal MDS

115 The impact range for Group 2 receptors (assuming a fleeing receptor) from pin pile installation is predicted to be <100 m from the NW piling location and <100 m from the SE location.

116 Atlantic salmon and sea trout are considered unlikely to be within range of any injurious effects from piling noise. In addition, as these VERs are anticipated to be transient across the site, any temporal impacts on these receptors are anticipated to be minimal. Therefore, the magnitude of the impact to Group 2 receptors from the temporal MDS is considered to be **low** (adverse).

Significance of Effects

117 Overall, the magnitude of the impact for Group 2 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 2 fish species which is not significant in EIA terms.

Group 3 VERs

Sensitivity

118 Group 3 receptors (mortality onset at >207 dB SPL_{peak} or >207 dB SEL_{cum}) have a swim bladder which is linked to the inner ear and so is directly involved in hearing. These species are considered to be the most sensitive to underwater noise, with direct detection of sound pressure, rather than just particle motion. The sensitivity rating assigned to each VER, and associated justification is provided in Table 21 below.

Table 21: Group 3 VERs Sensitivity.

GROUP 3 RECEPTOR	SENSITIVITY JUSTIFICATION
Herring	Medium Sensitivity. Herring do not have spawning grounds close enough to AyM to be affected by underwater noise and have high mobility, and consequently are considered likely to move away from injurious effects rather than remain stationary. Herring are known to be very reactive to underwater noise when not engaged in spawning (e.g., Skaret et al., 2005). Based on their mobile nature, herring are expected to recover quickly, return to normal behaviours, recolonizing areas shortly after disturbance. Herring are of national importance (Environment (Wales) Act 2016 Section 7 priority species).
Sprat, ling, hake, European eel, allis and twaite shad, smelt, haddock, horse mackerel, common dragonet, anglerfish, pogge, sand goby and poor cod.	Medium Sensitivity. Based on their mobile nature, these receptors are expected to recover quickly, returning to normal behaviours, recolonizing areas shortly after disturbance. Sprat are of regional importance, with commercial value to the region. Ling, hake and smelt are of national importance (Environment (Wales) Act 2016 Section 7 priority species). European eel are of international importance (Critically endangered on the IUCN Red List and Environment (Wales) Act 2016 Section 7 priority species).

GROUP 3 RECEPTOR	SENSITIVITY JUSTIFICATION
	Allis shad and twaite shad are of international importance (Appendix III of the Bern Convention respectively, Annexes II and V of the Habitats Directive, Schedule 5 of the Wildlife and Countryside Act 1981 and Environment (Wales) Act 2016 Section 7 priority species). Common dragonet, anglerfish, pogge, sand goby, horse mackerel and poor cod are of local importance. Little or no commercial importance. Not listed under nature conservation legislation. Likely prey items for fish, bird and marine mammal species.
Cod and whiting	Medium Sensitivity. Whiting have spawning grounds within the vicinity of the study area; whiting are pelagic spawners and are therefore not limited to specific sedimentary areas for spawning, and consequently are considered likely to move away from injurious effects. Whiting are of national importance (Environment (Wales) Act 2016 Section 7 Priority Species. Forms a key component of the fish assemblages across the AyM array area). Cod have spawning grounds within the vicinity of the study area; however, the spawning grounds also extend over much of the Irish Sea (Coull *et al*, 1998). Whilst cod are pelagic spawners, they exhibit preferences for coarse sand substrates for mating. Cod are however a highly mobile species, and consequently are considered likely to move away from injurious effects rather than remain stationary. Based on

GROUP 3 RECEPTOR	SENSITIVITY JUSTIFICATION
	their mobile nature, cod are expected to recover quickly, return to normal behaviours, recolonizing areas shortly after disturbance. Cod are of international importance. (Commercially important species (ICES, 2021b). Listed by OSPAR as threatened and/or declining and listed as vulnerable on the IUCN Red List.

119 Group 3 receptors are deemed to be of medium vulnerability, medium recoverability and regional to international importance. The sensitivity of the Group 3 receptors to mortality and potential mortal injury from underwater noise is therefore considered to be **medium**.

Magnitude of Impacts Resulting from the Spatial MDS

120 With regard to the spatial MDS, the modelling results (simultaneous piling of pin piles at the NW and SE of the array area) indicate that the maximum predicted range for mortality and potential mortal injury of stationary Group 3 receptors is up to 8,600 m from the piling locations ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 3 receptors are expected to be significantly less (<100 m) and within the immediate vicinity of the piling activity.

121 Given the broadscale nature of the spawning grounds of cod and whiting, the lack of any overlap with the herring spawning grounds by the Isle of Man and the wide distribution of the other species, against the likely spatial extent of the spatial MDS, the impact magnitude for mortality and potential mortal injury is considered to be **low** (adverse) for the spatial MDS.

Magnitude of Impacts Resulting from the Temporal MDS

122 Regards the temporal MDS (from the sequential piling of pin piles), the modelling results indicate that the maximum predicted range for mortality and potential mortal injury of stationary Group 3 receptors is up to 6,300 m from the NW piling location and 4,500 m from the SE location (SEL_{cum}-$^{(static)}$). Noise impacts on fleeing Group 3 receptors are expected to be significantly less (<100 m) and within the immediate vicinity of the piling activity.

123 When considering the spawning potential for Group 3 VERs the spawning potential calculation has again been utilised. Initially considering the potential spawning period of each receptor, before considering the potential impact as a proportion of the overall spawning potential.

124 In the context of the annual cod spawning periods (January to April) (Ellis *et al*. 2012) over three years the period is considered to be 8,568 hours.

125 The whiting spawning period (February to June) over three years is considered to be 10,728 hours.

126 This assumes that all piling will occur within the relevant spawning period which, based on the worst case of 896 hours over 37-74 days (dependent on the WTG model) is very unlikely. Given these receptors are pelagic spawners and therefore do not exhibit substrate dependency, and considering the mobile nature of the receptors, the magnitude of impact from mortality and potential mortal injury on spawning cod and whiting is considered to be **low** (adverse) for the temporal MDS.

127 All other Group 3 receptors do not have spawning grounds in the vicinity of the project, and are considered mobile, and therefore expected to flee from any disturbance from noise impacts. The impact magnitude for mortality and potential mortal injury on the remaining Group 3 VERs is therefore considered to be **low** (adverse) for the temporal MDS.

Potential Impact on VER Spawning Potential

128 With regards to the methodology outlined in paragraph 98 *et seq.*, the potential impact on the spawning potential for cod and whiting has been calculated for mortality and potential mortal injury.

129 As stated in paragraph 99, the VER spawning potential is determined by multiplying the spawning periods (hours) for the receptors by the total spawning area (across the Irish Sea). These values are tabulated for cod and whiting in Table 22.

Table 22: VER Total Spawning Potential.

VER	SPAWNING PERIOD (T)	SPAWNING AREA (A)	VER SPAWNING POTENTIAL
Cod (fleeing)	10,872 hours	9,261 km^2	100,685,592 km^2hr
Whiting (fleeing)	10,728 hours	38,721.620 km^2	415,405,539.360 km^2hr

130 To determine the percentage of the spawning potential of each receptor affected by the piling, the spatial and temporal impacts from piling are taken into consideration. As stated in paragraph 103, the 'affected spawning potential' is determined by multiplying the total piling time by the area of VER spawning grounds affected (area of overlap of noise contours of VER spawning grounds). The affected spawning potentials are provided for cod and whiting in Table 23 below.

Table 23: VER Affected Spawning Potential.

VER	TOTAL PILING TIME	AREA OF SPAWNING GROUND AFFECTED	AFFECTED SPAWNING POTENTIAL
Cod (fleeing)	896 hours	0.005 km^2	4.388 km^2hr
Whiting (fleeing)	896 hours	0.005 km^2	6.342 km^2hr

131 As stated in paragraph 104 to determine the percentage of spawning potential affected by piling noise, the affected spawning potential is expressed as a percentage of the total spawning potential for each species. These values are tabulated in Table 24 below.

Table 24: Percentage of Spawning Potential Affected.

VER	VER SPAWNING POTENTIAL	AFFECTED SPAWNING POTENTIAL	% OF SPAWNING POTENTIAL AFFECTED
Cod (fleeing)	100,685,592 km^2hr	4.388 km^2hr	0.000%
Whiting (fleeing)	415,405,539.360 km^2hr	6.342 km^2hr	0.000%

132 Using the cod Ellis *et al*. (2012) spawning ground extents which overlap the Irish Sea, and assuming a fleeing response from cod, the potential impact on spawning potential for cod from the temporal worst-case for AyM is 0.000 %.

133 Using the whiting Ellis *et al*. (2012) spawning ground extents which overlap the Irish Sea, and assuming a fleeing response from whiting, the potential impact on spawning potential for whiting from the temporal worst-case for AyM is 0.000 %.

134 It should be noted however this approach assumes that all piling will occur within the relevant spawning period which, based on the worst-case of 896 hours over 37-74 days (dependent on the WTG model) over three years is very unlikely. Given the broadscale nature of the spawning grounds, against the likely spatial extent of the spatial MDS and the duration of the temporal MDS, and the calculated impact on the identified species spawning potential, the impact magnitude for mortality and potential mortal injury is considered to be **low** (adverse) for both the spatial and temporal MDS.

Significance of Effect

135 Overall, the magnitude of the impact for Group 3 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 3 fish species which is not significant in EIA terms.

Eggs and Larvae VERs

Sensitivity

136 Sandeel, sole, mackerel, cod, plaice and whiting all have spawning grounds which overlap with the AyM array area (Volume 4, Annex 6.1 (application ref: 6.4.6.1)) and have broadscale coverage of the Irish Sea. Eggs and larvae are considered organisms of concern by Popper *et al.* (2014), due to their vulnerability, reduced mobility and small size. Taking this into consideration and given the broadscale nature of the spawning grounds, the sensitivity of eggs and larvae to mortality and potential mortal injury from underwater noise is considered to be **medium**. Thresholds of effects for eggs and larvae have been defined separately within the Popper *et al.* (2014) guidance, with damage expected to occur at 210 dB SEL_{cum} or >207 dB SPL_{peak}. Fish eggs and larvae are considered stationary receptors.

Magnitude of Impacts Resulting from the Spatial MDS

137 With regard to the spatial MDS (simultaneous piling of pin piles) the modelling results indicate that the maximum potential range for mortality and potentially mortal injury of eggs and larvae is up to 6,300 m from the NW piling location, and 4,500 m from the SE piling locations (based on $SEL_{cum}^{(static)}$).

138 Taking into consideration the overlap between the relevant spawning grounds with AyM (no overlap with the Isle of Man herring spawning grounds), the broad distribution of all the spawning grounds within the Irish Sea and more widely around the UK, the spatial magnitude mortality and potential mortal injury on eggs and larvae from piling within the array area is assessed as being **low** (adverse).

Magnitude of Impacts Resulting from the Temporal MDS

139 With regard to the temporal MDS (sequential piling of pin piles) the modelling results indicate that the maximum potential range for mortality and potentially mortal injury of eggs and larvae is up to 4,500 m from the NW location and up to 3,200 m from the SW location (based on $SEL_{cum}^{(static)}$).

140 As stated in Table 16 and Table 21, and presented in Figure 2, Figure 3, and Figure 6, sandeel, sole, mackerel, cod, plaice and whiting all have spawning grounds which overlap the AyM array area. The impact on the spawning potentials of the receptors are addressed previously in this chapter under their corresponding Popper *et al*, 2014 Groups and are therefore summarised in Table 25 below.

Table 25: Percentage of VER spawning potential affected by piling.

VER	PERCENTAGE OF SPAWNING POTENTIAL AFFECTED BY PILING
Sole	0.000%
Whiting	0.000%
Cod	0.000%
Sandeel	0.001%
Plaice	0.000%
Mackerel	0.000%

141 It should be noted that this assumes that all piling will occur within the relevant spawning period which, based on the worst-case of 896 hours over 37-74 days over three years is very unlikely. Considering the broadscale nature of the spawning grounds, and the minimal temporal overlap with the spawning periods, the temporal magnitude of mortality and potential mortal injury on eggs and larvae from piling within the array area is assessed as being **low** (adverse).

Significance of Effect

142 Overall, the magnitude of the impact for eggs and larvae has been assessed as **low** (adverse), with the sensitivity assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Shellfish VERs

Sensitivity

143 On the basis that shellfish do not possess swim bladders or other gas filled organs, it is considered that shellfish are primarily sensitive to particle motion rather than sound pressure (e.g., Popper and Hawkins, 2018). As there are currently no criteria for assessing particle motion, it is not possible to undertake a threshold-based assessment of the potential for injury to shellfish in the same way as can be done for fish. As such, a qualitative assessment of the potential for mortality or mortal injury has been made based on peer-reviewed literature.

144 Pile driving is recognised as a source particle motion, generating high levels of particle motion in the nearfield (Hazelwood and Macey, 2016) which could potentially result in injury or mortality to sensitive shellfish receptors. Impacts from particle motion are also likely to occur local to the source, with studies having demonstrated the rapid attenuation of particle motion with distance (Mueller-Blenkle *et al.* 2010). Studies on lobsters have shown no mortality effect on the species (>220 dB) (Payne *et al*. 2007). Similarly, studies of molluscs (e.g., mussels *Mytilus edulis* and periwinkles *Littorina spp.*) exposed to a single airgun at a distance of 0.5 m have shown no effects after exposure (Kosheleva, 1992). Studies of the impacts of seismic surveys on scallop species (e.g., Aguilar *et al*., 2013; Day *et al*., 2017; Przeslawski *et al*., 2018) suggest that the effects of underwater noise impacts on scallops is variable, depending on developmental stage and previous exposure to stressors. Przeslawski *et al*. (2018) noted that variability in impacts seen in that study (i.e., limited changes to population or individuals) and others such as Day *et al*. (2017) who noted adverse effects from behavioural changes may be linked to previous exposure of the studied stocks to fishing pressure or noise sources (seismic surveys in these studies). Taking this into consideration, shellfish VERs within the study area are deemed to be of local to international importance, medium vulnerability, and high recoverability. The sensitivity of these receptors to mortality and potential mortal injury from underwater noise is therefore considered to be **medium**.

Magnitude of Impacts

145 King scallop, queen scallop, Nephrops, common whelk, edible crab and lobster are known to be within the area, with the array area for AyM having a small overlap with the large scallop ground to the north of the site. Due to the commercial value and importance of scallop, brown crab, European lobster and *Nephrops* to the region, and proximity of key shellfish beds, spawning grounds and overwintering areas to the project, due consideration is given to the potential for impacts on these species from noise impacts during construction. Taking the widespread presence across UK waters into account, and the proportionately small numbers of individuals that would be affected (relative to the wider population), the magnitude of mortality and potential mortal injury on shellfish receptors is assessed as **low** (adverse).

Significance of Effect

146 Overall, the magnitude of the impact for shellfish has been assessed as **low** (adverse), with the sensitivity assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Recoverable injury

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

Group 1 VERs

Sensitivity

148 As noted previously in Table 16, Group 1 receptors (recoverable injury onset at >216dB SEL_{cum} or >213dB SPL_{peak}) are considered to be of **low** sensitivity to underwater noise.

Magnitude of Impacts Resulting from the Spatial MDS

149 With regard to the spatial MDS, the modelling results indicate that the maximum predicted range for recoverable injury of stationary Group 1 receptors is up to 3,000 m from the piling location ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 1 receptors from both locations are expected to be significantly less (<100 m) and within the immediate vicinity of the piling activity.

150 Spawning grounds for a number of Group 1 species around AyM (e.g. sole, sandeel, plaice) are widely distributed across the Irish Sea and along the western UK and therefore in the context of the wider environment, the impacts from underwater noise are considered to be of local to regional scale (local for recoverable injury based on the modelling results). Given the broadscale nature of the spawning grounds across the Irish Sea, the impact magnitude for recoverable injury is considered to be **low** (adverse) for the spatial MDS.

Magnitude of Impacts Resulting from the Temporal MDS

151 With regard to the temporal MDS, the modelling results indicate that the maximum predicted range for recoverable injury of stationary Group 1 receptors is up to 2,000 m from the NW location and 1,500 m from the SE location ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 1 receptors are expected to be significantly less (<100 m) and within the immediate vicinity of the piling activity.

152 With regard to the temporal MDS, the percentages of spawning periods potentially impacted from piling of pin piles are presented in Table 25. This assumes that all piling will occur within the relevant spawning period which, based on the worst-case 896 hours over 37-74 days (dependent on the WTG model) over three years is very unlikely.

153 Considering the broadscale nature of the spawning grounds, and the minimal temporal overlap with the spawning periods, the temporal magnitude of recoverable injury is considered to be **low** (adverse).

Impact on VER Spawning Potential

154 With regards to the methodology outlined in paragraph 98 *et seq.*, the potential impact on the spawning potential for sole, sandeel, plaice and mackerel has been calculated for recoverable injury.

155 As stated in paragraph 99, the VER spawning potential is determined by multiplying the spawning periods (hours) for the receptors by the total spawning area (across the Irish Sea). These values are tabulated for sole, sandeel, plaice and mackerel Table 26.

Table 26: VER Total Spawning Potential.

VER	SPAWNING PERIOD (T)	SPAWNING AREA (A)	VER SPAWNING POTENTIAL
Sole (fleeing)	6,552 hours	51,263 km^2	335,875,176 km^{2}hr
Sandeel (static)	8,064 hours	55,284 km^2	445,810,176 km^{2}hr
Plaice (fleeing)	8,640 hours	36,584.780 km^2	363,364,001.280 km^{2}hr
Mackerel (fleeing)	10,944 hours	33,202.120 km^2	316,092,499.200 km^{2}hr

156 To determine the percentage of the spawning potential of each receptor affected by the piling, the spatial and temporal impacts from piling are taken into consideration. As stated in paragraph 103, the 'affected spawning potential' is determined by multiplying the total piling time by the area of VER spawning grounds affected (area of overlap of noise contours of VER spawning grounds). The affected spawning potentials are provided for sole, sandeel, plaice and mackerel in Table 27 below.

Table 27: VER Affected Spawning Potential.

VER	TOTAL PILING TIME	AREA OF SPAWNING GROUND AFFECTED	AFFECTED SPAWNING POTENTIAL
Sole (fleeing)	896 hours	0.001km^2	1.759 km^{2}hr
Sandeel (static)	896 hours	5.823 km^2	5218.134 km^{2}hr
Plaice (fleeing)	896 hours	0.002 km^2	1.759 km^{2}hr
Mackerel (fleeing)	896 hours	0.002 km^2	1.759 km^{2}hr

157 As stated in paragraph 104 to determine the percentage of spawning potential affected by piling noise, the affected spawning potential is expressed as a percentage of the total spawning potential for each species. These values are tabulated in Table 28 below.

Table 28: Percentage of Spawning Potential Affected.

VER	VER SPAWNING POTENTIAL	AFFECTED SPAWNING POTENTIAL	% OF SPAWNING POTENTIAL AFFECTED
Sole (fleeing)	335,875,176 km^{2}hr	1.759 km^{2}hr	0.000%
Sandeel (static)	445,810,176 km^{2}hr	5218.134 km^{2}hr	0.001%
Plaice (fleeing)	363,364,001.280 km^{2}hr	1.759 km^{2}hr	0.000%
Mackerel (fleeing)	316,092,499.200 km^{2}hr	1.759 km^{2}hr	0.000%

158 To conclude, using the Ellis *et al*. (2012) sole spawning ground extents for the Irish Sea, based on a fleeing receptor, the potential impact on the spawning potential for sole from the temporal worst-case for AyM is 0.000%.

159 Using the sandeel spawning ground extents which overlap the Irish Sea, based on a stationary receptor, the potential impact on spawning potential for sandeel from the temporal worst-case for AyM is 0.001%.

160 Using the plaice spawning ground extents which overlap the Irish Sea, based on a fleeing receptor, the potential impact on spawning potential for plaice from the temporal worst-case for AyM is 0.000%.

161 Using the mackerel spawning ground extents which overlap the Irish Sea, based on a fleeing receptor, the potential impact on spawning potential for mackerel from the temporal worst-case for AyM is 0.000%.

162 It should be noted however this approach assumes that all piling will occur within the relevant spawning period which, based on the worst-case of 896 hours over 37-74 days (dependent on the WTG model) over three years is very unlikely. Given the broadscale nature of the spawning grounds, against the likely spatial extent of the spatial MDS and the duration of the temporal MDS, and the calculated impact on the identified species spawning potential, the impact magnitude for mortality and potential mortal injury is considered to be **low** (adverse) for both the spatial and temporal MDS.

Significance of Effect

163 Overall, the magnitude of the impact for Group 1 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 1 fish species which is not significant in EIA terms.

Group 2 VERs

Sensitivity

164 As noted previously in Table 20, Group 2 receptors (recoverable injury onset at 203dB SEL_{cum} or >207dB SPL_{peak}) are considered to be of **low** sensitivity to underwater noise.

Magnitude of Impacts Resulting from the Spatial MDS

165 With regard to the spatial MDS, recoverable injury ranges for Group 2 receptors (fleeing receptor) are predicted to be up to 120 m from the piling locations. Atlantic salmon and sea trout are thought to generally follow the coast, remaining within coastal waters rather than passing directly through the AyM site (as reviewed in the Fish and Shellfish Ecology Technical Baseline) and so are unlikely to be within range of any injurious effects from piling noise within the array area. Therefore, the magnitude of the impact to Group 2 receptors is considered to be **low** (adverse).

Magnitude of Impacts Resulting from the Temporal MDS

166 With regards the temporal MDS (piling of pin piles) the modelling results indicate that the maximum predicted range for recoverable injury of fleeing Group 2 receptors is <100m from the piling locations (SEL_{cum}-(fleeing)) within the immediate vicinity of the piling activity.

167 As stated in Table 20, Atlantic salmon and sea trout are considered unlikely to be within range of any injurious effects from piling noise. In addition, as these VERs are anticipated to be transient across the site, any temporal impacts on these receptors are anticipated to be minimal. Therefore, the magnitude of the impact to Group 2 receptors from the temporal MDS is considered to be **low** (adverse).

Significance of Effect

168 Overall, the magnitude of the impact for Group 2 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Group 3 VERs

Sensitivity

169 As noted previously in Table 21, Group 3 receptors (recoverable injury onset at 203dB SEL_{cum} or >207dB SPL_{peak}) are considered to be of **medium** sensitivity to underwater noise.

Magnitude of Impacts Resulting from the Spatial MDS

170 With regard to the spatial MDS (simultaneous piling of pin piles), the modelling results indicate that the maximum predicted range for recoverable injury of stationary Group 3 receptors is up to 12,000 m from the piling locations (SEL_{cum}(static)). Noise impacts on fleeing Group 3 receptors are expected to be significantly less (120 m) and within the immediate vicinity of the piling activity.

171 Given the broadscale nature of the spawning grounds of the relevant species and the wide distribution of the other species, against the likely spatial extent of the spatial MDS, the impact magnitude for recoverable injury is considered to be **low** (adverse) for the spatial MDS.

Magnitude of Impacts Resulting from the Temporal MDS

172 With regard to the temporal MDS (sequential piling pf pin piles), the modelling results indicate that the maximum predicted range for recoverable injury of stationary Group 3 receptors is up to 9,500 m from the piling locations (SEL_{cum}(static)). Noise impacts on fleeing Group 3 receptors are expected to be significantly less (< 100 m) and within the immediate vicinity of the piling activity.

173 The temporal impacts on Group 3 spawning receptors (cod and whiting) spawning periods are provided in Table 25. The magnitude of impact on the receptors was deemed to be **low** (adverse) for the temporal MDS.

Impact on VER Spawning Potential

174 With regards to the methodology outlined in paragraph 98 *et seq.*, the potential impact on the spawning potential for cod and whiting has been calculated for recoverable injury.

175 As stated in paragraph 99, the VER spawning potential is determined by multiplying the spawning periods (hours) for the receptors by the total spawning area (across the Irish Sea). These values are tabulated for cod and whiting Table 29.

Table 29: VER Total Spawning Potential.

VER	SPAWNING PERIOD (T)	SPAWNING AREA (A)	VER SPAWNING POTENTIAL
Cod (fleeing)	10,872 hours	9,261km^2	100,685,592 km^{2}hr
Whiting (fleeing)	10,728 hours	38,721.620 km^2	415,405,539.360 km^{2}hr

176 To determine the percentage of the spawning potential of each receptor affected by the piling, the spatial and temporal impacts from piling are taken into consideration. As stated in paragraph 103, the 'affected spawning potential' is determined by multiplying the total piling time by the area of VER spawning grounds affected (area of overlap of noise contours of VER spawning grounds). The affected spawning potentials are provided for cod and whiting in Table 30 below.

Table 30: VER Affected Spawning Potential.

VER	TOTAL PILING TIME	AREA OF SPAWNING GROUND AFFECTED	AFFECTED SPAWNING POTENTIAL
Cod (fleeing)	896 hours	0.007 km^2	6.342 km^{2}hr
Whiting (fleeing)	896 hours	0.007 km^2	6.342 km^{2}hr

177 As stated in paragraph 104 to determine the percentage of spawning potential affected by piling noise, the affected spawning potential is expressed as a percentage of the total spawning potential for each species. These values are tabulated in Table 31 below.

Table 31: Percentage of Spawning Potential Affected.

VER	VER SPAWNING POTENTIAL	AFFECTED SPAWNING POTENTIAL	% OF SPAWNING POTENTIAL AFFECTED
Cod (fleeing)	100,685,592 km^2hr	6.342 km^2hr	0.000%
Whiting (fleeing)	415,405,539.360 km^2hr	6.342 km^2hr	0.000%

178 Using the cod spawning ground extents (Ellis *et al*, 2012) which overlap the Irish Sea, based on a fleeing receptor, the potential impact on spawning potential for cod from the temporal worst-case for AyM is 0.000%.

179 Using the whiting spawning ground extents (Ellis *et al*, 2012) which overlap the Irish Sea, based on a fleeing receptor, the potential impact on spawning potential for whiting from the temporal worst-case for AyM is 0.000%.

180 Given the broadscale nature of the spawning grounds, against the likely spatial extent of the spatial MDS and the duration of the temporal MDS, and the calculated impact on the identified species spawning potential, the impact magnitude for mortality and potential mortal injury is considered to be **low** (adverse) for both the spatial and temporal MDS.

Significance of Effect

181 Overall, the magnitude of the impact for Group 3 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 3 fish species which is not significant in EIA terms.

Eggs and larvae

Sensitivity

182 As noted previously, eggs and larvae are considered to be of **medium** sensitivity to underwater noise. Under the Popper *et al*. (2014) criteria, there is not a numerical threshold for recoverable injury for eggs and larvae, but rather recommends a qualitative risk assessment approach for assessment, with a moderate risk in the near field and a low risk for intermediate and far field effects.

Magnitude of Impacts

183 Due to the overlap between the AyM array area and identified spawning grounds, there is the potential for moderate impacts to eggs and larvae in the near field. However, for all relevant species, any impacts would be to a very small proportion of the overall spawning ground. Considering the broad distribution of relevant spawning grounds within the Irish Sea and more widely within UK waters, the small scale of any effect and the proportionally small impact on any spawning grounds, the magnitude of effect on eggs and larvae from piling is assessed as being **low** (adverse).

Significance of Effect

184 Overall, the magnitude of the impact for eggs and larvae has been assessed as **low** (adverse), with the sensitivity assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Shellfish VERs

Sensitivity

185 As stated in paragraph 143, there are no criteria for shellfish sensitivity to noise at levels that may result in recoverable injury, and therefore, a qualitative assessment has been undertaken based on published literature. On the basis that shellfish do not possess swim bladders or other gas filled organs, it is considered that shellfish are primarily sensitive to particle motion rather than sound pressure (e.g., Popper and Hawkins, 2018). Pile driving is recognised as a source particle motion, generating high levels of particle motion in the nearfield (Hazelwood and Macey, 2016), and as a result shellfish are considered to be of **medium** sensitivity to underwater noise impacts.

Magnitude of Impact

186 As detailed in paragraph 144, it is understood that particle motion attenuates rapidly, and therefore impacts on shellfish from particle motion are likely to occur locally to the source. Taking this into account, and the broad distribution of these species within the Irish Sea and along UK coasts, the magnitude of impact on shellfish is considered to be **low** (adverse).

Significance of Effect

187 Overall, the magnitude of the impact for shellfish has been assessed as **low** (adverse), with the sensitivity assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Temporary threshold shift/hearing damage

188 Temporary threshold shift (TTS) is a temporary reduction in hearing sensitivity caused by exposure to intense sound. TTS has been demonstrated in some fishes, resulting from temporary changes in sensory hair cells of the inner ear and/or damage to auditory nerves. However, sensory hair cells are constantly added to fishes and are replaced when damaged and therefore the extent of TTS is of variable duration and magnitude. Normal hearing ability returns following cessation of the noise causing TTS, though this period is variable. When experiencing TTS, fish may have decreased fitness due to a reduced ability to communicate, detect predators or prey, and/or assess their environment. Volume 4, Annex 6.1(application ref: 6.4.6.1) presents the ranges at which TTS in fish may occur as a result of piling operations during the AyM construction phase and these are drawn upon in the following assessment.

Group 1 VERs

Sensitivity

189 As noted previously in Table 16, Group 1 VERs (TTS onset at >>186dB SEL_{cum}) are considered to be of **low** sensitivity to underwater noise.

Magnitude of Impacts Resulting from the Spatial MDS

190 With regard to the spatial MDS, the modelling results indicate that the maximum predicted range for TTS of stationary Group 1 receptors is up to 36,000 m from the piling locations ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 1 receptors are expected to be significantly less (17,000 m).

191 Spawning grounds for a number of Group 1 species within the study area (e.g., sole, sandeel, plaice and mackerel) are widely distributed across the Irish Sea and along the western UK and therefore in the context of the wider environment, the impacts from underwater noise are considered to be of local to regional scale in the context of the wider environment and the spawning grounds.

Magnitude of Impacts Resulting from the Temporal MDS

192 With regard to the temporal MDS (sequential piling of pin piles), the modelling results indicate that the maximum predicted range for TTS of stationary Group 1 receptors is up to 31,000 m from the piling locations ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 1 receptors are expected to be significantly less (13,000 m).

193 The total piling time for the array is 896 hours over a three-year construction period. The percentages of spawning periods potentially affected for these receptors are presented in Table 25.

Impact on VER Spawning Potential

194 In line with the methodology outlined in paragraph 98 *et seq.*, the potential impact from the temporal worst case on the spawning potential for sole, sandeel, plaice and mackerel have been calculated, assuming TTS contours would result in loss of spawning potential to give context to the timing impacts identified.

195 As stated in paragraph 99, the VER spawning potential has been determined for sole, sandeel, plaice and mackerel by multiplying the spawning periods (hours) for the receptors by the total spawning area (across the Irish Sea). These values are tabulated below in Table 32.

Table 32: VER Total Spawning Potential.

VER	SPAWNING PERIOD (T)	SPAWNING AREA (A)	VER SPAWNING POTENTIAL
Sole (feeling)	6,552 hours	51,263 km^2	335875176 km^{2}hr
Sandeel (static)	8,064 hours	55,284 km^2	445,810,176 km^{2}hr
Plaice (fleeing)	8,640 hours	36,584.780 km^2	316,092,499.200 km^{2}hr
Mackerel (fleeing)	10,944 hours	33,202.120 km^2	363,364,001.280 km^{2}hr

196 To determine the percentage of the spawning potential of each receptor affected by the piling, the spatial and temporal impacts from piling are taken into consideration. As stated in paragraph 103, the 'affected spawning potential' is determined by multiplying the total piling time by the area of VER spawning grounds affected (area of overlap of noise contours of VER spawning grounds). The affected spawning potentials are provided for sole, sandeel, plaice and mackerel in Table 33 below.

Table 33: VER Affected Spawning Potential.

VER	TOTAL PILING TIME	AREA OF SPAWNING GROUND AFFECTED	AFFECTED SPAWNING POTENTIAL
Sole (fleeing)	896 hours	452 km^2	138,880 km^2hr
Sandeel (static)	896 hours	1,828.794 km^2	1,638,599.424 km^2hr
Plaice (fleeing)	896 hours	452 km^2	138,880 km^2hr
Mackerel (fleeing)	896 hours	452 km^2	138,880 km^2hr

197 As stated in paragraph 104 to determine the percentage of spawning potential affected by piling noise, the affected spawning potential is expressed as a percentage of the total spawning potential for each species. These values are tabulated in Table 34 below.

Table 34: Percentage of Spawning Potential Affected.

VER	VER SPAWNING POTENTIAL	AFFECTED SPAWNING POTENTIAL	% OF SPAWNING POTENTIAL AFFECTED
Sole (fleeing)	335875176 km^2hr	138,880 km^2hr	0.121%
Sandeel (static)	445,810,176 km^2hr	1,638,599.424 km^2hr	0.368%

VER	VER SPAWNING POTENTIAL	AFFECTED SPAWNING POTENTIAL	% OF SPAWNING POTENTIAL AFFECTED
Plaice (fleeing)	316,092,499.200 km^2hr	138,880 km^2hr	0.044%
Mackerel (fleeing)	363,364,001.280 km^2hr	138,880 km^2hr	0.033%

198 Using the Ellis *et al.* (2012) sole spawning ground extents for the Irish Sea, and assuming a fleeing receptor, the potential impact on the spawning potential for sole from the temporal worst-case for AyM is 0.121%.

199 Using the sandeel spawning grounds extents which overlap the Irish Sea, and assuming a stationary receptor, the potential impact on spawning potential for plaice from the temporal worst-case for AyM is 0.368%.

200 Using the plaice spawning grounds extents which overlap the Irish Sea, and assuming a fleeing receptor, the potential impact on spawning potential for plaice from the temporal worst-case for AyM is 0.044%.

201 Using the mackerel spawning grounds extents which overlap the Irish Sea, and assuming a fleeing receptor, the potential impact on spawning potential for plaice from the temporal worst-case for AyM is 0.033%.

202 This assumes that all piling will occur within the relevant spawning period which, based on the worst-case of 896 hours over 37-74 days (dependent on the WTG model) over three years which to know how long is very unlikely.

203 Given the broadscale nature of the spawning grounds, against the likely spatial extent of the spatial MDS and the duration of the temporal MDS, and the calculated impact on the identified species spawning potential, the impact magnitude for TTS is considered to be **low** (adverse) for both the spatial and temporal MDS.

Significance of Effect

204 Overall, the magnitude of the impact for Group 1 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 1 fish species which is not significant in EIA terms.

Group 2 VERs

Sensitivity

205 As noted previously in Table 20, Group 2 receptors (TTS onset at >186dB SEL_{cum}) are considered to be of **low** sensitivity to underwater noise.

Magnitude of Impacts Resulting from the Spatial MDS

206 With regard to the spatial MDS, the modelling results indicate that the maximum predicted range for TTS of stationary Group 2 receptors is up to 36,000 m from the piling locations ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 2 receptors are expected to be significantly less (17,000 m).

207 Atlantic salmon and sea trout are thought to generally follow the coast, remaining within coastal waters rather than passing directly through the AyM site. There is a degree of uncertainty regarding the route taken by these species on migration and also there is uncertainty as to their reaction to underwater noise impacts measured as sound energy (SEL_{cum}) when considered to be most sensitive to particle motion. This reduced sensitivity to sound energy/pressure for this group (compared to Group 3), is reflected in the Popper *et al.* (2014) thresholds which states that TTS onset will occur at sound levels greater than 186 dB SEL_{cum} and as such, it should not be assumed that the contours modelled for the 186dB SEL_{cum} threshold are representative of potential impacts (including blocking effects) to Atlantic salmon and sea trout. Rather that area of effect will be smaller (and potentially significantly smaller) than that shown in the modelling.

208 Finally, a key consideration where large ranges are modelled is the change in the characteristics of underwater noise from an impulsive sound (which has a rapid rise time and more pronounced peak pressures) to non-impulsive (also called continuous) sound, with these different sound types having the potential for differing scales of effects. Typically, non-impulsive sounds are thought to result in impacts to marine organisms at higher sound levels, with this reflected in differing thresholds for the sound types (e.g., reviewed in Popper *et al*., 2014). Piling noise is thought to change to less impulsive characteristics within 5 – 10 km of the sound source (Hastie *et al*., 2019) and as such, there is the potential that impacts assuming an impulsive sound beyond this point significantly overestimates the true effect area.

209 Whilst the modelling (see Figure 8 and Figure 9) shows that the TTS onset contour reaches the coast to the west and south of the AyM site, the resolution of the modelling is such that small scale changes to sound propagation within the shallows (where there is rapid attenuation of underwater noise), which some sources suggest may be important to salmon migrations, are likely missed. This, combined with the uncertainties and conservatisms as discussed in paragraph 207, suggests that the received sound levels within the shallows would be much lower.

210 Furthermore, when fish are involved in key biological behaviours (e.g., feeding or spawning), the response to external (potentially adverse) stimulus is reduced (Skaret *et al*., 2005), with migratory instincts expected to be similarly strong biological drivers so as to override any potential deterrence effects from underwater noise. Wardle *et al*. (2001) noted that even where fish were startled by an air gun source initially, where the sound source was not visible the fish returned to the original swim path following initial reaction. This suggests that even if migratory fish were momentarily startled by piling noise, migration would continue either immediately or following cessation of the noise.

211 Therefore, when considering the above, the magnitude of the impact to Group 2 receptors is considered to be **low** (adverse).

Magnitude of Impacts Resulting from the Temporal MDS

212 With regard to the temporal MDS (piling of pin piles), the modelling results indicate that the maximum predicted range for TTS of stationary Group 2 receptors is up to 31,000 m from the piling locations ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 2 receptors are expected to be significantly less (13,000 m).

213 As stated in Table 20, Atlantic salmon and sea trout are considered unlikely to be within range of any injurious effects from piling noise. In addition, as these VERs are anticipated to be transient across the site, any temporal impacts on these receptors are anticipated to be minimal. Therefore, the magnitude of the impact to Group 2 receptors from the temporal MDS is considered to be **low** (adverse).

Significance of Effect

214 Overall, the magnitude of the impact for Group 2 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Group 3 VERs

Sensitivity

215 As noted previously in Table 21, Group 3 receptors (TTS onset at 186dB SEL_{cum}) are considered to be of **medium** sensitivity to underwater noise.

Magnitude of Impacts Resulting from the Spatial MDS

216 With regard to the spatial MDS, the modelling results indicate that the maximum predicted range for TTS of stationary Group 3 receptors is up to 36,000 m from the piling locations ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 3 receptors are expected to be significantly less (17,000 m).

217 The spawning grounds for a number of the Group 3 species overlap with the predicted TTS onset contours (Figure 10 and Figure 11). It should be noted that TTS in fish is completely recoverable and whether there are adverse ecological consequences to the individual from TTS is uncertain (i.e., it is not known whether the TTS would affect an ecologically relevant part of the hearing spectrum). It is likely that the predicted area for TTS onset is extremely conservative. Given the broadscale nature of the spawning grounds of the relevant species and the wide distribution of the other species, against the likely spatial extent of the spatial MDS, the impact magnitude for TTS is considered to be **low** (adverse) for the spatial MDS.

Magnitude of Impacts Resulting from the Temporal MDS

218 With regard to the temporal MDS (piling of pin piles), the modelling results indicate that the maximum predicted range for TTS of stationary Group 3 receptors is up to 31,000 m from the piling locations ($SEL_{cum}^{(static)}$). Noise impacts on fleeing Group 3 receptors are expected to be significantly less (13,000 m).

219 The temporal impacts on the spawning Group 3 receptors (cod and whiting) spawning periods are presented in Table 25. The magnitude of impact on the receptors was deemed to be **low** (adverse) for the temporal MDS.

Impact on VER Spawning Potential

220 In line with the methodology outlined in paragraph 98 *et seq.*, the potential impact from the temporal worst case on the spawning potential for cod and whiting have been calculated, assuming TTS contours would result in loss of spawning potential to give context to the timing impacts identified.

221 The VER spawning potential has been determined for cod and whiting by multiplying the spawning periods (hours) for the receptors by the total spawning area (across the Irish Sea). These values are tabulated below in Table 35.

Table 35: VER Total Spawning Potential.

VER	SPAWNING PERIOD (T)	SPAWNING AREA (A)	VER SPAWNING POTENTIAL
Cod (fleeing)	10,872 hours	9,261 km^2	100,685,592 km^2hr
Whiting (fleeing)	10,728 hours	38,721.620 km^2	415,405,539.360 km^2hr

222 To determine the percentage of the spawning potential of each receptor affected by the piling, the spatial and temporal impacts from piling are taken into consideration. The 'affected spawning potential' for cod and whiting is determined by multiplying the total piling time by the area of VER spawning grounds affected (area of overlap of noise contours of VER spawning grounds). The affected spawning potentials are provided for cod and whiting in Table 36 below.

Table 36: VER Affected Spawning Potential.

VER	TOTAL PILING TIME	AREA OF SPAWNING GROUND AFFECTED	AFFECTED SPAWNING POTENTIAL
Cod (fleeing)	896 hours	452 km^2	404,992 km^2hr
Whiting (fleeing)	896 hours	452 km^2	138,880 km^2hr

223 As stated in paragraph 104 to determine the percentage of spawning potential affected by piling noise, the affected spawning potential is expressed as a percentage of the total spawning potential for each species. These values are tabulated in Table 37 below.

Table 37: Percentage of Spawning Potential Affected.

VER	VER SPAWNING POTENTIAL	AFFECTED SPAWNING POTENTIAL	% OF SPAWNING POTENTIAL AFFECTED
Cod (fleeing)	100,685,592 km^2hr	404,992 km^2hr	0.402%
Whiting (fleeing)	415,405,539.360 km^2hr	138,880 km^2hr	0.033 %

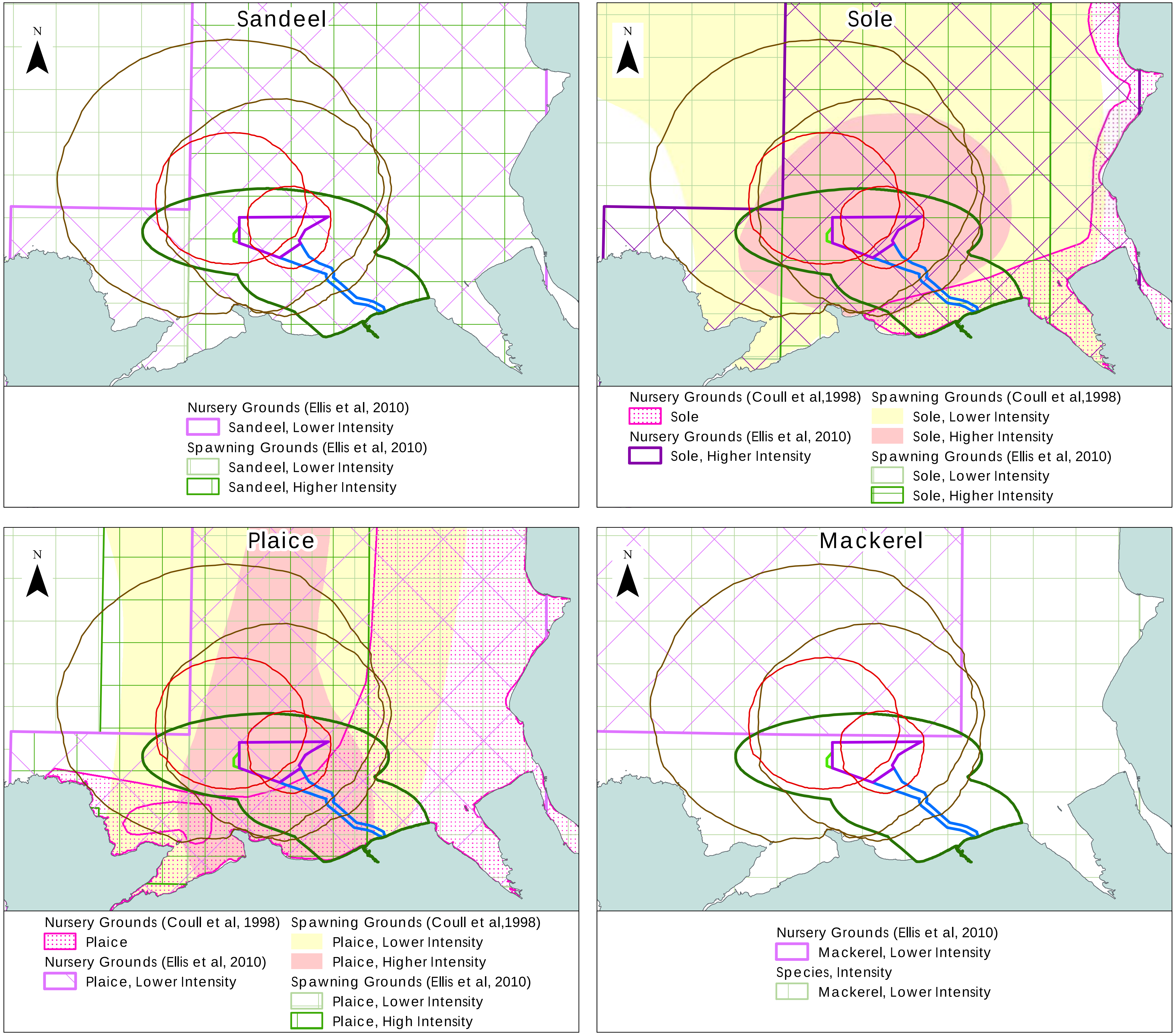
224 Using the Ellis *et al*. (2012) cod spawning ground extents for the Irish Sea, and assuming a fleeing receptor, the potential impact on the spawning potential for cod from the temporal worst-case for AyM is 0.402%.

225 Using the Ellis *et al*. (2012) whiting spawning ground extents for the Irish Sea, and assuming a fleeing receptor, the potential impact on the spawning potential for whiting from the temporal worst-case for AyM is 0.033%.

226 Given the broadscale nature of the spawning grounds, against the likely spatial extent of the spatial MDS and the duration of the temporal MDS, and the calculated impact on the identified species spawning potential, the impact magnitude for TTS is considered to be low (adverse) for both the spatial and temporal MDS.

Significance of Effect

227 Overall, the magnitude of the impact for Group 3 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 3 fish species which is not significant in EIA terms.



LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Sedimentary Zone of Influence
- 186dB Noise Contour (Fleeing)
- 186dB Noise Contour (Stationary)

0 10 20 40
Kilometres

Data Source:
Spawning and Nursery Grounds data from Centre for Environment, Fisheries and Aquaculture Science (Cefas)

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

186dB contour for the relevant fish spawning grounds

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	RM
2	24/01/2022	For Issue For ES	BPHB	AL

FIGURE NUMBER:

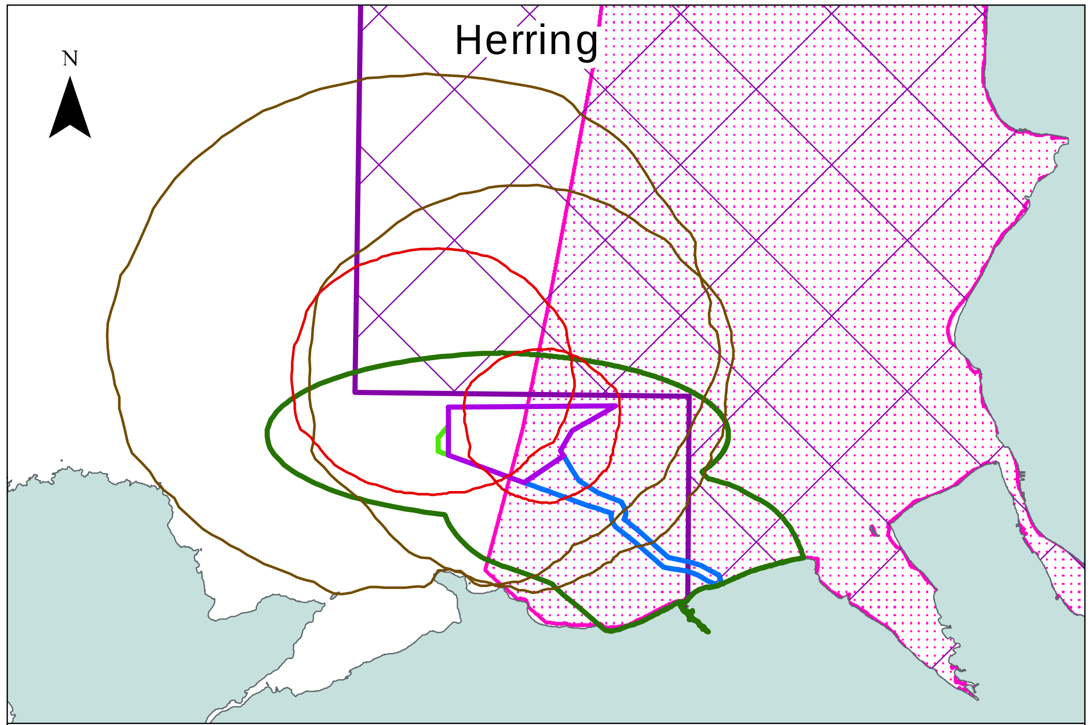
Figure 10

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:750,000	A3	WGS84	UTM30N

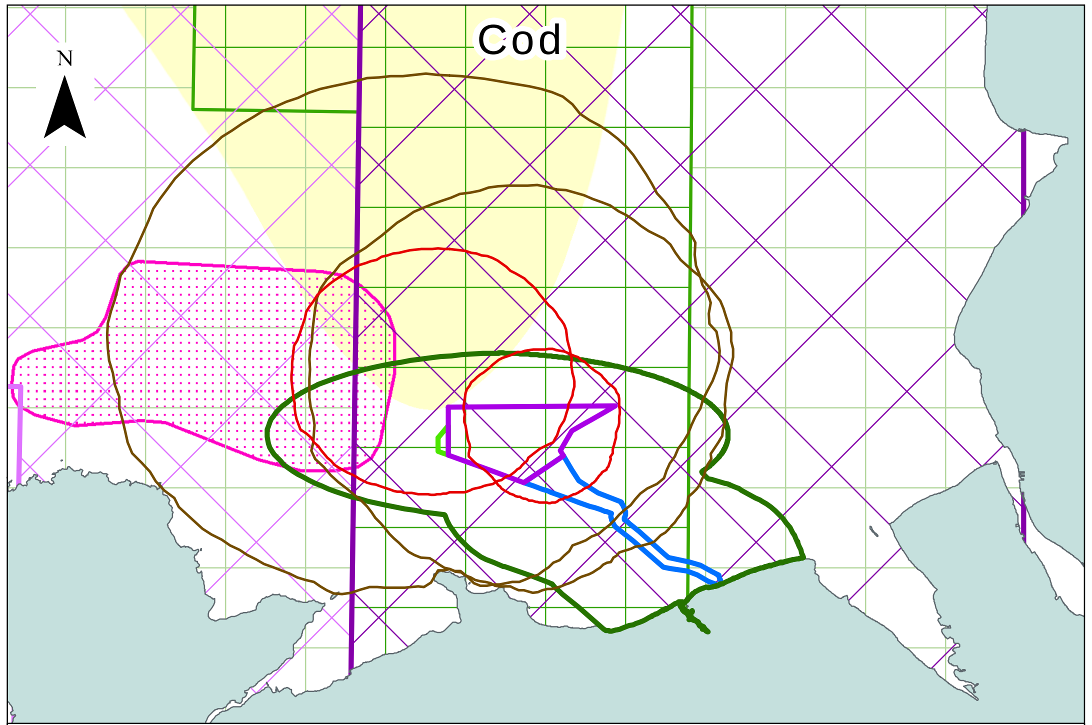
Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

Service Layer Credits:

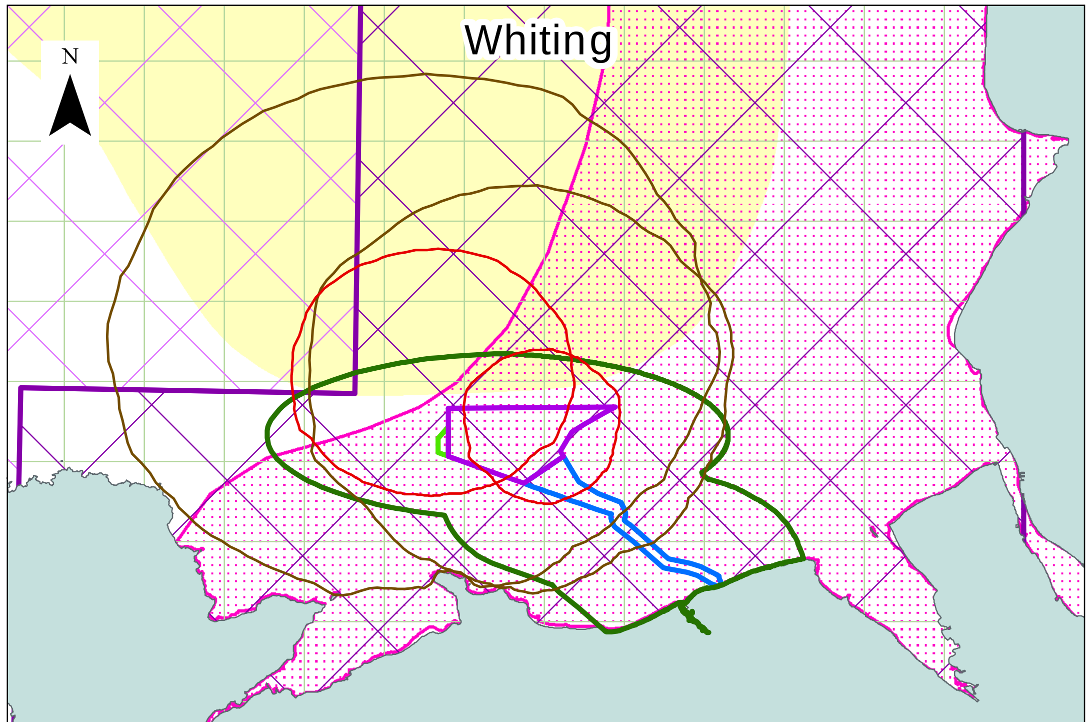
G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig10_186dB_Spawning_Grounds_1.mxd



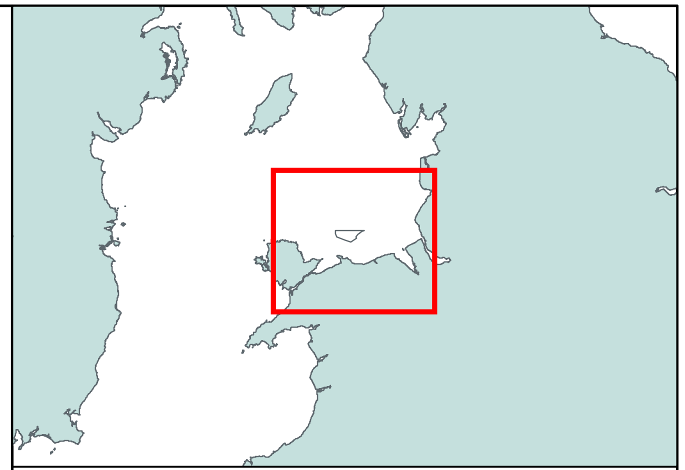
Nursery Grounds (Coull et al, 1998)
Herring
Spawning Grounds (Coull et al,1998)
Herring, Lower Intensity
Nursery Grounds (Ellis et al, 2010)
Herring, Higher Intensity



Nursery Grounds (Coull et al, 1998)
Cod
Spawning Grounds (Coull et al,1998)
Cod, Lower Intensity
Nursery Grounds (Ellis et al, 2010)
Cod, Lower Intensity
Cod, Higher Intensity
Spawning Grounds (Ellis et al, 2010)
Cod, Lower Intensity
Cod, Higher Intensity



Nursery Grounds (Coull et al, 1998)
Whiting
Spawning Grounds (Coull et al,1998)
Whiting, Lower Intensity
Nursery Grounds (Ellis et al, 2010)
Whiting, Lower Intensity
Whiting, Higher Intensity
Spawning Grounds (Ellis et al, 2010)
Whiting, Lower Intensity



LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- Sedimentary Zone of Influence
- 186dB Noise Contour (Fleeing)
- 186dB Noise Contour (Stationary)

0 10 20 40
Kilometres

Data Source:
Spawning and Nursery Grounds data from Centre for Environment, Fisheries and Aquaculture Science (Cefas)

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE: 186dB contour for the relevant fish spawning grounds

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	RM
2	24/01/2022	For Issue For ES	BPHB	AL

FIGURE NUMBER:

Figure 11

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:750,000	A3	WGS84	UTM30N

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

Service Layer Credits:

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig11_186dB_Spawning_Grounds_2.mxd

Eggs and larvae VERs

Sensitivity

228 As noted previously, eggs and larvae are considered to be of **medium** sensitivity to underwater noise. Under the Popper *et al*. (2014) criteria, there is not a numerical threshold for TTS for eggs and larvae, but rather recommends a qualitative risk assessment approach for assessment, with a moderate risk in the near field and a low risk for intermediate and far field effects.

Magnitude of Impacts

229 Due to the overlap between the AyM array area and identified spawning grounds, there is the potential for moderate impacts to eggs and larvae in the near field. However, for all relevant species, any impacts would be to a very small proportion of the overall spawning ground. Considering the broad distribution of relevant spawning grounds within the Irish Sea and more widely within UK waters, the small scale of any effect, the likely reduced ecological consequences of TTS to larvae, and the proportionally small impact on any spawning grounds, the magnitude of effect on eggs and larvae from piling is assessed as being **low** (adverse).

Significance of Effect

230 Overall, the magnitude of the impact for eggs and larvae has been assessed as **low** (adverse), with the sensitivity assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Shellfish VERs

Sensitivity

231 As stated in paragraph 143, there are no criteria for shellfish sensitivity to noise at levels that may result in TTS, and therefore, a qualitative assessment has been undertaken based on published literature. On the basis that shellfish do not possess swim bladders or other gas filled organs, it is considered that shellfish are primarily sensitive to particle motion rather than sound pressure (e.g., Popper and Hawkins, 2018). Pile driving is recognised as a source of particle motion, generating high levels of particle motion in the nearfield (Hazelwood and Macey, 2016). As the understanding of marine invertebrate sensitivity to particle motion is in its infancy (Lewandowski *et al.* 2016), there is limited information available on the potential for hearing damage on shellfish from particle motion. However, a study by Zhang *et al*. (2015) did suggest that severe particle motion could irreparably damage the statocysts of cephalopods at short range, causing hearing impairment. This was considered likely to occur as a result of pile driving, although thought to only occur at short range. As a result, shellfish are considered to be of **medium** sensitivity to underwater noise impacts.

Magnitude of Impact

232 As detailed in paragraph 144, it is understood that particle motion attenuates rapidly, and therefore impacts on shellfish from particle motion are likely to occur local to the source. Taking this into account, and the broad distribution of these species within the Irish Sea and along UK coasts, the magnitude of impact on shellfish is considered to be **low** (adverse).

Significance of Effect

233 Overall, the magnitude of the impact for shellfish has been assessed as **low** (adverse), with the sensitivity assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Behavioural impacts

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

235 There are no quantitative thresholds advised to be used to assess behavioural impacts, however, Popper *et al.* (2014) provide qualitative behavioural criteria for fish from a range of sources. These categorise the risks of effects in relative terms as 'high, moderate or low' at three distances from the source: near (10s of metres), intermediate (100s of metres), and far (1000s of metres), respectively. The behavioural criteria are summarised in Table 7 of Volume 4, Annex 6.2 (application ref: 6.4.6.2)

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

Group 1 VERs

Sensitivity

237 As noted previously in Table 16, Group 1 receptors are considered to be of **low** sensitivity to underwater noise.

Magnitude of Impact

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

Significance of Effect

239 Overall, the magnitude of the impact for Group 1 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 1 fish species which is not significant in EIA terms.

Group 2 VERs

Sensitivity

240 As noted previously in Table 20, Group 2 receptors are considered to be of **low** sensitivity to underwater noise.

Magnitude of Impact

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

Significance of Effect

242 Overall, the magnitude of the impact for Group 2 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 2 fish species which is not significant in EIA terms.

Group 3 VERs

Sensitivity

243 As noted previously in Table 21, Group 3 receptors are considered to be of **medium** sensitivity to underwater noise.

Magnitude of Impact

244 Spawning grounds for a number of Group 3 species overlap with the AyM site or are within the wider area (including herring spawning around the Isle of Man). Whilst the Popper *et al*. (2014) criteria suggest a high risk of behavioural disturbance in the intermediate field and a moderate risk in the far field, the risk assessment is likely to predicated on the individuals not being involved in activities with a strong biological driver (i.e., spawning or feeding). Specifically, Skaret *et al*. (2005) identified that herring (a Group 3 species), had a significantly reduced reaction to external stimulus when involved in spawning activity than when swimming. As such, it is likely that any behavioural impacts to fish would be significantly reduced when spawning, with consequently limited impact on spawning potential for the relevant species. Whilst there is a paucity of evidence on migratory behaviour of European eel, it is possible that migration would be an equally strong biological driver, with similar damping of behavioural reactions. Taking this into consideration, the magnitude of impact on Group 3 species is considered to be **low** (adverse).

Significance of Effect

245 Overall, the magnitude of the impact for Group 3 species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** for all Group 3 fish species which is not significant in EIA terms.

Eggs and larvae

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

Shellfish VERs

Sensitivity

247 As stated in paragraph 143, there are no criteria for shellfish sensitivity to noise, and therefore, a qualitative assessment has been undertaken based on published literature. Shellfish are considered a potential sensitive receptor to particle motion from piling, due to typically having low motility, and therefore are considered unlikely to be able to vacate the area at the onset of 'soft-start piling'; Roberts (2015) suggested that vibroacoustic stimuli may elicit and affect anti-predator responses, such as startle response in crabs and valve closure in mussels. Such responses would effectively be distractions from routine activities such as feeding. Behavioural changes in mussels have also been observed in response to simulated pile-driving, with increased filtration rates observed in blue mussels (Spiga *et al*., 2016). In addition to this, Samson *et al*. (2016) recorded a range of behavioural responses to underwater noise in cephalopods, including inking, colour changes and startle responses. Taking this into consideration, shellfish were considered to be of **medium** sensitivity to underwater noise impacts.

Magnitude of Impact

248 As detailed in paragraph 144, it is understood that particle motion attenuates rapidly, and therefore impacts on shellfish from particle motion are likely to occur local to the source. Taking this into account, and the broad distribution of these species within the Irish Sea and along UK coasts, the magnitude of impact on shellfish is considered to be **low** (adverse).

Significance of Effect

249 Overall, the magnitude of the impact for shellfish has been assessed as **low** (adverse), with the sensitivity assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Noise and vibration arising from cofferdam installation

250 As part of the landfall works, it may be necessary to install a cofferdam at the trenchless installation technique exit location seaward of MHWS. The cofferdam structure will be constructed from sheet piles which may be installed using percussive piling or vibropiling techniques. For the purposes of the potential impacts from noise and vibrations, percussive piling would result in the greatest impacts and so the focus of the following assessment is based on that technique.

Sensitivity

251 The maximum sensitivity of fish and shellfish receptors to underwater noise effects is **medium**.

Magnitude of Impact

252 The cofferdam will be situated up to 1,000 m seaward of MHWS. The current expectation is that the cofferdams may be installed either by a piling rig on an excavator (i.e., during low tide) or from a jack-up barge (i.e., either during high or low tide).

253 The noise from percussive piling for the cofferdams will, by the very nature of the activity (sheet piles, shallow target depth, low hammer energies), be of a much-reduced magnitude compared to that for foundation piling considered above. As such, it is assessed separately herein, with specific underwater noise modelling informing the assessment of potential impacts.

254 The noise modelling for cofferdam installation assumed the cofferdam is at 1,000 m from MHWS to result in the greatest propagation. The duration to install one sheet pile, including a soft start and ramp up was modelled as 60 minutes, with a maximum installation of eight piles per day.

255 The modelling (assuming piling at high water; i.e. deepest water) demonstrates that the risk of mortality is within 100 m from the piling location for fleeing and stationary receptors, with recoverable injury for a stationary receptor (Group 2 and Group 3; 203 dB SEL_{cum}) at up to 160 m from the piling location and TTS for a stationary receptor (186 dB SEL_{cum}) up to 1.3 km; all impact ranges for a fleeing receptor were <100 m from the piling location.

256 For the modelling at low water, all impact ranges are <100 m, with the exception of TTS for stationary receptors which extends to a maximum of 440 m from the piling location.

257 Whilst the cofferdam installation location overlaps with a number of spawning and nursery grounds for fish species in the area, this is a negligible area which may be affected by physical effects from the piling of the cofferdam compared to the area of the spawning/nursery grounds, with all physical impacts contained within the immediate (approx. 1 km) area.

258 Disturbance effects from underwater noise extend over a greater area than the physical effects (TTS and other physical injury impacts), however, currently there are no quantitative thresholds which are advised to be used for behavioural impacts (as discussed in paragraph 235), with Popper *et al*. (2014) recommending a risk assessment approach based on the sensitivity of the species to sound pressure and the distance to the sound source.

259 For the majority of fish species (excluding migratory species) identified as at risk from impacts from AyM in the area, the nearshore area which will be ensonified as a result of piling from the installation of the cofferdam is of limited importance and significant alternative habitat is available for spawning and or nursery and feeding. Therefore, displacement from this area will be extremely small scale and the duration of the impact very short-term (i.e. maximum of 8 hours of piling within a 24-hour period and installation occurring over a short period of time (days)).

260 For migratory species, only salmon use the inshore region around the cofferdam location as part of the migration route, with the other species (sea lamprey and sea trout) having a more oceanic migration route (as detailed within Volume 4, Annex 6.1 (application ref: 6.4.6.1)) (river lamprey tend not to leave the estuary mouth for their natal river and so are unlikely to be in the vicinity of the works). The cable corridor is greater than 2.5 km from any river mouth and any behavioural effects from the relatively quiet, rapidly attenuating sound source (due to the shallow waters) and short-term installation period are unlikely to result in any significant behavioural reactions at this distance.

261 Atlantic salmon on migration are thought to generally follow the coast and are therefore likely to occur within coastal waters rather than passing directly through the AyM site. Whilst the cofferdam works, with relatively high source levels could be along the migration route for the salmon following the coast from the west of the Dee Estuary, the associated piling will be short-term (days) and intermittent during the installation period. As such, a few days of noise within a localised area, which a highly mobile species such as salmon is capable of swimming around or may even continue to migrate through due to the strength of the biological driver to migrate overriding any avoidance reaction (e.g., Skaret *et al*. (2005)), will not result in anything more than a temporary, localised and non-physical barrier to migration. Even if a number of individuals are temporarily blocked during the period of the works, they can be expected to recommence migration towards the estuary following the cessation of the piling (e.g., Wardle *et al*. (2001) demonstrated that after an initial startle reaction to a noise source, fish returned to their original path).

262 As detailed in paragraph 144, it is understood that particle motion attenuates rapidly, and therefore impacts on shellfish from particle motion are likely to occur local to the source.

263 Taking this into account, the localised nature of the impact, and the broadscale distribution of the VERs across the Irish Sea, the magnitude of the impact is deemed to be **low** (adverse).

Significance of Effect

264 The maximum sensitivity of fish and shellfish receptors to underwater noise effects is **medium**. The magnitude of effect has been assessed as **low** (adverse). The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

Noise and vibration arising from UXO clearance

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

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

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

268 Injury and disturbance effects will impact a progressively larger area, with TTS and disturbance effects potentially reaching 10's of kilometres from the UXO location.

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

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

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

6.10.2 Temporary increase in SSC and sediment deposition

272 Temporary localised increases in suspended sediment concentration (SSC) and associated sediment deposition and smothering are expected from foundation and cable installation works (including HDD installation) and seabed preparation works (including sandwave clearance). This assessment should be read in conjunction with Volume 2, Chapter 2 (application ref: 6.2.2) and Volume 4, Annex 2.1 (application ref: 6.4.2.1) which provides the detailed offshore physical environment assessment (including project specific modelling of sediment plumes).

Magnitude of impact

273 Background surface SSCs are known to vary seasonally between 1.25 mg/l – 5 mg/l. Surface turbidity (represented by suspended particulate matter (SPM)) is relatively low across the offshore array area, with monthly averaged concentrations typically less than 5 mg/l across the whole year.

274 Table 10 presents the MDS associated with increases in SSC and deposition.

275 Seabed preparation for foundations, sandwave clearance for cable installation, cable trenching, drilling for foundations and spoil disposal are all predicted to result in sediment plumes and localised increases in SSC. Site-specific modelling of sediment plumes and deposition (Volume 4, Annex 2.1: Physical Processes Baseline Technical Report (application ref: 6.4.2.1)) from seabed preparation and installation activities along the proposed AyM offshore ECC, and within the offshore array area has been undertaken to quantify the potential footprint of the plumes, their longevity and the concentration of SSC as well as the subsequent deposition of plume material on the seabed.

276 In summary, sediment plumes caused by seabed preparation and installation activities are expected to be restricted to within a single tidal excursion from the point of release, with plumes expected to occur over a maximum distance of 11 – 12 km over a spring tide, from the source. This maximum dispersion is from the array area, with sediment dispersal being reduced within the ECC, with a maximum distance of 8.5 km. Sediment plumes are expected to quickly dissipate after cessation of the construction activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels (i.e., within a couple of tidal cycles). Sediment deposition will consist primarily of coarser sediments deposited close to the source (a few hundred metres), with a small proportion of silt deposition (reducing exponentially from source).

277 Release of bentonite (a non-toxic, natural clay mineral) during the trenchless installation technique punch out may result in a single, large plume of sediment in suspension into the water column. This will result in localised high levels of SSC within the nearshore, shallow waters. As presented in Volume 2, Chapter 2 (application ref: 6.2.2), the majority of the plume will be advected in the direction of the ambient tidal currents, which are broadly aligned to the coast. The direction of transport (either to the northeast or southwest) will depend on the state of the tide (flood or ebb) at the time of the release. It is expected that the plume would be dispersed to relatively low concentrations within hours of release and to background concentrations within a few tidal cycles. Due to the small grain size, it is expected that the bentonite will be diluted over time, without resulting in any notable settlement.

278 Taking the above into consideration, the impact of increased SSC and smothering from sediment deposition from construction activities is expected to be short-term, intermittent and of localised extent and reversible. The magnitude of the impact is therefore considered to be **low** (adverse).

Sensitivity of the receptor

279 The sensitivity rating assigned to each VER, and associated justification is provided in Table 38 below.

Table 38: Sensitivity of VERs to temporary increase in SSC and sediment deposition.

VER	SENSITIVITY JUSTIFICATION
Demersal spawning VERs (herring and sandeel).	Potential sandeel spawning grounds and prime and sub-prime habitats (Figure 6) are located within the ECC and the array area. However, any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the Irish Sea (maximum sediment plume dispersal extends across 1.66% of the sandeel spawning ground (Ellis et al, 2012)). Furthermore, the secondary effects of increased concentrations of SSC in the water column and smothering (from deposition of particles as a result of comparable activities such as dredging and screening of cargo), have been shown to be inconsequential to sandeel species (MarineSpace Ltd 2010). Sandeel eggs are also likely tolerant to increases in SSC and smothering from sediment deposition, due to the nature of resuspension and deposition within their natural high energy environment. Based on the species reduced sensitivity to increased SSC and deposition, sandeel are deemed to be of low vulnerability, medium recoverability and of regional importance, and therefore the sensitivity of the receptor is low. Impacts from increased SSC and sediment deposition are of greatest concern for herring eggs as smothering of the eggs may disrupt the development of the larvae, through either the sediment grains retarding growth or a reduction in oxygen availability around the eggs. The AyM site is not within a known herring spawning ground, with the spawning ground by the Isle of Man not being at

VER	SENSITIVITY JUSTIFICATION
	risk from the plumes from AyM works due to the tidal currents around AyM resulting in very limited spread of sediment plumes to the north (i.e., toward the Isle of Man). Adult herring are mobile and as such would be expected to avoid unfavourable areas. As the affected area is not a spawning ground, there would be no biological driver causing the fish to remain in the area. Taking this into consideration, herring are considered to be of low vulnerability, with high recoverability to the impact and of regional importance. Therefore, the sensitivity of the receptor to increases in SSC and sediment deposition from construction activity at AyM is low.
Pelagic spawning VERs with spawning grounds overlapping AyM (common sole, plaice, cod, whiting and mackerel).	Common sole, plaice, mackerel cod and whiting all have spawning grounds overlapping AyM. These receptors are pelagic spawners and do not exhibit substrate dependency. Therefore, sediment deposition within these spawning grounds will not result in any potential loss of available spawning habitats. These receptors are mobile, widely spread across the Irish Sea, and will experience exposure to naturally high variability to SSC within their natural range. The receptors are therefore considered to be broadly insensitive to sediment deposition. The sensitivity of these receptors to increases in SSC and sediment deposition from construction activity at AyM is considered to be low.
VERs of limited mobility (king scallop, queen scallop, Nephrops,	European lobsters are considered a key species within the area (ecologically and commercially); however, the species are not thought to exhibit a sedentary overwintering habit (as is observed in brown crab), being typically

VER	SENSITIVITY JUSTIFICATION
common whelk, edible crab and lobster)	mobile and therefore considered able to move away from sources of disturbance. Berried females are likely to be more vulnerable to increased SSC and smothering impacts as the eggs carried require regular aeration. Lobster is therefore considered to be of medium vulnerability, high recoverability and of regional importance, and therefore the sensitivity of the receptor is medium. Scallop can undertake limited swimming, although this is considered to be at a high energy cost and generally associated with predator avoidance, therefore this species is not expected to be able to travel large distances to avoid disturbance. Scallops are therefore considered to be of medium vulnerability, high recoverability (Marshall and Wilson, 2008) and of regional importance, and therefore the sensitivity of the receptor is medium. Edible crab are considered to have a high tolerance to SSC and are reported to be insensitive to short-term increases in turbidity; however, they may avoid areas of increased SSC as they rely on visual acuity during predation (Neal and Wilson, 2008). Berried female edible crab exhibit a largely sedentary lifestyle during the overwintering period whilst brooding eggs. During this time, they are considered a stationary receptor, burying themselves into soft mud and sand, and are therefore unlikely to move away from disturbances. Berried females are considered more vulnerable to smothering from sediment deposition, due to their sedentary nature at this time, and as the eggs carried require regular aeration. Taking this into account, edible crab are considered to be of high vulnerability during the overwintering period, high recoverability (Neal and

VER	SENSITIVITY JUSTIFICATION
	Wilson, 2008) and of regional importance, and therefore the sensitivity of the receptor is medium. Nephrops construct and inhabit complex burrows in environs characterised by stable mud. As with edible crab, berried females tend to be considered largely sedentary whilst brooding eggs, generally remaining within their burrows to overwinter, and are therefore unlikely to move away from disturbance. Berried females are considered more vulnerable to smothering from sediment deposition, as the eggs require regular aeration. However, since Nephrops are a burrowing species with the ability to excavate any sediment deposited within their burrows (Sabatini and Hill, 2008), they are not considered particularly vulnerable to increased SSC and smothering. Nephrops are considered to be of low vulnerability, high recoverability (Sabatini and Hill, 2008) and of regional importance, and therefore the sensitivity of the receptor is low. Common whelk are broadly distributed across the Irish Sea and are found across a range of habitats. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Therefore, taking into account their burrowing nature and their broad distribution, common whelk are therefore considered to be able to adapt to localised and short-term SSC plumes. Common whelk are considered to be of low vulnerability, high recoverability and of regional importance, and therefore the sensitivity of the receptor is low.

VER	SENSITIVITY JUSTIFICATION
Mobile VERs (thickback sole, flounder, dab, solenette, scaldfish, elasmobranchs, river and sea lamprey, Atlantic salmon, sea trout, Sprat, ling, hake, European eel, allis and twaite shad, smelt, haddock, horse mackerel, common dragonet, anglerfish, pogge, sand goby and poor cod).	All other identified VERs are mobile, and widespread throughout the Irish Sea and will experience exposure to naturally high variability to SSC within their natural range, with no substrate dependence for spawning. Therefore, the sensitivity of all other fish species is considered to be low.

Significance of effect

280 Increases in SSC and sediment deposition will represent a temporary and short-term intermitted impact, with a highly localised impact, affecting a small proportion of the fish and shellfish habitats within the study area.

281 Overall, the magnitude of the impact for all fish species has been assessed as **low** (adverse), with the maximum sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor significance*** for all fish species which is not significant in EIA terms.

282 The magnitude of the impact on shellfish species has been assessed as **low** (adverse), with the sensitivities of crab, lobster and scallop assessed as **medium** and the sensitivity of *Nephrops* assessed as **low**. It is not expected that any other shellfish species would have a greater sensitivity than these species explicitly considered herein. The effect is therefore considered to be of ***minor adverse significance*** for all shellfish species which is not significant in EIA terms.

6.10.3 Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish arising from construction activities

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

Magnitude of impact

284 The maximum area of direct damage and disturbance of subtidal habitat due to construction activities are described in Table 10. This equates to approximately 9.49% of the total seabed area within the AyM draft Order Limits.

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

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

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

Sensitivity of the receptor

288 The sensitivity rating assigned to each VER, and associated justification is provided in Table 39 below.

Table 39: Sensitivity of VERs to direct damage and disturbance.

VER	SENSITIVITY JUSTIFICATION
Demersal spawning VERs (herring and sandeel).	On account of the demersal spawning nature of sandeel they are considered to be vulnerable to the effects of direct damage and disturbance during the construction phase of development. Sandeel are considered most vulnerable during spawning when they are less mobile, with their eggs and larvae also considered to be unable to avoid this impact; therefore, in the case of this assessment, sandeel are considered stationary receptors. In addition to this, the species is considered to be reliant on the presence of suitable spawning substrates (i.e., sandy sediments). Therefore, sandeel are considered to be more vulnerable to direct damage and disturbance compared to other fish receptors as a result of this reliance on a specific habitat type (which is present within the AyM site). Sandeel habitats are widely distributed across the Irish Sea. In addition, the overlap of AyM with sandeel spawning grounds is small compared to the overall extent of spawning grounds across the Irish Sea (overlap of AyM of approximately 0.2 % of sandeel spawning ground (Ellis et al, 2012). Consequently, sandeel are deemed to be of high vulnerability to direct damage and disturbance, with medium recoverability (due to the temporary nature of the impact) and are considered to be of regional importance in the Irish Sea and are therefore considered to be of medium sensitivity to direct damage and disturbance during the construction phase.

VER	SENSITIVITY JUSTIFICATION
	Herring, although demersal spawners that exhibit substrate dependency, do not have any spawning grounds within the vicinity of AyM. Therefore, due to the mobile nature of herring, herring are expected to flee from the area on the onset of construction activities. Herring are considered to be not vulnerable to direct damage and as such the sensitivity of herring is considered to be negligible.
Pelagic spawning VERs with spawning grounds overlapping AyM (common sole, plaice and mackerel).	Due to the mobile nature of the other relevant fish species within the study area these species are considered to be not vulnerable to direct damage and as such the sensitivity of these species is considered to be negligible.
VERs of limited mobility (king scallop, queen scallop, Nephrops, common whelk, edible crab and lobster)	Typically, less mobile species (such as shellfish) are considered likely to have a greater vulnerability to direct damage and disturbance. Berried female edible crab, for example, exhibit a largely sedentary lifestyle during the overwintering period; for the purposes of the assessment brown crab are therefore considered a stationary receptor, and are considered unlikely to be able to move away from physical impacts to the seabed. Taking this into account, edible crab is considered to be of high vulnerability particularly during the overwintering period, but with high recoverability (Neal and Wilson, 2008) and are considered to be of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance during the construction phase is medium. European lobster are considered a key species within the area (ecologically and commercially); however, the species are not known to exhibit a sedentary

VER	SENSITIVITY JUSTIFICATION
	overwintering habit, being typically mobile and therefore the species are considered to have a greater ability to move away from disturbances by comparison to edible crab. European lobster are therefore considered to be of medium vulnerability, are considered to have a high recoverability and to be of regional importance and are therefore considered to be of low sensitivity to direct damage and disturbance from construction activities. Scallop are currently considered to be the highest value shellfish species in the UK. The area surrounding AyM is currently fished for scallop and therefore the species are typically exposed to a degree of disturbance under normal circumstances as a result of this dredge fishery. The species exhibits limited swimming, with this behaviour generally limited to predator avoidance. Scallops are therefore considered unlikely to be able to actively avoid disturbance. Scallop are therefore considered to be of medium vulnerability, high recoverability (Marshall and Wilson, 2008) and of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance from construction activities is medium. Berried female Nephrops tend to be considered largely sedentary and confined to particular habitat types, remaining in their burrows during the overwintering period. They are therefore considered unlikely to be able to move away from disturbance. Nephrops are therefore considered to be of high vulnerability during the overwintering period, are considered to exhibit high recoverability (Sabatini and Hill, 2008) and to be of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance from construction activities is medium.

VER	SENSITIVITY JUSTIFICATION
	Common whelk are broadly distributed across the Irish Sea and are found across a range of habitats. Common whelk typically burrow into mud to overwinter and emerge to feed when conditions improve. Common whelk are therefore considered to be of high vulnerability during the overwintering period, are considered to exhibit high recoverability and to be of regional importance, and therefore the sensitivity of the receptor to direct damage and disturbance from construction activities is medium.
Mobile VERs (thickback sole, flounder, dab, solenette, scaldfish, elasmobranchs, river and sea lamprey, Atlantic salmon, sea trout, Sprat, ling, hake, European eel, allis and twaite shad, smelt, haddock, horse mackerel, common dragonet, anglerfish, pogge, sand goby and poor cod).	Due to the mobile nature of the other relevant fish species within the study area these species are considered to be not vulnerable to direct damage and as such the sensitivity of these species is considered to be negligible.

Significance of effect

289 Direct damage and disturbance during the construction phase will represent a short-term and localised effect. The magnitude of the impact was determined to be **low** (adverse). The maximum sensitivity of the receptors was assessed as **medium**. The effect is therefore considered to be a maximum of ***minor adverse significance*** which is not significant in EIA terms.

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

290 As identified in Table 10 and assessed in Section 6.10.2, construction activities will re-suspend sediments. While in suspension, there is the potential for sediment-bound contaminants, such as metals, hydrocarbons and organic pollutants, to be released into the water column and lead to an effect on fish and shellfish receptors.

291 A review of subtidal sediment contamination within the AyM site was undertaken in Volume 2, Chapter 3 (application ref: 6.2.3) based on site-specific surveys within the AyM array and along the offshore ECC. The assessment identified that for all samples within the AyM site, all contaminants were below Cefas alert level 1. Two hydrocarbons were recorded as slightly above the Canadian Theoretical Effect Level (TEL) at a single sampling station adjacent to the array; however, the concentrations were below the Probable Effect Level, with no other samples throughout the array and ECC identified as above the TEL. Taking this into account, contaminant concentrations from across the array and ECC are considered unlikely to exert an effect on the marine environment.

Magnitude of impact

292 Due to known low contamination of the AyM site and the wider area, the risk of the potential release of sediment-bound contaminants will be very low. In addition, the nature of the subtidal sediments is predominantly medium to coarse sands (Volume 4, Annex 5.1: Benthic Ecology Subtidal Characterisation (Array) (application ref: 6.4.5.1); Annex 5.2: Benthic Ecology Subtidal Characterisation (Array) (application ref: 6.4.5.2); and Annex 5.3: Benthic Ecology Subtidal Characterisation (Array) (application ref: 6.4.5.3)), typically with relatively low levels of fines adhering to them and therefore very low levels of sediment-bound contaminants.

293 Following disturbance as a result of construction activities, the majority of re-suspended sediments are expected to be deposited in the immediate vicinity of the works. The release of contaminants such as metals, hydrocarbons and organic pollutants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and/ or currents and therefore increased bioavailability resulting in adverse eco-toxicological effects are not expected. The contaminants levels found are all comparable to the wider regional background and not considered to be recorded at a level that could result in a significant effect-receptor pathway if made bioavailable. The impacts as a result of the release of sediment-bound contaminants are therefore considered to be of **negligible** (adverse) magnitude.

Sensitivity of the receptor

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

Table 40: Sensitivity of VERs to the release of sediment contaminants.

VER	SENSITIVITY JUSTIFICATION
Demersal spawning VERs (herring and sandeel).	Potential sandeel spawning grounds and prime and sub-prime habitats (Figure 6) are located within the ECC and the array area. Spawning sandeel exhibit substrate dependency and are considered unlikely to flee from the release of sediment bound contaminants. However, any impacts on this species are expected to be relatively small in the context of the wider spawning habitat available across the Irish Sea (maximum sediment plume dispersal extends across 1.66% of the sandeel spawning ground (Ellis et al, 2012)). Fish eggs and larvae are, however, likely to be particularly sensitive, with potentially toxic effects of pollutants on fish eggs and larvae (Westerhagen, 1988). Effects of resuspension of sediment-bound contaminants (e.g., heavy metals and hydrocarbon pollution) on fish eggs and larvae are likely to include abnormal development, delayed hatching and reduced hatching success (Bunn et al., 2000). Sandeel of all life stages, are therefore deemed to be of medium sensitivity to the impact. Herring, although demersal spawners that exhibit substrate dependency, do not have any spawning grounds within the vicinity of AyM. Herring are therefore considered a mobile receptor and are less likely to be affected by marine pollution. Herring are therefore not considered to be vulnerable to the release of sediment bound contaminants, and as such the sensitivity of herring is considered to be low (adverse).

VER	SENSITIVITY JUSTIFICATION
Pelagic spawning VERs with spawning grounds overlapping AyM (common sole, plaice and mackerel).	Due to their increased mobility, adult fish are less likely to be affected by marine pollution. Fish eggs and larvae are likely to be particularly sensitive to the impact, it is on this basis, that these VERs are considered to be of medium sensitivity to the impact.
VERs of limited mobility (king scallop, queen scallop, Nephrops, common whelk, edible crab and lobster)	Filter-feeding shellfish are considered to be more sensitive to marine pollution due to the recognised bioaccumulation which occurs within this group. Shellfish also display limited mobility and are therefore not anticipated to flee from the impact. These VERs are therefore considered to be of medium sensitivity to the impact.
Mobile VERs (thickback sole, flounder, dab, solenette, scadfish, elasmobranchs, river and sea lamprey, Atlantic salmon, sea trout, Sprat, ling, hake, European eel, allis and twaite shad, smelt, haddock, horse mackerel, common dragonet, anglerfish, pogge, sand goby and poor cod).	Due to their increased mobility, adult fish are less likely to be affected by marine pollution and are therefore not considered to be vulnerable to the release of sediment bound contaminants, and as such the sensitivity of the VERs is considered to be low.

295 The fish and shellfish receptors are deemed to be of low to medium vulnerability, high recoverability and of local to international importance. The sensitivity of the receptors is therefore considered to be **low** to **medium**.

Significance of effect

296 The resuspension of contaminants as a result of sediment disturbance is predicted to occur on a small scale, with contaminants predicted to be rapidly dispersed by the tide. Overall, the magnitude of the impact is deemed to be **negligible**, and the sensitivity of receptors is considered to be **low** to **medium**. The effect is therefore considered to be of ***negligible – minor adverse significance*** which is not significant in EIA terms.

6.10.5 Impacts on fishing pressure due to displacement

297 During construction, the intensity of fishing activities may be reduced within the array area due to the required safety distances around construction vessels. Disruption to fishing activity along the ECC area is expected to be limited both temporally and spatially as any changes would be limited to the vicinity of the installation vessel as it moves along the route. As such, the focus herein is on the array area.

298 Changes to fishing pressure during construction may result in increased pressure on fish and shellfish outwith the array area due to displacement of fishing effort into the surrounding area.

Magnitude of the impact

299 Receptors likely to be affected by an increase in fishing pressure outside the AyM array area include those demersal fish and shellfish species targeted by commercial fisheries occurring within AyM (e.g., whelks and bass). It would not be expected that any changes in fishing activities in this area (should these effects occur at all) would lead to changes in populations of these species as any increase would be very localised and any population level effects would be minimised by fisheries management measures (e.g., quotas, days at sea, etc.).

300 The impact is predicted to be of a local spatial extent (adjacent to the AyM array area) and of a short-term duration. It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be **negligible** (adverse).

Sensitivity of the receptor

301 Fish and shellfish receptors in the study area are deemed to be insensitive to this impact and of local to international importance. The sensitivity of these receptors is therefore considered to be **negligible**.

Significance of the effect

302 Limited displacement of fishing activity within the AyM array area may lead to increases in fishing activity outside the array area. The extent to which commercial fisheries will be displaced will have a limited effect on fish and shellfish populations in the study area, with fish and shellfish receptors not likely to be sensitive to this change in fishing activity. Overall, it is predicted that the sensitivity of fish and shellfish receptors to displacement of fishing activity from the AyM array area is considered to be **negligible** and the magnitude is deemed to be **negligible**. The effect is therefore considered to be of ***negligible adverse significance*** which is not significant in EIA terms.

6.11 Environmental assessment: operational phase

6.11.1 Long-term loss of habitat due to the presence of turbine foundations, scour protection and cable protection

303 The presence of infrastructure such as foundations and cable protection at crossings have the potential to impact on fish and shellfish ecology by the removal of essential habitats for survival (e.g., spawning, nursery and feeding habitats).

Magnitude of impact

304 The long-term habitat loss due to the presence of foundations, scour protection and cable protection is expected to be up to a maximum of 1.7 km^2, which represents less than 0.1% of the fish and shellfish study area. Comparable habitats are present and widespread within the wider area.

305 The impact is predicted to be of local spatial extent (i.e., within the AyM Order Limits), of long-term duration, continuous and irreversible (within the lifetime of the project). It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude of impact is therefore deemed to be **low** (adverse).

Sensitivity of the receptor

306 The sensitivity rating assigned to each VER, and associated justification is provided in Table 41 below.

Table 41: Sensitivity of the VERs to long term loss of habitat.

VER	SENSITIVITY JUSTIFICATION
Demersal spawning VERs (herring and sandeel).	Sandeel are demersal spawners and are reliant upon the presence of suitable substrates for spawning (i.e., sandy sediments for sandeel). Furthermore, as well as laying demersal eggs, sandeel also have specific habitat requirements throughout their juvenile and adult life history. On account of this, this species is considered to be more vulnerable to long-term habitat loss depending on the availability of habitat within the wider region. The AyM array area and ECC overlap with a recognised area for sandeel spawning. However, the proportion of affected habitat within AyM is small in the context of the known wider sandeel habitats in the area (AyM overlap with sandeel spawning grounds across the Irish Sea amounts to 0.2%). Sandeel are consequently deemed to be of high vulnerability to long-term changes in substrate, with limited ability for recovery, and of regional importance within the Irish Sea, and therefore are considered to be of medium sensitivity. Herring, although demersal spawners that exhibit substrate dependency, do not have any spawning grounds within the vicinity of AyM. Therefore, due to the mobile nature of herring, herring are expected to flee from the area on the onset of construction activities. Herring are not considered to be vulnerable to long term loss of habitat and as such the sensitivity of herring is considered to be negligible.
Pelagic spawning VERs with spawning grounds	Pelagic spawning VERs are generalists and relatively insensitive to local variations in seabed substrate with widely distributed spawning and feeding grounds. Therefore, these receptors are considered to be of low vulnerability and high recoverability to

VER	SENSITIVITY JUSTIFICATION
overlapping AyM (common sole, plaice and mackerel).	long-term changes in seabed substrate and of regional importance within the Irish Sea and therefore are all considered to be low sensitivity.
VERs of limited mobility (king scallop, queen scallop, Nephrops, common whelk, edible crab and lobster)	Edible crab, common whelk and Nephrops have burrowing habits during varying life stages, whilst scallops prefer softer sediment and as such, the introduction of hard substrate over the softer sediments within the AyM array will reduce the habitat availability for these species. However, these species are substrate dependent rather than being philopatric and can therefore fully utilise adjacent areas which will be unaffected. European lobster are not known to exhibit and are therefore not considered particularly sensitive to long term habitat loss. As such, these receptors are considered to be of medium vulnerability and high recoverability and therefore considered to be of medium sensitivity.
Mobile VERs (thickback sole, flounder, dab, solenette, scaldfish, elasmobranchs, river and sea lamprey, Atlantic salmon, sea trout, Sprat, ling, hake, European eel, allis and twaite shad, smelt, haddock, horse mackerel, common	Mobile VERs are generalists and relatively insensitive to local variations in seabed substrate. Therefore, these receptors are considered to be of low vulnerability and high recoverability to long-term changes in seabed substrate and of regional importance within the Irish Sea and therefore are all considered to be low sensitivity.

VER	SENSITIVITY JUSTIFICATION
dragonet, anglerfish, pogge, sand goby and poor cod).	

Significance of effect

307 Long-term habitat loss will represent a long-term and continuous impact throughout the lifetime of the project. However only a relatively small proportion of the fish and shellfish habitats are likely to be affected in the context of wider habitats in the area. Most receptors are predicted to have some tolerance to this impact. Overall, the magnitude of the impact has been assessed as **low** for all species. The sensitivity of sandeel, and shellfish species assessed as **medium**, with all other species having lower sensitivities. The effect is therefore considered to be of ***negligible – minor adverse significance*** which is not significant in EIA terms.

6.11.2 Increased hard substrate and structural complexity as a result of the introduction of turbine foundations, scour protection and cable protection

308 Any introduction of infrastructure such as foundations and scour protection would result in the introduction of hard substrate to the currently predominantly soft seabed habitat of the AyM Order Limits. This would result in an increase in the heterogeneity of the seabed habitat and a change of the composition of the benthic community. As a result, an increase in the biodiversity of the benthic community in the vicinity of the area where hard substrate is introduced is expected to occur (Wilhelmsson and Malm, 2008). This increase in diversity and productivity of the seabed communities expected may have an impact on fish and shellfish receptors, resulting in either attraction or increased productivity.

Magnitude of impact

309 Up to 1.7 km^2 of new hard substrate is likely to be created in AyM as a result of foundation installation, scour protection and cable protection, which represents less than 0.1% of the fish and shellfish study area. The potential impact is predicted to be of local spatial extent (within the AyM Order Limits), and of long-term duration, continuous and irreversible (during the lifetime of the project). It is predicted that the impact has the potential to affect fish and shellfish receptors both directly and indirectly, and therefore the magnitude of effect is therefore considered to be **low** (adverse).

Sensitivity of the receptor

310 The sensitivity rating assigned to each VER, and associated justification is provided in Table 42 below.

Table 42: Sensitivity of the VERs to increased hard substrate and structural complexity.

VER	SENSITIVITY JUSTIFICATION
Demersal spawning VERs (herring and sandeel).	Sandeel preferred habitats and spawning areas are typically dominated by coarse sediments and sandy habitats. The array area and ECC located in preferred sandeel habitat and spawning grounds (see Figure 6). Due to the demersal nature of sandeel spawning, and their specific habitat requirements, they are considered to be of high vulnerability to permanent changes in the substrate, with no ability for recovery, and of regional importance. As a result of this, sandeel are of medium sensitivity to this impact. Herring have no spawning grounds within the vicinity of AyM, and therefore herring are considered to be of negligible sensitivity to the impact.
Pelagic spawning VERs with spawning grounds overlapping AyM (common sole, plaice and mackerel).	Pelagic spawners with spawning grounds overlapping AyM are widespread across the Irish Sea and do no display substrate dependency (like sandeel). These VERs are therefore considered to be of low vulnerability and medium recoverability and so are assessed as being of low sensitivity.
VERs of limited mobility (king scallop, queen scallop, Nephrops, common whelk, edible crab and lobster)	There is the potential for positive effects on crustacean species, such as brown crab and lobster, due to expansion of their natural habitats (Linley et al. 2007) and the creation of additional refuge areas. Novel habitats and new potential food sources may be created from foundations and scour protection installed in areas of sandy and coarse sediments, which could extend the habitat ranges of some shellfish species. However, the colonisation of new habitats by shellfish receptors could lead

VER	SENSITIVITY JUSTIFICATION
	to the introduction of non-indigenous and invasive species (see Volume 2, Chapter 5, Benthic Subtidal and Intertidal Ecology (application ref: 6.2.5) for detailed discussion), this may have indirect adverse effects on shellfish populations as a result of competition. The implementation of a PEMP, which will include a biosecurity plan, will ensure that the risk of potential introduction and spread of Invasive Non-Native Species (INNS) will be minimised. Taking this into consideration, shellfish receptors are deemed to not be vulnerable to increased hard substrate and structural complexity and are considered to be of local to regional importance to the area. Shellfish are therefore considered to be of low sensitivity to this impact.
Mobile VERs (thickback sole, flounder, dab, solenette, scadfish, elasmobranchs, river and sea lamprey, Atlantic salmon, sea trout, Sprat, ling, hake, European eel, allis and twaite shad, smelt, haddock, horse mackerel, common dragonet, anglerfish, pogge, sand goby and poor cod).	Mobile VERs (without spawning grounds within the vicinity of AyM) are widespread across the Irish Sea and do no display substrate dependency behaviours (like sandeel). These VERs are therefore considered to be of low vulnerability and medium recoverability and so are assessed as being of low sensitivity.

Significance of effect

311 There is some uncertainty associated with the likely effects of introduction of hard substrates into the marine environment on fish and shellfish receptors. Fish populations are unlikely to show noticeable benefits as a result of this impact, though there is evidence that shellfish populations (particularly brown crab and lobster) would benefit from the introduction of hard substrates (Roach and Cohen, 2015; Hooper and Austen, 2014; Krone *et al*., 2013). Demersal spawners, such as sandeel, are considered to have increased sensitivity to the introduction of hard substrate, due to their specific habitat requirements.

312 Overall, the magnitude of the impact on all receptors has been assessed as **low**. Sandeel, having specific requirements for spawning habitats, are considered to be of **medium** sensitivity, with all other fish and shellfish species considered to be of **low** sensitivity. The effect is therefore considered to be of ***minor significance*** for all receptors which is not significant in EIA terms.

6.11.3 Impacts on fishing pressure due to displacement

313 During operation, the intensity of fishing activities may be reduced within the array area due to the presence of infrastructure. Disruption to fishing activity along the ECC area is expected to be limited both temporally and spatially as any changes would be limited to only the period of any maintenance activities, all of which would be notified in advance. As such, the focus herein is on the array area.

314 Changes to fishing pressure during construction may result in reduced fishing pressure within the array area and increased pressure on fish and shellfish outwith the array area due to displacement of fishing effort into the surrounding area.

Magnitude of the impact

Reduced fishing pressure within the array area

315 Fishing activity may be reduced within AyM as a result of the physical presence of the infrastructure, assumed 50m operating distances around infrastructure and temporary safety zones around infrastructure undergoing major maintenance.

316 The impact is predicted to be of a local spatial extent (within the array area), long-term duration, continuous and irreversible (during the lifetime of the project). It is predicted that the impact will affect the fish and shellfish receptors directly. The magnitude is therefore considered to be **negligible** (beneficial).

Increased fishing pressure outwith the array area

317 Receptors likely to be affected by an increase in fishing pressure outside the AyM array area include those demersal fish species targeted by commercial fisheries occurring within AyM (e.g., scallops and flounder). It would not be expected that any changes in fishing activities in this area (should these effects occur at all) would lead to changes in populations of these species as any increase would be very localised and any population level effects would be minimised by fisheries management measures (e.g., quotas, days at sea, etc.).

318 The impact is predicted to be of a local spatial extent (adjacent to the AyM array area), long-term duration, continuous and irreversible (within the lifetime of the project). It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be **negligible** (adverse).

Sensitivity of the receptor

Reduced fishing pressure within the array area

319 A range of species are targeted by commercial fisheries in the area. these species are likely to observe the greatest benefit from a reduction in fishing effort within the AyM array area, although non-target fish caught as by-catch are also likely to benefit due to a reduction in fishing mortality.

320 The habitat protected from trawling may also become a refuge for young and spawning fish, thus providing benefits to fish populations beyond the immediate exclusion area (Byrne Ó Cléirigh *et al*., 2000). However, many of the commercially important fish species in the area are highly mobile and therefore may not significantly benefit from a reduction in fishing pressure. Additionally, any enhancements in abundances due to reduction in fishing efforts are likely to be followed by an increase in abundance of predator species.

321 Trawling can damage the seabed and its marine life (Hart *et al*., 2004). Therefore, the potential reduction in trawl fishing within AyM may benefit shellfish communities that were historically disturbed by trawling activity (e.g., scallops).

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

Increased fishing pressure outwith the array area

323 Fish and shellfish receptors in the study area are deemed to be insensitive to this impact and of local to international importance. The sensitivity of these receptors is therefore considered to be **negligible**.

Significance of the effect

Reduced fishing pressure within the array area

324 There is considerable uncertainty associated with the potential benefits to fish and shellfish populations as a result of the potential reduction of fishing activities within the AyM array area due to the mobility of most of the receptors identified. Potential benefits are most likely to be realised by species with limited mobility and specific habitat requirement. Overall, it is predicted that the sensitivity of fish and shellfish receptors to potential reduction in fishing pressure is considered to be **low** and the magnitude is deemed to be **negligible** beneficial. The effect will therefore be of ***negligible beneficial significance***, which is not significant in EIA terms.

Increased fishing pressure outwith the array area

325 Limited displacement of fishing activity within the AyM array area may lead to increases in fishing activity outside the array area. The extent to which commercial fisheries will be displaced will have a limited effect on fish and shellfish populations in the study area, with fish and shellfish receptors not likely to be sensitive to this change in fishing activity. Overall, it is predicted that the sensitivity of fish and shellfish receptors to displacement of fishing activity from the AyM array area is considered to be **negligible** and the magnitude is deemed to be **negligible** adverse. The effect is therefore considered to be of ***negligible adverse significance*** which is not significant in EIA terms.

6.11.4 EMF effects arising from cables during operational phase

326 Electromagnetic fields are produced as a result of the electricity passing through the cables (inter-array and export cables). EMFs will result from operation of up to 145 km of inter-array cable and 81.3 km of export cable. Three different EMF types can be generated by offshore wind cables: electric fields (E fields); magnetic fields (B fields); and induced electric fields (iE fields). Industry standard offshore wind cables all contain shielding which prevents E fields from passing into the marine environment and as such, these are not considered any further.

327 Cable shielding does not however significantly alter or prevent the emission of B fields. It is the movement of the B fields within a medium (i.e., seawater) which then causes the iE fields. These iE fields can either be produced by the movement of the alternating B field (in the case of alternating current (AC) transmission) through the seawater or by the movement of seawater and/or an organism through a static B field (in the case of direct current (DC) transmission).

Magnitude of impact

328 Many fish and shellfish species are thought to be able to sense electric and magnetic fields, with some species having developed specialised organs to facilitate this. The most well-known example of these is the Ampullae of Lorenzini in elasmobranchs, with this group of animals using electroreceptors to find prey. iE fields may cause either attraction or repulsion, with varying strength fields having been demonstrated to cause both reactions (Gill & Taylor 2001; Yano, *et al* 2000; Kalmijn 1982; Kimber *et al* 2011). The threshold for the change between attraction and avoidance of E fields in elasmobranchs is considered to be between 400 – 1,000µV/m (reviewed in CMACS, 2012) and these levels would only likely be found at or within 1 – 2 metres of the seabed for a cable buried at 1m. For deeper burial, the iE field at the seabed would be correspondingly lower.

329 In a review by Tricas and Gill (2011), it was noted that the sensitivity of elasmobranchs to E fields was highest at frequencies of 1 – 10 Hz, with a broader response frequency range of 0.01 – 25 Hz where fields intensities of 10x or greater were required to elicit a reaction. This suggests that weak fields such as those generated by offshore wind AC cables are likely to be mostly undetectable.

330 Some fish species are known to have magneto-receptors, with this thought to primarily be for the purposes of navigation (Walker *et al*., 2007). However, most of the research to date on magneto-reception in fish has been undertaken in migratory species such as Salmonidae, Anguillidae and Scombridae, with information on other species being limited (reviewed in Tricas & Gill, 2011). There have been suggestions (Gill & Kimber, 2005) that the presence of magnetic fields generated by cables may interrupt navigation and consequently migration.

331 EMFs monitored around subsea electricity cables have been shown to attenuate exponentially vertically and horizontally away from the cables, with the magnetic field generated by the cables typically having reached zero within 10m of the cable (reviewed by Tricas & Gill, 2011). Burial of the cables and protection with cable protection where shallow buried or surface laid will not reduce the strength of the fields, however, it moves the cables further from the receptors, and as such the receptors will be subject to reduced field strengths.

332 The impact is predicted to be highly localised, long-term duration, continuous and irreversible (within the lifetime of the project). It is predicted that the impact will affect fish and shellfish receptors directly. The magnitude is therefore considered to be **low** (adverse).

Sensitivity of the receptor

333 The sensitivity rating assigned to each VER, and associated justification is provided in Table 43 below.

Table 43: Sensitivity of the VERs to EMF effects arising from cables.

VER	SENSITIVITY JUSTIFICATION
VERs of limited mobility (king scallop, queen scallop, Nephrops, common whelk, edible crab and lobster)	Many marine invertebrates are thought to be magneto-sensitive, with this often being used for navigational purposes (migration etc.). However, evidence for potential impacts from anthropogenic B fields is limited and can be contradictory even within the same species. Studies on the green shore crab (*Carcinus maenas*) have been directly contradictory, with one study demonstrating reduced aggression in response to AC B fields matching those from an offshore wind farm (Everitt, 2008), however, another study showed no effects from static B fields (Bochert & Zettler, 2004). Brown shrimp (*Crangon crangon*) were recorded as being attracted to B fields of the magnitude expected from offshore wind cabling (ICES, 2003). One recent study (Hutchinson et al., 2020) has suggested potential changes to exploratory behaviour in American lobster (Homarus americanus) in response to DC B fields when in tanks placed near a subsea cable. Taking this into consideration, any effects on marine invertebrates are anticipated to only occur in the immediate vicinity of the cable. Therefore, marine invertebrates are deemed to be of low sensitivity to impacts from EMF.
Elasmobranchs	Elasmobranchs (sharks, skates and rays), especially demersal species, are known to be the most electro-receptive of all fish. A study commissioned by the MMO (2014) found no evidence to suggest that EMF posed a significant risk to elasmobranchs at the site or population level. A recent study by Hutchison et al (2020) observed an increase in exploratory/foraging behaviour in Little skate (*Leucoraja erinacea*) in

VER	SENSITIVITY JUSTIFICATION
	response to EMF. Taking this into consideration, elasmobranchs are deemed to be of low sensitivity to impacts from EMF.
Migratory species (European eel, river and sea lamprey, allis and twaite shad, Atlantic salmon and sea trout)	Studies on European eel have shown some deviation from migratory routes in response to low (5µT) DC B fields, however, the effects were short-term and short scale and not thought to impact on overall migration (Westerberg, 2000; Ohman et al., 2007). Interestingly, no effects were seen in European eel from AC fields of 9.6µT (Orpwood et al., 2015), suggesting that there may be differences in effects between DC and AC cabling. A review of potential effects of EMF on migratory fish for Scottish Natural Heritage (Gill & Bartlett, 2010) identified that there was insufficient evidence to be able to confirm whether any impacts would arise from the field strengths generated by offshore wind farm cabling. Taking this into consideration, it is considered unlikely that EMF will impact any migratory behaviours, and therefore migratory species are deemed to be of low sensitivity to impacts from EMF.
All other VERs (sandeel, herring, common sole, plaice and mackerel thickback sole, flounder, dab, solenette, scaldfish, sprat, ling, hake, smelt, haddock, horse mackerel, common dragonet,	A broad scale study of fish aggregations and directional movement around cables at Nysted offshore wind farm in Denmark, showed no evidence of any change in directionality or distribution of species as a result of the cable installation (Hvidt et al., 2004). Taking this into consideration, all other fish VERs are deemed to be of low sensitivity to impacts from EMF.

VER	SENSITIVITY JUSTIFICATION
anglerfish, pogge, sand goby and poor cod).	

334 Based on the information within Table 43, whilst it is possible that some fish and shellfish species present within the area around AyM may be able to detect the iE or B fields generated by the cables, it is unlikely that the field strengths will disrupt feeding, spawning or migratory behaviours. As such, the sensitivity of all species is assessed as **low**.

Significance of effect

335 The power cables used for AyM will produce both magnetic and induced electric fields in the surrounding water sediment and water column. The EMFs created will rapidly attenuate away from the cables and are unlikely to be at strengths which would result in any impacts to fish and shellfish. Overall, it is predicted that the sensitivity of fish and shellfish receptors to EMF from AyM is considered to be **low** and the magnitude is deemed to be **low** (adverse). The effect is therefore considered to be of ***minor significance*** which is not significant in EIA terms.

6.12 Environmental assessment: decommissioning phase

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

336 Decommissioning of offshore infrastructure for AyM may result in temporarily elevated underwater noise levels which may have effects on fish and shellfish species, with subsequent effects on spawning and nursery habitats. These elevated noise levels may be due to increased vessel movements and removal of the turbine foundations with the resulting noise levels dependant on the method used for removal of the foundation. The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment. As detailed in Volume 4, Annex 6.1(application ref: 6.4.6.1), the maximum levels of underwater noise during decommissioning would be from underwater cutting required to remove structures, with piled foundations cut approximately 1 m below the seabed. The noise levels from this process are expected to be much less than pile driving and therefore impacts would be less than as assessed during the construction phase.

337 Studies of underwater noise (decommissioning techniques) reported source levels which are similar to those reported for medium sized surface vessels and ferries (Malme *et al*. 1989; Richardson *et al*. 1995). The noise resulting from wind turbine decommissioning employing abrasive cutting is unlikely to result in any injury, avoidance or significant disturbance of local marine animals. Some temporary minor disturbance might be experienced in the immediate vicinity of the decommissioning activity, for example, from dynamically positioned (DP) vessels. The impact is predicted to be of highly local spatial extent, short-term duration, intermittent and reversible. Based on the information available at the time of writing, and due to the localised spatial extent, the expected magnitude is considered to be **negligible** (adverse) for all receptors. The sensitivity for all receptors to underwater noise is **low – medium**. The effect is therefore considered to be of ***negligible – minor adverse significance*** which is not significant in EIA terms.

6.12.2 Temporary increase in SSC and sediment deposition

338 Temporary increases in SSC and sediment deposition from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed Section 6.10.2 of this chapter.

339 To summarise, increases in SSC and sediment deposition will represent a temporary and short-term intermitted impact, with a highly localised impact, affecting a small proportion of the fish and shellfish habitats within the study area.

340 Overall, the magnitude of the impact for all fish species has been assessed as **low** (adverse), with the sensitivity of all species assessed as **low**. The effect is therefore considered to be of ***minor adverse significance*** for all fish species which is not significant in EIA terms.

341 The magnitude of the impact on shellfish species has been assessed as **low** (adverse), with the sensitivities of crab, lobster and scallop assessed as **medium** and the sensitivity of *Nephrops* assessed as **low**. It is not expected that any other shellfish species would have a greater sensitivity than these species explicitly considered herein. The effect is therefore considered to be of ***minor adverse significance*** for all shellfish species which is not significant in EIA terms.

6.12.3 Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish arising from construction activities

342 Direct damage and disturbance from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed in Section 6.10.3 of this chapter.

343 To summarise, the magnitude of the impact has been assessed as low for sandeel (due to the small area affected relative to the wider spawning habitat). Due to the demersal spawning nature of sandeel, the sensitivity has been assessed as **medium**. For other fish species, the magnitude of impact has been assessed as **negligible**, with a sensitivity of **low**. The effect is therefore considered to be of ***negligible* – adverse *minor significance*** which is not significant in EIA terms.

344 The magnitude of impact on shellfish receptors was assessed as being low, and the sensitivities of brown crab, scallop and *Nephrops* were all assessed as **medium** (sessile nature of these species either year-round or seasonally), with the sensitivity for lobster being **low**. It is not expected that any other shellfish species would have a greater sensitivity than these species explicitly considered herein. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

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

345 Direct and indirect seabed disturbances leading to release of sediment contaminants from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed in Section 6.10.4 of this chapter.

346 To summarise, the resuspension of contaminants as a result of sediment disturbance is predicted to occur on a small scale, with contaminants predicted to be rapidly dispersed by the tide. Overall, the magnitude of the impact is deemed to be **negligible**, and the sensitivity of receptors is considered to be **low to medium**. The effect is therefore considered to be of ***negligible – minor adverse significance*** which is not significant in EIA terms.

6.12.5 Impacts on fishing pressure due to displacement

347 Impacts to fishing pressure due to displacement from the decommissioning works will be similar to that for construction and are of a similar magnitude. The magnitude of the impact and the sensitivities of fish and shellfish to the impact are detailed in Section 6.10.5 of this chapter.

348 To summarise, limited displacement of fishing activity within the AyM array area may lead to increases in fishing activity outside the array area. The extent to which commercial fisheries will be displaced will have a limited effect on fish and shellfish populations in the study area, with fish and shellfish receptors not likely to be sensitive to this change in fishing activity. Overall, it is predicted that the sensitivity of fish and shellfish receptors to displacement of fishing activity from the AyM array area is considered to be **negligible** and the magnitude is deemed to be **negligible**. The effect is therefore considered to be of ***negligible adverse significance*** which is not significant in EIA terms.

6.13 Environmental assessment: cumulative effects

349 Cumulative effects can be defined as effects upon a single receptor from AyM when considered alongside other proposed and reasonably foreseeable projects and developments. This includes all projects that result in a comparative effect that is not intrinsically considered as part of the existing environment and is not limited to offshore wind projects.

350 A screening process has identified several reasonably foreseeable projects and developments which may act cumulatively with AyM. The full list of such projects that have been identified in relation to the offshore environment are set out in Volume 1, Annex 3.1: Cumulative Effects Assessment (application ref: 6.1.3.1).

351 The CEA methodology undertaken is detailed in Volume 1, Annex 3.1(application ref: 6.1.3.1) as part of the assessment all projects and plans considered alongside AyM have been allocated into 'tiers' reflecting their current stage within the planning and development process, these are listed in Table 44 below.

6.13.1 Identification of relevant plans and projects

352 The longlist has been reduced to a shortlist for assessment in this chapter based on a consideration of:

- Stage 1: Identification of whether a spatial overlap between the plans and projects and the AyM ZoI which could potentially result in significant effects;
- Stage 2: This list was then further refined to whether there may be a temporal overlap between the potential effects of the projects. A potential temporal overlap is defined as:
  - Proposed but not yet constructed (either pre- or post-consent);
  - Only partially constructed at the time that baseline characterisation was undertaken;
  - Recently completed, during the development of the baseline characterisation, and the full extent of the impacts arising from the development(s) may not be reflected in the baseline; and/ or

- May have consent or licences to undertake further work, such as maintenance dredging or notable maintenance works which may arise in additional effects.

- Stage 3: Defining the degree of certainty and data confidence was then considered to identify an appropriate tier for each of the projects.

353 The projects identified for the cumulative assessment on fish and shellfish ecology receptors are presented in Table 44 and Figure 12. No disposal sites were within the ZoI.

Table 44: Projects considered within the fish and shellfish ecology cumulative effect assessment.

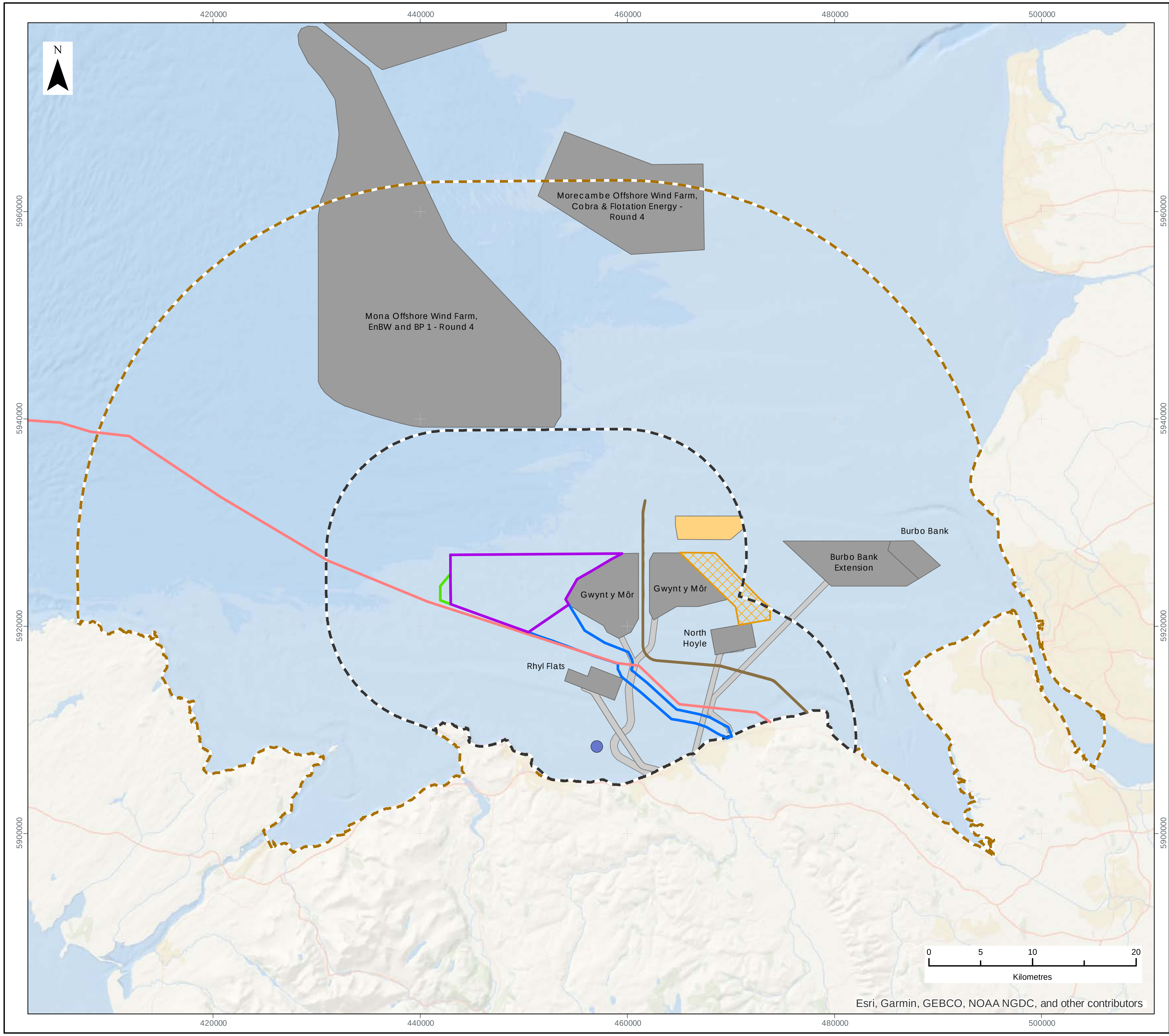
DEVELOPMENT TYPE	PROJECT	STATUS	DATA CONFIDENCE ASSESSMENT/ PHASE	TIER
Offshore Wind Farm	Gwynt y Môr	Operational	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	Rhyl Flats	Operational	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	North Hoyle	Operational	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1

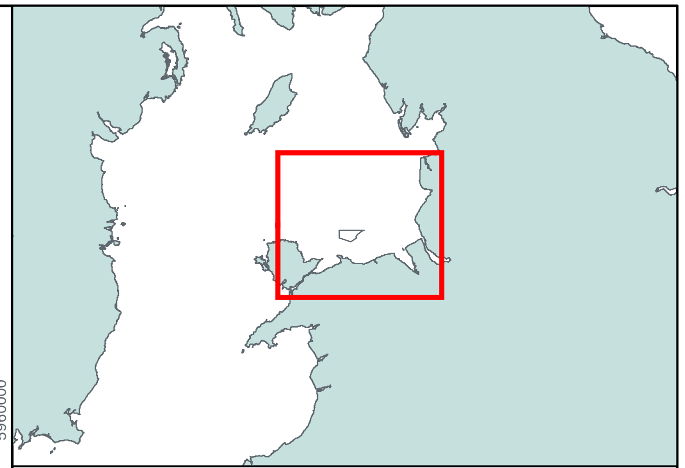
DEVELOPMENT TYPE	PROJECT	STATUS	DATA CONFIDENCE ASSESSMENT/ PHASE	TIER
Offshore Wind Farm	Burbo Bank	Operational	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	Burbo Bank Extension	Operational	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate	Tier 1
Offshore Wind Farm	Morgan and Mona – Round 4	Concept/early planning	Low – Limited data available in the public domain	Tier 3
Offshore Wind Farm	Morecambe – Round 4	Concept/early planning	Low – Limited data available in the public domain	Tier 3

DEVELOPMENT TYPE	PROJECT	STATUS	DATA CONFIDENCE ASSESSMENT/ PHASE	TIER
Interconnector	Geo-Eirgrid (East West Interconnector)	Active	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'	Tier 1
Tidal Energy	North Wales Tidal Energy Project between Prestatyn and Llandudno.	In development	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'	Tier 3 – no application has been submitted
Tidal Lagoon	Mostyn Tidal Lagoon	In development	Low - Limited data available in the public domain	Tier 3 – no application has been submitted
Aggregate Exploration and Option Area	Liverpool Bay (1808)	Active	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1

DEVELOPMENT TYPE	PROJECT	STATUS	DATA CONFIDENCE ASSESSMENT/ PHASE	TIER
Aggregate Production Area	Hilbre Swash (392)	Active	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
Aggregate Production Area	Hilbre Swash (393)	Active	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
Gas pipeline	Pipeline Eni (Gas)	Active	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
Methanol pipeline	Pipeline Eni (Methanol)	Active	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1

DEVELOPMENT TYPE	PROJECT	STATUS	DATA CONFIDENCE ASSESSMENT/ PHASE	TIER
Condensate pipeline	Pipeline Eni (Condensate)	Active	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1





LEGEND

- Array Area
- Offshore Export Cable Corridor
- Other Wind Farm Infrastructure Zone
- 12km Study Area
- Underwater Noise Zone of Influence
- Offshore Wind Farm
- Offshore Wind Farm Export Cable
- NWTE Tidal Energy Project
- Liverpool Bay Aggregate Exploration and Option Area
- Hilbre Swash Aggregate Production Area
- Oil and Gas Pipelines
- Geo-Rirgrid (East West Interconnector)

Data Source:
Subsea Cables Data from Kis Orca EMODnet © EMODnet - Human Activities.
Wind Farms and Wind Farm Export Cables from The Crown Estate © Crown Copyright.
Tidal Projects from The Crown Estate © Crown Copyright.
Aggregates data from The Crown Estate © Crown Copyright.

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

FIGURE TITLE:

Cumulative Effects Assessment Screened-in Projects

VER	DATE	REMARKS	Drawn	Checked
1	09/09/2021	For Issue For PEIR	BPHB	SM
2	28/03/2022	For Issue For ES	BPHB	AL

FIGURE NUMBER:

Figure 12

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:375,000	A3	WGS84	UTM30N

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

G:\GIS\GIS_Projects\0141 AyM\GIS\Figures\ES\Fish and Shellfish\AYM_F&S_Fig12_Cumulative_Projects.mxd

354 The cumulative MDS is described in Table 45 for each of the potential cumulative effects for this assessment. A description of the significance of cumulative effects upon fish and shellfish ecology receptors arising from each identified impacts is provided in the sub-sections below. No additional potential fish and shellfish ecology impacts or receptors are identified than when considering AyM cumulatively with the identified projects (Table 45) under the MDS.

Table 45: Cumulative MDS.

POTENTIAL EFFECT	SCENARIO	JUSTIFICATION
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Tier 1: No Tier 1 projects identified. Tier 2: No Tier 2 projects identified. Tier 3: The construction of the North Wales Tidal Energy project; The construction of the Mostyn tidal lagoon; The construction of the Morgan and Mona projects; and The construction of the Morecambe project.	If the North Wales Tidal Energy project, EnBW and BP projects and Cobra and Floatation Energy project are advanced then construction noise from those projects may result in cumulative noise with AyM construction.
Temporary increase in SSC and sediment deposition	Tier 1: Operation and maintenance of offshore windfarms including cables (Gwynt y Môr, Rhyl Flats, North Hoyle and Burbo Bank Extension);	If these intermittent activities overlap temporally with either the construction or maintenance of AyM, there is potential for cumulative SSC and sediment deposition to occur within the modelled plume footprints.

POTENTIAL EFFECT	SCENARIO	JUSTIFICATION
	Maintenance of operational cables, pipelines and outfalls (e.g., Pipeline Eni, Geo-Rirgrid (East West Interconnector) and wastewater outfalls); Maintenance of Point of Ayr Terminal; Aggregate production/exploration (Liverpool Bay (1808), Hilbre Swash (392) and Hilbre Swash (393)). Tier 2: No Tier 2 projects identified. Tier 3: The construction and operation of the North Wales Tidal Energy project.	

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

355 There is potential for cumulative mortality, injury, behavioural changes and auditory masking from noise and vibration as a result of construction activities associated with AyM and other projects (Table 45). For the purposes of this assessment, this additive impact has been assessed within 100 km of AyM, which is considered the maximum extent of impacts from noise as highlighted in noise modelling undertaken as part of the EIA, detailed in section 6.10.

356 The greatest risk of cumulative impacts of underwater noise on fish and shellfish species has been identified as being that produced by impact piling during the construction phase of other offshore energy sites within 100 km of AyM.

357 Injury or mortality of fish from piling noise and decommissioning activities would not be expected to occur cumulatively due to the small range within which potential injury effects would be expected (i.e. predicted to occur within tens to hundreds of metres of piling activity within each of the offshore wind farm projects) and the large distances offshore energy projects. Cumulative effects of underwater noise are therefore discussed in the context of behavioural effects, particularly on spawning or nursery habitats.

358 Due to the current planning stage of the relevant projects, there is no available data on either project scale or timings on which to undertake a quantitative or semi-quantitative assessment as such the discussion herein is qualitative.

359 As a worst-case assumption for the identified projects, it is assumed that project parameters regarding underwater noise would be similar to those for AyM (i.e., percussive piling using high hammer energies and large diameter monopiles). It is noted that there is a broadscale push from regulators and Statutory Nature Conservation Body's (SNCBs) within the UK towards the use of technologies to reduce the noise emitted during offshore wind construction works. The method used or the mechanism by which this may be enforced is yet to be determined however it may comprise using non-piled structures (e.g., GBS or suction bucket structures) or at source noise mitigation (e.g., bubble curtains or the BLUE piling system). As such, it is expected that any cumulative noise would be reduced compared to the worst-case scenario.

360 Based on the noise modelling for AyM, the greatest impact range for TTS (186 dB SEL_{cum}) for fish is 36 km (assuming a stationary receptor, simultaneous piling of piles). As such, it is possible that, if AyM and the other projects were to pile simultaneously that there would be an overlap between TTS impacts for the projects. However, this would only occur for the most hearing sensitive fish species (e.g., herring), with other, non-hearing specialist fish species, considered to be less at risk. It should be noted that the assumptions herein that these projects are constructed simultaneously is unlikely due to the planning process timescales in the UK and the availability of construction vessels (often very limited, particularly considering the other offshore wind projects which have overlapping construction timescales (e.g., those planned in the UK North Sea and worldwide).

361 Therefore, the cumulative impact of underwater noise on fish and shellfish is predicted to be of regional spatial extent, medium term duration, intermittent and reversible. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be **low** (adverse).

362 Sensitivities of fish and shellfish receptors to underwater noise are fully detailed in Section 6.10.1. Fish injury as a result of piling noise would only be expected in the immediate vicinity of piling operations, and the area within which effects on fish larvae would be expected is similarly small, though it is unclear whether effects on fish larvae would include injury or mortality. Effects on shellfish species are also predicted to be limited as these species are less sensitive to noise than fish species or would only be affected at ranges much less than those predicted for fish.

363 Behavioural effects on fish species as a result of piling noise are predicted to be dependent on the nature of the receptors, with larger impact ranges predicted for pelagic fish than for demersal fish species. The predicted behavioural response may be sufficient to result in temporary avoidance of these areas by these species, with some temporary redistribution of fish in the wider area between the affected areas. Between piling events, fish may resume normal behaviour and distribution, as evidenced by work of McCauley *et al.* (2000) which showed that fish returned to normal behavioural patterns within 14 to 30 minutes after the cessation of seismic airgun firing. However, there are some uncertainties over the response of fish to intermittent piling over a prolonged period and the extent that behavioural reactions will cause a negative effect in individuals.

364 The proportions of fish spawning and nursery habitats predicted to be affected by underwater noise from piling operations are expected to be small, particularly in the context of available spawning and nursery habitats within the southern North Sea (particularly for pelagic spawning species).

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

366 The majority of all other fish receptors within the study area lack swim bladders and are therefore deemed to be of low vulnerability, medium recoverability and of local to international importance. The cumulative noise from other projects is not expected at this stage to affect migratory pathways for Atlantic salmon, lamprey or European eel. The sensitivity of these receptors to cumulative noise impacts is therefore considered to be **medium**.

367 Shellfish are considered to be less sensitive to noise than fish as they do not possess a swim bladder, however they do show some sensitivity to increased particle motion (Roberts *et al*. 2016), with studies showing behavioural changes in shellfish in response to increased noise levels (Samson *et al.* 2016; Spiga *et al.* 2016). As a result of this, the sensitivity of shellfish is considered to be **medium**.

368 Overall, the magnitude of effect has been assessed as **low** and the sensitivity of all receptors assessed as **medium**. The effect is therefore considered to be of ***minor adverse significance*** which is not significant in EIA terms.

6.13.3 Cumulative temporary increase in SSC and sediment deposition

369 Though it is considered highly unlikely that each of the identified projects would be undertaking asset reburial or replacement (the activity likely to result in the largest plumes) simultaneously, due to the extremely infrequent nature of the need for these works, it is assumed that this would comprise the MDS for cumulative effects.

370 Volume 2, Chapter 2 (application ref: 6.2.2) presents a detailed cumulative assessment for the temporary increase in SSC (and associated deposition) resulting from AyM and other projects within the study area. Given the high levels of dispersion of the sediment as demonstrated by the project specific modelling, there is not anticipated to be a notable overlap with concentrated sediment plumes created from other maintenance and construction activities.

371 This is primarily owing to the predicted low concentrations at the extremities resulting from the rapid dispersion of the entrained SSC from the source of disturbance and the short-term nature of the AyM plumes. Sediment plumes generated by other projects, are anticipated to behave in a similar pattern as the sediments being disturbed and the types of disturbance are equivalent to those for AyM. The potential increases in SSC, when considered cumulatively, are still anticipated to be within natural variation within the ZoI. Therefore, the potential cumulative effects on fish and shellfish receptors from increases in SSC and sediment deposition are deemed to be equivalent to those from AyM alone and not significant in EIA terms.

6.14 Inter-relationships

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

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, O&M and decommissioning); to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project stages (e.g., subsea noise effects from piling, operational WTGs, vessels and decommissioning); and
- Receptor-led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, jack up vessel use etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short-term, temporary or transient effects, or incorporate longer term effects.

373 A description of the likely inter-related effects arising from AyM on fish and shellfish ecology is provided in Volume 2, Chapter 14: Inter-relationships (application ref: 6.2.14), with a summary of assessed inter-relationships provided below.

- Benthic Ecology – impacts to benthic ecology receptors may affect prey resource for fish and shellfish ecology receptors;
- Marine Water and Sediment Quality – impacts on water quality (i.e., resuspension of contaminants); and
- Commercial fisheries – changes to fishing intensity or gear types may affect fish and shellfish ecology receptors.

6.15 Transboundary effects

374 Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from AyM alone, or cumulatively with other projects in the wider area. A screening of potential transboundary effects was undertaken at Scoping which identified that there was potential for transboundary effects to occur in relation to fish and shellfish ecology. Specifically, it was identified that there was a risk of underwater noise impacts from piling during construction to affect migratory fish and the spawning grounds for fish and shellfish within waters around the Isle of Man and the Republic of Ireland.

375 Due to the distance between the proposed project and the Republic of Ireland, it is expected that underwater noise impacts will not overlap with the waters of that country. Specifically, the noise modelling suggests that sound levels from piling at AyM will reach approximately 125dB SEL whilst still within UK or Isle of Man waters. This sound level is below that generated by large vessels and as such is not likely to result in any discernible impacts to any fish or shellfish receptors and so impacts to this country are not considered any further.

376 Between AyM and the Isle of Man is a large scallop ground which is an important resource for the Isle of Man and is ecologically linked to scallop grounds within the waters of that nation (Neil and Kaiser, 2008), with south-north connectivity, may be important in relation to recruitment patterns further north (Close, 2014). The underwater noise assessment of impacts to shellfish has included an assessment of impacts to this scallop ground and concluded that there will be no significant effects arising from underwater noise.

377 In addition, a herring spawning ground is located to the east and south of the Isle of Man, with this species known to be highly sensitive to underwater noise. The underwater noise assessment of impacts of piling included consideration of the potential for piling noise from AyM to impact on herring spawning grounds. As detailed in Section 6.10.1, based on the underwater noise modelling, it is not expected that sound levels will be such that they would lead to any impacts to the herring grounds around the Isle of Man.

378 Therefore, it can be concluded that the construction noise from AyM will not lead to any significant transboundary effects.

6.16 Summary of effects

379 This chapter has assessed the potential effects on fish and shellfish ecology receptors arising from AyM. The range of potential impacts and associated effects considered has been informed by scoping responses, as well as reference to existing policy and guidance. The impacts considered include those brought about directly (e.g., by the presence of infrastructure at the seabed), as well as indirectly (e.g., the release of sediment contaminants from seabed disturbances). Potential impacts considered in this chapter, alongside any mitigation and residual effects are listed below in Table 46.

380 The impacts on relevant receptors from all stages of the project were assessed, including impacts from habitat loss, underwater noise, increased SSC and deposition and release of sediment contaminants.

381 Throughout the construction, operation and decommissioning phases, all impacts assessed were found to have either negligible, or minor effects on fish or shellfish receptors within the study area (i.e., not significant in EIA terms).

382 The assessment of cumulative impacts from AyM and other developments and activities, including offshore wind farms, concluded that the effects of any cumulative impacts would be of minor significance, and not significant in EIA terms.

Table 46: Summary of effects.

IMPACT		MAGNITUDE	SENSITIVITY OF VERS	MITIGATION MEASURES	RESIDUAL EFFECT
CONSTRUCTION					
Mortality, injury, behavioural impacts and auditory masking arising from noise and vibration	Mortality and potential mortal injury	Low adverse	Group 1 – Low Group 2 – Low Group 3 – Medium Eggs and larvae – Medium Shellfish – Medium	N/A	Minor adverse (not significant)
	Recoverable Injury	Low adverse	Group 1 – Low Group 2 – Low Group 3 – Medium Eggs and larvae – Medium Shellfish – Medium	N/A	Minor adverse (not significant)

IMPACT		MAGNITUDE	SENSITIVITY OF VERS	MITIGATION MEASURES	RESIDUAL EFFECT
	TTS/hearing damage	Low adverse	Group 1 – Low Group 2 – Low Group 3 – Medium Eggs and larvae – Medium Shellfish – Medium	N/A	Minor adverse (not significant)
	Behavioural impacts	Low adverse	Group 1 – Low Group 2 – Low Group 3 – Medium Eggs and larvae – Medium Shellfish – Medium	N/A	Minor adverse (not significant)
Temporary increase in SSC and sediment deposition		Low adverse	Demersal spawners - Low Pelagic spawners – Low VERs of Limited Mobility – Low to medium Mobile VERs - Low	N/A	Minor adverse (not significant)

IMPACT	MAGNITUDE	SENSITIVITY OF VERS	MITIGATION MEASURES	RESIDUAL EFFECT
Direct damage (e.g., crushing) and disturbance to mobile, demersal and pelagic fish, and shellfish	Low adverse	Demersal spawners – Negligible to Medium Pelagic spawners – Negligible VERs of Limited Mobility – Low to medium Mobile VERs – Negligible	N/A	Minor adverse (not significant)
Direct and indirect seabed disturbances leading to the release of sediment contaminants	Negligible adverse	Demersal spawners – Low to Medium Pelagic spawners – Medium VERs of Limited Mobility – Medium Mobile VERs – Low	N/A	Negligible – Minor adverse (not significant)
Impacts on fishing pressure due to displacement	Negligible adverse	All VERs – Negligible	N/A	Negligible adverse (not significant)

<table>
<tr><th colspan="2">IMPACT</th><th>MAGNITUDE</th><th>SENSITIVITY OF VERS</th><th>MITIGATION MEASURES</th><th>RESIDUAL EFFECT</th></tr>
<tr><td colspan="6">OPERATION</td></tr>
<tr><td colspan="2">Long term loss of habitat due to the presence of turbine foundations, scour protection and cable protection</td><td>Low adverse</td><td>Demersal spawners – Negligible to Medium
Pelagic spawners – Low
VERs of Limited Mobility – Medium
Mobile VERs – Low</td><td>N/A</td><td>Negligible – Minor adverse (not significant)</td></tr>
<tr><td colspan="2">Increased hard substrate and structural complexity as a result of the introduction of turbine foundations, scour protection and cable protection</td><td>Low adverse</td><td>Demersal spawners – Negligible to Medium
Pelagic spawners – Low
VERs of Limited Mobility – Low
Mobile VERs – Low</td><td>N/A</td><td>Minor adverse (not significant)</td></tr>
<tr><td>Impacts on fishing pressure due to displacement</td><td>Reduced fishing pressure within the array area</td><td>Negligible</td><td>Low</td><td>N/A</td><td>Negligible beneficial (not significant)</td></tr>
</table>

IMPACT		MAGNITUDE	SENSITIVITY OF VERS	MITIGATION MEASURES	RESIDUAL EFFECT
	Increased fishing pressure outwith the array area		Negligible		Negligible adverse (not significant)
EMF effects arising from cables during operational phase		Low adverse	VERs of Limited Mobility – Low Elasmobranchs – Low Migratory species – Low All other VERs – Low	N/A	Minor adverse (not significant)
DECOMMISSIONING					
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration		As for construction	As for construction	N/A	Negligible – Minor adverse (not significant)
Temporary increase in SSC and sediment deposition		As for construction	As for construction	N/A	Minor adverse (not significant)

<table>
<tr><th colspan="2">IMPACT</th><th>MAGNITUDE</th><th>SENSITIVITY OF VERS</th><th>MITIGATION MEASURES</th><th>RESIDUAL EFFECT</th></tr>
<tr><td colspan="2">Direct and indirect seabed disturbances leading to the release of sediment contaminants</td><td>As for construction</td><td>As for construction</td><td>N/A</td><td>Negligible – Minor adverse (not significant)</td></tr>
<tr><td colspan="2">Direct damage (e.g., crushing) and disturbance to mobile demersal and pelagic fish and shellfish arising from construction activities</td><td>As for construction</td><td>As for construction</td><td>N/A</td><td>Negligible – Minor adverse (not significant)</td></tr>
<tr><td rowspan="2">Impacts on fishing pressure due to displacement</td><td>Reduced fishing pressure within the array area</td><td rowspan="2">As for construction</td><td rowspan="2">As for construction</td><td rowspan="2">N/A</td><td>Negligible beneficial (not significant)</td></tr>
<tr><td>Increased fishing pressure outwith the array area</td><td>Negligible adverse (not significant)</td></tr>
<tr><td colspan="6">CUMULATIVE</td></tr>
</table>

IMPACT	MAGNITUDE	SENSITIVITY OF VERS	MITIGATION MEASURES	RESIDUAL EFFECT
Mortality, injury, behavioural changes and auditory masking arising from noise and vibration	Low adverse	Medium	N/A	Minor adverse (not significant)
Temporary increase in SSC and sediment deposition	Low adverse	Medium	N/A	Minor adverse (not significant)

6.17 References

Aguilar de Soto, N., Delmore, N., Atkins, J., Howrds, S., Williams, J. and Johnson, M. (2013). Anthropogenic noise causes body malformations and delays development in marine larvae. Scientific Reports , 2831; DOI:10.1038/srep02831.

Alheit, J. and Hagen, E. (1997). Long-term climate forcing of European herring and sardine populations. Fisheries Oceanography 6: 130-139.

Beggs, S.E. Cardinale, M. Gowen, R.J. & Bartolino, V. (2013). Linking cod (Gadus morhua) and climate: investigating variability in Irish Sea cod recruitment. Fisheries Oceanography 23: 54-64.

BEIS, (2016). UK Offshore Energy Strategic Environmental Assessment 3 (OESEA 3) Appendix 1a.4 – Fish and Shellfish. March 2016.

Bochert, R. and M. L. Zettler. (2004). Long-term exposure of several marine benthic animals to static magnetic fields. Bioelectromagnetics 25:498-502.

Brown and May Marine Ltd (BMM) (2011a). 'Burbo Bank Extension Offshore wind farm: Adult and Juvenile Fish Characterisation Survey'. 13th to 17th May 2011.

Brown and May Marine Ltd (BMM), (2011b). 'Burbo Bank Extension Offshore wind farm: Adult and Juvenile Fish Characterisation Survey.' 7th to 11th September 2011.

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

Byrne Ó Cléirigh Ltd, Ecological Consultancy Services Ltd (EcoServe) and School of Ocean and Earth Sciences, University of Southampton (2000). Assessment of Impact of Offshore Wind Energy Structures on the Marine Environment. Prepared for the Marine Institute.

Cefas (2005). 'Post-construction Results from The North Hoyle Offshore Wind Farm'. Paper for the Copenhagen Offshore Wind International Conference 2005

Cheong, S-H., Wang, L., Lepper, P. and Robinson, S. (2020). Characterisation of Acoustic Fields Generated by UXO Removal. Phase 2. NPL REPORT AC 19.

CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. Chartered Institute of Ecology and Environmental Management, Winchester.

Coull, K.A. Johnstone, R. and Rogers, S.I. (1998). Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd. Aberdeen, 63 pp.

Centre for Marine and Coastal Studies (CMACS) (2005a). 'Gwynt y Môr Offshore Wind Farm - Marine Ecology Technical Report', report to Npower Renewables (Report no: J3004/2005).

CMACS (2005b). 'Rhyl Flats Offshore Wind Farm Benthic Grab Survey 2006 Monitoring Report', report to RWE npower renewables (Report no: J3039/04-07 v.1.0).

CMACS (2012). East Anglia One Offshore Wind Farm: Electromagnetic Field Environmental Appraisal. Assessment of EMF on sub tidal marine ecology. APPENDIX 9.2 Electromagnetic Field Environmental Appraisal of East Anglia Three ES.

Dahl, P. H., Jenkins, A. K., Casper, B., Kotecki, S. E., Bowman, V., Boerger, C., Dall'Osto, D. R., Babina, M. A., and Popper, A. N. (2020). "Physical effects of sound exposure from underwater explosions on Pacific sardines (*Sardinops sagax*)," J. Acoust. Soc. Am. 147(4), 2383–2395.

Day, R.D., McCauley, R.D., Fitzgibbon, Q.P., Hartmann, K. and Semmens, J.M. (2017). Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop Pecten fumatus. PNAS 114 (40) E8537-E8546.

DECC (2011a), Overarching National Policy Statement for Energy (EN-1). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf [Accessed: November 2021].

DECC (2011b), National Policy Statement for Renewable Energy Infrastructure (EN-3). https://assets.publishing.service.gov.uk/government/uploads/system/

uploads/attachment_data/file/37048/1940-nps-renewable-energy-en3.pdf [Accessed: November 2021].

DECC (2011c). National Policy Statement for Electricity Networks Infrastructure EN-5. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37050/1942-national-policy-statement-electricity-networks.pdf [Accessed: Jan 2022]

DECC. (2021a), Draft Overarching National Policy Statement for Energy (EN-1). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015233/en-1-draft-for-consultation.pdf [Accessed: November 2021].

DECC. (2021b), Draft National Policy Statement for Renewable Energy Infrastructure (EN-3). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015236/en-3-draft-for-consultation.pdf [Accessed November 2021].

DECC (2016). UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3) Appendix 1a.4 Fish and Shellfish.

Ellis, J.R.. Milligan, S.P. Readdy, L. Taylor, N. and Brown, M.J. (2012). Spawning and nursery grounds of selected fish species in UK waters. Cefas Scientific Series Technical Report 147.

Everitt, N. (2008). Behavioural responses of the shore crab, Carcinus maenas, to magnetic fields. MSc Thesis, University of Newcastle-upon-Tyne: 94pp.

Frederiksen, M. Edwards, M. Richardson, A.J. Halliday, N.C. and Wanless, S. (2006). From plankton to top predators: bottom-up control of a marine food web across four trophic levels. Journal of Animal Ecology 75: 1259-1268.

Gill, A. B. & Taylor, H (2001). The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon elasmobranch fishes. 488. 2001b. Countryside Council for Wales Contract Science Report.

Gill, A. B. and A. A. Kimber. (2005). The potential for cooperative management of elasmobranchs and offshore renewable energy development in UK waters. Journal of the Marine Biological Association of the United Kingdom 85:1075-1081.

Gill, A.B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. and Wearmouth, V. (2009). COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-Sensitive Fish Response to EM Emissions from Sub-Sea Electricity Cables of the Type used by the Offshore Renewable Energy Industry. COWRIE-EMF-1-06.

Gill, A.B., and Bartlett, M. (2010). Literature Review on the Potential Effects of Electromagnetic Fields and Subsea Noise from Marine Renewable Energy Developments on Atlantic Salmon, Sea Trout and European Eel. Scottish Natural Heritage, Commissioned Report No. 401. (Sutton and Boyd, 2009).

Hastie, G., Merchant, N. D., Gotz, T., Russel, D. J. F., Thompson, P. and Janik., V. M. (2019). Effects of impulsive noise on marine mammals: investigating range-dependent risk. Ecological Applications, Volume 29, Issue 5.

Hawkins, A. D. and Popper, A. N. (2016). A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. ICES Journal of Marine Science, 74 (3): 635-651.

Hawkins, A., Roberts, L and Cheesman, S. (2014). Responses of free-living coastal pelagic fish to impulsive sounds. Acoustical Society of America.pp. 3101-3116.

Hawkins, A. D., Pembroke, A. E., and Popper A., N. (2014b). Information gaps in understanding the effects of noise on fishes and invertebrates, Rev. Fish Biol. Fisheries, [redacted], Springer International Publishing.

Hazelwood, R. and Macey, P. (2016). Modeling Water Motion near Seismic Waves Propagating across a Graded Seabed, as Generated by Man-Made Impacts. Journal of Marine Science and Engineering. 4. 47. 10.3390/jmse4030047.

Heath, M.R. Neat F.C. Pinnegar J.K. Reid D.G. Sims D.W. and Wright P.J. (2012). Review of climate change impacts on marine fish and shellfish around the UK and Ireland. Aquatic Conservation: Marine and Freshwater Ecosystems 22: 337-367.

Hooper, T., & Austen, M. (2014). The co-location of offshore windfarms and decapod fisheries in the UK: Constraints and opportunities. Marine Policy, 43, 295.

Hutchison, Z.L., Gill, A.B., Sigray, P., He, H. and King, J.W. (2020). Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom dwelling marine species. Scientific Reports 10:4219.

Hvidt, C. B., Bech, M., & Klaustrup, M. (2004). Monitoring programme-status report 2003. Fish at the cable trace. Nysted offshore wind farm at Rødsand. Bioconsult.

ICES (2018). Greater North Sea Ecoregion – Ecosystem overview. ICES Ecosystem Overviews.

ICES (2019). Scallop Assessment Working Group (WGSCALLOP).

ICES (2021a). Celtic Seas ecoregion – Ecosystem Overview. ICES Ecosystem Overviews

ICES (2021b). Cod (*Gadus morhua*) in Division 7.a (Irish Sea). ICES Advice on fishing opportunities, catch, and effort

Joint Nature Conservation Committee (JNCC) (2010). Guidelines for minimising the risk of injury to marine mammals from using explosives. JNCC, Peterborough.

Kalmijn, A. J. (1971). The Electric Sense of Sharks and Rays. Journal of Experimental Biology 55, 371–383.

Kimber, J. A., Sims, D. W., Bellamy, P. H. & Gill, A. B. (2011). The ability of a benthic elasmobranch to discriminate between biological and artificial electric fields. Marine Biology 158, 1–8, [redacted].

Kosheleva, V. (1992). The impact of air guns used in marine seismic explorations on organisms living in the Barents Sea. Contr. Petro Piscis II `92 Conference F-5, Bergen, 6-8 April, 1992. 6 s.

Krone, R. Gutowa, L. Joschko, T.J. Schröder, A. (2013). Epifauna dynamics at an offshore foundation Implications of future wind power farming in the North Sea. Marine Environmental Research, 85, 1-12.

Lewandowski J., Luczkovich J., Cato D. and Dunlop R. (2016). Summary Report Panel 3: Gap Analysis from the Perspective of Animal Biology: Results of the Panel Discussion from the Third International Conference on the Effects of Noise on Aquatic Life. In Popper A.N. and Hawkins A.D. The effects of noise on aquatic life, II. (pp. 1277 - 1282). Springer Science+Business Media, New York.

Lindegren, M. Diekmann, R. and Möllmann, C. (2010). Regime shifts, resilience and recovery of a cod stock. Marine Ecology Progress Series 402: 239-253.

Linley, E.A.S. Wilding, T.A. Black, K. 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.

Lockwood, S. J. (2005) 'Fish & Shellfish Resources Eastern Irish Sea'.

Malme, C. I., Miles, P. R., Miller, G. W., Richardson, W. J., Reseneau, D. G., Thomson, D. H., Greene, C. R. (1989). Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska, BBN Report No. 6945 OCS Study MMS 89-0005. Reb. From BBN Labs Inc., Cambridge, MA, for U.S. Minerals Managements Service, Anchorage, AK. NTIS PB90-188673.

MarineSpace Ltd, ABPmer Ltd, ERM Ltd, Fugro EMU Ltd and Marine Ecological Surveys Ltd, (2013). Environmental Effect Pathways between Marine Aggregate Application Areas and Sandeel Habitat: Regional Cumulative Impact Assessments. A report for BMAPA.

Marshall, C.E. & Wilson, E. (2008). Pecten maximus Great scallop. 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. [cited 07-11-2019]. Available from: [redacted]

McCauley, R. D. Fewtrell, J. Duncan, A. J. Jenner, C. Jenner, M-N. Penrose, J. D. Prince, R. I. T. Adhitya, A. Murdoch, J. and McCabe, K. (2000). Marine Seismic Surveys – A Study of Environmental Implications. Appea Journal, pp. 692-707.

Mitson, R.B. (1993). Underwater noise radiated by research vessels. ICES Marine Science Symposium 196: 147 – 152.

MMO (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: 978-1-909451-24-4.

MMO. (2019). 'United Kingdom commercial sea fisheries landings by Exclusive Economic Zone of capture: 2012 – 2018'.

Mueller-Blenkle, C., McGregor, P.K., Gill, A.B., Andersson, M.H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D.T. & Thomsen, F. (2010). Effects of Pile-driving Noise on the Behaviour of Marine Fish. COWRIE Ref: Fish 06-08, Technical Report 31st March 2010.

Neal, K. and Wilson E. (2008). Cancer pagurus Edible crab. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme. [redacted]

Ohman, M. C., Sigray, P. & 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. & J D Armstrong (2015). Effects of AC Magnetic Fields (MFs) on Swimming Activity inEuropean Eels Anguilla, Scottish Marine and Freshwater Science Vol 6 No 8.

OSPAR (2010). Quality Status Report 2010. OSPAR Commission, London, 176pp.

Payne, J.F. Andrews, C.A. Fancey, L.L. Cook, A.L. and Christian, J.R. (2007). Pilot Study on the Effect of Seismic Air Gun Noise on Lobster (Homarus Americanus) Canadian Technical Report of Fisheries and Aquatic Sciences No.2712:V + 46 (2007).

Popper A.N., and Hawkins A.D. (2018). The importance of particle motion to fishes and invertebrates. The Journal of the Acoustical Society of America 143, 470 (2018); doi: 10.1121/1.5021594.

Popper, A. N. Hawkins, A. D. Fay, R. R. Mann, D. Bartol, S. Carlson, Th. Coombs, S. Ellison, W. T. Gentry, R. Hal vorsen, M. B. Lokkeborg, S. Rogers, P. Southall, B. L. Zeddies, D. G. and Tavolga, W. N. (2014). Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

Przeslawski, R., Zuang, Z., Anderson, J., Carroll, A.G.,Edmunds, M., Hurt, L. and Williams, S. (2018). Multiple field-based methods to assess the potential impacts of seismic surveys on scallops. Marine Pollution Bulletin 129: 750-761.

Richardson WJ, Greene CR Jr, Malme CI, Thomson DH (1995) Marine mammals and noise. Academic Press, New York, 577 p

Roach, M and Cohen, M. (2015). Westermost Rough Fish & Shellfish Monitoring Report 2015; Including Comparison to Baseline Data 2013.

Roberts L. (2015). Behavioural responses by marine fishes and macroinvertebrates to underwater noise (Doctoral dissertation, University of Hull).

Roberts, L. Cheesman, S. Elliott, M. and Breithaupt, T. (2016). Sensitivity of Pagurus bernhardus (L.) to substrate-borne vibration and anthropogenic noise. Journal of Experimental Marine Biology and Ecology, 474: 185–194.

Sabatini, M. & 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. [cited 07-11-2019]. Available from: [redacted]

Samson JE, Mooney TA, Gussekloo SWS and Hanlon RT (2016). A Brief Review of Cephalopod Behavioral Responses to Sound. In Popper A.N., and Hawkins A.D. The effects of noise on aquatic life, II. (pp. 969 - 976). Springer Science+Business Media, New York.

Skaret, G. Axelsen, B. E. Nøttestad, L. Ferno, A. and Johannessen, A. (2005). The behaviour of spawning herring in relation to a survey vessel. ICES Journal of Marine Science, 62: 1061–1064.

Spiga I., Caldwell G.S. and Bruintjes R. (2016). Influence of Pile Driving on the Clearance Rate of the Blue Mussel, Mytilus edulis (L.). In: Fourth International Conference on the Effects of Noise on Aquatic Life. 2016, Dublin, Ireland: Acoustical Society of America.

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 BOEMRE 2011-09.

Wardle, C.S., Carter, T.J., Urquhart, G.G., Johnstone, A.D.F., Ziolkowski, A.M., Hampson, G. and Mackie, D. (2001). Effects of seismic air guns on marine fish. Contiental Shelf Research 0: 1-23.

Westerberg, H. (2000). Effect of HVDC cables on eel orientation. Pages 70-76 in Technische Eingriffe in marine Lebensraume. Bundesamtes für Naturschutz, Germany.

Westerhagen, H. V (1988). Sublethal Effects of Pollutants on Fish Eggs and Larvae. In: Fish Physiology. Volume 11, Part A, pp 253-234. Academic Press, New York.

Wilhelmsson, D. and Malm, T. (2008). Fouling assemblages on offshore wind power plants and adjacent substrata. Estuarine, Coastal and Shelf Science 79(3) pp 459-466.

Yano, K., H. Mori, K. Minamikawa, S. Ueno, S. Uchida, K. Nagai, M. Toda, and M. Masuda. (2000). Behavioral Response of Sharks to Electric Stimulation. Bulletin of Seikai National Fisheries Research Institute 78:13-30.

Zhang, Y, Shi F, Song J, Zhang X and Yu S (2015). Hearing characteristics of cephalopods: Modelling and environmental impact study. Integrative Zoology 10 (1) 141–151

[redacted]

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

RWE Renewables UK
Swindon Limited

Windmill Hill Business Park
Whitehill Way
Swindon
Wiltshire SN5 6PB
T +44 (0)8456 720 090
www.rwe.com

Registered office:
RWE Renewables UK
Swindon Limited Windmill
Hill Business Park Whitehill
Way
Swindon