Balliemeanoch Pumped Storage Hydro

Environmental Impact Assessment Report

Volume 2: Main Report
Chapter 1: Introduction

ILI (Borders PSH) Ltd

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Quality information

Prepared by	Checked by	Verified by	Approved by
Alexandra Hiley	Jackie Hill	Jackie Hill	David Lee
Consultant Marine Ecologist	Technical Director	Technical Director	Technical Director – Renewable Energy

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8. Marine Ecology

8.1 Introduction

This chapter of the EIAR has been produced by AECOM Ltd and identifies the potential impacts and effects to marine ecology and nature conservation that are considered as part of the EIA of the Development. A detailed description of the Development can be found within *Chapter 2: Project and Site Description.*

The Development is located at central national grid reference NN 03615 17578, approximately 4.4 km to the south of the village of Portsonachan and 9 km northwest of Inveraray in Argyll and Bute, Scotland. The Marine Facility is located south of Inveraray and is comprised of a jetty constructed into Loch Fyne, a sea loch extending from the Firth of Clyde (*Figure 2.3 Above Ground Infrastructure (Sheet 2)* (*Volume 3: Figures)* and *Figure 2.18 Indicative Temporary Marine Facility*, (*Volume 3: Figures)*). This jetty will facilitate the delivery of large, abnormal loads, reducing pressures to the local road network during the construction of the main PSH Development. The construction and operation of the jetty has the potential to affect marine ecological receptors in the vicinity of this Marine Facility.

This chapter sets out a review of the existing marine ecological baseline conditions and assesses the potential permanent and temporary impacts from the Development. The marine ecological receptors that are considered in this chapter are:

- Benthic ecology (including invasive non-native species; INNS);
- Fish and shellfish;
- Marine mammals; and,
- Relevant designated sites.

For planning and consenting purposes the marine environment is defined as any area seaward of the mean high-water springs (MHWS) mark of any tidally influenced water body. Thus, it includes intertidal zones, which are periodically exposed by the tide and subtidal zones which are always submerged. Terrestrial designations, habitats, and species, i.e. those above MHWS, are considered in *Chapter 8: Terrestrial Ecology*, whilst freshwater ecology is considered in *Chapter 7: Aquatic Ecology*. Impact pathways to any coastal seabirds and relevant designated sites are considered in *Chapter 9: Ornithology*.

This chapter should be read in conjunction with:

- *Chapter 2: Project and Site Description;*
- *Chapter 3: Approach to EIA;*
- *Chapter 18: Marine Physical Environment and Coastal Processes;*

Figures (Volume 3 Figures):

- *Figure 8.1: Benthic Ecology and Fish and Shellfish Study Area;*
- *Figure 8.2: Intertidal Benthic Habitats Observed during Phase I Walkover Surveys;*
- *Figure 8.3: Benthic Habitat Classification from Drop-Down Camera Transects Near the Proposed Jetty Location;*
- *Figure 8.4: PMF Occurrence During Drop-Down Camera Transects Near the Proposed Jetty Location;*
- *Figure 8.5: Migratory Fish Catchments Near the Development;* and
- *Figure 8.6: Shellfish Activity within Loch Fyne.*

Appendices (Volume 5 Appendices):

- *Appendix 8.1: Intertidal Survey Report (produced by Ocean Ecology)*
- *Appendix 8.2: Subtidal Benthic Survey Report;* and
- *Appendix 8.3: Marine Protected Area Assessment.*

8.2 Legislation and Policy

This section outlines legislation, policy, and guidance relevant to the appraisal of the potential effects on marine ecological receptors associated with the construction, operation, and decommissioning phases of the Development. For further information regarding the legislative context, refer to the standalone Planning Statement submitted with the Section 36 Application.

8.2.1 Legislation

This assessment has been undertaken within the context of relevant legislation, of projects, such as the Development, in UK waters. The following legislation is relevant to the appraisal of the policies, and guidance which concern the preservation of marine ecological receptors during the planning and execution potential effects on marine ecology associated with the Development:

- Marine and Coastal Access Act (MCAA) 2009 (HM Government, 2009);
- Marine (Scotland) Act 2010 (Scottish Government, 2010);
- Wildlife and Countryside Act 1981;
- Water Environment and Water Services (Scotland) Act 2003 (HMSO, 2003);
- The Water Environment (Controlled Activities) (Scotland) Regulations 2011. Scottish Statutory Instrument 2011 No. 209 (HMSO, 2009), as amended;
- Wildlife and Natural Environment (Scotland) Act 2011;
- The Conservation of Habitats and Species Regulations 2017 (amended 2019);
- The Environment (EU Exit) (Scotland) (Amendment etc.) Regulations 2019; and
- The Environment (EU Exit) (Miscellaneous Amendments) (Scotland) Regulations 2019.

8.2.2 National Planning Policy

The National Planning Framework 4 (NPF4) was formally adopted by Scottish Ministers on 13 February 2023. NPF4 includes the following statements of policy intent: "*To protect, restore and enhance natural assets making best use of nature-based solutions*" and "*To protect biodiversity, reverse biodiversity loss, deliver positive effects from development and strengthen nature networks*". Wherever possible and proportionate to the scale and nature of the project, the Development has therefore sought to deliver benefits for biodiversity, in addition to protecting existing biodiversity. NPF4 also states that major developments will only be supported where nature networks "*are in a demonstrably better state than without intervention*" using best practice and including future monitoring and management where appropriate.

Prior to the UK's exit from the European Union (EU), Scotland's SACs and SPAs were part of a wider European network of such sites known as the 'Natura 2000 network'. They were consequently referred to as 'European sites.' Now that the UK has left the EU, Scotland's SACs and SPAs are no longer part of the Natura 2000 network but form part of a UK-wide network of designated sites referred to as the 'UK site network'. However, it is current Scottish Government policy to retain the term 'European site' to refer collectively to SACs and SPAs (Scottish Government, 2020).

The following additional national and devolved policies include requirements concerning the preservation of biodiversity during the planning and execution of projects in UK waters:

- UK Marine Policy Statement (HM Government, 2011a);
- UK Post 2010 Biodiversity Framework (HM Government, 2012); and
- Scottish National Marine Plan (2015) (Scottish Government, 2015).

8.2.3 Local Planning Policy

The Argyll and Bute Local Development Plan 2 (LDP2) was adopted in February 2024. Planning policy relevant to nature conservation and the Development contained within LDP2 is summarised below in *Table 8.1 Summary of Potentially Relevant Policies of the Argyll and Bute LDP2*. Further details are presented in the standalone Planning

Statement submitted with the application for the Development, and are available from the Argyll and Bute Council website (https://www.argyll-bute.gov.uk/planning-and-building/planning-policy/local-development-plan-2).

Additional consideration has been given, where relevant, to the Clyde Regional Marine Plan, which creates a framework for integrated, sustainable, and coordinated planning and management of the Clyde Marine Region's (including Loch Fyne) environmental, economic, and community resources (Clyde Marine Planning Partnership, 2018).

Table 8.1Summary of Potentially Relevant Policies of the Argyll and Bute LDP2

Planning Policy	Summary of Purpose
Policy 28 – Supporting Sustainable Aquatic and Coastal Development	Proposals for marine and freshwater aquaculture, marine and coastal developments will be supported where it can be demonstrated that there will be no significant adverse effects, directly, indirectly or cumulatively on: The landscape/coastal character, seascape or visual amenity (including Isolated Coast, Wild Land and National Scenic Areas); and The natural, built and/or historic or archaeological sites and their settings; and Designated sites, habitats and species for nature conservation, (including Priority Marine Features, wild migratory salmonids, and European Protected Species); and Ecological status of coastal and transitional water bodies and biological carrying capacity (water quality & seabed impacts); and Commercial and recreational activity (including other coastal/marine users (MOD)), and navigational interests (including anchorages); and Amenity, arising from operational effects (waste, noise, light and odour), and Public access (access to and along the coast will be maintained and enhanced wherever possible).
Policy 30 – The Sustainable Growth of Renewables	The Council will support renewable energy developments where consistent with the principles of sustainable development and it can be demonstrated that there would be no unacceptable environmental effects, including on ecological features.
Policy 73 – Development Impact on Habitats, Species and Biodiversity	The Council will consider nature conservation legislation, the Argyll and Bute Biodiversity Strategy and Action Plan and the Scottish Biodiversity Strategy when assessing developments. Where a development is likely to have effects on important habitats or species, the Council will require the developer to undertake appropriate surveys and, if necessary, to prepare a mitigation plan. Development proposals likely to have an adverse effect on protected species and habitats will only be permitted where it can be justified in accordance with the relevant protected species legislation.
Policy 74 – Development Impact on Sites of International Importance	This policy sets out the strict requirements for developments potentially affecting European sites, including compliance with the Habitats Regulations.
Policy 75 – Development Impact on Sites of Special Scientific Interest and National Nature Reserves	This policy sets out requirements for developments affecting Sites of Special Scientific Interest (SSSI) and National Nature Reserves (NNR). Where adverse effects on these are possible, developments must demonstrate that integrity of the sites/interests would not be compromised, or that social, economic or environmental benefits of national important clearly outweigh adverse effects on the sites/interests, and that there no suitable alternative locations.

8.3 Consultation

The summary of consultation comments provided in *Table 8.2 Summary of Consultation* has been prepared from responses provided from consultees on the Marine Ecology section of the Scoping Report (AECOM, 2022).

Table 8.2 Summary of Consultation

Consultee	Key Issue	Summary of Response	Action Taken
Peel Port Group	Invasive Non-Native Species	Risk assessment required as part of further environmental assessments.	Included in EIAR (see *Section 8.6 Baseline Environment* and *Section 8.7 Assessment of Effects*)
NatureScot	Potential impacts on the Upper Loch Fyne and Loch Goil Nature Conservation Marine Protected Area (MPA).	Video survey of seabed required to confirm extent of protected features. Mitigation required to minimise impact from siltation, debris from construction, loading, transport, and from any ballast water. Vessel movement information required.	Video surveys were conducted in 2021. Results summarised in *Appendix.2: Subtidal Benthic Survey Report (Volume 5: Appendices*). Mitigation measures provided in EIAR Section 8.9 Mitigation and Monitoring. Vessel movements are provided in EIAR Chapter 19: Shipping and

Consultee	Key Issue	Summary of Response	Action Taken
			Navigation, and are considered here for relevant receptors in Section 8.7 Assessment of Effects.
	Marine Mammals	'The Protection of Marine European Protected Species from Injury and Disturbance: Guidance for Scottish Inshore Waters' should be considered in relevant mitigation measures. There is a risk of disturbance to harbour porpoise (*Phocoena Phocoena*), bottlenose dolphin (*Tursiops truncatus*), harbour seal (*Phoca vitulina*), and grey seal (*Halichoerus grypus*). EPS license may be required.	Relevant mitigation, including JNCC mitigation protocols, are included in *Section 8.9 Mitigation and Monitoring*. Impacts to these species considered in *Section 8.7 Assessment of Effects*.
Argyll and Bute Council	Benthic Ecology	Applicant is requested to submit their Intertidal Phase 1 Survey and Subtidal Benthic Survey.	Survey results provided in *Appendices 8.1: Intertidal Survey Report and 8.2: Subtidal Benthic Survey Report.*
	Benthic Ecology	Applicant to undertake an Intertidal Phase 1 Survey and a Subtidal Benthic Survey to inform likely significant effects to priority marine features of Loch Fyne Nature Conservation Marine Protected Area (NCMPA).	Surveys conducted in 2021. Results provided in *Appendices 8.1: Intertidal Survey Report and 8.2: Subtidal Benthic Survey Report.*
	Marine Ecology	Possible Likely Significant Effects to cetaceans, seals, basking sharks.	Assessment of potentially significant effects to these receptors discussed in *Section 8.7 Assessment of Effects*.
	Marine Ecology	Applicant is to submit a Biosecurity Management Plan.	A Biosecurity Management Plan based on the measures included in the Loch Fyne Marine Biosecurity Plan will be included in the CEMP to be produced by the project contractor.
	Fish and Shellfish Ecology	Loch Shira is an important nursery area for salmon and sea trout populations and is part of the Loch Fyne Marine Consultation Area.	Assessment of likely significant effects to migratory fish populations, such as salmon and sea trout, are discussed in *Section 8.7 Assessment of Effects*.
	Marine Mammals and Fish and Shellfish Ecology	As a measure of good practice, it is advised that the applicant apply for a European Protected Species License for the possible disturbance of cetaceans and under Part I, Section 16(3)(i) of the Wildlife and Countryside Act 1981 a license to disturb basking shark.	Applications for an EPS license and license to disturb basking shark will be included in the CEMP to be produced by the project contractor.
	Marine Mammals	The Applicant will adopt JNCC mitigation protocols to minimise disturbance to marine mammals from piling.	Mitigation measures, including the use of JNCC mitigation for piling, are outlined in *Section 8.9 Mitigation and Monitoring*. Where feasible, vibro-piling will be used during construction of the Marine Facility.
	Water Quality	The applicant must adopt pollution prevention strategies for potential of diesel, hydraulic or battery spillages into the environment.	Mitigation measures, including best practice measures and appropriate pollution prevention guidance, are outlined in *Section 8.9 Mitigation and Monitoring*
	Noise and Vibration	Mitigation measures to abate noise and vibration should be deployed during construction and predicted noise and vibration levels should be detailed within the EIAR.	Mitigation measures, including the use of JNCC mitigation for piling, are outlined in *Section 8.9 Mitigation and Monitoring*. Predicted noise levels are detailed in *Section 8.7 Assessment of Effects*.
Marine Scotland Science	Marine Mammals	Detail on the abundance of marine mammal species within the area is lacking.	Marine mammal abundance and distribution is detailed in *Section 8.6 Baseline Environment*.

8.4 Study Area

The Study Area used for this assessment has been defined as including the likely Zone of Influence (ZoI) where potential significant effects may arise from the Development to marine receptors. The ZoI, and therefore also the Study Area, is specific to each receptor, recognising both the mobility of each receptor and the likely impact pathways to that receptor. A summary of the Study Area for each receptor is defined below, with further details provided in relevant sections for each receptor:

- **Benthic Ecology** - The extent of the Study Area is based on the greatest likely impact to benthic ecological receptors, which is considered to be increased levels of suspended sediment and sediment deposition. This area covers a 700 m buffer around the Marine Facility, which reflects the maximum tidal excursion distance on a flood and ebb tide, over which particles in suspension may travel. Sites designated for the protection of benthic receptors will also be considered within this area. The Study Area is shown *on Figure 8.1 Benthic Ecology and Fish & Shellfish Study Area* within *Volume 3: Figures*.
- **Fish and Shellfish** - The extent of the Study Area is based on the greatest likely impact to fish and shellfish receptors, which is considered to be underwater sound (UWS) associated with piling. Migratory fish may also be associated with the Development area, which can travel to and from natal rivers outside the maximum ZoI. As such, a regional approach has also been adopted which includes designated sites associated with migratory routes for fish species associated with the Development area. The Study Area is shown on *Figure 8.1 Benthic Ecology and Fish & Shellfish Study Area* within *Volume 3: Figures*
- **Marine Mammals** - Marine mammals are highly mobile and transient species, and as such, there are potential implications to wider populations resulting from localised impacts. Therefore, the Study Area has been determined at a scale that reflects the range of relevant marine mammal populations. For cetaceans, the Inter Agency Marine Mammal Working Group (IAMMWG) has established species-specific management units (MUs) for common species according to population structure, movement and habitat use, and relevant management boundaries (IAMMWG, 2023). ICES has also divided European waters into ecoregions, which set boundaries for monitoring ecosystems based on biogeographic and oceanographic features, as well as existing political, social, economic, and management divisions, that also refer to cetacean populations (ICES, 2022).
- **For pinnipeds,** the Special Committee on Seals (SCOS) has outlined Seal Management Units (SMUs) based on expert knowledge and opinion of seal ecology in the UK, using a pragmatic approach to management without inferring discrete populations (SCOS, 2021). The Development occurs within the Southwest Scotland SMU, with consideration given to the adjacent West Scotland – South SMU to consider any potential connectivity. With regard to designated sites, species' ecology and habitat connectivity are considered to determine likely effects to associated populations. The Study Area is shown *on Figure 8.1 Benthic ecology and Fish & Shellfish Study Area* within *Volume 3: Figures*).

8.5 Methods

This EIAR applies the appraisal methodology detailed in *Chapter 4: Approach to EIA*. The identification and appraisal of effects and mitigation are based on a combination of CIEEM guidelines for ecological assessments in the UK (CIEEM, 2018), professional judgment, and the application of relevant guidelines.

8.5.1 Guidance and Standards

Key guidance documents used to inform the assessment of Development impacts on marine ecological receptors include:

- Chartered Institute for Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in Britain and Ireland – Terrestrial, Freshwater, Coastal and Marine (CIEEM, 2018);
- Centre for Environment, Fisheries and Aquaculture Science (Cefas) Guidance Note for Environmental Impact Assessment in respect of Food and Environment Protection Act (FEPA) and Coast Protection Act (CPA) requirement (Cefas, 2004);
- Cefas Chemical Action Levels (MMO, 2014) for sediment quality thresholds and Canadian Sediment Quality Guidelines (CCME, 2001);
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Judd, 2012).

- Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury to marine mammals from piling noise (JNCC, 2010);
- The Protection of Marine EPS From Injury and Disturbance: Draft Guidance for Scottish Inshore Waters (Marine Directorate, 2020);
- JNCC guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise Special Areas of Conservation (SACs) (JNCC, 2020);
- Scotland's Marine Assessment (Marine Scotland 2020); and
- The ASCOBANS Agreement 1992 makes provision for the protection of cetaceans through monitoring, research, public awareness, pollution control and data sharing. This agreement has been signed by eight European countries bordering the Baltic and North Seas (including the English Channel) and includes the United Kingdom (UK). A number of guidance documents are available on the ASCOBANS website (UNEP, 1992).

8.5.2 Assessment Scope

The assessment considers effects during the three phases of the Development lifespan, construction, operation, and decommissioning as described in *Chapter 2: Project and Site Description*. The assessment scope described in this chapter was informed by the guidance listed in *Section 8.5.1 Guidance and Standards*, desk study results and published guidance for specific ecological features (as referenced where appropriate below), the responses of consultees, and professional expertise. For the purposes of this assessment, important marine ecological features were taken to include:

- Qualifying features of Marine Protected Areas (MPA);
- Marine features of Special Areas of Conservation (SAC);
- Marine species listed on Schedules 2 and 4 of the Habitats Regulations,
- Marine species listed on Schedules 5 and 8 of the WCA,
- Priority Marine Features, as adopted by Scottish ministers (Tyler-Walters et al., 2016); and,
- Species or habitats indicated to be priorities in the Argyll and Bute Local Biodiversity Action Plan.

8.5.3 Baseline Data Collection

Marine ecological baseline conditions were established by undertaking a combination of desktop review of published information, project-specific survey data, and consultation with relevant organisations. This aims to provide a robust and up-to-date characterisation of the marine environment within the Study Area.

A desktop review included published and publicly available information and consultation with relevant organisations, including NatureScot and Marine Directorate (formerly Marine Scotland). Where relevant, this information has been used to inform marine ecological baseline characterisation for the Development. The range of data sources that have been used to inform the baseline description and appraisal include:

- European Marine Observation Data Network (EMODnet) Seabed Habitats Project data for broad-scale habitat maps of the Study Area (EU Sea Map, 2021);
- European Union Nature Information System (EUNIS) for classifying benthic habitats (European Environment Agency, 2012);
- JNCC Marine Protected Area (MPA) Habitat Mapper for detailed information on MPAs in the region (JNCC, 2023);
- Marine Life Information Network for habitat and species sensitivity assessments, where available;
- Marine Directorate (formerly Marine Scotland) Information Map Layers (NMPi)[1];
- International Council for the Exploration of the Sea (ICES) data;
- Updated Cefas Fisheries Sensitivity Maps in British Waters (Coull *et al*., 1998);
- Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al*., 2012);

[1] https://marine.gov.scot/maps/nmpi

- Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas (Reach *et al*., 2013);
- Sandeel sediment habitat preferences in the marine environment (Holland *et al*., 2005);
- SCANS (Small Cetacean Abundance in the European Atlantic and North Sea) data (Gilles et al., 2023)[2];
- Inter-Agency Marine Mammal Working Group (IAMMWG, 2023);
- Sea Mammal Research Unit (SMRU);
- Habitat-based predictions of at-sea distributions for grey and harbour seals in the British Isles (Carter, et al., 2022);
- Distribution models for 12 species of cetacean covering the North-east Atlantic (Waggitt J. J., et al., 2020);
- Hebridean Whale and Dolphin Trust marine mammal sightings distribution maps;
- Designated site condition assessments as available;
- Academic papers and online reports as available for the Study Area; and
- Relevant environmental statements from other projects as available.

In addition to the desktop review, project-specific surveys were undertaken in December 2021 to characterise intertidal and subtidal benthic habitats within the Benthic Ecology Study Area. Results are summarised below with full details provided in *Appendix 8.2: Subtidal Benthic Survey Report (Volume 5: Appendices)*

8.5.4 Assessment Methodology

This chapter applies the environmental appraisal methodology detailed *Chapter 4: Approach to EIA.* The identification and appraisal of effects and mitigation for marine ecology are based on a combination of Chartered Institute of Ecology and Environmental Management (CIEEM) guidelines for ecological impact assessments in the UK (CIEEM, 2018), professional judgment, and the application of relevant guidelines as outlined above. Potential effects are assessed according to the potential magnitude of impacts and sensitivity of relevant environmental features, using terminology as outlined in *Chapter 4: Approach to EIA*.

Additionally, NatureScot recommends that the concept of the favourable conservation status for species should be applied at a national (Scottish) level to determine the level of significance of an effect (SNH, 2018). However, consideration of effects at all scales is important (CIEEM, 2022), and where an impact may not affect conservation status at the national level, the potential for effects on conservation status at regional and local scales has also been considered.

A detailed description of the CIEEM method for impact assessment is provided in *Appendix 6.1: Method for EcIA (Volume 5: Appendices);* however; it is important to note that the matrix approach is not sufficient for marine ecological assessments, and professional judgement has also been exercised and applied where appropriate.

8.5.5 Limitations And Assumptions

The availability of data for marine mammals, fish and shellfish is considered sufficient to characterise the baseline and as such provides a good understanding of the existing environment. However, due to the mobile nature of these taxa, there is the potential for variability in the actual usage of an area by different species. As a result, each survey contributing to the available library of research, realistically, only provides a snapshot in time.

For example, the SCANS data for marine mammals occur in summer (predominantly July), therefore only providing summer distributions. It is understood that the densities of cetaceans around the British Isles is likely greatest during this time period and as such, the abundances presented in Section 8.6 Baseline Environment are considered to represent the worst-case scenario and indicate the greatest abundances likely to be encountered within the Study Area.

[2] The SCANS project is a large-scale ship and aerial based survey effort to quantify cetacean abundance and distribution in UK and European Atlantic Waters. It first began in 1994 (SCANS I) with boat-based line and aerial line transect surveys following methods of Hiby and Lovell (1998), initially in the North and Celtic seas. It has since evolved and has been repeated in 2005 (SCANS II), 2016 (SCANS III), and 2022 (SCANS IV). Abundance estimates are divided into blocks. The relevant block containing the cable corridor are Block CS-F, although consideration is also given to the adjacent block CS-D.

Furthermore, available data for fish and shellfish is typically broad, providing only an indication of where species are present or absent, often relating to ICES boundaries. Therefore, a precautionary approach is adopted when considering the presence of sensitive receptors in the Study Area.

With regard to the subtidal benthic surveys, although the sampling design and collection process for the survey data analysed provided robust data on the benthic communities, interpreting these data to determine biotopes has three main limitations:

- It can be difficult to interpolate data collected from discrete sample locations to cover the whole Study Area and to define the precise extent of each biotope, even with site-specific data;
- Benthic communities generally show a transition from one biotope to another and therefore, boundaries of where one biotope ends and the next begins cannot be defined with absolute precision; and
- The classification of the community data into biotopes is not always straightforward, as some communities do not readily fit the available descriptions in the biotope classification system and the classification for subtidal benthic communities is generally regarded as incomplete.

8.6 Baseline Environment

The marine ecological baseline relevant to the Development is summarised below. Further findings of the desk and field-based studies, including evaluation of the relevant conservation value of identified ecological features is provided within the technical appendices that accompany this chapter *Appendices 8.1: Intertidal Survey Report, 8.2 Benthic Survey Report* and *Appendix 8.3 Marine Protected Area Assessment (Volume 5: Appendices)*.

8.6.1 Benthic Ecology

Benthic ecology refers to the diversity, abundance, and function of organisms living on (epifauna) or in (infauna) the seabed. Benthic communities are found in all marine habitats, from the deepest parts of the ocean to the intertidal zone. Physical factors such as water depth, seabed and/or sediment type, water movement and supply of organic matter determine habitat types and species present, and therefore the composition of benthic communities.

The Study Area has been defined based on the greatest potential impact pathway to benthic receptors, which has been identified as sediment dispersion. It encompasses an area of 700 m around the Marine Facility (*Figure 8.1 Benthic Ecology and Fish & Shellfish Study Area (Volume 3: Figures)*) and has been determined using spring tidal excursion data, as the estimated maximum travel distance for a particle carried in suspension can be related to the length of the major axis of the tidal excursion ellipse (see *Chapter 18. Marine Physical Environment and Coastal Processes*).

The Study Area includes a range of benthic habitats including rocky intertidal habitats and areas of mud and sandy mud and macroalgal communities in the subtidal. The following subsections provide an overview of published information that has been used to characterise baseline conditions for benthic ecology within the Study Area, as well as a summary of data collected during project-specific benthic surveys (as reported in *Appendices 8.1: Intertidal Survey Report and 8.2: Benthic Survey Report (Volume 5: Appendices)*).

The sensitivity value of benthic ecological receptors present within the Study Area varies by taxonomic group, as some species are of high conservation value and thus may be considered to have high sensitivity.

8.6.1.1 Intertidal Ecology

There is a paucity of recent records for Loch Fyne's intertidal area, however, two reviews have collated historical information available for the region (Connor and Little, 1998; Wilding et al., 2005). These studies indicate that the intertidal area of Loch Fyne exhibits low habitat diversity and is mostly comprised of bedrock and boulders. These habitats support communities typical of rocky shores at temperate latitudes and are dominated by fucoid algae and barnacles before transitioning to communities dominated by *Laminaria saccharina* and red foliose algae in the infralittoral zone[3]. To supplement this information, project-specific surveys of the Development's intertidal area have been conducted.

The Scottish Association for Marine Science also conducted a Strategic Environment Assessment for the Clyde Sea (Wilding, et al., 2005), which also identified the coastline of Upper Loch Fyne as consisting of mainly boulders and bedrock, with some areas of sediment shores. The upper shore was characterised by bands of brown algae

[3] Infralittoral refers to shallow subtidal areas nearest the shore, excluding the intertidal zone.

Pelvetia canaliculata and *Fucus spiralis*, and the upper shore barnacle *Chthamalus montagui*. In the midshore, substrate cover varied by wave exposure, with exposed substrate dominated by barnacles and sheltered areas exhibiting thick fucoid (e.g. *Ascophylum nodosum, Fucus vesiculosus,* and *F. serratus*) growth. Sediment shores were all confined to the head of the loch, with sediments ranging from cobbles to fine sand. Embayments exhibited sparse to thick fucoid cover, with blue mussel (*Mytilus edulis*) beds beneath the algal stands in the lower midshore. The lower shore primarily consisted of sand overlying gravel, with little to no algal cover. In this zone, the lugworm *Arenicola marina* was present at high densities. Where the lower shore consisted of coarser sediments, *F. serratus* and *M. edulis* were the dominant organisms.

Project-specific Phase I walkover and unmanned aerial vehicle (UAV) surveys indicated that the intertidal area within the Development it exhibited a range of broadscale littoral rock and sediment habitats with various algal communities typical of intertidal areas. The habitats observed were assigned to EUNIS biotopes (*Table 8.3 Habitat Types Observed in the Intertidal Survey Area*). No Priority Marine Features (PMFs) were observed in the intertidal survey area (*Appendix 8.1: Intertidal Survey Report*) (*Volume 5 Appendices*).

Table 8.3 Habitat Types Observed in the Intertidal Survey Area

EUNIS BSH	EUNIS Code	EUNIS Description
A1.3	**A1.311**	*Pelvetia canaliculata* on sheltered littoral fringe rock
	A1.312	*Fucus spiralis* on sheltered upper eulittoral rock
	A1.3142	*Ascophyllum nodosum* on full salinity mid eulittoral mixed substrata
	A1.3151	*Fucus serratus* on full salinity sheltered lower eulittoral rock
	A1.322	*Fucus spiralis* on sheltered variable salinity upper eulittoral rock
	A1.324	*Ascophyllum nodosum* and *Fucus vesiculosus* on variable salinity mid eulittoral rock
A1.4	**A1.421**	Green seaweeds (*Enteromorpha spp.* and *Cladophora spp.)* in shallow upper shore rockpools
	A1.451	*Enteromorpha spp.* on freshwater-influenced and/or unstable upper eulittoral rock
A2.1	**A2.111**	Barren littoral shingle
A2.2	**-**	Littoral sand and muddy sand
B3.1	**-**	Supralittoral rock (lichen or splash zone)

8.6.1.2 Subtidal Ecology

Several survey efforts have been conducted within Loch Fyne to establish the distribution of PMFs in the Firth of Clyde area (Allen et al., 2013). Drop down video and grab sampling surveys were conducted between August and October in 2010 to identify biotopes at 44 sites. A total of 14 different biotopes were recorded, with several PMF habitats and species observed throughout the loch, including burrowed mud, fireworks anemone (*Pachycerianthus multiplicatus*), flame shell (*Limaria hians*) beds, horse mussel (*Modiolus modiolus*) beds and ocean quahog (*Arctica islandica*).

Grab sampling conducted in July 2015 by NatureScot, also characterised benthic infauna at 17 sites within the loch (Allen, 2017). A total of 279 taxa were identified, with the primary taxa (>50% of total abundance) including polychaetes, nematodes, brittle stars, and molluscs. Of these, the only PMFs observed included the flame shell and horse mussel.

Project-specific drop-down camera benthic surveys were also conducted in September 2021, which revealed that the benthic habitat near the proposed jetty location was largely composed of two broad-scale habitats: 'sublittoral macrophyte dominated sediment' (EUNIS A5.5) and 'mud and sandy mud' (EUNIS A5.3). Other broadscale habitat types observed patchily throughout the survey area include 'Atlantic and Mediterranean low energy infralittoral rock' (EUNIS A3.3), 'Atlantic and Mediterranean low energy circalittoral rock' (EUNIS A4.3), 'sand and muddy sand' (EUNIS A5.2) and 'mixed sediment' (EUNIS A5.4). The distribution of benthic habitats observed during drop-down camera surveys is provided in *Figure 8.3: Benthic Habitat Classification from Drop-Down Camera Transects Near the Proposed Jetty Location (Volume 3: Figures)*.

Areas of mud and sandy mud were further classified into 'infralittoral sandy mud' (EUNIS A5.33) and 'Seapens and burrowing megafauna in circalittoral fine mud' (EUNIS A5.361), with areas of A5.361 classifying as the PMF 'burrowed mud' for which the Upper Loch Fyne and Loch Goil MPA is designated. Areas of sublittoral macrophyte-dominated sediment were further classified 'Kelp and seaweed communities on sublittoral sediment' (EUNIS A5.52), which also qualifies as a PMF. Additionally, occasional occurrences of the PMF species fireworks anemone were observed throughout the transects. The distribution of PMF observations is provided in *Figure 8.4: PMF Occurrence During Drop-Down Camera Transects Near the Proposed Jetty Location (Volume 3: Figures).*

Project-specific grab sampling supported these results, with most grab sample sediments classified as infralittoral and circalittoral sandy mud (EUNIS A5.33 & A5.34). Additional habitats were observed sporadically across the sites and included ‘infralittoral coarse sediment’ (EUNIS A5.13), ‘infralittoral muddy sand’ (EUNIS A5.24), ‘infralittoral mixed sediment (EUNIS A5.43), and ‘circalittoral mixed sediment’ (EUNIS A5.44). Particle size analysis further indicated that most sites exhibited similar compositions of sand and mud with varying amounts of gravel. Macrofaunal sampling indicated that the infaunal assemblage at each site was dominated by polychaetes and bivalves, with no PMFs observed in grab samples. Detailed grab sampling results can be found in *Appendix 8.1: Benthic Survey Report (Volume 5: Appendices)*.

A number of marine habitats are referred to in the Argyll and Bute Council’s Local Biodiversity Action Plan: ‘mud habitats in deep water’, ‘sheltered muddy gravels’, and/or ‘sublittoral sands and gravels’ (Argyll and Bute Council, 2009). However, based on water depth of the proposed jetty and PSA analysis habitats within the Development area are unlikely to qualify as mud habitats in deep water or sheltered muddy gravels. Sublittoral sands and gravels may occur, but benthic habitat observed was primarily comprised of muddy habitats.

8.6.1.3 Invasive Non-Native Species

Marine Invasive Non-Native Species (INNS) pose significant threats to native ecosystems. They often compete for the same resources as local species but lack natural predators and, when not properly managed, can outcompete native species.

In 2015, Loch Fyne was surveyed by NatureScot as part of an effort to identify early warning signs of INNS, and several Non-Native Species (NNS) were identified (Cook, Beveridge, Twigg, & Macleod, 2015). In these surveys, natural and artificial structures and settlement panels were used to assess community composition for the presence of INNS at sites in the upper, middle, and lower reaches of the loch. Structures were visually surveyed while settlement panels were preserved in ethanol and surveyed under a microscope.

Whilst five invertebrate INNS were identified within Loch Fyne, only one, the modest barnacle (*Austrominius modestus*), was observed on the settlement panels in the upper loch. This species is widely distributed across the UK. Additional INNS observed in other areas of the loch included the orange-tipped sea squirt *Corella eumyota*, erect bryozoans *Bugula simplex*, and *Tricellaria inopinata*, Japanese skeleton shrimp *Caprella mutica,* and the alga *Codium fragile.* This study also highlighted several INNS that had previously been reported south of Loch Fyne in the Clyde area, including the colonial ascidian *Botrylloides violaceus*, carpet sea squirt *Didemnum vexillum*, leathery sea squirt *Styela clava*, and the macroalga wireweed, *Sargassum muticum*.

Of these, *D. vexillum* is the only INNS to have been reported as establishing itself within Loch Fyne (Marine Scotland, 2020). The carpet sea squirt can spread rapidly, forming dense colonies on the seabed and other substrates, which can lead to the exclusion of other benthic species, degradation of functional habitats, and habitat homogenisation. The carpet sea squirt proliferates particularly on man-made submerged structures including docks, moorings, vessel hulls and aquaculture equipment (Brown, 2020). Within Loch Fyne, its presence has been confirmed in Portavadie, near the mouth of the loch (approximately 45 km from the Development; Marine Scotland, 2020). However, the Clyde Marine Plan has reported that *D. vexillum* has colonised the upper, middle and lower extents of the loch (Clyde Marine Planning Partnership, 2018) though it has been primarily observed in the intertidal zone (Marine Scotland, 2020). A biosecurity plan for Loch Fyne[4] indicates that industrial activities within the loch pose a high risk of spreading *D. vexillum* through vessel movement and disturbance of substrates (Brown, 2020).

No INNS were observed during project-specific surveys. Additionally, whilst the remaining non-native species are not considered established within the loch, the proximity of the Study Area to these populations indicates the potential for future colonisation within Loch Fyne and the Study Area.

8.6.2 Fish and Shellfish Ecology

This section discusses the fish and shellfish species occurring within the Study Area. The Study Area has been informed based on the maximum theoretical potential ZoI for impacts likely to occur as a result of the Development, which would be UWS from piling activities. In the absence of specific guidance for fish and shellfish ecology with regard to the impacts from UWS, advice from JNCC has been adhered to which states an effective deterrent range

[4] A voluntary plan funded by Marine Scotland and developed by the users and community of Loch Fyne, Argyll, Scotland with the support of C2W Consulting. (Gov Scot, 2020).

for UWS associated with monopile installation is 26 km for harbour porpoise. As such, the Study Area for fish and shellfish will reflect this range.

The Development is also likely to interact with migratory fish which can travel to and from natal rivers, outside the maximum ZoI. Guidance produced by ABPmer (2014) recommends that a regional approach should be adopted for migratory fish to ensure any fish which may pass through the Study Area and therefore any other sites which may have interaction with the Development, but are beyond the initial screening distance, are also considered. For the purpose of this section, additional disturbance is considered to occur where the Study Area falls in front of a migratory route into a river. As such, any designated sites which protect rivers that flow into the loch within the Study Area have also been considered, to ensure any potential interactions between the Development and potential migration routes are included.

The sensitivity value of fish and shellfish present within the Study Area varies by taxonomic group. Pelagic species are likely to be of low to medium sensitivity, whereas demersal and / or migratory species may be of medium to high sensitivity.

8.6.2.1 Diadromous Fish

Diadromous fish are those which seasonally migrate between fresh and marine water bodies. Several species are protected under international and national conservation legislation and are known to be present in the Study Area (*Table 8.4 Diadromous Fish Species Known to Occur in Loch Fyne and their Conservation Designations*).

Loch Fyne is a sea loch, extending inland from the Firth of Clyde, with upper Loch Fyne (past Newton Bay) known to have varying salinity due to freshwater inputs (Argyll and Bute Council, 2009). Twenty-two rivers run into Loch Fyne, many of which have been identified as important locations for diadromous species. Of these catchments, 14 have been surveyed to identify present fish populations (Argyll Fish Trust 2012), having observed Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), European eel (*Anguilla anguilla*), European flounder (*Platichthys flesus*), lamprey (*Lampetra* spp), and three-spined stickleback (*Gasterosteus aculeatus*). Eel were observed in nine catchments, and flounder, lamprey, and stickleback in fewer than five catchments each (Argyll Fisheries Trust, 2012).

Six of these catchments were surveyed again in the summer months of 2020 for juvenile Atlantic salmon and sea trout, five of which occur in the upper Loch Fyne area: Array, Shira, Kinglas, Fyne, and Leacann (*Figure 8.5: Migratory Fish Catchments Near the Development (Volume 3: Figures))*; Argyll Fisheries Trust, 2020). Surveys were conducted at 42 sites within these catchments using electrofishing during low-medium flow conditions. A total of 52 juvenile salmon were found across four of the five catchments, with no observations in the Kinglas catchment since 2017 (Argyll Fisheries Trust, 2020). For trout, a total of 66 juveniles were observed, with individuals reported from every catchment (Argyll Fisheries Trust, 2020). Density ranges of fish present at sites within each catchment is provided in *Table 8.5 Juvenile Atlantic Salmon and Sea Trout Densities in Catchments Which Flow into Upper Loch Fyne*.

Both Atlantic salmon and sea trout are anadromous migratory species, migrating from the sea into freshwater for spawning. Spawning typically occurs in the upper reaches of rivers in gravelly substrate (Heessen *et al*., 2015; NASCO, 2012). The migration of juveniles down-river to the ocean usually occurs from late spring, with most fish having migrated by June (Thorstad *et al*., 2012; NatureScot, 2023a). Once salmon have spent another one to five years at sea, the adults then return to their spawning rivers, which in Scotland usually occurs in the period November to December, but may extend from October to February (NatureScot, 2023a). Atlantic salmon are protected in the UK as an Annex II species, however, there are no sites designated for their protection within the Study Area.

Trout exhibit a similar life cycle to Atlantic salmon, though the adult marine stage of sea trout is shortened both spatially and temporally. Some individuals migrate back to freshwater environments after only a very short period of time feeding at sea, whilst ‘maidens’ only return to freshwater after a minimum of a year at sea (Gargan *et al*., 2006). Adult sea trout returning to freshwater to spawn are more likely to stray from natal rivers compared to salmon. Both sea trout and Atlantic salmon are included in the Argyll and Bute Council’s local biodiversity action plan (Argyll and Bute Council, 2009).

Lamprey are also an anadromous migratory species, with the river (*Lampetra fluvialitis*) and sea lamprey (*Petromyzon marinus*) species known to migrate from marine habitats to freshwater to spawn. The river lamprey migrates upstream in autumn and spring, but spawning only occurs in spring (April – May) as autumnal migrants are undeveloped (NatureScot, 2023b). Sea lampreys migrate upstream to spawn in spring and early summer, primarily between May and June (NatureScot, 2023b).

Lamprey are usually found in coastal waters, estuaries, and accessible rivers, with juveniles often found in large congregations (Maitland, 2003a). They generally spend one to two years in estuaries, before moving upstream (Zancolli *et al.,* 2018). Only the river lamprey (*L. fluvialitis*) is protected in the UK as an Annex II species, although there are no sites within the Study Area designated for their protection.

The European eel is a catadromous migratory species, migrating from freshwater to the sea for spawning. They are considered critically endangered on the IUCN Red List (2023) and are a PMF in Scotland. Eels migrate upstream into freshwater predominately during spring but may continue to do so until early Autumn. Once within freshwater habitats, eel remain for five to 15 years, before they begin their downstream migration through rivers and estuaries back towards marine spawning grounds, predominately between August and December (Behrmann-Godel and Eckmann, 2003; Chadwick *et al.,* 2007). Some eels do not migrate into freshwater but instead inhabit estuaries before returning to spawning grounds.

Table 8.4 Diadromous Fish Species Known to Occur in Loch Fyne and their Conservation Designations

Common name	Latin Name	Conservation Designations
Atlantic salmon	*Salmo salar*	• UK Biodiversity Action Plan (BAP) Priority Species • Scottish Biodiversity List • Priority Marine Feature – Scotland • Argyll and Bute LBAP • OSPAR list of Threatened and/or Declining species and habitats
Brown / sea trout	*Salmon trutta*	• UK BAP Priority Species • Scottish Biodiversity List • Priority Marine Feature – Scotland
European eel	*Anguilla anguilla*	• Priority Marine Feature – Scotland • 'Critically Endangered' IUCN Red List
Lamprey	*Lampetra* spp.	• UK BAP Priority Species (river lamprey (*Lampetra fluviatilis*) only) • Scottish Biodiversity List • Priority Marine Feature – Scotland (river lamprey only) • Annex II of the Habitats Directive • Annex V of the Habitats Directive (river lamprey only) • Environmental Liability Directive (brook lamprey (*Lampetra planeri*) only)

Sources:
UK BAP Priority Species (JNCC, 2007)
Scottish Biodiversity List (Marine Scotland, 2013)
Priority Marine Features – Scotland (SNH, 2014)
Argyll and Bute (LBAP) (Argyll and Bute Council, 2009)

Table 8.5 Juvenile Atlantic Salmon and Sea Trout Densities in Catchments Which Flow into Upper Loch Fyne

Catchment	Salmon (individuals 100 m^{-2})		Sea Trout (individuals 100 m^{-2})	
	Fry	Parr	Fry	Parr
River Array	0.8-54.8	0-4.6	0-20.0	0-6.4
River Shira	0-22.4	0-3.6	0-87.4	0-9.4
River Fyne	0-36.1	0-6.7	0-5.0	0-11.2
River Kinglas	0	0	0.7-12.1	0.6-2.8
Leacann Water	3.3-10.6	0-1.3	0.8-6.7	0.6-10.7

8.6.2.2 Pelagic Fish

There is a paucity of records regarding the distribution of pelagic fish species present within Loch Fyne. Whilst a few fishing harbours are registered within the loch, it is not considered a regular commercial fishing ground for any pelagic species (JNCC, 2015). Management plans for the region are primarily concerned with salmon and trout

(Argyll Fisheries Trust, 2009), but local recreational angling has reported that mackerel (*Scomber scombrus*) may be numerous in summer months and herring are occasionally present (Argyll and Bute Council, 2009).

The adjacent Firth of Clyde has historically supported important fisheries, namely for demersal species and herring, however, these fisheries are considered to have since collapsed (Lawrence and Fernandes, 2021). Despite this, the area has still been recorded as an important nursery ground for herring (*Clupea harengus)* and mackerel, as well as an important spawning ground for sprat (*Sprattus sprattus*; Coull et al., 1998; Ellis et al., 2012).

Herring is an important commercial species and represents a significant prey species for many predators, including large gadoids (such as cod), dogfish, sharks, marine mammals and birds (ICES, 2006). It was once abundant in the Firth of Clyde, with Loch Fyne contributing to a major spawning herring fishery in the mid-1800s (Thurstan and Roberts 2010). Herring is found mostly in continental shelf areas up to depths of 200 m (Whitehead, 1986), with juveniles generally distributed in shallower waters of 15-40 m before migrating into deeper waters to join the adult stock after two years, and spawning occurring along the seabed (Heessen *et al*., 2015). Little information is available regarding herring distribution within Loch Fyne, with the stock historically associated with the Firth of Clyde considered to have not yet recovered since its collapse, with low biomass in the region (Lawrence and Fernandes, 2021). Whilst there are no recent records of herring within upper Loch Fyne, the area is mapped as a high-intensity nursery area for this species (Ellis et al., 2012), although the Study Area does not include sediments suitable for spawning.

Sprat is a short-lived, small-bodied pelagic schooling species that is relatively abundant in shallow waters. Sprat is an important food resource for a number of commercially important predatory fish, as well as seabirds and marine mammals. Sprat has recently been reported with great numbers in the Firth of Clyde, representing an increase in local stock biomass since 2010 (Lawrence and Fernandes, 2021). There are no recent records of sprat from Loch Fyne, but the loch has been identified as an important spawning ground for sprat (Coull et al., 1998).However,sprat are batch spawners with pelagic eggs and larvae and are considered to have no interaction with the benthos.

Atlantic mackerel once comprised an important fishery in the Firth of Clyde but have long-since declined in the region (Thurstane and Roberts 2010). Nonetheless, the Study Area has been identified as a low-intensity nursery area for mackerel (Ellis et al., 2012). Mackerel are an entirely pelagic species and form an important part of the diet of sharks, tuna and dolphin (Tappin *et al*., 2011). They are batch spawners with pelagic eggs and larvae (Murua and Saborido-Rey, 2003) and are considered to have no interaction with the benthos.

8.6.2.3 Demersal Fish

Observations of other fish species in upper Loch Fyne have primarily consisted of demersal fish species, which are species known to live or feed near the seabed. Demersal species have also historically been part of important fisheries in the Clyde region, with cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), hake (*Merluccius merluccius*), saithe (*Pollachius virens*), and whiting (*Merlangius merlangu*s) previously reported as comprising over 80% of demersal fish landings in the area (Hislop 1986; Connor and Little 1998). Today, reports indicate that biomass of demersal fish remains high, but many individuals are subject to bycatch in local shellfish fisheries (Lawrence and Fernandes, 2021).

Cod have historically been abundant in the Clyde, with increased landings observed into the 1960s before experiencing a 99% decline in abundance and biomass after 1984 and reaching a historical low in spawning biomass (Thurstan and Roberts 2010). The most recent assessment of the region has also reported no recovery in terms of abundance or biomass 10 years following the closure of the area to fishing, with young cod believed to be susceptible to bycatch in *Nephrops* fishery areas (Clarke et al., 2015). A survey of semi-pelagic white fish within Loch Fyne reported cod in both lower and upper Loch Fyne. Only 8 individuals were landed from trawls in the upper loch, but greater abundances were recorded in the lower Loch (Turrell et al., 2016).

Haddock are common throughout British waters, occurring around rock, sand, gravel, and shells from 40-300 m depth (Barnes 2008a). In the Firth of Clyde, haddock also used to comprise an abundant fishery in the region, prior to a collapse in the 1980s (Thurstan and Roberts 2010; McIntyre et al., 2012). The remaining demersal fishery in the Clyde is mixed, with haddock comprising one of the predominant species caught, although overall biomass is still comparatively low (McIntyre et al., 2012). Fishing tows within Loch Fyne reported a limited number of individuals (n<20) in the upper loch, with much greater abundances reported in the lower loch near the entrance to the firth (n>1500; Turnell et al., 2016).

Hake are common throughout the western British Isles, from the western English Channel and Irish Sea to western Scotland (Barnes 2008b). Like other demersal species, hake was also an important species in the Firth of Clyde in the late 1900s, with 57% of total Scottish landings for this species coming from the Clyde (Thrustan and Roberts 2010). Since the 1990s, the landings of hake from this area have declined to virtually zero, although they are still recorded as bycatch in other fisheries (McIntyre et al., 2012). Fishing tows in Loch Fyne have reported relatively few individuals in both the upper and lower reaches of the loch ($n \leq 21$; Turnell et al., 2016). The Study Area has also been identified as a low intensity nursery ground for this species (Ellis et al., 2012).

Saithe are particularly common off the north-west coasts of Scotland and Ireland (Barnes 2008c). Juveniles spend 1-2 years in shallow inshore surface waters before moving offshore to demersal habitats (Smith and Hardy 2001). Saithe have similarly become rare in the Firth of Clyde since the 1980s, following overexploitation (Thurston and Roberts 2010; Hunter et al., 2016). Today they comprise a portion of the mixed demersal fishery that operates in the region (McIntyre et al., 2012).

Five sandeel species occur in Scottish seas, with the two most common species known as Raitt's sandeel (*Ammodytes marinus*) and lesser sandeel (*A. tobianus*) (NatureScot, 2023c). Their distribution across Scotland is patchy but generally concentrated around sandbanks and other areas of suitable sediment (NatureScot 2023c). Sandeel are an important element of the food chain in the north Atlantic as prey for other fish species, sea birds and marine mammals (Dipper, 2001). They are a burrowing species, spending large proportions of the year under the sediment surface (Van der Kooij *et al*., 2008). They are known to have strong habitat preferences with regard to sediment type, with reduced selection and even avoidance observed in habitats with higher proportions of fine gravel, fine sand, coarse silt (Holland et al., 2005). In western Scotland, inshore fisheries of *A. marinus* were abundant prior to 2000 (Marine Scotland, 2020). Sandeel have not since been recorded in any efforts concentrated within the Firth of Clyde or Loch Fyne. Nonetheless, the Study Area has been identified low intensity nursery area for sandeel, with the adjacent waters of the Firth of Clyde identified as important spawning grounds (Coull et al., 1998; Ellis et al., 2012).

Whiting is a bentho-pelagic species which can be found in association with a variety of different seabed types including sediment and rocky areas (Barnes, 2008). Following declines in several fisheries, whiting now comprise one of the main fish communities within the Firth of Clyde (McIntyre et al., 2012; Hunter et al., 2016). Tows within Loch Fyne have reported mostly low numbers of individuals within both the upper and lower reaches of the loch, with the greatest abundance reported at the entrance to the firth (Turrell et al., 2016). The Study Area overlaps with a high intensity nursery ground for whiting (Coull et al., 1998; Ellis et al., 2012), however, juvenile whiting are considered pelagic and have no interaction with the benthos.

8.6.2.4 Elasmobranchs

Elasmobranchs include sharks, skates, and rays. Scotland's waters are home to over 30 different species, 25 of which occur in coastal waters (Scottish Government, 2011). Of these species, eight are listed as PMFs: basking shark (*Cetorhinus maximus*), blue shark (*Prionace glauca*), common skate complex (*Dipturus batis* and *D. intermedius*), leafscale gulper shark (*Centrophorus squamosus*), porbeagle shark (*Lamna nasus*), Portuguese dogfish (*Centroscymnus coelolepis*), sandy ray (*Leucoraja circularis*), and spiny dogfish (*Squalus acanthias*). Blue shark, porbeagle shark, sandy ray, and Portuguese dogfish are all primarily pelagic/oceanic or deepwater species and are unlikely to occur near the Development.

Basking shark are a particularly important species on the west coast of Scotland where they are known to commonly occur (Marine Scotland, 2020). They are found in their greatest concentrations locally in summer months, with seasonal migrations to offshore waters or southern areas common in winter months (Doherty et al., 2017; Marine Scotland, 2020). However, recent telemetry studies have indicated that basking sharks exhibit some degree of site fidelity (Doherty et al., 2017; Marine Scotland, 2020). The Sea of Hebrides has been recognised as a particular hotspot for this species and has recently been designated as an MPA (Marine Scotland, 2020). Some sightings have historically been reported in the Firth of Clyde and Loch Fyne (Marine Scotland, 2020) though distribution and habitat suitability modelling has indicated that the loch itself is unlikely to host suitable habitat or persistent populations, and individuals are likely to remain restricted to the Firth of Clyde (Paxton et al., 2014; Austin et al., 2019; Marine Scotland, 2020). As such, whilst occasional basking sharks may occur within the loch, it is unlikely they will occur in persistently high numbers near the Development.

The common skate complex is a demersal elasmobranch with a historically high abundance in Scotland and the North Sea. Overexploitation has led to the decline of this species and it is now listed as critically endangered on the IUCN red list. In Scotland, a particular hotspot for this species has been identified and designated as an MPA – Loch Sunart to the Sound of Jura MPA (approximately 207 km from the Development). Once thought to primarily inhabit deeper habitats, a recent tracking study within the MPA has indicated that this species makes extensive use of shallow-water habitats, including habitats <10 m (Thorburn et al., 2021). Additionally, modelling has indicated that the lower reaches of Loch Fyne may also serve as core habitat in winter months, with seasonal migration patterns indicating that individuals move to shallow waters over winter (Thorburn et al., 2021). However, previous surveys in Loch Fyne (1988-1990) only reported a single skate, with more recent video surveys of the loch not reporting any (Moore, 2019). Furthermore, they are considered to have a below average abundance compared to other regions in western Scotland (Mills, Sheridan, & Brown, 2017; Clyde Marine Planning Partnership, 2018). As such, whilst occasional common skates may occur within the Study Area, it is unlikely that they will be present in high numbers near the Development.

The spiny dogfish is primarily a benthopelagic species but can be found in inshore waters. In Scotland, they occur on the west coast, with recent tagging studies indicating their presence in Loch Etive and the Firth of Lorn, with Loch Etive serving as a mating and nursery ground (Thorburn et al., 2018). Once thought to be abundant in the Firth of Clyde, as evident by fishing records, there is a paucity of records regarding their catch or distribution in the region today (McIntyre et al., 2012). Loch Fyne has been reported as serving as a high intensity spawning area for spiny dogfish (Ellis et al., 2012), however, surveys within the loch have not reported this species in recent years (Scottish Natural Heritage, 2019). As such, it is unlikely that they will occur in high number near the Development.

8.6.2.5 Shellfish

Shellfish is a broad term used to describe a large group of marine invertebrates that possess an exoskeleton (e.g., crustaceans, and molluscs) that are used as food. Shellfish are usually benthic, demersal, subtidal and/or intertidal during their adult stages. Shellfish are predominantly crustaceans and molluscs but other groups such as squid and octopus may also be commercially important in some areas.

Loch Fyne is primarily a recognised shellfish water for its production of Pacific oyster (*Crassostrea gigas*) in both the upper and lower reaches of the loch (SEPA, 2022). The northern basin has also been observed to support blue mussel (*Mytilus edulis*) production, while the middle and lower basins of the loch have also supported otter shell (*Lutraria lutraria*), razor clam (*Ensis arcuatus*), and scallops (*Chlamys opercularis;* SEPA, 2011). It is also thought that the loch provides commercially important density of the Norwegian lobster *Nephrops norvegicus*, with the upper loch identified as having a moderate monetary value in regards to *Nephrops* trawling (Kafas et al., 2014).

Pacific oyster were initially introduced into the UK for mariculture, with ‘escapees’ now having established populations in various regions (Hughes, 2008). They typically occur in sheltered waters on hard surfaces from the lower intertidal zone to the shallow subtidal (NIMPIS, 2022). In Loch Fyne, one oyster farm exists in the upper loch, near Ardkinglas (SEPA, 2022), which has previously reported an annual turnover around £10 million per year (Argyll and Bute Council 2009).

Blue mussel are common throughout the coasts of the British Isles, with large commercial beds located in the estuaries of western Scotland (Tyler-Walters 2008). They typically occur from the high intertidal to the shallow subtidal, attached to rocky surfaces and along piers in sheltered harbours, often forming dense aggregations (Tyler-Walters 2008). They are known to naturally occur throughout Loch Fyne and have previously been farmed in the northern loch, however the most recent assessment of the Loch Fyne shellfish water indicates that these sites have since been declassified (SEPA 2022).

The langoustine, *Nephrops norvegicus*, is considered one of the main target commercial species within Loch Fyne (Argyll and Bute, 2009). Trawlers operate throughout the majority of the loch, including the Study Area, except the shallow sill area around Otter Spit (***Error! Reference source not found.*** *(Volume 3: Figures)*). Nephrops typically occur on sublittoral soft sediments and are commonly associated with fine cohesive mud which is stable enough to support their burrows (Hill and Sabatini 2008). Considerable populations are known from the Clyde region, with Scotland’s sea lochs known to serve as important habitats (Marine Scotland, 2020). Furthermore, Nephrops is commonly associated with the PMF habitat ‘burrowed mud’ (Marine Scotland, 2020), which is a designated feature of the Loch Fyne and Loch Goil MPA, within which the Development is situated.

8.6.2.6 Spawning and Nursery Grounds

The occurrence, distribution and abundance of many fish and shellfish within the Study Area is determined by their propensity to aggregate within specific areas to spawn. ‘Spawning grounds’ are defined either by the species behaviour and may, therefore, cover a wide area, or by specific habitat preferences (e.g., gravel), which may restrict spatial extent. Fish exhibit several modes of reproduction, the most common being broadcast spawning, where eggs and sperm are released into the water column (Ellis *et al*., 2012). Other species deposit egg-cases or egg mats onto the seafloor making them more vulnerable to seabed disturbance.

Fisheries sensitivity maps presented by Coull *et al*. (1998) and Ellis *et al*. (2012) provide important information on the locations of spawning (where eggs are laid) and nursery (common locations for juveniles) grounds for selected species of fish and shellfish in the Study Area. The data indicate that the Study Area and therefore the Development fall within important spawning grounds for sprat (Coull et al., 1998) and important nursery grounds for cod, common skate, hake, herring, mackerel, sandeel, and spiny dogfish (Ellis et al., 2012).

However, several of the aforementioned species present in the Study Area are broadcast spawners or release eggs in the water column (e.g., whiting, sprat, mackerel, and cod). Therefore, once eggs have spawned, they become pelagic and are carried away by ocean currents, dispersing throughout the water column. As such, eggs of these species are expected to be transported away from the Development, making them unlikely to be at risk of impact. The only species carried forward for detailed appraisal and assessment of potential impacts resulting from the Development are herring and sandeel.

In Scotland, the Firth of Clyde has historically been home to a spawning population of herring, which remained one of the last known spawning populations following overexploitation in the region (Frost and Diele, 2022). However, pollution and further degradation has occurred in the area and herring are no longer considered to spawn in great numbers (ICES 2019). Herring are known to spawn in high energy environments, selecting structurally complex habitats and coarse substrates (e.g. gravel, shells, small rocks, shingle, coarse sand; Frost and Diele, 2022). Within the Firth of Clyde, present-day spawning is largely restricted to the ridges of Ballantrae Bank and the coast of Arran (Frost and Diele, 2022). Furthermore, project-specific benthic surveys reported that the Study Area was largely comprised of muddy sediments. As such, when considering the remaining distribution of spawning herring in the Clyde region and the unsuitability of the habitat within the Study Area, it is unlikely any herring spawning will occur near the Development.

Sandeel spawning is associated with specific habitat types, which typically consist of coarse sand with small contributions of mud and sometimes gravel. Particle size analysis (PSA) for sites within the Development area yielded sediment samples with mud composition ranging from 18-62% (*Appendix 8.2 Subtidal Benthic Survey Report*). This exceeds the percent of mud considered suitable for sandeel spawning. Analysis of PSA conducted by NatureScot in upper Loch Fyne also reported sediment types not suitable for sandeel spawning, comprised primarily of mud with varying amounts of sand, classified as ‘slightly gravelly sandy mud’ (Allen, 2017). As such, it is unlikely that any suitable sandeel spawning habitat is present near the Development.

8.6.3 Marine Mammal Ecology

There are two groups of marine mammals found in UK waters: cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals). Most are wide ranging and those recorded within the study area are likely to be individuals from larger biological populations present along the UK coast. All marine mammal species are of high conservation value and sensitivity to impacts from Development activities range from low to high depending on the activity and species.

8.6.3.1 Cetaceans

The Development is located within ICES Celtic Seas Ecoregion (ICES 2022). Within this ecoregion, thirteen marine mammals species are considered to commonly occur or be regular visitors: Atlantic white-sided dolphin (*Lagenorhynchus acutus*), bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), cuvier’s beaked whale (*Ziphius cavirostris*), fin whale (*Balaenoptera physalus*), harbour porpoise (*Phocoena phocoena*), orca (*Orcinus orca*), long-finned pilot whale (*Globicephala melas*), Minke whale (*B. acutorostrata*), northern bottlenose whale (*Hyperoodon ampullatus*), Risso’s dolphin (*Grampus griseus*), Sowerby’s beaked whale (*Mesoplodon bidens*), sperm whale (*Physeter macrocephalus*), and white-beaked dolphin (*L. albirostris*).

Most of the above species are considered pelagic, occurring primarily offshore in deep waters and unlikely to occur near the Development. However, Atlantic white-sided dolphin, bottlenose dolphin, harbour porpoise, orca, minke whale, and white-beaked dolphin are known to regularly inhabit or visit shallow coastal habitats and as such may occur near the Development. These, and all cetacean species are protected in UK waters and are of international conservation importance (*Table 8.6 Protection Status for the Most Common Cetaceans Present within the study area*).

Table 8.6 Protection Status for the Most Common Cetaceans Present within the study area

Common Name	Latin Name	Wildlife and Countryside Act, 1981	EC Habitats Directive (Annex)	Bonn Convention (Appendix)	Bern Convention (Appendix)	ASCOBANS	Scottish Priority Marine Feature
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	✓	IV	II	II	✓	Offshore waters
Bottlenose dolphin	*Tursiops truncatus*	✓	II, IV	II	II	✓	Offshore & territorial waters

Harbour porpoise	*Phocoena phocoena*	✓	II, IV	II	II	✓	Offshore & territorial waters
Orca	*Orcinus orca*	✓	IV	II	II	✓	Offshore & territorial waters
Minke whale	*Balaenoptera acutorostrata*	✓	IV	-	II, III	-	Offshore & territorial waters
White-beaked dolphin	*L. albirostris*	✓	IV	II	II	✓	Offshore & territorial waters

The IAMMWG has further defined management units for the most common species in the UK, based on population structure, movement and habitat use, and relevant management boundaries (IAMMWG, 2023). As such, the study Area for cetaceans reflects the relevant MUs of each species.

For Atlantic white-sided dolphin, minke whale, and white-beaked dolphin, the Development falls within the Celtic and Greater North Sea IAMMWG MU. For bottlenose dolphin and harbour porpoise, it occurs within the Coastal West Scotland & Hebrides IAMMWG MU for bottlenose dolphin and West Scotland IAMMWG MU respectively. No MU has been defined for orca.

The most recent effort to understand the abundance of cetaceans in UK waters has been the SCANS IV surveys, which estimated the abundance of small cetaceans across the northeastern Atlantic and North Sea. The programme commenced in 1994 with boat-based line transect and aerial surveys, and has since been repeated in 2005, 2016, and 2022. Abundance estimates are divided into blocks, with block CS-F containing the Development. Considering the wide-ranging nature of marine mammals, consideration has also been given to the adjacent block CS-D (*Image 8. 1 SCANS IV Survey Blocks*, below). It is important to note that SCANS surveys were conducted in the summer (predominantly July) and therefore data is only representative of summer distributions (Hammond, et al., 2021). However, it is understood that the densities of cetaceans around the British Isles are likely to be highest during this season (Waggitt et al., 2019).

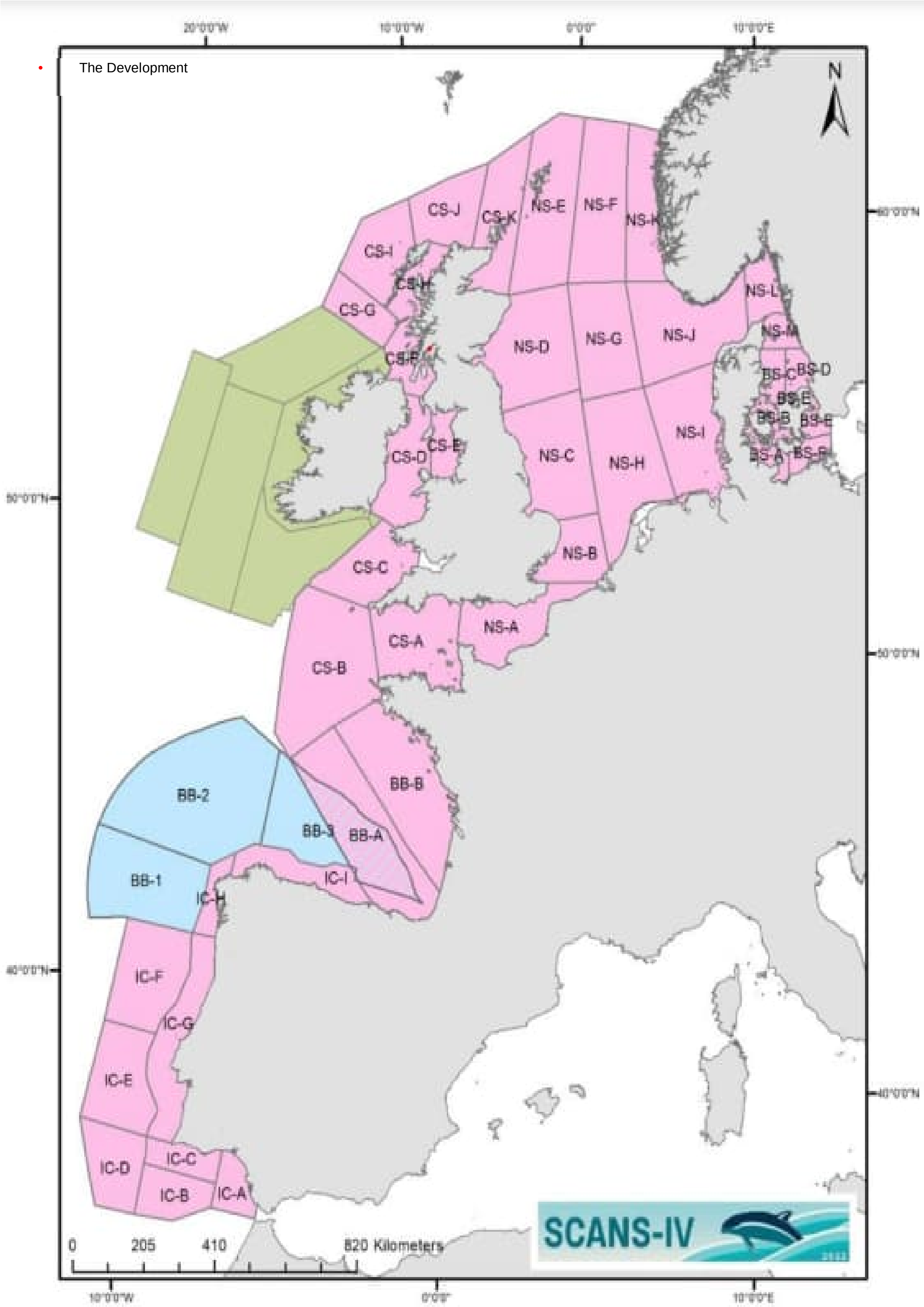

Image 8. 1 SCANS IV Survey Blocks

The most recent abundance estimates for the IMMWG MUs and relevant SCANS IV block data are provided in *Table 8.7 Abundance and Density Estimates for Cetaceans in the Study Area*.

Table 8.7 Abundance and Density Estimates for Cetaceans in the Study Area

Species	IAMMWG MU	MU Abundance	MU UK EEZ Abundance	SCANS IV Block CS-F Density (ind. Km^{-2})	SCANS IV Block CS-D Density (ind. Km^{-2})

Harbour porpoise	West Scotland	28,936	24,305	0.20	0.28
Bottlenose dolphin	Coastal West Scotland & Hebrides	N/A	45	0.78	0.35
Minke whale	Celtic and Greater North Sea	20,118	10,288	0.01	0.01
Atlantic white-sided dolphin	Celtic and Greater North Sea	18,128	12,293	0	0
White-beaked dolphin	Celtic and Greater North Sea	43,951	34,025	0	0
Orca	N/A	N/A	N/A	N/A	N/A

Harbour porpoise are widespread and abundant throughout UK waters. They most commonly occur in continental shelf waters less than 100 m deep and are frequently observed in coastal bays and estuaries. Harbour porpoise are widespread around the seas of Scotland, with the inner Hebrides designated for the protection of this species. Lower Loch Fyne is also considered to host groups of harbour porpoise (Argyll and Bute Council, 2009). Within the ?Firth of Clyde, harbour porpoise have been detected with passive acoustic monitoring (PAM) surveys, with sightings also reported in both the lower and upper reaches of Loch Fyne (Brown 2018; Hebridean Whale and Dolphin Trust 2023). Additionally, modelling of harbour porpoise distribution in the North Sea indicates that sea surface temperature, distance to coast, depth, and distance to sandeel grounds are important predictor variables in describing their distribution (Gilles, et al., 2016) as harbour porpoise forage mainly for sandeel (Maeda, et al., 2021). However, within Loch Fyne, no preferred sandeel grounds were identified (*Section 8.6.2 Fish and Shellfish Ecology*). Nevertheless, occasional sightings within the loch and proximity to the firth suggest individuals may occur near the Development.

Bottlenose dolphin have a near global distribution and are common throughout UK waters. In Scotland, resident populations exist in the Moray and Cromarty Firths along the east coast, but only occur in small groups along the west coast, particularly around the Hebrides (Sea Watch Foundation, 2012a). There are two recognised ecotypes of bottlenose dolphins – a coastal ecotype which primarily occurs within 30 km of the coastline and exhibits habitat fidelity, and a wide-ranging offshore ecotype (Hague, Sinclair, & Sparling, 2020). The most recent assessment of bottlenose dolphin sightings and distribution in western Scotland reported sightings from around the Firth of Clyde and into the lower reaches of Loch Fyne, but also estimated that abundance is approximately five times greater on the east coast than the west coast (Thompson et al., 2011). Predicted density and distribution of the offshore ecotype reported low densities in the northern Irish Sea and Firth of Clyde, with a lack of any seasonal variation (Waggitt et al., 2020). Furthermore, the lower loch is considered to host groups of bottlenose dolphin (Argyll and Bute Council, 2009), but very limited sightings have been reported within the upper loch (Hebridean Whale Trust 2023). As such, whilst occasional individuals may be present within the vicinity of the Development, it is unlikely bottlenose dolphin will occur in large numbers.

The minke whale is relatively common in UK waters with much of its distribution concentrated in coastal waters around Scotland. They are most commonly seen in areas of strong currents around headlands and islands, but have also been observed entering estuaries, bays, and inlets (NatureScot 2023d). The waters around the Hebrides are known to host a seasonal abundance of minke whale between July and September (NatureScot 2023d), with occasional observations of individuals reported within Loch Fyne (Hebridean Whale and Dolphin Trust, 2023). Atlantic white-sided dolphin occur primarily in temperate and subarctic waters of the northern Atlantic, most commonly along the continental shelf slope in western Ireland and north-west Britain (Sea Watch Foundation, 2012b). In the waters off western Scotland, they occur in social groups of 2-30 individuals (Hebridean Whale and Dolphin Trust 2023). In summer months they migrate to more coastal waters but are still rarely seen within the continental shelf in the Hebrides (Hebridean Whale and Dolphin Trust 2023). When considering this in conjunction with the lack of assessment during the SCANS IV surveys, they are unlikely to occur within the study area.

The white-beaked dolphin is endemic to the northern Atlantic and North Sea (Sea Watch Foundation, 2012c). It occurs primarily in continental shelf waters less than 200 m deep and is common in the waters of western Ireland and Scotland (Sea Watch Foundation, 2012). On the west coast of Scotland, they occur primarily around the northern Minch and Western Isles (Calderan et al., 2013). When considering this in conjunction with their absence in the SCANS IV surveys, it is unlikely that this species will occur near the Development.

In UK waters, orcas are common in northern and western Scotland. A resident group is known to range widely around the west coast of the UK and Ireland. A separate population are seasonal visitors to Northern Scotland, particularly the Shetland and Orkney Islands. In the Hebrides there is a small group of killer whales called the West Coast Community, which include just eight individuals that have been seen in the Clyde and around Arran. However, no sightings have been reported within the upper loch (Hebridean Whale Trust 2023), nor have they been reported in the SCANS IV surveys and as such are unlikely to occur within the study area.

8.6.3.2 Pinnipeds

Two seal species are known to occur in the northeast Atlantic, the harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*), with the UK known to support important populations of both species. Scotland in particular supports high concentrations, accounting for 80% and 85% of the UK population respectively for harbour and grey and seals (SCOS, 2023. The Development falls within the Southwest Scotland MU for both species, where the most recent count data are 1,709 individuals for harbour seal and 517 individuals for grey seal (SCOS, 2023).

Both species are known to forage over large distances, coming onshore at haul-out sites to rest, breed, and moult. Harbour seals forage up to 273 km from their haul out site, but typically remain within 50 km of the coastline (Russell & McConnell, 2014; Russel, Jones, & Morris, 2017; Carter et al., 2022), whilst grey seals are known to forage up to 448 km from their haul-out sites (Carter et al., 2022).

Recent modelling of at-sea seal distribution in the UK has indicated that Loch Fyne is not likely to support any grey seals but may support very low numbers (>0.05% of the at-sea population) of harbour seal (Carter et al., 2022). Furthermore, no breeding colonies for grey seal are known to occur within Loch Fyne or the Firth of Clyde region, but small haul out sites for harbour seal (supporting <100 individuals) may occur within the loch (SCOS, 2021).

Recent aerial surveys of the area have been conducted by the Sea Mammal Research Unit at the University of St Andrews, which tracked the abundance and distribution of seals in Scotland during the summer moult period from 2016-2019 (Morris et al., 2021). The most recent data for Loch Fyne (2018) indicated that harbour seals were abundant (*Image 8.2 Harbour Seal Distribution by 10 km Squares from Aerial Surveys Conducted During Moult in August 2016-2019 source: Morris et al., 2021,* below) within the loch, exhibiting an increasing population trend between 1989 (n=136) and 2018. Harbour seal haul-out locations near Lochgilphead (Argyll & Bute, 2009) but these are over 100 km south of the development. Grey seals were also reported, but at much lower numbers (n<10; *Image 8.3: Grey Seal Distribution by 10 km Squares from Aerial Surveys Conducted During Moult in August 2016-2019 source: Morris et al., 2021*, below), indicating that they are not likely resident in the area (Morris et al., 2021).

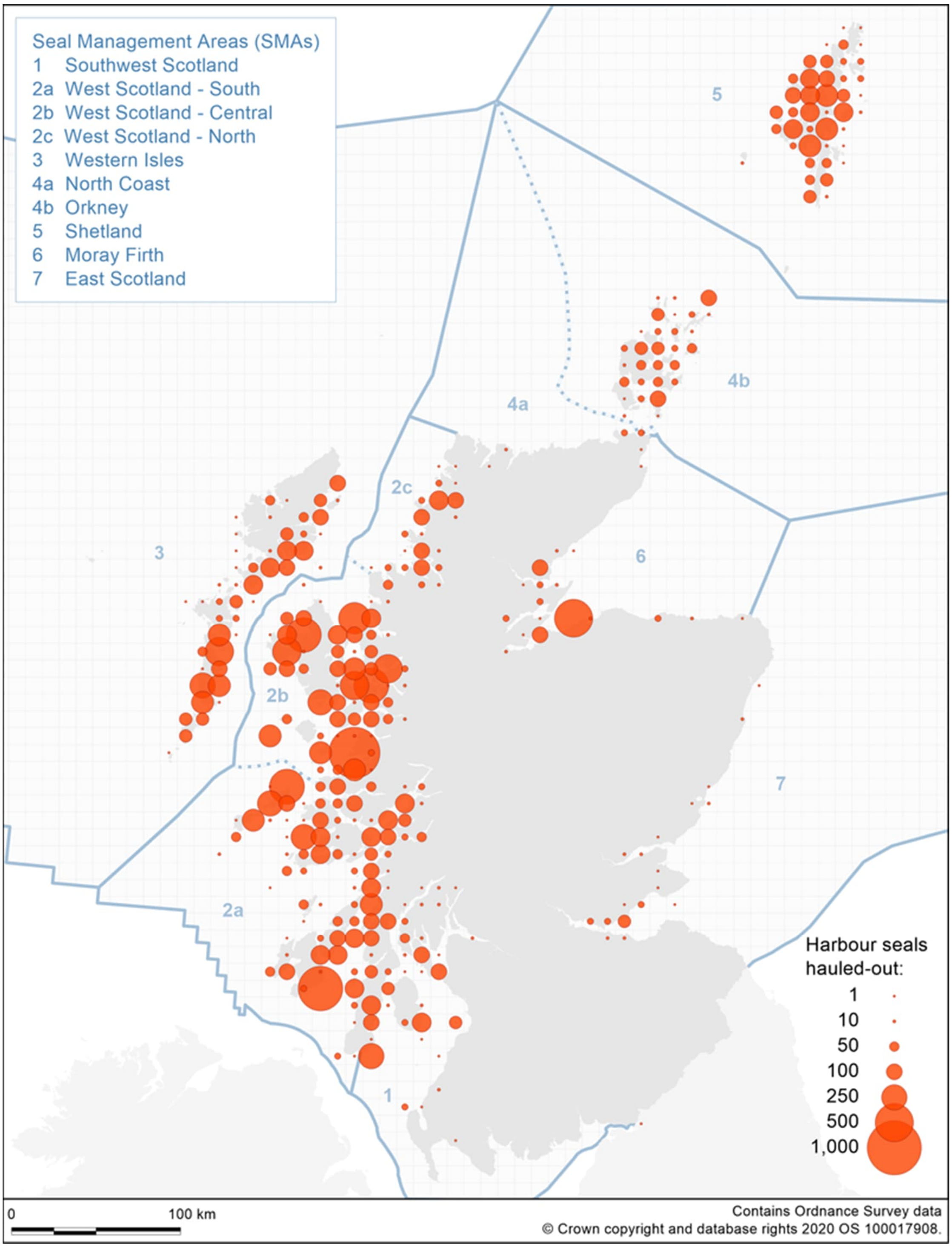

Image 8.2 Harbour Seal Distribution by 10 km Squares from Aerial Surveys Conducted During Moult in August 2016-2019 ***source: Morris et al., 2021***

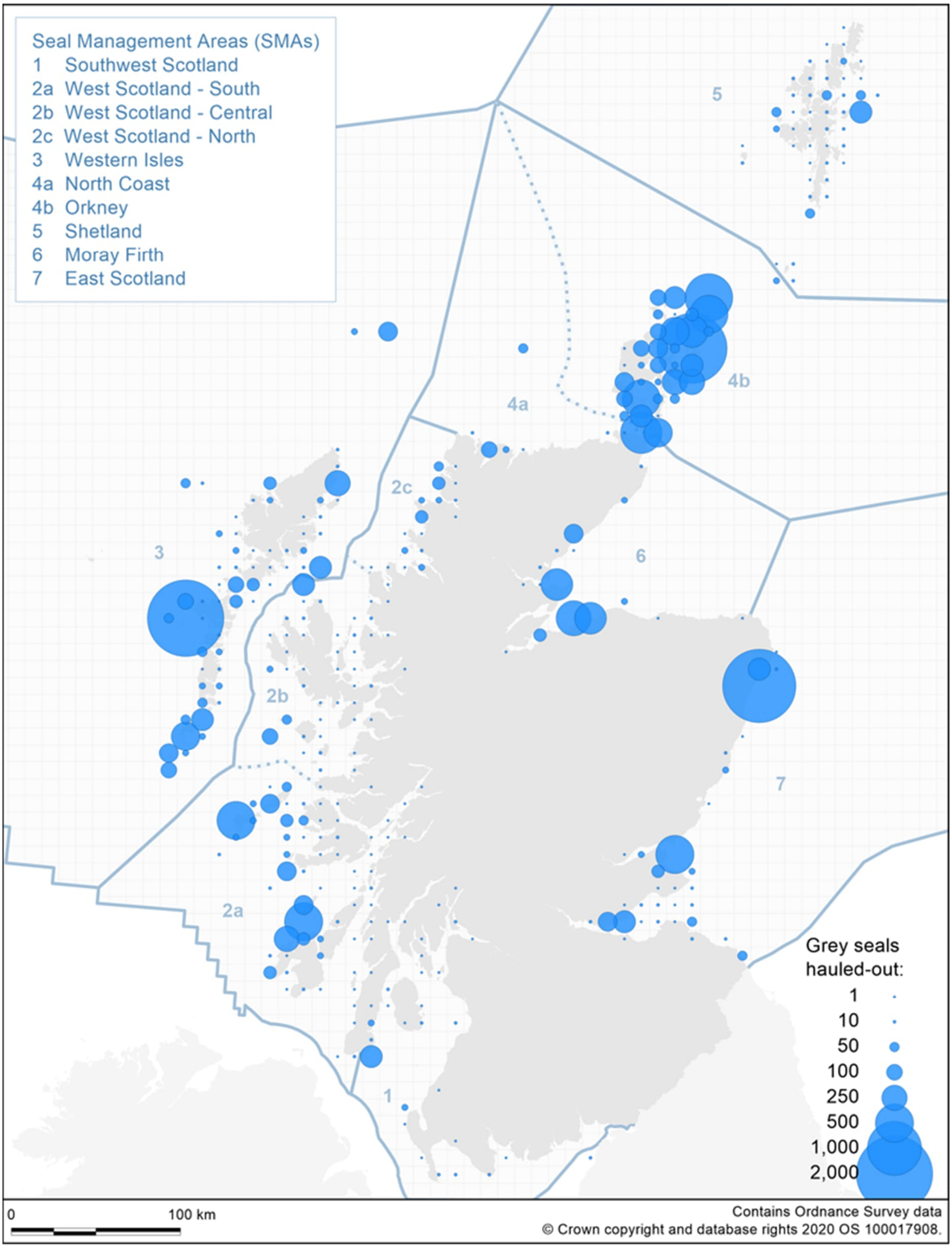

Image 8.3: Grey Seal Distribution by 10 km Squares from Aerial Surveys Conducted During Moult in August 2016-2019 *source: Morris et al., 2021*

8.6.4 Designated Sites

Several sites designated for the protection of marine ecological features occur within the study areas of relevant receptors. These include:

- Upper Loch Fyne and Loch Goil MPA (0 km) – overlaps with the Development, designated for the protection of burrowed mud, flame shell beds (*Limaria hians*), horse mussel beds (*Modiolus modiolus*), and ocean quahog aggregations (*Arctica islandica*);

- The Maidens SAC (~156 km) – designated for the protection of grey seal;
- North Channel SAC (~166 km) – designated for the protection of harbour porpoise;
- Skerries and Causeway SAC (~178 km) – designated for the protection of harbour porpoise;
- South-east and Islay Skerries SAC (~179 km) – designated for the protection of harbour seal
- Inner Hebrides and the Minches SAC (~187 km) – designated for the protection of harbour porpoise; and,
- Sea of Hebrides MPA (~255 km) – designated for the protection of minke whale.

The Development directly overlaps with the Upper Loch Fyne and Loch Goil MPA (*Figure 8.1: Benthic Ecology and Fish and Shellfish Study Area (Volume 3: Figures)*) and as such, direct impacts to the designated features of this site are likely to occur. These have been considered in *Appendix 8.3 MPA Assessment.*

The remaining designated sites are each located >150 km from the Development area. Although the marine mammal species for which these sites are designated are known to range over great distances, no connection has been reported between the populations of these sites and Loch Fyne. Occasional visitors are known to occur within the upper reaches of the loch, but no resident populations or regular visitors occur (Sea of Hebrides Trust, 2023). As such, these sites have been screened out of any further assessment and only the Upper Loch Fyne and Loch Goil MPA is considered

8.6.5 Summary

A variety of important marine habitats and organisms occur within the study area which may be subject to impacts from project activities. The Development occurs within the Upper Loch Fyne and Loch Goil MPA, which is designated for the protection of burrowed mud habitats, flame shell beds, horse mussel beds, ocean quahog aggregations, and sublittoral mud and mixed sediment communities. Project-specific benthic surveys observed the PMFs ‘burrowed mud’ and ‘kelp and seaweed communities on sublittoral sediment’, which comprise the majority of the study area.

Loch Fyne is a sea loch, with numerous rivers which have been identified as important locations for diadromous fish species that run into the loch. As such, Atlantic salmon, brown trout, European eel, and lamprey may all be present within the study area with Atlantic salmon and sea trout included in the Argyll and Bute Council’s local biodiversity action plan. Additionally, tows within the upper loch have reported the presence of demersal fish including cod, haddock, and hake, which may be present near the Development.

Marine mammals may also be occasional visitors to the area, although no resident populations have been recorded within the loch. The outer and inner Hebrides are known to support resident populations of several marine mammal species, and as such, occasional individuals of harbour porpoise, bottlenose dolphin, and minke whale may occur. Similarly, occasional grey seals may occur near the development but they are not considered resident. The most abundant marine mammal within the loch is likely to be harbour seal, which have been reportedly observed in high numbers.

A summary of receptors sensitivity is provided in *Table 8.8 Summary of Receptor Sensitivity*.

Table 8.8 Summary of Receptor Sensitivity

Receptor	Relevant Species or Habitats	Sensitivity	Justification
Benthic Ecology	Kelp and seaweed communities on sublittoral sediment Burrowed mud Fireworks anemone	High	These habitats and species were observed in project-specific benthic surveys and are designated as PMFs in Scotland. Burrowed mud is also a designated feature of the Loch Fyne and Loch Goil MPA.
Fish and Shellfish	Migratory fish (e.g. Atlantic salmon, sea trout, European eel, lamprey)	High	Atlantic salmon, European eel, and lamprey are protected in the UK as Annex II species under the Conservation of Habitats and Species Regulations 2017. All species are PMFs in Scotland. Both Atlantic salmon and sea trout are associated with rivers in the upper loch and as such, may migrate through the Development area.
Marine Mammals	Harbour seal Harbour porpoise	High	Protected in the UK as Annex II species under the Conservation of Habitats and Species Regulations 2017 and listed as PMFs in

Receptor	Relevant Species or Habitats	Sensitivity	Justification
	Bottlenose dolphin		Scotland. Harbour seal are resident in the lower loch, with harbour porpoise and bottlenose dolphins likely occasional visitors.
Designated Sites	Upper Loch Fyne and Loch Goil MPA	High	Directly overlaps with Development. Designated for the protection of burrowed mud, sublittoral mixed sediment, flame shell beds, horse mussel beds; and ocean quahog aggregations. Of these features, only burrowed mud was observed in project-specific benthic surveys within the study area.

8.6.6 Future Baseline

The Firth of Clyde is a highly anthropogenically influenced region, subject to heavy shipping traffic, pollution, and overexploitation of marine species, which has resulted in marked changes in its marine faunal communities (Thurstan and Roberts 2010). It has since become the subject of numerous local environmental regulations and policies, particularly in relation to fishing and as such, it is possible that local community compositions and populations of marine fauna may change over time.

In particular, data indicate that the harbour seal population is increasing within the study area, individuals having more than doubled in number locally between 1989 and 2018 (Morris et al., 2021). Thus, it is likely that the local population of harbour seals may continue to increase.

Furthermore, it is noted that as environmental variables, such as sea surface temperature, are altered with predicted climate change, there may be shifts and / or expansions of the distribution of marine faunal populations. However, only the piles are expected to be left *in situ* permanently, which are unlikely to pose long-term impacts to the local environment. When considering population trends, it takes several years before changes in population structure are apparent. Therefore, considering the short-term nature of impacts from the construction of the Marine Facility, it is unlikely that significant changes to baseline conditions will occur within the life cycle of the project

8.7 Assessment of Effects

This section describes the potential impacts of the Project on the benthic ecology receptors during the pre-construction, construction, operational, and decommissioning phases (*Chapter 2: Project and Site Description*). The appraisal has been undertaken in accordance with the methodology presented in *Chapter 3: Approach to EIA Methodology*, with consideration given to the CIEEM guidance for Ecological Impact Assessment (*Section 8.5.1: Guidance and Standards*). The following pathways detailed in *Table 8.9 Summary of Potential Impacts* have been assessed in the appraisal.

Table 8.9 Summary of Potential Impacts

Potential Impact	Receptor	Zone of Influence (ZoI)	Development Phase
Effects from underwater sound (UWS)	Fish & Shellfish Ecology Marine Mammal Ecology	Disturbance to some cetaceans may occur up to 26 km (Dahne, 2013; Tougaard et al., 2013; JNCC 2020)	Construction, operation, and decommissioning
Permanent Loss of Benthic Habitat	Benthic Ecology	Installation of 72 piles of 0.6 m diameter giving a total footprint of 20.4 m2	Construction
Benthic habitat modification from the introduction of artificial structures on the substrate	Benthic Ecology	Installation of 72 piles of 0.6 m diameter giving a total footprint of 20.4 m2	Construction
Temporary physical disturbance to subtidal benthic habitats and species	Benthic Ecology	Footprint of jack up barge spud legs on the seabed estimated to be ~12 m2 (4 legs of 2 m diameter each).	Construction
Temporary increase in SSC and sediment deposition leading to turbidity, smothering effects and contaminant mobilisation	Benthic Ecology Fish & Shellfish Ecology	Fine particulates may disperse up to 700 m away from the Marine Facility	Construction

Disturbance to habitats and species due to scour from hydrodynamic change	Benthic Ecology Fish & Shellfish	Small region (<1 m) in the immediate vicinity of each pile	Operation
Airborne sound and visual disturbance	Marine Mammal Ecology	500 – 1,500 m	Construction, operation, and decommissioning
Vessel collision risk	Marine Mammal Ecology	Localised	Construction, operation, and decommissioning
Reduction in water quality (discharges, unplanned releases, and accidental leaks and spills from vessels)	Benthic Ecology Fish & Shellfish Ecology Marine Mammal Ecology	700 m	Construction, operation, and decommissioning
Introduction and spread of INNS	Benthic Ecology	700 m	Construction, operation, and decommissioning

8.7.1 Construction Phase

8.7.1.1 Underwater Sound

For underwater sound impact appraisals, the applied metrics are sound pressure level (SPL) and sound exposure levels (SEL). The SPL is a measure of the amplitude or intensity of a sound and is typically measured as a peak value. In contrast, the SEL is a time-integrated measurement of the sound energy, which takes account of the level of sound as well as the duration over which the sound is present in the marine environment.

Construction works required for the Development require the installation of steel piles to construct the marine jetty. The installation method is expected to be dominated by in-water vibratory piling but there may be a requirement to use drop hammer impact piling to toe the piles into bedrock to install the Marine Facility, which may produce high Sound Pressure Levels (SPL) that can be detected by many groups of marine fauna, including fish and marine mammals. The impact of anthropogenic sound on marine fauna depends on a range of factors including the frequency and intensity of the sound source, the duration of the sound, normal background levels, as well as the sensitivity and behaviour of the receiving animal, and possible habituation to background sound sources.

The sound characteristics of Development activities have been determined on the basis of equipment specifications and literature values as provided in *Table 8.10 Characteristics of Underwater Sound Sources Generated by the Development's Construction Phase*. The sound level for these activities were only available for a distance of 10 m from the sound source.

Table 8.10 Characteristics of Underwater Sound Sources Generated by the Development's Construction Phase

Development Activity	Nature of the sound source	Operating Frequency	SPL_{peak} dB re 1μPa @ 10 m
Impact piling (600 mm)	Impulsive	<500 Hz (Reyff, 2012)	183-205 (California Dept. of Transport, 2007; Jimenez-Arranz, 2020)
Vibratory piling (600 mm diameter steel pile)	Continuous	20-40 Hz (Jimenez-Arranz, 2020)	173-178 SPLrms (Jiminez-Arranz, 2020)
Use of project vessels	Continuous	Low to high frequency	160-184

Marine Mammals

Marine mammals rely on sound for a range of important ecological functions. Underwater sound from anthropogenic activities can negatively impact marine mammals, as it can affect their ability to echolocate and communicate and can even cause physical harm (Southall et al., 2007). Cetaceans in particular, produce and receive sound over a wide range of frequencies for communication, orientation, predator avoidance and foraging (Tyack, 2008).

Severe responses, such as indirect death from strandings in particular, have only been recorded in beaked whales specifically relation to military sonar (e.g. see Southall et al., 2013). The most likely responses to underwater sound from construction in the marine environment are damage or injury to auditory apparatus and disturbance.

Depending on the intensity and frequency of the sound source, exposure can result in several impacts to marine mammals, which are categorized as follows:

- Auditory injury - a consequence of damage to the inner ear of marine mammals, the organ system most directly sensitive to sound exposure. Hearing loss or a shift in hearing thresholds can be permanent or temporary:
  - Permanent Threshold Shift (PTS) - is a permanent elevation in hearing threshold. PTS can occur from a variety of causes, but it is most often the result of intense and / or repeated noise exposures; and
  - Temporary Threshold Shift (TTS) - is a recoverable elevation in hearing threshold most commonly resulting from long-term noise exposure not high enough to cause PTS.
- Behavioural responses – are highly variable and context-specific, ranging from increased alertness, altering vocal behaviour, interruption to feeding or social interaction, alteration of movement or diving behaviour, temporary or permanent habitat abandonment. Minor or temporary behavioural responses are often simply evidence that an animal has heard a sound; and
- Masking – anthropogenic underwater sound may partially or entirely reduce the audibility of signals of interest such as those used for communication and prey detection.

The scale of impact of UWS on marine mammals is largely determined by physiology and is dependent upon a species' auditory range. Thus, for the determination of the impact of UWS, marine mammals have been categorized into functional hearing groups based on their peak hearing range. These groups are detailed in *Table 8.11 Marine Mammal Hearing Groups, Auditory Bandwidth and Potential Species within the Study Area*, along with representative species from each category that may be present within the study area.

Table 8.11 Marine Mammal Hearing Groups, Auditory Bandwidth and Potential Species within the Study Area

Functional Hearing Group	Auditory Band Width[5]	Species	Species potentially present in the study area
Low frequency cetaceans	7 Hz – 35 kHz	Baleen whales	Minke whale
High frequency cetaceans	150 Hz – 160 kHz	Dolphins, toothed and beaked whales	Bottlenose dolphin
Very high frequency cetaceans	275 Hz – 160 kHz	True porpoise and some small whales	Harbour porpoise
Pinnipeds in water	75 Hz – 100 kHz	Seals	Harbour seal

The most up-to-date sound exposure criteria for auditory injury in marine mammals have been published by the United States National Marine Fisheries Service (NMFS), often referred to as the NOAA (National Oceanic and Atmospheric Administration) thresholds (NMFS, 2018). For impulsive sounds, NMFS suggest thresholds of 196 dB re 1µPa^{2}s for TTS in very high frequency cetaceans (such as harbour porpoise) and 212 dB re 1µPa^{2}s in pinnipeds (NMFS, 2018). For continuous sounds, there are no SPL thresholds. Thus, the NMFS thresholds are based on M-weighted[6] SELs for PTS and TTS only.

There are no quantitative thresholds for behavioural disturbance in the latest guidance (NMFS, 2018; Southall, et al., 2019). Published guidance on disturbance ranges, called the effective deterrent range (EDR), associated with monopile installation by impact piling suggests 26 km (JNCC, 2020) for harbour porpoise, the most noise sensitive of the cetacean species. The details of thresholds for both marine mammals and fish are provided in *Table 8.12 PTS and TTS Thresholds for Marine Mammals Exposed to UWS Sources.*

The Development will use vibratory piling predominantly, with impact piling potentially required for the final stages of the installation. For impact piling, the sound source will be impulsive, which could be associated with injury. For vibratory piling, the primary sound source will be continuous, which is predominantly associated with behavioural changes in marine fauna.

[5] Estimated lower to upper frequency hearing cut-off (Southall et al., 2007)
[6] M-weighting gives deemphasized frequencies outside of marine mammal hearing ranges, giving greater value to frequencies within their hearing ranges.

Table 8.12 PTS and TTS Thresholds for Marine Mammals Exposed to UWS Sources (Southall et al., 2019)

Hearing Group	Continuous		Impulsive			
	PTS SEL_{cum}	TTS SEL_{cum}	PTS SEL_{cum}	PTS SPL_{peak}	TTS SEL_{cum}	TTS SPL_{peak}
Low frequency cetaceans	199	179	183	219	168	213
High frequency cetaceans	198	178	185	230	170	224
Very high frequency cetaceans	173	153	155	202	140	196
Pinnipeds in water	201	181	185	218	170	212

The estimated programme of construction works for the jetty is a period of 12 months (*Chapter 2: Project and Site Description*). The period in which piling will take place is currently unknown but considering a likely worst-case scenario of one pile installation per day, this would equate to 72 days when some kind of piling could occur.

Vibratory piling, which is expected to be the main pile installation method, produces underwater sound at a significantly lower sound intensity than impact piling (*Table 8.10 Characteristics of Underwater Sound Sources Generated by the Development's Construction Phase*). Most of the sound produced during vibratory piling is radiated within the frequency range of the vibration frequency of the pile driver, which is generally between 20 and 40 Hz (Matuschek and Betke 2009). This is generally a range at which marine mammals, other than low frequency cetaceans, are not as sensitive (Southall et al., 2007).

Whilst no resident marine mammal populations exist near the Development, occasional visitors, primarily harbour seals and harbour porpoise, may occur which would thus be subject to impact from Development activities. For vibratory piling, the operating frequency is not within the peak auditory band width for these species and the sound from vibratory hammers rises relatively slowly (California DoT, 2009). As such, is very unlikely to result in injury. There is expected to be some disturbance but considering the low intensity and continuous nature of the sound source from vibratory piling, and the hearing range of the most likely species to be present, it is considered to be minor and not significant.

Should impact piling occur, it is considered to pose a risk of auditory injury to marine mammals. Impact piling can operate at frequencies up to 500 Hz, with SEL values that vary depending on pile composition and dimensions. For ~600 mm steel piles, the SEL values are approximately 170-180 dB re 1 $\mu Pa^2 s$ (NOAA, 2017), with much greater peak SPL values. Peak SPL values associated with impact piling can exceed thresholds for PTS and TTS for low and very high frequency cetaceans, and pinnipeds. Additionally, behavioural responses have been observed in high frequency cetaceans such as harbour porpoises up to 20 km from a piling site. Following pile-driving activities, a short-term reduction in porpoise detections was recorded, indicating that impact piling is likely to result in significant displacement of individuals (Graham et al., 2017).

Embedded mitigation measures are in place per guidance from JNCC on minimising the risk of injury to marine mammals during impact piling activities (JNCC, 2010). The mitigation includes the use of marine mammal observers (MMO) and soft-start procedures (see *Section 8.9 Mitigation and Monitoring*). The purpose of the soft-start period is to allow sound to build gradually, allowing any marine mammals present to easily move away from the immediate area, and as no impact piling will start if animals are within the 500 m observation zone, injury is unlikely to occur.

Some disturbance is expected but considering the embedded mitigation this is considered to result in minor behavioural changes only. Furthermore, impact piling is intermittent, with gaps in between piles and pauses during piling operations. These intervals allow for avoidance behaviour and for recovery if any impacts such as TTS were to occur. Despite the high sensitivity of the receptor, the number of individuals likely to be affected is low, as marine mammal species are considered only occasional visitors. Therefore, as impacts are considered to be predominantly behavioural with appropriate mitigation in place, the magnitude of the impact is considered to be low, and the significance of effects from impact piling on marine mammals is considered **minor adverse** and thus **not significant**.

Fish and Shellfish

Fish use sound for communication, prey location and predator avoidance (Fay and Popper, 2000). They perceive sound through their ears and lateral line (termed the 'acoustico-lateralis system') which are sensitive to vibrations created by sound sources. Some have a gas-filled sack known as a swim bladder which can also be used for sound detection (Hawkins, 1993) but can be vulnerable to rapid changes in pressure.

Responses to sound depend on whether the sound source is present at a level and within the range of frequencies to which an individual is sensitive. Most fish cannot hear sound above 1 kHz, however, some sub-members of the Clupeidae family (herring and Alosidae or shads) are capable of detecting significantly higher frequencies, up to several thousand kHz for Atlantic herring for example and some species in this group in the ultrasonic range (Mann et al., 2001).

Depending on the intensity and frequency of the sound source, UWS exposure can result in several impacts on fish, including:

- Physical or physiological effects – generally only occur when exposed to very high amplitude, impulsive sounds such as explosions;
- Auditory injury or damage, including damage to the inner ear, sensory hair cells and otoliths (Parvin et al., 2006) and temporary threshold shift (TTS), a recoverable elevation in hearing threshold;
- Masking of auditory cues; and
- Behavioural changes, including changes in movement and swimming direction, alterations to migratory routes, changes in feeding patterns and breeding, and displacement / avoidance behaviour.

The scale of impact of UWS on fish is also largely determined by physiology, particularly whether the fish has a swim bladder or not, and whether the swim bladder aids in hearing sensitivity and hearing range (Popper et al., 2014). As such, fish have been categorised based on morphological features and the resulting sensitivity to UWS, which can be used when assessing impacts (*Table 8.13 Fish Sensitivity to UWS*).

Table 8.13 Fish Sensitivity to UWS

Sensitivity	Description	Examples of species in the study area
High hearing sensitivity fish	Hearing involves a swim bladder or other gas volume. Species such as these are susceptible to barotrauma and can detect both sound pressure and particle motion.	Atlantic cod Herring Other species of the Clupeidae family
Medium hearing sensitivity fish	Species possess a swim bladder but it is not required for hearing. These species can only detect particle motion, not sound pressure, but they are still susceptible to barotrauma.	Atlantic salmon Sea trout European eel
Low hearing sensitivity fish	These species do not have a swim bladder or any other gas-filled chamber. Such species only detect particle motion rather than sound pressure and are less susceptible to barotrauma.	Lamprey Flatfish Elasmobranchs

The most up-to-date thresholds for impacts to fish come from the 2014 ANSI standards (Popper & et al., 2014). The thresholds for impulsive sounds are quantitative for all hearing groups but for continuous sounds are quantitative only for the highest hearing sensitivity fish (the herring family) in relation to recoverable injury and TTS. The thresholds for low or medium sensitivity fish, are relative, providing likely risk levels (high, moderate or low) for injury, threshold shift or behavioural disturbance in medium or low hearing sensitivity fish at three relative distances from the source defined in relative terms as near (N), intermediate (I), and far (F) (Popper et al, 2014). While it would not be appropriate to ascribe particular distances to effects because of the many variables in making such decisions, “near” might be considered to be in the tens of meters from the source, “intermediate” in the hundreds of meters, and “far” in the thousands of meters. These thresholds are provided in

Table 8.14 Injury and Disturbance Thresholds for Fish from Sound Sources.

Table 8.14 Injury and Disturbance Thresholds for Fish from Sound Sources[7]

	Continuous				Impulsive			
Receptor Group	Mortality	Recoverable injury	TTS	Low level disturbance	Mortality/mortal injury	Recoverable injury	TTS	Low level disturbance

[7] All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist.

Low sensitivity fish	(N/I/F) Low	(N/I/F) Low	(N) Moderate; (I/F) Low	(N/I) Moderate (F) Low	>219 dB SELcum >213 dB peak	>216 dB SELcum >213 dB peak	>>186 dB SELcum	(N) High (I) Moderate (F) Low
Medium sensitivity fish	(N/I/F) Low	(N/I/F) Low	(N) Moderate; (I/F) Low	(N/I) Moderate (F) Low	>210 dB SELcum >207 dB peak	>203 dB SELcum >207 dB peak	>186 dB SELcum	(N) High (I) Moderate (F) Low
High sensitivity fish	(N/I/F) Low	170 dBrms re 1 µPa for 48 h 48 hours	150 dBrms re 1 µPa for 12 h 12 hours	(N) High (I) Moderate (F) Low	>207 dB SELcum >207 dB peak	>203 dB SELcum >207 dB peak	>186 dB SELcum	(N/I) High (F) Moderate

Species from all three hearing groups have the potential to be present near the Development. For high sensitivity hearing fish (e.g. cod and herring), both vibratory and impact piling have the potential to reach peak SPL values which may exceed the auditory threshold for recoverable injury. However, species of primary concern within the Development area are migratory species, such as Atlantic salmon and sea trout, which are considered to be of medium sensitivity and unlikely to be adversely affected by vibratory piling. Impact piling, however, has the potential to exceed peak SPL values for injury and even mortality of all fish hearing groups.

For impact piling operations, embedded mitigation measures are in place per guidance from JNCC on minimising the risk of injury to marine mammals during piling activities (JNCC, 2010), which include the use of soft-start procedures (see *Section 8.9 Mitigation and Monitoring).* It is anticipated that the soft-start period will allow for any fish present to easily move away from the immediate area, thus likely resulting in only minor behavioural changes. Furthermore, impact piling is intermittent, with gaps in between piles and pauses during piling operations. These intervals allow for avoidance behaviour and for recovery if any impacts such as TTS were to occur. Despite the high sensitivity of the receptors, the number of individuals likely to be affected is low, as fish species are likely to be only occasional visitors during migration patterns. Furthermore, piling works will occur over a small area comparatively to the area of loch available for migration and the nearest catchment associated with migratory fish is located approximately 2.3 km from the Marine Facility (River Array). Therefore, as impacts are considered to be predominantly behavioural with appropriate embedded mitigation in place, the magnitude of the impact is considered to be low, and the significance of effects from impact piling on fish is considered **minor adverse** and thus **not significant**.

For vibratory piling, the latest quantitative underwater sound thresholds for fish (Popper et al., 2014) indicate that the risk of mortality or mortal injury from vibratory piling for all hearing categories and functional groups is low. Furthermore, the sound from vibratory hammers rises relatively slowly (California DoT, 2009). As such, the magnitude is considered low and the significance of effects from vibratory piling on marine fauna (including fish and marine mammals) is considered **minor adverse** and thus **not significant**.

8.7.1.2 Permanent Loss of Benthic Habitat Due to the Installation of Steel Piles

The construction of the Marine Facility in Loch Fyne will be associated with the placement of approximately 72 piles into the benthic substrate, which will be left *in situ* long-term following the completion of the construction phase, resulting in permanent habitat loss of benthic habitat.

Each pile will be 600 mm in diameter (see *Chapter 2: Project and Site Description*), resulting in the permanent loss of benthic habitat of 20.4 m^2. Within the study area, there were two habitats observed, the PMFs 'kelp and seaweed communities on sublittoral sediment' and 'burrowed mud', during benthic surveys. Of these, the construction of the Marine Facility is considered to largely overlap with the 'kelp and seaweed communities on sublittoral sediment' as the burrowed mud was also observed in deeper water further offshore (see *Appendix 8.1: Benthic Ecology Survey Report (Volume 5: Appendices)*), outside the direct footprint of the Marine Facility.

Considering that 'kelp and seaweed communities on sublittoral sediment' are of conservation importance in Scotland (as noted by PMF designation), the sensitivity of this receptor is high. However, this biotope has been observed throughout both lower and upper Loch Fyne, as reported in both historical records and recent surveys (Allen, 2013), suggesting it is common and widely distributed throughout the loch. Furthermore, as the Development is situated within Loch Fyne and Loch Goil MPA, which does not have this habitat as a designated feature, it is unlikely that it occurs in important concentrations within the Development area.

When considering this in conjunction with the relatively small area of impact and the fact that the overall footprint will be divided into smaller segments by each pile, it is likely that the integrity of the overall habitat will remain intact. As such, the magnitude of impact has been assessed as low, and the overall significance of permanent habitat loss on benthic ecological receptors has been assessed as **minor adverse** and therefore **not significant.**

8.7.1.3 Benthic Habitat Modification from the Introduction of Artificial Structure on the Seabed

The construction of the Marine Facility in Loch Fyne will be associated with the installation of approximately 72 piles into the seabed, which will be left *in situ* long-term following the completion of the construction phase, resulting in the permanent introduction of artificial structures. Each pile will result in the replacement of 20.4 m^2 of benthic habitat by artificial structures.

Within the study area, two benthic habitats were observed, the PMFs 'kelp and seaweed communities on sublittoral sediment' and 'burrowed mud'. Of these, the Marine Facility is considered to only overlap with the 'kelp and seaweed communities on sublittoral sediment', which has been observed throughout both lower and upper Loch Fyne, as reported in both historical records and recent surveys (Allen, 2013), suggesting it is common and widely distributed. Furthermore, the Upper Loch Fyne and Loch Goil MPA does not include this habitat as a designated feature, suggesting it is unlikely to occur in important concentrations within the Development area.

The construction of the Marine Facility also has the potential to provide new surface area for colonisation by a range of epifaunal species, including INNS (see below for assessment of '*Introduction and Spread of INNS*'), altering the local community composition. Studies looking at the colonisation of offshore wind infrastructure shows marked zonation of epifaunal communities with the upper reaches dominated by mussels, macroalgae, and barnacles, which are replaced by filter-feeding arthropods and then anemones at greater depths (Galparsoro et al., 2022). Similar colonisation may occur in on the steel piles of the Marine Facility. However, many of these epifaunal species are likely to be naturally present on the surrounding reef habitat and whilst diversity may be lower, and abundance of some species may be higher on the plies, the overall impact to local diversity is expected to be minor.

When considering this in conjunction with the relatively small area of impact and the fact that the overall footprint will be divided into smaller segments by each pile, it is likely that the integrity of the overall habitat will remain intact. As such, the magnitude of impact has been assessed as low, and the overall significance of benthic habitat modification from the introduction of artificial structures has been assessed as **minor adverse** and therefore **not significant.**

8.7.1.4 Temporary Disturbance of Benthic Habitats

As piling works will require the use of a jack up barge (JUB), the placement of spud legs on the seabed will likely result in the temporary disturbance on benthic habitats. The Marine Facility is expected to require the placement of 72 piles, in which a worst-case scenario has been assumed that the barge will be repositioned for every pile, thus impacting new areas of the seabed with each placement.

As vessel specifications are not available at this stage, the exact footprint associated with the barge placement is unknown, as barge legs can vary in size and number, but has been estimated to be a total of 12 m^2. The project-specific surveys have indicated that the proposed location of the Marine Facility overlaps primarily with the benthic habitat 'kelp and seaweed communities on sublittoral sediment', which is a PMF. Despite the high sensitivity of this receptor, it is considered to be widespread in coastal shallow waters throughout the loch, as it has been noted both in recent surveys and historical data (Allen, 2013). This habitat is considered to have medium sensitivity and high resilience to physical disturbance, with growth rates allowing rapid recovery from loss and damage (Stamp & Mardle, 2022). The JUB spud legs are likely to be placed on the seabed, at each location, for a very short time period and so whilst there is likely to be some damage and potential mortality this will be small in scale and seaweed plants are expected to recover. Furthermore, the Development occurs within an MPA which has not noted this habitat as a designated feature, suggesting it does not occur in important concentrations locally.

When considering the likely widespread nature of this habitat, the small spatial scale of the effect, the temporary nature of the disturbance and likely rapid recovery, the magnitude of impact has been assessed as low. Therefore, the significance of temporary disturbance to benthic habitats from the use of a JUB during piling activities is considered **minor adverse** and thus **not significant.**

8.7.1.5 Temporary Increase in SSC and Sediment Deposition Leading to Turbidity, Smothering Effects and Contaminant Mobilisation

Whilst no dredging is required for the Development, the installation of piles is likely to result in a temporary increase in SSC concentrations. This has the potential to mobilise sediments into the water column that could increase local SSC and turbidity, creating a plume at some distance from the cable corridor before settling onto the seabed. There are several potential effects to marine ecological receptors associated with increased SSC and sediment deposition, including:

- Reduced photosynthesis resulting in reduced primary production in marine seaweed and algae;
- Smothering of benthic invertebrate species;
- Decreased visibility in visual predators which results in decreased feeding success;
- Clogging of feeding and respiratory apparatus;
- Potential barriers to movement and migration for mobile species;
- Egg and larvae mortality; and
- Indirect effects of released sediment contaminants, such as heavy metals and hydrocarbons.

The largest sediment plumes and highest levels of SSC are associated with the disturbance of sediments that exhibit a high proportion of fine particulate material, such as muds and clays, which remain in suspension longest and settle to the seabed more slowly. Coarse material, such as sand and gravel settle to the seabed quickly, typically within a few hours of disturbance, with sediment likely transported a distance of meters to tens of meters from the source. As sediment disperses, prevailing tides and currents contribute to dilution over a broad area and a reduction in SSC levels, returning water column turbidity to baseline conditions within hundreds to a few thousand metres from the point of release, depending on particle size.

Sediment dispersion distances were estimated using tidal excursion ellipse data (see *Chapter 18: Marine Physical Environment and Coastal Processes*). The estimated travel distance for a particle carried in suspension can be related to the length of the major axis of the tidal excursion ellipse, where maximum tidal excursion on an ebb and flow tide reaches approximately 300 m around the Marine Facility in the nearshore and 700 m around the Marine Facility near the center of the loch (ABPmer, 2017). Mean particle size distribution at study sites sampled within the Development area ranged from 38.1-73.6% for sand, 17.8-61.6% for mud, and 0.3-14.0% for gravel (*Appendix 8.2: Subtidal Benthic Ecology Survey Report*). This indicates that some sediment particles are likely to gradually settle out of suspension, with coarse particles settling quickly whilst finer particles have the potential to extend to the maximum reaches of the spring tidal excursion.

Increased SSC can affect filter feeding organisms, such as fish and shellfish, clogging and damaging feeding and breathing equipment. Impairment in the growth of filter-feeding bivalves has also been observed at suspended particulate matter concentrations greater than 250 mg/L (Widdows, Feith, and Worral, 1979). Similarly, functioning fish gills may be impaired due to clogging, although sensitivity varies by species. For example, demersal fish may be more susceptible to smothering effects as they live closest to the seabed. Furthermore, the increased deposition associated with SSC increase may smother important benthic habitats.

With regard to sediment-bound contaminants, a recent assessment of contaminants present in sediment and marine biota concluded that contaminant concentrations were highest in the Irish Sea, including the Clyde Marine Region (Marine Scotland, 2020). Contaminants of concern in this region noted in sediments which may lead to adverse effects included mercury, lead, and polychlorinated byphenyls (PCBs). Additionally, heavy metal input into the Clyde Marine Region has historically been high, with elevated water concentrations of chromium noted in the inner estuary. However, concentrations within sediments and inputs into the Clyde were considered stable or declining for all substances measured. Within Loch Fyne, sediment cores have previously reported increased concentrations of trace metals, such as lead, copper, and zinc (Krom et al., 2009).

Contaminants will be associated with finer material such as silts and clays, which comprise low-moderate proportions of the sediment within the study area. Where finer sediments do occur, dilution of suspended particulate matter is anticipated to occur rapidly with distance from the Marine Facility. In addition, natural disturbance to the sediment such as during storm events and periods of strong wave action will mobilise contaminants and subject benthic habitats and species to temporary and localised changes in water quality. As a result, these habitats and species will have a tolerance to moderate changes in the surrounding water quality.

As a fjordic loch[8], Loch Fyne is a sheltered environment where the sills contribute to stable conditions within each of the loch's basins (Brown, 2020). As a result, tidal currents within the loch are weak (Brown, 2020), which is reflected by the relatively low maximum tidal excursion distances. Despite the high percentage of fine particulates in some sediment samples, much of the sediment will remain localised to the Marine Facility. Whilst this lessens the overall footprint of impact, it may result in increased levels of sediment deposition within that area.

[8] Fjordic lochs are carved by glacial movements

Within the study area, several benthic PMFs were observed: the habitats 'burrowed mud', 'kelp and seaweed communities on sublittoral sediment', and the fireworks anemone. As burrowed mud is already composed of fine particulate sediments, increased sediment deposition over this feature is unlikely to affect its conservation objectives. A recent study of suspended fine particulates in aquatic vegetation patches observed an increased retention of fine particulates over vegetation canopies, which is considered to trigger positive feedback as the sediment is rich in organic material (Solar et al., 2021).

As much of the immediate study area around the Marine Facility is composed of 'kelp and seaweed communities on sublittoral sediment', this may contribute to an increased retention of SSC in the immediate vicinity. Finally, the fireworks anemone is also a known inhabitant of muddy habitats, which can extend up to 30 cm from the substrate. As such, it is considered to have a low intolerance to smothering from sediment deposition and increased SSC (Wilding and Wilson, 2008).

With regard to fish and shellfish, Atlantic salmon, trout, and Nephrops are most likely to be present within the study area. Salmonids can have an increased sensitivity to SSC due to reduced feeding success resulting from reduced vision (Abbotsford, 2021). Increased SSC can also create a migration barrier between freshwater and marine habitats. However, the nearest river which supports diadromous fish species is approximately 2.14 km north (River Array). When considering this in conjunction with the small ZoI associated with increased SSC, it is unlikely that migratory fish will be affected as these areas can be easily avoided during any movement through the loch. In addition, Nephrops are known to inhabit burrowed mud habitats and are considered tolerant to both increased SSC and smothering from excess sediment deposition, as they are scavengers which burrow into muddy substrates (Hill and Sabatini, 2008).

As such, the sensitivity of marine features within the study area is considered to be low. When considering the small footprint of the piles associated with the Marine Facility and that the benthic community is composed of features known to occur in muddy habitats with low intolerance to effects from sediment deposition, the magnitude has also been assessed as low. Therefore, the significance of increased SSC on marine ecological receptors has been assessed as **negligible** and therefore **not significant.**

8.7.1.6 Airborne Sound and Visual Disturbance

Operations during the construction phase, such as piling and use of supporting vessels could result in changes in visual stimuli and an increase in airborne sound, which could impact marine mammals. Cetaceans are not considered to be particularly sensitive to changes in visual stimuli or airborne sound as their primary sense relates to underwater sound. However, pinnipeds spend time hauled out on land and at the sea-surface, making them more susceptible to these airborne sound and visual stimuli. These can lead to avoidance behaviour disturbance effects which could cause individuals to stop resting, feeding, travelling and / or socialising, with possible long-term effects of repeated disturbance resulting in permanent displacement and / or a decline in fitness and productivity. In general, shipping traffic more than 1,500 m away from a haul-out site is not thought to evoke any reaction. However, studies of harbour seals have shown a flight response to boats occurs at a distance of around 500 m (Anderson, Teilmann, Dietz, Schmidt, & Miller, 2012).

Harbour seals, considered resident in the loch, are known to occasionally haul out between Loch Gilp and Otter Narrows, which is approximately 30 km from the Development. There are no known haul out sites in the vicinity of the Marine Facility. Thus, changes in visual stimuli from construction activities, including any lighting from the vessels, are not anticipated to cause disturbance to hauled-out harbour seals. Loch Fyne is also not thought to provide important foraging habitat for this species, with a very low density of animals present (Carter et al., 2022). However, as harbour seals are known to forage at some distance from haul out sites (Carter et al., 2022), there is potential for the presence of some individuals to be present during project activities. There is therefore the potential for any surfaced harbour seals to be affected while foraging.

Telemetry data has indicated avoidance behaviour in seals during piling activities for offshore windfarm construction (Russell et al., 2016). Sounds associated with vibro-piling are much less than that associated with impact piling, which are considered below the thresholds for behavioural responses in pinnipeds. As such, with most piling activity to be vibratory, and a soft-start in place for an impact piling, it is unlikely that the air-borne produced sound will elicit a significant disturbance response in present seals. Additionally, any disturbance effects are likely to be limited to minor avoidance behaviour as highly mobile animals that forage over extensive ranges, such movements are not considered likely to have any meaningful effect on the availability of prey or the energetic expenditure required for foraging.

Whilst all marine mammal species are of high conservation value and thus of high sensitivity, they are considered to have high tolerance to, and recoverability from short-term and temporary disturbance and thus considered to have a low sensitivity to airborne sound and visual disturbance, resulting in a low magnitude. As such, any effects to marine mammals from airborne sound and / or visual disturbance due to Development activities is considered to be **minor adverse** and thus **not significant**.

8.7.1.7 Vessel Presence and Marine Mammal Collision Risk

The installation of the Marine Facility will primarily involve the deployment of a jack up barge (JUB). As construction of the Marine Facility is expected to take place over a 12-month period, the JUB will largely only transit over a small area as the jetty is constructed. As such, it likely only poses a collision risk with marine mammals during its transit to and from the site.

Vessel strikes with marine mammals can result in physical impairment, which may reduce foraging abilities and fitness at an individual level, or even mortality (Southall, et al., 2019; Moore, et al., 2013). Marine mammals, particularly cetaceans, are considered to be fast swimming, agile species, with rapid reflexes and good sensory capabilities (Hoelzel, 2002). Moreover, marine mammals possess a thick subdermal layer of blubber or fat deposits which provides a level of protection to their vital organs, meaning they are reasonably resilient to minor strikes and collisions (Wilson, Batty, Daunt, & Carter, 2007). The most lethal and serious injuries to marine mammals are believed to be caused by large ships, typically 80 m and longer with large drafts, as well as vessels travelling faster than 14 knots (Laist, Knowlton, Mead, Collet, & Podesta, 2001). Higher vessel speeds produce a greater impact force and larger drafts have been associated with increased mortality (Southall, et al., 2019; Dahne, et al., 2013; Rockwood, Calambokidis, & Jahncke, 2017).

Avoidance behaviour exhibited by cetaceans is often associated with fast, unpredictable vessels such as speedboats and jet-skis (Bristow & Reeves, 2001; Gregory & Rowden, 2001), while neutral or positive reactions, particularly in dolphins have been observed with larger, slower moving vessels such as cargo ships (Ng & Leung, 2003; Sini, Canning, Stockin, & Pierce, 2005). Although there have been reports of vessel strikes with marine mammals, evidence of risk is limited. Mortality and injury of cetaceans resulting from vessel strikes have been mostly reported in large baleen whales which are slow swimming (IAMMWG, 2015). There are few reports of vessel strikes with harbour porpoise and other small cetaceans, likely due to the avoidance behaviour of these species (particularly porpoises (Wisniewska, et al., 2018; Roberts, Collier, Law, & Gaion, 2019).

The risk to pinnipeds is considered to be generally lower than that for cetaceans (Jones, et al., 2017). Although there have been reports of vessel strikes to pinnipeds, including several cases of ‘corkscrew’ type injuries ascribed to vessel propellers and thrusters, evidence of risk is limited (Bexton, Thompson, Brownlow, Milne, & Bidewell, 2012). Later research has shown that very similar form injuries were the result of predation from grey seals and may be responsible for a high proportion of the assume propellor duct injuries (Brownlow et al., 2016). For slow-moving dredging operations (Todd, et al., 2015) individual seals have been seen to easily avoid vessel movements.

Whilst large marine mammals, such as whales, are considered primarily at risk of collision with vessels, many different species, including small cetaceans and seals, have also been reported as involved in vessel strikes in the wider Atlantic (Winkler, Panigada, Murphy, & Ritter, 2020). However, when considering the low abundance of marine mammals within the study area, the likelihood of the Project vessels colliding with marine mammals is low. Furthermore, a self-propelled jack up barge may travel at consistent speeds of around 5 knots. At this speed, small cetaceans and seals can easily avoid the vessel, greatly reducing the risk of collision.

Although the occurrence of any collisions could cause injury or death, which would be considered a moderate or high sensitivity for a receptor of high conservation value, the likelihood of vessel collision with marine mammals is appraised as unlikely when considering the agility of marine mammals and the slow vessel operation speeds. Therefore, the magnitude of impact is considered negligible, and the impact significance is considered **minor adverse** and thus **not significant**.

8.7.1.8 Reduction in Water Quality due to Discharges, Unplanned Releases, and Accidental Leaks and Spills from Vessels

The accidental release of pollutants (e.g., oil, fuels, lubricants, chemicals) and planned release of wastewater could occur from any of the vessels associated with the Development. Such releases, as well as mobilisation of any sediment-bound contaminants, have the potential to reduce water quality, leading to consequences to marine fauna, including benthic invertebrates, fish and shellfish, and marine mammals.

To ensure the risk of accidental spills is as low as reasonably practicable (ALARP), the Development will adhere to relevant guidance (e.g., Pollution Prevention Guidance) and comply with all relevant health, safety, and environmental legislation. This includes compliance with regulations relating to International Convention for the Prevention of Pollution from Ships (the MARPOL Convention 73 / 78) with the aim of preventing and minimising pollution from ships. Preparedness and swift responses are essential for effective spill management and as such, response plans will be in place should an incident occur. Control measures and shipboard oil pollution emergency plans (SOPEP) will be in place and adhered to under MARPOL Annex I requirements for all vessels. Any planned effluent dischargers will also be compliant with MARPOL Annex IV 'Prevention of Pollution from Ships' standards.

Moreover, an Emergency Spill Response Plan and Waste Management Plan will be implemented during the Construction phase of the Project to minimise releases (*Chapter 2: Project and Site Description*). Appropriate Health, Safety, and Environment (HS&E) procedures will also be implemented, with strict weather and personnel limits to reduce any risk of accidental spillage. With consideration of this good practice mitigation, the likelihood of an accidental spillage occurring from any of the vessels is considered to be very low. Should a spill occur, the impact would be of very small magnitude, short-term and localised to the Development. Any releases will be rapidly dispersed and diluted by wave and tidal movements.

When considering the low likelihood of accidental releases from vessels and rapid dilution of any mobilised sediment-bound contaminants, the magnitude of impact is assessed as negligible. Irrespective of the value and sensitivity of marine fauna, it can therefore be concluded that the effect on marine ecological receptors from adverse water quality is **negligible** and therefore **not significant**.

8.7.1.9 Introduction and Spread of INNS

The are multiple pathways associated with Construction phase activities which have the potential to result in the accidental introduction of INNS. International vessels may release ballast water into the water column and / or the addition of hard substrata to the seabed (e.g., piles) may act as potential stepping-stones for new species. Whilst most non-native species are unlikely to become invasive, those that do can out-compete native species and introduce diseases which could result in significant changes to community composition and mortality.

The installation of the Marine Facility will involve the placement of 72 piles on the seabed. Artificial structures in the marine environment are readily colonised by INNS, with some species known to be almost exclusively associated with artificial structures (Hurst 2016). These structures are known to favour colonisation by range-shifting species and act as either a stepping stone or as a direct vector for their dispersal (Mineur et al., 2012), indicating the potential for detrimental changes to native benthic habitats and species.

INNS considered to be of concern to Loch Fyne include wireweed (*Sargassum muticum*), Japanese skeleton shrimp, and the parasite *Gyrodactylus salaris* which poses a threat to Atlantic salmon populations (Argyll and Bute Council, 2009).

No INNS were observed during project-specific surveys, but previous surveys of the loch have observed the modest barnacle, carpet sea squirt, erect bryozoans *B. simplex* and *T. inopinata*, the orange-tipped sea squirt, Japanese skeleton shrimp*,* leathery sea squirt*,* and the alga *C. fragile* (Marine Scotland, 2020). Of these, only the modest barnacle and carpet sea squirt have been observed within the upper loch. The modest barnacle *A. modestus* is well established around the UK and out-competes some native barnacle species on the shore. In comparison, the carpet sea squirt is capable of covering extensive areas of the substratum. It is known to colonise artificial structures, rocks, boulders and even tide pools and is usually found in low energy environments where water motion is limited (Gibson-Hall & Bilewitch, 2018). A marine biosecurity plan for Loch Fyne has indicated that industrial activities within the loch pose a high risk of spreading carpet sea squirt through the use of vessels (Brown, 2020).

For this reason, all project vessels will adhere to the International Convention for the Control and Management of Ships' Ballast Water and Sediments with the aim of preventing the spread of INNS (IMO, 2022). In addition, vessels will be required to adhere to the IMO guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species (Biofouling Guidelines) (resolution MEPC.207(62). These measures lower the probability of INNS transmission from vessels to the benthic habitat.

The GB Invasive Non-Native Species Strategy also provides guidance for the prevention, detection, eradication and management of INNS, including marine species (NBN, 2021). Best practice measures will be adopted in compliance with the relevant IMO guidance regarding ballast water, should it be present, and biofouling. These measures will reduce the overall risk of introduction of INNS, resulting in a low magnitude of change.

When considering these embedded mitigation measures, the spread of any existing non-native species is considered unlikely. Although the sensitivity of benthic receptors to INNS introduction may be low to high, the introduction of INNS is unlikely and thus appraised to be of **negligible** magnitude and therefore **not significant.**

8.7.2 Operation Phase

The presence of the Marine Facility will involve the installation of 72 piles, which may alter the local hydrodynamics of the marine environment and result in disturbance to habitats and species from scour and hydrodynamic changes.

Both benthic ecological receptors and fish and shellfish rely on local currents for certain life history stages. For example, benthic invertebrates, fish, and/or shellfish may have pelagic egg or larval stages which rely on local currents for distribution. In Loch Fyne, flow rate was found to influence the distribution of flame shell beds (Millar et al., 2019).

However, hydrodynamic modelling conducted for the Marine Facility (*Chapter 18: Marine Physical Environment and Coastal Processes*) concluded that local hydrodynamics or sediment pathways would not be altered under normal conditions. Even with wind events that contribute to current speed magnification, the Marine Facility is considered to have minimal influence on both the flow regime and bed shear stress. Should any localised changes occur from the Marine Facility's presence, they are expected to rapidly dissipate and thus are unlikely to affect marine ecological receptors beyond the immediate vicinity around each of the piles. As such, the magnitude of impact is appraised as **negligible** and therefore **not significant.**

At the end of the operational phase of the Development the deck of the Marine Facility is expected to be removed but the piles will remain *in situ*. This is to enable the Marine Facility deck to be reinstated to allow for maintenance and repairs to the PSH scheme, should they be needed. The additional potential impact pathways to marine ecological receptors are expected to be the same as those identified for vessel use for the construction phase of the Development (see *Section 8.7.1 Construction Phase**Error! Reference source not found.***). As such, additional effects are predicted to be **negligible / minor adverse** and therefore **not significant.**

8.7.3 Decommissioning Phase

The approximated operational lifetime of PSH is in the region of 100 years. As such, decommissioning has been scoped out of assessment as the decommissioning of large-scale pumped storage hydro projects is extremely rare due to the long operational lifespan of the facility, and a decision would be made at a future time whether to refurbish the PSH or to decommission the scheme. At this time, potential decommissioning effects are therefore considered to be similar to and associated with the components described in the operational project phase. Should future works occur, a refurbishment plan or detailed decommissioning plan would be prepared as required as this may be subject to a separate planning application at the time.

8.8 Cumulative Effects

8.8.1 Inter-Cumulative Effects

At this stage, no other schemes or developments have been identified as reasonably foreseeable which have the potential to pose cumulative effects to marine ecological receptors. Therefore, the effects to marine ecological receptors are predicted to be **negligible** and **not significant**.

8.8.2 Intra-Cumulative Effects

No inter-cumulative effects have been identified between marine ecological receptors and other environmental impacts of the Development. All other activities associated with the Scheme are land-based and unlikely to affect the marine environment. Therefore, the effects are predicted to be **negligible** and thus **not significant**.

8.9 Mitigation and Monitoring

8.9.1 Embedded Mitigation

The following embedded mitigation measures have been incorporated into the Development design which aim to avoid and/or minimise impacts to marine ecological receptors:

- The installation of the piles during the construction of the jetty will be undertaken using vibratory piling wherever possible and impact piling only used where necessary to drive the pile toe into bedrock;
- Where impact piling is used the project will follow the JNCC guidance to minimise the risk of injury to marine mammals (JNCC, 2010) and such measures will be incorporated into the project CEMP;
- Measures in the Loch Fyne Marine Biosecurity Plan (Gov Scot, 2020) relevant to the construction methods used in the marine environment will be adopted and incorporated into the project CEMP;
- All vessels will follow the International Regulations for Preventing Collisions at Sea 1972 (COLREGS) and International Convention for the Safety of Life at Sea 1974 (SOLAS);

- All vessels will be in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL) regulations and will therefore be equipped with waste disposal facilities onboard. The discharging of contaminants is not permitted within 12 NM from the coast to preserve bathing waters;
- Control measures and shipboard oil pollution emergency plans (SOPEP) will be in place and adhered to under MARPOL Annex I requirements for all vessels;
- Ballast water discharges from all vessels will be managed under International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (Ballast Water Management Convention); and,
- All vessels will adhere to the International Maritime Organisation guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species (Biofouling Guidelines) (resolution MEPC.207(62).

8.9.2 Additional Mitigation, Compensation and Enhancement

Aside from the embedded mitigation measures described in *Section 8.9 Mitigation and Monitoring,* no additional mitigation measures or monitoring have been identified as required following the appraisal.

8.10 Residual Effects

No additional mitigation was required as no significant effects on marine ecological receptors were identified. As such, the residual effects of the Development remain as reported in *Section 8.7 Assessment of Effects,* the following tables therefore present a summary of the marine ecology impact assessment (*Table 8.15: Summary of Construction Effects* and *Table 8.16: Summary of Operation Effects*) and demonstrate that there are no expected significant effects during construction and operation on marine ecology/biodiversity.

Table 8.15: Summary of Construction Effects

Receptor	Description of Effect	Effect	Additional Mitigation	Residual Effects	Significance
Benthic Ecology	Permanent loss of benthic habitat due to installation of piles	Minor adverse	N/A (All mitigation is embedded)	Minor adverse	Not significant
	Habitat modification from introduction of artificial surfaces on the seabed	Minor adverse	N/A (All mitigation is embedded)	Minor adverse	Not significant
	Temporary disturbance of benthic habitats	Minor adverse	N/A (All mitigation is embedded)	Minor adverse	Not significant
	Temporary increase in SSC and sediment deposition	Negligible	N/A (All mitigation is embedded)	Negligible	Not significant
	Reduction in water quality	Negligible	N/A (All mitigation is embedded)	Negligible	Not significant
	Introduction and spread of INNS	Negligible	N/A (All mitigation is embedded)	Negligible	Not significant
Fish and Shellfish Ecology	Effects from UWS	Minor adverse	N/A (All mitigation is embedded)	Minor adverse	Not significant
	Temporary increase in SSC and sediment deposition	Negligible	N/A (All mitigation is embedded)	Negligible	Not significant
	Reduction in water quality	Negligible	N/A (All mitigation is embedded)	Negligible	Not significant
Marine Mammal Ecology	Effects from UWS	Minor adverse	N/A (All mitigation is embedded)	Minor adverse	Not significant
	Airborne sound and visual disturbance	Minor adverse	N/A (All mitigation is embedded)	Minor adverse	Not significant

Receptor	Description of Effect	Effect	Additional Mitigation	Residual Effects	Significance
	Vessel presence and collision risk	Minor adverse	N/A (All mitigation is embedded)	Minor adverse	Not significant
	Reduction in water quality	Negligible	N/A (All mitigation is embedded)	Negligible	Not significant

Table 8.16: Summary of Operation Effects

Receptor	Description of Effect	Effect	Additional Mitigation	Residual Effects	Significance
Benthic Ecology	Disturbance to habitats and species due to scour from hydrodynamic change	Negligible	N/A (All mitigation is embedded)	Negligible	Not significant
Fish and Shellfish	Disturbance to habitats and species due to scour from hydrodynamic change	Negligible	N/A (All mitigation is embedded)	Negligible	Not significant

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