13 FISH ECOLOGY

13.1 The table below provides a list of all the supporting studies which relate to the fish ecology impact assessment. All supporting studies are provided on the accompanying CD.

Details of study	Location on supporting studies CD
Benthic survey for Phase 1 of the MeyGen tidal stream energy project, Inner Sound, Pentland Firth (ASML, 2011)	OFFSHORE\Seabed interactions
MeyGen EIA Coastal Processes Modelling – Modelling setup, calibration and results (DHI, 2012)	OFFSHORE\Seabed interactions
Underwater noise impact study, Inner Sound, Pentland Firth (Kongsberg, 2012)	OFFSHORE\Marine Wildlife\Underwater noise
Distribution and abundance of marine mammals and basking sharks in the Inner Sound and wider Pentland Firth and Orkney waters (RPS, 2011a)	OFFSHORE\Marine Wildlife\Marine mammals

13.1 Introduction

13.2 This section assesses the effects of the proposed Project on fish ecology. A separate section (Section 14) considers potential impacts on commercial fisheries. The assessment has been undertaken by Xodus.

13.3 Scottish waters are estimated to support 250 fish species, with 166 commercial and non-commercial fish species recorded from the north-eastern coast of Scotland (Barnes *et al.*, 1996). This section provides a baseline description of the fish populations in the Inner Sound of the Pentland Firth and puts them into context of Scottish, UK, European and World-wide conservation.

13.2 Assessment Parameters

13.2.1 Rochdale Envelope

13.4 In line with the Rochdale Envelope approach, this assessment considers the maximum ('worst case') project parameters. Identification of the worst case scenario for each receptor (i.e. Environmental Impact Assessment (EIA) topic) ensures that impacts of greater adverse significance would not arise should any other development scenario be taken forward in the final scheme design. Table 13.1 describes the detail of the project parameters that have been used in this assessment and explains why these are considered to be worst case. The potential impacts from alternative Project parameters have been considered in Section 13.9.

Project parameter relevant to the assessment		'Maximum' Project parameter for impact assessment	Explanation of maximum Project parameter
Turbine	Number	86 turbines	The maximum number of turbines poses the greatest encounter rate.
	Layout	45m cross-flow spacing and 160m down-flow spacing	An indicative layout for 86 turbines has been used to inform the modelling. The indicative layout is based on 45m cross-flow spacing and 160m down-flow spacing. This results in 6 rows of 11 turbines and 1 row each of 5, 7 and 8 turbines
	Rotor diameter	16m for collision risk 20m for barrier effect	Collision risk: The 16m rotor diameter results in the highest encounter probability for the fish encounter model. Barrier effect: For the barrier effect the 20 m rotor results in a higher swept area and a greater proportion of the Pentland Firth being occupied by the turbine rotors.
	Blade thickness	N/A	This Project parameter does not influence the fish impact assessment. Blade thickness is not an input parameter to the fish collision risk model.
	Blade width	2.3m	The blade width is a key input parameter to the fish encounter model and the maximum width results in the highest encounter rate.
	Blade pitch	10°	The blade pitch is a key input parameter to the fish encounter model and the pitch of 10° results in the highest encounter rate.
	Number of blades per rotor	3	The 3 bladed rotor results in a higher encounter rate than the 2 bladed rotors.
	Rotational speed	20rpm	The highest rotational speed results in the highest encounter rate.
	Minimum clearance between sea surface and turbine blade	8m	The minimum clearance is considered for estimating encounters with the turbine. The minimum represents the worst case. Fish are assumed to pass over the turbine.
	Clearance from blade tip to seabed	4.5m	The minimum clearance is considered for estimating encounters with the turbine. The minimum represents the worst case. Fish are assumed to pass under the turbine.
	Operational noise	26 x 2.4MW turbines for noise generation	The 2.4 MW turbine produces the highest noise and an array of 36 turbines of 2.4MW produces higher noise emissions than an array of 86 turbines of 1MW.
	Decommissioning	All turbines removed at decommissioning	All turbines will be removed at decommissioning.
Turbine support structure	Maximum drilling cuttings released into marine environment	86 monopile Turbine Support Structure (TSS)	The drilled monopile TSS will result in the maximum release of drill cuttings to the marine environment. Assuming the maximum number of 86 TSSs, the maximum amount of drill cuttings that can be generated from turbine support installations is 17,200m^2 (total for 86 TSSs).
	Maximum seabed footprint	86 Gravity Base Structure (GBS) TSS	Each GBS TSS has a maximum footprint of 40m x 30m. The total footprint for 86 turbines is 0.103km^2.
	Installation noise	Pin-pile TSS	Pin pile drilling produces higher noise output than monopole drilling based on available data. Pin pile source levels are 178 dB re 1 μPa at 1 m.
	Decommissioning	86 Monopile	86 Monopile TSSs will be cut at the seabed. The bottom on the piles below the seabed will remain in-situ.
	Maximum amount of compressor lubricant released into the marine environment	86 monopile TSS	Monopile drilling operations will take approximately 4 hours per pile. A compressor is used to pump air into the drilled holes to lift cuttings clear. The lubricant will be discharged to sea along with the cuttings at a maximum rate of 5 litres per hour, i.e. 20m^3 per monopile and 1,720m^3 for all 86 installed over 3 years.
Cable connection to shore	Maximum cable footprint on seabed	86, 120mm unbundled cables each 1,300m in length with split pipe armouring	The maximum physical area of the seabed occupied by the cables has been calculated as 0.027km^2. Based on a maximum 1.3km of cable from Horizontal Directional Drill (HDD) bore exit to turbine, and a cable diameter of 120mm (x2 to account for split pipe armouring) for 86 turbines.

Project parameter relevant to the assessment		'Maximum' Project parameter for impact assessment	Explanation of maximum Project parameter
	Decommissioning	86, 120mm unbundled cables, each 1,300m in length	All cables laid on the seabed will be fully removed at decommissioning.
	Electromagnetic fields (EMF)	0.013km^2 of 6.6kV cables	The maximum area of the seabed affected by the magnetic field of the cables has been calculated as 0.013km^2. Based on a maximum 1.3km of cable from HDD bore exit to turbine and maximum cable diameter of 120mm for 86 turbines.
Cable landfall	Maximum drilling cuttings released into marine environment	29, 0.6m HDD bores, drilled from either Ness of Quoys or Ness of Huna	The majority of drill cuttings generated from the drilling of the HDD bores will be returned to shore and not discharged to sea; however it is estimated that the contents of the last 10m of each bore could be discharged to sea and the seabed breakthrough. Of the two potential HDD scenarios, the greatest potential volume of cuttings discharged to sea at breakthrough will result from last 10m of 29 boreholes of 0.6m diameter 82m^2).
Vessels	Installation vessel physical presence	1 Dynamic Positioning (DP) vessel for the duration of the installation for year 1 and 2 2 DP vessels for year 3 installation	Installation activities will be carried out by a single DP vessel during year 1 and 2, all installation activities to be undertaken using a single DP vessel. If other smaller vessels used to undertake some of the work of the DP vessel, no concurrent multiple vessel activities will take place, i.e. no more than one vessel on site at any one time. Year 3 installation will require a maximum 2 DP vessels for TSS installation. These two vessels may be present on site at the same time during year 3.
	Installation vessel noise	Tug vessel noise	Tugs represent the noisiest vessels and are used to represent the highest possible noise source during installation operations. Tug source levels are 172 dB re 1 µPa at 1 m.
	Maintenance vessel physical presence	1 DP vessel present every 2.8 days	Based on a maximum 86 turbine array, 1 DP vessel will be present a maximum of 130 times (i.e. single slack tide operation) per year i.e. the DP vessel present on site every 2.8 days.
	Maintenance vessel noise	Tug vessel noise	Tugs represent the noisiest vessels and are used to represent the highest possible noise source during installation operations. Tug source levels are 172 dB re 1 µPa at 1 m.
Onshore Project components	-	N/A	As there are no proposed works in the intertidal area along the coast the onshore aspects of the Project do not influence the fish ecology impact assessment.

Table 13.1: Rochdale Envelope parameters for the fish ecology assessment

13.2.2 Area of assessment

13.5 It is also important to define the geographical extent of the assessment. The focus of the impact assessment is potential impacts on fish ecology using the Project area and adjacent waters. There is variation in the area over which impacts occur and the area over which an impact may occur can vary significantly between species based on their ecology and the range over which their populations can be found. Therefore, potential impacts have been set in the context of a wider study area over which fish encountered in the Project area are thought to range.

13.6 It should be noted that at the time of undertaking the assessment the distance from the shore at which the HDD bores would emerge was considered to be between 700 and 2,000m, although the exact distance was unknown. The assessment here is based on the worst case, where the cables emerge from shore at 700m.

13.3 Legislative Framework and Regulatory Context

13.3.1 Legislation

13.7 The relevant legislation and policy is set out in Section 3. The following is of particular relevance to the assessment of fish ecology:

- EU Habitats Directive (Directive 92/43/EEC);
- The Habitats Regulations 1994 (as amended in Scotland) implements species protection requirements of the Habitats Directive in Scotland, on land and inshore waters;
- UK Biodiversity Action Plan (UK BAP); UK Governments response to the convention on Biological Diversity (CBD), which the UK signed up to in 1992 in Rio de Janeiro;
- Conservation of European Wildlife and Natural Habitats Convention (Bern convention);
- Wildlife and Countryside Act 1981, and
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora.

13.8 The following sections provide further details on the specific aspects of the above conservation and management legislation relevant to fish ecology.

13.3.2 Environmental Impact Assessment guidance

13.9 In addition to the EIA guidance published by Marine Scotland and SNH the guidelines developed by the Centre for Environment Fisheries and Aquaculture (CEFAS) (2004) for undertaking EIA in support of licensing of offshore wind farm developments under the Food and Environment Protection Act 1985 (FEPA) and the Coast Protection Act 1949 (CPA) are largely applicable. Although of the Marine Licence has replaced the FEPA and CPA licences, the CEFAS (2004) guidance is still considered to be applicable.

13.10 The CEFAS (2004) guidance states that there is potential for the construction, development and use of offshore wind farms (in the present case, tidal arrays) to impact fish resources, and it details a number of factors an EIA should take into account when assessing impacts on those resources. The EIA should present information that describes fish resources within the tidal array site and in the wider area. The presence and relative importance of fish resources should be described and assessed. Important fish resources include those species:

- Of significant importance in commercial and recreational fisheries;
- Of conservation importance;
- Susceptible to the effects of electromagnetic fields (EMF); and
- Restricted geographical distribution and/or locally abundant in the area.

13.11 For those fish resources identified as important the following aspects of their ecology should be considered:

- Spawning grounds;
- Nursery grounds;

- Migration routes; and
- Feeding grounds.

13.12 In addition to the above guidance the Institute of Ecology and Environmental Management (IEEM) have developed guidance for ecological impact assessment in Britain and Ireland for the marine and coastal environment. Although the IEEM guidance does not contain specific guidance for fish impact assessment they have been considered where relevant in this chapter.

13.3.3 EU Habitats Directive

13.13 The EU Habitats Directive 92/43/EEC (as amended) lists eight fish species in Annex II. To meet the requirements outlined in Article 3 of the Habitats Directive, Special Areas of Conservation (SACs) have been designated in UK waters to contribute to the European network of important high-quality conservation sites that will make a significant contribution to conserving these species. Of those fish species listed on Annex II of the Directive, Atlantic salmon (*Salmo salar*) and sea lamprey (*Petromyzon marinus*) have the potential to be present in the Pentland Firth (Table 13.2).

13.14 There are a number of SACs designated for Atlantic salmon which have been identified during the EIA from which Atlantic salmon have the potential to pass through the Inner Sound during their migrations. These are identified in Figure 13.1. The nearest SAC for any fish species to the Project is the River Thurso, designated for supporting Atlantic salmon, located approximately 21 km to the west.

13.3.4 Biodiversity Action Plans

13.15 The UK Biodiversity Action Plan (UKBAP) identifies a list of species of conservation concern in response to the Convention on Biological Diversity. A Caithness Local Biodiversity Action Plan (CLBAP) was published in 2003 by the Caithness Biodiversity Group (2003), where it states that 'the plan attempts to set out what can be done in the next five to ten years'. In addition, the Orkney Local Biodiversity Action Plan published in 2002-2007 (OLBAP) has been reviewed following its expiration and a further Plan (2008-2011) has been published which sets out to guide the conservation and enhancement of key features of biodiversity in Orkney over the coming years (OLBAP Steering Group, 2008). There are a number of sea fish species listed on the above BAPs that have the potential to be present in Pentland Firth (Table 13.2).

13.3.5 Priority Marine Features

13.16 A draft list of priority marine features (PMF) in inshore waters adjacent to Scotland, including those for which future Marine Protected Areas (MPA) will be designated under the Marine (Scotland) Act 2010, has recently been drawn up and circulated for consultation (Scottish Natural Heritage (SNH), 2011). The list, which is provisional and may be subject to future revision, includes a number of fish species that may be present in the Pentland Firth (refer to Table 13.2).

13.3.6 The Convention for the Protection of the Marine Environment of the North East Atlantic

13.17 The Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) is the mechanism by which 15 governments of Western Europe work together to protect the marine environment of the north-east Atlantic. In 2003, the UK government committed to establishing a well-managed, ecologically coherent network of Marine Protected Areas (known as the OSPAR MPA commitment). Marine SACs designated under the Habitats Directive (Section 13.3.3) have been submitted as the UKs initial contribution to the OSPAR network.

13.18 A list of marine habitats and species considered to be under threat or in decline within the north-east Atlantic has been produced by OSPAR (OSPAR, 2008). A number of fish species on the list may be present in the Pentland Firth (Table 13.2).

13.3.7 International Union for Conservation of Nature

13.19 The International Union for Conservation of Nature (IUCN) has compiled a Red list of threatened species that are facing a high risk of global extinction. The list (IUCN, 2011) includes fish species that are potentially or known to present in the Pentland Firth and identifies their conservation status (Table 13.2).

Species	Legislation / environmental sensitivity or management plan									
	Annex II of the EU Habitats Directive	EPSp	BAP species	Priority Marine Feature	OSPAR	IUCN Red List	Bern Convention Appendix II	Bern Convention Appendix III	CITES Appendix II	EU Management Plans
Angler fish, (*Lophius piscatorius*)			X	X (juv.)						
Atlantic salmon, (*Salmo salar*)	X		X	X	x					
Basking shark, (*Cetorhinus maximus*)			X	X	x	X (v)	X		X	
Blue shark, (*Prionace glauca*)			X			X (nt)		X		
Cod, (*Gadus morhua*)			X		x	x (v)				X
Common skate, (*Dipturus sp.*)			X	X	x	X (ce)				
European eel, (*Anguilla anguilla*)			X	X	x	X (ce)				X
Haddock, (*Melanogrammus aeglefinus*)						X (v)				
Hake, (*Merluccius merluccius*)			X							X
Halibut, (*Hippoglossus hippoglossus*)			X			X (v)				
Herring, (*Clupea harengus*)			X							X
Kitefin shark, (*Dalatias licha*)						X (nt)				
Ling, (*Molva molva*)			X	X						
Mackerel, (*Scomber scombrus*)			X	X						
Monkfish, (*Squatina squatina*)			X							
Norway pout, (*Trisopterus esmarkii*)				X						
Plaice, (*Pleuronectes platessa*)			X							X
Porbeagle, (*Lamna nasus*)			X		x			X		
Saithe, (*Pollachinus virens*)				X (juv.)						
Sandeel, (*Ammodytes marinus*)			X	X						
Sand goby, (*Pomatoscistus minutus*)				X						
Sea lamprey (*Petromyzon marinus*)	X		X	X	X			X		
Sea trout, (*Salmo trutta*)			X							
Shortfin mako, (*Imagelsurus oxyrinchus*)						X (v)		X		
Spiny dogfish (*Squalus acanthias*)						X (v)				
Spotted ray, (*Raja montagui*)					x					
Spurdog, (*Squalus acanthias*)			X		x	X (v)				
Tope, (*Galeorhinus galeus*)			X			X (v)				
Whiting, (*Merlangius marlangus*)			X							

Table 13.2: Finfish species potentially present in the Pentland Firth with specific conservation / environmental sensitivities and/or management plans. juv. = juvenile, v = vulnerable, nt = near threatened, ce = critically endangered

13.3.8 The Convention on the Conservation of European Wildlife and Natural Habitats

13.20 The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) principle aims are to ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention), to increase cooperation between contracting parties, and to regulate the exploitation of those species (including migratory species) listed in Appendix 3 of the convention. To implement the Bern Convention in Europe the European community adopted, amongst others, the EU Habitats Directive (Section 13.3.3). In the UK the Bern Convention was implemented into UK law by the Wildlife and Countryside Act (1981 as amended). Seventeen fish species are listed on Appendix II of the Bern Convention and are strictly protected against disturbance, capture, killing or trade. Approximately 120 fish species are listed on Appendix III of the Convention, and although these species are afforded protection, exploitation is permitted (in exceptional circumstances), with prohibitions on particular hunting methods and equipment.

13.3.9 Wildlife and Countryside Act 1981

13.21 Basking sharks are protected under Schedule 5 of the Wildlife and Countryside Act (1981 as amended) which prohibits the killing, injuring or taking by any method of those wild animals listed on Schedule 5 of the Act. The Nature Conservation (Scotland) Act 2004, Part 3 and Schedule 6 make amendments to the Wildlife and Countryside Act (1981 as amended), strengthening the legal protection for threatened species to include 'reckless' acts. The Act makes it an offence to intentionally or recklessly disturb basking sharks. Licensing requirements under the Wildlife and Countryside Act (1981 as amended) are similar to those for European Protected Species (EPS) protected under Annex IV of the Habitats Directive.

13.3.10 The Conservation on International Trade in Endangered Species of Wild Fauna and Flora

13.22 CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement which aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Species listed under Appendix II are those identified as not currently threatened with extinction but will become so if their trade or any products made from them, are not subject to strong regulations. Basking shark is the only fish species listed under Appendix II relevant to the Pentland Firth area (Table 13.2).

13.3.11 European Union management plans

13.23 Certain commercially important fish stocks have been assigned specific management plans by the EU in order to ensure long term management, protection and (where appropriate) recovery of these stocks. There are a number of fish species that have the potential to be present in the Pentland Firth which have specific management plans. These management plans are summarised in Table 13.3 below. Species specific management plans aim to help EU countries meet targets to aid recovery of depleted populations and to maintain commercially exploited stocks.

Species	EU management plan summary
Cod	Multi-annual plans are in place for several stocks, including the North Sea and West of Scotland.
European eel	EU management plans specify that EU countries need to enable 40% of adult eels to escape to the sea for spawning purposes, Plans aim to protected eels by limiting fisheries, making it easier for eels to migrate through rivers and through restocking suitable inland waters with young eel.
Hake	The northern stock (present in the North Sea), is considered by the EU as stable (no further information was available at the time of writing).
Herring	The west of Scotland herring stock is covered by a long term EU management plan. Atlanto-Scandian stocks are jointly managed by Norway under a long-term management plan. The main aim of the EU management plan is for establishment of multi-annual plan with the objective to ensure stock exploitation at a maximum sustainable yield.
Plaice	The majority of plaice stocks are stable, with the objective of the EU management plan to return stocks to a level within safe biological limits to protect and conserve stocks. Multi-annual management plans have been developed in consultation with Norway, with the aim to preserve stocks by exploiting the maximum sustainable yield. Attainment of this objective through fishing effort limitation is set for 2015.

Table 13.3: Outline of EU Management Plans concerning species relevant to the Pentland Firth

13.4 Assessment Methodology

13.4.1 Environmental Impact Assessment scoping and consultation

13.24 Since the commencement of the Project, consultation on fish ecology issues has been ongoing. Table 13.4 summarises all consultation relevant to fish ecology. In addition, relevant comments from the EIA Scoping Opinion are summarised in Table 13.5, together with responses to the comments and reference to the Environmental Statement (ES) sections relevant to the specific comment.

Date	Stakeholder	Consultation	Topic / specific issue
7th April 2011	Marine Scotland and SNH	Pre-Scoping meeting	EIA surveys and studies required and the data needs for each EIA study.
27th May 2011	Marine Scotland, statutory consultees and non statutory consultees	Submission of EIA Scoping Report	Request for EIA Scoping Opinion from Marine Scotland and statutory consultees and request for comment from non statutory consultees.
6th June 2011	Marine Scotland and SNH	Meeting	Discussion on SACs to be assessed within the HRA process and species to be considered.
30th June – 2nd July 2011	Local stakeholders	Public Event - EIA Scoping	Public event to collate information/opinions on proposed EIA scope.
8th August 2011	Marine Scotland and SNH	Submission of document for comment	Submission of HRA Screening Report.
30th September 2011	Marine Scotland and SNH	Letter	Response to HRA Screening Report.
31st September 2011	Marine Scotland, The Highland Council, statutory consultees and non statutory consultees	Receipt of EIA Scoping Opinion	Receipt of response to EIA Scoping Report and other comments from non statutory consultees.
3rd October 2011	Marine Scotland	Project update meeting	EIA progress and specific discussion on data requirements for fish ecology impact assessment and collision modelling requirements.
27th October 2011	Lord Thurso	Meeting	Discussion regarding the project, potential Atlantic salmon issues and consultation going forward.
2nd November 2011	Marine Scotland, Marine Scotland Freshwater Laboratory and SNH	Meeting	Discussion of assessment methodology; data requirements; preliminary assessment results and HRA requirements. Discussion on the collision model and use of SNH Collision Risk Model for birds and wind farms for assessing fish encounter rate.
23rd November 2011	Marine Scotland and SNH	E-mail	Confirmation of the SACs to be considered for Atlantic salmon within the HRA.
6th – 7th December 2011	Local stakeholders	Public Event – pre application consultation	Public event to communicate the findings of the EIA to local stakeholders.
2nd March 2012	Marine Scotland and SNH	Meeting	Final meeting to close out HRA approach to the Project and discuss results of encounter studies.
9th March 2012	Caithness District Salmon Fishery Board	Meeting	Consultation with salmon fisheries board to discuss potential issues and approach to impact assessment.

Table 13.4: Consultation undertaken in relation to fish ecology

Name of organisation	Key concerns	Response	ES section within which the specific issue is addressed
Whale and Dolphin Conservation Society (WDCS)	Basking sharks potentially occurring in the Inner Sound requiring monitoring and protection.	Observation surveys commissioned by MeyGen has included reporting any basking sharks seen. Operational monitoring for basking sharks will be incorporated in the marine mammal monitoring protocol.	Section 11 Marine Mammals.
SNH	Data sources & survey design for fish and shellfish - Marine Scotland Science is the primary source for information on commercial fish and shellfish in Scottish waters. For spawning information, the applicant should also be aware of Ellis *et al* (2010)	Scope of work for the fish ecology impact assessment was agreed with Marine Scotland, within which a fish and shellfish survey was not required to inform the baseline. Ellis *et al*. (2010) has been utilised.	Section 13.5 Baseline Description.
SNH	Spawning and nursery grounds are not spatially or temporally fixed, potentially moving according to the conditions of the substrate, seabed habitats, climate and hydrodynamic regimes. Marine Scotland Science and CEFAS should be able to advice on the most appropriate data sources relating to spawning and nursery grounds, and whether any additional surveys are required. They should also be contacted to discuss mitigation measures if there is any overlap between the development site and the location of spawning events/nursery grounds.	Original discussions with Marine Scotland (7th April 2011) and also later discussions (3rd October 2011) identified the most recently available data and that the proposed approach (without the collection of additional survey information) was appropriate. The need for mitigation measures has been determined by the likelihood of spawning grounds to be in the Inner Sound and the proportion of the wider spawning ground affected.	Section 13.5 Baseline Description Sections 13.6.1 Loss of Spawning Grounds and 13.6.2 Loss of Nursery Grounds
SNH	Many fish and shellfish have strong associations with particular habitats or substrate types, sometimes varying for different life-history stages of a species.	Associations of fish with particular habitats and substrate types and changes with the life-history stages of fish have been taken into account	Section 13.5 Baseline Description
SNH	Fish and shellfish to consider: In determining species to consider within the EIA, we recommend that in addition to the UK Biodiversity Action Plan (BAP) the applicant includes the OSPAR Threatened and Declining and the Scottish Priority Marine Features (PMF)13 list as part of the criteria. These include some commercial species of fish, and for some the juvenile life stages	Fish species listed on BAP, OSPAR Threatened and Declining and the Scottish (PMF) have all been considered as part of the EIA.	Section 13.3 Legislative Framework and Regulatory Context and Section 13.5 Baseline Description
SNH	The impacts of underwater noise on the spawning behaviour of fish is a potential concern, and should be considered with regard to installation, operation, maintenance and decommissioning of the array. It should be noted that different species of fish have differing sensitivities to underwater noise, and this should be considered in the EIA.	Species likely to spawn in the Project area and their sensitivity to underwater noise have been considered in the impact assessment. Differing fish species sensitivities have also been considered in the impact assessment.	Section 13.6.3 Impact 13.3 Noise, Section 13.7.3 Impact 13.14: Noise and Section 13.8 Potential Impacts During Decommissioning.
SNH	Other potential impacts which should be considered include disturbance due to EMF and the barrier effect. Benthic and demersal species are more likely to be vulnerable to the potential barrier effects of EMF than pelagic species and should be considered accordingly. The ES should consider the vulnerability of different species (e.g. benthic / demersal / pelagic / migratory), their likely levels of sensitivity, and to what extent cable protection / armouring can limit exposure to EMF.	The potential impacts of EMF and barriers to movement have been considered as part of the EIA and the vulnerability of different species have been considered accordingly during the impact assessment.	Section 13.7.4 Electromagnetic Fields.
SNH	Collision risk will also need to be considered.	The collision risk has been considered in the impact assessment.	Section 13.7.6 Impact 13.17: Collision
SNH	Impacts on migratory species (e.g. barrier effects and disturbance) are correctly identified as a matter to be considered in the ES. However, this currently appears to only give consideration to diadromous species. Many fully marine fish and shellfish also exhibit migratory behaviour, usually associated with the breeding/spawning cycle (e.g. between shallow and deeper water). The ES should consider the potential for impacts on these species also.	The risk to other fully marine species during migrations from spawning and nursery grounds has been considered where appropriate.	Section 13.6 Impacts during Construction and Installation, Section 13.7 Impacts during Operations and Maintenance and Section 13.8 Impacts during Decommissioning
SNH	Basking sharks may use the area for passage and/or feeding.	The impact assessment presents as much data as possible on the known distribution of basking sharks in the Project area. The presence of basking sharks and their conservation status has been considered throughout the impact assessment.	Section 13.6 Impacts during Construction and Installation, Section 13.7 Impacts during Operations and Maintenance and Section 13.8 Impacts during Decommissioning.
SNH	We would advise that European eel and sea trout should be considered together with Atlantic salmon.	These three species have been considered during the impact assessment.	Section 13.5.2 Diadromous Fish, Section 13.6 Impacts during Construction and Installation, Section 13.7 Impacts during Operations and Maintenance and Section 13.8 Impacts during Decommissioning
SNH	Noise will be produced during the installation. Information on levels of noise production should be provided and, using published literature, decide what impact, if any, this will have on fish movements through the area. In this regard the recent review commissioned by SNH may be helpful: it considers the current state of knowledge with regard to the potential impacts of noise, associated with marine renewable energy, on Atlantic	The potential impact of noise generated during installation on fish species passing through the Project has been considered as part of the impact assessment. The SNH commissioned report has been utilised where appropriate.	Section 13.6.3 Impact 13.13 Noise

Name of organisation	Key concerns	Response	ES section within which the specific issue is addressed
	salmon, sea trout and European eel.		
SNH	Operational noise - Once the devices are installed and operational, there is the potential for the development to generate noise over the longer term. It is unclear what levels of noise will be generated and what impact this may have on fish. Noise monitoring work undertaken at EMEC may help to address this	The potential impact of noise generated during operation on fish species passing through the Project has been considered as part of the impact assessment. It was the intention for MeyGen to use underwater noise data measured from candidate tidal turbines to inform the noise modelling and impact assessment. To date it has not been possible to record the underwater noise from candidate turbines operating. Alternative data sources were used to inform the impact assessment. MeyGen intends to use underwater noise data collected from candidate turbines to verify the modelling work.	Section 13.7.3 Impact 13.14 Noise
SNH	Electromagnetic effects (EMF) - The response of fish to EMF is poorly understood and the applicant should consider this The SNH review may be helpful in considering EMF with regard to Atlantic salmon, sea trout and European eel.	The response of fish to EMF and the current poor understanding of this is considered in the impact assessment. The SNH review has been used to inform the impact assessment.	Section 13.7.4 Impact 13.15 Electromagnetic Fields
SNH	The above impacts should also be considered in terms of cumulative and in-combination impacts. They should also be considered for the different life stages of the species concerned	The cumulative and in-combination impacts have been considered as part of the impact assessment and HRA.	Section 13.10 Cumulative Impacts
SNH	Atlantic salmon of River Thurso SAC, Berriedale and Langwell Waters SAC, River Borgie SAC, River Naver SAC, River Oykel SAC, River Moriston SAC, River Spey SAC, and Little Gruinard River SAC. The proposed tidal array may be located within the migratory pathways of Atlantic salmon from these designated sites. Construction and operational noise/vibration may give rise to disturbance of Atlantic salmon. There is also the potential for collision risk and disturbance from EMF. We advise that there is potential for the proposal to have likely significant effects on Atlantic salmon.	This section and the HRA report have considered the impacts to SAC fish species.	Section 13.10 Cumulative Impacts
SNH	Indirect impacts on fish regarding reduced/impaired foraging resources, due to impacts on benthic ecology.	A comprehensive benthic ecology baseline has been established through a field survey, upon which the impact assessment is based.	Section 10 Benthic habitats and Ecology and Section 13.5.1
Marine Scotland	Marine Scotland agrees that the area is unlikely to be a key spawning ground for the fish species mentioned on page 30 of the EIA Scoping Report. However, the possibility of cumulative effects from the displacement of predatory fish and fishing activity would need to be investigated, along with the potential cumulative effects from surrounding sites, to rule out any adverse effects on nearby spawning grounds to the east and west of Stroma.	The potential cumulative effects from the displacement of predatory fish and fishing activity have been considered as part of the impact assessment.	Section 14 Commercial Fisheries and Section 13.10 Cumulative Impacts
Marine Scotland	Marine Scotland also agrees with the elasmobranch species listed in the EIA Scoping Report, Common skate, Spiny dogfish, Thornback Ray, White Skate, Basking Shark and Cuckoo Ray. The Marine Conservation Society has also sighted Basking Sharks in the area.	The presence of these species within the Project area has been considered as part of EIA. Basking shark sightings data including that from the MeyGen Marine Mammals boat-based observation survey, from the Marine Conservation Society and from local wildlife observers has been utilised in the assessment.	Section 13.5 Baseline Description, Section 13.6 Impacts during Construction and Installation, Section 13.7 Impacts during Operations and Maintenance and Section 13.8 Impacts during Decommissioning
Marine Scotland	Landing figures for the area suggest a high concentration of Spiny dogfish (*Squalua acanthias*) within the ICES statistical rectangle 46E6. The presence and abundance of this critically endangered, IUCN Red listed species within the area of search, along with the species mentioned above, should be investigated using a suitable fish survey.	The spiny dogfish is a demersal species. There is no trawl fishing activity currently taking place within the Project area, fishing is instead dominated by small potting vessels. As a result it is unlikely that catches of spiny dogfish within 46E6 were within the Project area.	Section 14 Commercial Fisheries and Section 13.5 Baseline Description
Marine Scotland	Consideration should be given to the impact of EMF on elasmobranchs in the area through aggregation, displacement, avoidance or disruption to feeding behaviours.	The potential impacts of EMF on fish ecology have been considered as part of the EIA.	Section 13.7.4. Impact 13.15: Electromagnetic Fields
Marine Scotland	With regards to migratory fish, advice should be sought from Marine Scotland Science Freshwater Laboratory regarding possible migratory fish impacts. Tagged salmon from rivers along the northern coast of Scotland have been recaptured both east and west of the rivers of release indicting that the species may migrate through the proposed site as there can be a preference for post-smolt migratory routes to be relatively close to shore (2.5-5 km). Marine Scotland Science Freshwater Laboratory will be best placed to advise on possible issues and measures that may need to be taken into account.	Through discussion with the Marine Scotland Freshwater Laboratory (13th October 2011) it has been established that Atlantic salmon are likely to travel through the Project area. However, the distance that smolts travel from shore is considered to be unknown at this time although there is evidence to suggest from other countries that smolts may travel 2.5-5km from the shore during migrations (Iain Malcolm pers. comm.) Advice was sought on the information available and how this could be addressed within the ES.	Section 13.5 Baseline Description, Section 13.6 Impacts during Construction and Installation, Section 13.7 Impacts during Operations and Maintenance and Section 13.8 Impacts during Decommissioning
Marine Scotland	Offshore renewable developments have the potential to directly and indirectly impact diadromous fish of	The potential impacts to these species have been considered as part of the EIA.	Section 13.5 Baseline Description, Section 13.6 Impacts during Construction

Name of organisation	Key concerns	Response	ES section within which the specific issue is addressed
	freshwater fisheries interest including Atlantic salmon, anadromous brown trout (sea trout) and European eel. These species use the coastal areas around Scotland for feeding and migration and are of high economic and / or conservation value. As such they should be considered during the EIA process. Developers should also note that offshore renewable projects have the potential to impact on fish populations at substantial distances from the development site.		and Installation, Section 13.7 Impacts during Operations and Maintenance and Section 13.8 Impacts during Decommissioning
Marine Scotland	In the case of Atlantic salmon information will be required to assess whether there is likely to be any significant effect of developments on rivers which are classified as Special Areas of Conservation (SAC's) for Atlantic salmon under the Habitats Directive. Where there is the potential for significant impact then sufficient information will be required to allow Marine Scotland to carry out an Habitats Regulations Appraisal.	It is recognised by the Marine Scotland Freshwater Laboratory that there is currently a lack of information on salmon. However, there is data available on the 'wetted area' of rivers available and this combined with a smolt estimate from the North Esk can be used to determine the proportion of the population from these rivers that will pass through the Inner Sound. This information along with the published review of information available on salmon will be used to determine the impacts to Atlantic salmon in the EIA and the Habitats Regulations Appraisal.	Section 13.11 Habitats Regulations Appraisal and HRA Report (MeyGen, 2012)
Marine Scotland	In order that Marine Scotland is able to assess the potential impacts of marine renewable devices on diadromous fish and meet legislative requirements the developer should consider the site location (including proximity to sensitive areas), type of device, and the design of any array plus installation methodology. Specifically we request that developers provide information in the following areas: 1. Identify use of the proposed development area by diadromous fish (salmon, sea trout and eels) (a) Which species use the area? Is this for feeding or migration? (b) At what times of year are the areas used? (c) In the case of salmon and sea trout what is the origin / destination of fish using the area? 2. Identify the behaviour of fish in the area (a) What swimming depths do the fish utilise (b) Is there a tendency to swim on or offshore. 3. Assess the potential impacts of deployed devices on diadromous fish during deployment, operation and decommissioning phases. Potential impacts could include: (a) Strike (b) Avoidance (including exclusion from particular rivers and subsequent impacts on local populations) (c) Disorientation that could potentially affect behaviour, susceptibility to predation or by-catch, or ability to locate normal feeding grounds or river of origin (d) Delayed migration. 4. Consider the potential for cumulative impacts if there are multiple deployments in an area. 5. Assess 1-4 above to determine likely risk. (a) If there are insufficient data to determine use of the development area, these should be obtained (b) If there are insufficient data on the origin / destination of fish using the area then these should be obtained (c) Where it is not possible to obtain site specific data, the developer should make a convincing argument why this is the case and apply appropriate expert judgement based on published information. 6. If there is any remaining doubt as to the potential impacts of a particular development, then the developer should recommend a scientifically robust monitoring strategy to assess any impacts either on stocks as a whole, or on particular rivers as necessary.	The presence and utilisation of the Project area for salmon, sea trout and eels has been considered as part of the impact assessment. The cumulative impacts of multiple deployments in the area have also be considered as part of the EIA process. Through discussion with the Marine Scotland Freshwater Laboratory (13th October 2011) it has been established that Atlantic salmon are likely to travel through the Project area. However, the distance that smolts travel from shore is considered to be unknown at this time although there is evidence to suggest from other countries that smolts may travel 2.5-5km from the shore during migrations (Iain Malcolm pers. comm.) Advice was sought on the information available and how this could be addressed within the ES. Scientifically robust methods of determining the origin and destination of diadromous fish species have not been developed. The movements of diadromous fish in the North Sea and North Atlantic are considered to be a wider strategic issue and it would be impossible for a single developer to undertake this level of study. However, MeyGen intends to work with The Crown Estate, Marine Scotland and the wider industry to further understand this issue.	Section 13.5 Baseline Description, Section 13.6 Impacts during Construction and Installation, Section 13.7 Impacts during Operations and Maintenance, Section 13.8 Impacts during Decommissioning and Section 13.12 Proposed Monitoring
Marine Scotland	Marine Scotland Science has completed a review of migratory routes for Atlantic salmon, sea trout and eels relevant to Scotland. This will assist the developers in identifying what pre-existing information is available and what supplementary site specific data will be required.	This document has been utilised in the impact assessment.	Section 13.5 Baseline Description, Section 13.6 Impacts during Construction and Installation, Section 13.7 Impacts during Operations and Maintenance and Section 13.8 Impacts during Decommissioning
SEPA	The ES should consider how the risks of introducing marine non-native species (MNNS) will be minimised.	MNNS will be considered within the ES and if required appropriate mitigation measures identified.	Section 13.6.11 Impact 13.11 Marine Non-Native Species (MNNS).

Table 13.5: Scoping comments relevant to fish ecology

13.4.2 Desk based study

13.25 This ES section and more specifically, the fish ecology baseline description is, in its entirety, based upon a comprehensive desk-based study. Data sources used to determine the fish ecology baseline were as follows:

- Landings statistics from ICES rectangle 46E6 from Marine Scotland as presented in the Section 14 Commercial fisheries;

- Technical reports and reviews for offshore energy Strategic Environmental Assessments (SEA) (e.g. DECC, 2009; Faber Maunsell, 2007);
- Species spawning and nursery ground maps and spawning periods (Coull *et al*., 1998; Ellis *et al*., 2010);
- Marine Scotland report on migratory fish (Malcolm *et al*., 2010);
- National Biodiversity Network (NBN http://data.nbn.org.uk/) and Marine Life Information Network (MarLIN; www.marlin.ac.uk/) websites;
- Marine Conservation Society (MCS) basking shark sightings reports (MCS, 2008; 2009);
- Sightings of specific fish species recorded during the MeyGen commissioned marine mammal and bird observation surveys (RPS, 2011);
- Stakeholder consultation/scoping opinions; and
- Video data from benthic survey carried out between the 25th and 27th July 2011.

13.4.3 Field survey

13.26 Through consultation with Marine Scotland, a site specific fish ecology survey was not considered a requirement for the proposed Project. The highly energetic conditions of the Inner Sound create conditions difficult for equipment deployment and recovery and fishing practices which surveys would use to collect data are not practised in the Inner Sound for this very reason (see Section 14 Commercial Fisheries). Large sea areas would also need to be covered to sample some of the wider ranging species i.e. Atlantic salmon and this level of survey is not feasible. A detailed and comprehensive literature search was undertaken to collate data on the species likely to be present in Inner Sound and to investigate their ecological requirements of the area. As many fish species are highly mobile the baseline investigation considers data available for the wider Pentland Firth area and for migratory fish the rivers they migrate from and the routes they take through the Project area were considered. As such the species list may be considered to include a greater range than regularly use the proposed Project area.

13.4.4 Significance criteria

13.27 The EIA process and methodology are described in detail in Section 8. Each assessment section is, however, required to develop its own criteria for the 'sensitivity of receptor' and 'magnitude of impact' aspects since the definition of these will vary between different topics. For fish ecology, the significance criteria used in this section is based on the methodology described in Section 8 but the sensitivity of the receptor and magnitude of impact are defined in Table 13.6 and Table 13.7 respectively.

13.28 The environmental consequences of impacts are then considered by reference to the relevant criteria in the EIA Regulations. The significance of impacts in relation to the EIA Regulations is defined in Section 8, Table 8.2.

Sensitivity of receptor	Definition
Very High	▪ Fish species affected are designated under international legislation (e.g. IUCN red list, EU Habitats Directive). ▪ In the context of a particular impact, species which are considered extremely sensitive to the impact[1].
High	▪ Fish species affected are designated under UK and Scottish legislation. ▪ In the context of a particular impact, species which are considered highly sensitive to the impact[1].
Medium	▪ Fish species affected are designated under local legislation (e.g. Local BAP species) and are vulnerable to the impacts in question. ▪ In the context of a particular impact, species which are moderately sensitive to the impact[1].
Low	▪ Fish species that are not designated under national or international legislation. ▪ In the context of a particular impact, species which are not very sensitive to the impact[1].
Negligible	▪ Fish species with little or no local importance or sensitivity to the impacts in question. ▪ In the context of a particular impact, species which show no sensitivity to the impact[1].
Note: [1]In the context of some impact certain species may be very sensitive to the impact (e.g. herring and noise) but are not designated under certain the legislation that would make them of very high sensitivity. In addition there may be some receptors that are very high sensitivity due to their designation under international legislation but in the context of the particular impact they demonstrate no sensitivity to the impact and can be considered of low sensitivity.	

Table 13.6: Definitions for sensitivity of receptor

Magnitude of impact	Definition
Severe	▪ Prolonged / widespread disturbance to fish species to the baseline condition, with long term or permanent effects on any or all of the following: spawning grounds, nursery grounds, migration routes and / or feeding grounds. ▪ These would result in long term changes in population size. ▪ Impact highly likely to occur.
Major	▪ Medium-term and localised disturbance or change to the baseline condition to fish species, with medium-term and recoverable affects in the medium-term on: spawning grounds, nursery grounds, migration routes and / or feeding grounds. ▪ Populations would recover in the medium term. ▪ Impact likely to occur.
Moderate	▪ Short-term and localised disturbance or change to the baseline condition to fish species, with short-term and recoverable affects on: spawning grounds, nursery grounds, migration routes and / or feeding grounds. ▪ Populations would show recovery in the short-term. ▪ Impact will possibly occur.
Minor	▪ Detectable disturbance or change to the baseline condition to fish species and no long-term noticeable effects above the level of natural variation experiences in the area. ▪ Impacts are not sufficient to be observed at the population level. ▪ Impact unlikely to occur.
Negligible	▪ Imperceptible or no changes to the baseline condition including to: spawning grounds, nursery grounds; migration routes; and / or feeding grounds. ▪ No changes experienced at the population level. ▪ Impact highly unlikely to occur.
Positive	▪ An enhancement of an ecosystem or population parameter.

Table 13.7: Definitions for magnitude of impact

13.4.5 Data gaps and uncertainties

13.29 The desk based review provides some indication of the presence (or absence) of fish species within the area and whether spawning and nursery grounds are present. In addition the behaviour of fish species within the Project area can not be directly observed and how these species may use the site directly is also not available and would be unlikely to be obtained from undertaking fish surveys due to the temporal and spatial variability inherent in marine fish populations. Therefore, some assumptions have to be made in order to carry out the assessment. In the case of spawning and nursery grounds, which may change location and be temporally variable, information on the area of which spawning has been recorded or can be expected has been used. This information is of very coarse quality and can only be used in the context it is provided. In this respect if the spawning ground covers the Project area it is assumed spawning takes place here, unless there is evidence to the contrary.

13.30 For migratory species the exact routes they will take on their movements to and from feeding and spawning grounds are not always known. Where information is available it has been used to determine whether species travel through the Project area or to make assumption on the migratory routes taken. If these data are not available then an assumption has been made that migration through the Project area occurs. As a result there is still some uncertainty over the impacts related to migratory fish species. However, the assessment may over-rate the impacts that are predicted through the use of precautionary assumptions.

13.31 For many of the impacts that are discussed in Section 13.6, Section 13.7 and Section 13.8, there has been some research into the potential for these impacts to occur and the severity of these impacts. In some instances (e.g. Electromagnetic Fields (EMF)) the evidence is inconclusive and a precautionary approach has been taken.

13.32 Where there is no current evidence available (i.e. collision risk) approaches applied to other receptors (e.g. seabirds) have been adapted for fish or professional judgement and experience has been used in order to assess any impacts.

13.5 Baseline Description

13.5.1 Benthic environment

13.33 A number of surveys of the seabed of the Inner Sound have been undertaken which provide an indication of the seabed substrata present in the area (iXSurvey, 2009; Moore, 2009; 2010; Moore and Roberts 2011; ASML, 2011). A complete description of the benthic environment and these surveys is in Section 10 Benthic Habitats and Ecology. In summary the seabed in the Inner Sound is heterogeneous, but the majority of the deployment area is composed of scoured bedrock, with patches of sand, megarippled sand and sandbanks with coarse gravel only present in isolated patches directly south and south-west of Stroma. The scoured bedrock extends into the cable corridor although this area is more dominated by kelp forest/park. The benthic communities on the scoured bedrock of the deployment area were dominated by scour-tolerant fauna including the barnacle *Balanus crenatus* and the hydroid *Tubularia indivisa*.

13.5.2 Diadromous fish

13.34 This section reviews the presence of diadromous fish (also known as migratory fish) that are known to be present in the Pentland Firth.

13.35 Diadromous fish are species of fish which spend part of their life at sea, but migrate up rivers in order to breed. Several species of fish living in Scottish rivers migrate between the sea and the upper reaches of rivers during their life cycle.

13.36 This section concentrates on three species of diadromous fish, the Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*) and European eel (*Anguilla anguilla*) that have the potential to be present in the Pentland Firth. Atlantic salmon and sea trout are anadromous (migrating from the sea to fresh water to spawn) whereas European eel are catadromous and migrate from fresh water to the sea to spawn.

Atlantic salmon

13.37 Atlantic salmon are widely distributed in Scotland and salmon populations are recognised as being of national and international importance.

13.38 The juvenile life stage of salmon takes place in fresh water, which typically lasts between one to four years before surviving fish migrate to the sea as smolts. Following entry to the sea, fish are known as post-smolts until the spring of the following year. After one winter at sea a salmon is called a grilse. Atlantic salmon grow rapidly by feeding at sea before returning to their native rivers to spawn. The length of time a salmon spends in the sea before returning to their river of origin to spawn varies from one to five winters (Marine Scotland, 2011a).

13.39 The adult fish may spawn in quite small headwater streams as well as in suitable areas in larger water courses. Adult fish enter rivers from the sea at almost any time of year, but they migrate into smaller spawning streams on elevated flows following rainfall in the autumn. Spawning takes place between late October and early January (CEFAS, 2004), after which a small proportion of the adult fish return seaward over a period of up to several months (salmon returning to the sea following spawning are termed kelts). The proportion of adults returning to the sea following spawning is in the region of 20 to 36% (Hendry and Cragg-Hine, 2003).

13.40 Catches of Scottish salmon between 2003 and 2007 accounted for 60% and 12% of the UK and European nominal catch (fish killed and retained), respectively (Malcolm *et al*., 2010). Atlantic salmon have been identified as a species of conservation importance; they are listed in Annex II of the Habitats Directive, a UK BAP Priority species, a Scottish PMF and are included on the OSPAR list of marine habitats and species considered to be under threat or decline in the north-east Atlantic (Section 13.3.6). In recognition of the importance of Scottish salmon populations, 17 rivers have been designated SACs for Atlantic salmon. During consultation all 17 of these SACs were identified to potentially be influenced by the Project, where Atlantic salmon from these sites could pass through the Project area during their migration. These sites are shown in Figure 13.1.

13.41 The nearest designated SAC salmon river to the lease area is the River Thurso, located approximately 21km to the west (Figure 13.1). The river supports a higher proportion of multi sea-winter salmon than is found in many rivers further south in the species' range. The more northerly location of the river and the cooler ambient water temperature, results in slower-growing juveniles which smolt at an older age, and tend to return to the river to spawn as older multi-winter salmon.

13.42 There is limited information available on the at sea migrations of salmon. Smolts are believed to move offshore in schools to deep-sea feeding areas. Adult and sub-adult salmon from Scottish rivers pass through or make use of areas around west Greenland, east Greenland and the Faroe Islands (Malcolm *et al*., 2010). The routes by which they depart and return to rivers in the north of Scotland, including the River Thurso are not known, but it is assumed that on return they swim along the coast seeking olfactory[1] cues that help them identify the correct river (Lockwood, 2005).

13.43 Salmon post-smolts originating in Scottish rivers are thought to use near-shore areas at the commencement of their marine navigation but based on current information it is not possible to describe how migratory routes vary with river of origin, or to define the duration or extent of their initial dependence on near and offshore areas (Malcolm *et al*., 2010). However, evidence does suggest smolts originating from east coast rivers do travel through the Pentland Firth on their way to feeding grounds. In terms of the migratory behaviour of smolts less is known. Some evidence from Canada shows that smolts stay relatively close to shore, (Lacroix *et al*., 2005), although these studies have not been conducted in Scotland, and where coastal currents are substantial there is evidence to suggest smolts avoid these areas (Malcolm *et al.,* 2010). Evidence also suggest that smolts spend most of their time in the top 1 to 6m of the water column (Davidson *et al.,* 2008; Plantelech Manel-La *et al*., 2009), although again these studies were conducted in Norweigian fjords rather than open water surrounding Scotland. The fact that many smolts are caught in surface trawls also suggests that smolts spend most of their time in the top few metres of the water column (Malcolm *et al.,* 2010).

13.44 During a review of adult salmon tagging studies in Scottish waters, Malcolm *et al*. (2010) reported that as well as Atlantic salmon from the east coast moving through the Pentland Firth in a easterly direction towards their natal rivers, movement from the east to the north coast in a westerly direction may be relatively common for both grilse and multi-winter salmon. However, the numbers involved in the westerly movement are likely to be lower than the main movement east. Some fish tagged on the east coast of Scotland, including near Montrose and the Black Isle, have been later recaptured on the north coast of Scotland, indicating that these fish would have passed through the Pentland Firth area. The coastal

[1] Olfactory: Of, relating to, or contributing to the sense of smell.

tagging studies identified by Malcolm *et al*. (2010) reported very few re-captures within the Pentland Firth, including in the Inner Sound itself.

13.45 Whilst at sea salmon typically spend most of their time close to the surface, but they often dive, sometimes to depths of 280m. The complex nearshore directional movements of salmon remain poorly understood and their behaviour at this stage may be linked to a range of local environmental conditions such as tidal movements, home river discharges, diurnal rhythms and other biological and physical cues.

13.46 Based on the available information and taking a precautionary approach it is assumed that Atlantic salmon do pass through the Inner Sound during their migrations to and from the sea as well as the rest of the Pentland Firth. It is also assumed that both Adult salmon and smolts pass through the turbine deployment area although evidence may point to the contrary; that smolts and adult salmon may pass over the turbines or avoid areas of high current velocities.

Sea trout

13.47 Sea trout are the migratory form of brown trout and have a very similar life history to Atlantic salmon. The main difference between the two species is that immature sea trout often return to fresh water to overwinter. Also in contrast to salmon, sea trout appear to remain within nearshore waters rather than undergoing extensive migrations offshore (DECC, 2009).

13.48 The NBN gateway provides data records from the Biological Records Centre database for freshwater fishes of sea trout at a number of river mouths to the west of the Inner Sound. Records of sea trout originate from the rivers Link, Heilen, Harland, Murkle and Thurso (Figure 13.1). The closest of these river mouths is that of the Link, located approximately 7km to the west of the proposed Project area.

13.49 Trout spawn in winter from October to January. The eggs are shed in redds cut by the female in the river gravel, usually in upstream reaches, although many spawn in gravel below weirs. Most sea trout tend to remain in coastal waters once they leave freshwater systems (Kallio-Nyberg *et al*., 2002).

13.50 Malcolm *et al*. (2010) concluded that given the data available to date, no reliable conclusions can be drawn on the marine distribution of adult sea trout. In addition there is limited information on swimming depths for adult sea trout, although data from Norway suggests shallow swimming depths (<3m) with frequent dives to approximately 30m (Malcolm *et al*., 2010).

13.51 However, given the close proximity of sea trout sightings to the Project area and their known behaviour, a precautionary approach assumes that sea trout will pass through the Inner Sound. As for salmon, it is also assumed that sea trout pass through the turbine deployment area although evidence may point to sea trout passing over the turbines or avoiding areas of high current.

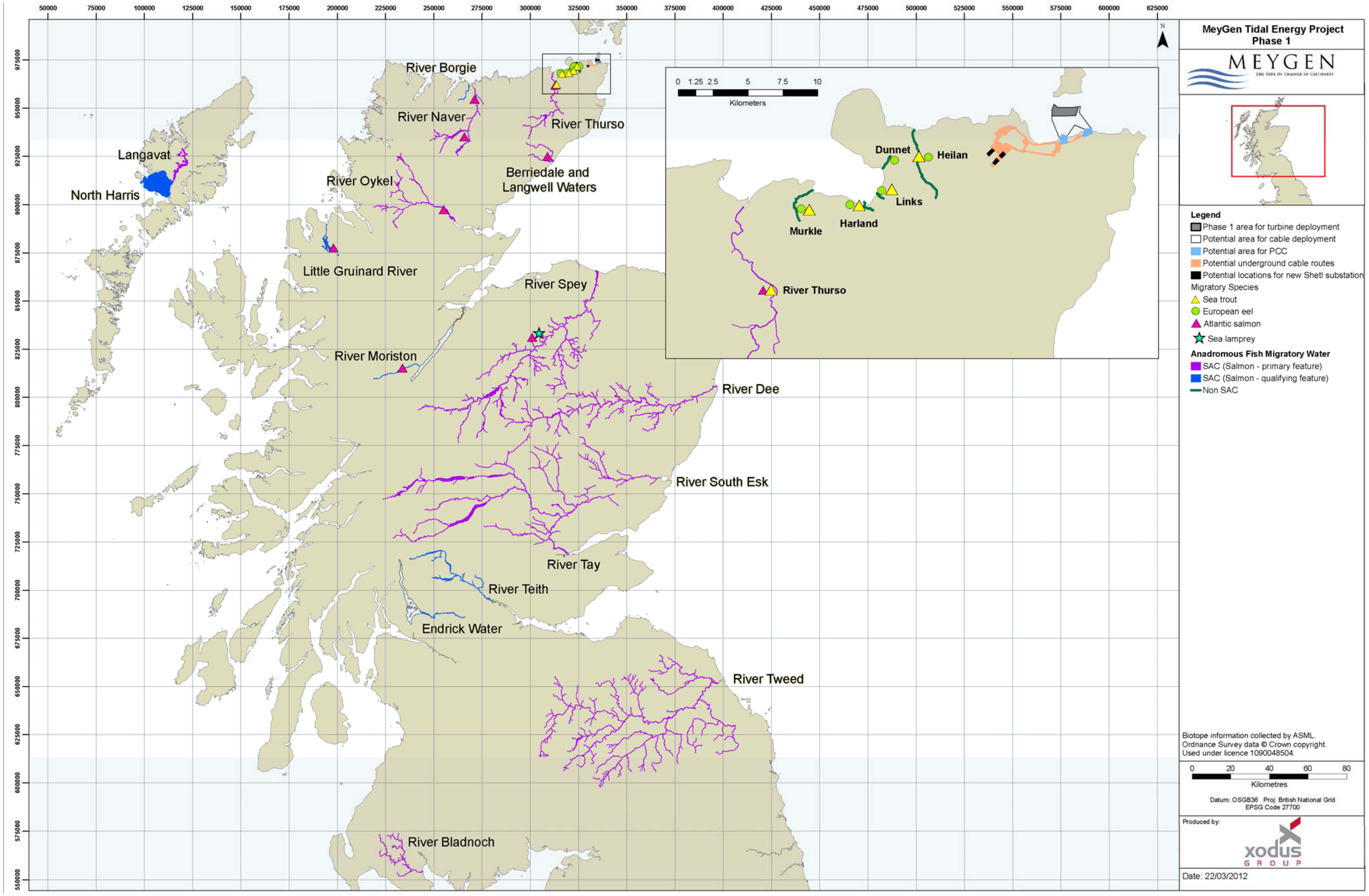

Figure 13.1: Diadromous fish rivers and SACs

European eel

13.52 The life cycle of the European eel is well known. Spawning occurs in the Sargasso Sea (in the mid Atlantic Ocean), after which larval eels cross the Atlantic Ocean. By the time they reach the European continental shelf, including the UK, they have metamorphosed into 'glass eels' at around 5cm in length. Some of these glass eels remain in the sea, some ascend European rivers and some move back and forth between marine, estuarine and fresh water environments. During this time, they develop pigmentation and are referred to as 'yellow eels'. After the continental growth stage which can last from 30-60 years, the yellow eels metamorphose into 'silver eels' and begin the return migration to the Sargasso Sea (Malcolm *et al*., 2010).

13.53 Very little is known about the routes undertaken or the nature of eel migrations as juveniles and as adults. However, for both migrations it is possible that a significant proportion of the total European population may pass through the seas around Scotland (Malcolm *et al*., 2010). The timing of migration peaks in Scottish waters is poorly recorded but Malcolm *et al*. (2010) inferred that glass eels pass through Scottish waters principally from September to December. In addition, glass eels destined for Scottish rivers must remain in coastal regions until April to May before river temperatures rise sufficiently for them to enter fresh water. The majority of return silver eel migration is likely to take place between September and January.

13.54 Both juvenile and adult eels can be found throughout the water column (up to 300m) and the depth selected can vary with the time of day and the state of the tide.

13.55 There is evidence to suggest that the Pentland Firth is used widely by eels that colonise the eastern seaboard, where there is a high probability of eels being encountered in the northern Scottish rivers (Malcolm *et al*., 2010).

13.56 The NBN gateway holds data records of European eel at a number of river mouths to the west of the Inner Sound, from the Biological Records Centre database for freshwater fishes. Records are from the rivers Link, Heilen, Harland, Dunnet, Murkle and Thurso (Figure 13.1). The closest of these river mouths is that of the Link located approximately 7 km to the west proposed Project area. Although there is very little information available that would indicate the European eel pass through the Inner Sound area, the close proximity of sightings to the Project area, and the use of the wider Pentland Firth by European eel a precautionary approach assumes that European eel do pass through the Inner Sound.

Sea lamprey

13.57 Lampreys belong to a small group of fish known as Agnatha (jawless), the most primitive of all living vertebrates. Although not true fish they are referred to here for convenience. Sea lamprey (*Petromyzon marinus*) spawn in gravel beds of freshwater streams and mature in the open sea. However relatively little is known about the precise habitats occupied by adult sea lampreys (Maitland, 2003) as it is uncommon in the UK (DECC, 2009). The main population of this species are found in the Bristol Channel and adjacent offshore waters (DECC, 2009). Notably, there are no records on the NBN gateway of lamprey species in the north-east coast of Scotland. River Lamprey are generally found no further north than the Great Glenn (Maitland, 2003) and sea lamprey are absent from most northern rivers. Many northern Scottish rivers are unsuitable due to their high flow rates (Maitland, 2003). Based on this evidence it is unlikely that sea lamprey will be present within the Project area.

13.58 However, as sea lamprey is present in the River Spey there is the potential for migrants of this species to be present within the Inner Sound. In addition the River Spey SAC is one of the rivers that are provided by SNH as requiring HRA and as a result the sea lamprey is considered within this impact assessment, although the impacts are very much considered in general terms to all fish species.

13.5.3 Elasmobranchs

13.59 Elasmobranchs are fish species which include sharks, rays and skates. All elasmobranchs are cartilaginous fishes, whose skeletons are composed of cartilage, rather than bone. These animals are collectively referred to as elasmobranchs because they are in the Class Elasmobranchii.

13.60 Shark species expected to be to be present in the Pentland Firth include basking shark (*Cetorhinus maximus*), spurdog (*Squalus acanthias*), tope (*Galeorhinus galeus*), lesser spotted dogfish (*Scyliorhinus canicula*) and porbeagle (*Lamna nasus*) (Faber Maunsell, 2007). Kitefin shark (*Dalatias licha*), shortfin mako (*Isurus oxyrinchus*), blue shark (*Prionance glauca*) nurse hound (*Scyliorhinus stellaris*) and spiny dogfish (*Squalua acanthias*) may also be present in the Pentland Firth (MarLIN, 2011; Scottish Government pers comm., 2011).

13.61 The main species of skate and ray on the north coast of Scotland are thornback ray (*Raja clavata*), cuckoo ray (*Raja naeus*) and spotted ray (*Raja montagui*) (Faber Maunsell, 2007). Common skate (*Dipturus intermedia* and *Dipturus flossata*) a species of conservation concern, may also be present in the Pentland Firth and the Inner Sound area. Records of this species (including records of egg cases) suggest that waters surrounding Orkney, the Pentland Firth and north of Scotland may be used by the common skate.

Nursery grounds

13.62 The Pentland Firth has been identified as nursery ground for spurdog, tope, thornback and the spotted rays (Ellis *et al.,* 2010) Figure 13.2 displays the areas in which nursery grounds may occur. However, the specific location of nursery grounds may change from year to year depending on a number of environmental variables and the seabed conditions within specific areas.

Basking shark

13.63 The basking shark is the largest fish in the North Atlantic and the second largest in the world, growing up to 10m. Basking sharks generally live in open waters but migrate towards the shore during the summer months, where they can be seen swimming slowly feeding on plankton in the surface waters with their mouths wide open. While basking sharks will spend most of their feeding time at the surface they do swim beneath the surface when they are not feeding. However, the depths at which they swim are not very clear. Basking sharks are viviparous, producing live pelagic young.

13.64 The Marine Conservation Society (MCS) has been collating UK-wide sightings of basking sharks since 1987 in a project called Basking Shark Watch, through which they have temporal and spatial data of over 21,000 sharks from over 5,200 records. Sighting distribution maps show large concentrations of sightings on the west coast of Scotland, however sightings have been recorded along the majority of the north Scottish coast, including within the Pentland Firth (MSC, 2008). Sightings in the Pentland Firth in this database are as recent as 2009 (MCS, 2009). Sightings in Scotland in 2008 accounted for 6% of the total (n=67) reported sightings for the whole of the UK. The annual variability in sightings in Scotland from 2004 to 2009 indicates that the number of sightings in Scotland have decreased significantly. Since 2007 sightings in Scotland have decreased by 81% from 345 to 67 (MSC, 2009). The decrease in sightings in Scotland should be considered with caution as they may be an artefact of reduced sightings effort or poor sighting conditions.

13.65 Over 90% of basking shark sightings in the UK are reported between the months of May and August, when sightings peak earliest in the southwest UK and lastly in Scotland around August (MSC, 2008). Sightings in 2009 were highest in the months of July to September (MSC, 2009).

13.66 A number of wildlife tours operate around the Stroma, including the John o' Groats to Orkney Ferry Company and North Coast Marine Adventure. These companies, alongside individuals, often report basking shark sightings to Caithness Sea Watching (www.caithness-sea-watching.co.uk). Basking shark sightings sent to Caithness Sea Watching in 2011 on the whole are very low for the north coast of Scotland. In 2011 to date there have been two recorded sightings of a basking shark just off John o' Groats Harbour, within the Inner Sound. In 2010 there were four sightings of basking sharks north of John o' Groats Harbour and one in Gills Bay, all in the Inner Sound. Individual basking shark sightings were also recorded off Duncansby Head (three sightings) and Thurso Bay (five sightings) to the east and west of the Inner Sound, respectively. In 2009, two sightings were reported just off the coast of John o' Groats, with an additional one to the north of Stroma and one to the west of Stroma. Also there were three sightings in Thurso Bay and two in the Pentland Firth.

13.67 During the marine mammal and bird observation surveys between October 2009 and September 2011 conducted within the Inner Sound and covering the Project area, one basking shark was observed, in

September 2010 (RPS, 2011). The survey results coupled with the historic data suggest the frequency of basking sharks is low with 1 to 5 spotted in any given year.

Spurdog

13.68 The spurdog is a widely distributed pelagic species and occurs mainly at depths between 10 and 100m. They tend to aggregate in large shoals of the same size or sex. They are viviparous and produce live young of between 20 and 30cm in length. There is some evidence that they may undertake extensive migrations. Mature females migrate inshore to give birth to their young. North Sea landings of spurdog have declines markedly, and the north-east Atlantic stock is estimated to be at approximately 5% of the biomass after the second word war. Spurdog in the North Sea are currently managed by a quota, with the TAC (Total Allowable Catch) reduced by 87% between 1999 and 2005 (ICES, 2011a).

13.69 The Pentland Firth is part of a spurdog nursery, although the main nursery grounds are located to the west of the Project (Ellis *et al*., 2010; Figure 13.2). Conditions within the Inner Sound maybe unsuitable for juvenile spurdog, hence the location of the main nursery grounds to the west of the Project.

Tope

13.70 The tope is a pelagic species with a widespread distribution at depths down to about 50m. They are viviparous, producing live pelagic young. They tend to be solitary, migrating offshore in winter. They arrive in coastal waters in September peaking in October/November before migrating to deep-water in January (Faber Maunsell, 2007). Tope are active and strong swimming sharks and are predominantly encountered near the seabed. Tope are very popular with recreational fishers as it is one of the largest shark species that can be targeted in UK waters (Shark Trust, 2009a). Ellis *et al*. (2010) identified the Pentland Firth as a nursery for tope (Figure 13.2) and the wider nursery area includes the Project. Adult Tope are also likely to be present within the area.

Lesser spotted dogfish

13.71 The lesser-spotted dogfish is very common in UK waters. It is a bottom dwelling shark most usually found over sand, mud, algae, gravel and rocky bottoms from the shallow sublittoral to depths of about 60m. It is an opportunistic predator feeding on a wide range of macrobenthic fauna with hermit crabs, cockles and whelks being dominant prey items (Shark Trust, 2009b). Spawning takes place in shallow water and the large egg purses are found close inshore where they attach to the substrate by tendrils (Faber Maunsell, 2007).

13.72 It is one of the few sharks that appear to be increasing in biomass, thought to be because most individuals caught by trawls survive when they are returned to the sea (Faber Maunsell, 2007).

Porbeagle

13.73 The porbeagle, is a pelagic shark that is widely distributed in the northern North Sea from the surface to about 145m depth. It is mainly an offshore species although it is not uncommon closer inshore. It appears to migrate northwards in the summer. Occasional fisheries have developed especially on the west coast of Scotland and off Shetland. It is often found around man-made structures such as North Sea oil and gas platforms (Faber Maunsell, 2007).

Kitefin shark

13.74 The kitefin shark is a deepwater, sporadically distributed species. The shark is encountered more commonly on the outer continental shelf to at least 1,800m, although is has been found as shallow as 37m. It is most common encountered below 200m. It is normally encountered either on or near the seabed but readily ranges from well off the bottom and is often caught in the water column (Shark Trust, 2009c). Thus species is likely to be relatively uncommon within the Project area as it is generally found in much deeper water.

Shortfin mako

13.75 The shortfin mako is an oceanic and coastal pelagic species which can be found in surface waters down to depths of 700m. It is a powerful and active shark and is thought to be the fastest species of shark reaching speeds of up to 80kph (Barnes, 2008a). It feeds primarily on bony fish such as mackerel, herring, cod and whiting (Shark Trust, 2009d). The shortfin mako is more likely to be found further offshore and although they may be occasional visitors to the area they are unlikely to be present in large numbers.

Blue shark

13.76 Blue sharks are a pelagic species and are probably the most widely ranging shark found in the main oceans and seas of the world, from the surface to at least 400m. It is a migratory species and it undertakes north-south migrations in the north-east Atlantic, seasonally visiting British and Irish waters in the summer months. The blue shark feeds on relatively small prey, especially squid and bony fishes (Queiroz, 2007). Blue shark may be occasional visitors to the area but are most likely to be found further out to sea.

Nurse hound

13.77 The nurse hound is a large cat-shark that can reach up to 1.6m in length. It is found throughout Britain and Ireland in both inshore waters and offshore continental shelves. It is commonly found over rough and rocky or coralline grounds and seaweed beds (such as those within the proposed cable corridor), down to a depth of up to 100m. It is commonly encountered on or just above the seafloor (Barnes, 2008b). It feeds on a variety of benthic organisms, including fish, crustaceans and cephalopods.

Thornback ray

13.78 Of the ray species, the thornback ray is likely to be the most commonly encountered ray species in the Pentland Firth. As with all ray species it is demersal and occurs in depths between 2 and 60m (Faber Maunsell, 2007). It frequents a wide variety of seabed types from mud, sand, shingle and gravel, although it is less frequently recorded on coarser sediment types. They are also found on patches of sediment among rocky outcrops and boulders and maybe found in these areas within the Project area. However, the substrate types in the Project Area are unlikely to be the favoured habitat of this species. Thornback ray feed on fish such as sand eels, herring, sprats and small flatfish; however shore and swimming crabs and brown shrimps are its main food source. Although it is a non migratory species, it often moves close inshore during the spring (Wilding & Snowden, 2008).

13.79 Waters to the west of the Pentland Firth have been identified as nursery grounds for the thornback ray (Ellis *et al*.., 2010; Figure 13.2).

Cuckoo ray

13.80 The cuckoo ray is relatively common and small bodied species of ray that is found around the majority of the UK. It is typically more of an offshore species than the spotted ray or thornback ray and therefore is likely to be only be an occasional visitor to the Project area. It is found over most types of ground in depths of 12 to 290m around the British Isles. It feeds on small crustaceans, worms and small fish, such as sandeels (Ellis *et al*., 2008).

Spotted ray

13.81 The spotted ray inhabits inshore and shallow shelf seas, in depths of 8 to 283m, though it is most abundant in waters less than 100m. Juveniles tend to occur closer inshore on sandy sediments, where adults are more common offshore on sand and coarse sand-gravel substrates. These substrates are uncommon in the Project area (characterised by rocky biotopes (Section 10 Benthic Ecology) and therefore the spotted ray is unlikely to be common within the area that turbines are deployed. Juveniles feed on small crustaceans, with adults feeding on larger crustaceans and fish (Ellis *et al.*, 2008). Spawning grounds for spotted ray are found throughout the Pentland Firth (Ellis *et al*., 2008, Figure 13.2).

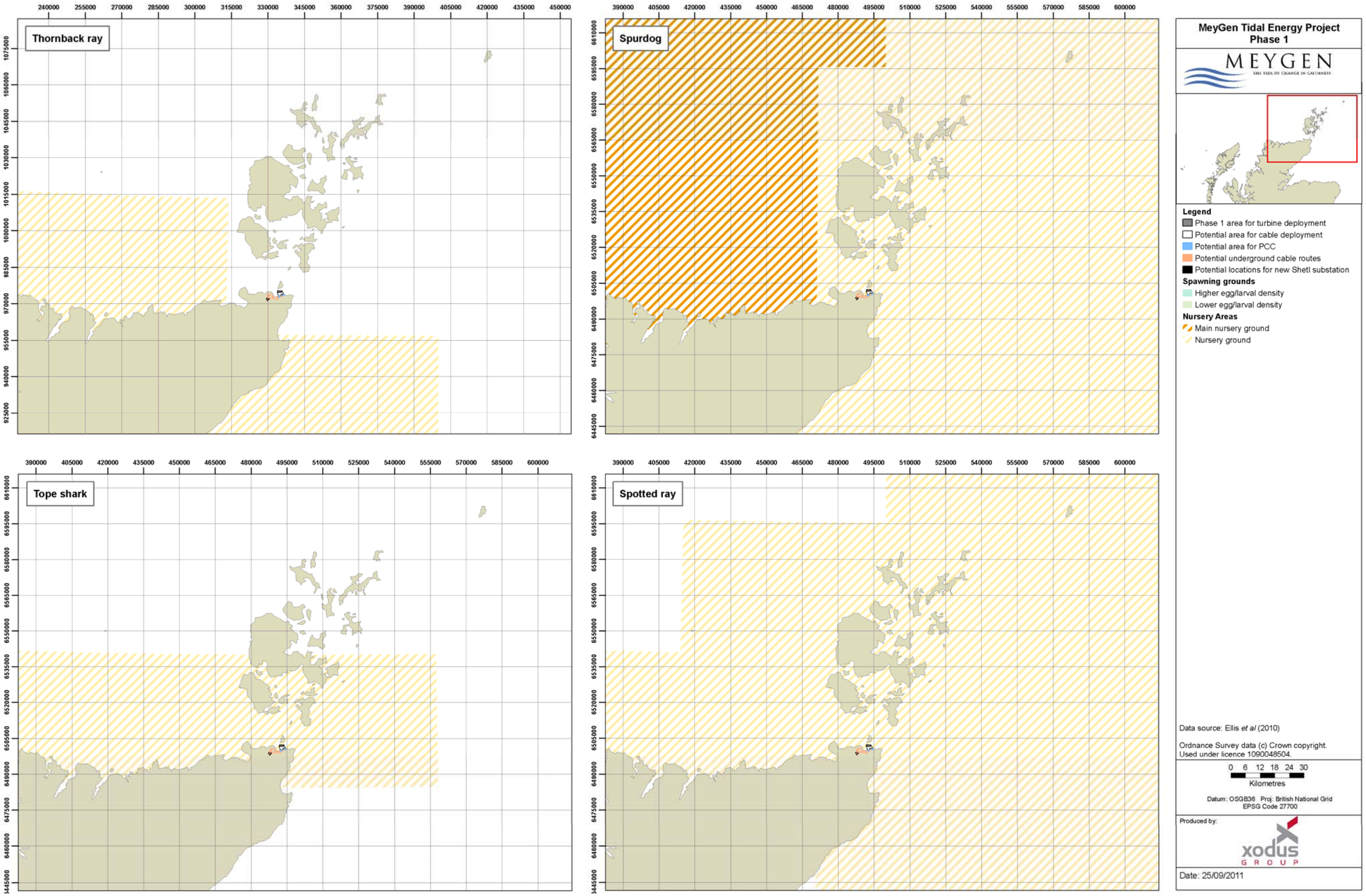

Figure 13.2: Sharks and ray nursery ground areas around the Project area and wider Pentland Firth (Ellis *et al*., 2010)

Common skate

13.82 The common skate is a large demersal ray with a long pointed snout, occurring on sandy and muddy substrates, feeding on flat fish, sand eels, crabs and bristle worms. Adult common skates occupy depths of 10 to 600m, whereas juveniles inhabit shallower waters. Common skate are listed in the IUCN Red List as 'critically endangered', due to continuing population declines. The habitat types most commonly occupied by this species are not present within the Project area and therefore this species is likely to be uncommon in the project area.

Spiny dogfish

13.83 The spiny dogfish is a coastal shark species well known for their voracious and opportunistic predatory behaviour. Swimming in large "packs," they will attack schools of fishes smaller than themselves, including cod, haddock, mackerel and herring (McMillan & Morse, 1999). They are considered to be the most abundant shark species globally. They prefer to swim close to the seabed and are a slow swimming species. They can be found over the continental and upper slopes down to approximately 900m (Shark Foundation, 2011).

13.84 Landings data analysed as part of the Commercial Fisheries section (Section 14) for ICES rectangle 46/E6 identified spiny dogfish in catches. However, this species is caught mostly using mobile gear and tidal currents within the Project area are largely unsuitable for trawling. As a result it is highly unlikely that the catches of this species within the rectangle equate to catches within the Project area. However, given the species ubiquitous nature and their prey species there is the potential for spiny dogfish to be present within the Project area.

13.5.4 Other finfish

13.85 In order to identify the presence of, and obtain an indication of the abundance of other finfish species in the Pentland Firth, including the Inner Sound, fisheries landings data for the period of 2006-2010 have been analysed. These analyses are given in the Commercial Fisheries section (Section 14) and as such will not be repeated. Pelagic, demersal and shellfish are landed in ICES rectangle 46/E6 where demersal fish species accounted for 25-38% and pelagic species 13-28 % of the total landings (see Section 14). Shellfish landings accounted for the remainder.

13.86 It is recognised that fishing methods and species targeted by fishermen are to a large extent, market driven. As a result, in addition to landings data, other sources have been used to determine the presence of finfish species. As part of the EIA process it is not considered necessary to assess potential impacts on each of the species listed in Table 13.8. Only those species that are considered to be important have been reviewed in further detail below. The criteria for importance include:

- Species identified of conservation importance or that have specific EU management plans (Section 13.3);
- Those species which spawn within or have nursery grounds within the Pentland Firth;
- Species that are considered to be important ecologically or particularly sensitive to activities associated with the Project (e.g. sandeels and herring); and
- Species that are considered to be commercially important (landing value greater than £5,000 per year – Section 14 Commercial Fisheries).

Finfish species	
Blue ling, (*Molva dypterygia*)	Monkfish, (*Lophius piscatorius*)
Blue whiting, (*Micromesistius poutassou*)	Norway pout, (*Trisopterus esmarkii*)
Cod, (*Gadus morhua*)	Ocean sunfish, (*Mola mola*)
Conger eels, (*Conger conger*)	Plaice, (*Pleuronectes platessa*)
Greater forked beard, (*Phycis blennoides*)	Poor cod, (*Trisopterus minutus*)
Haddock, (*Melanogrammus aeglefinus*)	Pollock, (*Pollachius pollachius*)
Hake, (*Merluccius merluccius*)	Red gurnard, (*Aspitriglia cuculus*)
Halibut, (*Hippoglossus hippoglossus*)	Red mullet, (*Mullus surmuletus*)
Herring, (*Clupea harengus*)	Saithe, (*Pollachius virens*)
Horse mackerel, (*Trachurus trachurus*)	Sandeels, (*Ammodytes spp*)
John dory, (*Zeus* faber)	Sole, (*Solea solea*)
Lemon sole, (*Microstomus kitt*)	Sprat, (*Sprattus sprattus*)
Ling, (*Molva molva*)	Torsk, (*Brosme brosme*)
Mackerel, (*Scomber scombrus*)	Turbot, (*Scophthalmus maximus*)
Megrim, (*Lepidorhombus whiffiagonis*)	Whiting, (*Merlangius merlangus*)

Table 13.8: Finfish species not considered within the EIA (Coull *et al*., 1998; Ellis *et al*.; 2010; Faber Maunsell, 2007; RPS, 2011; Scottish Government, pers. comm.; 2011; ASML, 2011)

Spawning and nursery grounds

13.87 Coull *et al*. (1998) and Ellis *et al*. (2010) identified areas within which spawning and nursery activities may take place for a number of fish species of commercial and conservation importance in UK waters. These species and the areas in relation to the Project are displayed in Figure 13.3, Figure 13.4 and Figure 13.5. However, it is worth noting that these areas are indicative of the area within which spawning and nursery activities may take place, where spawning and nursery areas may change from year to year depending on environmental conditions.

13.88 The Pentland Firth has been identified as part of a main nursery area for blue whiting and anglerfish; it is also is part of the nursery grounds for hake, mackerel, ling, sandeel, saithe, herring, haddock, lemon sole, whiting and cod. The main nursery areas for whiting and herring are located to both the east and west of the Pentland Firth, along the western and eastern Scottish coast and mackerel's main nursery areas are to the west of Scotland, and Ireland (Ellis *et al.,* 2010, Coull *et al.*, 1998: Figure 13.3, Figure 13.4 and Figure 13.5).

13.89 The Pentland Firth is part of the spawning grounds for sandeel, where coastal regions to the southeast of the Pentland Firth have been identified as areas of higher egg/larval density during these spawning periods (Figure 13.5; Ellis *et al*., 2010). Sandeel spawn between November and February (Coull *et al*., 1998; Table 13.9). The waters surrounding Orkney, including the Pentland Firth have also been identified as spawning grounds for herring (Coull *et al*., 1998; Table 13.9). The herring located in these waters have been identified as spawning between July and September (CEFAS, 2007; Table 13.9). Lemon sole have also been identified as using the waters surrounding Orkney and north Scotland for spawning between April and September (Coull *et al*., 1998; Table 13.9). Although not within the Pentland Firth Ellis *et al*. (2010) have identified that in the adjacent ICES rectangle of 46E7 (February to June (Coull *et al*., 1998; Table 13.7), high densities of whiting egg and larvae are present during spawning (Figures 13.3b).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Herring							✓	✓	✓			
Lemon sole				✓	✓	✓	✓	✓	✓			
Sandeel	✓	✓									✓	✓
Whiting		✓	✓	✓	✓	✓						

Table 13.9: Seasonal spawning periods for fish species in the Pentland Firth (Coull *et al*., 1998; Cefas, 2007)

Haddock

13.90 Haddock is a widely distributed demersal species throughout Scottish waters, where adults occur at depths between 40 and 300m, over rock, sand gravel or shells (Barnes, 2008d). Spawning takes place in deeper waters away from the Pentland Firth. In their first year of life haddock are pelagic and carry out vertical migrations (Faber Maunsell, 2007). The nursery grounds are widely distributed around the Scottish coast, where the waters both to the west and east of the Inner Sound, but not directly within the Inner Sound have been identified as nursery grounds for haddock (Coull *et al*., 1998; Figure 13.3).

13.91 Haddock is a commercially valuable species, where it is caught in mixed demersal fisheries alongside cod and whiting. Haddock have been identified to be of conservation importance where they are categorised as vulnerable on the IUCN red list.

Lemon sole

13.92 The lemon sole is a commercially important flatfish occurring throughout the Scottish waters, where it is in greatest abundance around the Outer Hebrides, Orkney and Shetland (Faber Maunsell, 2007). It is commonly found on stony bottoms between depths of 20 and 200m (Barnes 2008g).

13.93 Spawning for lemon sole occurs from April to July in deep water and the pelagic eggs and larvae occupy progressively deeper water as they develop (Faber Maunsell, 2007). The Pentland Firth is part of identified nursery and spawning grounds for lemon sole (Coull *et al*., 1998; Figure 13.3) and these cover the area of the Inner Sound.

Herring

13.94 Herring is a pelagic species that is widely distributed in Scottish waters. During the day they remain close to the sea bottom or in deep water, and they undertake diurnal feeding migrations into surface waters, often at dusk (Faber Maunsell, 2007). They are filter feeders that feed on a variety of planktonic organisms. The pelagic larvae, feed on copepods and other small planktonic organisms. Calanoid copepods are the predominant prey items during the juvenile life stages, but euphausids, hyperiid amphipods, juvenile sandeels, and fish eggs are also eaten. Larger herring predominantly consume copepods with small fish, arrow worms and ctenophores (ICES, 2011b).

13.95 Based on the spawning area and the timing of spawning herring have been divided into sub-populations. As previously discussed the waters surrounding Orkney, including Pentland Firth and the Inner Sound have been identified as herring spawning grounds during August and September (Coull *et al*., 1998; Figure 13.3). This area is part of the wider Buchan/Shetland spawning ground of the most northerly race of herring, which spawn off the northeast of Scotland as well as around Orkney and Shetland (Faber Maunsell, 2007).

13.96 Although herring are reported to deposit their sticky demersal eggs on a variety of substrates ranging from boulders, rock, small stones, coarse sand, shell fragments, macrophytes and man-made structures such as lobster pots; gravel is widely considered to be the preferred spawning substrate (Drapeau, 1973; Rogers & Stock, 2001). The eggs adhere to the seabed, forming extensive egg beds. According to Reid *et al*. (1999), spawning occurs in areas of well-mixed water with reasonably strong tidal currents (1.5 to 3 knots) often on shoals and banks in relatively shallow water (approximately 15 to 40m). These high-energy environments provide aeration and reduce siltation and accumulation of metabolites (Stevenson & Scott, 2005).

13.97 After hatching the larvae are pelagic and drift with the currents and the juvenile nursery grounds tend to be close inshore. The nearest to the Pentland Firth is south, in the coastal waters of the Moray Firth, as far north as Wick on the east coast of mainland Scotland (Coull *et al*., 1998). After about a year they migrate further offshore to the adult feeding grounds before returning to spawn in their well defined areas.

13.98 As outlined above and in Section 10 Benthic Ecology the surveys conducted of the Inner Sound reported that the majority of the seabed within the Inner Sound, including the Project area is comprised of current scoured bedrock. The small areas of sediment to the north of the proposed Project area comprise of patches of shelly gravel and are likely to be unsuitable for herring, particularly given the high tidal flows of up to 3.6 knots (see Physical Environment and Sediment Dynamics, Section 9).

Blue whiting

13.99 Blue whiting is a widely distributed oceanic and benthoplegic species found off western and northern Scotland, the North Sea and western coasts of Ireland and the British Isles. It inhabits the continental slope and shelf down to a depth of more than 1,000m, where it may take nocturnal vertical migrations to the surface (Barnes, 2008c). They are commonly found in shoals 30 to 400m from the surface in water between 150 to 3,000m deep (DECC, 2009). They feed primarily on small crustaceans such as euphausiids.

13.100 Blue whiting is very abundant in deep waters to the north of Orkney in February, and spawning takes place between February and April along the continental slope to the west of Scotland at depths of 300 to 600m. After spawning fish migrate to the North and Norwegian Seas to feed. Juvenile blue whiting remain in their nursery grounds for between two and four years before returning to spawn for the first time (DECC, 2009). The Pentland Firth is on the eastern boundary of the main blue whiting nursery area, which covers a wide area including the west of Shetland and northern North Sea (Ellis *et al*., 2010; Figure 13.4). Due to their depth range this species is unlikely to be present within the Inner Sound and the Project area.

Cod

13.101 Cod is a widely distributed demersal species that occurs throughout UK waters. Tagging has revealed that cod migrate in late summer and early autumn from the west coast to the north coast and return in the late winter and early spring (Faber Maunsell, 2007). Cod are batch spawners, where spawning can take place in 10 to 20 batches during a two to three month period. The larvae are planktonic and feed on various species of zooplankton, however after a couple of months the juveniles become more benthic in habit and begin to school (FAO, 2004).

13.102 Cod spawn away to the south of the Pentland Firth during January to April; however the Pentland Firth is part of a larger cod nursery area which occurs over much of the North Sea (Ellis *et al*., 2010; Figure 13.4).

13.103 Atlantic cod are omnivorous, feeding on a variety of invertebrate and fish species, including crabs, gobiid and some gadoid (cod-like) fish and zooplankton (Hop *et al*., 1992). Cod is an important exploited fish species on the North Atlantic, where the North Sea cod population was the first EU fish stock to be brought under long-term management. Cod is caught within ICES rectangle 46E6 and landings have shown an increase over the last few years (Section 14). However, stocks of cod in the North Atlantic are considered to be seriously depleted and outside safe biological limits (Baxter *et al*., 2011).

Hake

13.104 Hake is a demersal species that is usually found between 70 and 350m, but may also occur within a wider depth range from inshore waters (30 to 1,000m). It is commonly observed feeding alone on the bottom especially during the daytime and in shoals in the water column during the night (FAO, 2011; Barnes, 2008e). It is a top predator in the demersal community of the north-east Atlantic; mainly preying on blue whiting, horse mackerel and clupeids such as herring (Murua, 2010).

13.105 The spawning period for hake is very long and varies with populations, with the west Scotland population spawning between May and August. In their first three years juveniles live on muddy bottoms, where they feed on crustaceans (especially euphausiids and amphipods) and are unlikely to be found within the Project area which is mostly rocky substrate (ASML, 2011). Adults feed mainly on fish (small hake, anchovies, sardines and gadoid species) and squid (FAO, 2011). The Pentland Firth is part of a hake nursery ground, which extends over the majority of the northern and central North Sea and the west coast of the British Isles (Ellis *et al*., 2010; Figure 13.4).

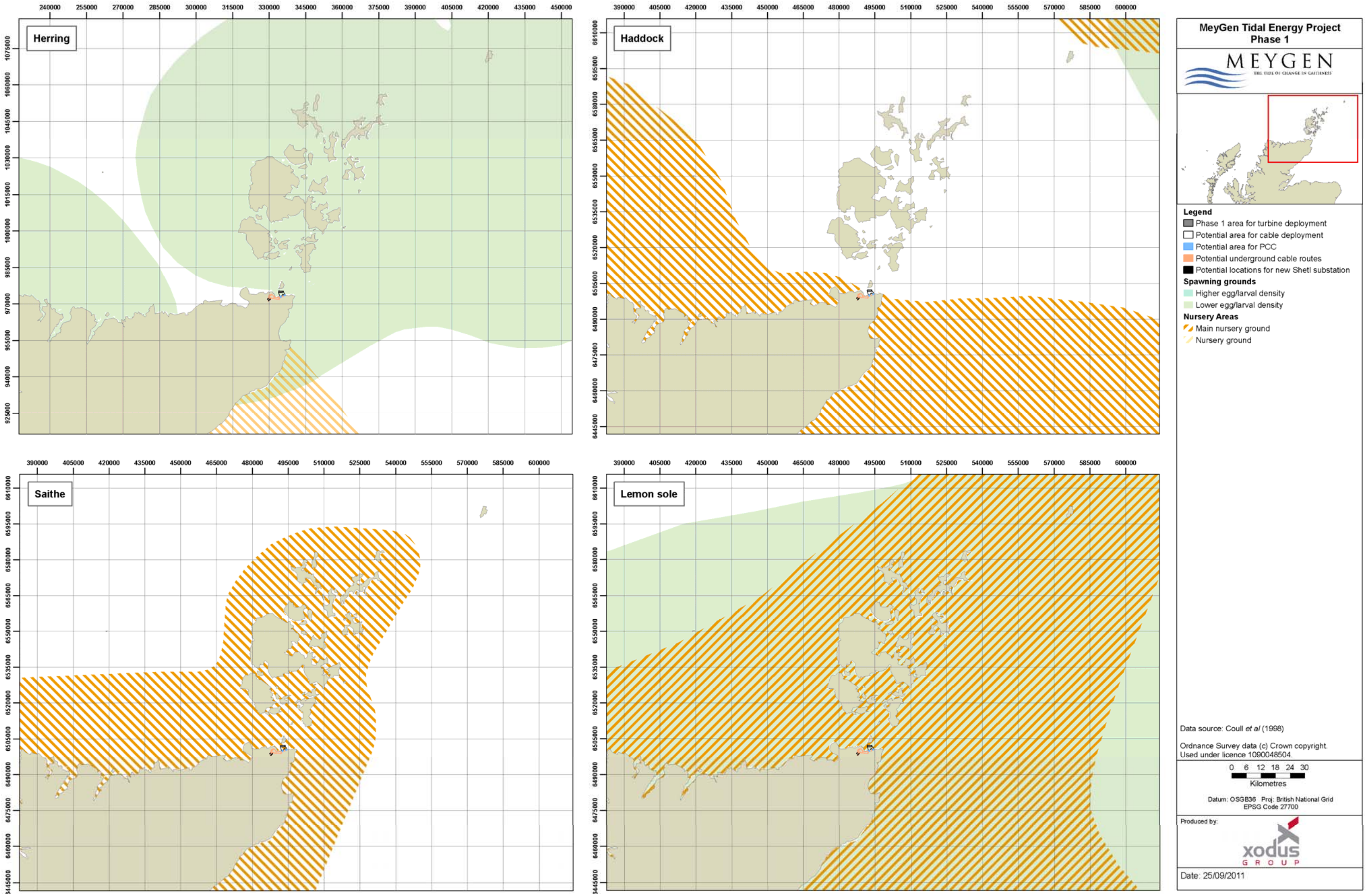

Figure 13.3: Fish spawning and nursery areas around the Project area and wider Pentland Firth (Coull *et al.*, 1998)

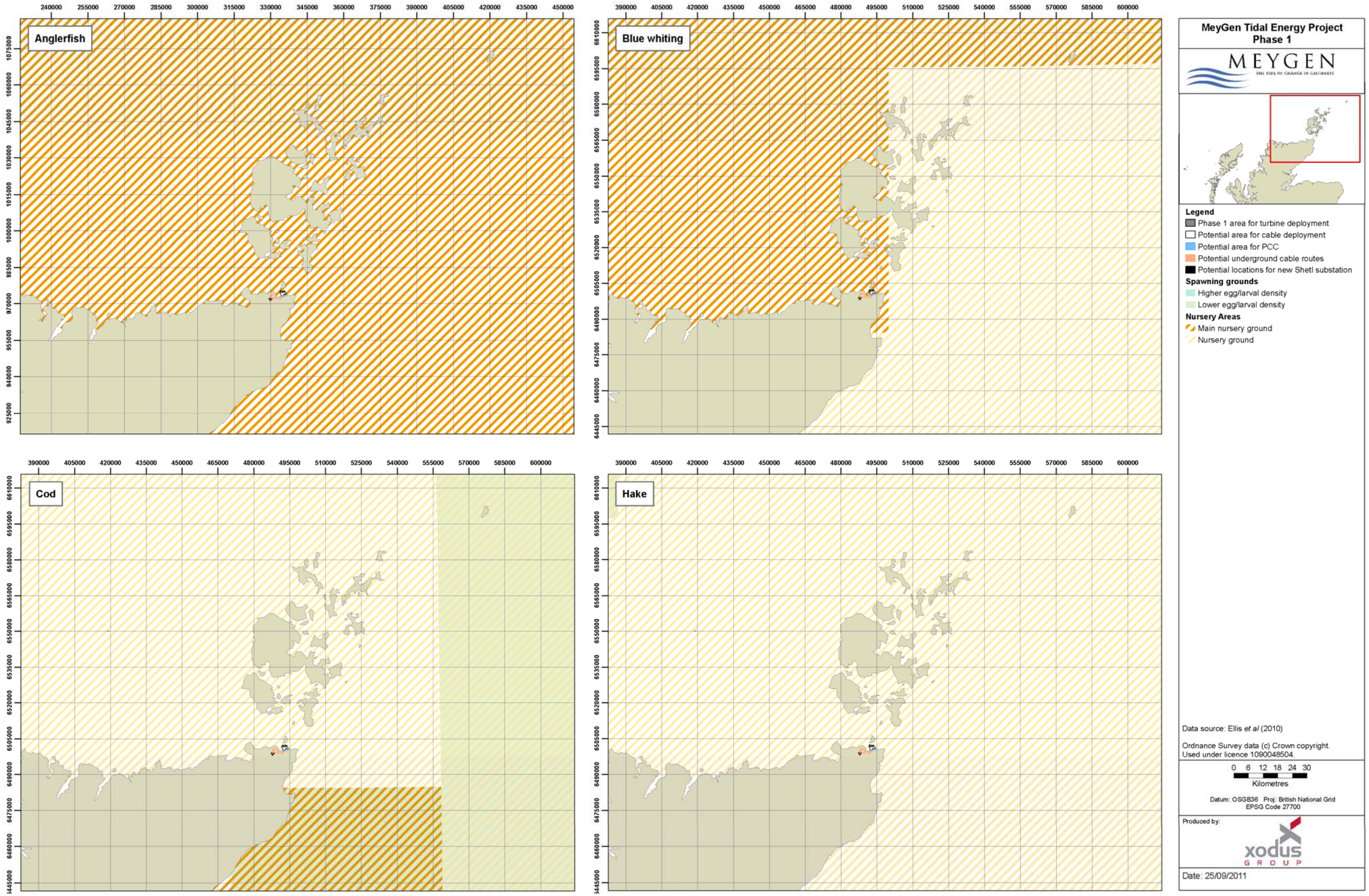

Figure 13.4: Fish spawning and nursery areas around the Project area and wider Pentland Firth (Ellis *et al*., 2010)

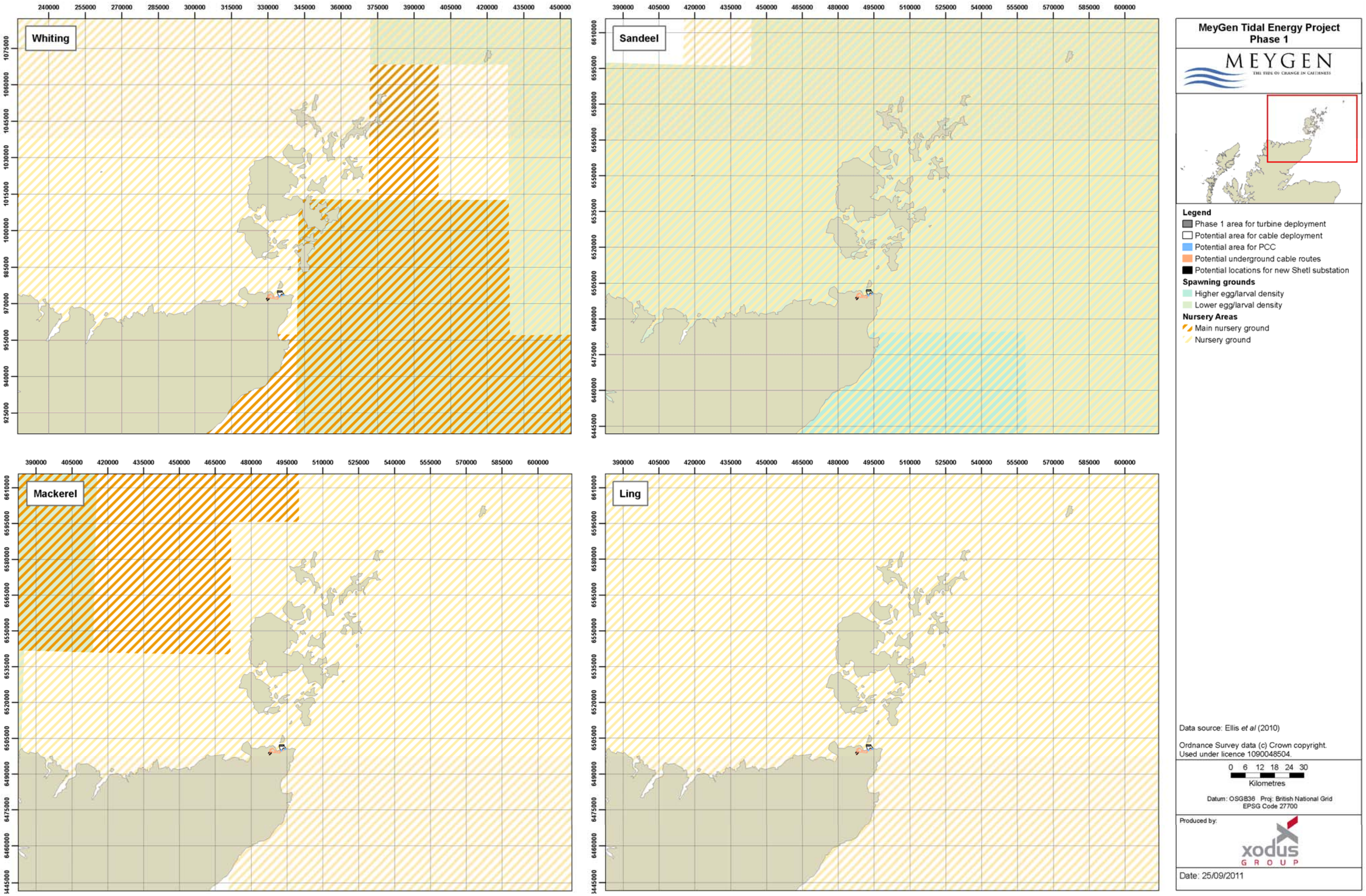

Figure 13.5: Fish spawning and nursery areas around the Project area and wider Pentland Firth (Ellis *et al*., 2010)

Halibut

13.106 Halibut is mainly a benthic and demersal species and more infrequently pelagic. They are usually found on sand, gravel, or clay substrates and not on soft mud or on a rocky seabed. Historically they were found throughout British waters although the current distribution is relatively unknown. It is a highly sought after commercial species, being the largest flatfish in the world, reaching up to 2.5m in length (Barnes, 2008f). High fishing intensity has resulted in depletion of stocks in several areas of the north-east Atlantic (Glover *et al*., undated).

13.107 Halibut spawn in deep water (between 300 and 700m) between December and March, after which adult halibut leave the spawning grounds and travel to both deep and shallow waters, inshore and offshore. Juvenile halibut adopt a benthic lifestyle and coastal areas, around the Norwegian coast in waters of depths of 20 to 60m often serve as nursery areas before halibut under take their migrations further offshore into the north-east Atlantic (Glover *et al*., undated).

13.108 Landings of halibut in ICES rectangle 46E6 have been very low over the last few years although the relative value of such landings is still comparatively high (Section 14). The species is unlikely to be found in any great numbers within the Project area due to the lack of suitable habitat (as they are not found in areas of rocky substrate).

Ling

13.109 Ling is the largest species of the cod (gadoid) family and they are widely recorded around the British Isles. It is a deep water species found at depths of up to 600 m but juveniles and occasionally adults are found as shallow as 10 m. This species is primarily solitary and benthic in habit, found amongst rocks, crevices and wrecks in deep water (Rowley, 2008).

13.110 The waters surrounding Orkney, including Pentland Firth and the Inner Sound have been identified as ling nursery grounds during August and September (Ellis *et al*., 2010; Figure 13.5).

Mackerel

13.111 Mackerel are a pelagic species whose presence in Scottish waters is transitory. The spawning grounds for the western stock of mackerel lie to the south and west of the British Isles and after spawning the fish migrate northwards to feeding ground in the northern North Sea and the Norwegian Sea. The migration route generally follows the edge of the continental shelf; however some enter coastal waters in June and remain throughout the summer (Faber Maunsell, 2007).

13.112 The Pentland Firth is part of the wide nursery area for the western stock, where the main nursery area extends along the entire outer continental shelf to the west of the British Isles (Ellis *et al*., 2010; Figure 13.5).

13.113 Mackerel is a commercially important species. However landings of mackerel in ICES rectangle 46E6 have decreased in recent years (Section 14) but it is likely that Mackerel are present in the Project area during the summer.

Megrim

13.114 Megrim is a demersal flatfish that occurs around the majority the British Isles coastline. It is found mostly on soft mud or muddy sands at depths between 50 and 300m. Megrim prey on other small fish including sandeels, dragonets and gobies (Picton & Morrow, 2010). It spawns between January and April, with spawning peaks occurring in February and March (Seafish, 2011).

13.115 Megrim is a high valued species caught in ICES rectangle 46E6 (Section 14) and is likely to be caught as part of the mixed demersal fishery which includes Nephrops, monkfish and cod. However, Megrim are unlikely to be present within the Project area due to their preference for muddy sediments.

Monkfish

13.116 The monkfish is widely distributed around Scotland both on the shelf and on the continental slope to depths of approximately 1,000m. They are primarily ambush predators, enticing prey, mainly fish, towards their large gaping mouths with a lure that extends from the top of their head (Faber Maunsell, 2007).

13.117 Spawning takes place in deep water with each female thought to produce just one batch of eggs between January and June. Juvenile monkfish descend to the seabed after 3 to 4 months spent in the water column and are generally found in shallower water than adults. Female monkfish do not mature until they are at least seven years old and so the species is particularly vulnerable to overfishing (DECC, 2009). Adults of up to 13 years have been reported from Scottish waters (Faber Maunsell, 2007). Spawning is shown to take place throughout the Pentland Firth (Figure 13.4)

13.118 Monkfish are a highly valued commercial species, and statistics show them as being caught in ICES rectangle 46/E6 these landings are likely to be mis-reported (Marine Scotland, pers. comm.) and it is unlikely that monkfish are present within the Project area.

Norway pout

13.119 Norway pout is a small, abundant gadoid fish that attains a length of about 20cm and lives for about three years. The adults are widely distributed throughout UK waters depths between 40 and 100m (Faber Maunsell, 2007). Juvenile Norway pout feed mainly on copepods and planktonic tunicates, with adults feeding on a range of crustaceans and small fish (ICES, 2011c). Spawning occurs over a wide area to the west, north and east of Orkney, which is also mirrored in the nursery areas (Coull *et al*., 1998).

13.120 Norway pout is an important food item for a number of commercially important species including hake, cod, whiting, mackerel and pollock (Sweet, 2009).

Plaice

13.121 Plaice is a widely distributed demersal flat fish, which is found throughout British waters from intertidal areas to depths of 8m (Faber Maunsell, 2007). Plaice mostly live on sandy bottoms; although they also live on gravel and mud. They are often seen on sand patches in rocky areas and may potentially be present in the Project area in small numbers. Young fish in their first year live in very shallow water, after which they being to move into deeper water when they become about 15cm in length (Ruiz, 2007). Plaice feed on a range of benthic organisms including razor clams and cockles, sand eels, worms, brittle stars and crustaceans.

13.122 Plaice spawn throughout their adult stage, at localised spawning locations. Spawning is from December to March and the eggs and larvae are pelagic. The nursery grounds are found in sandy areas. The nearest spawning and nursery grounds to the Pentland Firth for plaice are to the south along the east coast of Scotland approximately 20km from the Inner Sound (Ellis *et al*., 2010).

Saithe

13.123 Adult saithe are found in the deeper waters (approx 100 - 200m) at the edge of the continental shelf. Spawning takes place from January to April east of Shetland and to the west of the Outer Hebrides.

13.124 The nursery areas are in the inshore waters of the west of Scotland and around Orkney and Shetland, where young fish remain for two to three years before migrating to deeper waters. The Pentland Firth is included in part of the large saithe nursery ground within includes the majority of the coastal waters of mainland Scotland (Coull *et al*., 1998; Figure 13.3).

13.125 The diet of juvenile saithe is a similar diet to adults, where they are known to consume a wide range of fish species such as herring, cod, and sandeel as well as benthic invertebrates. Adult saithe feed on a range of demersal prey, including crustaceans and fish species such as sandeel, Norway pout, and haddock (Rogers & Stocks, 2001).

Sandeel

13.126 Although there are five species of sandeel in Scottish waters approximately 90% of the commercial catch of sandeels consists of the species *Ammodytes marinus* (Faber Maunsell, 2007). Sandeels are a shoaling species which lie buried in the sand during the night, and hunt for prey in mid-water during daylight hours. They feed primarily on planktonic prey such as copepods and crustacean larvae, but they can also consume polychaete worms, amphipods, and small fish including other sandeels. Sandeels have neither swim bladder, nor fins capable of compensatory movements, and in order to remain clear of the bottom they must swim continually (Rogers & Stocks, 2001).

13.127 During the winter sandeel remain in the sediment only emerging to spawn. They reach sexual maturity at around age two and spawn in December/January. The eggs are demersal and are laid in clumps that stick to sandy substrata until they hatch during February and March, after which the larvae are found in the water column. After metamorphosis they settle in sandy seabeds amongst the aggregations of adults (van Deurs *et al*., 2009). As a result there is very little movement between spawning and feeding grounds.

13.128 The Pentland Firth is part of a sandeel spawning ground with low egg/larval density. Higher egg and larval density spawning grounds can be found to the south of the Pentland Firth along the north-east Scottish coast. As outlined above and in Section 10 Benthic Habitats and Ecology the surveys conducted of the Sound on Stroma reported that the majority of the seabed within the Inner Sound, including the majority of the Project area is comprised of current scoured bedrock. As a result it is unlikely that sandeels use the Project area directly as a spawning ground, due to the lack of available suitable habitat. During grab sampling of the small area of sediment within the lease area ASML (2011) reported one individual sandeel in one grab sample.

13.129 The Pentland Firth is also part of a wider nursery ground for sandeel (Ellis *et al*., 2010; Figure 13.5). Therefore the Inner Sound can be considered an area of low importance for sandeel populations.

13.130 As well as being a major component of commercial fisheries in Scottish waters, sandeels are an important resource for predatory fish and seabirds. No sandeels were landed from ICES Rectangle 46E6 over the last five years of data collection (Section 14).

Whiting

13.131 Whiting is a widely distributed demersal species occurring at depths between 30 and 100m throughout Scottish waters. It can be found near mud and gravel bottoms, but also above sand and rock (Barnes, 2008h).

13.132 Whiting has a prolonged spawning period from February to June (Table 13.9) throughout its range but with the main spawning areas being to the west of Shetland and east coast of Scotland. The eggs and larvae are pelagic and the young, often associated with jellyfish, remain pelagic until they attain a length of about 10cm when they adopt a demersal habit. The nursery grounds tend to be located inshore (including within sea lochs) and juveniles will remain in these areas for one or two years (Faber Maunsell, 2007). The eastern outer reaches of the Pentland Firth have been identified as spawning grounds for whiting and the whole Pentland Firth is part of a wider area identified as a whiting nursery ground (Ellis *et al*., 2010; Figure 13.5).

Other fish sightings

13.133 One ocean sunfish was observed during the marine mammal and bird observation surveys (RPS, 2011). The fish are large pelagic ocean ranging species and this sighting is considered to have been a rare occurrence for the Pentland Firth.

13.5.5 Sensitivity to tidal array development

13.134 The Scottish Marine Renewables SEA (Faber Maunsell, 2007) identifies the sensitivity of fish species to impact associated with wave and tidal developments. Table 13.10 has been adapted from the information contained in the SEA and lists those fish species or species groups that potentially are present within the Project area and may be considered to be sensitive to the proposed tidal energy development.

Species	Smothering	Change in suspended sediment	Increased turbidity	Substratum loss	Decrease in water flow	EMF	Underwater noise
Spurdog	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Yes	Unknown
Lesser spotted dogfish	Low	Not relevant	Unknown	Not relevant	Not relevant	Yes	Unknown
Basking shark	Not sensitive	Low	Unknown	Not relevant	Not relevant	Yes	Unknown
Porbeagle	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Yes	Unknown
Tope	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Yes	Unknown
Thornback ray	Low	Not relevant	Unknown	Not relevant	Not relevant	Yes	Low
Common skate	Low	Not relevant	Not sensitive	Low	Not relevant	Yes	Not sensitive
Herring	High (demersal eggs)	Medium (filter feeder)	Medium	High (spawning areas)	High (spawning areas)	Not sensitive	High
Salmon	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Yes	Medium
Sea trout	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Yes	Unknown
Cod	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Yes	High
Haddock	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Not sensitive	Unknown
Whiting	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Not sensitive	Unknown
Norway pout	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Not sensitive	Unknown
Saithe	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Not sensitive	Unknown
Sandeel	High (especially demersal eggs)	Low	Unknown	High (spawning areas)	Medium	Not sensitive	Unknown
Mackerel	Not sensitive	Not relevant	Unknown	Not relevant	Not relevant	Not sensitive	Unknown
Lemon sole	Low	Low	Unknown	Not relevant	Not relevant	Not sensitive	Low
Plaice	Low	Low	Unknown	Not relevant	Not relevant	Yes	Low

Table 13.10: Sensitivity of certain fish species to impacts from tidal arrays (Faber Maunsell, 2007)

13.135 Available data indicate that, of the potential effects caused by tidal energy development, the possible effects of EMF on elasmobranch and migratory fish behaviour, and substratum loss and smothering for fish species that have demersal eggs are of greatest concern.

13.6 Impacts during Construction and Installation

13.136 This section assesses the potential impacts during the construction and installation phase of the Project. The assessment of direct habitat disturbance upon the benthic community within the Project site is presented in Section 10 Benthic Habitats and Ecology. It is estimated that the total footprint of the Turbine Support Systems (TSS) and the cables on the seabed will be 0.130km^2.

13.6.1 Impact 13.1: Loss of spawning grounds

13.137 The Pentland Firth has been identified (using CEFAS data, Coull *et al*., 1998; Ellis *et al*., 2010) as being part of wider spawning grounds for herring, lemon sole, sandeel and whiting.

13.138 The Project has the potential to result in the direct loss of spawning grounds through the placement of structures on the seabed, including tidal devices and cables.

13.139 Both sandeel and herring are demersal spawners, where the placement of eggs on the seabed takes place in suitable sandy or gravelly habitats. The seabed in the Project area is considered to be unsuitable for both herring and sandeel spawning, and as such are unlikely to be using the area for spawning. In addition, whiting spawning grounds, although identified within the Pentland Firth, are understood to be located to the east of the Project, and as such, whiting are assumed to not use the Project area for spawning. As a result the Project is likely to cause no significant effect on herring, sandeel or whiting spawning grounds.

13.140 The wider spawning ground for lemon sole covers an area of 209,549 km^2 and the construction phase of the Project will impact upon much less than 0.01% of this total spawning area. Although lemon sole spawn in the summer months (Table 13.9) which is when the majority of installation works are to take place, the small area that may be impacted coupled with the fact that lemon sole produce pelagic eggs rather than requiring specific spawning substrate or areas mean that the magnitude of the impact of the Project on lemon sole spawning is negligible. Based on the fact that sandeel and herring are unlikely to spawn in the Inner Sound and that the lemon sole do not have specific spawning ground requirements the sensitivity of the receptor is considered to be negligible also.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Negligible	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.1
▪ No mitigation measures proposed as no significant impact predicted.

13.6.2 Impact 13.2: Loss of nursery grounds

13.141 The Pentland Firth has been identified (using CEFAS data, Coull *et al*., 1998; Ellis *et al*., 2010) as being part of wider nursery grounds for blue whiting, angler fish, hake, mackerel, ling, sandeel, saithe, herring, haddock, lemon sole, whiting, cod, spotted ray, spurdog and tope. Given the size of the nursery grounds for these species, the fact that many nursery grounds for some of these species are found on substrate not present within the Project area and that the Project will affect much less than 0.01% of the nursery grounds for these species the impacts are expected to be have minimal effect, if at all.

13.142 As juveniles blue whiting, mackerel, saithe, cod, haddock, whiting, herring, ling, lemon sole, anglerfish, hake, spotted rays, spurdog and tope are highly mobile, and as such if any individuals are present within the Project site at the time of construction they are likely to vacate the area once construction begins. As there is similar habitat close to the Project area disturb individuals will be able to quickly find new habitat and any disturbance will be temporary and short-lived.

13.143 It is therefore unlikely that any change to the baseline condition of these species caused by the Project will be detectable against natural variations in juvenile and population numbers and the impact magnitude will be negligible. Due to the area affected being such a small proportion of the nursery grounds of species in the vicinity of the Project the sensitivity of the receptor is considered to be negligible.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Negligible	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.2
▪ No mitigation measures proposed as no significant impact predicted.

13.6.3 Impact 13.3: Noise

13.144 An underwater noise impact study within the Inner Sound was conducted by Kongsberg Maritime Ltd (Kongsberg, 2012), which included acoustic modelling to investigate the underwater noise propagation from the Project (a copy of this report is provided on the supporting studies CD).

13.145 The main activities during construction and installation that have the potential to cause impact to fish species through the generation of noise are the drilling for the monopiles and cable bore holes and vessels. Noise is generated during drilling principally through the action of the drill bit on the surrounding rocks; whereas noise from vessels can be generated as a result of a number of components, including propeller blade rotation, engine cylinder firing and flow through the water.

13.146 During Year 1 and 2 the turbines will be installed one at a time, and drilling will only take place at one location at any given time. However, during Year 3 it may be necessary to have parallel drilling operations, therefore the worst case scenario for noise generation will be during the installation of later turbines when installation noise will be coupled with operational noise from the previously installed and operating turbines. It is this worst case multiple source noise event that is assessed in this section.

13.147 Kongsberg (2012) used existing examples of noise levels recorded from an oil drilling rig for drilling noise (McCauley *et al.,* 1998) and a range of vessels to input into the acoustic models to assess the impacts of construction noise. However, Kongsberg (2012) could not be certain if the underwater noise as recorded by McCauley *et al.* (1998) was due entirely to the action of the drill bit on the seabed rock or included other noise emissions such as the drill vessel.

13.148 Kongsberg (2012) reported that very few tidal turbines have been installed in UK waters and of these, only data pertaining to the MCT turbine, Bristol Channel is publicly available (Richards *et al*., 2007). The MCT turbine is a horizontal axis, single rotor turbine with an output of 300kW. This is much smaller than the 2.4 MW turbine proposed here as the worst case scenario for sound under the principles of the Rochdale Envelope, but it is the only turbine for which detailed noise measurements are available. To account for the size difference Kongsberg (2012) extrapolated the noise data from the MCT turbine to account for the differences in turbine size at Bristol Channel and Inner Sound, to generate data comparable with a 2.4MW device.

13.149 The potential impacts of underwater noise on fish are dependant on species specific hearing capabilities and sound detection apparatus. When species specific ranges are calculated, which compare the source noise with the hearing threshold of the target species (the minimum noise level species are able to hear), is evident that 'unweighted' ranges are unrealistic.

13.150 According to Vella *et al*., (2001) the sensitivity of fish species to noise is dependant upon:

- The audible threshold;
- The presence of a swim bladder and its size and physical coupling to the ear;
- The resonance frequency of the otolith system; and
- Behavioural factors, such as aggregation or shoaling behaviour.

13.151 The hearing ability of fish varies greatly across species types. Typically, fish sense sound via particle motion in the inner ear which is detected from sound-induced motions in the fish's body. The detection of sound pressure is restricted to those fish which have air filled swim bladders; however, particle motion (induced by sound) can be detected by fish without swim bladders (Faber Maunsell, 2007).

13.152 Table 13.11 displays a summary of fish species, their differing levels of hearing specialism and hearing sensitivity. Highly sensitive species such as herring, have elaborate specialisations of their auditory apparatus, where these species are characterised by the presence of a otic bulla, a gas-filled sphere, connect to the swim bladder, which enhances hearing ability. The gas filled swim bladder in species such as cod and salmon may be involved in their hearing capabilities, so although there is no direct link to the inner ear, these species are able to detect lower sound frequencies and as such are considered to be of medium sensitivity to noise. Flat fish and elasmobranchs have no swimbladders and as such are considered to be relatively less sensitive to sound pressure (Nedwell *et al.*, 2004). As a result within this impact assessment herring has been used as the most sensitive species that could be affected by noise from the Project, as it is the most sensitive species that has the potential to be present in the Inner Sound.

Species	Family	Swimbladder connection	Sensitivity
Atlantic salmon	Salmonidae	None	Medium
European eel	Anguillidae	None	Medium
Herring	Clupeoidea	Prootic auditory bullae	High
Cod	Gadidae	None	Medium
Haddock	Gadidae	None	Medium
Hake	Merluccidae	None	Medium
Plaice	Pleuronectidae	No swimbladder	Low
Common skate	Rajidae	No swimbladder	Low
Mackerel	Scombridae	None	Medium

Table 13.11: Summary of hearing specialisation levels in fish species potentially present in the Project area (Nedwell *et al.*, 2004)

13.153 Noise measurements taken in the Inner Sound have indicated that the background noise levels are generally high, as a result of the strong tides and turbulent waters which naturally generate noise under water (Kongsberg, 2011). The noise assessment presents background underwater noise data for the Inner Sound as narrowband Pressure Spectral Density levels in dB re.1μPa^2.Hz-1 over the frequency range from 20 Hz to 150 kHz. Background noise levels in the Inner Sound are variable, lying in the range 106 – 139 dB re 1 μPa.

13.154 Consequently, fish species are only likely to be impacted when noise generated during installation and commissioning activities are above these high background levels.

13.155 The effects of noise on fish can be divided into three main categories (Hastings and Popper, 2005) (closest to source of noise and greatest severity of impact first):

- Lethal and physical injury;
- Hearing damage (temporary and permanent hearing loss); and
- Behavioural responses and masking of biological relevant sounds.

13.156 Kongsberg (2012) presents a detailed investigation to assess the potential impact of noise generated as part of the proposed Project. Based on a detailed literature review the following criteria are used:

- 240 dB re 1 μPa (peak exposure limit) – lethality;
- 90 dB_{ht} above species specific hearing threshold – strong behavioural reaction; and
- 75 dB_{ht} above species specific hearing threshold – mild behavioural reaction.

13.157 Behavioural response and auditory injury from underwater sound is often assessed by comparing the received sound level with the auditory threshold of the receptor. Nedwell *et al*. (2005 and 2007) and Parvin *et al*. (2006) compare the underwater noise with receptor hearing threshold across the entire receptor auditory bandwidth in the same manner that the dB(A) is used to assess noise source in air for human subjects. This dB_{ht}[2] criteria, used in these studies is behavioural based, where received sound levels of 90 dB above hearing threshold (comparable with 90dB(A) in air) are considered to cause a strong behavioural avoidance, and levels of 75dB above hearing threshold invoke a mild behavioural response. It is understood that this criterion has not been validated by either rigorous peer-review or experimental study. It is recognised there are limitations on these assessment criteria and further work in this area is required. MeyGen will be monitoring noise to verify the assessment of noise generated by the Project. These criteria are the best currently available and have therefore been applied to this assessment.

13.158 As outlined in Section 11 acoustic impact criteria have been developed for species of marine mammal sensitive to noise. Yelverton and Richmond (1981) stated that marine mammal fatalities arise when peak pressures exceed 240 dB re 1 μPa and this may be applied to fish as well. Hearing damage criteria have also been developed for marine mammals (Section 11), but have yet to be developed for fish species as there have been difficulties in translating the results gained under controlled laboratory experiments to open water (Popper and Hastings 2009).

13.159 Consequently because marine mammals are considered to be more sensitive to underwater noise when compared to fish species, the outcomes of the modelling for marine mammals (based on the available marine mammal criteria) are considered to represent the worst case hearing damage impacts for fish species, where overall, the impact to fish species is likely to be much less than that of marine mammals. Further details on the acoustic impact criteria for marine mammals can be found in Section 11.

13.160 The broadband source level for vessel noise is considered as 172dB re 1μPa at 1m based on a tug vessel being the noisiest vessel being used during installation operations. Analysis of published drilling noise measurements indicate that a broadband source level of 144dB re 1μPa at 1m is considered representative for the activities at the Inner Sound site.

13.161 Kongsberg (2012) report that underwater pin pile drilling tends to be a low noise level operation, at least compared with other activities. In a relatively noisy environment such as the Inner Sound, it may be assumed that the drilling noise will propagate over only short distances before it falls below background noise levels. The modelling undertaken for the Inner Sound confirms this, with drilling noise falling to background noise levels at a range of 0.5km from the noise source.

13.162 The source level for drilling activities is considerably below the level at which lethal injury to fish might occur and it is therefore unlikely that any marine animals will be killed by the underwater noise from pile drilling. For construction activities Kongsberg (2012) reported that no behavioural reactions are likely to be seen in hearing generalist fish. They are the most insensitive of generic species to the man-made noises that may be generated by the Project. Drilling noise is sufficiently low that hearing generalists would need to be less than 1m from the source of the drilling activity to elicit any (strong or mild) behavioural response.

13.163 Kongsberg (2012) reported that for hearing specialist fish, no strong behavioural reactions to any Project related man made noises are likely. When exposed to vessel noise, mild behavioural avoidance may occur out to a maximum distance of approximately 14m (Kongsberg, 2012). Hearing specialists would need to be less than 1m from the source of the drilling activity to elicit a strong behavioural response.

13.164 For marine mammal species the noise levels associated with vessels were sufficiently low such that the hearing damage impact criteria were not met, and as such it can be confidently extrapolated that there is not likely to be a hearing damage impact to fish species from vessels.

[2] The dBht method has been developed based on work by Nedwell *et al.* (2005, 2007) and Parvin *et al.* (2006) where the underwater noise is compared with receptor hearing threshold across the entire receptor auditory bandwidth. This dB_{ht} criteria is behavioural based, where received sound levels of 90 dB above hearing threshold are considered to cause a strong behavioural avoidance, and levels of 75 dB above hearing threshold invoke a mild behavioural response.

13.165 Kongsberg (2012) reported that the noise arising from the TSS pile drilling is considerably lower than that generated during the operation of the turbines. As a result the noise generated from socket drilling of an additional turbine would have no discernable increase in sound levels compared to the operation of the turbines alone. Kongsberg (2012) reported that the operational noise from 36 turbines[3] would result in a mild behavioural avoidance in hearing specialist fish up to 68m from the array and a strong behavioural avoidance within 18m of the array Hearing generalist would only elicit a behavioural response (mild or strong) if they were less than 1m from the tidal array.

13.166 Based on the modelling conducted by Kongsberg (2012), none of the installation (and operation) scenarios would generate noise levels that would result in lethal or physical injury to marine mammals. Therefore, fish species are also unlikely to be exposed to noise that would cause mortality or injury.

13.167 During EIA scoping SNH raised concerns over the impacts of underwater noise on fish spawning. As outlined in Section 13.5.1 the seabed in the Project area is considered to be unsuitable for both herring and sandeel spawning, and as a result it is only possible that lemon sole could use the Project area for spawning. Lemon sole are flatfish species which do not have swim bladder, and as such can be considered be of low sensitivity to underwater noise. Modelling conducted by Kongsberg (2012) determined that hearing generalist fish would be unable to detect drilling and vessel noise unless they were within 1m of the noise source. As such it is not likely that their spawning behaviour would be affected significantly as a result of the noise generated during construction and installation operations.

13.168 The most sensitive receptor (hearing specialist fish) are used to undertake the assessment using a precautionary approach and as a result the sensitivity of the receptor is considered to be high. However, as the noise levels are relatively low, unlikely to cause injury or mortality and the ranges for behavioural reactions are very small, any impacts are likely to be imperceptible. Therefore, the impact magnitude is considered to be negligible. Hearing generalist fish (e.g. Atlantic salmon) are likely to experience an impact of lesser significance.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
High	Negligible	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 13.3

- Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case.
- Where possible the use of soft start (gradual ramping up) of operations that will emit noise into the Project area will be used.
- MeyGen accepts that there is some uncertainty over the noise generated during drilling and turbine operation and as a result commits to conducting noise monitoring for the initial turbines installed and candidate turbine technology to validate the noise modelling.

13.6.4 Impact 13.4: Increased turbidity

13.169 Activities related to the construction of the Project, such as cable laying and device placement can result in temporary increases in turbidity through sediment resuspension (release of drill cuttings material is covered in Section 13.6.9). Increased turbidity can have effects on foraging, social and predator/prey interactions (Faber Maunsell, 2007). Table 13.12 provides a summary of risks associated with increased concentrations of suspended sediments.

[3] A 36 turbine array of 2.4MW turbines has been used in the assessment as it produces greater noise than an array of 86 turbines of 1MW rated power

Sediment increase (mg/l)	Risk to fish and their habitat
0	No risk
<25	Very low risk
25-100	Low risk
100-200	Moderate risk
200-400	High risk
>400	Unacceptable risk

Table 13.12: Risk to fish and their habitats by sediment concentration (Department of Fisheries and Oceans, Canada, 2000)

13.170 Resuspension of existing sediment, resulting in increased turbidity from the placement of turbines and cables on the seabed during installation operations is likely to be very low in magnitude, due to the lack of existing sediment on the seabed in the Project area (Table 13.12).

13.171 The increase in turbidity during offshore installation will be short term and will only affect localised areas. Coarser sediment fractions are likely to be re-deposited on the seabed within approximately 50m of the works (Faber Maunsell, 2007). The naturally occurring sediments in the study area, although limited, are mainly coarse grained. Therefore, the majority of re-suspended material will fall out of suspension within 50m of the works and the effect on turbidity will be localised and minimal.

13.172 Herring have a medium sensitivity to increases in suspended sediment concentrations (Faber Maunsell, 2007 Table 13.12) and are taken forward as the most sensitive species. Therefore the sensitivity is considered to be medium. The Scottish renewables SEA states that all other fish species (relevant to this EIA), for which sensitivity is known, have low or no sensitivity to this impact (Faber Maunsell, 2007). The increases in sediment are expected to be low and therefore the magnitude of the impact is assessed as minor.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Minor	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 13.4

- No mitigation measures proposed as no significant impact predicted.

13.6.5 Impact 13.5: Smothering

13.173 Activities related to the construction of the Project, such as cable laying and placement of gravity based TSSs can result in temporary increases in turbidity through sediment resuspension (as discussed in Section 13.6.4, the release of drill cuttings material is covered in Section 13.6.9). However, as the sediment resettles on the seabed there is the potential for the settling sediment to smother important fish habitats.

13.174 Smothering of fish habitat could occur within the immediate vicinity of the seabed of disturbing works, including turbine installation (including placement of gravity based TSS) and cable laying. The impact is only expected to be temporary, as excess material deposited will be re-suspended and distributed by natural hydrodynamic processes (Faber Maunsell, 2007).

13.175 Based on the sensitivity data available from MarLIN most fish species within the Pentland Firth are not sensitive to, and therefore not affected by, the impacts of smothering (Faber Maunsell, 2007). However, certain demersal species: lesser spotted dogfish, thornback ray, common skate, lemon sole and plaice which are likely to be present in the Pentland Firth all have a low sensitivity to smothering (Faber Maunsell, 2007). In addition the spawning areas of herring and sandeels are highly sensitive to smothering impacts (Faber Maunsell, 2007, Table 13.10). As discussed in Section 13.5.1, the nature of the habitat in the Project area is considered to be unsuitable for both herring and sandeel spawning, and as such these species are unlikely to be using the area for spawning. Such habitat does exist to the east and west of the Project. However, as shown in Section 9 the impacts to the sediment in these areas as a result of the Project are negligible and sediment from these areas is not removed from this area or disturbed. Therefore, it is unlikely that any spawning areas associated with these species will be affected by the Project.

13.176 Smothering associated with the deposition of sediments disturbed or generated by the installation of the turbines, cables and bore holes is expected to be a temporary impact, as excess material deposited will be re-suspended and distributed by natural hydrodynamic processes (Faber Maunsell, 2007). The naturally turbulent conditions should ensure any deposition on the seabed is quickly dispersed and does not accumulate into large deposits (see Section 9 Physical Processes and Sediment Dynamics).

13.177 As most fish species within the Pentland Firth are not sensitive to the impacts of smothering (Faber Maunsell, 2007) the sensitivity is considered as low. Given that the spawning and nursery grounds in the Project area represent a very small proportion of the wider spawning and nursery grounds the magnitude of the impact is considered to be negligible.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Low	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.5
▪ Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case. ▪ Minimise as far as practicable the depth and diameter of the turbine foundation piles (without compromising technical performance). ▪ Minimise as far as practicable the volume of drill cuttings released into the marine environment during breakthrough of HDD bores, by implementing a closed loop recycling system to return drill cuttings and fluid from the HDD to shore.

13.6.6 Impact 13.6: Changes to prey species

13.178 The potential for the Project to cause changes to prey species such as benthic invertebrates and bony fish is limited (Section 10). As discussed in this section the main prey species of other fish are small clupeids such as herring and sandeels, other small fish such as Norway pout and juvenile cod, whiting, saithe and other gadoids. The nursery areas for most of these species are unlikely to be impacted and it is unlikely that the availability of juvenile fish will change to an extent that they will be less available to predators. The same can be said for herring and sandeels as the Project area represents unsuitable substrate for spawning animals. It is also likely that vessel noise will cause most fish species to move away from the area so that they will still be available to predators that have also moved from the area.

13.179 As the majority of fish species in the area are free ranging and roam large areas of the sea they are unlikely to be resident in the Project area. In addition the small area that the Project covers is unlikely to provide a refuge habitat for most of these species to hide from predators. Therefore, any fish species that move from the area during construction will not become more available to predators by making them more concentrated in surrounding areas or by removing important habitat that is used to avoid predators. Therefore, increased predation on prey species that could affect population sizes is very unlikely to occur.

13.180 Given that impacts to benthic and fish prey species are considered to be generally negligible the magnitude of impact is also considered to be negligible. The species that feed in the Pentland Firth are highly mobile and will be able to access food resources in other areas or once they have passed through the Project area. Therefore the sensitivity is considered to be negligible.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Negligible	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.6
▪ No mitigation measures proposed as no significant impact predicted.

13.6.7 Impact 13.7: Release of sediment bound contaminants

13.181 The release of contaminated sediments during device and cable installation may cause potentially detrimental effects on species that are sensitive to contamination. However there is no indication that any of the limited sediments present in the Project area have been contaminated. There is a general lack of development in the area, however the Dounreay reactor represents the only major potential contamination pathway within the vicinity of the Project. Radiochemical analysis of grab samples from the benthic survey, showed no evidence of contamination from artificial radioactivity in any of the samples (ASML, 2011). As outlined in Section 10, there is a dredge spoil disposal site located in the proposed turbine deployment area that has not been in use since the 1970's. The seabed surveys identified the whole area to be composed of bedrock, indicating that in the high energy tidal environment sediments disposed at the site have since dispersed away from the site.

13.182 The sediment adjacent to the turbine deployment area will settle very close to where it was disturbed as it consists of large sized particles that are likely to travel a very short distance. The models in Section 9 suggest there is no net transport of sediment from the area and the natural sediment transport within the Project area will be unaffected. As a result it is unlikely that contaminated sediments (if they are present) will be disturbed in a manner that may affect the fish species present in the Project area.

13.183 The potential impacts on water quality have been discussed further in Section 9 and have been shown to be negligible. Combined with a lack of evidence for any contamination in the area the magnitude of impact is considered to be negligible. The sensitivity of fish in the Project area is considered medium due to the likelihood of fish being able to avoid any pollution events. Protected species that occur in the area have much higher sensitivity to the impact but again their mobility will allow them to move away from areas of pollution and again their sensitivity will be medium

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.7
▪ No mitigation measures proposed as no significant impact predicted.

13.6.8 Impact 13.8: Accidental spillage from vessels

13.184 The discussion around this impact focuses on the potential impacts associated with the release of a large inventory of fuel oil from a vessel. This is considered to be the worst case potential accidental pollution impact. Other smaller inventories of polluting substances may potentially be released during the course of the Project. These impacts and their potential consequences are discussed further in accidental events (Section 24).

13.185 The total oil inventory for the large DP installation vessels is likely to be in the region of 6,000,000 to 8,000,000 litres of marine diesel stored in a number of separate tanks. The worse case spill from a single tank rupture is likely to be in the region of 600,000 litres of marine diesel released into the marine environment.

13.186 Oil spills can have a number of environmental impacts. Actual effects will vary depending on a wide range of factors including the volume and type of oil spilt and the sea and weather conditions at the time of the spill. Effects will also be dependent on the presence of environmental sensitivities in the path of the spill.

13.187 Even in the event that an oil spill resulted in the loss of inventory from a DP vessel, fish are highly mobile and are able to detect these pollutants and as a result are expected to avoid areas where pollution has occurred. The main sensitivities for fish species are nursery and spawning areas and the Inner Sound for fish species that occur in the vicinity of the Project only represents a small portion of these areas or is not suitable for spawning or populations of juvenile fish due to the strong tidal currents.

13.188 The sensitivity of fish is considered medium due to the fact it is expected fish are to some extent able to move away from polluted areas. In the event a large spill does occur the magnitude of impact is considered to be major.

13.189 The potential for a loss of a large fuel oil inventory from a vessel is defined as extremely remote (see Impact 24.1, Section 24).

Impact significance (see Section 24 for impact ranking methodology)

Sensitivity of receptor	Magnitude of impact	Consequence	Likelihood *(See section 24)*	Impact significance *(See section 24)*	Significance (EIA Regs) *(See section 24)*
Medium	Major	Major	Extremely remote	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.8

Although no significant impacts have been identified, mitigation measures have been provided due to the potential consequence of the event:

- All vessels associated with Project operations will comply with IMO/MCA codes for prevention of oil pollution and any vessels over 400 GT will have onboard Ship Oil Prevention Emergency Plans (SOPEPs).
- All vessels associated with Project operations will carry onboard oil and chemical spill mop up kits.
- Where possible vessels with a proven track record for operating in similar conditions will be used.
- Vessel activities associated with installation, operation, routine maintenance and decommissioning will occur in suitable conditions to reduce the chance of an oil spill resulting from the influence of unfavourable weather conditions.

13.6.9 Impact 13.9: Release of drill cuttings and fluid

13.190 As outlined in Section 10, drill cuttings and fluid will be released into the marine environment during pile drilling for the turbine foundations and during break through for the cable bores.

Pile drilling

13.191 Monopile drilling operations will take approximately 4 hours per pile and a total of 30 hours to complete the preparations for each turbine support structure. Drilling the holes for each pile will generate rock cuttings which will be discharged directly to the seabed. Seawater (with no additives) will be used as the drilling fluid to lubricate the drill bit and aid in the removal of cuttings from the hole. A compressor will be used to pump air into the drilled holes in order to lift the cuttings clear as required. This compressor will use a lubricant which will be discharged to sea along with any cuttings to a maximum of 5 litres per hour (i.e. 200m^3 per turbine support structure, or 17,200m^3 for all 86 turbines installed over a 3 year period).

HDD drilling

13.192 For HDD operations the lubricant to be used is bentonite which is non-toxic. Therefore, the main potential environmental impact is likely to result from the physical settlement of rock cuttings onto the seabed with benthic fish species being the most susceptible to exposure to these cuttings. The drill cuttings are likely to consist predominantly of a fluid paste (incorporating the finest silt and clay-sized particles) with occasional larger fragments up to pebble-sized flakes, all of which are mobile in the marine environment. The largest and heaviest particles will settle relatively quickly to the seabed in the close vicinity of the drilling centre, whilst in this energetic locality the finest particles will remain in suspension for some time.

13.193 The cables to shore will be routed through bores directionally drilled from onshore. The maximum volume of drill cuttings that will be discharged at bore breakthrough is 82m^2. As with the drill cuttings, benthic fish species are most likely to be exposed to the contents of the breakthrough of the bore holes.

13.194 The dynamic environment (resulting from intense wave action and tidal activity) into which the operational discharge will be released means that drill cuttings will be dispersed into the wider marine area; the Pentland Firth is one of highest energy coastal environments in the UK (see Section 9). The lack of sediment across almost all of the Project area and the likely cable corridors indicates a dynamic environment in which solids are unlikely to accumulate.

13.195 As outlined in Section 10, the release of drill cuttings and fluids in the marine environment is not likely to cause a significant impact to the benthic ecology of the Project area. As a result, no indirect impacts on fish prey species are anticipated. In addition, the fish species in the Inner Sound are highly mobile (more so than benthic invertebrates) and will be able to move away from areas where drill cuttings are discharged. The area affected will also represent a significantly small (<0.01%) of the area available to fish species that spawn and have nursery areas within the Inner Sound.

13.196 As outlined in Table 13.10 the sensitivity of some of some fish species, including plaice, dogfish and plaice to smothering is considered to be low (Faber Maunsell, 2007). Sensitivity is considered to be high for herring and sandeel demersal eggs, however, as highlighted previously it is not anticipated that either of these species use the Project area for spawning.

13.197 As most fish species within the Pentland Firth are not sensitive to the impacts of increased sedimentation (Faber Maunsell, 2007) the sensitivity is considered low. Given that the volumes released will be relatively low the magnitude of the impact is considered to be minor.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Low	Minor	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 13.9

- Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case.
- Minimise as far as practicable the depth and diameter of the turbine foundation piles (without compromising technical performance).
- Lubricant used in the compressor to drive air into the drilled piles will be non-toxic and seawater will be used as a drilling fluid, negating the need for any additional chemical input.
- Minimise as far as practicable the volume of drill cuttings released into the marine environment

during breakthrough of HDD bores, by implementing a closed loop recycling system to return drill cuttings and fluid from the HDD to shore.

13.6.10 Impact 13.10: Collisions

13.198 The risk of collision during installation operations is only likely to arise through the interaction with installation vessels. Of the fish species that are present within the Project area, basking sharks are particularly slow moving, and swim close to the surface, especially when feeding and, therefore, potential does exist for collisions to occur between this large fish species and vessels used in construction and installation operations. Their slow moving nature makes basking sharks the most at risk fish species from collision during installation operations. However, it is worth noting that the numbers and density of basking sharks in the area is considered to be very low suggesting the potential of such an interaction is very low.

13.199 As basking sharks are afforded protection similar to that of a EPS under the Wildlife and Country side Act (1981 as amended) they are considered to be of very high sensitivity. The magnitude of the impact is based on the number of vessels using the Inner Sound and the limited period over which vessel activity will increase as a result of the Project. A negligible magnitude impact is assumed.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Very high	Negligible	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 13.10

- No mitigation measures proposed as no significant impact predicted.

13.6.11 Impact 13.11: Marine non-native species

13.200 Invasive Marine Non-Native Species (MNNS) pose a significant threat to biodiversity as they may have negative impacts on native species and threaten regional ecosystems. Should a non-native fish species be introduced into the marine environment of the Inner Sound there is no guarantee that the species will be tolerant of the conditions and it is in fact more likely that the species will be unable to reproduce and initiate a local population. For such a population to develop the species would need to be tolerant of the environmental conditions of the Inner Sound (e.g. temperature, salinity, suspended sediment, high flow velocities), make use of existing food sources (e.g. organic content of sediment, prey species) and be able to outcompete the native species. Alternatively it must be able to exploit a previously unfilled ecological niche. Where these conditions are met then the native populations may experience a reduction in numbers or a complete failure. The only viable vector through which non-native fish species could be introduced into the Inner Sound would be through ballast water from vessels used during construction and installation. However, the majority of vessels that will be employed on the Project are likely to have been operating within the North Sea and North Atlantic and are therefore unlikely to be carrying any species that may be considered non-native.

13.201 The impact of MNNS could in theory extend, in the long term, over a large area. This could lead to a high ranking for magnitude of impact. However, the impact is considered extremely unlikely to occur and to balance the scale of impact against the likelihood of impact occurring, a magnitude of impact of minor is assigned. Sensitivity of receptor is considered to be medium.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Medium	Minor	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 13.11

- Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case.
- All vessels involved in all stages of the Project will adhere to all relevant guidance and legislation (including the IMO guidelines and the International Convention for the Prevention of Pollution from Ships (MARPOL)) regarding ballast water and transfer on non-native marine species

13.7 Impacts during Operations and Maintenance

13.7.1 Impact 13.12: Loss of habitat

13.202 The placement of the turbines and cables on the seabed will be likely to impact on fish habitat available within the Inner Sound. The placement of the turbines and cables onto the seabed will exclude the seabed habitats directly beneath from use by species found in the region for the life of the Project as feeding, spawning and nursery areas. As shown in Impact 13.1 and Impact 13.2 the total area affected for spawning and nursery grounds is much less than 0.01% of the total area available to all the species that spawn in the Inner Sound and wider Pentland Firth, north coast of Scotland and North Sea. In addition the area lost to the placement of turbine foundations and cables represents a very small proportion of the Inner Sound, with a total of 0.103km^2 being occupied by these structures. Therefore it is unlikely that feeding areas will be restricted or significantly reduced.

13.203 As the area of impact is so small and the fish species recorded in the area are highly mobile, the impact on fish species ability to feed is expected to be equally small. The area of spawning and nursery ground is also small and unlikely to significantly affect the ability of these species to reproduce. Therefore, it is unlikely that any effects to the fish populations in the Inner Sound will be experienced due to the presence of the turbines and cables on the seabed and the magnitude is considered negligible. Herring and sandeel are particularly sensitive to loss of habitat for spawning but are unlikely to spawn in the area. As a result the sensitivity of the receptor is considered low as most species have large spawning grounds and are highly mobile, able to move to other areas to spawn and feed. The magnitude of the impact is considered to be negligible due to the very small are of habitat affected and the small proportion of the Inner Sound and wider Pentland Firth occupied by the Project infrastructure.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Low	Negligible	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.12

- No mitigation measures proposed as no significant impact predicted.

13.7.2 Impact 13.13: Increase of available habitat

13.204 The device foundations and cable protection are likely to be colonised by numerous marine organisms (Section 10). Evidence from offshore wind farms, indicates that the array structures could act as a refuge for some fish and prey species (Linley *et al*., 2007). As a result the colonisation by fauna on the structures could result in an increase in food availability. In addition the physical structure of the foundations may attract some fish species, as they could provide protection against predation or the prevalent current and thus save fish energy (OSPAR, 2004). This increase in prey species and available habitat might not cause a direct increase in productivity, but could result in a spatial shift in the fish resource such as acting as a fish aggregation device (CEFAS, 2004). Anecdotal evidence from deployment of tidal turbines at EMEC suggests the foundations of tidal devices have a similar effect (Alex Alliston pers. comm., 2011).

13.205 Post construction monitoring at offshore wind farms in the UK have not identified any short term negative environmental impacts on fish populations caused by the construction of wind farms (BoWind, 2009; npower renewables, 2008). In fact, at Horns Rev offshore wind farm monitoring revealed a marked increased in fish fauna diversity, with shoals of cod, bib and whiting observed around the turbine bases (Leonhard & Pedersen, 2004). However, these increases are expected to be imperceptible in the context of the wider population. Therefore the magnitude of the impact is expected to be minor. Given that fish species do not show significant increases in population this suggests low sensitivity to this impact.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Low	Minor positive	Minor positive	Positive

MITIGATION IN RELATION TO IMPACT 13.13
▪ No mitigation measures proposed as no significant impact predicted.

13.7.3 Impact 13.14: Noise

13.206 As outlined in Kongsberg (2012) and Section 13.6.3 an underwater noise impact study within the Inner Sound was conducted by Kongsberg Maritime Ltd, which included acoustic modelling to investigate the underwater noise propagation from the Project. Further details on the modelling conducted can be found in Kongsberg (2012).

13.207 The main activity during operation of the turbines that has the potential to cause impact to fish species through the generation of noise is from the operating turbines themselves, including rotating machinery noise and water movement noise. The worst case scenario for operational noise comes from the operation of all 36, 2.4MW turbines in the Inner Sound. It is this multiple source noise event that is assessed in this section.

13.208 Kongsberg (2012) used extrapolated data from the MCT turbine (Richards *et al*., 2007) to conduct the noise modelling used in this impact assessment.

13.209 As outlined in Section 13.6.3 the effects of underwater noise can be separated into three main categories.

- Lethal and physical injury;
- Hearing damage (temporary and permanent hearing loss); and
- Behavioural responses and masking of biological relevant sounds.

13.210 As outlined in Section 13.6.3 hearing damage criteria have not been developed for fish species. They have been developed for marine mammals (Section 11). Consequently because marine mammals are considered to be more sensitive to underwater noise compared to fish species, the outcomes of the modelling for marine mammals (based on the available criteria) are considered to represent the worst case hearing damage impacts for fish species, where overall, the impact to fish species is likely to be much less that that of marine mammals.

13.211 Behavioural response and auditory injury from underwater sound is often assessed by comparing the received sound level with the auditory threshold of the receptor. Nedwell *et al*. (2005 and 2007) and Parvin *et al*. (2006) compare the underwater noise with receptor hearing threshold across the entire receptor auditory bandwidth in the same manner that the dB(A) is used to assess noise source in air for human subjects. This dB_{ht} criteria, used in these studies is behavioural based, where received sound levels of 90dB above hearing threshold (comparable with 90dB(A) in air) are considered to cause a strong behavioural avoidance, and levels of 75dB above hearing threshold invoke a mild behavioural response. It is understood that this criterion has not been validated by either rigorous peer-review or experimental study. Observations of behavioural avoidance with concurrent acoustic measurements in the field are sparse, and hence the behavioural avoidance criteria must be treated with some caution.

13.212 Based on the modelling conducted by Kongsberg (2012), the operation of 36, 2.4MW turbines[4] would generate noise levels that are below those levels that would result in lethal or physical injury to marine mammal species within the Project area and wider Inner Sound area. Therefore, it is unlikely that lethal or physical injury effects to fish would occur, including hearing sensitive species such as herring and European eel.

13.213 Operational activities tend to give rise to higher levels of underwater noise compared with drilling activities (Kongsberg, 2012). The background noise levels in the Inner Sound are variable, lying in the range 106 – 139dB re 1μPa, and therefore have the potential to drown out the operational noise on occasion. When background levels are at their highest, operational noise may fall to background levels within 300m of the turbines. This distance may increase to in excess of 14km when background noise levels are at their lowest (Kongsberg, 2012). There is also likely to be a direct correlation between background noise and the noise generated by the turbine. As background noise falls due to decreases in tidal flow, the noise generated by the turbine (as the turbine slows) will also decrease.

13.214 During the operation of 36, 2.4MW turbines, using weighted impact criteria, the thresholds for strong and mild reactions for hearing generalists are not met. Hearing generalists would need to be less than 1m from the source of the noise to exhibit a behavioural response. Kongsberg (2012) reported that for the operation of 36, 2.4MW turbines strong behavioural reactions in hearing specialists (e.g. herring) would occur up to 18m from the tidal array and mild behavioural reactions up to 68m from the tidal array. In terms of hearing damage, Kongsberg (2012) determined that neither temporary nor permanent hearing damage criteria would be met for cetaceans as a result of the operation, and as such hearing damage is also unlikely to occur for fish species present in the Project area.

13.215 During EIA scoping concerns were raised over the impacts of underwater noise on fish spawning. As outlined in Section 13.5.1 the seabed in the Project area is considered to be unsuitable for both herring and sandeel spawning, and as a result it is only possible that lemon sole could use the Project area for spawning. Lemon sole are flatfish species which do not have a swim bladder, and as such can be considered to be of low sensitivity to under water noise. Modelling conducted by Kongsberg (2012) determined that strong behavioural reaction would take place within 1m of the turbine array for these types of fish species. However, the nature of the reaction is unknown but there is the potential it would illicit an avoidance reaction. Also, it is unlikely that spawning behaviour would be affected as the area over which this might occur will represent less than 0.01% of the entire spawning area for species that spawn in the vicinity of the Project.

13.216 Further concerns have been raised regarding the impact of noise on migratory fish species. Salmon are considered to have relatively low sensitivity to sound and given the impact to other fish species is considered to be relatively low (including hearing specialist species such as herring and European eel) it is unlikely that any impacts will occur to salmon other than behavioural reactions as they approach the turbines. However, salmon are unlikely to hear the turbines until they are very close to them as the noise generated by the turbines is very localised (see Kongsberg, 2012). Being hearing generalists salmon would not hear the noise generated by the array until they were less than 1m from the closest turbine.

13.217 The most sensitive fish species is considered for the assessment of this impact. Herring and cod are considered to be the most sensitive to noise (Table 13.10) and therefore the receptor is considered to be of high sensitivity. The magnitude of the impact is considered to be negligible due to the noise not resulting in mortality or injury and the range at which behavioural reactions could be observed being only a few meters. There is uncertainty in the reaction of fish to the noise generated by the turbines however fish are only likely to be exposed to noise while they pass close to the array. Therefore, the impact is highly unlikely to occur given the small proportion of the Inner Sound and the fish population ranges the Project covers.

[4] A 36 turbine array of 2.4MW turbines has been used in the assessment as it produces greater noise than an array of 86 turbines of 1MW rated power

13.218 The most sensitive receptor (hearing specialist fish) are used to undertake the assessment using a precautionary approach and as a result the sensitivity of the receptor is considered to be high. However, as the noise levels are relatively low, unlikely to cause injury or mortality and the ranges for behavioural reactions are very small, any impacts are likely to be imperceptible. Therefore, the impact magnitude is considered to be negligible. Hearing generalist fish (e.g. Atlantic salmon) are likely to experience an impact of lesser significance.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
High	Negligible	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 13.14

- Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case.
- Where possible the use of soft start (gradual ramping up) of operations that will emit noise into the Project area will be used.
- MeyGen accepts that there is some uncertainty over the noise generated during drilling and turbine operation and as a result commits to conducting noise monitoring for the initial turbines installed and candidate turbine technology to validate the noise modelling.

13.7.4 Impact 13.15: Electromagnetic fields (EMF)

13.219 Ambient electric (E) and magnetic (B) fields detected within the marine environment are generated by both natural and anthropogenic sources. The predominant naturally occurring EMF in the marine environment is from the earth's geomagnetic field, however, E-fields can also be naturally emitted as a result of biochemical, physiological and/or neurological process within an organism, known as bioelectric fields (Gill & Bartlett, 2010). Anthropogenic sources of EMF include those from subsea power cables.

13.220 Power cables, such as those used to export electricity generated from tidal arrays, produce E- and B-fields when current passes through them. The B-field is detectable outside of the cable structure and this in turn creates a further induced E field (iE). Studies have shown that EMF radiate beyond the cable into both seawater and the seabed. However, the field emitted by the cables are limited spatially and the field decays rapidly with horizontal and vertical distance from the cables (Normandeau *et al*., 2011). Figure 13.5 is a simplified overview of the fields associated with industry-standard submarine cables, highlighting the magnetic and induced electrical fields that are of interest for fish species.

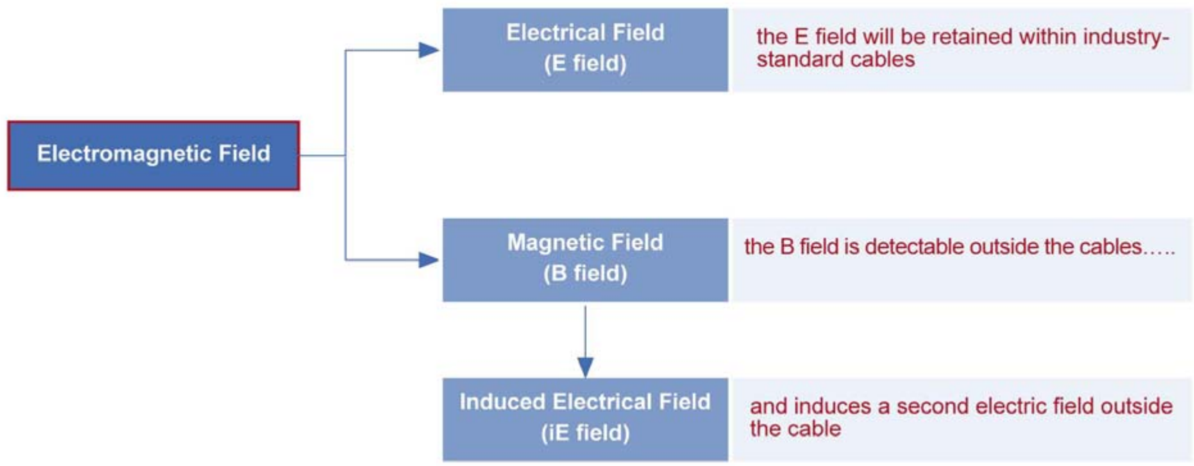

Figure 13.5: Overview of the fields associated with subsea power cables (Gill *et al*., 2005).

13.221 A number of fish species found in Scottish waters are known to be able to detect electric and magnetic fields and thus will be able to detect EMF emitted from subsea power cables. Elasmobranch species are the main group of organisms which are known to be able to detect E-fields. They possess specialised electroreceptor pores in their skin from which they detect bioelectric emissions from prey, conspecifics[5] and potential predators/competitors. Other fish species, including migratory species, that are electrosensitive do not possess specialised electroreceptors but are able to detect induced voltage gradients associated with water movements and geomagnetic emissions. These include European eel, cod, plaice and Atlantic salmon, which all have the potential to be present in the Project area (Gill *et al*., 2005). Fish species that are able to detect magnetic fields include all species able to detect induced electrical fields, and those able to detect magnetite. In addition to those species already listed, sea trout and mackerel are also capable of detecting B-fields. However, in general, open water species of fish, including salmonids, are not considered to be as reliant of this sense and are therefore considered to be significantly less sensitive than elasmobranchs to EMF (Faber Maunsell, 2007).

13.222 The University of Liverpool Centre for Marine and Coastal Studies (CMACS) and Cranfield University have undertaken studies, largely funded through COWRIE, (although recently a report was commissioned by SNH) to investigate EMF emission from typical offshore subsea cables, in the context of the E- and B-fields (e.g. CMACS, 2003, Gill *et al*., 2005; 2009; Gill & Bartlett, 2010). These studies have largely been driven by the need to consider the effects of EMF resulting from offshore wind farm subsea cabling.

13.223 During the course of the above detailed research, desk-based, laboratory and field studies have been undertaken. However, it is still generally considered that the current state of knowledge regarding the EMF emitted from subsea power cables is too variable and inconclusive to make an informed assessment of any possible environmental impact of EMF.

13.224 The first report of the COWRIE EMF study (CMACS, 2003) based on offshore wind developments made the following findings:

- There is no direct generation of an E-field outside of the cable;
- B-fields generated by the cable created induced E-fields (iE) outside of the cable, irrespective of shielding;
- B-fields are present in close proximity to the cable and the sediment type in which a cable is buried has no effect on the magnitude of B-field generated;
- The magnitude of the B-field on the 'skin' of the cable (i.e. within millimetres) is approximately 1.6μT which will be superimposed on any other B-fields (e.g. Earth's geomagnetic field); and
- The magnitude of the B-field associated with the cable fall to background levels within 20m.

13.225 Considering the results of the modelling undertaken as part of the research, in respect of significance to electro-sensitive fish, the report found the following:

- EMF emitted by a industry standard subsea cable will induce E-fields;
- Cables will emit approximately 91μV/m at the seabed adjacent to a cable buried to 1m. This level of E-field is on the boundary of E-field emissions that are expected to attract and those that repel elasmobranchs;
- The iE-fields calculated from the B-field were also within range of detection by elasmobranchs;
- Changing the permeability or conductivity of the cable may effectively reduce the magnitude of the iE-field;

[5] Belonging to the same species

- To reduce the iE-field that is below the level of detection of elasmobranchs will require a material of very high permeability, hence any reduction in E-field emission would minimise the potential for an avoidance reaction by a fish if it encountered the field but may still result in an attraction response; and

- The relationship between the amount of cabling present, producing iE-fields and the available habitat of electro-sensitive species is an important consideration.

13.226 In addition to this, further research funded by COWRIE conducted by Gill *et al*. (2009) in which the impact of controlled EMF within mesocosm (with the magnitude and characteristics associated with offshore wind farm) on electro-sensitive fish was conducted. From which the following was found:

- There is evidence that benthic elasmobranch species studied did respond to the presence of EMF emitted by a subsea cable. The responses were, however, variable within a species and also during times of cable switch on and off, day and night;

- The overall spatial distribution of fish was non-random, and dogfish were more likely to be found within the zone of EMF emission during times when the cable was switched on; and

- There did not appear to be any differences in the fish response by day or night or over time.

13.227 Gill and Bartlett (2010) were commissioned by SNH to review the current state of knowledge with regard for the potential for Atlantic salmon, European eel and sea trout to be affected by marine energy developments, focusing on an understanding of EMFs (as well as noise), on behaviour of the three species. The main findings of the report in relation to EMF were:

- Atlantic salmon and European eel can use the earths magnetic field for orientation and direction during migrations. Juvenile sea trout respond to both the earths magnetic field and artificial magnetic fields;

- Current knowledge suggests that EMFs from subsea cables and cabling orientation may interact with migrating eels (and possibly salmonids) if their migration or movement routes take them over the cables, particularly in shallow waters (<20m). The effect if any could be a relatively trivial temporary change in swimming direction, or potentially a more serious avoidance response or delay to migration. Where this will represent a biologically significant effect cannot yet be determined;

- All three species are likely to encounter EMF from subsea cables either during adult movement phases of their life or their early life stages during migration within shallow, coastal waters adjacent to the natal rivers; and

- The review identified no clear evidence that either attraction or repulsion due to anthropogenic EMF will have an effect on any of three fish species identified in the report.

13.228 A recent report produced for the Department of the Interior in the US (Normandeau *et al*., 2011) provides a comprehensive review of studies to date on potential effects of EMF on marine fauna. The report modelled the expected EMF's from a range of power cables and reviewed the available information on sensitive marine species. The report drew the following conclusions:

- The field is strongest directly over the cable and decreases rapidly with horizontal and vertical distance from the cable;

- The cable magnetic field is perpendicular to the direction of the cable. A water current or organism moving parallel to the cable magnetic field will not generate an induced electric field. Orientation of the cables relative to the flow of water and migration routes can reduce the potential impacts;

- Marine species are more likely to react to the magnetic fields of DC cables than AC cables. DC cables were found to have a greater impact as they can influence the intensity of the local geometric field;

- The risk of interference only exists in the areas surrounding the cables where sensory capabilities overlap with the cable EMF; and

- Magnetic fields can be minimised by placing the cables close together, allowing the field vectors to cancel each other out.

13.229 At a worst case the cabling for the array will include 1.3km of subsea cabling from the devices to the subsea boreholes which cover a maximum of be $0.013km^2$ or 0.07% of the Inner Sound. The cables are designed with a screen that completely surrounds the conductor, resulting in the E-field being present between the conductor and the screen therefore the E-field outside the cable will be zero.

13.230 The magnetic field from the cables will be well below that of the Earths magnetic field which is between 30 and 70μT and may not be detectable by the fish species that are present in the area as they move across the cables. It is not known to what extent the exact magnitude of the iE-field emissions will be from the cables used for the array but it is considered likely to be low. This implies that the iE-field would be lower than the range that could either attract or repel electrosensitive fish species (Gill *et al*., 2009). There is currently no clear evidence to suggest that either attraction or repulsion will have a detrimental impact on elasmobranch or salmonid species.

13.231 The direction of the field will also influence the potential impact on sensitive species. As indicated by Normandeau *et al*., (2011) the cable magnetic field is perpendicular to the direction of the cable and an organism moving parallel to the cable magnetic field will not generate an induced electric field. Given that the cables will be laid across the flow and many fish species (particularly salmon) will move with the flow through the Inner Sound the impact from the iE-field will be reduced. For other species that are not migrating through the area this will mean that impacts will only occur when fish are orientated in the same direction as the cables. Based on 1,300m of cable along the seabed (and 700m of cable beneath the seabed in boreholes) the cables cover 0.07% of the Inner Sound seabed the potential for this to occur is considered low. In addition the use of AC cables rather than DC cables also has the potential to reduce the impacts (Normandeau *et al*., 2011).

13.232 During periods of slack water, low tidal velocities and high tidal velocities when the turbines are not generating (27% of the time) electricity the cables will not produce any iE-fields as power will not be travelling through them. Thus, there will be periods when no electricity is being produced and any fish passing over the cables will not be exposed to EMF. During periods of the highest tidal velocities when magnetic fields are at their highest there is the potential that fish will be moving passively with the tidal flows and will be exposed to the cables for a much shorter period. Many species may avoid the area at the highest flows and will therefore not come into contact with the cables and their associated field during periods when the field is at its highest.

13.233 There are insufficient data available with which a judgement can be made about the potential for EMF to impact on a particular species. However it is considered that the effects will be influenced to some extent by their habitat preferences. Bottom dwellers such as skates, rays and dogfish use electroreception as their main sense for food detection. More open water species such as tope and mako, may encounter EMF near the seabed but will spend a significant amount of time in the water column hunting. As a result the potential for impact is considered to be highest for species that depend on electroreception to detect benthic prey (CMACS, 2005).

13.234 The Inner Sound is potentially inhabited by a number of benthic elasmobranch species of national and international conservation concern, in addition other potentially sensitive fish species including salmonids may use the Inner Sound during their migration through the Pentland Firth which are also of national and international conservation concern. However, the fact that the maximum iE-field is likely to be less than the earth's magnetic field, the field strength will vary with the tidal phase, fish will potentially travel parallel to the field, and the small area of the Inner Sound occupied by the cables would suggest the potential for any negative impacts on magnetically or electrically sensitive species as a result of EMF would be low.

13.235 Elasmobranchs are considered the most sensitive species to this impact and are therefore taken forward as the receptor for this particular impact. Therefore, sensitivity is considered to be high.

13.236 Based on the small proportion of the Inner Sound covered by cables, the very low levels of EMF produced by the cable, the orientation of the field with the direction of water flow and that the iE-field is likely to be significantly lower than that of the earth's magnetic field the magnitude of the impact is considered to be minor. Impacts are not expected to result in noticeable changes in the fish populations in the vicinity of the Project.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
High	Minor	Moderate	Significant

MITIGATION IN RELATION TO IMPACT 13.15
▪ Where cables are not within boreholes they will be laid where possible within natural crevices and cracks within the seabed ensuring that the majority of the cable is below the seabed. ▪ The length of the drilled boreholes for the cable will be (as far as technically and commercially possible) to increase the length of cable under the seabed. ▪ Cables will be bundled into groups of 3 minimising the magnetic field by placing the cables close together, allowing the field vectors to cancel each other out. ▪ In addition ongoing research by Marine Scotland and their advisors which will be monitored for further indications of successful mitigation strategies.

Residual impacts

13.237 Increasing the length of cable that would be beneath the seabed would be greatly reduce the impact of the magnetic fields by further shielding and field produced by the cables. Placing the cables within natural crevices and within cracks in the seabed will also reduce the potential for exposure to fish species. Bundling of the cables will ensure the field vectors cancel each other out further reducing the field that fish species will be exposed to. With all these measures implemented the potential for fish to be exposed to EMF is further reduced so that the impact magnitude is reduced to negligible. This is because any changes will be imperceptible.

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
High	Negligible	Minor	Not Significant

13.7.5 Impact 13.16: Barriers to movement

13.238 Tidal array developments have the potential to form a barrier to usual migration and transit patterns of marine, elasmobranch and anadromous fish species. The array has the potential to act as a barrier due to physical presence, aversive reactions to underwater noise, EMF or perceptions of devices and associated infrastructure. This impact is particularly pertinent in more constrained environments, such as mouths of sea lochs or in narrow sounds.

13.239 A barrier effect is most likely to be perceived by mobile fish species which frequently transit through the Project area. As outlined above although there is no direct data to confirm, as a precautionary approach it is assumed that Atlantic salmon, sea trout and European eel do pass through the Inner Sound during their migrations. Sea trout may pass through the array itself but evidence from Norway suggests that they tend to use the top 6m of the water column and make occasional dives to deeper water (Malcolm *et al*., 2010). However, there is still some uncertainty over whether this behaviour occurs in Scottish waters. There are no marine fish or elasmobranch species which are known to use the Inner Sound during specific migrations, although marine and elasmobranch species do exhibit migratory behaviour between spawning and nursery grounds. Some fish species are considered to inhabit this particular stretch of water as juveniles (nursery grounds) and may migrate away from the waters when they migrate to join the adult population.

13.240 A maximum of 86 turbines will be located in water that is deeper than 31.5 m. At a worst case the minimum clearance from the blade tip to the sea surface will be 8m. The 86 turbines are likely to be positioned in nine rows from 5 to 11 wide (Figure 5.6, Section 5). Table 13.13 provides the width in metres that each row could potentially occupy as a physical barrier to the movement of fish in relation to the width of the Inner Sound at that point.

Turbine row	Number of turbines	Width of row (m)[1]	Width of the Inner Sound at that point (m)	% of the width of the Inner Sound influenced by the Project
1: Most western	5	194	3,201	6.06
2	7	289	3,112	9.29
3	8	336	3,078	10.92
4	11	480	3,020	15.89
5	11	480	3,100	15.48
6	11	480	3,158	15.53
7	11	480	3,091	15.53
8	11	482	3,098	15.56
9: Most eastern	11	482	3,031	15.90

Notes:[1] The total width between northern and southern turbine.

Table 13.13: Linear distances of the Inner Sound between Caithness and Stroma that is occupied by each row of the turbine array

13.241 The maximum width of the Inner Sound that will be taken up by the array is 482m which occurs on the two most eastern rows. This equates to a maximum of 6.89% of the narrowest point of the Pentland Firth (7km wide at its narrowest point) where a physical barrier to movement is present. Therefore at a minimum 93.1% of the Pentland Firth will not be acting as a physical barrier to fish species.

13.242 If a cross section is taken through the Pentland Firth and the swept area of the turbines at their widest point is used, we can calculate the area of the water column occupied by the turbines. If we consider that the first and second rows are staggered behind each other in order to ensure the wake from the turbine in front does not affect the turbine behind it, the first two rows can be considered a single row. Therefore, the swept area of 22 turbines is 0.007km^2. At the same point the Inner Sound, based on the width of each of the depth contours the cross section of the Pentland Firth is 0.33km^2. Therefore the area available for fish to migrate through without the turbines present is more than 98% of the Pentland Firth.

13.243 However, there is the potential that the noise generated by the turbines may add an additional barrier to that already presented by the physical presence of the turbines, extending the barrier a further 63m (the mild avoidance threshold from Kongsberg (2012)) from the turbine blades at the edge of the array and to the water surface above the array. For 86 turbines of 1MW the mild avoidance criteria distance is 63m. If this distance is added to each of the ends of the widest row the array takes up 608m or 9.2% of the Pentland Firth in terms of the width.

13.244 On a cross sectional basis the barrier effect is less. Using the maximum depth of the turbine deployment area of 38m and adding the additional area of the noise form the tips of the most northerly and southerly turbines to the width of the array the cross sectional area of the potential barrier is 0.023km^2. This represents approximately 7.0% of the Pentland Firth cross section. Therefore 93% of the Pentland Firth is still available for fish to swim through without experiencing a barrier effect.

13.245 The most sensitive species to the barrier effect are those that migrate through the Pentland Firth and it is not anticipated that the array will be perceived by these species as a barrier. If this assumption were to prove to be incorrect, the array will occupy only a small fraction of the potential area of the Inner Sound, leaving the majority of the Inner Sound and wider Pentland Firth available for migration.

13.246 It is not known whether salmon smolts use the Inner Sound exclusively during their migrations to feeding grounds at sea and it is thought the Pentland Firth as a whole will be utilised by the east coast population. As the Inner Sound only represents a small proportion of the total area of the Pentland Firth there is the potential that a only a small proportion of the smolt population migrates through the Project area. There is some evidence from Norway to suggest that smolts will utilise the top part of the water column and will move quickly through the Inner Sound reducing the likelihood that they will encounter the array and experience a barrier effect although there is no evidence to say that the Scottish population shows similar behaviour. In addition, in areas of strong currents there is evidence that they will tend to stay close to the coast rather than move into the stronger currents and so may well avoid the area completely as they move through the Inner Sound.

13.247 Adult salmon returning to their natal rivers may also experience barrier effects but they are also likely to use the entire Pentland Firth and not just the Inner Sound. Adult eels are also likely to use the entire Pentland Firth during their migrations and being hearing specialists they have a much larger range at which behavioural reactions to the noise of the turbines will occur. However, it is not understood how fish species will react to the turbine noise. Again as the Inner Sound only represents a small proportion of the total area of the Pentland Firth there is the potential that only a small proportion of the population migrates through the Project area, with the remainder using the wider Pentland Firth. Therefore, there is the potential for the majority of the population to avoid the array and use the remaining accessible space to complete their migrations. In addition, the barrier effect will only present itself when the turbines are operational. For 58.1% of the time the turbines are getting up to speed and will only rotate at the rated speed for 14.6% of the time, so are turning for 73% of the time. Therefore, for the remaining 27% of the time the turbines are not rotating and do not present a barrier to movement.

13.248 In order to assess the impacts from barrier effects the most sensitive species are considered as the receptor, i.e. migratory fish species that use the Pentland Firth during their migrations to and from feeding and / or breeding grounds. Of these species the European eel is probably the most sensitive due to its sensitivity to noise. Therefore the sensitivity of the receptor is considered to be very high due to the eel being protected under Annex II of the Habitats Directive. As an impact is considered to be highly unlikely to occur the magnitude is considered to be negligible.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Very high	Negligible	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 13.16
▪ No mitigation measures proposed as no significant impact predicted.

13.7.6 Impact 13.17: Collision with turbines

13.249 Collision with rotating turbines is considered to be a key potential effect during device operation (Faber Maunsell, 2007). A collision here is understood to be an interaction with a fish and a marine renewable energy device that may result in physical injury, however slight. Due to the low number of active devices and lack of established commercial-scale deployments, data derived from monitoring programmes to directly quantify encounters with turbines, whether collisions occur and the proportion of near-misses are not yet available. This section examines encounter rate (but will refer to collision risk studies where relevant) as it is not clear at this stage whether a collision will occur. An encounter may lead to a collision, but only if the animal in question is not able to take appropriate avoidance or evasive reaction. Many species that occupy the same part of the water column as the turbines are predatory and/or preyed upon; therefore they are manoeuvrable and aware of their environment.

13.250 Each device will have a minimum clearance of 4.5m from the seabed and therefore it is expected that demersal and benthic species will pass under the device without encountering the device. In addition the turbines will have a minimum clearance of 8m from the sea surface, and as such species such as basking shark, are likely to pass over the structures when they are positioned close to the surface within the water column. As a result it is generally considered that pelagic and bentho-pelagic fish will be the most likely to be at risk of collisions with devices as their diurnal vertical migration behaviours forces them to occupy all depths of the water column at some time during the day or night (Faber Maunsell, 2007). The Project area is potentially utilised by a number of pelagic and bentho-pelagic species of International conservation importance: Atlantic salmon, sea trout, European eel, spurdog, tope, shortfin mako and cod.

13.251 To support the Scottish Marine Renewables SEA, Wilson *et al*. (2007) were commissioned to investigate collision risk[6] between marine renewable energy devices and fish. The study identified the following:

- Collision risks are not well understood for any marine vertebrates;
- Man-made collision risks are more diverse and common than generally supposed;
- Underwater collision risks typically become well studied after they have become a conservation concern;
- Animals appear to behave illogically when faced with novel situations;
- Subtleties of device design (e.g. shape, colour) as well as environmental conditions (e.g. turbidity, flow rate) can markedly change collision rates;
- Objects in the water column will naturally attract fish and their predators;
- Stationary objects in flowing water can herd fish upstream until they become exhausted limiting their behavioural options;
- The proximity and relative orientation to other objects will impact escape options and the combined collision risk while topography will impact escape options and animal approach angles;
- Collision risk will vary with age of organism, with juveniles likely to be more at risk than adults because of reduced abilities or experience;
- The potential for animals to escape collisions with marine renewable energy devices will depend on their body size, social behaviour (e.g. schooling), foraging tactics, curiosity, habitat use, underwater agility and sensory capabilities; and
- A variety of warning devices and renewable device adaptations have been developed for fish recognition of underwater collision issues.

13.252 In addition to this study, ABPmer (2010) were commissioned by the Marine Renewable Energy Strategic Framework for Wales (MRESF) to produce a report that would provide further evaluation of the fish collision risk with wave and tidal stream energy devices. The key conclusions of the study were that:

- There is a general lack of information on relevant characteristics of devices that might inform the evaluation of collision risk. Where data are available, it relates to a single prototype device and there is little, if any, information available on the environmental characteristics of devices and arrays of devices in particular;
- The opportunity for fish to engage in long range avoidance is likely to be a function of the source levels of underwater noise associated with devices, background noise levels and the particular hearing sensitivities of different fish species. For hearing sensitive fish (e.g. herring) analysis suggests that they maybe able to detect and avoid individual operational tidal stream devices at distances between 120 and 300m (depending on the depth of water) even when background noise levels are comparatively high. However, for hearing insensitive fish, the projected source noise

[6] Collision risk is the risk or probability that a collision with a turbine occurs. This differs from encounter rate in that it estimates that probability that the turbine blade and an object will come into physical contact resulting in injury or mortality.

levels of tidal devices are unlikely to be below levels at which these species might exhibit an avoidance reaction;

- The extent to which fish might exhibit close range evasion of tidal stream devices is a function of the visibility of the devices, details of device structure and operation, the visual acuity and maximum swimming speeds of different species of fish and near-field behavioural responses. There are no published direct observational studies on the near-field interaction of fish with tidal stream devices and it remains unclear how fish might respond on encountering such devices; and

- The extent of damage to fish associated with collision with a tidal stream device is largely a function of the characteristics of the device. The position of the device in the water column is also important in governing the exposure of fish to collision risk.

13.253 ABPmer (2010) presented risk matrices (Table 13.14) to provide a broad evaluation on the contribution of the three main factors; long range avoidance, close range evasion and potential physiological damage cause by collision with different types of wet renewable devices. Based on these risk matrices diadromous fish (such as Atlantic salmon) are at medium to high risk of physiological damage, as a result of a collision with a horizontal axis turbine. However, the ability of diadromous fish to evade devices at long distance were assessed as low to high (depending on hearing capabilities). Because Atlantic salmon are considered hearing generalists (Fay and Popper, 1997) their ability to avoid devices at long distances is considered to be medium. The ability to avoid turbines at close range was assessed as medium to high for diadromous fish such that they should be able to evade the device from between 20 and 50m and are unlikely to get very close to a turbine.

Factor	Pelagic bony		Pelagic elasmo-branch	Demersal elasmobr-anch	Demersal bony		Diadromous			Confidence
Hearing sensitivity[1]	High	Medium	Low	Low	Medium	Low	High	Medium	Low	-
Ability to avoid device at long distances	High	Very low	Very low	Very low	High	Very low	High	Low	Very low	Low
Ability to evade device at close range	Medium – high		Medium-low	No pathway	Medium-high		Medium – high			Low
Potential physiological damage	Medium – high		Medium – high	No pathway	Medium – high		Medium – high			Low
Ability to avoid device at long distances	High: Exhibit signs of avoidance at distances > 50m from device Medium: Exhibit signs of avoidance at distances > 20m from device Low: Exhibit signs of avoidance at distances > 10m from device Very low: Likely to exhibit signs of avoidance at distances <10m from device									
Ability to evade device at close range	High: Most fish should easily be able exhibit an evasion response with very few strikes predicted Medium: Most fish should easily be able to exhibit an evasion response although some strikes are possible Low: Some fish will have difficulty evading the device with strikes possible. No pathway: No pathway as an evasion response is not required.									
Potential physiological damage	High: High risk of physiological damage and/or mortality to many individuals Medium: Moderate risk of physiological damage to some individuals Low: Low risk of physiological damage.									
Note: [1]The different types of hearing sensitivity only apply to the 'ability to avoid a device at long distances'. The range of hearing sensitive fish categories that were considered by APBmer (2010) reflect the availability of audiogram and/or hearing threshold information which could be applied to the matrix.										

Table 13.14: Risk matrices for a single horizontal axis turbine for differing fish groups; derived by ABPmer (2010)

13.254 Wilson *et al*. (2007) modelled potential encounter rates for a horizontal axis turbine array (100 x 8m radius turbines) for herring, as an example species, off the Scottish coast. The model incorporated a number of assumptions about the vertical distribution of herring, their swimming speeds and distribution. The model also assumed that the fish were neither attracted to nor avoided the immediate area around the turbine (i.e. did not actively avoid or be attracted to the turbines). While these assumptions could be refined further, the intention of the model was to derive an estimate for the number of potential physical encounters between rotors and animals. The model predicted that in a year of operation 2% of the herring population would encounter the rotor blades. It is important to emphasise that encounters are not collisions and that the encounter rate provides an indication of the proportion of the population that could occupy the same space as the turbines. It is also worth noting that the model used by Wilson *et al*. (2007) did not allow for laminar flow effects which may carry smaller animals (such as salmon smolts) around the rotors, thus minimising the potential for and encounter with a turbine to occur. Up to rated power the flow around the turbines will be laminar. Post rated power the blades will be deliberately stalled to shed power.

13.255 In the case of salmon the Inner Sound only represents a small proportion of the total area of the Pentland Firth. Therefore, there is the potential that only a small proportion of the east and north coast smolt and adult population migrates through the Project area, reducing the potential for encounters with the turbine to occur. In addition there is some evidence from Norway to suggest that smolts will use the top part of the water column and so may not come into contact with the array unless they undertake dives to deeper water to feed. Given that in areas of strong currents there is evidence that smolts will tend to stay close to the coast rather than move into the stronger currents (Malcolm *et al*., 2010) this further reduces the possibility of encountering the Project. As discussed above there is the potential that noise emitted by an array or turbine may provide fish with early warning of the turbines location so that they can avoid it. Despite the noise from the turbines being relatively low and salmonids only being able to detect it less than 1m from the array there remains the potential they could evade a turbine further reducing the potential for an encounter.

13.256 In order to assess the potential impact of encounter rates on fish Xodus (2012) undertook an encounter study to estimate the proportions of fish encountering the turbines. The migrations of salmon take them though the Pentland Firth and the turbine deployment area of the Project and this 'pinch point' makes them the worst case from a modelling perspective. Many other species will have a much wider distribution and the entire regional population will not pass through the same point all at once. As a result salmon are taken to be the most sensitive species to this impact and impacts are addressed in the context of this species. Other migratory fish that pass through the Pentland Firth are considered to be as sensitive as salmon but due to less data being available the study focused on salmon. Other marine fish species are considered to be less sensitive or equally as sensitive depending on their ecology in comparison to salmon and are assessed based on the results of the study on salmon.

13.257 In order to provide an estimate of the probability of either a smolt (a young salmon migrating to feeding grounds from their home river) or adult salmon; adult salmon were separated into 1SW (one sea winter or grilse salmon) and MSW (multi-sea winter salmon) categories based on the differences in these two groups life history strategies[7].

13.258 A number of steps were undertaken to estimate the probability of a salmon (smolt, 1SW and MSW) encountering the array as they migrate through the Pentland Firth:

- Calculate the proportion of the salmon population that passes through the Pentland Firth (estimated as 90% based on anecdotal evidence on poaching of salmon from Orkney (J. Godfrey pers. comm., 2011), small salmon runs in the lochs of Orkney (Headley, 2012) and occasional catches of salmon in Shetland;

- Calculate the area, in cross section, of the Pentland Firth occupied by the tidal array. The swept area of a single row of 11 turbines is $0.0035km^2$ which covers 1.04% of the Pentland Firth. However, the turbine rows are staggered in order to ensure the wake from the turbine in front does

[7] One sea winter salmon will only spend one winter at sea before retuning to spawn whereas multi-sea winter salmon will spend between 2 and 5 winters at sea before returning to spawn and they can vary greatly in size, which has the potential to affect the probability that they will encounter the turbines.

not affect the performance of the turbine behind. As a result the first two rows of 11 turbines cover 2.08% of the Pentland Firth. Taking a precautionary principle this is considered to represent the cross sectional area of the Pentland Firth the array covers and the probability that the tidal array will be encountered;

- Establish the probability that the turbines are operational. For 58.1% of the time the turbines are getting up to speed and will only rotate at the rated speed for 14.6% of the time. Therefore, in total the turbines will be turning for 72.7% of the time; and
- Establish the potential salmon encounter rate with turbines using the model developed by Band (2000) and Band *et al*., (2007) for birds encountering wind turbines using the same principle that an object of *x* width and *y* length will encounter a rotor of *z* diameter rotating at a known speed.

13.259 Each step is combined to estimate the probability of a potential turbine encounter experienced by each component of the salmon population migrating through the Pentland Firth both as adults and smolts. These data are then applied to population estimates of smolt and adult populations derived from data provided by Marine Scotland (G. Smith, pers. comm., 2011) and ICES (2011).

13.260 Due to a lack of data in relation to salmon ecology a number of assumptions were made in undertaking the study. In most instances a precautionary assumption was made in order to provide a worst case estimate of the probability of an encounter taking place. The overriding assumptions made in undertaking the study were:

- Salmon smolts from the east coast of Scotland migrate along the east coast and then through the Pentland Firth. A small proportion (around 10%) migrate through the Orkney Islands and the Fair Isle Channel; and
- There is some movement by adults east and west along the north coast and so some adult salmon returning to the north coast may also pass through the Pentland Firth.

Encounter model

13.261 In order to provide an estimate of the probability of an encounter for a fish moving through the turbine blades the model for bird encounters with wind turbines developed by Band (2000) and Band *et al*., (2007) was utilised by Xodus (2012). During consultation with Marine Scotland and SNH the Band model was recommended as a potential model to estimate encounter rate for salmon as the principles underlying the model for birds travelling through the air are applicable to fish moving through the water column.

13.262 The model considers that birds use a linear passage through an area (with flow/against flow) as they fly through wind turbines. A similar process is assumed for salmon moving through water that is occupied by tidal turbines. The Band model is a well established model within the wind farm industry and has been peer reviewed on a number of occasions.

13.263 The model uses physical details on the size and speed of a bird, to compute encounter rates for a bird flying through a rotating rotor. A similar principle is assumed for salmon, in that the physical dimensions and swimming speed of a salmon are used instead of those of a bird and the wind turbine dimensions are replaced by those of a tidal turbine.

13.264 In the Band model (Band (2000) and Band *et al*. (2007)) a bird is simplified in shape to a flying cross with length, wingspan, and speed, and is assumed to be always flying perpendicularly towards the rotor. The same is assumed for a salmon but wing span is replaced by width of the salmon.

Model inputs

13.265 The process uses input parameters on the number of blades on the turbine, the rotation speed of the blades, the width of the blade and the pitch of the blade. In providing the inputs for the model the data used was provided by the worst case scenario developed under the principles of the Rochdale Envelope (Table 13.1).

13.266 Rotor blades are assumed to be laminar (i.e. with zero blade thickness) but they have length (20m diameter, 10m radius), a chord width (2.3m) which varies along the length of the blade tapering towards the tip, and a pitch angle (the angle between the blade and the rotor plane of 10°) which also varies along the length of the blade.

13.267 Based on the evidence that smolts are likely to travel passively with the tide (A. F. Youngson, pers. comm., 2012) a mean tidal current speed of 2.5ms^{-1} has been assumed as the speed at which smolts will travel through the area of the turbines. For adults that move with the tide as they return to their natal rivers the same average tidal speed has been assumed. For adults this is likely to be precautionary as they are most likely to travel at speeds above that of the tidal current (Hawkins *et al*., 1979).

13.268 The input parameters on the size of the object that passes through the rotor are considered within the original Band model as bird length and wingspan. These parameters now become the length and width of a salmon. In order to gain an estimate of the width of a salmon girth data is used, assuming that a fish is a circle in cross section. Equations developed to estimate the weight of a fish from its length and girth are rearranged to allow the girth of a fish to be estimated from length and weight data. The equation used is:

$$G = \sqrt{800W/L}$$

13.269 where *G* is the girth of a salmon, *W* is the weight in pounds and *L* is the length in inches. The measurements are then converted to cm. Data on the length and weight of one sea winter (1SW) and multiple sea winter (MSW) fish were then taken from data provided by Marine Scotland (2011b). These data were also used to estimate the girth and width of fish, so that an average width and length of 1SW and MSW fish could be used within the model. A 1SW fish has an average length of 67cm with a width of 12 cm and a MSW fish has an average length of 79cm and a width of 14cm based on the data from Marine Scotland (2011b). The length of a smolt was considered to be maximum of 15cm (R. Gardiner, pers.comm., 2012). A fish of this size is assumed to have a width of 2cm.

Population estimates for adult salmon and smolts

13.270 In order to provide some context to the probabilities estimated by the encounter study population data for smolts and 1SW and MSW salmon were required. These data, once applied to the probability of encounter would allow the implications of the encounters to be understood at a population level and whether impacts to the population would be significant or not. Data on salmon in Scotland are not readily available. Data that was available has been applied to the east coast population to allow an estimate of the numbers passing through the Pentland Firth to be estimated.

13.271 In order to estimate the population size of smolts data on the number of smolts form the North Esk was used as it is the only data set available on smolt population size. An estimate of the number of smolts per m^2 could then be estimated based on the wetted area[8] of the North Esk. This density was then used as an estimate of smolt density for all rivers on the east and north coast of Scotland so that a population size of smolts could be estimated. Based on the number of smolts between 2005 and 2009 in the North Esk and the wetted area of river catchments on the east coast of Scotland the number of salmon smolts migrating through the Pentland Firth was calculated. Making the assumption that all east coast river smolts and a proportion from north coast rivers migrate through the Pentland Firth (a precautionary 50%) and using the 2.5%ile of the ‘wetted area’ a total of 8,342,569 fish was estimated. Data were provided by the Marine Scotland Freshwater Laboratory and represents the best available data on smolt populations in Scotland (G. Smith pers. comm., 2011).

13.272 For adults ICES publish estimates of 1SW and MSW salmon for Scotland on an annual basis. In order to calculate the population of adults passing through the area data form ICES (2011) was taken for 1SW and MSW adult salmon. To provide an east coast estimate the total catches of 1SW and MSW for the north,

[8] The area of the river that is suitable habitat for salmon. The estimate has been made using Monte Carlo re-sampling of habitat availability estimates and the 2.5%ile represents the lowest estimate.

east and west coasts were examined to provide a proportion of the population that migrate to each coast (data provided Marine Scotland Freshwater Science, G. Smith, pers. comm., 2011). Based on these catches 88% of the population is assumed to migrate to east coast rivers. This was used to estimate the east coast populations of 1SW and MSW adult salmon as it represented a higher than expected proportion and was considered precautionary. Using these data 272,188 1SW and 202,969 MSW salmon migrate through the Pentland Firth.

Encounter probability and population effects on salmon

13.273 The first step in analysing the encounter rate for salmon was to understand the probability of an encounter with the array taking place. This combined each of the probabilities outlined above to provide an overall probability of encounter. These probabilities were then applied to the estimated numbers of smolts, 1SW and MSW salmon to put them into the context of population level effects. Avoidance rates are then applied to account for the ability of adult salmon to actively avoid the turbines and the likelihood that smaller smolts may get swept around the blades.

13.274 The Band model estimated the probability of an encounter occurring between a smolt based on the size of the smolt and the worst case turbine parameters as 0.120. For adult salmon the encounter rate was estimated as 0.282 for 1SW adults and 0.330 for MSW adults. Combined with the probability of travelling through the Pentland Firth (0.9), the probability of encountering the array in the Pentland Firth (0.011) and the probability of the turbines being operational (0.727) the probability of a smolt encountering the turbine was estimated as 1.63×10^{-3}. Applied to the overall population of smolts migrating through the Pentland Firth this represents approximately 13,614 fish or 0.16% of the smolt population that migrates through the Pentland Firth.

13.275 For adults the probability was estimated as 3.83×10^{-3} and 4.49×10^{-3} for 1SW and MSW adults respectively. This represented 1,044 (0.38% of the east coast population) 1SW and 911 (0.45% of the east coast population) MSW adult salmon.

13.276 With the application of avoidance rates the probability of a encounter decreases considerably. Although smolts are likely to be swept passively along by the tide they have the potential to be swept by laminar flow around the blades and may also have the ability to move up or down or side to side within the flow moving them through the Pentland Firth. In the case of adult salmon they are expected to have the capability to see, hear and feel the effect of the operating turbines before they arrive at the area where the blades are rotating. They will also have the strength to be able to avoid the array by swimming above, below or around and be able to evade the turning blades at close range and can be considered equally as capable as birds at avoiding turbine blades. Thus a range of avoidance rates from 50% to represent the passive sweeping of smolts in the laminar flow around the blades to a high avoidance rate of 99.5% used for some bird populations (Urquhart, 2010) were applied. The results of this process are shown in Table 13.155.

Avoidance rate	Probability	Smolts	1SW	MSW
50%	0.50	8.16×10^{-4}	1.92×10^{-3}	2.24×10^{-3}
75%	0.25	4.08×10^{-4}	9.59×10^{-4}	1.12×10^{-3}
80%	0.20	3.26×10^{-4}	7.67×10^{-4}	8.98×10^{-4}
90%	0.10	1.63×10^{-4}	3.83×10^{-4}	4.49×10^{-4}
95%	0.05	8.16×10^{-5}	1.92×10^{-4}	2.24×10^{-4}
96%	0.04	6.53×10^{-5}	1.53×10^{-4}	1.80×10^{-4}
99%	0.01	1.63×10^{-5}	3.83×10^{-5}	4.49×10^{-5}
99.5%	0.005	8.16×10^{-6}	1.92×10^{-5}	2.24×10^{-5}

Table 13.15: Probability of encounter at avoidance rates from 50 to 99.5%

13.277 The results show that the application of an avoidance rate for smolts reduce the probability of an encounter to between 8.16×10^{-4} for a 50% avoidance rate to 8.16×10^{-6} for a 99.5% avoidance rate. These probabilities equate to between 6,807 and 68 smolts or 0.08% to less than 0.001% of the smolt population that migrates through the Pentland Firth. For 1SW adults the probabilities range from 1.92×10^{-3} to 1.92×10^{-5} which equates to between 522 and 5 1SW salmon or 0.19% to 0.002% of the 1SW population. For MSW adults slightly higher probabilities are seen, from 2.24×10^{-3} to 2.24×10^{-5}, resulting in numbers of MSW fish of between 455 and 5 or between 0.22% and 0.002% of the MSW population.

13.278 At a population level this proportion is unlikely to have any significant population effects even if we were to assume that every encounter resulted in a physical injury, disorientation or mortality. Application of avoidance rates of between 50 and 99.5% show that population level effects are further reduced and even with a low avoidance rate of 50% are reduced to 0.1% or less of the regional population of smolts and 0.2% or less for both 1SW and MSW adults. With higher avoidance rates which are consistent with the conclusions drawn by ABPmer (2010) and the assumption that fish are equally as capable at avoiding moving objects as birds, the encounter rate is further reduced. At the assumed rate of 95% the proportion of the population of 1SW and MSW adults is less than 0.002% and smolts 0.001%.

13.279 In addition evidence may suggest smolts swim in the surface waters and that adults spend significant time in the top 10m of the water column (Malcolm *et al*., 2010). If a probability of smolts and adult salmon encountering the array based on the height they swim in the water column was applied to the model then the encounter probability and numbers of fish encountering the array would be further reduced.

13.280 The encounter study (Xodus, 2012) also included a much smaller area than may be used for migration by using the narrowest part of the Pentland Firth. However even with the precautionary approach the numbers that are estimated, even without applying avoidance criteria, are relatively small and are unlikely to affect the total numbers of fish that reach their rivers each year. It is likely that the vast majority of fish would make it back to their rivers. In addition the study did not take into account the potential that smolts and adult salmon will spend a significant proportion of their time in surface waters during their migrations based on data from Norway and Canada (Malcolm *et al*., 2010). Smolts may be found in the first 6m of the water column column (Davidson *et al.,* 2008; Plantelech Manel-La *et al*., 2009) and adults between 4 and 10m of the surface (Holm *et al*., 2005; Starlaugsson, 1995). Adults will they often dive, sometimes to depths of 280m in order to feed but the lack of food species (e.g. herring, sandeels and juvenile fish) in the Project area would suggest these dives are unlikely. Therefore, the probability of encounter may be further reduced if the depth at which smolts and adults swim is also considered. In addition, it is likely that smolts may hug the coastline on their initial migrations (Malcolm *et al*., 2010), further reducing the probability that they will encounter the turbines. Areas of high current such as the Inner Sound may also be avoided (J. Godfrey, pers. comm., 2011) so that smolts and adults may only move through the Inner Sound at slack tides when the turbines and not operational.. This will further reduce the encounter rates estimated by Xodus (2012) ensuring any population effects are minimal.

Impacts to other migratory species

13.281 In terms of the impacts to other migratory fish species it is likely that any impacts will be lesser than those experienced by salmon. For instance adult eels may also use the Pentland Firth during their migrations and being hearing specialists they have a much larger range at which behavioural avoidance of the noise of the turbines will occur (see Table 13.14). Therefore, encounters for these fish may be less likely than for salmon, if not the probabilities of an encounter will at least be similar. Therefore, there is the potential for the majority of the population to avoid the array and use the remaining accessible space to complete their migrations. Given the results of the encounter modelling above it is unlikely that a significant proportion of the eel population would be affected.

13.282 For sea trout the encounter rate will be no greater than that of salmon and is potentially reduced as there is some evidence from Norway to suggest sea trout spend most of their time in the top 6m of the water column (Malcolm *et al.,* 2010). Sea trout also dive in order to feed but the lack of prey speciesin the Inner Sound suggests this behaviour would be unlikely. These dives are relatively infrequent and given the results for salmon it is unlikely that sea trout will be affected to any greater extent.

13.283 Sea lamprey may also be affected but would not be expected to be impacted to any greater extent than sea trout and eels. The migratory habits of sea lamprey are not known but they are not expected to migrate in large numbers through the Pentland Firth in the same way as salmon. Therefore, encounter rates are expected to be much lower.

Impacts to marine fish species

13.284 For other fish species it is difficult to estimate the populations that pass through the Pentland Firth. Most of these species are highly mobile and range over most of the North Sea, Northeast Atlantic and the north coast of Scotland. Data is not available on the proportion that passes through the Project area or even the Pentland Firth. Populations that do not undergo extensive migration in the manner of salmonids and eels their much wider distribution and marine based life histories make them less susceptible to population level impacts from encounters with the turbine array.

13.285 Table 13.14 suggest that pelagic bony fish will be able to avoid the devices at close range and the hearing sensitivity of some species enables them to detect the turbine array at long range (i.e. herring). Overall their ability to evade the turbines is considered to be equally as good as salmon and if they do encounter the array they will be able to avoid it in a similar way to salmon. A similar ability to avoid the turbines is considered for demersal fish which have a similar hearing capability to salmon (medium, see Section 13.6.3). For demersal elasmobranchs the 4.5m clearance above the seabed ensures that impacts are unlikely. Pelagic elasmobranchs are considered less able to evade the turbines. However, given the low density of basking sharks (the main species of concern in this category) impacts are likely to be very low. Other pelagic elasmobranchs such as shortfin mako are highly manoeuvrable predators that chase fast moving prey and are likely to be able to take evasive action. They are also expected to be present in low numbers. As a result the impacts to other marine fish species, either due to their wide distribution, hearing capabilities, ability to evade the turbines or their low densities, are expected to be similar or lower than impacts to salmon.

Impact significance

13.286 Taking Atlantic salmon forward into the assessment their sensitivity to the impact is considered to be very high due to their migrations taking the vast majority of the east coast population through the Pentland Firth and their conservation status under Annex II of the Habitats Directive. However, based on the results suggesting that the proportion of the population affected is likely to be imperceptible among natural variation in the population the magnitude of the impact is considered to be negligible.

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Very high	Negligible	Minor	Not Significant

MITIGATION IN RELATION TO IMPACT 13.17
▪ Although no significant impact has been identified, mitigation measures have been provided on a precautionary approach to ensure this remains the case and impact predictions made here are correct. ▪ MeyGen accepts that there is uncertainty about some potential impacts from the Project and is committed to undertaking a post installation monitoring programme in order to determine the nature of those impacts. Appropriate monitoring will be agreed with Marine Scotland. ▪ To the extent further mitigation is required over and above the first mitigation proposed for Impact 13.15, MeyGen is committed to working with the regulator to identify reasonable measures to mitigated against this impact. ▪ As a result no specific mitigation measures for this impact have been identified but ongoing research by Marine Scotland and their advisors which will be monitored for further indications of successful mitigation strategies.

13.7.7 Impact 13.18: Changes in water flow

13.287 The changes in water flow resulting from extraction of tidal energy will potentially impact on habitats and species that are sensitive to changes in tidal flows and wave exposure. For fish species this impact mainly applies to herring spawning grounds and sandeel, which have high and medium sensitivity (Faber Maunsell, 2007, Table 13.10).

13.288 However, as noted above herring spawning grounds and sandeels are not present in the vicinity of the turbine deployment area. Therefore, the sensitivity of receptor is considered negligible. Modelling undertaken to understand the impact on the hydrodynamic regime in the vicinity of the Project shows no impact to water flow in the area (see Section 9) and the magnitude of impact is therefore considered to be minor.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Negligible	Minor	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.18
▪ No mitigation measures proposed as no significant impact predicted.

13.7.8 Impact 13.19: Changes to prey species

13.289 The potential for the Project to cause changes to prey species such as benthic invertebrates and bony fish is limited (Section 10 Benthic Habitats and Ecology, Section 13.6 and Section 13.7). As discussed in this section the main prey species of other fish are small clupeids such as herring and sandeels, other small fish such as Norway pout and juvenile cod, whiting, saithe and other gadoids. The nursery areas for most of these species are unlikely to be impacted and it is unlikely that the availability of juvenile fish will change to an extent that they will be less available to predators. The same can be said for herring and sandeels as the Project area represents unsuitable substrate for spawning animals. It is also likely that turbine noise will cause most fish species to move away from the area so that they will still be available to predators that have also moved from the area. However, there is the potential for some prey to find refuge in the turbine array making them unavailable to predators that no longer move within the area occupied by the turbines.

13.290 As the majority of fish species in the area are free ranging and roam over large areas of the sea they are unlikely to be resident in the Project area. Even if they do move into the turbine array area they will not be resident for long and any population overspill (due to limited increases in populations) will add to the populations available both within and outside the array. In addition the small area that the Project covers is unlikely to provide a refuge habitat for most of these species to hide from predators. Any fish species that move from the area during operation will not become more available to predators by making them more concentrated in surrounding areas as they are generally mobile and will not be concentrated within particular areas. Therefore, increased predation on prey species that could affect population sizes is very unlikely to occur.

13.291 Given that impacts to benthic and fish prey species are considered to be generally negligible the magnitude of impact is also considered to be negligible. The species that feed in the Pentland Firth are highly mobile and will be able to access food resource sin other areas or once they have passed through the Project area. Therefore the sensitivity is also considered to be negligible.

Impact significance

Sensitivity of receptor	Magnitude of impact	Consequence	Significance
Negligible	Minor	Negligible	Not Significant

MITIGATION IN RELATION TO IMPACT 13.19
▪ No mitigation measures proposed as no significant impact predicted.

13.7.9 Impact 13.20: Accidental spillage from vessels

13.292 The vessels to be used during operations and maintenance will be the same size or smaller than those during construction and installation and will therefore have similar inventories of oil. The likelihood of spillage, mitigation measures and residual impacts are the same as those described for vessel spillage during construction and installation (Impact 13.8).

13.8 Impacts during Decommissioning

13.293 The potential impacts during decommissioning are expected to be, at worst of the same nature and magnitudes as those during the construction phase. The impacts considered during the construction phase which would also be applicable to decommissioning include:

- Changes to spawning and nursery grounds and prey species;
- Noise generated during recovery and vessel activities;
- Disturbance due to removal activities;
- Increased turbidity and potential smothering due to removal activities;
- Disturbance and release of sediment bound contaminants;
- Introduction of non-native marine species; and
- Accidental spillage from vessels.

13.294 The mitigation proposed to minimise potential impacts will be the same as the mitigation proposed during construction and installation.

13.9 Potential Variances in Environmental Impacts

13.295 The impact assessment above has assessed the worst case Project options with regards to impact to fish ecology. This section provides a brief overview of the potential variances between the worst case Project option assessed and alternative Project options. The Project option that could potentially be used, but has not been assessed specifically above is the use of gravity and pin piles based TSSs instead of monopiles.

13.296 The installation of gravity based TSSs would have a lesser impact on fish ecology than the installation of the monopiled TSSs. The installation of the gravity base TSSs would generate less noise during installation, due to there not being a requirement to drill, the installation would not release drill cuttings or fluids into the marine environment during installation; reducing the risk of smothering and changes to turbidity.

13.297 For impacts to the seabed the footprint of the gravity based TSSs has been assessed as this would result in a larger footprint on the seabed (30 x 20m for each gravity based TSS compared to 10 x 10m for monopiled). The use of the monopile TSS would reduce the areas lost from fish spawning and nursery grounds and indirect impacts on benthic prey species.

13.298 For drill cuttings and release of fluids the use of pin piles will reduce the volume of cuttings produced. For monpiles the amount of drill cuttings released per socket will be 200m^3 whereas pin piles will only produce 5m^3 per socket, a total of 15m^3 per TSS.

13.299 In addition, should the export cable boreholes emerge from the seabed closer to the array site and therefore occupy a smaller physical area of the seabed this has the potential to reduce a number of impacts. These impacts include a reduction in a loss from fish spawning and nursery grounds, indirect impacts on benthic prey species through a reduction in direct seabed footprint and the potential for impact from EMF, as EMF emitted from the cables could be dampened as they transmit through the bedrock before they reach the seabed surface.

13.300 In terms of noise impact, the use of 86 turbines of 1MW will result in a lesser noise impact than if 36 turbines of 2.4MW are used. The range at which hearing specialists elicit a strong avoidance will be reduced by 4m and a mild avoidance by 5m.

13.301 When the barrier effect is considered the 36 turbines of 2.4MW will represent a less wide barrier even if the effect of a noise barrier is considered as each row will only contain less turbines, thus reducing the barrier presented to fish even if the greater noise form the 2.4MW devices is considered.

13.302 For collision risk the installation of 36 turbines of 2.4MW will further reduce the probability of salmon (or any fish) encountering the array. The area of the Pentland Firth occupied by the array will be much smaller, therefore, the probability of encountering a turbine will be greatly reduced.

13.10 Cumulative Impacts

13.10.1 Introduction

13.303 MeyGen has in consultation with Marine Scotland and The Highland Council identified a list of other projects (MeyGen, 2011a) which together with the Project may result in potential cumulative impacts. The list of these projects including details of their status at the time of the EIA and a map showing their location is provided in Section 8; Table 8.3 and Figure 8.1 respectively.

13.304 Having considered the information presently available in the public domain on the projects for which there is a potential for cumulative impacts, Table 13.616 below indicates those with the potential to result in cumulative impacts from a Fish Ecology perspective. The consideration of which projects could result in potential cumulative impacts is based on the results of the project specific impact assessment together with the expert judgement of the specialist consultant.

Project title	Potential for cumulative impact	Project title	Potential for cumulative impact	Project title	Potential for cumulative impact
MeyGen Limited, MeyGen Tidal Energy Project, Phase 2	✓	SHETL, HVDC cable (onshore to an existing substation near Keith in Moray)	✓	OPL, Ocean Power Technologies (OPT) wave power ocean trial	✓
ScottishPower Renewables UK Limited, Ness of Duncansby Tidal Energy Project	✓	Brough Head Wave Farm Limited, Brough Head Wave Energy Project	✗	MORL, Moray Offshore Renewables Ltd (MORL) offshore windfarm	✓
Pelamis Wave Power, Farr Point Wave Energy Project	✓	SSE Renewables Developments (UK) Limited, Costa Head Wave Energy Project	✗	SSE and Talisman, Beatrice offshore Windfarm Demonstrator Project	✓
Sea Generation (Brough Ness) Limited, Brough Ness Tidal Energy Project	✓	EON Climate & Renewables UK Developments Limited, West Orkney North Wave Energy Project	✗	BOWL, Beatrice Offshore Windfarm Ltd (BOWL) offshore windfarm	✓
Cantick Head Tidal Development Limited, Cantick Head Tidal Energy Project	✓	EON Climate & Renewables UK Developments Limited, West Orkney South Wave Energy Project	✗	Northern Isles Salmon, Chalmers Hope salmon cage site	✗
SSE, Caithness HVDC Connection - Converter station	✗	ScottishPower Renewables UK Limited, Marwick Head Wave Energy Project	✗	Northern Isles Salmon, Pegal Bay salmon cage site	✗
SSE, Caithness HVDC Connection - Cable	✗	SSE Renewables Developments (UK) Limited, Westray South	✗	Northern Isles Salmon, Lyrawa salmon cage site	✗

Project title	Potential for cumulative impact	Project title	Potential for cumulative impact	Project title	Potential for cumulative impact
		Tidal Energy Project			
RWE npower renewables, Stroupster Windfarm	×	EMEC, Wave Energy test site (Billia Croo, Orkney)	×	Scottish Sea Farms, Bring Head salmon cage site	×
SSE, Gills Bay 132 kV / 33 k V Substation Phase 1: substation and overhead cables (AC)	×	EMEC, Tidal energy test site (Fall of Warness, Orkney)	×	Northern Isles Salmon, Cava South salmon cage site	×
SSE, Gills Bay 132 kV / 33 k V Substation Phase 2: HVDC converter station and new DC buried cable	×	EMEC, Intermediate wave energy test site (St Mary's Bay, Orkney)	×	Scottish Sea Farms, Toyness salmon cage site	×
SHETL, HVDC cable (offshore Moray Firth)	×	EMEC, Intermediate tidal energy test site (Head of Holland, Orkney)	×	Northern Isles Salmon, West Fara salmon cage site	×

Table 13.16: Summary of potential cumulative impacts

13.305 The following sections summarise the nature of the potential cumulative impacts for each potential project phase:

- Construction and installation;
- Operations and maintenance; and
- Decommissioning.

13.10.2 Potential cumulative impacts during construction and installation

13.306 All of the projects listed above have the potential to contribute cumulatively during construction and installation to all of the potential impacts identified and discussed throughout the fish ecology impact assessment. These impacts include:

- Changes to spawning and nursery grounds and prey species due to activities which affect the seabed;
- Noise generated during vessel activities;
- Increased turbidity and potential smothering;
- Disturbance and release of sediment bound contaminants;
- Introduction of non-native marine species; and
- Accidental pollution events.

13.307 Currently there is no information regarding proposed installation dates and therefore it is difficult to assess whether they will occur at the same time as the MeyGen Project. However, cumulative impacts arising from installation of multiple marine renewable projects at the same time as the proposed installation are not anticipated as the majority of impacts are expected to localised (e.g. turbidity, smothering and release of drill cuttings and fluids[9]). It is however possible for cumulative and in-combination impacts to fish to arise from operation and maintenance of the MeyGen Project and the construction, installation operation and maintenance of these other projects in the Pentland Firth and the wider east coast of Scotland.

13.308 The installation of additional projects in the Pentland Firth and the wider east coast of Scotland has the potential to contribute to increased loss of fish spawning and nursery grounds. The spawning and nursery grounds within which the MeyGen Project is located are part of much wider areas, where these areas are not necessarily fixed spatially or temporally. As a result it is unlikely that cumulative impacts of increased loss of spawning and nursery grounds within the Pentland Firth will have an impact magnitude of greater than minor. In addition any impacts from increased sedimentation, introduction of non-native marine species and the release of sediment bound contaminants are unlikely to have a cumulative impact as the projects will all be at different stages of development. For these impacts a cumulative impact of a magnitude of minor or less would be expected.

13.309 In terms of accidental events, the likelihood of an oil spill at two project sites simultaneously is considered to be extremely remote and as a result cumulative impacts are unlikely to occur. In the event that such an incident did occur, measures will be in place to ensure the incident is tackled immediately and contingency plans to minimise environmental impacts implemented. Given the nature of an accidental event i.e. non routine, the likelihood for cumulative impacts is considered to be extremely remote. However, given that operations may be ongoing simultaneously there will be a slight increase in the risk of oil spills. Other projects will also have management and mitigation in place to reduce/remove the likelihood of an accidental event. As a result it is considered that any impacts will be remain not significant.

13.310 The installation of additional projects in the Pentland Firth and the wider east coast of Scotland has the potential to contribute underwater noise which could impact fish species. Of the noise generated during construction, vessel and drilling noise was considered to be undetectable by all fish species greater than 1m of the source and no mortality of injury was considered to result from the noise generated. The other proposed projects are some distance from the current Project (see above) and as a result there is little likelihood of in-combination or cumulative noise impacts from the current Project and other proposed projects in the vicinity.

13.10.3 Potential cumulative impacts during operations and maintenance

13.311 All of the projects listed above have the potential to contribute cumulatively during operations and maintenance of the Project. These impacts include:

- Noise generated during vessel activities and turbine operation;
- Risk of encountering the turbines during operation (only for the tidal stream project listed in Table 13.6);
- Barrier effects during operation (only for the tidal stream project listed in Table 13.6);
- EMF disruption due to installation of offshore electrical cables; and
- Accidental pollution event during maintenance operations.

13.312 The installation of additional projects in the Pentland Firth and the wider east coast of Scotland has the potential to contribute underwater noise which could impact fish species. Of the noise generated during all phases of the MeyGen Project, it could at worse cause mild behavioural impact to fish species up to 68m from the array (operation of 36 turbines of 2,4MW). There are no other proposed projects within this distance of the current Project (see above) and as a result there is little likelihood of in-combination or cumulative noise impacts from the current Project and other proposed projects in the vicinity.

[9] Cumulative impacts from discharges of drill cuttings would only be a potential impact if other developers used piled foundations.

13.313 The installation of additional projects in the Pentland Firth and the wider east coast of Scotland and their associated cabling increases the sources from which EMF could be emitted. However, as outlined in Section 13.7.4 the possible negative effects of EMF are considered to be localised in nature as a result it is unlikely that cumulative impacts of EMF from multiple marine renewable projects in the Pentland Firth will result in an impact magnitude of greater than minor.

13.314 Marine renewable developments have the potential to form a barrier to usual migration and transit patterns of fish species. In general such developments have the potential to act as a barrier because of the physical presence of the turbines, aversive reactions to underwater noise, EMF or perceptions of devices and associated infrastructure. As outlined in Section 13.7.5 this impact is particularly pertinent in more constrained environments, such as mouths of sea lochs or in narrow sounds. The Pentland Firth is a wide (~15km) channel and all the proposed marine renewable projects within it are not located in the centre of the channel. As a result it is not anticipated that the cumulative impacts of barriers to movements from multiple marine renewable projects in the Pentland Firth will result an impact magnitude of greater than minor.

13.315 As outlined in Section 13.7.6 encounters with marine renewable energy devices is considered to be a key potential effect during device operation (Faber Maunsell, 2007). Of the proposed marine renewable projects in the Pentland Firth the largest areas that potentially could be developed are the Ness of Duncansby tidal energy project and the MeyGen Tidal Energy Project, Phase 2. These projects also sit within the migration path of Atlantic salmon.

13.316 Given the results of the encounter study (Xodus, 2012) the population level effects are unlikely to be significant even if the proportions increased based on the presence of these projects. Given the scale of this development (95MW for the Ness of Duncansby and 312MW for the MeyGen Tidal Energy Project, Phase 2), there is the potential for a cumulative impact to occur. However, in relation to the width of the Pentland Firth it is considered unlikely that the magnitude of the impact will increase significantly. The number of turbines in a row for the MeyGen Tidal Energy Project, Phase 2 will not increase above that of Phase 1. The maximum number of turbines in a row will be 11. Therefore, the proportion of the width of the Pentland Firth occupied by the Project will remain the same and the encounter probability will not increase. For the Ness of Duncansby site the potential is that the encounter probability may double. However, given the probabilities estimated it is unlikely this will cause any significant effects. As both smolts and adults are likely to swim in the top 6 to 10m of the water column it is likely that that most tof the salmon population migrating through the Pentland Firth will also swim above the Ness of Duncansby site and the MeyGen Tidal Energy Project, Phase 2. Therefore, it is unlikely that any significant effects will occur. However, as outlined in Section 13.7.6 MeyGen accepts that there is uncertainty about some potential impacts from the Project and is committed to undertaking a post installation monitoring programme in order to determine the nature of those impacts. Appropriate monitoring will be agreed with Marine Scotland. The findings of this programme have the potential to further understand potential cumulative impacts of encounters from these other proposed marine renewable developments in the future.

13.317 Through EIA scoping, Marine Scotland expressed concerns over the possibility of cumulative effects from the displacement of predatory fish and fishing activity and the potential effects on nearby spawning grounds to the east and west of Stroma (Section 13.5). Section 14 Commercial Fisheries outlines that the local conditions and tidal currents within the development area are largely unsuitable for mobile gear types such as dredging and trawling and the main gear types used for fishing in the area are static and mainly take the form of creeling or pots targeting shellfish species. As a result there is no risk of the displacement of fishing activity for fish species adversely effecting nearby spawning grounds. Should the development result in the displacement of predatory fish it could also result in the displacement of prey fish species, marine mammals and bird species. As a result the displacement effects would largely be balanced out, and the perceived alteration in displacement would be minimal.

13.318 In terms of accidental events, the likelihood of an oil spill at two project sites simultaneously is considered to be extremely remote and as a result cumulative impacts are unlikely to occur. In the event that such an incident did occur, measures will be in place to ensure the incident is tackled immediately and contingency plans to minimise environmental impacts implemented. Given the nature of an accidental event i.e. non routine, the likelihood for cumulative impacts caused by accidental events (i.e. an accidental event occurring in the same time period at one or more of detailed projects and this Project) is considered to be extremely remote. However, given that operations may be ongoing simultaneously there will be a slight increase in the risk of oil spills. Other projects will also have management and mitigation in place to reduce/remove the likelihood of an accidental event. As a result it is considered that any impacts will be remain not significant.

13.10.4 Potential cumulative impacts during decommissioning

13.319 Although it is possible that a number of the impacts that may occur during decommissioning (e.g. noise emissions, seabed impact) could act cumulatively with other developments, there is limited scope for much of this since it is highly unlikely that the other developments would be decommissioned at the same time as this development, or that of the MeyGen Phase 2 project (which would likely be decommissioned at the same time as the proposed Project).

13.10.5 Mitigation requirements for potential cumulative impacts

13.320 No mitigation is required over and above the Project specific mitigation.

13.11 Habitats Regulations Appraisal

13.321 For projects which could affect a Natura site, a competent authority (in this case Marine Scotland for offshore and The Highland Council for onshore) is required to determine whether the Project will have a likely significant effect on the qualifying interests of any Special Protection Areas (SPAs) and any Special Areas of Conservation (SACs). Depending on the outcome of this determination, the competent authority will undertake an Appropriate Assessment of the implications of the Project for the Natura site's conservation objectives. The responsibility for provision of information with which to inform the Appropriate Assessment rests with the applicant.

13.322 There are few SACs designated for fish species within the direct vicinity of the Project. However, due to the migratory nature of fish species for which SACs are designated, sites from further afield may be require consideration and therefore there has been a need to investigate the potential Likely Significant Effects on a large number of SAC sites designated for their fish interests. This assessment is presented in a separate HRA report (see HRA document on the supporting studies CD, MeyGen, 2012).

13.12 Proposed Monitoring

13.323 The majority of potential impacts on fish have been assessed as being not significant. The potential impact of EMF impact was assessed to be potentially significant before mitigation but not significant with the implementation of appropriate mitigation measures. Although the results conclude that the Project does not pose a significant risk to fish, MeyGen recognises that due to the emerging nature of the tidal energy industry there is uncertainty about some potential impacts especially where these have yet to be verified by operational monitoring in the industry.

13.324 Where impacts cannot be fully quantified (e.g. turbine collision risk). MeyGen is committed to developing a fish monitoring programme. This programme will be based on the 'Survey, Deploy And Monitor' strategy in accordance with Scottish Government policy (currently available in draft).

13.325 MeyGen has recognised that being the first application for a commercial scale tidal stream project in Scotland and the first from The Crown Estate's Pentland Firth and Orkney Waters leasing round, has meant that there is potential for the Project to form part of an industry wide strategic monitoring programme that will benefit future projects as well.

13.326 Where strategic monitoring is appropriate, MeyGen would look to a collaborative effort between the Project, wider industry, regulators and stakeholders to take this forward in the most efficient way for the interest of the Project and future projects elsewhere in Scotland and the UK.

13.327 With particular regard to diadromous (migratory routes and behaviour) and elasmobranch (behaviour) fish species, there is overarching lack of scientific data. MeyGen is aware of the strategic research being carried out by the Scottish Government and academic institutions will help reduce that knowledge gap which will help verify this EIA and give greater confidence in future assessments. However, based on the prohibitively high level of effort required and the non-site-specific nature it is not believed that this is something that an individual developer should be actively involved in.

13.328 As part of this EIA and the MeyGen commitment to post-installation monitoring, the draft SNH survey and monitoring guidance (MacLeod *et al*., 2011; Sparling *et al*., 2011) has been reviewed. Although this guidance does not, and cannot, give specific details of what fish monitoring should take place, based on the general approaches described and on current knowledge of the site (obtained from the extensive baseline surveys), it is likely that the monitoring programme could include the following:

- Disturbance and displacement;
- Collection of underwater noise measurements of the candidate prototype tidal turbines. The data collected will be used to validate the underwater noise modelling completed to inform the impact assessment; and
- Collision Risk. MeyGen believes that understanding fish behaviour around tidal turbines and the risk of collisions occurring is fundamental for the industry to progress. It is therefore proposed that this potential impact is considered as strategic research and therefore monitoring development in cooperation with regulators, stakeholders and other developers. Monitoring could include: Installation of one or more active monitoring systems on one or more tidal device to better understand the near-field response of fish species to operating tidal devices.

13.329 The EIA has concluded that the Project could have a potentially significant impact on elasmobranch species. The effect of EMF on these species is being researched by the Scottish Government and it is understood that this will give greater confidence in the assessment and the mitigation outlined. MeyGen does not propose any site-specific monitoring for EMF impacts.

13.330 MeyGen will work with the regulator (Marine Scotland) and its advisory bodies (e.g. SNH) to agree the details of appropriate monitoring and will ensure that the monitoring programme is aligned with industry best practice. Methods for assessing disturbance and displacement impacts and collision risk can potentially be linked with similar effort required for Section 11 Marine Mammals and Section 12 Ornithology.

13.331 Where monitoring indicates that specific mitigating measures may be reasonably required, MeyGen is committed to put these in place.

13.13 Summary and Conclusions

13.332 A wide number of finfish species have the potential to be present in the Pentland Firth. In terms of anadromous fish the Atlantic salmon, sea trout and European eel all the potential to be present and each of which have afforded a least some conservation recognition under various conventions and regulations.

13.333 A number of elasmobranch species also have the potential or are known to be present in the Pentland Firth. These include the basking shark, spurdog, tope, lesser-spotted dogfish, porbeagle, kitefin shark, shortfin mako, blue shark, nurse hound and thornback, cuckoo and spotted rays. The Pentland Firth has been identified as nursery ground for spurdog, tope, thornback and the spotted rays (Ellis *et al*., 2010). A number of these elasmobranch species have been identified as of conservation importance under a number of conventions and pieces of legislation, in particular the basking shark.

13.334 In addition, a number of other important finfish species are likely to be present within the Pentland Firth. These include species of commercial importance (monkfish, herring, haddock, whiting, cod, megrim and saithe), species that are known to use the waters as nursery and/or spawning grounds (haddock, herring, lemon sole, saithe, anglerfish, blue whiting, cod, hake, ling mackerel, sandeel and whiting) and species that are considered to be important ecologically or particularly sensitive to activities associated with the Project (sandeels and herring).

13.335 A number of potential impacts associated with the construction, installation, operation, maintenance and decommissioning of the Project of fish ecology have been assessed. This assessment identified a number of key issues associated with fish ecology, including loss of spawning and nursery grounds, noise from construction, installation, operation, maintenance and decommissioning, EMF from the installed subsea cables and encounters with the array during turbine operation.

13.336 The seabed of the Project area is considered to be unsuitable for both herring and sandeel spawning, and as a result it is only possible that lemon sole could use the Project area for spawning. But as pelagic spawners and the area being part of a much larger spawning area the overall impact of loss of spawning grounds was considered to be negligible / not significant. Similarly, although the Project area is located within identified nursery areas for a number of fish species, these are part of much wider nursery grounds for all of these species and as such the impact is considered to be negligible / not significant.

13.337 Underwater noise will be generated during installation and operation of the Project. Fish hearing sensitivity differs between species, where species with a gas filled swim bladder, including those with a link to the inner ear, such as herring and cod are considered to be more sensitivity to noise than fish with no swimbladders, such as flat fish and elasmobranchs. Underwater noise impact modelling conducted by Kongsberg (2012) indicated that in the worst case noise generation scenario (operation of all 36 turbines of 2.4MW) would not result in lethal or physical injury to fish species and is unlikely to result in hearing damage. Strong avoidance behaviour by hearing specialist fish would occur up to 18m from the tidal array and mild behavioural avoidance up to 68m from the tidal array. Given that fish species are only likely to be impacted when passing through the Project area, the impacts are only likely to result in behavioural changes. Once the fish move away from the area they will no longer be impacted and the impact is considered to be minor / not significant.

13.338 A number of electrosensitive fish species are potential present within the Inner Sound, these include a number of elasmobranch’s, Atlantic salmon, European eel, sea trout, cod, plaice and mackerel. All of which are potentially at risk from the impacts of EMF, including salmonoids during their migrations. There is currently insufficient data available with which a judgement can be made about the potential for EMF to impact on a particular species. However, potential for impact is considered to be highest for species that depend on electroreception to detect benthic prey - skates, rays and dogfish (CMACS, 2005). The research conducted to date does not provide significant evidence to suggest any negative impacts on magnetically or electrically sensitive species as a result of EMF, however there is an overall degree of uncertainty over this issue. As a result the overall impact of EMF is considered to be moderate/ significant before the application of mitigation. Following application of mitigation measures including using natural crevices in the seabed to lay the cable, ensuring the cable bores are as long as possible and bundling the cables together the impact is reduced to minor/not significant. MeyGen is committed to continued consultation with Marine Scotland and SNH and wider marine renewable stakeholders to ensure the Project is completed and operated to the most up to date industry best practice.

13.339 Collision with rotating turbines is considered to be a key potential effect during device operation (Faber Maunsell, 2007). A number of reports have been commissioned in recent years which provide useful overviews of the factors likely to influence collision risks posed by marine renewable energy devices (Wilson *et al*., 2007; ABPmer, 2010). However, there is a lack of empirical knowledge it is still not possible to quantify the risk posed by the Project. Based on a precautionary encounter study based on the Band model for birds the overall impact of collision risk is considered to be minor/not significant. No specific mitigation measures were identified for this impact; however MeyGen is committed to working with the regulator to identify reasonable measures to mitigate against this impact. Additionally, MeyGen is committed to undertaking a post installation monitoring programme in order to determine the nature of this impact, with the appropriate monitoring to be agreed with Marine Scotland.

13.340 Overall through the implementation of proposed mitigation strategies and commitments the impact of the proposed Project on fish ecology is considered to be not significant.

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