# 11 MARINE MAMMALS

11.1 The table below provides a list of all the supporting studies which relate to the marine mammal impact assessment. All supporting studies are provided on the accompanying CD.

| Details of study | Location on supporting studies CD |
|---|---|
| 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 |
| Analysis of towed hydrophone data collected for MeyGen (Ecologic UK, 2011) | OFFSHORE\Marine Wildlife\Marine mammals |
| Underwater noise baseline survey and acoustic emission propagation modelling (Kongsberg, 2012) | OFFSHORE\Marine Wildlife\Underwater noise |
| MeyGen tidal stream turbine array environmental impact assessment: modelling encounter rate between turbines and marine mammals (SRSL, 2012) | OFFSHORE\Marine Wildlife\Marine mammals |

## 11.1 Introduction

11.2 As an integral part of the Environmental Impact Assessment (EIA) process, MeyGen must determine the potential impacts that deployment of the tidal turbines could have on marine mammals. This section assesses the potential for, and possible magnitude of, these impacts, as well as specifying appropriate mitigation measures where necessary. A number of specialists have contributed to this assessment:

- RPS – visual observation surveys and production of the baseline description (including input from Dr Caroline Weir);
- Dr Jonathon Gordon – acoustic monitoring survey;
- Scottish Association for Marine Science, Research Services Limited (SRSL) – marine mammal encounter modelling; and
- Xodus – Impact assessment and ES Section write up.

11.3 Although information on the interactions between marine mammals and novel tidal technologies is limited, this assessment draws upon a series of survey and technical reports prepared for MeyGen to better define this relationship, as well as considering expert opinion and the output from additional desk-based research. Where relevant there is consideration of the outcome of assessments undertaken to inform the consenting of other UK tidal energy projects at the European Marine Energy Centre (EMEC), in the Sound of Islay, in Strangford Lough and at the Skerries, off the coast of Anglesey, North Wales. Environmental monitoring of some tidal turbine prototypes is currently underway and where results are available these have been used (e.g. biannual reporting from Strangford Lough, MCT deployment in Northern Ireland and TGL deployment at EMEC). Information from the EMEC-based Reliable Data Acquisition Platform Tidal (ReDAPT) programme[1], which aims to deliver the most detailed environmental and performance information yet collected, is not available for inclusion in this Environmental Statement (ES) due to the programme being at an early stage[2]. The environmental information will be reviewed when made publicly available to ensure that this assessment and the associated mitigation measures are aligned with the most recent relevant data.

[1] The ReDAPT project is commissioned and funded by the Energy Technologies Institute and aims to install and test a 1MW tidal turbine at EMEC, delivering detailed environmental and performance information not previously achieved at this scale in real sea conditions. The performance data will be used to validate a variety of models and will provide substantial data on tidal resource and environmental assessment.

[2] TGL, the manufacturer of one of the candidate turbines is a key partner in the ReDAPT programme.

## 11.2 Assessment Parameters

### 11.2.1 Rochdale Envelope

11.4 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. 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.

11.5 Table 11.1 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 11.9.

| Project Parameter relevant to the assessment | | 'Maximum' Project parameter for impact assessment | Explanation of maximum Project parameter |
|---|---|---|---|
| **Turbines** | Number | 86 turbines | The encounter modelling considers up to the maximum proposed 86 turbines. |
| | Layout | 45m cross-flow spacing and 160m down-flow spacing | An indicative layout for 86 turbines has been used to inform the noise modelling. The indicative layout is based on 45m cross-flow spacing and 160m down-flow spacing.<br>A layout was not required for the encounter modelling. There is presently a lack of knowledge / evidence on how marine mammals navigate through an array of tidal turbines. |
| | Number of blades per rotor | Three blades | Increasing the number of blades increases the area surface area which mammals may encounter. |
| | Rotor diameter | 18/20m | As a general rule, increasing the rotor diameter increases the amount of water swept by the moving blades, increasing the likelihood of a mammal coming into contact with the blades.<br>However, the encounter risk modelling shows that either 18 or 20m rotor diameter may be considered worst case (see Table 11.16) depending on which species is being considered, due to differences in depth distribution behaviour for different species. |
| | Maximum height of nacelle above seabed | 14.5/16 m | This value is used to calculate the depth horizon swept by the turbine, which will have an effect on which species are likely to encounter it, since different species make different use of the water column. This value differs depending on whether the 18m or 20m diameter rotors are being considered.<br>The encounter risk modelling shows that either 18 or 20m rotor diameter may be considered worst case (see Table 11.16) depending on which species is being considered, due to differences in depth distribution behaviour for different species. |
| | Minimum clearance between sea surface and turbine blade | 8m | This value is used to calculate the depth horizon swept by the turbine, which will have an effect on which species are likely to encounter it, since different species make different use of the water column. |
| | Clearance from blade tip to seabed | 5.5/6.5 m | The minimum clearance between the turbine blade tip and the seabed is 5.5m for the 18 m diameter rotors and 6.5 m for the 20 m diameter rotors. This value is used to calculate the depth horizon swept by the turbine, which will have an effect on which |

| | | | |
|---|---|---|---|
| | | | species are likely to encounter it.<br>The encounter risk modelling shows that either 18 or 20m rotor diameter may be considered worst case (see Table 11.16) depending on which species is being considered, due to differences in depth distribution behaviour for different species. |
| | Blade thickness | 0.3 m (average blade thickness) | The encounter model requires an average blade thickness as a model input. Blade thickness tapers towards the end of the blade and therefore the model uses average thickness across the length of the blade. |
| | Cut in flow speed | 0.5m/s | The 18m and 20m diameter designs start operating in tidal flows of 0.5m/s. Cut in velocity influences the period of time during the tidal cycle when the turbine blades are rotating. This parameter is an input to the encounter model. |
| | Cut out flow speed | 4.5m/s for 18m rotor diameter<br>4.5m/s for 20m diameter rotor | Either three bladed, 18m or 20m rotor diameter may be considered worst case in the encounter modelling depending on which species is being considered. As the two different turbines designs have slightly different cut out speeds, both are considered worst case parameters.<br>The encounter risk modelling shows that either 18 or 20m rotor diameter may be considered worst case (see Table 11.16) depending on which species is being considered, due to differences in depth distribution behaviour for different species.<br>Cut out velocity influences the period of time during the tidal cycle when the turbine blades are rotating. This parameter is an input to the encounter model. |
| | Rotational speed | 8rpm (at cut in) to 14rpm (maximum) for 18m diameter, three blades<br>8rpm (at cut in) to 20rpm (maximum) for 20m diameter, three blades | Either three bladed, 18m or 20m rotor diameter may be considered worst case in the encounter modelling, depending on which species is being considered. As the two different designs have slightly different rotational speeds, both are considered worst case parameters.<br>The encounter risk modelling shows that either 18 or 20m rotor diameter may be considered worst case (see Table 11.16) depending on which species is being considered, due to differences in depth distribution behaviour for different species.<br>The speed of the turbine blades influences the relative velocity of the blades and marine mammal. This parameter is an input to the encounter model. |
| | Operational noise | 36 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 drill cuttings released into marine environment | Monopile 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). |
| | 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 1m. |
| | 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 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.<br>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 | One Dynamic Positioning (DP) vessel for the duration of the installation for year one and two and two DP vessels for year three installation | Installation activities will be carried out by a single DP vessel during year one and two, all installation activities to be undertaken using a single DP vessel.<br>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.<br>Year three installation will require a maximum two DP vessels for TSS installation. These two vessels may be present on site at the same time during year three. |
| | Installation vessel noise | Tug vessel noise | Noise data for DP vessels are currently unavailable. Of the vessel noise data available 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 1m. |
| | Maintenance vessel physical presence | One DP vessel present every 2.8 days | Based on a maximum 86 turbine array, one 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 | Noise data for DP vessels are currently unavailable. Of the vessel noise data available tugs represent the noisiest vessels and are used to represent the highest possible noise source during maintenance operations. Tug source levels are 172 dB re 1 µPa at 1m. |

Table 11.1: Rochdale Envelope parameters for the marine mammals assessment

### 11.2.2 Area of assessment

11.6 It is also important to define the geographical extent of the assessment area. The focus of the marine mammal impact assessment is potential impacts on marine mammals 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 range over which their populations can be found. Therefore, potential impacts have also been set in the context of a wider study area over which marine mammals encountered in the Project area are thought to range and in context of the regional populations for specific species.

## 11.3 Legislative Framework and Regulatory Context

### 11.3.1 Relevant legislation and guidance

11.7 In addition to the EIA Regulations the following legislation is key to the marine mammal assessment:

- EC Habitats Directive 92/43/EEC;
- Nature Conservation (Scotland) Act 2004;
- Wildlife and Countryside Act 1981;
- Conservation (Natural Habitats, &c.) Regulations 1994 (as amended);
- Bern Convention;
- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention); and
- Marine (Scotland) Act 2010 – Part 6 concerns the conservation of seals, and makes it an offence to kill, injure or take seals. The Act exempts activities for which a European Protected Species Licence has been granted (under Regulation 44 of the Conservation (Natural Habitats) Regulations 1994).

11.8 A review of all applicable legislation has been undertaken as part of the marine mammal baseline report (RPS, 2011a; available on the supporting studies CD) and is not repeated in full here.

11.9 The approach to the impact assessment has been developed with reference to the principals and guidance provided by Scottish Natural Heritage (SNH) on EIA (SNH, 2009), the MarLIN species and ecosystem sensitivities guidelines (Tyler-Walters *et al*., 2001) and the IEEM guidelines for marine ecological impact assessment (IEEM, 2010).

### 11.3.2 Conservation and management

#### *Cetaceans (whales and dolphins)*

11.10 All species of cetacean occurring in UK waters are protected under the Bern Convention and are listed in Annex IV (species of community interest in need of strict protection) of the EU Habitats Directive as European Protected Species (EPS) where the killing, disturbance or the destruction of these species or their habitat is banned (Article 12). Two species, the bottlenose dolphin *Tursiops truncatus* and the harbour porpoise *Phocoena phocoena*, are also listed in Annex II as species whose conservation requires the designation of Special Areas of Conservation (SAC). Cetaceans are listed in Schedule 5 of the Wildlife and Countryside Act 1981 which prohibits their deliberate killing, injuring or disturbance. The Nature Conservation (Scotland) Act 2004 makes amendments to the Wildlife and Countryside Act 1981 in Scottish waters, including the addition of 'reckless' acts to species protection which make it an offence to intentionally or recklessly disturb a cetacean. Selected species are also protected by the Bonn and OSPAR Conventions, and all toothed whales, or odontocetes, (except for the sperm whale) are protected under the ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas) Agreement.

11.11 Species of cetacean occurring regularly in UK waters are designated as UK Biodiversity Action Plan (UKBAP) species, and 18 species are included on the Scottish Biodiversity List. The conservation status of the species most frequently recorded in the Inner Sound is given in the baseline description (Section 11.5), whilst further information on the UKBAP and OSPAR lists is given in the Benthic Impact Assessment (Section 10). Seven cetacean and two seal species are listed on the Scottish Priority Marine Features List (PMF; SNH, 2011).

#### *Pinnipeds (seals)*

11.12 All pinniped species occurring in UK waters are listed in Appendix III of the Bern Convention and in Annex V of the EU Habitats Directive as species of community interest for which the taking in the wild and exploitation may be subject to management measures. Two species, the grey *Halichoerus grypus* and harbour *Phoca vitulina* seals, are also listed in Annex II as species whose conservation requires the designation of SACs. The harbour seal is a UK BAP priority species.

## 11.4 Assessment Methodology

### 11.4.1 Scoping and consultation

11.13 Since the commencement of the Project, consultation on marine mammal issues has been ongoing. Table 11.2 summarises all consultation relevant to marine mammals. In addition, relevant comments from the Scoping Opinion are summarised in Table 11.3, together with responses to the comments and reference to the ES sections relevant to the specific comment.

| Date | Stakeholder | Consultation | Topic/specific issue |
|---|---|---|---|
| 11th August 2009 | SNH | Meeting | Site visit and meeting to discuss bird and marine mammal survey methodology. |
| 24th September 2009 | SNH | Submission of document | Survey methodology |
| 17th November 2009 | SNH | Submission of document | Revised survey methodology |
| 24th December 2009 | SNH | Receipt of consultation | Confirmation on survey methodology changes |
| 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 Scoping Report | Request for Scoping Opinion from Marine Scotland and statutory consultees and request for comment from non-statutory consultees. |
| 6th May 2011 | Marine Scotland and SNH | Submission of document for comment | Submission of interim survey report summarising the results from first 18 months of survey. |
| 30th June – 2nd July 2011 | Local stakeholders | Public Event - EIA Scoping | Public event to collate information/opinions on proposed EIA scope. |
| 6th June 2011 | Marine Scotland and SNH | Meeting | Presentation of survey results from first 18 months of survey and discussion on EIA and cumulative impact assessment scope and HRA 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 (THC), statutory consultees and non-statutory consultees | Receipt of Scoping Opinion | Receipt of response to Scoping Report and other comments from non-statutory consultees. |
| 3rd October 2011 | Marine Scotland | Project update meeting | Report on EIA progress including presentation of survey results. |
| 20th October 2011 | Marine Scotland and SNH | Teleconference | Discussion on proposed scope of marine mammal encounter modelling. |
| 2nd November 2011 | Marine Scotland and SNH | Meeting | Discussion of proposed assessment methodology; data requirements; preliminary assessment results and HRA requirements. |

| Date | Stakeholder | Consultation | Topic/specific issue |
|---|---|---|---|
| 6th – 7th December 2011 | Local stakeholders | Public Event – pre application consultation | Public event to communicate the findings of the EIA to local stakeholders. |
| 16th February 2012 | Marine Scotland and SNH | Teleconference | Discussion of encounter modelling results and their interpretation. |
| 2nd March 2012 | Marine Scotland and SNH | Meeting | Final meeting to close out HRA approach to the Project. |

Table 11.2: Consultation undertaken in relation to marine mammals

| Name of organisation | Key concerns | Response | ES Section within which the specific issue is addressed |
|---|---|---|---|
| THC | Given the large ranging distance of cetaceans and other marine mammals, the cumulative impacts need to be considered regarding the potential effects with other proposed renewable developments | Dealt with as part of this ES Chapter; other developments as discussed with Marine Scotland have been included. | Section 11.10 Cumulative Impacts |
| Marine Scotland | The ES should show that the applicants have taken account of the relevant wildlife legislation and guidance. It needs to be categorically established which species are present on and near the site, and where, before the application is considered for consent.<br>The presence of protected species such as European Protected Species must be included and considered as part of the application process. | All chapters reference relevant legislation and guidance.<br>The presence of EPS has been considered within the relevant ES chapters. | Section 11.3 Legislation<br>Section 11.5 Baseline Description |
| Marine Scotland | Will the applicant utilise information from surveys being undertaken in the area by the Scottish Government and The Crown Estate and how will it, or their own data, be analysed? Expected uncertainty in the estimates of populations or distributions should be presented. | Full details of the data collected and analysis undertaken are in the Abundance and distribution of marine mammals in the Inner Sound and adjacent waters report (RPS, 2011a).<br>Baseline report addresses uncertainty in regional population numbers by presenting different survey estimates. Site density estimates numbers are presented with confidence intervals to quantify uncertainty.<br>Scottish Government and The Crown Estate commissioned work has not been published within a timeframe to allow consideration of these data in this assessment, but as site specific data has been collected this is not considered a critical data gap. | Summarised in Section 11.5 Baseline Description<br>Section 11.5 Baseline Studies and RPS (2011a)<br>N/A |
| Marine Scotland/SNH | Will the encounter model be temporally resolved?<br>Revise species list for encounter model based on baseline information.<br>Avoidance rates need to be included and explained.<br>Are cumulative issues being dealt with in the encounter modelling itself and, if so, how? | The model takes account of current velocity relating to tidal state where data allow<br>Species list revised<br>Avoidance rates included and full explanation given<br>Cumulative issues dealt with in the chapter but not explicitly in the modelling | SRSL Encounter Modelling (2012)<br>All described in Sections 11.6, 1.7 and 11.8 Impact Assessment except cumulative impacts which are discussed in Section 11.10 |
| SNH | We support MeyGen Ltd.'s commitment to the draft Survey, Deploy and Monitor Policy. Considering the lease area is situated within a highly sensitive location (i.e. adjacent to known important seal haulouts and in an area of high sightings of cetaceans), it is likely that extensive pre-development device testing and monitoring, and site characterisation surveys would be required. | Site specific characterisation surveys have been undertaken and where results from prototype monitoring are available these have been used to inform this impact assessment. Further pre-development monitoring will become available prior to turbine deployment and MeyGen will, as necessary, consider the results of this. | Section 11.5 Baseline Description and Section 11.6 Impact Assessment |
| SNH | Within the proposed development area EPS may be present both in the marine environment and consideration of these species must be included as part of the application process. | The presence of EPS is considered within this (and other relevant) ES chapters | Conservation status (including EPS) in the assessment rankings throughout Section 11 |
| SNH | With regard to seals we would draw attention to the SCOS 2009 report, the SNH report on harbour seal surveys in Orkney, and the recently published SNH report on the utilisation of space by seals in the Pentland Firth and Orkney waters. We highlight the sharp fall there has been in the UK population of harbour (common) seals and note that the applicant will need to consider this in their EIA. The harbour seal Potential Biological Removal (PBR) will need to be carefully considered in any assessment. | The data sources are noted and this impact assessment addresses the issues raised | Description of regional use by seals in Section 11.5 Baseline Description<br>Impact related to population numbers and PBR in Sections 11.6, 11.7 and 11.8 Impact Assessment |
| SNH | Certain haulout sites have been identified for protection under the Marine (Scotland) Act 2010; it is an offence to harass seals at these sites and we recommend that any works that may cause potential disturbance to seal haulouts is considered in the ES. The island of Stroma is important for harbour and grey seals – particularly for grey seal pupping – and is included in the proposed list for designated haulouts. | MeyGen will have due regard to the ongoing consultation on seal haul-out sites under the Marine (Scotland) Act and seal haul out sites considered as part of the EIA. | Haulout locations presented in Section 11.5 Baseline Description and impact on haulouts described where relevant in Sections 11.6 - 11.8 Impact Assessment |
| SNH | Survey results should be used to inform the likelihood of disturbance to cetaceans during the various phases of the proposal. The ES should provide information on the acoustic properties of any 'significant underwater noise' generating activities and the frequency and duration at which these will occur. We recommend that the potential impacts on marine mammals from noise are carefully assessed in the ES. The ES should also provide appropriate mitigation measures to avoid any potential impacts. The noise monitoring data gathered at EMEC should be used to inform the ES for the proposed | The potential impact of noise generated during operation on marine mammal species passing through the development has been considered as part of the impact assessment.<br>It was the intention for MeyGen to use underwater noise data measured from prototype 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 | Underwater noise baseline summary and acoustic emission propagation modelling has been undertaken (Kongsberg, 2012) and impact assessment presented in Sections 11.6, 11.7 and 11.8 |

| Name of organisation | Key concerns | Response | ES Section within which the specific issue is addressed |
|---|---|---|---|
| | deployment. | collected for candidate turbines to verify the modelling work. | |
| SNH | Collision risk will also need to be assessed, and the monitoring work at EMEC for both the Atlantis and TGL device should be used to inform the ES. | Reference made to the outcome of strain gauge monitoring conducted by TGL at the Falls of Warness EMEC test site. The results of this monitoring will also feed into the monitoring strategy that MeyGen propose to employ. | Section 11.7 Impact Assessment for Operations and Maintenance |
| SNH | Vessel collision should be included in the impact assessment. | This impact has been assessed | Sections 11.5 Baseline Description and 11.6 Impact Assessment |
| SNH | Harbour seals are vulnerable to any impacts which could lead to their further population decline or prevent their recovery. We highlight, therefore, the report by SMRU on the preliminary findings of investigations in to the causes of the recent number of "corkscrew" injuries to seals. The injuries are consistent with the seals being drawn through a ducted propeller such as a Kort nozzle or some types of Azimuth thrusters. | This marine mammal impact assessment has included consideration of potential 'corkscrew' injuries | Section 11.5 Baseline Description Sections 11.6, 11.7 Impact Assessment |

Table 11.3: Scoping comments relevant to marine mammals

### 11.4.2 Supporting studies

***Baseline report (RPS, 2011a)***

11.14 MeyGen commissioned RPS to prepare a marine mammal baseline report (RPS, 2011a; report provided on supporting studies CD) using a combination of a desk-based study of literature and available data sources, and an analysis of the baseline data collected during two years of MeyGen-commissioned boat- and shore-based surveys aimed at determining marine mammal distribution, abundance, seasonality and behaviour within the Inner Sound. The purpose of the report was to provide MeyGen with a robust understanding of existing marine mammal activity in and around the Inner Sound and thus establish a baseline against which the impact assessment can be undertaken.

11.15 Methods for boat and land based surveys were developed, trialled and refined in consultation with Marine Scotland and SNH. The boat-based surveys involved two approaches to data gathering; firstly, boat transect surveys based on modified European Seabird at Sea methods (Tasker *et al.*, 1984) collected distributional data and secondly, stationary boat surveys at fixed locations were used to collect behavioural data. All marine mammals encountered during the surveys (conducted between October 2009 and September 2011) were recorded along with details of species, numbers present, the precise time of day, direction of movement, and dive frequency/duration.

11.16 Land-based vantage point survey methods were adapted from approaches to terrestrial vantage point surveys; three vantage point locations on the Caithness coastline were selected and observations made during two to three visits each month over the same time period as the boat-based surveys. The area of sea scanned from each vantage point ranged out to a maximum distance of 2km. Marine mammal observations were recorded as per the boat-based surveys. The coverage of the boat- and land-based surveys is shown in Figure 11.1.

11.17 Sightings data gathered during boat-based transect surveys were mapped in a Geographical Information System (GIS) to show the distribution of sightings across the survey area and interpreted in conjunction with survey effort data. GIS plots were produced which displayed overall and seasonal animal relative abundance, showing marine mammal sightings overlying a 0.25km$^2$ grid in which cell shading indicates the number of animals sighted per km transect travelled.

11.18 Sightings data gathered during boat-based transect surveys were also analysed using DISTANCE software (Thomas *et al.*, 2009) to generate marine mammal density (number of animals per km$^2$) and abundance outputs. The number of sightings greatly effects how precise final estimates of density and abundance will be and therefore DISTANCE analysis was only relevant to those most frequently sighted marine mammals (harbour porpoise and grey seal).

11.19 Sightings data gathered during boat-based stationary point surveys and during land-based vantage point surveys were simply tabulated to show species occurrence in the survey area. It is envisaged that the dataset will provide a useful index against which to compare future monitoring data.

11.20 To provide a context to the site specific information, and to support the considerations given in the assessment to the distance over which species sighted in Inner Sound might range, RPS conducted a literature review on marine mammals of Orkney and Pentland Firth waters. Key literature reviewed included:

- Abundance and behaviour of cetaceans & basking sharks in the Pentland Firth and Orkney waters (Evans *et al*., 2010);
- Atlas of cetacean distribution in northwest European waters (Reid *et al*., 2003);
- SCANS I and II (Hammond *et al*., 1995, 2002, SCANS II, 2008);
- Special Committee on Seals (SCOS) reports (SCOS, 2009, 2010, 2011);
- Utilisation of space by grey and harbour seals in the Pentland Firth and Orkney waters (SMRU, 2011); and
- Strategic Environmental Assessment reports (Hammond *et al*., 2003, 2004, Scottish Executive, 2007).

***Acoustic monitoring (Ecologic, 2011)***

11.21 Harbour porpoises are small and undemonstrative cetaceans and thus can be difficult to sight at sea, especially when visual sighting conditions are not ideal. However, they vocalise frequently (Akamatsu *et al.*, 2007), producing characteristic 'click' vocalisation that can be detected at a range of several hundred metres using specialist acoustic detection equipment and acoustic analysis software. Towed hydrophone[3] systems for porpoises have been in development over the last few decades (Chappell *et al.*, 1996, Gillespie & Chappell, 2002, Gillespie *et al.*, In Press). Acoustic detection is generally less affected by weather conditions than visual detection and can continue in poor sighting conditions and at night, which are highly significant practical advantages. Previous extensive use has been made of Passive Acoustic Monitoring (PAM) during surveys for harbour porpoises in tidal rapid areas in Welsh waters where towed hydrophones have been reported as particularly useful for surveys in these habitats. They are unaffected by strong tidal currents which can lead to disturbed waters and poor sighting conditions even in good weather conditions.

[3] Hydrophones are microphones that detect sound underwater.

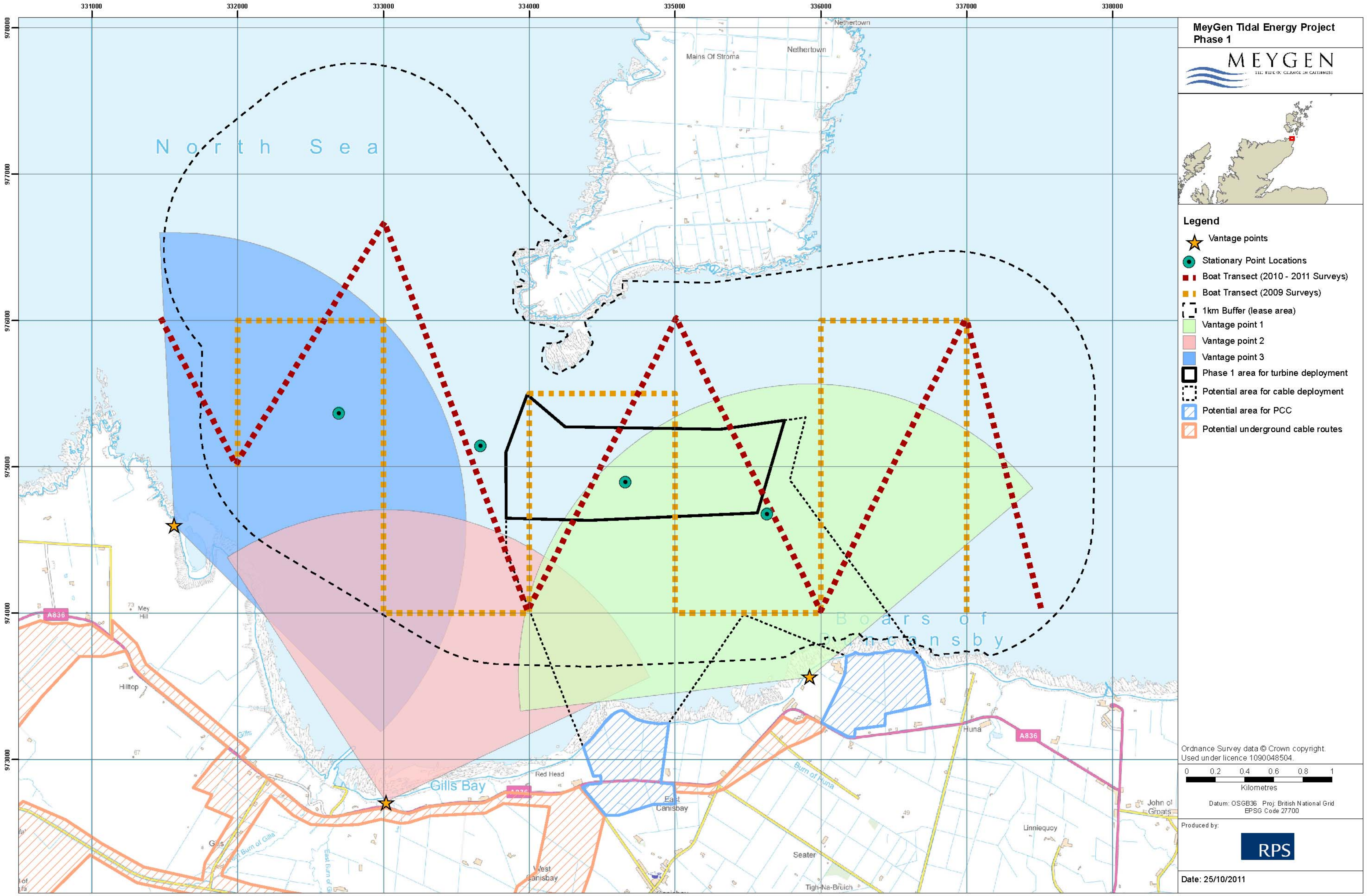


Figure 11.1: Boat survey route, static point locations and land based vantage point viewsheds for the Meygen Tidal Energy Project. The orange line indicates the boat route originally used (two surveys) which was then modified to the red route for all remaining ones

11.22 Ecologic UK was commissioned to undertake acoustic survey across the Inner Sound to trial the performance of PAM systems in the particular conditions encountered in the Inner Sound. The output data, in the form of acoustic detection rates, was used to make a qualitative assessment of the likely efficiency of the visual surveys for harbour porpoise detection. PAM was deployed on the final three marine mammal surveys; the survey methodology and data analysis techniques are presented in detail in a separate technical report produced by Ecologic UK (2011; provided on supporting studies CD) but the key results are included in this assessment.

### *Underwater noise (Kongsberg, 2012)*

11.23 MeyGen commissioned Kongsberg to provide an assessment of the impact of underwater sound on marine mammals in the Inner Sound. Underwater sound arises during the installation, operation and decommissioning stages of the Project. Kongsberg identified pile drilling, turbine operation and vessel movements as requiring specific analysis. The noise generating activities were reviewed and the noise source characteristics discussed in terms of their source level[4] and frequency using data from the peer-reviewed literature (Kongsberg, 2012; provided on the supporting studies CD).

11.24 Kongsberg collected measurements of background underwater noise in the Inner Sound during August 2011 (Kongsberg, 2012) which demonstrated that, from an oceanographic perspective, the Inner Sound is a turbulent location. The results of this baseline noise survey are presented in Section 11.6.1.

11.25 Acoustic propagation modelling was undertaken using a suite of computer programs to investigate the underwater noise propagating along a set of transects radiating from the centre of the Project area. This took into account site-specific data relating to the bathymetry, oceanography and geo-acoustics of the Inner Sound. This allowed Kongsberg to determine how the noise emissions from the identified sources behave with increasing distance from the source. Acoustic impact modelling was subsequently carried out to determine the ranges over which acoustic impacts on various marine mammal species might arise.

11.26 The modelling programs themselves are based on mature and rigorous scientific methodologies that have been reviewed extensively in the international literature over a number of years. Kongsberg (2012) consider it of fundamental importance that acoustic modelling is based on peer-reviewed techniques.

11.27 Following consultation with Marine Scotland regarding the scope of the noise assessment, the scenarios that were modelled were as follows:

- Single source:
  - Drilling noise, reflecting the noise generated principally through the action of the drill bit on the seabed;
  - Vessel noise, reflecting the noise generated by the presence of a tug during installation, maintenance and decommissioning activities; and
  - Operational noise, reflecting the noise generated by 1 x 1MW turbine or by 1 x 2.4MW (based on the results, 2.4MW turbine considered the worst case in terms of noise emissions and thus carried forward into the assessment).
- Multiple source:
  - Drilling noise and the noise emitted by the DP installation vessel;
  - Operational noise for the first operational phase, covering noise emissions for 12 x 2.4MW operational turbines;
  - Operational noise for the first operational phase (12 x 2.4MW operational turbines) and installation noise for either one turbine or for two turbines concurrently; and
  - Operational noise for 36 x 2.4MW operational turbines.

11.28 The following list details the terms relevant to the noise assessment:

- The source level (SL) is the apparent strength of a sound source at (usually) 1m from the source;
- The received level (RL) is the strength of the acoustic field at a given depth and range relative to the source;
- The peak sound level is the maximum absolute value of the instantaneous sound pressure recorded over a given time interval (this applies to transient pressure pulses such as an explosion or a single pile hammer strike);
- The Root-Mean-Square (RMS) Sound Pressure Level (SPL) is used to quantify noise of a continuous nature, including shipping, sonar transmissions, drilling or cutting operations, or background sea noise; it is the mean square pressure level measured over a given time interval and represents a measure of the average sound pressure level over that time;
- The Sound Exposure Level takes account of the problems associated with the time period over which the SPL is averaged by summing the acoustic energy over a measurement period, effectively taking into account both the level of the sound and the duration over which the sound is present in the environment;
- M-Weighting frequency functions can be applied to the SEL to take account of the differences in marine mammal species' response to specific sound frequencies, effectively making the values used to determine responses species specific; and
- This has been taken a stage further where the underwater noise is compared with receptor hearing threshold across the entire receptor auditory bandwidth - this is termed dBht.

11.29 Using preliminary information from the marine mammal observation survey work, MeyGen identified a number of marine mammals on which Kongsberg focussed their assessment; these included the short-beaked common dolphin (*Delphinus delphis)*, harbour porpoise and minke whale (*Balaenoptera acutorostrata)* and the two pinnipeds the grey seal and harbour seal. Although site survey work did not show common dolphin as being users of the site, it offers a useful proxy for other similar dolphin species that were observed (e.g. Risso's *Grampus griseus*). In addition, Kongsberg considered a number of fish species in the report, the results of which have been discussed in Section 13.

11.30 Data are presented using underwater noise impact assessment metrics for generic species of marine animal, with impact zones calculated based on proposed criteria from various studies. The metrics themselves consist of unweighted metrics for fatality and physical injury through to the M-weighting metrics used to quantify audiological damage. Behavioural impacts are assessed using both unweighted metrics and the $dB_{ht}$ technique. Kongsberg (2012) note that these criteria have had little or no validation under open water conditions and that auditory injury data from controlled tests with a few captive animals have been used as the basis for developing the auditory injury criteria. Observations of behavioural avoidance with concurrent acoustic measurements are sparse and the behavioural avoidance criteria must be considered speculative. Kongsberg (2012) make no judgement as to the validity of the impact criteria, simply applying the metrics to the predicted noise levels in order to determine the range over which the effect arises.

11.31 The diversity of thresholds considered by Kongsberg (2012) is shown in Table 11.4, along with a note on whether the thresholds have been used to determine impact in this assessment. Even for similar impacts, a number of different thresholds have been proposed by a range of authors. The main assessment sections discuss which of the behavioural thresholds are most appropriate for this project; where thresholds have been determined to be inappropriate for this project, a full explanation is given in the relevant assessment section.

11.32 The impact zones for the noise sources assessed have been used to inform the noise sections of this impact assessment (Sections 11.6 - 11.8); these consist of impact ranges for fatality, physical injury, audiological damage and behavioural impacts. The impacts relating to single types of noise operating in

[4] Source level is the effective level of sound at a distance of one metre from the cause of the noise - it can be viewed as a measure of how much energy a sound has and crudely how loud it is.

isolation are determined. Subsequently, cumulative impacts are assessed where multiple noise sources are operating and for which the impact zones from adjacent sources may overlap.

| Potential impact | Threshold value proposed in the literature | Reference | Has this threshold been used to determine impact? |
|---|---|---|---|
| **Cetaceans** | | | |
| **Injury or death** | | | |
| Lethality | 240dB re 1 µPa (Peak) | Yelverton and Richmond (1981) | Yes |
| **Hearing damage (permanent or temporary)** | | | |
| Onset of permanent change in hearing (permanent threshold shift, or PTS[5]) | 230dB re 1 µPa (Peak) | Southall *et al.* (2007) | Yes (but PTS not expected from the estimated noise levels) |
| Onset of temporary change in hearing (Temporary threshold shift; TTS) | 224dB re 1 µPa (Peak) | Southall *et al.* (2007) | |
| Onset of temporary change in hearing (TTS) in harbour porpoise | 193.7dB re 1 µPa (Peak) | Lucke *et al*. (2009) | Yes |
| Onset of permanent change in hearing (PTS) | 215dB re.1µPa$^2$s SEL M-Weighted | Southall *et al.* (2007) | Yes (but PTS not expected from the estimated noise levels) |
| Onset of temporary change in hearing (TTS) | 183dB re 1µ Pa$^2$s SEL M-Weighted | Southall *et al.* (2007) | Yes |
| Onset of temporary change in hearing (TTS) in harbour porpoise | 164.3dB re 1 µPa$^2$s SEL | Lucke *et al*. (2009) | Yes |
| Onset of auditory injury | 180dB re 1 µPa (RMS) | US NMFS, (1995) | Yes |
| **Behavioural effects** | | | |
| Aversive behavioural reaction in harbour porpoise (e.g. swimming away from the location of a sound source) | 168dB re 1 µPa peak-peak | Lucke *et al*. (2009) | No - threshold not considered relevant to specific noise emissions - see Section 11.7.1 |
| Aversive behavioural reaction in harbour porpoise | 164.3dB re 1 µPa$^2$s SEL | Lucke *et al*. (2009) | No - threshold not considered relevant to specific noise emissions - see Section 11.7.1 |
| Behavioural disturbance (termed 'Level B - Harassment') | 160dB re 1 µPa (RMS) | US NMFS, (1995) | No - threshold not considered relevant as not species specific - see Section 11.6.1 |
| 'Low level' disturbance | 140dB re 1 µPa (RMS) | HESS (1997) | No - threshold not considered relevant as not species specific - see Section 11.6.1 |
| 'Strong' behavioural reaction | 90dB$_{ht}$ above species specific hearing threshold | Nedwell *et al.* (2005) | Yes |
| 'Mild' behavioural reaction | 75dB$_{ht}$ above species specific hearing threshold | Nedwell *et al.* (2005) | Yes |
| **Pinnipeds** | | | |
| **Injury or death** | | | |
| Lethality | 240dB re 1 µPa (Peak) | Yelverton and Richmond (1981) | Yes |
| **Hearing damage** | | | |
| Onset of permanent change in hearing (PTS) | 218dB re 1 µPa (Peak) | Southall *et al.* (2007) | Yes (but PTS not expected from the estimated noise levels) |
| Onset of temporary change in hearing (TTS) | 212dB re 1 µPa (Peak) | Southall *et al.* (2007) | Yes |
| Onset of permanent change in hearing (PTS) | 203dB re.1µPa$^2$s SEL M-Weighted | Southall *et al.* (2007) | Yes (but PTS not expected from the estimated noise levels) |
| Onset of temporary change in hearing (TTS) | 183dB re 1µ Pa$^2$s SEL M-Weighted | Southall *et al.* (2007) | Yes |
| Onset of auditory injury | 190dB re 1 µPa (RMS) | US NMFS, (1995) | Yes |
| **Behavioural effects** | | | |
| Behavioural disturbance (termed 'Level B - Harassment') | 160dB re 1 µPa (RMS) | US NMFS, (1995) | No - threshold not considered relevant as not species specific - see Section 11.6.1 |
| 'Low level' disturbance | 140dB re 1 µPa (RMS) | HESS (1997) | No - threshold not considered relevant as not species specific - see Section 11.6.1 |
| 'Strong' behavioural reaction | 90dB$_{ht}$ above species specific hearing threshold | Nedwell *et al.* (2005) | Yes |
| 'Mild' behavioural reaction | 75dB$_{ht}$ above species specific hearing threshold | Nedwell *et al.* (2005) | Yes |

Table 11.4: Summary of underwater noise impact criteria for cetaceans and pinnipeds

### *Marine mammal encounter risk (SRSL, 2012)*

11.33 Following consultation with relevant stakeholders (including Marine Scotland), MeyGen commissioned SRSL (2012; provided on the supporting studies CD) to provide an assessment of encounter rate between the turbines and marine mammals in the Inner Sound.

11.34 A full collision model is not yet possible because too little is known about the actual responses of animals to the presence of turbines. The encounter model is based on a 3-dimensional model for estimating encounter rates between pelagic marine animals and their pelagic predators (Gerritsen and Strickler, 1977). This model has been used in a number of studies of predator-prey interaction on many scales and was modified by Bailey and Batty (1983) and applied to predation between medusae and fish that depends upon passive collision rather than a directed attack, a process analogous to encounters between animals and turbine blades.

11.35 Encounter rate for a single predator can be simply expressed as the product of the volume swept by the predator per unit time and the density of prey.

11.36 The volume spent and the density of prey depend on a number of technical parameters related to the turbine dimensions (the values of which are set out in the Rochdale Envelope, Table 11.1, and described in further detail in SRSL, 2012) and characteristics of the physical environment (e.g. tides).

[5] PTS is a permanent elevation of the hearing threshold as a result of noise exposure having physically damaged the hearing apparatus. This 'deafness' can be frequency specific in that the recipient of the noise dose may only be affected at the specific frequencies that comprise the noise emissions to which they were exposed. TTS is a similar physiological reaction to noise as PTS but the elevation of the hearing threshold is a temporary reaction and the 'deafness' to the frequencies to which the recipient was exposed is reversible. Both, however, could represent an inability to detect some or all other noise sources.

11.37 In addition, a number of biological inputs are necessary:

- Species selection
  - It is important to determine early on which species should be considered in the model, since different species use the water column differently, which can affect the encounter rate. Based on the survey information (presented in Section 11.5), four species (harbour porpoise, minke whale, grey seal and harbour seal) were selected as the focus of the modelling.
- Density
  - To determine the actual number of animals which may encounter the turbines, the model requires animal density in numbers per cubic metre. This is a function of surface density, the proportion of time spent in any depth range and the depth span of that depth range. If animals distribute their time evenly between depths then density per cubic meter is simply, surface density/depth.
  - Surface densities of the four species of interest were estimated using a combination of baseline survey data for the Inner Sound and a range of values from the scientific literature, where available. The methods for calculating these density estimates for each of the species considered are summarised in the Baseline Description (Section 11.5) and further explained in SRSL (2012).
- Depth distribution
  - At its deepest the turbine deployment area is a little less than 40 m deep and the entire seabed is therefore well within the diving capabilities of the species of interest. If the depth distribution of an animal, expressed as the proportion of time spent at different depths, is not known it can only be assumed that animals move at random within the vertical plane making equal use of all depths. Obviously animals do not use all depths equally and their actual depth distribution may lead to an increase or decrease in density within the depth range of a turbine relative to what may be assumed from random use of the water column.
  - Exploratory work conducted at SAMS has shown that it is possible to use summary reports of tagged animals to recreate information on time-depth allocation (i.e. the proportion of time a species spends in different depths).
  - The depth distribution for the species of interest is detailed in SRSL (2012), along with details of the sources used to inform this distribution (including dive data available for harbour seals diving within the Project site).
- Swimming speed
  - Although the velocity of the turbine blade dominates this type of encounter scenario, swimming speed also needs to be considered to determine relative velocity between the turbine blades and mammals; swimming speeds are detailed in SRSL (2012).

11.38 Following input of values for the parameters described above, the model outputs an encounter rate of number of animals per year, for one turbine. The Project will consist of many turbines operating as an array. SRSL (2012) have therefore scaled up the encounter rate for one turbine to cover the three stages of turbine installation:

- Maximum of 10 turbines by the end of year one;
- Maximum of 20 turbines by the end of year two; and
- Maximum of 86 turbines by the end of year three.

***Other supporting studies***

11.39 A number of other studies have been prepared during the course of this EIA which have been used to inform the marine mammal impact assessment:

- A desk based study has been carried out in order to provide information on the fish species present in the MeyGen study area and highlight those that have the potential to be impacted by the Project (Section 13). The results of the desk study will be used to determine how the Project is likely to affect the marine and migratory fish species and elasmobranch species (sharks and rays) that use the Inner Sound for feeding, breeding and nursery areas and during migrations. Marine mammal foraging behaviour has the potential to be impacted by changes in abundance, distribution or behaviour of prey fish species; and
- ASML (2011) have carried out a benthic survey to determine the characteristics of the seabed, the benthic species and biotopes present within the proposed Project area and its surrounds. The results of the survey have been presented in Section 10, alongside an assessment on how the Project may affect the benthic environment and the habitats and species (including shellfish) present in the study area. Marine mammal behaviour, feeding and habitat use may be impacted by changes in benthic species and habitats.

### 11.4.3 Significance criteria

11.40 The EIA process and methodology are described in detail in Section 8. Each individual assessment is, however, required to develop its own criteria for the 'sensitivity of receptor' and 'magnitude of impact' aspects as the definition of these will vary depending on the focus. For marine mammals, the significance criteria used in this section is based on the methodology described in Section 8.2.2 but the sensitivity of the receptor and magnitude of impact are defined in Table 11.5 and Table 11.6. The magnitude of the impact has been described with respect to the proportion of the regional population that may be affected by a specific impact. The magnitude and probability are combined to evaluate the environmental consequence of the impact.

| Sensitivity of Receptor | Definition |
|---|---|
| Very high | ▪ Species which form qualifying interests of internationally designated sites.<br>▪ Globally threatened species (e.g. high ranking on the IUCN list).<br>▪ Species present in internationally important numbers. |
| High | ▪ Species which contribute to an international site but which are not listed as qualifying interests.<br>▪ Species which form qualifying interests of nationally designated sites.<br>▪ Species present in nationally important numbers. |
| Medium | ▪ Species which contribute to a national site but which are not listed as qualifying interests.<br>▪ Species present in regionally important numbers.<br>▪ Species on Annex II of the European Habitats Directive.<br>▪ Species listed as EPS.<br>▪ Species listed in Schedule V of the Wildlife and Countryside Act.<br>▪ Species listed as priority species in the UKBAP. |
| Low | ▪ Any other species of conservation interest (e.g. LBAP, PMF species). |
| Negligible | ▪ Species of no conservation concern. |

Table 11.5: Definitions for sensitivity of receptor

| Magnitude of Impact | Definition |
|---|---|
| Severe | ▪ Decline in abundance or change in distribution of the entire regional population.<br>▪ No/very slow return to baseline conditions anticipated following decommissioning.<br>▪ Impact highly likely to occur. |
| Major | ▪ Decline in abundance or change in distribution of a majority of regional population.<br>▪ Return to baseline conditions anticipated to take many years following decommissioning.<br>▪ Impact likely to occur. |
| Moderate | ▪ Decline in abundance or change in distribution of a large minority of regional population.<br>▪ Good potential for return to baseline conditions following decommissioning (up to a few years).<br>▪ Impact will possibly occur. |
| Minor | ▪ Decline in abundance or change in distribution of a very small proportion of regional population.<br>▪ Return to baseline conditions likely within a year following decommissioning.<br>▪ Impact unlikely to occur. |
| Negligible | ▪ No decline in abundance or change in distribution of regional population.<br>▪ Rapid return to baseline conditions following decommissioning.<br>▪ Impact extremely unlikely to occur. |

Table 11.6: Definitions for magnitude of impact

### 11.4.4 Data gaps and uncertainties

11.41 With regards to the marine mammal baseline survey, effort was restricted to a degree as a result of poor weather conditions. However, only two surveys were unable to be completed (October 2010 and December 2010; 22 out of 24 months were completed) and overall survey conclusions are considered to be unaffected by this. As a result of the challenging sea conditions of the Inner Sound, it should be noted that some sightings of marine mammals could not be identified to species level, but the number of these sightings was low and is unlikely to affect the overall survey conclusions.

11.42 It should be noted that a key strategic source of data was not available to MeyGen during the period over which this EIA was conducted:

- Scottish Government and Crown Estate commissioned aerial survey data (birds and marine mammals) of the Pentland Forth and Orkney Waters (PFOW).

11.43 In the absence of data to confirm some of the information required to conduct the assessment, a number of assumptions have been made for marine mammal assessment:

- That the thresholds used to estimate the extent of injury or behavioural response are true thresholds (see Kongsberg 2012 for further discussion of thresholds);
- That animals will leave an area when TTS achieved (such that there is no PTS; see Table 11.4); and
- That the assumptions made regarding the noise modelling are accurate. As these are largely of a highly technical nature, they have not been repeated here but are described in detail with supporting information in the relevant technical reports (and summarised within relevant sections herein).

11.44 It should also be recognised the information used to inform the assessment of noise impacts is based on modelled information (Kongsberg, 2012) and that it has not been verified with measurements of operational turbines. As such, some variation in the values presented might be expected.

11.45 The potential for injurious collisions between large marine animals (such as marine mammals) and marine energy convertors are among the key areas of environmental uncertainty. The actual magnitude of the hypothetical issue is likely to become clearer as the sector develops, but because of the current low number of active devices and the few locations of established commercial scale deployments, data derived from monitoring programmes to directly quantify collisions and near misses are limited at this time.

11.46 A full collision model (providing estimates of collision rates) is not yet possible because too little is known about the actual responses of animals to the presence of turbines. However in order to inform this assessment it has been possible to undertake modelling in order to quantify how often marine mammals may ‘encounter’ the tidal turbines. The estimate of the potential interaction rate is intended to provide an understanding of the scale of the issue and sensitivity to physical and behavioural parameters. It is also important to note that while encounter rates can help gain a perspective on collision rates, especially when data on responsive movements eventually becomes available, collisions themselves are likely to result in a wide range injuries from trivial to fatal. The relationships between strikes and injury for marine mammals have yet to be considered in terms of tidal turbines. Thus when considering encounter rates it is important that it is not assumed that all encounters lead to collisions and that all collisions will result in the death or mortal injury of the animals involved (SRSL, 2012). The results of the work undertaken as part of this impact assessment provide valuable insight into the issues of most concern and also help inform what will be appropriate monitoring. This approach has previously been used to inform assessment in the Skerries Tidal Stream Array EIA. It was also presented as a proposed EIA approach in the Scottish Marine Renewables SEA (Scottish Executive, 2007).

11.47 One of the important inputs to the encounter modelling undertaken to inform this impact assessment is animal density per cubic metre. It was not possible to generate density estimates for all the species being considered in the model from the Project specific survey data. Therefore estimates were made using a combination of Project specific data and a range of values from scientific literature. Full justification of the density estimates used in the model is provided in SRSL (2012).

11.48 Having completed work in order to estimate the potential number of encounters there could be between marine mammals and tidal turbines, it is then necessary to gain an understanding of the number of interactions relative to the size of the source populations or stocks of the species under consideration. The abundance and trends of British and European marine mammal populations are currently not well defined. A variety of efforts are underway to clarify the situation (particularly for cetaceans) though these are ongoing and not yet available to inform this impact assessment. However, rather than ignore this issue pending future information, work has been undertaken in order to best estimate regional populations/stock sizes. Full details are provided in SRSL (2012).

## 11.5 Baseline Description

### 11.5.1 Key species

11.49 MeyGen commissioned RPS to undertake a review of marine mammal use of the proposed project area. This review is summarised below; for further information on species described here, or for other rare species, see the full technical report (RPS, 2011a), provided on the supporting studies CD. RPS (2011a) determined that 10 cetacean species are either casual or regular visitors to the Pentland Firth; these are the mysticete (baleen whale) the common minke whale, the odontocetes (toothed whales and dolphins) sperm whale *Physeter macrocephalus*, killer whale *Orcinus orca*, long-finned pilot whale *Globicephala melas*, Risso’s dolphin, bottlenose dolphin, Atlantic white-sided dolphin *Lagenorhynchus acutus*, white-beaked dolphin *Lagenorhynchus albirostris*, short-beaked common dolphin and harbour porpoise and the two pinniped species the grey seal and the harbour seal (RPS, 2011a). Key notes relevant to these species are described in the following sections. Following completion of the work by RPS, some additional data relevant to the assessment was made available, in particular in relation to population estimates for specific marine mammal species. Where required, these data have been included and referenced.

### 11.5.2 Mysticetes (low-frequency marine mammals)

***Common minke whale***

11.50 The common minke whale is distributed throughout the northern Hemisphere in tropical, temperate and polar seas, although the highest densities occur in relatively cool waters over the continental shelf (<200m depth) (Reid *et al*., 2003). The minke whale is the most frequently recorded baleen (or mysticete) whale species in British shelf waters (Evans, 2008), including the Orkney and Pentland region. The total abundance of minke whales in the entire SCANS II survey area[6] was 18,614 animals (SCANS II, 2008).

11.51 The Pentland Firth and Orkney region is seemingly of some importance for minke whales during the summer months (Hammond *et al*., 2003) and the species should be expected to occur throughout the area. In north Scotland, peak sightings occur between June and August (Weir *et al*., 2001, Evans *et al*., 2003); most minke whales are thought to move out of British waters during the winter, in a seasonal migration to offshore or more southerly waters (Hammond *et al*., 2003, Anderwald & Evans, 2008).

11.52 In Scottish waters, sandeels are the most important prey species for minke whales, comprising 62% of the diet by weight (Pierce *et al*., 2004). Clupeids (herring and sprat) account for around 30% of the diet (Pierce *et al*., 2004). They often forage in areas of upwelling or strong currents around headlands and small islands (Evans *et al*., 2010).

11.53 As population structuring in UK or European waters is not yet identified, current advice from JNCC is that the northeast Atlantic stock estimate of 80,487 provided by the International Whaling Commission (IWC) is relevant when considering the likely number of minke whale that may use the wider area. However, this is a relatively large area and so a further geographic restriction to the SCANS II total estimate for UK waters provides for a more regional population estimate. On that basis, it is considered that 18,614 may use the wider area at one stage or another.

### 11.5.3 Odontocetes (mid- and high-frequency marine mammals)

#### *Sperm whale*

11.54 The sperm whale has a worldwide distribution, inhabiting waters from the equator to the poles in both hemispheres (Evans, 1997, Reid *et al*., 2003). However, this species exhibits age and sex segregation, with only adult males occurring at the highest latitudes (Evans, 1997). As sperm whales are a deep-diving species their distribution in UK seas is centred in offshore waters to the north and west of Scotland where depth exceeds 200m. A population estimate of 363 sperm whales for offshore waters north and west of Scotland exists (MacLeod *et al*., 2009) but abundance has not been calculated for shelf waters where this species does not normally occur.

11.55 Sperm whales do not typically venture onto the continental shelf but the location of Orkney at the northern end of the UK and adjacent to the shelf edge means that the islands are occasionally (less than annually) visited by sperm whales that have strayed away from deep-water habitat. However, records of this species indicate that it is unlikely to occur in the Inner Sound site. Most sperm whale sightings are reported between July and December (Evans, 1997, Reid *et al*., 2003) but winter surveys in deep water have shown them to be present year-round (Weir *et al*., 2001),

11.56 Sperm whales primarily predate upon medium or large squid, but they also take octopus and deep-diving fish species such as rays, sharks, lantern fish and gadoids (Evans, 1997).

#### *Killer whale*

11.57 Killer whale distribution extends from the equator to the ice edges in both hemispheres, but within the UK they are most common off north and west Scotland. Killer whales are commonly sighted along the Caithness coast and around the Orkney and Shetland Islands (Bolt *et al*., 2009), which represents their main area of concentration in UK waters. The individuals that frequent Orkney and Shetland waters are known to range widely, with some of the same marked animals photographed off Shetland being resighted in the Outer Hebrides, around the Faroe Islands and in Iceland (Foote *et al*., 2010). Killer whale abundance was not calculated during the SCANS I[7] or SCANS II surveys due to lack of sightings but abundance estimates ranging from 4,413 animals (in Norway) to 26,774 (in Canada) have been declared; Foote *et al*. (2010) compiled images of 896 marked individuals from across the north-east Atlantic (Scotland, Iceland and Norway), but no abundance estimate has yet been calculated.

11.58 Killer whales are recorded throughout the year in UK waters, and their seasonal movements are likely related to prey. In the nearshore waters off northern Scotland they are primarily recorded in the summer from May to July (Evans *et al*., 2010).

11.59 Killer whales primarily prey on fish species such as herring, mackerel and cod, as well as cephalopods, but they will also take rays, sharks, seabirds, turtles, seals and other cetaceans (Jefferson *et al*., 1991). Around the Northern Isles, offshore killer whales associate with trawlers fishing for herring and mackerel suggesting predation on those fish species (Luque *et al*., 2006), while nearshore whales have been observed predating on common and grey seals, eider ducks, seabirds and mackerel (Bolt *et al*., 2009).

#### *Long-finned pilot whale*

11.60 In the North Atlantic, pilot whales are found from Mauritania northwards to Iceland, Norway and Greenland. Within UK waters, the pilot whale is primarily considered to be a deep-water species, with its main concentrations located along the continental slope and in oceanic areas to the north and west of Scotland (Weir *et al*., 2001, Evans *et al*., 2003, Reid *et al*., 2003). There are scattered records of this species throughout the Orkney Islands and in the Pentland Firth region but they are not considered to be a common species in nearshore waters of the region. Pilot whale abundance was not calculated during SCANS I or SCANS II surveys due to lack of sightings but an abundance estimate of 22,034 has been produced for offshore waters north and west of Scotland (MacLeod *et al*., 2009).

11.61 Data indicate that pilot whales inhabit UK waters throughout the year (Evans *et al*., 2003). Most sightings from Orkney and Pentland Firth waters have been recorded from May to August (Evans *et al*., 2010).

11.62 Long-finned pilot whales prey primarily on squid and a wide variety of deep-water fish species (Hammond *et al*., 2003, Evans *et al*., 2010).

#### *Risso's dolphin*

11.63 The Risso's dolphin is widely distributed in both north and south hemispheres and in north-west Europe it is found both on the shelf (less than 200m depth) and in slope waters along the Atlantic seaboard (Weir *et al*., 2001, Reid *et al*., 2003). Within the UK they are particularly concentrated in The Minch in north-west Scotland, in parts of the Irish Sea and off south-west Ireland (Reid *et al*., 2003) but they are regularly observed around the Northern Isles (Evans *et al*., 2010). No abundance estimates exist for Scottish waters, or for wider UK waters (Evans *et al*., 2003); Risso's dolphin abundance was not calculated during SCANS I or SCANS II due to a lack of sightings and the number of animals using the Pentland Firth region is unknown.

11.64 Risso's dolphins are observed regularly in the Orkney Islands and Pentland Firth region, though not in high numbers (Weir *et al*., 2001, Evans *et al*., 2010), with sightings occurring particularly along the west coasts of Hoy and the Orkney mainland. Evans *et al*. (2010) reported that the Caithness mainland coast and the Orkney Islands were used by Risso's dolphins for both feeding and for breeding purposes. Risso's dolphins may occur on a reasonably regular basis in the Inner Sound region but in small numbers.

[6] The SCANS-II (Small cetaceans in the European Atlantic and North Sea) survey was carried out in June and July 2005, and its objective was to estimate small cetacean abundance in the North Sea and European Atlantic continental shelf waters. It provides the most precise broad-scale estimates of cetacean abundance in UK waters. Vessel surveys (19,614km search effort) and aerial surveys (15,902km search effort) were combined to produce overall abundance estimates for the SCANS II region. Block J was the block comprising Orkney and Shetland, which included the Caithness and inner Moray Firth region but had been extended from SCANS I to include the outer Moray Firth.

[7] The SCANS I (Small cetacean abundance in the North Sea) survey was an intensive sightings survey for harbour porpoises and other small cetaceans in the North Sea and adjacent waters using line transect methods. It took place between June and August 1994 using a combination of ship and aerial surveys. The survey area was stratified into blocks based on logistics and expected cetacean occurrence, and aimed to calculate absolute abundance of cetacean species. Orkney/Shetland was surveyed as a combined Survey Block J (31,059km2), which included the Caithness and inner Moray Firth region. It was surveyed by aircraft between June and August 1994 but it received less coverage than hoped for due to adverse weather conditions. None of the effort was in favourable sighting conditions of sea state two or less, and only 47% of the total coverage was in sea state four or less. None of the transects went through the Pentland Firth, but three crossed through the Orkney Islands. For the aerial survey there were sufficient data to calculate abundances only for harbour porpoises.

11.65 The species is found in Orkney and Pentland waters throughout the year, with peaks in both sightings and number of individuals between May and September and particularly between June and August (Evans et *al*., 2010).

11.66 In British waters their diet comprises octopus, cuttlefish and small bottom-dwelling squid (Reid *et al*., 2003). In Scotland, the stomach contents of 11 stranded Risso's dolphins consisted almost exclusively of octopus (Pierce *et al*., 2007).

### Bottlenose dolphin

11.67 Bottlenose dolphins have a worldwide distribution (Reid *et al*., 2003) and are distributed throughout UK shelf waters, often close to shore; two larger aggregations are found in the Moray Firth (north-east Scotland) and Cardigan Bay (Wales). The total abundance of bottlenose dolphins in the entire European shelf survey area was calculated as 12,645 animals (SCANS II, 2008) and the north-east Scotland population is thought to number around 200 animals (Thompson *et al*., 2011).

11.68 In northern Scotland this species is concentrated in the Moray Firth and it does not occur regularly along the north mainland coast or in Orkney and Shetland. Although there are some sightings of this species at Duncansby Head, Dunnet Bay and Thurso Bay on the Caithness coast and along the west coast of Hoy in Orkney it is unlikely to be common in Pentland Firth waters.

11.69 Bottlenose dolphins inhabit UK waters throughout the year but in most coastal areas the greatest numbers are recorded between May and October (Evans *et al*., 2003, Reid *et al*., 2003).

11.70 The bottlenose dolphin takes a wide range of benthic and pelagic fish species in addition to cephalopods; in Scottish waters the stomach contents of stranded animals indicate that the species preys primarily upon cod, saithe and whiting (Santos *et al*., 2001).

### Atlantic white-sided dolphin

11.71 Atlantic white-sided dolphins inhabit cold temperate and subpolar waters of the North Atlantic and in the UK are predominantly found along the slope to the north and west of Scotland (Northridge *et al*., 1997, Weir *et al*., 2001, Reid *et al*., 2003). Atlantic white-sided dolphin abundance was not calculated during SCANS I or SCANS II due to lack of confirmed sightings, but a 1998 abundance survey calculated a total of 74,626 white-sided dolphins in waters to the north and west of Orkney (MacLeod, 2004).

11.72 In Orkney and the Pentland Firth region, sightings of this species are primarily along the west coasts of Hoy and the Orkney mainland. Although sightings are relatively scarce this species may occur annually in the region (and likely in large groups), but its core distribution is centred over deeper waters to the north-west. As such it should be expected in the Inner Sound site only on a very occasional basis.

11.73 White-sided dolphins inhabit Scottish waters throughout the year, but peak numbers are recorded between June and November (Weir *et al*., 2001). In Orkney and Pentland the majority of sightings are reported from July to September (Evans *et al*., 2010).

11.74 Atlantic white-sided dolphins feed on a variety of fish and cephalopod prey, particularly gadoids such as blue whiting, whiting, cod and hake, as well as herring, lantern fish, mackerel and horse mackerel (Reid *et al*., 2003).

### White-beaked dolphin

11.75 White-beaked dolphins are endemic to the North Atlantic and range from the UK northwards to Greenland, Iceland and the Barents Sea. The species approaches the southern limit of its distribution within the UK, where it exhibits a distinctly northern occurrence centred around Scotland (Northridge *et al*., 1995, 1997, Weir *et al*., 2001, Reid *et al*., 2003, Canning *et al*., 2008). They typically inhabit shelf waters of less than 200m (Reid *et al*., 2003). The abundance of white-beaked dolphins in the entire SCANS II survey area was 22,664 animals (SCANS II, 2008) but in the waters surrounding Orkney and Shetland an abundance of 1,157 animals was calculated (Hammond *et al*., 1995, 2002).

11.76 The white-beaked dolphin is the most abundant dolphin species in Scottish shelf waters, and consequently it is one of the most commonly sighted cetaceans in the Pentland Firth (Weir *et al*., 2001, Reid *et al*., 2003). Sightings are widely distributed around the Orkney Islands and Pentland Firth region, with no obvious areas of concentration. This species should be expected to occur within the Pentland Firth region year-round, but probably not in large numbers.

11.77 White-beaked dolphins inhabit UK shelf waters throughout the year, although sightings are most numerous in coastal waters during the summer months between June and September (Weir *et al*., 2001, Evans *et al*., 2003, Reid *et al*., 2003, Weir *et al*., 2007, Canning *et al*., 2008).

11.78 Haddock and whiting were the most important prey items in the diet of white-beaked dolphins in British waters, representing 43% and 24% respectively of the total reconstructed weight (Canning *et al*., 2008). Cod, herring and mackerel were of some importance (Canning *et al*., 2008).

### Short-beaked common dolphin

11.79 Common dolphins are amongst the most abundant of the world's cetacean species and are distributed worldwide (Evans *et al*., 2003, Reid *et al*., 2003), occurring most commonly in the British Isles along the Atlantic seaboard (Weir *et al*., 2001, Evans *et al*., 2003, Reid *et al*., 2003, Evans, 2008). It has become increasingly common in Scottish shelf waters, particularly along the west coast and east as far as the Moray Firth (MacLeod *et al*., 2008, Robinson *et al*., 2010). The total abundance of common dolphins in the entire SCANS II survey area was 63,366 animals but an abundance of 3,546 common dolphins has been reported for offshore waters north and west of Scotland (MacLeod *et al*., 2009).

11.80 Within Orkney and Pentland Firth waters the common dolphin is not currently considered to be numerous; to date, the species has been recorded only at scattered locations, particularly along the north coast of Caithness from Strathy Point to Duncansby Head.

11.81 The common dolphin occurs in British waters year-round but in Scottish waters numbers tend to increase during the summer and in North Sea waters it is recorded mostly between June and September (Reid *et al*., 2003). Most records in northern Scotland have been between May and November (Evans *et al*., 2010).

11.82 Common dolphins feed on a range of epipelagic and mesopelagic[8] fish, shrimps and squid, and especially schooling fish such as mackerel, sprat, pilchard and blue whiting (Reid *et al*., 2003).

### Harbour porpoise

11.83 The harbour porpoise is distributed throughout temperate and subarctic waters of the North Pacific and North Atlantic oceans and is the most abundant cetacean to occur in north-west European shelf waters (Evans *et al*., 2003). It is the most frequently-sighted and widely-distributed cetacean species in UK waters, where the highest densities occur along the North Sea coast, around the Northern Isles and the Outer Hebrides and off Pembrokeshire in Wales (Northridge *et al*., 1995, Evans *et al*., 2003, Reid *et al*., 2003). The total abundance of harbour porpoises in the entire SCANS II survey area was 385,617 animals (SCANS II, 2008), with the density twice as high as estimated from SCAN I surveys (SCANS II, 2008).

11.84 Harbour porpoise are distributed widely all around the Orkney Islands and are also found throughout the Pentland Firth, including Thurso Bay, Dunnet Bay and Gills Bay. The waters around Stroma, including the Inner Sound, are used regularly by porpoises.

11.85 The harbour porpoise is found within UK and Irish waters throughout the year (Evans *et al*., 2003), including a year-round occurrence in the Orkney and Pentland Firth region (Northridge *et al*., 1995, Hughes, 1998). In the waters around Stroma annual peaks in harbour porpoise sightings are between July and September (Colin Bird, SeaWatch Foundation Group Co-ordinator, pers. comm., Sept 2011).

[8] Epipelagic fish are associated with the surface layers of the water body, generally the upper 200m. Mesopelagic species are associated with the middle layers of water bodies, where light still penetrates but at levels too low for photosynthesis to occur (200 - 1,000m).

11.86 In Scottish waters, 80% of harbour porpoise diet is comprised of whiting and sandeels (Santos *et al*., 2004). Other important prey categories are gadoids (haddock, saithe and Pollack), Norway pout and poor cod (Santos *et al*., 2004). Section 13, Fish Ecology demonstrates the majority of these prey species may be found in the Project area.

11.87 SRSL (2012) undertook an analysis of harbour porpoise data to generate a likely regional population estimate for harbour porpoise in the absence of such a figure being available in the literature or from advisory bodies. This combined information on the ranging behaviour of porpoises from a single site of capture in Danish waters with area-wide density estimates from the North Sea (SCANS-II). Based on this work it can be assumed that 55,276 harbour porpoise (95% Confidence Interval = 27,597 – 107,591) might be expected to reach, and at some point use, the Inner Sound. Further details are given in SRSL (2012).

### 11.5.4 Pinnipeds

#### *Grey seal*

11.88 Grey seals occur only in the north Atlantic and in the Barents and Baltic Seas, with their main concentrations located along the Canadian and US eastern seaboards and in north-east Europe (SCOS, 2011). The UK contains around 45% of the total world breeding population of grey seals, and 90% of those breed in Scotland with major concentrations in the Outer Hebrides and in Orkney (SCOS, 2011). The total UK grey seal population at the start of the 2009 breeding season was estimated at 119,400 animals (SCOS, 2011).

11.89 Grey seals breed during the autumn, with pupping occurring between August and December (SCOS, 2010), although in northern Scotland most pupping occurs between October and late November (Hammond *et al*., 2003). Moulting takes place between January and April (Hammond *et al*., 2003, SCOS, 2010). Seals spend more time ashore during the breeding and moulting seasons and at-sea densities will be lower at these times (Hammond *et al*., 2003). Pup production on the island of Stroma in 2008 was 1,397 animals, making it one of the most important grey seal breeding sites in northern Scotland.

11.90 Aerial surveys conducted in August 2008 estimated between 2,000 and 4,000 grey seals to be concentrated particularly at haulout sites at the Pentland Skerries, Stroma, south-west Hoy and the Scottish mainland coast around Thurso (SMRU Ltd., 2011). Their haulout distribution during the non-breeding period is different from during the breeding season, with more widespread use of the northern part of Orkney. Particular concentrations of seals occur within the Pentland Firth at this time, especially on the Pentland Skerries and Stroma, and along the Scottish mainland coast between Duncansby Head and Dunnet Head. Haulouts of key importance (as described in the recent Scottish Government consultation) are shown in Figure 11.2 (Scottish Government, 2011).

11.91 Grey seals feed mostly on the seabed on small demersal fish species, primarily in water depths of less than 100m. In the UK their diet includes sandeels, whitefish, flatfish and some cephalopods (SCOS, 2010).

11.92 Potential Biological Removal (PBR) is a widely used method of calculating whether current levels of anthropogenic mortality are consistent with reaching or exceeding a specific target population for a species. Using this tool, the Scottish Government issues limits on the number of seals that can be removed from a population before that population might be affected. For grey seals in the Orkney and North Coast (of Scotland) management area in 2012 this number is estimated to be 959 animals (Scottish Government, 2012).

11.93 A regional population estimate for the Orkney and North Coast Management Area of 15,976 grey seals exists. This region is the unit used by Scottish Government to assist with PBR calculations, which is based on the numbers of grey seals that are counted during August surveys of harbour seals. This summer count is more representative of the population of grey seals that spend the majority of the year in any particular area. This count is lower than the minimum number (Nmin) used in the PBR calculation because a large proportion of grey seals will be offshore when the August count is made. The count is corrected using data on the haul-out probability from seals tagged with GPS or ARGOS transmitters over the period the surveys are undertaken.

#### *Harbour seal*

11.94 Harbour seals have a circumpolar distribution with 30% of the European population found in UK waters. 80% of the UK population (around 25,650; SCOS, 2010) is distributed around the west coast, the Hebrides and the Northern Isles of Scotland (Duck *et al*., 2010). Until 2000, Orkney was the main stronghold for harbour seals in the UK, but a decline of approximately 67% has been noted since the late 1990s[9] (SCOS, 2010).

11.95 Harbour seals are present in UK waters year-round. Pups are born during the summer in June and July, and during this period they disperse and females spend a high proportion of time ashore with their pups (Hammond *et al*., 2003, SCOS, 2011). Around Orkney, most pups are born in June (Thompson *et al*., 2001). The annual moult occurs from late July to early September (peaking in August) (Hammond *et al*., 2003), and numbers at haulout sites are highest at this time. The main moulting haulouts in the Pentland Firth region are at Gills Bay, the south-western tip of Stroma and around Scapa Flow (SMRU Ltd, 2011). Harbour seal haulouts tend to be in sheltered, tidally exposed areas on sandbanks, mud flats and skerries. Haulouts of key importance (as described in the recent Scottish Government consultation) are shown in Figure 11.2 (Scottish Government, 2011).

11.96 Harbour seals are likely to use the Pentland Firth for foraging or while en route to other foraging areas, but there is a lack of published at-sea distribution data from the individual animals most likely to use this region.

11.97 Harbour seals take a wide range of prey species including small pelagic and demersal fish and cephalopods (SCOS, 2011). In Shetland, whiting, herring, sandeel and garfish are the most important prey species (Brown *et al*., 2001).

11.98 The PBR for harbour seals in the Orkney and North Coast (of Scotland) management area in 2012 is estimated to be 18 animals (Scottish Government, 2012).

11.99 A regional population estimate for the Orkney and North Coast Management Area of 2,979 harbour seals exists. This region is the unit used by Scottish Government to assist with PBR calculations. These estimates are made during the moulting season when individuals of this species aggregate. Outside of this time, including the breeding season when the animals segregate, the abundance and distribution of harbour seals in the Pentland Firth and Orkney region is not known.

### 11.5.5 Site-specific details (including species density and distribution in the water column)

#### *Summary*

11.100 Boat-based transect surveys (that is, where the boat moves along a pre-determined route; see Figure 11.1) recorded a total of 29 cetacean sightings and 142 pinniped sightings within the survey area, covering two species of cetacean and two pinnipeds (RPS, 2011a). The harbour porpoise dominated cetacean observations, with 27 sightings recorded. The minke whale, with one sighting, was the only baleen whale recorded. Sightings of dolphins during boat-based surveys were uncommon and species could not always be identified. Grey seals dominated pinniped observations, with 119 sightings recorded. Harbour seals were also observed, but on only 11 occasions. The distribution of all sightings made during the boat-based transect surveys is shown in Figure 11.3, which indicates marine mammal relative abundance (i.e. the number of sightings per km travelled, by boat). Sightings are distributed throughout the survey area, although sightings of cetaceans are more numerous in the western portion of the survey area and pinniped sightings show some concentration towards the east of the survey area.

11.101 Boat-based stationary point surveys (that is, where the boat remains at one location for a period of time; see Figure 11.1) recorded a total of 5 cetacean sightings and 37 pinniped sightings within the survey area; these were the same species as identified during the boat-based transect surveys and, as with transect sightings, the harbour porpoise dominated cetacean observations and the grey seal dominated pinniped observations.

[9] Disease, hunting, over-fishing and predation by killer whales have been proposed as reasons behind this decline but there is no clear understanding as to the cause.

11.102 Land-based vantage point surveys recorded a total of 95 cetacean sightings and 84 pinniped sightings within the survey area. Four species of cetacean and two pinniped species were positively identified. The harbour porpoise again dominated cetacean observations (89 sightings) but minke whale, killer whale and Risso's dolphin were also observed. Grey seals dominated pinniped observations, as predicted by the boat-based surveys, with 61 sightings recorded. The land-based surveys recorded a large number of individual seal records (grey and common seals were sighted on 81 occasions, representing 2,604 animals, including 26 occasions when a total of 1,400 individuals were observed on land) as a result of the survey area including seals hauled out on Stroma and adjacent rock outcrops[10].

11.103 Towed hydrophones were used to collect further data on harbour porpoise (Ecologic UK, 2011). Analysis of these data indicates that the overall acoustic detection rate for harbour porpoise was higher than the visual detection rate. This could suggest that the visual sightings rates may not accurately reflect actual levels of harbour porpoise activity in the Inner Sound. Acoustic detections made during surveys are shown against visual boat-based porpoise sightings in Table 11.7. The detection rate for the surveys has been considered when using density estimates for porpoise. In some cases, the density estimates have been compared to the regional means to give an indication of the potential variability in estimates for the site and region.

| Survey (2011) | Acoustic survey | | Visual survey | |
|---|---|---|---|---|
| | Recording (hours) | Acoustic detections (per hour) | Effort (hours) | Visual sightings |
| May | 2.65 | 9.06 | 3.10 | 0 |
| June | 4.23 | 9.93 | 4.47 | 0 |
| July | 1.97 | 7.11 | 4.65 | 2 |
| August | 5.52 | 3.80 | 4.18 | 1 |
| Total | 14.37 | 7.03 | 16.40 | 3 |

Table 11.7: Summary of acoustic detection effort, harbour porpoise detections and detection rates (Ecologic UK, 2011)

### *Harbour porpoise*

11.104 In accordance with regional distribution patterns and seasonal trends, sightings data indicates that the harbour porpoise is the most frequently-sighted and numerous cetacean species occupying the Inner Sound. Most boat-based sightings comprised either single animals (38%) or pairs (25%) with the largest group sighted comprised 12 individuals. Of the land-based sightings, 42% of sightings were of groups of 10 or more individuals, and the largest group sighted comprised approximately 100 individuals. Sighted animals were observed travelling, and in larger groups were seen foraging and breaching. Density estimates are shown in Table 11.8.

| Number of harbour porpoise per km$^2$ | |
|---|---|
| Mean density | Peak density |
| 0.105 | 0.600 |
| 95% CI: 0.055 - 0.202 | 95% CI: 0.226 - 1.594 |

Table 11.8: Inner Sound harbour porpoise density estimates (RPS, 2011a).

11.105 Porpoises are widely distributed across the Inner Sound but densities appear to be highest across the western portion of the survey area in Gills Bay and off the south-western tip of Stroma (Figure 11.4). These sightings occurred throughout the year but peaked in late summer (July – September), although in summer were more evenly distributed throughout the survey area than in autumn where sightings were concentrated in the western portion of the survey area and in and around Gills Bay. The preference for the west of the area, at least at certain times of the year, appears to be confirmed by the acoustic survey which suggests that there are more animals towards the west of the study area (Ecologic UK, 2011).

11.106 Sightings of feeding animals indicate that the Inner Sound provides harbour porpoise with foraging habitat.

11.107 SRSL (2012) undertook analysis to estimate the time this species may be present at different water depths with reference to two previous studies (Westage *et al*., 1995 and Teilmann *et al*., 2007 as cited in SRSL, 2012). This analysis indicated that harbour porpoises make many dives that are not to the seabed which maybe when feeding on pelagic species and travelling.

### *Other cetaceans*

11.108 Although the minke whale is the most frequently recorded baleen whale species in the Orkney and Pentland region (and the only baleen whale recorded in the survey area), they were sighted infrequently during the baseline surveys. Only three sightings were made during the 22 survey months, all of solitary travelling animals, and all in August or October, in line with regional patterns. It is considered unlikely that the Inner Sound comprises important habitat for this species.

11.109 Although unlikely to use the area with any regularity, this species was considered in the encounter risk model to cover a worst case scenario. The model requires a local density estimate which could not be calculated from the few sightings made during the boat-based visual transect surveys (RPS, 2011a). Instead, SRSL calculated densities based on SCANS-II survey results from the larger area (including the Pentland Firth) weighed the estimate by half (since the SCANS-II density was based on summer survey effort) to provide an annual mean density estimate of 0.011 minke whales per km$^2$. As no data is presently available to allow an estimate of the time this species may be present at different water depths, a random distribution throughout the water column has been assumed for the encounter modelling.

11.110 Two sightings of killer whales were made during land-based observations on consecutive days in May 2010, both recording groups of six to seven individuals with only one male in each (the remainder of the groups comprised females and juveniles). Sightings made during survey were in accordance with regional sightings data, which indicates that killer whales have a regular occurrence in the Pentland Firth and Orkney region and in the waters around Stroma during summer months. It is not thought that the Inner Sound provides important habitat for this species.

11.111 A single sighting of a Risso's dolphin was from land-based observations June 2010, when three animals (two adults and one juvenile) were recorded. Survey findings are in line with regional spatial and temporal distribution patterns, with Risso's dolphins present in the region on a regular basis but in small numbers. It is not thought that the Inner Sound provides important habitat for this species.

### *Grey seal*

11.112 Grey seal were the most numerous and frequently sighted marine mammal species in the Inner Sound during the Project specific marine wildlife surveys, The majority of at-sea sightings were of single animals (mostly of adults, though some juveniles were observed) swimming, diving and feeding. Density estimates calculated from the boat based survey are shown in Table 11.9.

11.113 Additional to this significant numbers of animals were observed hauled out on the Stroma shoreline or on adjacent rock outcrops (over 1,000 individuals during the 2 years of survey). On six occasions more than 100 individuals were observed hauled out on Stroma, with a peak count of 268 individuals in a single sighting record, with both adults and juveniles observed.

| Number of grey seal per km$^2$ | |
|---|---|
| Mean density | Peak density |
| 0.226 | 0.555 |
| 95% CI: 0.073 - 0.699 | 95% CI: 0.0122 - 25.286 |

Table 11.9: Inner Sound grey seal density estimates (RPS, 2011a)

11.114 The numbers of sightings, and the overall sightings rates, were slightly higher across the eastern half of the survey area between the Boars of Duncansby and Stroma (Figure 11.5).

11.115 At-sea grey seal sightings occurred throughout the year but numbers peaked in spring and again to a lesser extent in November. During the spring and winter peaks, sightings were concentrated across the eastern half of the survey area, though observations were made throughout the survey area. Land-based

[10] Note that survey coverage did not include haulout sites at Gills Bay

sightings similarly recorded grey seals throughout the year but, in contrast to the boat-based data, sightings data indicates a peak in sightings of at-sea seals during summer months (approximately 50% of all sightings were made between June and August). Sightings of large groups of seals (adults and pups) hauled out on land peaked in winter months; groups comprising more than 100 hauled-out individuals were observed on the Stroma shoreline in October and November.

11.116 With regard to how much time this species might spend at different water depths, there is no data available for the Inner Sound. SRSL (2012) report that for both grey and harbour seals, studies that are available report very similar patterns of underwater behaviour. Broadly speaking seals are expected to roam over a large area, but only undertake dives indicative of foraging (termed U dives in SRSL, 2012) in specific locations. Similarly there may be locations where no feeding takes place, but through which seals may pass on a regular basis (termed as V dives in SRSL, 2012). The encounter modelling has considered both types of dives profiles for grey seals.

***Harbour seal***

11.117 A total of 18 sightings of single harbour seals were made during boat-based surveys and seven sightings of a total of 21 individuals recorded during land-based vantage point surveys; five of these were of animals at sea and two of animals hauled out on Stroma. The majority of sightings were of adults, although three juveniles were recorded. Animals have been observed swimming and hauled out.

11.118 Boat-based sightings were distributed across the survey area, with no apparent concentration of sightings in a particular area (Figure 11.5). At-sea harbour seal sightings occurred throughout the year and sightings peaked in winter and spring. Land-based sightings also recorded harbour seal throughout the year. In contrast to the boat-based data, the number of sightings was highest (although still low) during June (two sightings) and August (two sightings), when adults and pups were observed. Given the small number of sightings it is not possible to discern any seasonal variation in spatial distribution within the survey area.

11.119 Although there were a relatively small number of sightings of animals at-sea in the Sound, there are known moulting haulout sites at Gills Bay and on the south-western tip of Stroma and the harbour seal would be expected to be encountered in the Inner Sound.

11.120 Insufficient sightings were made during the baseline survey work to reliably estimate local density. Since no published density estimates (in terms of animals per $km^2$) were available in the scientific literature for harbour seals for this area, SRSL (2012) estimated density for the site using shore based counts along northern Caithness (83 seals) and southern Orkney (754 seals; SMRU Ltd. 2011). Making the assumption that seals rarely travel beyond 30km from their haul-out site to forage (Tollit *et al*. 1998), the SMRU Ltd. (2011) data were used together with an estimated sea surface area of 30km around each haul-out site to estimate harbour seal density across the area as 0.202 seals per $km^2$. Following further consultation, MeyGen instructed RPS to conduct additional analysis of the baseline survey data to determine a crude density value for harbour seals per $km^2$. The value calculated, 0.169 seals per $km^2$, is close to (albeit slightly lower than) that calculated by SRSL (2012) but does not include corrections for weather conditions and sea-state. As such, the value calculated by SRSL (2012) has been taken through to the assessment sections below.

11.121 With regard to how much time this species might spend at different water depths, SRSL (2012) report that for both grey and harbour seals, studies that are available report very similar patterns of underwater behaviour. Broadly speaking seals are expected to roam over a large area, but only undertake dives indicative of foraging (termed U dives in SRSL, 2012) in specific locations. Similarly there may be locations where no feeding takes place, but through which seals may pass on a regular basis (termed as V dives in SRSL, 2012). Harbour seal data for Inner Sound was available from SMRU. These data indicated that harbour seals are predominately undertaking U dives and feeding in the Project area rather than transiting through it (SRSL, 2012). Therefore it was decided in consultation with Marine Scotland that the encounter modelling for harbour seal would only consider U dives, whilst the U and V dive scenarios would be run for grey seals.


Figure 11.2: Location of key seal haulouts (Scottish Government, 2011).

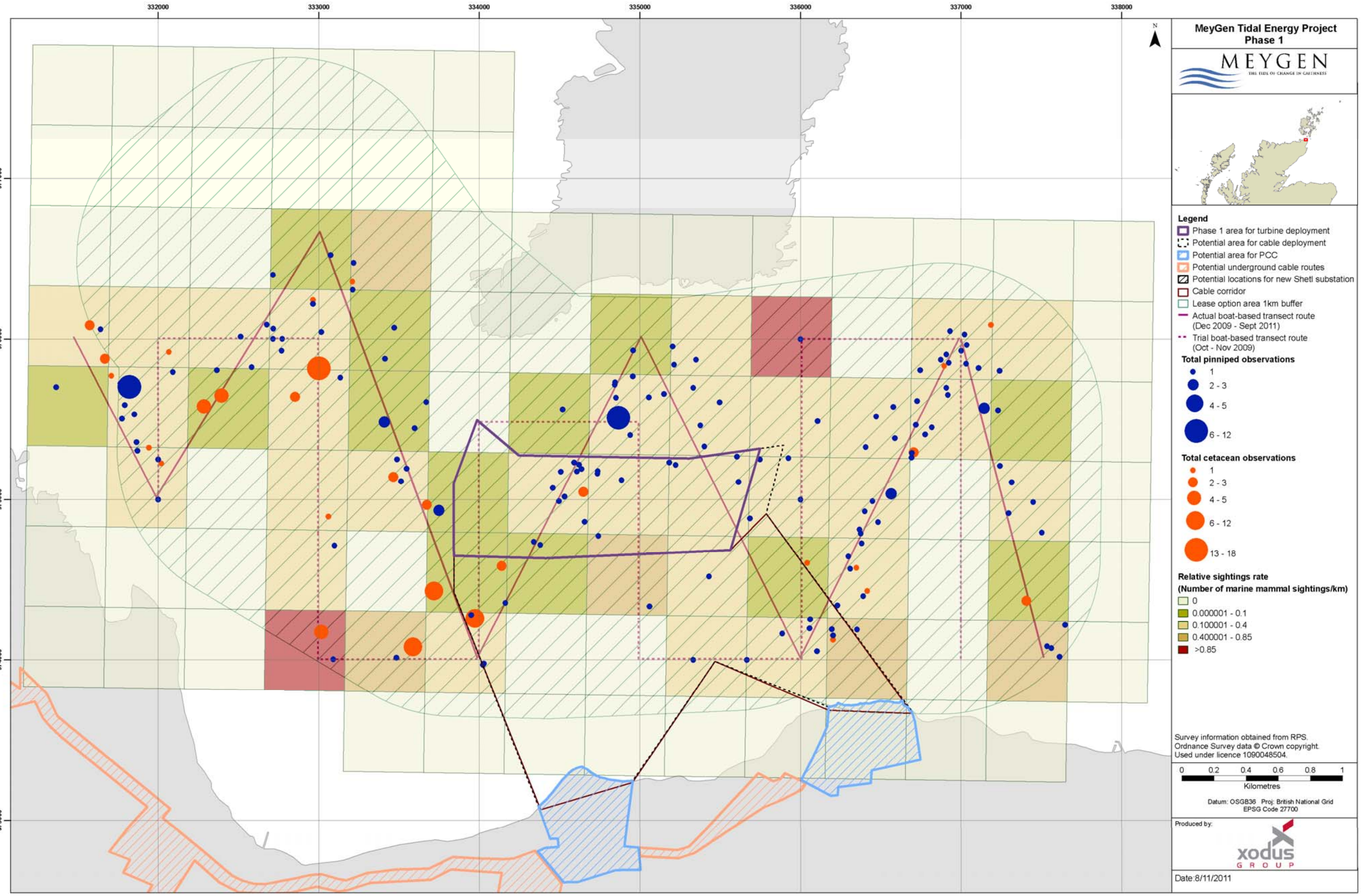


Figure 11.3: Location of marine mammal sightings during boat transect surveys within the survey area (RPS, 2011a)

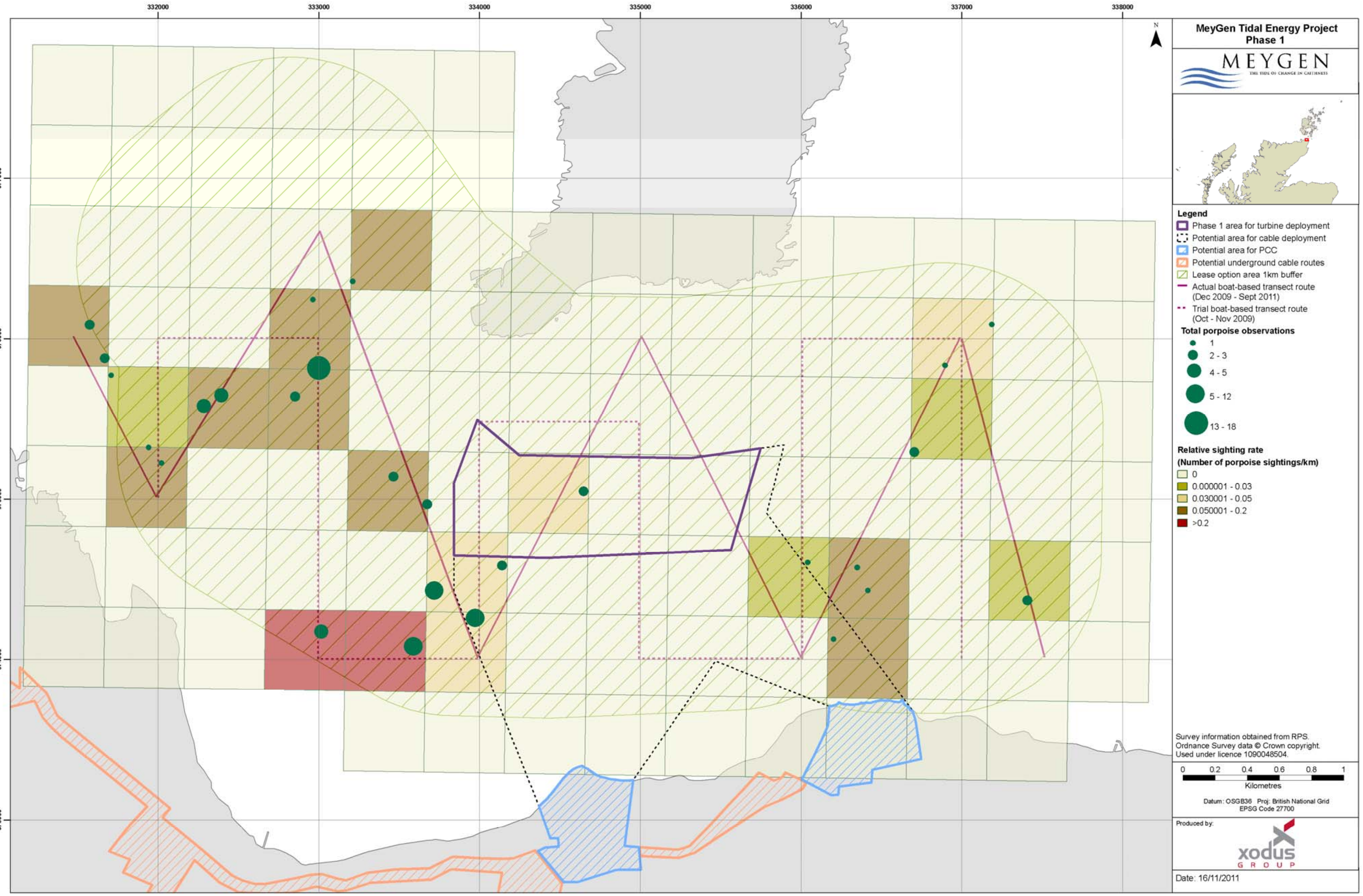


Figure 11.4: Location of harbour porpoise sightings during boat transect surveys within the survey area (RPS, 2011a)

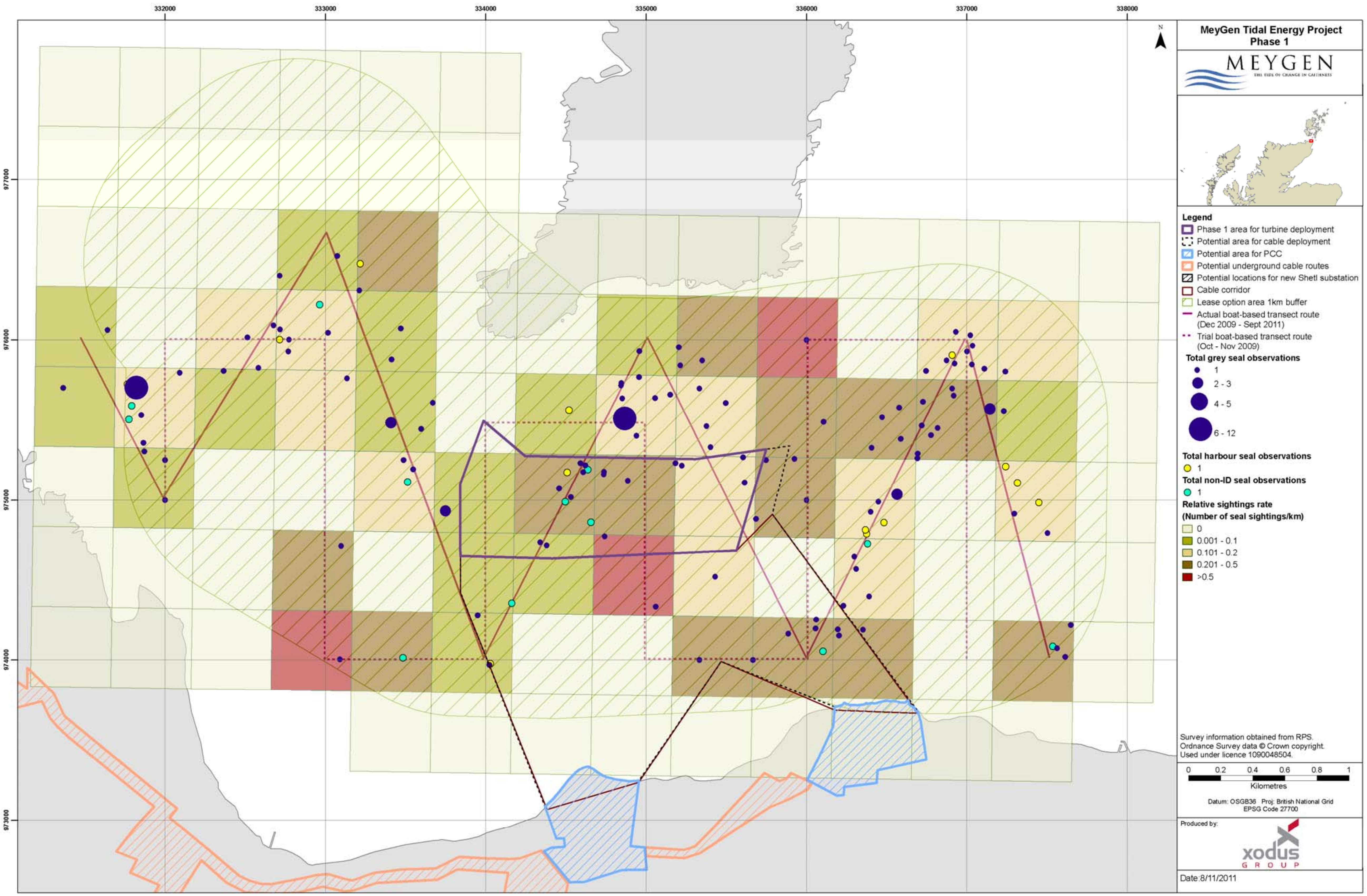


**Figure 11.5: Location of seal sightings during boat transect surveys within the survey area (RPS, 2011a)**

## 11.6 Impacts during Construction and Installation

11.122 The EIA process has identified a number of potential impact mechanisms relevant to marine mammals. With regards to the construction and installation periods of the Project, these are noise emissions, ship strikes, increased turbidity, indirect effects via prey species and accidental events.

11.123 The potential sensitive receptors are those species that have been identified by the RPS (2011a) baseline surveys (Section 11.5) as making use of the area:

- Harbour porpoise;
- Harbour seal; and
- Grey seal.

11.124 Other cetaceans, such as minke whale, killer whale and Risso's dolphin, may be sighted and are discussed where relevant.

### 11.6.1 Impact 11.1: Noise (TSS pile drilling, construction vessels)

#### *Project environment*

11.125 A number of species of marine mammal are regularly present in the Inner Sound area (Section 11.5); many of these species make use of underwater sound and have hearing that is highly tuned for the undersea environment (Richardson *et al*. 1995). Their susceptibility to impacts arising through the introduction of man-made noise into the marine environment is well-documented (e.g. Southall *et al.*, 2007). Such man-made sound for this Project could include vessels and drilling activity.

11.126 For each sound type and source of that sound, a short summary of the nature of the sound emitted is provided, followed by the results of the noise modelling conducted by Kongsberg (2012) and a conclusion on the range to which any auditory or behavioural impacts on marine mammals may extend. The extent that any impact may have at the population level is subsequently discussed.

11.127 To inform the noise assessment, MeyGen commissioned Kongsberg (2012) to undertake measurements of background underwater noise in the Inner Sound. From an oceanographic perspective, the Inner Sound is a turbulent location and the underwater noise data acquired indicates a generally high noise level environment; huge eddies many metres in diameter, seabed material being moved around under the influence of the tidal flow, movement of sand, larger stones rolling over the seabed, seal vocalisations, the Orkney Islands ferry *MV Pentalina* and smaller fishing vessels all contribute to noise levels.

11.128 Kongsberg quantified the background sea noise for the Inner Sound (Table 11.10) and took this information forward to the noise propagation modelling (Kongsberg, 2012).

| Metric | Inner Sound |
|---|---|
| Background noise[11] | 106 – 139dB re 1 µPa |
| Weighted for low-frequency marine mammals[12] | 102 – 131dB re 1 µPa |
| Weighted for mid-frequency marine mammals | 106 – 139dB re 1 µPa |
| Weighted for high-frequency marine mammals | 106 – 139dB re 1 µPa |
| Weighted for pinnipeds | 105 – 137dB re 1 µPa |

Table 11.10: Summary of background sea noise measurements undertaken in the Inner Sound, August 2011 (Kongsberg, 2012)

[11] This has been measured over a period of time using root mean square sound exposure level.
[12] As different species can perceive the same sound as presenting a different 'loudness', the background levels have been 'corrected' to account for this.

#### Introduction

#### Drilling noise - introduction

11.129 Noise is generated during drilling principally through the action of the drill bit on the surrounding rocks. In comparison to hammered piles, the noise generated from the drilling of piles (as proposed for this project) is significantly less. The level of noise created is dependent on the degree to which the seabed rock is consolidated; a soft clay will produce lower levels of sound compared to that generated by a harder granite layer. It is known that sediment coverage of the seabed in the Inner Sound is sparse (see Benthic Habitats and Ecology, Section 10) so it is expected that considerable levels of sound may arise

11.130 McCauley *et al.* (1998) provide examples of noise levels recorded from an oil drilling rig in the Timor Sea, offshore north Australia. During drilling, the highest noise levels measured were around 115 - 117dB re 1µPa at distances of 100 - 400m from the rig, indicating a source level of around 144dB re 1 µPa at 1m, just above the background noise recordings detailed in Table 11.10. It is not clear whether the underwater noise was due entirely to the action of the drill bit on the seabed rock as additional noise may have been introduced into the water through equipment on the drilling rig. In addition, it is unknown whether oil drilling is representative of the drilling likely to be carried out in connection with the TSS installation programme at Inner Sound. Nedwell *et al.* (2010) report on underwater noise levels generated during foundation socket drilling at the EMEC tidal site, The Falls of Warness. In this case, source levels were found to be 178 dB re 1 µPa at 1m. Although the report does not give information on the seabed sediment type and coverage, it is known that The Falls of Warness site has similar sandstone bedrock to the Project site and as it is a strong tidal area there is likely to be only a thin covering of sand, if any. Kongsberg (2012) report that analysis of published drilling noise measurements indicate that limits of 144dB re 1 µPa at 1m to 178dB re 1 µPa at 1m may be considered representative for the drilling associated with TSS installation for the Project and it is these data that have been used in the analysis described in this report.

11.131 Kongsberg (2012) report that underwater drilling tends to be a low noise level operation, at least compared with piling 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 distance of 0.5km from the noise source.

#### *Drilling noise - lethal injury*

11.132 The source level for drilling activities (i.e. how loud it is) is considerably below the level at which lethal injury to marine mammals (cetaceans and pinnipeds) might occur (being 240dB) (Table 11.4) and it is therefore unlikely that any marine animals will be killed by the underwater noise from pile drilling.

#### *Drilling noise - hearing damage*

11.133 Source levels are also below those at which hearing damage might occur, even when taking into account more conservative criteria (being 193.7dB) (e.g. proposed by Lucke *et al*., 2009, for harbour porpoises and those put forward by the US NMFS, 1995; Table 11.4).

#### *Drilling noise - changes in behaviour*

11.134 Where injury is not likely, changes to behaviour become the most significant route for impact. There are a number of criteria that have been proposed for behavioural disturbance against which the drilling noise (and indeed other acoustic emissions are not likely to generate sound levels in excess of the 'Level B – Harassment' or 'Low Level Behavioural' thresholds (being 160dB and 140dB respectively) (described in Table 11.4).

11.135 Kongsberg (2012) note, however, that these threshold values are independent of which species is being considered (termed 'unweighted') and therefore may not reflect the true range of impact on behaviour. When species specific impact ranges are calculated, which compare the source noise with the actual hearing threshold of the target species, it is evident that these unweighted (non-species specific) ranges are not appropriate. As such, the $dB_{ht}$ metric, which makes use of such species specific hearing ability[13], is used in each noise impact assessment in this chapter when considering behaviour.

11.136 Using the species specific $dB_{ht}$ model it is shown that drilling noise is of a sufficiently low level that all species of cetacean and pinniped would need to be within 1m of the drill to exhibit strong or even mild behavioural reactions (Table 11.11). As this distance is so small and as it is unlikely that animals would be able to approach within 1m of the source since the drill itself will be surrounded by a conductor sleeve of 2.8m diameter, there is effectively no likely impact on behaviour from the drilling activities.

| Species group and impact receptor | Strong avoidance (90$dB_{ht}$) | | Mild avoidance (75$dB_{ht}$) | |
|---|---|---|---|---|
| | Precautionary conditions | Typical conditions | Precautionary conditions | Typical conditions |
| Pinnipeds | | | | |
| Vessel | <1m | <1m | 14m | 14 - 18m |
| Drilling | <1m | <1m | <1m | <1m |
| Odontocetes | | | | |
| Vessel | <1m | <1m | 28m | 28m |
| Drilling | <1m | <1m | <1m | <1m |
| Mysticetes | | | | |
| Vessel | 56m | 56m | 1,176m | 620 - 1,036m |
| Drilling | <1m | <1m | <1m | <1m |

Table 11.11: Behavioural impact ranges for receptor groups during drilling and vessel operations[14]

### *Vessel noise - introduction*

11.137 In addition to a noise model simply allowing assessment of the temporal and spatial nature of marine mammal avoidance behaviour within the study area, it is also possible to take the dimensions of the zones of possible impact and determine the numbers of animals likely to be present within those zones, based on the marine mammal density data derived from site-specific surveys or from published data where this information is not available. In the case of drilling, the zones of possible impact are so small and the local/regional density estimates so low that no animals are expected to be affected.

11.138 Noise from shipping is a major contributor to the overall noise in a given sea area due principally to the large numbers of ships present, their wide distribution and their mobility. Sound levels and frequency characteristics are related approximately to ship size and speed, but even amongst vessels of similar classes there can be variation.

### *Vessel noise - lethal injury*

11.139 The source level for construction vessels is considerably below the levels at which lethal injury to species of marine mammal might occur (Kongsberg, 2012, use a value of 172dB re 1 µPa at 1m for vessels). No marine mammals will be killed as a consequence of this underwater noise.

[13] The $dB_{ht}$ 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 90dB above hearing threshold are considered to cause a strong behavioural avoidance, and levels of 75dB above hearing threshold invoke a mild behavioural response.

[14] During the winter months, the sound speed tends to increase uniformly with depth leading to upwardly refracting profile by the month of February. During late spring and early summer, increased heating by the sun of the topmost layers gives rise to an increase in the sound speed over the top 10 - 20m. This is followed by a seasonal thermocline (rapid change in temperature over a small change in depth) which gives rise to a downwardly refracting profile. Given these two profiles, longer range acoustic propagation is more likely to occur during winter than during summer. In order to adequately characterise the environment acoustic propagation modelling has been undertaken using the February and August sound speed profiles as these two months are most likely to give rise to the maximum and minimum propagating conditions. Propagation distances for vessel and drilling operations in this table are based on physical conditions for summer months as this is when these operations are most likely to occur.

### *Vessel noise - hearing damage*

11.140 Source levels associated with the vessels are also below the levels at which hearing damage might occur.

### *Vessel noise - changes in behaviour*

11.141 Kongsberg (2012) report that vessel noise could remain audible out to ranges of 1 - 14km depending on the prevailing levels of background noise and operational status of the turbines. Considering species specific thresholds, pinnipeds might show a mild avoidance of noise levels within 14 - 18m of vessels and strong avoidance at <1m (Table 11.11). Similar values are the case for harbour porpoise and the dolphin species that may be found in the area, although mild avoidance could extend out to 28m (Table 11.11).

11.142 In terms of the mysticetes, which in the case of this Project extend to the infrequently sighted minke whale, strong avoidance may be experienced out to around 56m (Table 11.11). Mild avoidance is possible out to 1,036m from the vessel (Table 11.11).

11.143 However, the mild avoidance reaction is primarily a cognitive response, in that the animal will detect and be aware of the sound (Nedwell *et al.,* 2005), but it certainly does not represent a certain movement from an area. Indeed, Nedwell (2007) reports that habituation to these levels of noise is possible. Southall *et al*. (2007) also highlighted the fact that the interpretation of behavioural responses is very limited by uncertainty as to what constitutes biologically significant disturbance (i.e. disturbance that could affect feeding or breeding, for example). As such, mild avoidance is likely to be of little consequence to marine mammals in the Inner Sound and it is instead the strong behavioural response that is likely to be the relevant threshold for this Project; the area ensonified to the 90$dB_{ht}$ threshold for strong avoidance will therefore be considered for assessment in this chapter.

11.144 Considering the area of strong behavioural impact for construction vessels, the zones of possible impact are so small and the local/regional density estimates so low that no animals are expected to be in those zones on most occasions and thus few, if any, negatively affected.

11.145 Licences issued for work at the EMEC tidal test facility in the Fall of Warness required an observation effort to be undertaken which focused on the detection of any large-scale temporal responses of Harbour seal behaviour to the operations. An observation programme was devised by EMEC in close conjunction with the Sea Mammal Research Unit and Scottish Natural Heritage to cover installation of a monopile foundation using a jack-up barge and a gravity-base foundation and nacelle from a DP vessel (EMEC, 2010). Although the responses by seals to such operations are variable, and although insufficient information was collected to allow statistical analysis of the results, it is clear that seals remained present at the site during such operations and that although some seals appeared to respond through movement to the operations, seals were also recorded showing no response at all other than to continue whatever behaviour they were engaged in previously (EMEC, 2010).

### *Drilling and vessel summary*

11.146 Drilling and vessel noise emissions are not predicted to cause fatalities to any marine mammal species. Some behavioural changes may be observed but the distance within which this is predicted to occur are so small (matter of metres) that impacts are not expected to be significant. Note that the first 12 x 2.4MW turbines will be operational before the remaining 24 x 2.4MW turbines are installed and that the operational noise (these scenarios are detailed in Section 11.7.1) will render installation noise inaudible to marine species.

11.147 For the purposes of the noise assessments, it is assumed that once a marine mammal has been exposed to noise levels that could cause a temporary change in hearing ability (TTS) it will leave the vicinity of the activities and not return during the operation (note that evidence suggests that it is unlikely that an animal would choose to stay in close proximity to the source of a loud noise; Tougaard *et al*., 2003). In order to assess the potential for this to impact upon marine mammals at a population level, the number of marine mammals deemed to have 'left' the region can be placed in context with the number of animals expected to use the region over a set period (in this case the period of the installation operations). As no animals should be exposed to TTS from the installation operations, no animals are expected to leave the region and no population level impacts are therefore expected.

11.148 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, as the noise levels are relatively low, are not considered loud enough to cause injury or mortality and the ranges for behavioural reactions are small compared to the likely range of most species; any impacts are likely to be limited in extent. Therefore, the magnitude of impact is considered to be minor.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Minor | Minor | Not significant |
| | | | |

**MITIGATION IN RELATION TO IMPACT 11.1**

- No injury impact is expected due to the low levels of noise emissions and no marine mammal observer (the general role of which is to assist in mitigation of the injury impact) is therefore required. Note, however, that the principles of the JNCC guidance on protection of marine European protected species from injury and disturbance (JNCC, 2010) and of relevant guidelines on minimising the risk of injury to marine mammals will be adopted as necessary (for example, reducing the duration of noise emitting activities).

### 11.6.2 Impact 11.2: Ship strike (installation vessels) and ducted propellers

11.149 Increased vessel traffic during the installation phase presents an increased risk of marine mammals colliding with vessels. Wilson *et al*. (2007) identifies the main drivers in influencing the number and severity of strikes as a result of shipping as:

- Vessel type and speed;
- High levels of ambient noise resulting in difficulty in detection of approaching vessels;
- Weather conditions and time of navigation affecting the ability of crew to locate marine mammals; and
- Marine mammal behaviour, which is species-specific (but appears to affect juveniles and sick individuals more often than animals in good health as juveniles are inexperienced in how to respond to ship presence and sick animals may be unable to remove themselves from an impact situation and may be less able to recover).

11.150 Vessels travelling at 7ms$^{-1}$ or faster are those most likely to cause death or serious injury (Wilson *et al*., 2007). Vessels involved in the installation of the tidal array are likely to be travelling considerably slower than this, and therefore collision risk is expected to be lower than that posed by commercial shipping activity. The period of greatest vessel presence will be during the installation of the tidal devices (turbine support structures and nacelles) but will be restricted to good weather months and continue for a 3 year period.

11.151 Severely damaged seal carcasses have been found on beaches in eastern Scotland, along the North Norfolk coast in England, and within and around Strangford Lough in Northern Ireland. All the seals had a characteristic wound consisting of a single smooth edged cut that started at the head and spiralled around the body which would have been fatal (Thompson *et al.*, 2010). The extremely neat edge to the wound strongly suggests the effects of a blade with a smooth edge applied with considerable force, while the spiral shape is consistent with rotation about the longitudinal axis of the animal (Thompson *et al.*, 2010).

11.152 Thompson *et al.* (2010) report preliminary findings of investigations into the causes of a number of these ‘corkscrew’ injuries to seals. The injuries are considered consistent with the seal being drawn through a ducted propeller such as a Kort nozzle or some types of Azimuth thrusters[15]. These systems are common to a wide range of ships including tugs, self propelled barges and rigs, various types of offshore support vessels and research boats and may be used on the installation vessels in this project. The Pentland Firth is a well-trafficked area (see Shipping and Navigation, Section 15) and the installation vessels are unlikely to be different to some of the existing vessels operating in the region. Thompson *et al.* (2010) report that all the other explanations of the injuries that have been proposed, including suggested Greenland shark predation are difficult to reconcile with the actual observations and, based on the evidence to date, seem very unlikely to have been the cause of these mortalities.

11.153 Two possible mechanisms that cause seals to interact with ducted propellers are attraction to concentrations of food associated with the vessel or an inappropriate response to an acoustic signal from the ship. However, at the time of writing, a link between this spiral injury phenomena and the use of vessels with ducted propellers has not been proven (Thompson *et al*., 2010) and no such injuries have been recorded during marine mammal observations at the EMEC Fall of Warness tidal test site (EMEC, 2010).

11.154 As this is an emerging issue and it is not clear yet the extent to which this may be occurring, it is difficult to quantify the potential level of impact, especially as the geographic spread is unknown and no regional estimates of this type of injury are available. Information presented by Thompson *et al.* (2010) shows 15 carcases showing corkscrew injuries having been recorded from Scotland at the point of report publication (13 harbour seals and two grey seals). Although these numbers are low, the uncertainty regarding the extent of the impact is such that the ease with which assessment rankings can be assigned is less than for other, better understood impacts. To ensure that the possible impact is appropriately captured in light of the lack of available data, and in line with the precautionary approach, it is considered that the magnitude ranking should be set artificially high, relative even to the worst-case scenario presented here. To that end, the magnitude of impact has been up-ranked to moderate. The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Moderate | Moderate | Significant |

**MITIGATION IN RELATION TO IMPACT 11.2**

- It is understood that investigation is ongoing on the potential link between spiral injuries in seals and ducted propellers and that mitigation measures relevant to minimising the risk of seal spiral injuries and fatalities are currently being developed at an industry and regulator level. MeyGen commit to undertaking frequent reviews of the literature regarding this topic and to regularly discuss advances in understanding of this topic with relevant regulatory and advisory bodies. MeyGen will apply appropriate mitigation, as deemed necessary in consultation with Marine Scotland and SNH, should vessels with ducted propellers be found to be responsible for seal mortalities.

***Residual impacts***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Minor | Minor | Not significant |

[15] The Kort nozzle is a shrouded, ducted propeller assembly. An azimuth thruster is a configuration of ship propellers placed in groups that can be rotated in any horizontal direction, making a rudder unnecessary.

### 11.6.3 Impact 11.3: Disturbance due to physical presence of vessels

11.155 It is possible that the physical presence of vessels associated with the installation of the tidal devices or of the cables to shore could disturb seals hauled out on land (Scottish Executive, 2007). Noise is a key factor in the potential for disturbance (see Section 11.6.1 for noise modelling) but it has been highlighted that the physical presence of the installation vessels themselves may also cause a disturbance impact. Scottish Executive (2007) state that this impact would be most significant for breeding seals that were hauled out on the coast since the adults could exhibit flight reactions which result in them temporarily abandoning their young. In addition, seals that are undertaking the annual moult spend more time out of the water and if they are alarmed to the extent that they move into the water then they may lose condition as a result of additional energetic costs.

11.156 Brasseur and Reijnders (1994, in Scottish Executive, 2007)) suggest that vessels more than 1,500m from hauled out grey or harbour seals would be unlikely to evoke any reaction in the seals but that they could be expected to detect the presence at between 900 and 1,500m. At closer than 900m a flight reaction could be expected. These distances are similar to those described by Andersen *et al.* (2011, in Skeate *et al*., 2012) who noted flushing of harbour seal from a Danish haul-out into the water at distances of 510 – 830m at the approach of boats and Jansen *et al*. (2010, in Skeate *et al.*, 2012) who noted disturbance by cruise ships likely at less than 500m, with the chance of response increasing by 25-fold at less than 100m. The location of important haul out sites is shown in Figure 11.2; the shortest distance between these sites and the Project site, including cable route corridor to shore, is shown in. Table 11.12.

| Site | Species | Distance from Project site | Within possible impact range? |
|---|---|---|---|
| Ness of Quoys | Harbour seal | Within possible cable route | Flight reaction possible |
| Mell head Skerry | Grey seal | 0.3km north | Flight reaction possible |
| Gills Bay | Grey seal | 0.6 km north | Flight reaction possible |
| Stroma north | Grey seal | 2.75 km north | No |
| Muckle Skerry | Grey seal | 10 km east | No |
| Pentland Skerries | Grey seal | 10.5 km east | No |
| Switha | Harbour seal | 14.8 km north | No |

Table 11.12: Minimum distance between proposed designated seal haul out sites and the Project site

11.157 Skeate *et al*. (2012) report analysis of data collected during installation of the Scroby Sands offshore wind farm off the Norfolk coast (which was built close to a haul-out and breeding site for harbour seal) that showed a significant post-construction decline in haul-out counts. This decline was not thought to be related to the environmental factors considered (although cause and effect could not be unequivocally established) and Skeate *et al*. (2012) instead suggest that noise generated by the pile-driving of the wind turbine bases led to the displacement of the seals. This noise source will be absent from this Project, so the impact is likely to be much less than described by Skeate *et al.* (2012). However, it is important to note that the authors state that the failure of harbour seals to fully recover during the study was, at least in part, linked to that species sensitivity to vessel activity.

11.158 It seems possible, therefore, that seals at three of the sites above (Table 11.12) may demonstrate a flight response to the vessels involved in the installation activities. However, evidence from the installation of a tidal turbine in Strangford Lough MCT shows there to have been no major impact detected on harbour seals or grey seals; relative abundance of seals as measured by shore based visual surveys, annual counts of seals at haul out and breeding sites has not shown any detectable change which can be attributable to the SeaGen turbine (Royal Haskoning, 2011). The two important haul out sites in Strangford Lough are, at their closest within the 900m distance at which a flight response might be expected, suggest that the either the response zones described above are an over estimate, or a repetition of this action is not actually detrimental to the state of the population. Short-term marine mammal observations undertaken during installation of the foundations for a TGL tidal turbine at the Falls of Warness EMEC test site in Orkney (approximately 11 hours over three days) suggested that the seals that were observed were unaffected by the presence of the installation barge.

11.159 Scottish Executive (2007) state that a disturbance impact would be most significant for breeding seals. It is interesting therefore to note that Andersen *et al*. (2011, in Skeate *et al*., 2012) have shown that seals were more reluctant to leave a haul out site and that they returned much more quickly during the breeding season, limiting any possible impact.

11.160 Skeate *et al*. (2012) state that no effect of vessel activity was evident for grey seals, with the fact that numbers of this species were increasing demonstrating the species' tolerance of vessel activity. Interestingly, the authors also note that part of this site-specific tolerance may be linked to habituation of at least some animals to the single tourist vessel that regularly visited the site; numerous vessels pass through the Pentland Firth and Inner Sound, close by the haul out sites (Shipping and Navigation , Section 15).

11.161 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, given that only a small percentage of the regional population of harbour seals is likely to be disturbed to any extent, and as the evidence suggests that grey seals are even less susceptible to such effects, the magnitude of impact is considered minor.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Minor | Minor | Not significant |

| MITIGATION IN RELATION TO IMPACT 11.3 |
|---|
| ▪ No mitigation measures proposed as no significant impact predicted. |

### 11.6.4 Impact 11.4: Increased turbidity

11.162 Increased turbidity can occur during seabed disturbing installation activities, as fine particles travel further from the disturbed area, swept by tidal currents. Disturbance of seabed sediments could cause localised and short term increases in turbidity and therefore reduced visibility for marine mammals. Increased turbidity may affect the foraging ability of marine mammals, principally seals, who are dependent upon visual cues to track prey (Scottish Executive, 2007).

11.163 The magnitude of the impact will depend on the high number of variables involved in determining both background and project caused suspended sediment levels and turbidity. The turbines will be sited on a rocky seabed and thus there is likely to be very little sediment that could be moved into the water column. The main source of turbidity will instead be drill spoil from the drilled piles and the horizontally drilled cable boreholes. However, the turbines will be installed in a number of phases over three years and there will consequently be long periods of time between discharge events over which time the cuttings will settle out of the water column. Even when discharge is occurring, the rate is expected to occur at a rate of approximately only 5 litres per hour. At this rate it is likely, given the high energy environment into which they will be discharged, that cuttings will be dispersed rapidly and any elevated turbidity in the immediate vicinity of the discharge site will be very short lived.

11.164 The Benthic Habitats and Ecology impact assessment undertaken as part of this EIA (Section 10) has determined that any increase in turbidity or suspended sediment levels is expected to be temporally and spatially restricted, largely due to the small volumes released and the high energy environment of the Inner Sound.

11.165 Grey and harbour seals have been identified as having a high sensitivity to reductions in visibility, whilst cetaceans have a moderate sensitivity to this impact. However, many seals inhabit areas of almost persistent turbidity (such as the southern North Sea and The Wash and Thames Estuary on the south east coast of England) and it would seem unlikely that increased turbidity would be a significant issue. In addition, whilst seals are known to use eyesight for finding prey and navigating, they can successfully hunt in turbid and unlit waters. Porpoises and dolphins use echolocation regularly when foraging and are unlikely to be impacted by temporary increases in turbidity.

11.166 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, given that very little sediment exists to be moved into the water column and as any cuttings will be dispersed rapidly, any elevated turbidity in the immediate vicinity of the discharge site will be very short lived and the magnitude of impact is considered negligible.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Negligible | Negligible | Not significant |

| MITIGATION IN RELATION TO IMPACT 11.4 |
|---|
| ▪ No mitigation measures proposed as no significant impact predicted. |

### 11.6.5 Impact 11.5: Indirect effects via prey species

11.167 The marine mammals that have been shown to use the Inner Sound prey on a variety of fish and shellfish species and it is possible that mammals may be affected if those prey species are negatively impacted by any of the installation activities. For example, potential impacts include loss of fish and shellfish habitat and disturbance from noise.

11.168 Assessing the biological significance of impacts to prey species is challenging but the dietary specialisations or opportunistic nature of a marine mammal may determine their ability to adapt to potential short-term or long-term changes in prey availability. Grey seals feed mostly on the seabed on small demersal fish species (sandeels, whitefish, flatfish and some cephalopods; SCOS, 2010), whilst harbour seals prey upon small pelagic and demersal fish and cephalopods. Harbour porpoise diet is comprised mostly of whiting and sandeels (Santos *et al*., 2004). Note that the diet of most marine mammals is varied and ordinarily comprised of a number of different species. As such, it is likely that they would be capable of filling a short term absence of one prey species with another that will be present in the area. Diet is described further in the marine mammal baseline report (RPS, 2011a).

11.169 The Fish Ecology assessment (Section 13) concluded that installation related impacts on each of these potential prey species are likely to be minor or negligible. In addition, the Benthic Habitat and Ecology assessment (Section 10) concluded that there would be no significant impact on shellfish resources in the area. Marine mammals that prey on these species should therefore be unaffected.

11.170 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, as the species on which marine mammals are likely to prey will be unaffected to any significant extent by the Project, the magnitude of impact is considered to be negligible.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Negligible | Negligible | Not significant |

| MITIGATION IN RELATION TO IMPACT 11.5 |
|---|
| ▪ No mitigation measures proposed as no significant impact predicted. |

### 11.6.6 Impact 11.6: Accidental spillage from vessels

11.171 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 significantly smaller inventories of polluting substances may be potentially released during the course of the Project. These impacts and their potential consequences are discussed further in Accidental Events (Section 24).

11.172 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.

11.173 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.

11.174 Even in the event that an oil spill resulted in the loss of inventory from a DP vessel, marine mammals 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 issue will be where this pollutant washes up and accumulates on haulout sites since an aversion by seals to the pollutant may displace them from preferred haulout sites. Such a situation will be more of a concern during the grey seal pupping season since juveniles do not initially have a waterproof coat and movement from a haulout site could negatively impact on pup survivability rates. As sensitivity is limited by species and time of year (grey seal pups are born from the end of September until mid December) it is unlikely that a total loss of inventory will affect directly affect marine mammal species in the area, especially as their mobility will allow them to move away from areas of pollution. It could affect marine mammals if prey species (fish and shellfish) were adversely affected by accidental release of contaminants, but the Fish Ecology assessment (Section 13) concludes that this is unlikely.

11.175 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. In the event a large spill does occur the magnitude of impact is considered to be major. 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 11.6 |
|---|
| ▪ Although the impact has not been identified as significant, additional control measures have been identified.<br>▪ 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 SOPEPs.<br>▪ All vessels associated with Project operations will carry onboard oil and chemical spill mop up kits.<br>▪ Where possible vessels with a proven track record for operating in similar conditions will be employed.<br>▪ 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. |

## 11.7 Impacts during Operation and Maintenance

### 11.7.1 Impact 11.7: Operational noise

*Existing data*

11.176 As with installation operations, it has been noted (e.g. Scottish Government, 2007) that the operational phase of tidal energy projects could impact upon marine mammals, with those impacts ranging from possible injury to behavioural effects.

11.177 Very few tidal turbines have been installed in UK waters and only data pertaining to the MCT turbine in the Bristol Channel is currently publicly available (Richards *et al*., 2007). The MCT turbine is a horizontal axis, single rotor turbine with an output of 300kW, much smaller than the maximum 2.4MW units proposed for the Inner Sound. Underwater noise was recorded at a number of ranges from the operational tidal turbine during March 2005 and Kongsberg (2012) have used the available information to calculate an estimated value for the larger Inner Sound turbines.

*Turbine installation with 12 x 2.4MW turbines operational - introduction*

11.178 Kongsberg (2012) predict that operational turbines are expected to give rise to higher levels of underwater noise compared with pile drilling activities but, even then, the background noise levels in the Inner Sound are variable and have the potential to drown out the operational noise from time to time; for example, when background levels are at their highest, operational noise may fall to background levels as close as 0.3km from the turbines. When background levels are at their lowest, this distance may increase to in excess of 14km; however, background noise levels will be at their lowest when the tide is not running and as the tidal turbines will be non-operational when the tide is not running, this distance is likely to be a gross overestimate.

11.179 Kongsberg (2012) modelled noise propagation for 12 x 2.4MW turbines (which are expected to emit noise with a source level of 178 dB re 1 uPa) together with the drilling operations for either one turbine or for two turbines concurrently. However, since the noise emissions from drilling are considerably lower than those generated during the operation of the turbines there is no discernible increase in sound levels over and above that of the operational noise of the 12 x 24MW turbines alone. Consequently, the impact ranges modelled for the operational impact of 12 x 2.4MW turbines apply also to the impact of 12 x 24MW operational turbines with drilling activity (Table 11.4).

*Turbine installation with 12 x 2.4MW turbines operational - lethal injury or hearing damage*

11.180 Fatal injury and temporary (TTS) or permanent changes in hearing (PTS) are not considered likely due to the low noise levels.

11.181 Hearing damage does have the potential to arise when the cumulative dosage of underwater sound builds up over a period of time. Kongsberg (2012) developed a simple 'dose' model to consider an animal entering the Inner Sound at a speed of $5ms^{-1}$, swimming due east on a constant bearing and approaching the operational turbine no closer than a distance of 1,000m. Under these conditions neither TTS nor PTS are likely to occur for either cetaceans or pinnipeds. The more precautionary TTS impact criterion proposed for harbour porpoise by Lucke *et al*. (2009) will not be exceeded either.

*Turbine installation with 12 x 2.4MW turbines operational - behavioural changes*

11.182 Kongsberg (2012) report that the threshold for aversive behaviour in harbour porpoise, also proposed by Lucke *et al*. (2009), is likely to be met after an exposure time of approximately 57 seconds. However, the values proposed by Lucke *et al*. (2009) have been derived from controlled experiments using impulsive airgun noise emissions, a very different noise source to that likely from operational turbines. Impulsive sound, such as that from air guns and hammered piling, is ordinarily received as loud bangs as the noise is emitted entirely over a very short period of time, to which animals may display a 'reflex' reaction, as a human might to a clap behind the head. Continuous noise, such as that likely from operation of the turbines, is not emitted in loud pulses in an ordinarily quiet environment (unlike the air guns detailed above). It seems therefore possible for the specific situation of operational turbines that these lower values (obtained from a very different type of activity) are unlikely to be particularly appropriate. As such, this threshold can be discounted, TTS concluded to be unlikely, and behavioural impact the ranges defined by the $75dB_{ht}$ and $90dB_{ht}$ values be considered.

11.183 The ranges within which these behavioural avoidance thresholds (defined by Nedwell *et al*., 2005) will be exceeded are shown in Table 11.13 and Figure 11.6).

| Species group | Strong avoidance ($90dB_{ht}$) | Mild avoidance ($75dB_{ht}$) |
|---|---|---|
| Pinnipeds | 8m | 80m |
| Odontocetes | 63m | 1.3km |
| Mysticetes | 266m | 4.9km |

Table 11.13: Behavioural impact ranges for species exposed to operational noise from 12 x 2.4MW turbines (this is the same as for 12 2.4MW turbines with installation of either one turbine or two turbines concurrently)

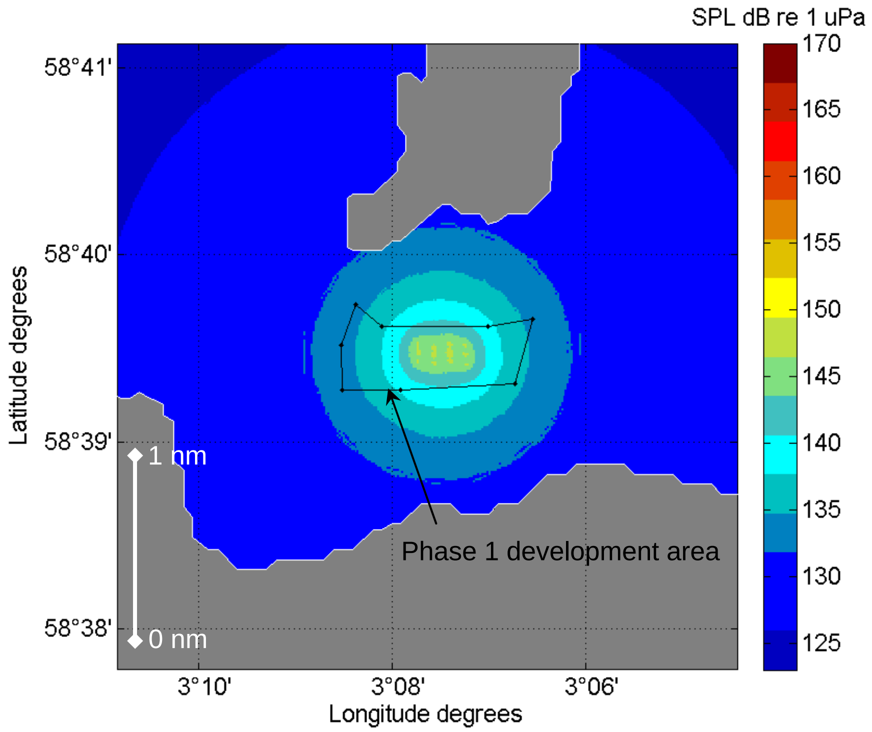


Figure 11.6: Effect of cumulative acoustic footprint for 12 x 2.4MW (this is the same as for 12 x 2.4MW turbines with installation of either one turbine or two turbines concurrently)

11.184 There is unlikely to be any impact on behaviour from 12 x 2.4MW operational turbines and drilling for either one or two turbines concurrently outwith 8m of the array for seals and 63m for odontocetes (including harbour porpoise, killer whales and Risso's dolphins). For mysticetes, this range might extend to 266m.

### *36 x 2.4MW turbines operational - lethal injury or hearing damage*

11.185 As with installation activities and with 12 x 2.4M operational turbines, source levels for the full array of 36 x 2.4MW operational turbines are considerably below the levels at which lethal injury to species of marine mammal might occur and it is therefore unlikely that any marine animals will be killed as a consequence of the underwater noise from any of the activities associated with the Project. Similarly, neither PTS nor TTS are likely to occur in cetaceans or pinnipeds.

### *36 x 2.4MW turbines operational - behavioural changes*

11.186 Using weighted impact criteria, that is those corrected for species hearing abilities, the area of possible impact on pinnipeds from 36 x 2.4MW operational turbine devices is expected to extend only to 38m for strong avoidance (Table 11.14, Figure 11.7). As has been noted from the baseline survey and data review, certain locations on the Inner Sound and Stroma coast are frequently utilised as seal haulouts (Figure 11.2). These impact ranges are in water and animals hauled out on land will not experience levels that are sufficiently high to cause any disturbance. If, however, animals were experiencing disturbance in the waters around the haulout then it may cause individuals to stop using that haulout. However, pinnipeds will not experience levels sufficiently high to cause strong avoidance anywhere near the haulouts as these are located above water and well beyond 38m from the turbines. The mild avoidance range may extend up to 168m from the turbine array and would also not overlap with waters around the haulouts. As the noise levels will not cause strong avoidance, the routes to the haulouts are unimpeded by noise levels and the noise will be undetectable in air, use of haulout sites throughout the Inner Sound is expected to remain unchanged.

| Species group | Strong avoidance ($90dB_{ht}$) | Mild avoidance ($75dB_{ht}$) |
|---|---|---|
| Pinnipeds | 38m | 168m |
| Odontocetes | 98m | 2.9km |
| Mysticetes | 588m | 11.9km |

Table 11.14: Behavioural impact ranges for species exposed to operational noise from 36 x 2.4MW operational turbines

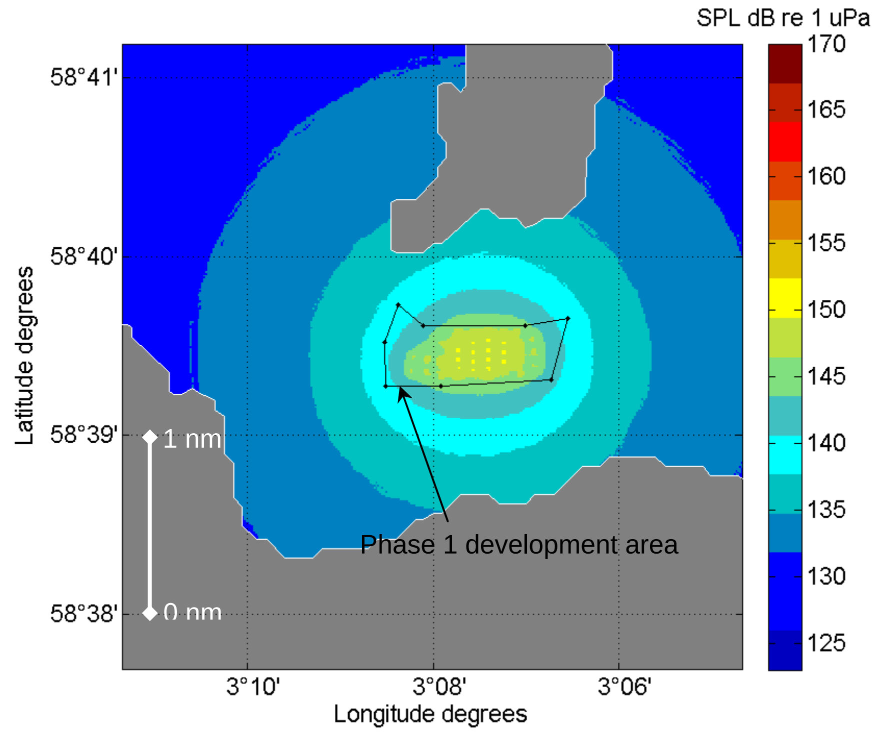


Figure 11.7: Effect of cumulative acoustic footprint for 36 x 2.4MW

11.187 When the weighted impact criteria for odontocetes are considered, strong avoidance might be expected up to 98m from the edge of the Project area (Table 11.14, Figure 11.7). For mysticetes, the strong avoidance distance is 588m (Table 11.14, Figure 11.7). As with pinnipeds, the mild avoidance behaviour extends to larger distances but it is expected to represent a detection and recognition of the noise source and not necessarily a sustained avoidance; where the noise level is this low and no injury or physical effect is manifest then the cetaceans might reasonably be expected to habituate to the noise and react no further. However, the same cannot be said for strong avoidance as for this level of noise emission, the limited available data suggest a strong avoidance reaction for most individuals experiencing that levels, to the extent that the reaction could be instinctive if sufficiently high. To that end, animals may be excluded from habitat where noise levels are sufficient to elicit strong behavioural avoidance. For pinnipeds, this could remove the tidal array area and 38m around it from use, assuming the animals did not tolerate the strong behavioural noise emissions. However, as grey seals may travel in excess of 100km and harbour seals over 20km from haulout sites to forage; the possible removal of a very small area of the Inner Sound is not considered significant.

11.188 For odontocetes (including killer whales and Risso's dolphins), the strong behavioural avoidance might be expected out to 98m from the array, removing a very small area of sea from use if these species will not tolerate the 'strong' behavioural avoidance noise emissions. A number of odontocete species are thought to use the wider area but most have been infrequently sighted in the Inner Sound and the area is unlikely to represent critical habitat for most species. The exception is for harbour porpoise which have been seen travelling, and in larger groups foraging and breaching and the area excluded area may represent a useful habitat for this species (as the rest of the Inner Sound and Pentland Firth may). Although direct evidence is not available for UK harbour porpoise movement, tagged individuals from the Bay of Fundy, North America, covered a home range of 50,000km$^2$ and travelled hundreds of kilometres in a relatively short time period (Read and Westgate, 1997). In addition, evidence from genetic analysis suggests porpoises in the northeast Atlantic behaves as a 'continuous' population that widely extends over thousands of kilometres, although significant isolation by distance is seen to occur (Fontaine *et al*., 2007). Harbour porpoise sighted in Inner Sound will range widely in the Pentland Firth and Orkney Waters and likely much further as they form are part of a larger European population. Indeed, harbour porpoise density recorded within the Inner Sound from the marine mammal surveys shows that the areas of highest harbour porpoise density (Figure 11.4) are outwith the possible impact ranges (Table 11.14).

11.189 For mysticetes, much of the Inner Sound is likely to be ensonified to a level that could result in strong behavioural avoidance, such that these species may no longer use the Inner Sound (depending on the extent of the behavioural reaction). However, sightings data indicate an almost complete lack of mysticetes, with only three sightings of one minke whale in the entire 22 months of survey. As such, the possible area excluded is unlikely to be of any importance to such species and the impact likely to be very low.

11.190 It is possible to take the areas of possible impact defined by Kongsberg (2012) and determine the approximate numbers of animals likely to be present within the zones of strong behavioural influence; those numbers are shown in Table 11.15.

| Species | Zone of possible impact (km$^2$)[16] | Density (animals/km$^2$)[17] | Number of individuals possibly present in zone of possible impact at one time |
|---|---|---|---|
| **Pinnipeds** | | | |
| Grey seal | 1.35 | 0.699 | 0.94 |
| Harbour seal | 1.35 | 0.202 | 0.27 |
| **Odontocetes** | | | |
| Harbour porpoise | 1.68 | 0.202 | 0.34 |
| **Mysticetes** | | | |
| Minke whale | 5.20 | 0.011 | 0.06 |

Table 11.15: Approximate number of marine mammals that may be located within the 'strong avoidance' zone from 36 x 2.4MW operational turbines at any one time

11.191 It is expected that one or fewer of any species could be expected to experience strong behavioural avoidance at any one time during operation of 36 x 2.4MW turbines. Considering the regional population sizes of these species and the fact that the impact is not considered to be sufficient to interfere with vital life processes (e.g. foraging over a wide-spread area, hauling out where relevant), these numbers are likely of little concern at a population level.

11.192 Southall *et al.* (2007) present comments from Morton & Symonds (2002) and Harwood (2001) stating that in contrast to terrestrial mammals where there might not be alternative areas for the animals to move to (due to lack of connectivity between habitats), there will usually be adjacent areas for cetaceans to move to that are within the natural range of their populations, and hence compensate for the loss of, or displacement from, a particular area of habitat. This is almost certainly the case with pinnipeds as well, but it is thought that there may be a territorial element to such species use of feeding areas on the seabed. As such, an individual seal may that is excluded from an area may have to move further from the device (or noise ensonified area) to find suitable alternative feeding grounds. As noted, however, it is not considered that the Project area represents critical feeding habitat and the effect, if any, is likely to be limited to a small number of seals. The subsequent additional energy required (if any) to travel so further sites will be inconsequential at the population level.

11.193 It is interesting to note that monitoring evidence for the Strangford Loch site shows that both harbour porpoise and harbour seals are regularly sighted within areas around the turbines that the site noise modelling predicted they could be excluded from (Royal Haskoning, 2011). The impact ranges predicted for the Project are likely therefore to be worst case scenarios and the number of animals that may be affected and the range over which effects may be felt are likely to be an overestimate.

11.194 For the purposes of the noise assessments herein, it is assumed that once a marine mammal has been exposed to noise levels exceeding TTS it will leave the vicinity of the activities and not return. In order to assess the potential for this to impact upon marine mammals at a population level, the number of marine mammals deemed to have 'left' the region can be placed in context with the number of animals expected to use the region over a set period (in this case the period of the installation operations). Considering even the situation involving the swimming animal in the Inner Sound described by Kongsberg above (that is an animal that swims through the area at 5ms$^{-1}$), no cetaceans or pinnipeds should be exposed to TTS from the operation of the 36 x 2.4 MW turbines and thus none are expected to leave the region and no population level impacts are expected. The one exception described by Kongsberg (2012) from the modelling was that harbour porpoises could experience TTS when the lower Lucke *et al.* (2009) value is considered; as described above however, this threshold is considered too low to be realistic.

11.195 It should be noted that the threshold for aversive behaviour in harbour porpoise is likely to be met after 18 seconds exposure to the turbine noise emissions. However, as previously noted, this value is considered inappropriate for the type of turbine noise emissions and, instead, the avoidance behaviour defined by the 90dB$_{ht}$ value should be considered.

### *36 x 2.4MW turbines operational - noise barrier*

11.196 In addition to the possibility that noise emissions could cause behavioural, or in limited cases auditory impacts, the noise emissions from the turbines could present a 'noise barrier' to movement if the levels were such that marine mammals could not (or would not) tolerate them and consequently fail to move into or through the area that they otherwise would have traversed. Noise emissions are considered sufficiently high to effect possible behavioural avoidance; if that avoidance was extreme then the animals may not enter the area of that noise level. As noted above, pinnipeds might show strong avoidance out to 38m around the turbines. As this group contains the most commonly observed species in Inner Sound (the grey seal), the noise barrier to the largest species group in the area will not extend much past the physical barrier of the turbines itself (the impact of which is assessed in Section 11.7.5). Even for odontocetes, this distance only extends to 98m around the turbines, leaving much of the Inner Sound (which is approximately 2 - 3km wide) available for through transit without possibility of noise-induced impact. Less of the Inner Sound would be available for minke whale and other mysticetes, but only three sightings of such species were made in 22 months of surveys and the Inner Sound does not therefore appear to represent an important, or even frequently used, passage.

11.197 Pinnipeds could choose to 'break through' the noise barrier to get to an area beyond; depending on the noise emissions and the time taken to pass through the area of increased noise, it is possible that injury could be expected. The 'dose' model described above shows that pinnipeds would not be expected to experience any impacts of noise regardless of the length of time which they spend submerged within the area (which extends only 38m around the edge of the turbine area).

11.198 For odontocetes, including the second most commonly sighted marine mammal the harbour porpoise, strong avoidance might be expected out to 98m from the turbine. If the strong avoidance means that the animals will not enter an area that is ensonified as such, this could present a noise barrier in the centre of the Inner Sound (representing the tidal turbine area and a 98m buffer around it) for all species of dolphin and for harbour porpoise (Table 11.14). Harbour porpoise are shown to use the north west of the 2 - 3km wide Inner Sound more than other areas. The establishment of a noise barrier in the middle of the Inner Sound of strong avoidance would not stop animals entering the Inner Sound from any direction using the most frequently visited area. In addition, animals could choose to 'break through' what noise barrier might exist to get to an area beyond; considering the noise emissions, the 'dose' model described above shows that injury would not be expected when passing through the noise 'barrier'.

[16] The zone of possible impact is based on a project area of 1.1km$^2$ in which avoidance is expected, plus a buffer round the project area which reflects the distances detailed in Table 11.14.

[17] Note that for harbour porpoise and grey seal this has been generated from site specific sightings and that this density is the maximum monthly density recorded and thus represents a worst case scenario for mammals impacted. For the remaining species, sightings were so low that density could not be estimated and thus regional values have been used. They are consequently higher than would be expected for Inner Sound and thus also represent a worst case scenario.

11.199 For mysticetes (including the minke whale) this barrier of strong avoidance could extend up to 588m out from the tidal turbine area (Table 11.14), far from forming a noise barrier across the 2 - 3km wide Inner Sound. This species group is not expected to use the area with any regularity (three sightings in two years of survey suggests the Inner Sound does not comprise important habitat for this species) and the actual presence of the noise barrier is unlikely to affect regional area use for mysticetes in general. Mysticetes could choose to 'break through' the noise barrier to get to an area beyond and, depending on the noise emissions and the time taken to pass through the area of increased noise, it is possible that injury could be expected. However, the 'dose' model described above shows that this is not the case for any mysticete.

11.200 Evidence defining barrier effects, or lack of such effects, from tidal turbines is currently not available as a result of the novel nature of tidal arrays. However, the SeaGen tidal turbine in the narrows of Strangford Lough, Northern Ireland, is an example of an individual turbine for which such information is becoming available. The turbine itself (comprising twin 16m diameter rotors) sits in the centre of a narrow tidal channel, a water body that is regularly traversed by a number of marine mammals, including harbour seals and harbour porpoise. SMRU Ltd conducted a tagging deployment on harbour seals within Strangford Lough to provide a description of the movements of the seals in relation to the Strangford Lough Narrows and wider coastline. Seal tracks were used to assess the extent to which movements have changed during the pre- and post-installation phases of the SeaGen project (Royal Haskoning, 2010). The tracks showed a large amount of individual variability, with some individuals remaining within the Lough and Narrows and others making long journeys to and from the Lough; although it is likely the case that animals will avoid the area of the turbine itself, the results indicate that there is no barrier effect as a result of SeaGen presence or operation for seals (Royal Haskoning, 2010). For harbour porpoise, acoustic loggers were deployed around Strangford Lough; although there were fewer detections of harbour porpoise during operation, there appears to be no difference in harbour porpoise detections north or south of the turbine, indicating that for this species the SeaGen device does not present a barrier to movement for this species either (Royal Haskoning, 2010). Although the specifics of the MeyGen project described herein differ from the SeaGen project, the results of the SeaGen monitoring programme seem to support the conclusion drawn above for the Project that the introduction of tidal turbines does not necessarily represent a barrier to movement between foraging, haulout or other important sites.

11.201 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, as the noise levels are relatively low, are not considered loud enough to cause injury or mortality and the ranges for behavioural reactions are small compared to the likely range of most species, any impacts are likely to be limited in extent. Therefore, the magnitude of impact is considered to be minor.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Minor | Minor | Not significant |

| MITIGATION IN RELATION TO IMPACT 11.7 |
|---|
| ▪ Although no specific mitigation measures are proposed. Operational monitoring will be implemented in order to confirm the impact predications made here (see Section 11.12). |

### *11.7.2 Impact 11.8: Maintenance noise*

11.202 The main impact of maintenance activities is likely to extend to the noise emissions from the vessels involved in those activities. Taking a worst case scenario, the vessels would be the same as those used in the installation operations. The source (or noise) level would be below that at which lethal injury to species of marine mammal might occur, no marine mammals will be killed as a consequence of this underwater noise.

11.203 In this assessment, it has been assumed that once an animal experiences a temporary change in hearing (TTS) then the animal will leave to area. TTS is, however, not expected to occur from maintenance operations (e.g. vessel use), no animals are expected to leave the region and thus no population level impacts are expected because of this.

11.204 This vessel noise could remain audible out to ranges of 1 - 14km depending on the prevailing levels of background noise. However, source (or noise) levels associated with the vessels are below the levels at which hearing damage might occur. Maximum ranges for strong behavioural impact would be less than 1m for pinnipeds and odontocetes and less than 56m for mysticetes.

11.205 As undertaken for the installation operations, the number of animals that may experience noise levels above thresholds at which negative impact may be experienced can be calculated. As with the installation operations, however, the zones of possible impact are so small and the local/regional density estimates so low that no animals are expected to be in those zones on most occasions.

11.206 Note also that maintenance noise will generally only occur around slack water as this is when it is possible to remove the turbines. There will not therefore be vessels in the area during the fastest flowing stages of the tidal cycle, which is when turbine noise emissions will be at their are highest, and there will be therefore be reduced likelihood of any possible cumulative effect from these two noise sources.

11.207 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, as the noise levels will be limited in spatial extent (an absolute maximum of 56m from vessels for even the most sensitive species) and will occur only during the installation period, the magnitude of impact is considered to be negligible.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Negligible | Negligible | Not significant |

| MITIGATION IN RELATION TO IMPACT 11.8 |
|---|
| ▪ No mitigation measures proposed as no significant impact predicted |

### 11.7.3 Impact 11.9: Ship strike (maintenance vessels) and ducted propellers

11.208 Increased vessel traffic has been identified as presenting an increased risk to marine mammals, through collision between vessel and animal and through possible interaction between ducted propellers and individual animals.

11.209 Vessels associated with the maintenance activities are planned to be on-site for minor maintenance once every two years per turbine and for major maintenance once every 10 years per turbine. Unplanned maintenance may be required between these times. These vessels will be slow travelling when moving to the turbines and extremely slow or stationary when engaged in the maintenance activities. As such, these vessels are much less likely to cause death or injury through collision than commercial shipping activity.

11.210 However, the possibility that seals are interacting with ducted propellers has been raised and, as with the installation activities, MeyGen will apply appropriate mitigation, as deemed necessary in consultation with Marine Scotland and SNH, should they use vessels with ducted propellers.

11.211 As noted in Section 11.6.2 for installation vessels, the possible impact from the use of ducted propellers is currently difficult to quantify and it is necessary to take a precautionary view of the impact when assigning magnitude levels. Using the same logic described in Section 11.6.2, the pre-mitigation magnitude has been assigned a higher ranking due to the uncertainty surrounding the possible impact.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Moderate | Moderate | Significant |

| MITIGATION IN RELATION TO IMPACT 11.9 |
|---|
| ▪ It is understood that investigation is ongoing on the potential link between spiral injuries in seals and ducted propellers and that mitigation measures relevant to minimising the risk of seal spiral injuries and fatalities are currently being developed at an industry and regulator level. MeyGen commit to undertaking frequent reviews of the literature regarding this topic and to regularly discuss advances in understanding of this topic with relevant regulatory and advisory bodies. MeyGen will apply appropriate mitigation, as deemed necessary in consultation with Marine Scotland and SNH, should vessels with ducted propellers be used, to avoid any significant impact. |

***Residual impact***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Minor | Minor | Not significant |

### 11.7.4 Impact 11.10: Turbine collision

11.212 Risk of collision between a moving turbine blade and a marine mammal is thought to be a key potential effect of tidal turbine operation and it is considered that all species of marine mammals that use the Project area are at some risk of collision impact, which could ultimately result in death or injury. Whilst a distinction can be drawn between species that forage in the water column or at the seabed (a distinction which is made in the modelling below), they all must return to the surface to breathe and so regularly transit the water column.

11.213 A number of factors including the visibility, audibility, dimensions and rotation speed of the turbine blades, how important the location is for feeding or breeding and the extent of long range avoidance and close range evasion all interact to determine the likelihood of collision.

11.214 To support the Scottish Marine Renewables SEA Wilson *et al*. (2007) were commissioned to investigate collision risk between marine renewable energy devices and marine mammals. The study identified that:

- Collision risks are not well understood for any marine vertebrates;
- Man-made collision risks are more diverse and common than generally supposed (the rate of whale–ship strikes is a significant example);
- Underwater collision risks typically become well studied after they have become a conservation concern;
- Animals may appear to behave illogically when faced with novel situations;
- Subtleties of gear design (shape, colour etc.) as well as environmental conditions (turbidity, flow rate etc.) can markedly change collision rates;
- Objects in the water column will naturally attract fish and consequently their predators (e.g. marine mammals);
- 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 the animal, with juveniles likely to be more at risk than adults because of reduced abilities or experience; and
- The potential for animals to escape collisions with marine renewable devices will depend on their body size, social behaviour, foraging tactics, curiosity, habitat use, underwater agility and sensory capabilities.

11.215 Collision risk can be assessed qualitatively by considering the behaviour and abundance of animals at risk in the location that devices are to be deployed. However, in order to make a more quantitative assessment, a collision risk model is required. It has not been possible, for this project or for any other tidal projects thus far, to develop a collision risk model because there is not sufficient information on the far-field or near-field behavioural responses of marine mammals to tidal turbines to enable a robust quantification of potential strike rates.

11.216 Since collision risk can be thought of as a function of encounter rate and the probabilities of marine mammal avoidance and evasion, modelling of encounter rates was considered an appropriate substitute to inform this EIA. MeyGen therefore commissioned SRSL to model marine mammal encounter rates (SRSL, 2012). This approach has previously been used to inform assessment in the Skerries Tidal Stream Array EIA. It was also presented as a proposed EIA approach in the Scottish Marine Renewables SEA (Scottish Executive, 2007). The approach also follows similar principles to those presented to ICES on seals by Davies and Thompson (2011).

11.217 For the species most likely to be recorded in the Project area, the number of animals likely to encounter each turbine each year has been calculated (Table 11.16). In consultation with Marine Scotland and SNH it was agreed to focus on four key marine mammal species; harbour porpoise, minke whale and the grey and harbour seals. For the two other cetacean species sighted during baseline surveys (killer whale and Risso's dolphin; see Section 11.5), sightings rates were extremely low and actual densities are likely to be much lower than for any of the species considered in the modelling. Encounter rates would also therefore be much lower. In addition, SAMS (pers. comm.) note that the unpredictable, transitory and occasionally extremely coastal behaviour exhibited by killer whales (for example, during seal hunting) takes encounter modelling beyond plausibility.

***Encounter model***

11.218 The details of how the encounter model was set up and the inputs used are given in Section 11.4.2 and in SRSL (2012) provided on the supporting studies CD.

11.219 Due to current uncertainty on exact turbine design, the encounter modelling was conducted to cover a range of turbine scenarios, including a turbine with two or three blades that exhibited an 18 or 20m rotor diameter. This allowed testing of the assumptions regarding which of these parameters was worst case (as shown in Table 11.1) to ensure that the worst case encounter rates are described herein. SRSL (2012) report that the dive types of seals differ between feeding and travelling events to the extent that encounter risk is likely to be very different. Whilst both dive types have been modelled for grey seals, evidence obtained for harbour seal dives in the Inner Sound (from SMRU Ltd) shows that dives most closely resemble the feeding dives and thus only this type of dive has been modelled for this species. Variable dive types are not considered to occur for the cetacean species of interest and thus only one dive type has been modelled.

***Encounter probability and population effects***

11.220 The model described above provides an output of encounter rate in terms of number of animals likely to encounter one turbine each year. However, the Project will see up to a maximum of 86 turbines installed over a 3 year period (maximum of ten turbines by the end of year one, maximum of 20 turbines by the end of year two). The number of encounters per turbine per year has therefore been multiplied by ten, 20 and 86 to provide an indicative encounter rate for the different stages of the array, on the assumption that the encounter rate increases linearly.

11.221 The results derived from the model and the inputs described above are shown in Table 11.16. The red highlighted cells represent the worst case encounter modelling results that have been taken forward for further assessment. Overall, encounter rates were higher for the three-bladed turbine than the two-bladed version. This is due to encounter rate being dependent on both relative velocity of turbine blade and animal and also the effective encounter radius. For all species considered, the turbine blade component of encounter radius is greater than that contributed by the animal itself. Although mean blade velocity will be lower for the three-bladed configuration, this is not sufficient to fully compensate for the greater encounter radius added by the extra blade. It must be stressed that this greater encounter rate for the three-bladed device may not carry through to a greater risk of collision because a two bladed device will present different sensory cues to an approaching animal than a three-bladed turbine, particularly in terms of fewer cues at close range. The lower velocities of the three bladed versions are also likely to result in more encounters being evaded. Encounter rates also varied between the 20m and 18m versions with differences between species due to their differing depth distribution behaviour which determines density per cubic metre within the depth range swept by the turbine blades.

| Rotor diameter (m) | Number of blades | Animal density data source | Vertical distribution of animal in water column | Encounter rate (animals per year) | |
|---|---|---|---|---|---|
| Harbour seal | | | | Density from project specific survey data | Density estimate from HO counts |
| 18 | 2 | Project specific survey<br>Haul out counts | SMRU dive data | 4.8 | 5.7 |
| 18 | 3 | Project specific survey<br>Haul out counts | SMRU dive data | **6.5** | **7.8** |
| 20 | 2 | Project specific survey<br>Haul out counts | SMRU dive data | 4.8 | 5.7 |
| 20 | 3 | Project specific survey<br>Haul out counts | SMRU dive data | 6.5 | 7.7 |
| Grey seal | | | | Density from project specific survey data | Upper 95% CI from project specific survey data |
| 18 | 2 | Project specific survey | Non-random U dive | 3.7 | 11.4 |
| 18 | 2 | Project specific survey | Non-random V dive | 16 | 49.6 |
| 18 | 3 | Project specific survey | Non-random U dive | 5.1 | 15.7 |
| 18 | 3 | Project specific survey | Non-random V dive | 22.1 | 68.3 |
| 20 | 2 | Project specific survey | Non-random U dive | 4.0 | 12.3 |
| 20 | 2 | Project specific survey | Non-random V dive | 16.2 | 50.1 |
| 20 | 3 | Project specific survey | Non-random U dive | **5.4** | **16.8** |
| 20 | 3 | Project specific survey | Non-random V dive | **22.1** | **68.4** |
| Harbour porpoise | | | | Density from project specific survey data | Upper 95% CI from project specific survey data |
| 18 | 2 | Project specific survey | Non-random | 3.5 | 6.6 |
| 18 | 3 | Project specific survey | Non-random | 4.8 | 9.3 |
| 20 | 2 | Project specific survey | Non-random | 3.6 | 6.8 |
| 20 | 3 | Project specific survey | Non-random | **4.9** | **9.4** |
| Minke whale | | | | SCANS II data | |
| 18 | 2 | SCANS II | Random | 2.9 | |
| 18 | 3 | SCANS II | Random | **4.1** | |
| 20 | 2 | SCANS II | Random | 2.9 | |
| 20 | 3 | SCANS II | Random | 3.9 | |

Table 11.16: Number of animals that may encounter a single turbine's blades (detail of modelling scenarios available in SRSL, 2012)

11.222 It is clear from the encounter modelling that numerous animals from each species type are likely to encounter turbines in the array each year. The extent to which this may impact on the regional population is not immediately clear, however, since encounter models do not predict the outcome of an encounter (i.e. injury or mortality); an encounter may lead to a collision but only if the animal in question does not take appropriate avoidance or evasive action. As they are highly mobile underwater, marine mammals have the capacity to avoid and evade marine turbine devices provided they have the ability to detect the objects, perceive them as a threat and then take appropriate action at long or short range (Gordon *et al*., 2011). Since there is no information on the degree to which marine mammals will actually make appropriate manoeuvres (Wilson *et al*., 2007), predicted encounter rates must be very carefully interpreted as a worst case scenario.

11.223 The affect that avoidance and evasion will have on the estimated encounter rate (shown in Table 11.16) can be investigated by applying a range of avoidance estimates ranging from 50 to 100%; the outcome of the application of these values is shown in Table 11.17, which shows a scaling up of encounter rate from one turbine to the 10, 20 and 86 turbine scenarios that represent the three phases of the Project. As well as providing an estimate of the percentage of the regional population that might be affected, it provides an estimate of the levels of avoidance that would be required to ensure that the PBR for grey and harbour seals would not be breached (the orange shaded cells in the table indicate where PBR numbers could be breached).

| | | Density data from Project specific data (except minke whale as sightings rate too low) | | | | | | Other species density estimate (harbour seal haul out estimate, harbour porpoise and grey seal upper 95% CI from Project survey) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Avoidance Rate[18] | 10 turbines | | 20 turbines | | 86 turbines | | 10 turbines | | 20 turbines | | 86 turbines | |
| | | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population |
| Harbour porpoise | 50 | 25 | 0.04 | 49 | 0.09 | 211 | 0.38 | 47 | 0.09 | 94 | 0.17 | 404 | 0.73 |
| | 75 | 12 | 0.02 | 25 | 0.04 | 105 | 0.19 | 24 | 0.04 | 47 | 0.09 | 202 | 0.37 |
| | 80 | 10 | 0.02 | 20 | 0.04 | 84 | 0.15 | 19 | 0.03 | 38 | 0.07 | 162 | 0.29 |
| | 90 | 5 | 0.01 | 10 | 0.02 | 42 | 0.08 | 9 | 0.02 | 19 | 0.03 | 81 | 0.15 |
| | 95 | 2 | 0.00 | 5 | 0.01 | 21 | 0.04 | 5 | 0.01 | 9 | 0.02 | 40 | 0.07 |
| | 98 | 1 | 0.00 | 2 | 0.00 | 8 | 0.02 | 2 | 0.00 | 4 | 0.01 | 16 | 0.03 |
| | 99 | 0 | 0.00 | 1 | 0.00 | 4 | 0.01 | 1 | 0.00 | 2 | 0.00 | 8 | 0.01 |
| | 99.5 | 0 | 0.00 | 0 | 0.00 | 2 | 0.00 | 0 | 0.00 | 1 | 0.00 | 4 | 0.01 |
| | 100 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |

[18] Includes both far-field avoidance and near-field evasion.

| | | Density data from Project specific data (except minke whale as sightings rate too low) | | | | | | Other species density estimate (harbour seal haul out estimate, harbour porpoise and grey seal upper 95% CI from Project survey) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Avoidance Rate[18] | 10 turbines | | 20 turbines | | 86 turbines | | 10 turbines | | 20 turbines | | 86 turbines | |
| | | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population | Encounter rate | % of Regional Population |
| Minke whale | 50 | | | | | | | 21 | 0.11 | 41 | 0.22 | 176 | 0.95 |
| | 75 | | | | | | | 10 | 0.06 | 21 | 0.11 | 88 | 0.47 |
| | 80 | | | | | | | 8 | 0.04 | 16 | 0.09 | 71 | 0.38 |
| | 90 | | | | | | | 4 | 0.02 | 8 | 0.04 | 35 | 0.19 |
| | 95 | | | | | | | 2 | 0.01 | 4 | 0.02 | 18 | 0.09 |
| | 98 | | | | | | | 1 | 0.00 | 2 | 0.01 | 7 | 0.04 |
| | 99 | | | | | | | 0 | 0.00 | 1 | 0.00 | 4 | 0.02 |
| | 99.5 | | | | | | | 0 | 0.00 | 0 | 0.00 | 2 | 0.01 |
| | 100 | | | | | | | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Grey seal feeding | 50 | 27 | 0.17 | 54 | 0.34 | 232 | 1.45 | 84 | 0.53 | 168 | 1.05 | 722 | 4.52 |
| | 75 | 14 | 0.08 | 27 | 0.17 | 116 | 0.73 | 42 | 0.26 | 84 | 0.53 | 361 | 2.26 |
| | 80 | 11 | 0.07 | 22 | 0.14 | 93 | 0.58 | 34 | 0.21 | 67 | 0.42 | 289 | 1.81 |
| | 90 | 5 | 0.03 | 11 | 0.07 | 46 | 0.29 | 17 | 0.11 | 34 | 0.21 | 144 | 0.90 |
| | 95 | 3 | 0.02 | 5 | 0.03 | 23 | 0.15 | 8 | 0.05 | 17 | 0.11 | 72 | 0.45 |
| | 98 | 1 | 0.01 | 2 | 0.01 | 9 | 0.06 | 3 | 0.02 | 7 | 0.04 | 29 | 0.18 |
| | 99 | 1 | 0.00 | 1 | 0.01 | 5 | 0.03 | 2 | 0.01 | 3 | 0.02 | 14 | 0.09 |
| | 99.5 | 0 | 0.00 | 1 | 0.00 | 2 | 0.01 | 1 | 0.01 | 2 | 0.01 | 7 | 0.05 |
| | 100 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Grey seal travelling | 50 | 111 | 0.69 | 221 | 1.38 | 950 | 5.95 | 342 | 2.14 | 684 | 4.28 | 2941 | 18.41 |
| | 75 | 55 | 0.35 | 111 | 0.69 | 475 | 2.97 | 171 | 1.07 | 342 | 2.14 | 1471 | 9.21 |
| | 80 | 44 | 0.28 | 88 | 0.55 | 380 | 2.38 | 137 | 0.86 | 274 | 1.71 | 1176 | 7.36 |
| | 90 | 22 | 0.14 | 44 | 0.28 | 190 | 1.19 | 68 | 0.43 | 137 | 0.86 | 588 | 3.68 |
| | 95 | 11 | 0.07 | 22 | 0.14 | 95 | 0.59 | 34 | 0.21 | 68 | 0.43 | 294 | 1.84 |
| | 98 | 4 | 0.03 | 9 | 0.06 | 38 | 0.24 | 14 | 0.09 | 27 | 0.17 | 118 | 0.74 |
| | 99 | 2 | 0.01 | 4 | 0.03 | 19 | 0.12 | 7 | 0.04 | 14 | 0.09 | 59 | 0.37 |
| | 99.5 | 1 | 0.01 | 2 | 0.01 | 10 | 0.06 | 3 | 0.02 | 7 | 0.04 | 29 | 0.18 |
| | 100 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Harbour seal | 50 | 33 | 1.09 | 65 | 2.18 | 280 | 9.38 | 39 | 1.31 | 78 | 2.62 | 335 | 11.26 |
| | 75 | 16 | 0.55 | 33 | 1.09 | 140 | 4.69 | 20 | 0.65 | 39 | 1.31 | 168 | 5.63 |
| | 80 | 13 | 0.44 | 26 | 0.87 | 112 | 3.75 | 16 | 0.52 | 31 | 1.05 | 134 | 4.50 |
| | 90 | 7 | 0.22 | 13 | 0.44 | 56 | 1.88 | 8 | 0.26 | 16 | 0.52 | 67 | 2.25 |
| | 95 | 3 | 0.11 | 7 | 0.22 | 28 | 0.94 | 4 | 0.13 | 8 | 0.26 | 34 | 1.13 |
| | 98 | 1 | 0.04 | 3 | 0.09 | 11 | 0.38 | 2 | 0.05 | 3 | 0.10 | 13 | 0.45 |
| | 99 | 1 | 0.02 | 1 | 0.04 | 6 | 0.19 | 1 | 0.03 | 2 | 0.05 | 7 | 0.23 |
| | 99.5 | 0 | 0.01 | 1 | 0.02 | 3 | 0.09 | 0 | 0.01 | 1 | 0.03 | 3 | 0.11 |
| | 100 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |

Table 11.17: Number of animals that may encounter the blades of the turbines based on a range of possible avoidance rates (orange highlights show where the PBR is exceeded).

### *Avoidance and evasion*

11.224 What the encounter rates and evidence of avoidance capability means to the actual risk of collision can be explored by studying avoidance (medium to long range aversion to the presence of turbines) and evasion (short range avoidance of turbine components). Wilson *et al*. (2007) report that responses to the tidal devices are likely to occur on two spatial scales; at long range the marine mammals have the option to avoid the area of device placement (i.e. swim around) and at closer range they can evade the particular structures (i.e. dodge or swerve). Little is known yet about behavioural reactions but detection distances can be determined (Wilson *et al*., 2007). Given the audibility of the operating turbines described in Section 11.6, it is likely that marine mammals will be able to detect the turbines at various ranges, out to approximately 14km in some cases. Marine mammals are thus likely to be able to recognise the presence of the stationary noise source (the turbine) and will have time on any approach to this noise source to ready an avoidance response. Similarly, the noise propagation modelling suggests that there may be strong behavioural reactions by marine mammals around the turbines themselves which may lead to the marine mammals swimming away or around the turbines themselves, further limiting the likelihood of encounter.

11.225 Where marine mammals do not take avoidance measures at longer ranges, they are likely to come close to the turbine devices. In terms of reactions on approaching the blades, marine mammals ordinarily encounter obstacles in the water column and are clearly adept at dodging or swerving those obstacles, whether they are stationary such as the seabed or moving like predators. In daytime and clear waters, underwater structures may be visible at ranges of tens of meters underwater, and hence give sufficient warning for visual species to exhibit avoidance and evasion if necessary (Wilson *et al*., 2007). Note also that collision risk is expected to be greater for turbines deployed in regions of moderate to high turbidity, or if the turbines increase turbidity, because of reduced visibility (Scottish Executive, 2007), but it is known that the water column in the Project area does not hold a high sediment content and it is not likely that the turbines will resuspend any sediment themselves (see Section 9).

### *Examples of avoidance and evasion*

11.226 Some understanding of how marine mammals react around these devices may be derived from existing tidal developments. For example, the Environmental Monitoring Programme (EMP) for the SeaGen tidal device in Strangford Lough has involved the assessment of all seal carcasses found in the lough and in post mortem none have shown signs of interaction with the SeaGen turbine, suggesting an absence of recurring fatal encounters between seals and the tidal turbine (Royal Haskoning, 2011).

11.227 Data from telemetry and acoustic studies in Strangford Lough suggest that there may be a degree of local avoidance by marine mammals of operating turbines, though no reduction in overall seal or harbour porpoise transit rates through the narrows in which the turbine is located (Royal Haskoning, 2011). For example, there was evidence of a redistribution of harbour seals during turbine operation over approximately 250m around the turbine. Although Royal Haskoning (2011) suggest that this is probably of little biological significance, it indicates that harbour seals may well be detecting the presence of the turbine and responding to it to ensure no collision. Royal Haskoning (2011) state that this pattern of avoidance was similar regardless of whether the turbine was operating or not operating, suggesting that it was not a direct result of noise produced by the operating turbine, nor necessarily related to moving turbine rotors, and instead may have been due to the presence of the structure, or, importantly from a collision perspective, a learned "habit" of avoidance.

11.228 Interestingly, monitoring of the SeaGen device showed that seals transited at a relatively higher rate during periods of slack tide. As Royal Haskoning (2011) note in the EMP, this would clearly have the effect of reducing collision risk if seals were preferentially transiting during periods when the turbine was not operating.

11.229 As part of the deployment of a single TGL tidal device at the Falls of Warness EMEC test site in Orkney, TGL placed strain gauges in the blades of the turbine to monitor impact between objects in the water column and the device, with the main aim being to determine whether marine mammals had made contact with the device (TGL, 2011). The monitoring and extensive processing and post-processing analysis of data collected during a nine day monitoring period across a range of tidal states showed no evidence of any marine mammal impact on the blades of the device (TGL, 2011). Concurrent with the analysis, there were no reported sightings of injured or dead marine mammals in the locality of the turbine test site (TGL, 2011).

### *Multiple turbines*

11.230 In addition to the current uncertainty on marine mammal behaviour around these types of renewable devices, it is also not currently understood how the reaction of a marine mammal to one turbine affects the encounter rate for other/multiple turbines. When the animals are at long range, multiple devices will provide a larger target and more cues for animals to avoid but they also act as a larger combined area that will need to be avoided (Gordon *et al.*, 2011). As the distance at which an animal may respond gets larger than the immediate vicinity of a turbine, avoidance behaviour will become possible and the number of turbines an animal might encounter when transiting is likely to fall. For example, once the range of response exceeds half the distance between two adjacent turbines then an animal will have the possibility of skirting around the outside of an array without actually entering it. This would be analogous to a person approaching a forest in fog. If there is enough visibility to see two trees at once then it's possible to work around the forest without entering it. If avoidance operates for marine vertebrates at such scales then encounter rates are likely to scale more to the number of turbines at the perimeter approached, rather than the entire array.

11.231 If animals do not avoid turbines at long range and turbine separation distance is greater than the animals are able to detect, at close range multiple devices could produce a more complex set of cues for approaching animals and increase the collision risk (Gordon *et al*., 2011). The tactics taken to minimise contact with one device could lead to greater likelihood of contact between the animal and another device, or could instead guide the animal away from the array (Gordon *et al*., 2011). However, the noise modelling suggests that animals will be able to detect the turbines at much greater than the turbine separation distance and multiple devices therefore seem most likely to produce greater cues at long range, raising the prospect of bringing about a reduction in the number of animals coming into close proximity to the turbines.

### *Implication of an encounter*

11.232 In spite of these uncertainties, what is clear from the application of a range of possible avoidance rates is that some marine mammals are likely to encounter the turbine blades. What is unclear is the extent to which an encounter translates into injury or death. Wilson *et al*. (2007) comment that the effect may range from minor injuries such as abrasions to temporary or permanent debilitation (internal injuries, surface wounds, damage to delicate organs such as eyes) to more significant injuries (major cuts, amputations or internal trauma). In terms of minor collisions, the skin of a seal is considerably more resistant to abrasion than that of cetaceans. Depending on severity and bodily location these injuries may result in recoverable injury, long-term debilitation, delayed or instant mortality (Wilson *et al*., 2007). Injury is likely to be much more common than instant mortality since marine mammals are relatively robust to potential strikes as a result of the thick layer of blubber that protects defend the vital organs. However evidence from ship strikes suggests that for impacts with large objects, a blubber layer is insufficient to provide adequate protection (Laist *et al*., 2001).

### *Worst case assumptions*

11.233 In summary, it is likely that the encounter rates predicted are likely to be an overestimate of the real encounter rate since:

- The worst case Project parameters have been used as inputs to the model;
- Density estimates for some of the species are likely to be overestimates;
- Monitoring evidence for other devices suggests a high degree of avoidance of tidal devices;
- Noise modelling shows the devices are likely to be audible over a number of kilometres, increasing the likelihood of early detection by mammals;
- Linear scaling up from one turbine to multiple turbines is likely to give an overestimate of encounter rates; and
- The differing nature of the types of movement through the water column by marine mammals (e.g. feeding dives involve a lot of time at the seabed whilst travelling dives involve less time) means that how the area is used will affect, to an extent, the encounter rate. For example for seals since feeding dives involve more time at the seabed, encounter rate is reduced as the blades are positioned further up in the water column. In contrast to the assessment of exclusion of seals from an area where the impact is greater in areas used for feeding, the impact of the turbines with respect to collision risk will be less in areas where feeding dives are more common than travelling dives. For grey seals, this species was observed feeding in the area and the true average possible encounter rate is likely to be somewhere between the encounter rates for the feeding and travelling dives, with each trip having a likelihood of encounter that depends on the purpose of that trip, or, on an even finer scale, of that dive.

11.234 In order to help the interpretation of the encounter modelling results and understand how best to apply the Scottish Government Survey, Deploy and Monitor Policy with respect to the marine mammal collision impacts, impact assessment results have been presented for the for years one, two and three.

### *Cetaceans*

11.235 Considering the above, it is likely that avoidance rates will be at the upper end of the scale described in Table 11.17. For harbour porpoise, this means that less than 0.10% of the regional population would encounter the turbines annually and a smaller portion yet actually seriously injured or killed by the collision. For minke whales, less than around 0.20% would encounter the turbines and fewer still actually be injured or killed. The population level effects for these species are likely therefore to be inconsequential.

### *Pinnipeds*

11.236 For grey seals, the numbers possibly encountering the device at the higher avoidance rates are sufficiently low in all cases that the PBR (959 grey seals; Scottish Government, 2012) will not be reached and population effects are not expected, especially when it is considered that the encounter rate, even with the avoidance factored in, does not represent serious injury or fatality in all cases. Note for grey seals that all Scottish regional grey seal populations have shown prolonged growth and some have now stabilised, and the seals are highly mobile between populations, such that the importance of the sub populations themselves is likely reduced (Scottish Government, 2011).

11.237 For harbour seals, the number that could possibly encounter the devices is approximately one quarter of that predicted for grey seals. The Orkney and North Scotland harbour seal population is much smaller than the grey seal population and these numbers are consequently closer to the PBR (18 animals;

Scottish Government, 2012). However, for higher avoidance rates (74%, 87% and 97% for ten turbines, 20 turbines and 86 turbines respectively), the number of animals that might be impacted is still below the PBR.

***Impact rankings***

11.238 For harbour porpoise, minke whale and grey seal, the number possibly encountering the turbines is relatively low, but the uncertainty regarding the extent of the impact is such that the ease with which assessment rankings can be assigned is less than for other, better understood impacts. To ensure that the possible impact is appropriately captured in light of the lack of available data, and in line with the precautionary approach, it is considered that the rankings should be set artificially high. To that end, a lower value of 90% will be assumed for avoidance, even though the available evidence described herein suggests it will be higher. For harbour seals, the numbers potentially affected are sufficiently close to the PBR to warrant an increased ranking relative to the other species groups. As such, they are presented in the impact table below as a separate entry.

11.239 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, as the percentage of the regional population that might be affected is so small for harbour porpoise, minke whale and grey seal, the magnitude of impact is considered to be minor. For grey seals, it is also seen that the PBR will not be reached for anything other than very low avoidance. For the harbour seal, the majority, or even large minority, of the population is similarly not expected to be affected. However, the PBR level (at which population level effects may start to occur) may be breached if avoidance was to fall below 97% (and all encounters resulted in death) for 86 turbines and therefore a magnitude of major has been assigned (see Table 11.6 for magnitude definitions).

***Impact significance***

| Scenario | Sensitivity of harbour porpoise, minke whale and grey seal | Magnitude of impact | Consequence | Significance |
|---|---|---|---|---|
| 10 Turbines | Medium | Minor | Minor | Not Significant |
| 20 Turbines | Medium | Minor | Minor | Not Significant |
| 86 Turbines | Medium | Minor | Minor | Not Significant |

| Scenario | Sensitivity of harbour seal | Magnitude of impact | Consequence | Significance |
|---|---|---|---|---|
| 10 turbines | Medium | Minor | Minor | Not Significant |
| 20 Turbines | Medium | Minor | Minor | Not Significant |
| 86 Turbines | Medium | Major | Major | Significant |

**MITIGATION IN RELATION TO IMPACT 11.10**

- Based on extreme worst case modelling, the results presented above indicate that significant impacts are not expected on any species other than harbour seal. And that even then, significant impacts will be potentially linked to the larger array rather than intimal smaller array deployment. MeyGen therefore propose in line with the Scottish Government Survey, Deploy and Monitor Policy that the monitoring of the deployments in years one and two will allow for a better definition of avoidance rates and to better understand the possible impact of the full 86 turbine array. It will also inform the potential requirement for future mitigation and ensure no significant impacts on marine mammals.

***Residual impact***

| Sensitivity of harbour seal | Magnitude of impact for 86 turbines | Consequence for 86 turbines | Significance for 86 turbines |
|---|---|---|---|
| Medium | Minor | Minor | Not Significant |

### 11.7.5 Impact 11.11: Physical barrier to movement

11.240 There exists the potential for tidal arrays to form a barrier to the usual transit patterns of marine mammals through an area to waters far beyond or to access feeding/breeding grounds, either because of a physical barrier (which will stop animals passing by) or perceptions of devices or maintenance activities (if there is some innate response by the mammals to move away from vessels or structures). This is particularly relevant in a constrained area such as the Inner Sound.

11.241 Where marine mammals perceive an area as unavailable (for whatever reason) and do not then make use of that area, the animals can be considered as having been excluded from marine foraging/breeding habitats or, in the case of seals, terrestrial breeding/moulting habitats. Whilst it is considered likely that alternative foraging and breeding areas will generally be available to marine mammal species, there is a potential for devices to limit access to key areas (such as feeding hotspots), either because the devices themselves are located in such areas or because they present a perceived barrier which prevents access to such hotspots beyond. There are no marine mammals known to use the Inner Sound during specific migrations, and animals engaged in local movements as part of foraging, breeding and other life tasks will be the most likely receptors of any impact. Where species may be interchanging between populations over a larger scale (for example, bottlenose dolphins may move between the Moray Firth population and the Scottish west coast population; Robinson *et al*., 2009) then it is highly likely that they would use the wider Pentland Firth during these movements in addition to Inner Sound (if they do in fact use Inner Sound at all).

11.242 The turbines may present a barrier via two mechanisms; the physical barrier that the turbines themselves represent and the noise barrier that the any acoustic emissions might erect. The noise barrier has been described in Section 11.7.1. As the noise emissions extend out from the array, the possible barrier erected by the noise emissions is inherently larger than that possibly presented by the physical presence of the turbines (although it by no means constitutes a barrier across the whole of the Inner Sound). However, the physical barrier presented by the turbines can be considered the minimum barrier that the tidal array will present, but it may also represent the actual extent of the barrier if the noise emissions do not actually represent an increased barrier size (see Section 11.7.1 for discussion).

11.243 The extent to which this physical barrier will impact on marine mammals in the area will depend to a degree on the footprint of the project relative to remaining sea space in the Inner Sound (i.e. can animals pass round either side of the turbine or array noise) but also to the marine mammals' use of the area. Where the noise barrier assumes that the entire depth of the water column is unavailable in the areas where noise is above a certain level, the physical barrier extends only to the dimensions of the turbine blades as marine mammals could pass above, below or round those blades.

11.244 In terms of the physical barrier, each turbine presents an obstacle in the vertical plane, in that the marine mammals will be unable (or unwilling) to pass through the swept area of the turbine blade. As a worst case assumption, the turbine blades will have a radius of 20m which represents an area of approximately 314m$^2$ per turbine. The widest row of turbines will comprise 11 turbines and provide the greatest 'barrier area' of any of the rows of turbines. This row will present a swept area of approximately 3,454m$^2$ and it is this area that marine mammals are assumed to be unable to pass through. In the context of the vertical area available across the Inner Sound, the turbines present a barrier of approximately 8% of the area. Compared to that across the Pentland Firth as a whole, the turbines present a barrier of less than 1%. It is reasonable therefore to expect that the physical barrier will not introduce an obstacle to movement; all species and any individual marine mammal entering any part of the Inner Sound or the Pentland Firth can still reach any other part of the Inner Sound or Pentland Firth without coming into contact with the turbines. Marine mammals approaching the turbines will be able to move around, above or below the turbines. Although the turbines are sited across some of the deepest channel, no exclusively deep diving marine mammals are known to use the area. Indeed, marine mammals must regularly surface to breath and are consequently capable of passing over the top of the turbines. This is something that the marine mammals may not even need to do, however, if they instead use the waters to the north and south of the devices. All turbines will be located in water that is deep enough to provide a minimum clearance from the blade tip to the sea surface of 8m.

11.245 As detailed in Section 11.7.1, evidence from the SeaGen tidal turbine in the narrows of Strangford Lough, Northern Ireland, suggests that although it is likely the case that animals will avoid the area of the turbine itself (whether due to visual or auditory cues, or some other mechanism), the results indicate that there is no barrier effect as a result of SeaGen presence or operation for seals (Royal Haskoning, 2010). Similarly for harbour porpoise, although there were fewer detections of harbour porpoise during operation, there appeared to be no difference in harbour porpoise detections north or south of the turbine, indicating that for this species the SeaGen device does not present a barrier to movement for this species either (Royal Haskoning, 2010). Although the specifics of the MeyGen project described herein differ from the SeaGen project, the results of the SeaGen monitoring programme seem to support the conclusion drawn above for the Project that the introduction of tidal turbines does not necessarily represent a barrier to movement between foraging, haulout or other important sites.

11.246 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, as turbines are likely to represent, at a maximum, only around 8% of the Inner Sound and as movement through the Inner Sound will remain otherwise unrestricted, the magnitude of impact is considered to be negligible.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Negligible | Negligible | Not significant |

| MITIGATION IN RELATION TO IMPACT 11.11 |
|---|
| ▪ No specific mitigation measures are proposed as no significant impact predicted. Operational monitoring will be implemented in order to confirm the impact predications made here (see Section 11.12). |

### 11.7.6 Impact 11.12: Indirect effects via prey species

11.247 As described in Section 11.6.4, it is possible that mammals may be affected if those prey species are negatively impacted by any of the operation or maintenance activities. Since the Fish Ecology (Section 13) and Benthic Ecology (Section 10) assessments concluded that installation related impacts on each of these potential prey species are likely to be minor or negligible, subsequent impacts on marine mammals that prey on these species should be of a similar nature.

11.248 It is possible, however, that the turbine support structures may provide new habitat for fish and shellfish species (the aggregation of fish around marine structures and man-made objects placed in the sea is well-documented e.g. Inger *et al.* 2009) and foraging success or efficiency of marine mammals in the area could increase. Although animals may not forage amongst the turbines, the effect could be to increase the prey availability around the turbines, which would be likely to remain accessible. This positive benefit is difficult to quantify, however, and it is possible that the deterrent effect of the operating noise emissions may limit marine mammal access to the waters around the turbines, limiting any benefit.

11.249 The marine mammal species that may be found at the site meet many of the criteria for medium sensitivity of receptor (e.g. some species are listed on Annex II of the EU Habitats Directive or are listed as EPS) and the sensitivity of receptor is therefore ranked as medium. However, as the species on which marine mammals are likely to prey will be unaffected to any significant extent by the Project, the magnitude of impact is considered to be negligible.

***Impact significance***

| Sensitivity of receptor | Magnitude of impact | Consequence | Significance |
|---|---|---|---|
| Medium | Negligible | Negligible | Not significant |

| MITIGATION IN RELATION TO IMPACT 11.12 |
|---|
| ▪ No mitigation measures are proposed as no significant impact predicted. |

### 11.7.7 Impact 11.13: Accidental spillage from vessels

11.250 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.

## 11.8 Impacts during Decommissioning

11.251 The tidal turbines will be removed from the TSS to a recovery vessel and returned to shore. The cables will be recovered to a vessel, the Horizontal Directional Drilling (HDD) bores filled at the breakthrough location and the piles cut at the seabed.

11.252 Decommissioning activities are assumed to generate noise levels similar to those generated during pile drilling. Decommissioning noise at one site at a time is therefore assumed to introduce no additional underwater noise to the environment over and above the noise generated from turbines in operational mode and impacts are likely to be equal or less to those described previously.

11.253 The likelihood and magnitude of impact of ship strike, increased turbidity, effects via prey species, barrier effect or collision risk will also be the same or less than during the installation and operation and maintenance activities and do not warrant additional assessment.

## 11.9 Potential Variances in Environmental Impacts

11.254 This impact assessment has assessed the maximum potential impacts associated with the project options with regards to impact on marine mammals. Relative to the application of the Rochdale Envelope approach in the consenting of other offshore renewables developments (e.g. offshore wind farms) the MeyGen consenting envelope does not involve large scale variability in key design parameters or impact footprints with regards to potential impacts on marine mammals.

11.255 An alternative project option that could potentially be followed through but which has not been assessed is the siting of turbines using TSS on the seafloor or installation via monopile instead of pin pile. Use of gravity based structures would result in a reduced noise output from the installation activities as drilling would not be required and the possible impact would be limited to the noise emissions from the installation vessels.

11.256 The turbine collision impact assessment has been based on the maximum number of turbines that could be installed by the end of each installation year (i.e. 10 in year one, 20 in year two and 86 in year three). Should a lesser number of turbines be installed, then the potential number of encounters and therefore potential marine mammal deaths, would be less than predicted.

## 11.10 Cumulative Impacts

### 11.10.1 Introduction

11.257 MeyGen has in consultation with Marine Scotland and Highland Council identified a list of other projects (MeyGen, 2011) 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.

11.258 Having considered the information presently available in the public domain on the projects for which there is a potential for cumulative impacts, Table 11.18 below indicates those with the potential to result in cumulative impacts from a marine mammal 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 Tidal Energy Project | ✓ | Northern Isles Salmon, Lyrawa salmon cage site | ✓ |
| 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 11.18: Summary of potential cumulative impacts

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

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

### 11.10.2 Potential Cumulative Impacts during Construction and Installation

11.260 The nature of the possible cumulative impact will depend on the nature of the development; for example, there will be no cumulative operational effects with cable projects. However, the potential for cumulative impact exists in the installation phase with all other project types. The scope for such cumulative impact will, however, be limited to projects for which the installation schedule is similar to that of the MeyGen project.

11.261 The MeyGen Tidal Energy Project Phase 2 will introduce a further 312MW of tidal turbines into the Inner Sound. The exact number, location and layout within the Agreement for Lease area is not defined and will incorporate lessons learned from and technology advancements beyond Phase 1 of the Project. These factors will influence the potential for, nature of and significance of any cumulative impacts.

11.262 The impact ranges from installation vessels for other projects are likely to be of a similarly small scale as predicted for the Project and therefore the scope for cumulative impact is minimal since each project will be excluding very small areas from use at worst. In terms of installation of the devices themselves, piling for numerous large diameter wind turbines is likely to dwarf the relatively small behavioural impact ranges from wave and tidal devices. The main responsibility for reducing impact over these large ranges lies with the wind developers, which can be effected through the relevant EIA processes. Due to the location of the wind lease areas (much to the south and shielded by land) then it is not anticipated that areas of impact should be coincident and no in combination effects are likely. However, the cumulative impact of each project excluding small areas and the wind projects excluding larger areas might make a large proportion of a habitat unavailable for a particular marine mammal species use. As described above, however, the home ranges of the cetaceans using the Orkney and Pentland Firth Waters are part of much wider areas and as a result it is unlikely that cumulative impacts of temporary inability to enter an area (which is the worst case) will have an impact magnitude of greater than minor. No key breeding sites have been identified for cetaceans in this area.

11.263 Installation and maintenance vessels will be slow moving for all these developments and the risk of ship strike is much lower than for other vessel traffic. No cumulative effects are considered likely.

11.264 The possibility for cumulative impact on seals exists for the use of ducted propellers, however, as the high energy environment makes use of such vessels likely. Even though individual projects are unlikely to impact on many, or any, seals, the low PBR for the harbour seal especially means the prospect is raised. The possibility of cumulative impact is raised when the numbers that may be affected through interaction with the turbine blades are added to those possibly affected by interaction with ducted propellers. As it is an emerging issue and mitigation measures are not fully developed at this time, it is not possible to state there will be no cumulative impact. MeyGen commit to deploying relevant mitigation and monitoring measures should they use ducted propellers to limit the potential for impact. As such, the impact is expected to be minimal and cumulative impact with other developments considered unlikely.

11.265 Note that aquaculture sites and activities in Scapa Flow were identified as of possible concern for the Project during the EIA scoping phase but possible impact mechanisms do not overlap with those described in this chapter. However, aquaculture operators may apply to Marine Scotland for a licence to shoot seals in order to protect the health, welfare and status of their farmed fish stocks. As such, when placing potential impacts on seals in a wider regional context, it will be useful to consider the PBR for the Orkney & North Coast Seal Management Area. The number that may be removed for grey seals is high (959) and the combined number at risk from the Project and aquaculture will be highly unlikely to ever approach this value. For harbour seals, the PBR for 2012 is very low (18; Scottish Government, 2012) and it is unlikely that aquaculture interests would receive permission to shoot multiple animals. Indeed, permission has been given for removal of only seven animals (correct $1^{st}$ February, 2012; Scottish Government, 2012) and the cumulative impact with the small number that could be licensed for shooting is therefore extremely unlikely to have a population effect.

### 11.10.3 Potential Cumulative Impacts during Operations and Maintenance

11.266 Whilst installation noise emissions will be temporary for the relatively short installation periods, operational noise is a continuous emission throughout the operational life cycle. In this respect the emissions from wave and wind projects will be of an entirely different nature to tidal and cumulative impacts are unlikely. There are only five other tidal projects in the whole area, plus MeyGen Phase 2, and the potential for cumulative impact is thus further reduced. Considering the operational impact ranges and the nature of those impacts, pinnipeds and odontocetes (including harbour porpoise, killer whales and Risso's dolphins) would be unlikely to experience any large areas of habitat exclusion or any impacts on larger scale movements from area to area. Although the possible strong behavioural reaction ranges are likely to extend over some hundreds of metres for mysticetes and although there are two further tidal sites on the north coast of the Pentland firth, the fact that the Phase 1 (and Phase 2) Project area are relatively enclosed within Inner Sound means that these impact ranges are very unlikely to overlap and there should not be any cumulative noise barrier across the Pentland Firth. The extended ranges of possible behavioural impact make cumulative impacts on mysticetes theoretically more likely than other marine mammals as the ranges are larger. However, mysticete density is very low compared to other species and the number that might be excluded from some areas will be very low.

11.267 It is possible that wind and wave devices will present a perceived physical barrier, much like described for the turbine in this Project. This could give rise to cumulative effects if large scale movements of animals are affected or if the devices block access to important feeding or breeding grounds. This is unlikely to be the case, however, as the devices are expected to represent a very small percentage of the available water column and marine mammals will be required to make only small deviations around devices to continue to access whatever it is they were trying to gain access to.

11.268 The turbine collision impact assessment highlights that there may be a risk to marine mammal populations from the presence and operation of the turbines. The percentage of the regional population of the cetacean species that might come into contact with the Project turbines is considered to be extremely low. As the effect is likely to be similarly low from the MeyGen Phase 2 and Ness of Duncansby and Cantick Head sites, the cumulative impact is likely to be low also. It is possible that different cetacean species use the three sites differently; where a species used one site and not others then that species would not be susceptible to any sort of cumulative impact. It is therefore not possible for a definitive assessment on potential cumulative impacts until site specific cetacean data for other Project locations is publically available.

11.269 For harbour seals, the local density of animals is very low and the number predicted to potentially encounter the devices also very low. As a result, the number that may be affected by the Project in terms of the local population is low. Cumulative effects with other developments therefore seem unlikely. However, the PBR for this species is very low and if a similar collision risk was present from the other proposed tidal projects, the cumulative impact may be sufficient to result in the PBR being reached, which could cause population level effects.

11.270 The distribution of seal haul outs in the Pentland Firth shows that the Inner Sound area hosts a relatively greater number of haul out sites than the waters surrounding the other two tidal lease areas (Ness of Duncansby and Cantick Head) in the Pentland Firth (SMRU Ltd, 2011, Scottish Government, 2011). As such, any cumulative impact with these other two sites would, in all likelihood, not be a linear scaling up of the possible worst case impact described from the Project herein. The possible cumulative impact from the MeyGen Phase 2 development may also not be a linear increase from that described for the Project herein; increasing the number of turbines may increase the number of animals likely to come in contact when the impact from one turbine is scaled up, but increasing the number of turbines will increase the auditory and visual cues to their presence, which may decrease the risk of collisions per turbine. Once monitoring results are available in order to better define avoidance rates this will allow for determination of potential impacts from larger and multiple arrays.

11.271 MeyGen commit to developing relevant mitigation and monitoring measures in consultation with Marine Scotland and SNH to limit the potential for impact. As such, it is anticipated that it will be possible to restrict the impact on the marine mammals in the Inner Sound and consequently limit the possibility for cumulative impact with other developments.

### 11.10.4 Potential Cumulative Impacts during Decommissioning

11.272 The potential for cumulative impacts with other projects during the decommissioning phase of the Project is unclear as such activities are not currently defined (they will be developed following best practice at the time) and information on other projects is similarly unavailable. Decommissioning activities for the Project are likely to generate noise levels similar to those generated during pile drilling and cumulative impacts related to decommissioning noise are unlikely to be greater than for installation activities.

11.273 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 development (which would likely be decommissioned at the same time as the proposed development).

### 11.10.5 Mitigation Requirements for Potential Cumulative Impacts

11.274 No mitigation is required over and above the Project specific mitigation. It should however be noted that there is still some uncertainty over the potential impacts on marine mammals from potential collision with the tidal turbines. Should monitoring of the early years of deployment indicate mitigation is required to avoid significant cumulative impacts, MeyGen will develop and adopt mitigation as appropriate.

## 11.11 Habitat Regulations Appraisal

11.275 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.

11.276 Due to the distances over which marine mammal species for which SACs are designated can travel, there has been a need to investigate the potential Likely Significant Effects on a number of SAC sites designated for their marine mammal interests. This assessment is presented in a separate HRA report (see HRA document on the supporting studies CD, MeyGen, 2012).

## 11.12 Proposed Monitoring

11.277 The majority of potential impacts on marine mammals have been assessed as being negligible or minor. There is however still some uncertainty around the potential for impacts from collision with the turbines and MeyGen recognises the need for operational monitoring in order to better clarify these uncertainties.

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

11.279 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 program that will benefit future projects as well.

11.280 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.

11.281 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 marine mammal 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 some or all of the following:

- Disturbance and displacement;
  - Targeted observations of all marine mammals to determine how area use or behaviour may have changed over time;
  - Acoustic monitoring of harbour porpoise (and incidentally other echo-locating species) using static loggers to assist with determining area use;
  - 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;
- Collision risk;
  - MeyGen believes that understanding marine mammal 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. This impact assessment has indicated seals as the species group of most concern. Monitoring could include:
  - Continuation of ongoing seal tagging programme in the Inner Sound;
  - Installation of one or more active monitoring systems on one or more tidal device to better understand the near-field response of marine mammals (and other marine species) to operational tidal devices; and
  - Shoreline monitoring for marine mammal carcases and subsequent necropsy to determine if interaction between marine mammals and turbines/ducted propellers is occurring.

11.282 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 (including underwater noise) and collision risk can potentially be linked with similar effort required for Section 12 Ornithology and Section 13 Fish Ecology.

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

## 11.13 Summary and Conclusions

11.284 Boat-based and land-based surveys of the Inner Sound recorded four cetacean (harbour porpoise, minke whale, killer whale and Risso's dolphin) and two pinniped species (grey and harbour seal) over 22 monthly surveys. The harbour porpoise dominated cetacean observations, with the minke whale, killer whale and Risso's dolphins only sighted on a few occasions. Grey seals dominated pinniped observations, with relatively few harbour seals recorded. Marine mammal sightings were distributed throughout the survey area, although sightings of cetaceans were more numerous in the western portion of the survey area and pinniped sightings seemed to show some concentration towards the east of the survey area. A large number of seals were observed hauled out on Stroma and adjacent rock outcrops.

11.285 A number of potential impacts associated with the installation, operation, maintenance and decommissioning of the Project on marine mammals have been assessed. This assessment identified a number of key issues including noise emissions, ship strikes, increased turbidity, indirect effects via prey species, accidental events, physical barriers and collision risk.

11.286 The noise (source) level for drilling and vessel activities (both during installation and maintenance activities) is considerably below the level at which lethal injury to marine mammals might occur and it is therefore predicted that no marine animals will be killed as a result of underwater noise emissions. Noise (source) levels are also below levels at which hearing damage might occur. In the case of behavioural responses to the noise, the zones of possible impact from drilling and vessel operations are so small (up to 1m for drilling and around a maximum of 50m for vessels, depending on the species) and the local/regional density estimates so low that no animals are expected to be affected.

11.287 As with installation and maintenance activities, noise (source) levels for operational turbines are considerably below the levels at which lethal injury to species of marine mammal might occur. For operational turbines, strong avoidance might be expected up to 38m for seals, 98m for odontocetes and 588m for mysticetes. Combining these ranges with local density estimates suggests approximately one or fewer of any species could be expected to experience strong behavioural avoidance at any one time during turbine operation. Considering the regional population sizes of these species and the fact that the impact is not considered to be sufficient to interfere with vital life processes, these numbers are likely of little concern at a population level.

11.288 No marine mammals of any species should experience a change in hearing ability (permanently or temporarily) from the installation operations and no marine mammals should be exposed to temporary hearing changes from the operational period, thus no animals are expected to leave the region and no population level impacts are expected.

11.289 In addition to the possibility that noise emissions could cause behavioural impacts, the noise emissions from the turbines could present a 'noise barrier' to movement. For pinnipeds, this would only apply to around 38m out from the turbine array. For odontocetes, this could occur out to 98m from the turbine, which could present a noise around the tidal array in the centre of the Inner Sound. This would not stop animals travelling through the Inner Sound, however, as they could use the waters to the north or south of the array. For mysticetes (including the minke whale) this barrier of strong avoidance could effectively remove a slightly larger area from use, extending to approximately 588m around the tidal array. This species group is not expected to use the area with any regularity and the actual presence of the noise barrier is unlikely to affect regional area use for mysticetes in general.

11.290 The devices can also form a physical barrier, with each turbine presenting an obstacle in the vertical plane, through which marine mammals may be unable (or unwilling) to pass through. As a worst case, the widest row of turbines the turbines present a barrier of approximately 8% of the sea area available across the Inner Sound. Compared to that across the Pentland Firth as a whole, the turbines present a barrier of less than 1%. It is reasonable therefore to expect that the physical barrier will not introduce an obstacle to movement. Information from monitoring of marine mammals around the SeaGen tidal turbine in the narrows of Strangford Lough showed it is likely the case that seals and harbour porpoise animals will avoid the area of the turbine itself but that there is no barrier effect as a result of SeaGen presence or operation (Royal Haskoning, 2010).

11.291 Risk of collision between a moving turbine blade and a marine mammal is considered to be a key potential effect of turbine operation and it is considered that all species of marine mammals are at some risk of this collision impact, which could ultimately result in death or injury. Little is known about behavioural reactions around such devices but some understanding of how marine mammals react around these devices can be derived from existing tidal developments. For example, monitoring of the SeaGen tidal device in Strangford Lough has involved the assessment of all seal carcasses found in the lough and in post mortem none have shown signs of interaction with SeaGen. Data from seal telemetry and acoustic studies in Strangford Lough suggest that there may be a degree of local avoidance by marine mammals of operating turbines.

11.292 Taking account of possible avoidance rates, it is likely that less than 0.10% of the regional population of harbour porpoise would encounter the turbines annually and a smaller portion yet actually seriously injured or killed by the collision. For minke whales, less than 0.20% of the regional population would encounter the turbines and fewer still actually be injured or killed. The population level effects for these species are likely therefore to be inconsequential. For grey seals, the numbers of animals possibly encountering the device at the higher avoidance rates are sufficiently low in all cases that the PBR (959 grey seals) will not be reached and therefore regional population effects are not expected, especially when it is considered that the encounter rate, even with the avoidance factored in, does not represent serious injury or fatality in all cases. For harbour seals, the number that could possibly encounter the devices is approximately one quarter that predicted for grey seals. However, the Orkney and North Scotland harbour seal population is much smaller than the grey seal population and these numbers are consequently closer to the PBR, although for higher avoidance rates still remain below it.

11.293 MeyGen will apply appropriate mitigation, as deemed necessary in consultation with Marine Scotland and SNH, including deployment of a satisfactory monitoring protocol. This monitoring will be instigated to cover the operation of the initial ten to 20 (maximum) turbines that will be installed in years one and two. The monitoring will allow for a better definition of the avoidance rates to better understand the possible impact of the full 86 turbine array and to inform the potential requirement for additional, future mitigation.

11.294 Vessels involved in the Project will be slow travelling when moving to the site and extremely slow or stationary when engaged in the activities at the turbine locations. As such, these vessels are much less likely to cause death or injury through collision than commercial shipping activity. A number of 'corkscrew' injuries have been reported in both grey and harbour seals and it is though that these may relate to interaction between the seal and specific types of ship propellers (e.g. propellers that have been shrouded with a nozzle, or a configuration of propellers placed in groups that can be rotated in any horizontal direction). These systems are common to a wide range of ships including tugs, self propelled barges and various types of offshore support vessels and may be used on the installation vessels in this project. It is understood that investigation is ongoing on the potential link between these injuries ducted propellers and that mitigation measures relevant to minimising the risk of seal spiral injuries and fatalities are currently being developed at an industry and regulator level. MeyGen will apply appropriate mitigation, as deemed necessary in consultation with Marine Scotland and SNH, should vessels with ducted propellers be used, in order to avoid any significant impact.

11.295 The benthic impact assessment undertaken as part of this EIA (Section 10) has determined that any increase in turbidity or suspended sediment levels is expected to be temporally and spatially restricted, largely due to the small volumes released and the high energy environment of the Inner Sound. Negative effects on marine mammals (through, for example, limiting ability to search for prey) are therefore not expected.

11.296 It is possible that mammals may be affected if fish/shellfish prey species are negatively impacted by any aspect of the Project. Both the fish and benthic ecology assessments concluded, however, that impacts on potential prey species are likely to be minor or negligible and marine mammals that prey on these species should therefore be unaffected.

11.297 It is possible that an accidental loss of diesel from vessels involved in the Project could impact negatively on marine mammal species through toxicological effects or through smothering by oil. However, marine mammals are highly mobile and are able to detect these pollutants and as a result are expected to avoid areas where pollution has occurred. Even where diesel may accumulates on seal haulout sites, sensitivity is limited by species and time of year (grey seal pups may be most at risk but are born from only the end of September until mid December). Given the low likelihood of loss of diesel and the ability of marine mammals to move away from affected areas in the short term, accidental pollution as a result of the Project is considered to be non-significant.

11.298 Any impacts that decommissioning operations may have on marine mammals will occur at a similar or lesser magnitude than the impacts described for those installation and operation phases. In conjunction with an agreed decommissioning plan, the decommissioning of the turbines is not expected to impact significantly on marine mammals.

11.299 The impact assessment herein shows that PBR for grey seals is unlikely to be reached and this species is unlikely to be affected by the Project at a population level. The assessment shows, however, that the risk of collision may be such that the low PBR value for harbour seals could be exceeded and negative effects may be felt at the population level. However, the turbines will be installed in a staged 3 year programme, increasing from ten turbines to 20 turbines to a maximum of 86 turbines; during this time MeyGen will undertake a monitoring programme which will better define the avoidance rates for species using the area and inform the potential requirement for additional, future mitigation.

11.300 The scale of the individual effects of the installation, operation and decommissioning of the devices are not expected to combine with those from other projects in the wider area to produce significant negative cumulative impacts.

11.301 MeyGen has committed to undertaking monitoring of marine mammals in the vicinity of the tidal array and within Inner Sound to determine that the impact is as assessed above. This plan will be developed with the relevant authorities and will consider all available guidance and best practice.

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

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