Proposal for a strategic regional Pre-Construction Marine Mammal Monitoring Programme in respect of the BOWL and MORL Wind Farm Developments

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25th March 2014

Rev								
	Prepared By		Checked By		Approved By		Date of Issue	
1	PT	**20 Jan 2014**	MB/CR		JW/SP			
2	PT	**31 Jan 2014**	MB/CR		JW/SP			
3	PT	**18 Feb 2014**	MB/CR		JW/SP			
4	PT	**24 Mar 2014**	MB/CR		JW/SP		25 Mar 2014	

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Glossary

AEP	**Auditory Evoked Potentials**
BOWL	**Beatrice Offshore Windfarm Ltd**
CMR	**Capture-Mark-Recapture**
DEVELOPERS	**BOWL & MORL**
MMMP	**Marine Mammal Monitoring Programme**
MORL	**Moray Offshore Renewables Ltd**
NERC	**Natural Environment Research Council**
NNR	**National Nature Reserve**
SAC	**Special Area of Conservation**
SSER	**Scottish Southern Energy Renewables**
STAKEHOLDER GROUP	**MS, MSS, SNH and other key stakeholders**
STEERING GROUP	**MS, BOWL, MORL, TCE (as relevant) and other funding parties**

Introduction

The following document provides the proposed methodologies to undertake the Pre-Construction Monitoring Programme for marine mammals in the Moray Firth.

In February 2009, The Crown Estate awarded an exclusivity agreement to SSE Renewables (formerly Airtricity) and SeaEnergy Renewables (hereafter referred to as BOWL – Beatrice Offshore Wind Farm Ltd) for the development of the Beatrice Wind Farm in the outer Moray Firth within Scottish Territorial Waters.

BOWL is proposing to develop, construct and operate the Beatrice Offshore Wind Farm (the Wind Farm) and associated offshore transmission works (OfTW), together known as 'the Project'. The Wind Farm Site is located approximately 25 km south, south-east of Wick, Caithness and is located on the Smith Bank, a bathymetric high in the outer Moray Firth. The Wind Farm Site is, at its closest point, 13.5 km from the coastline (see Figure 1.1).

In January 2010 the Crown Estate awarded Moray Offshore Renewables Limited (MORL) a Zone Development Agreement for Zone 1 of their Third Round of offshore wind licensing. Zone 1 is located on the Smith Bank in the outer Moray Firth. It lies at its closest point 12 nautical miles (approx 13.5 statute miles or 22km) from the Caithness Coast. It covers an area of 281 square nautical miles or 520 square km, and ranges from 37m-57m (60-180 feet or 20-31 fathoms) in depth (see Figure 1.1). The current consent applications by MORL relate to three wind farm sites located within the Eastern Development Area of Zone 1. The total area of these three sites extends to 295 square km.

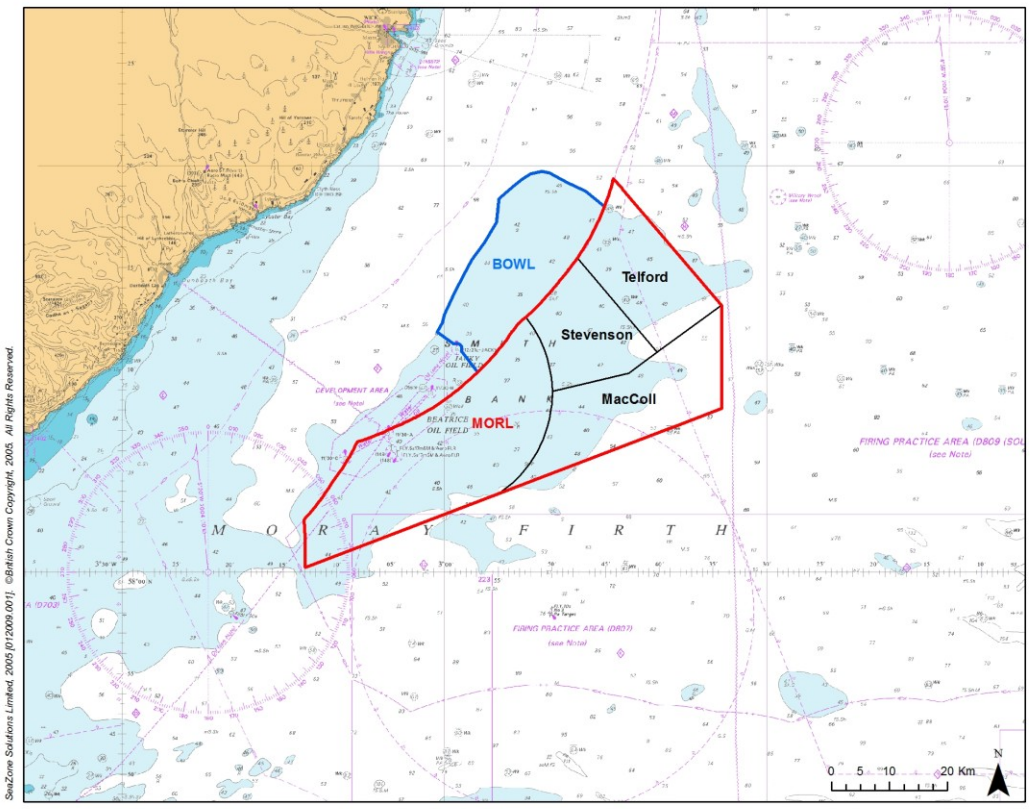

Figure 1.1 BOWL and MORL site locations

Since the submission of the developer's respective consent applications and Environmental Statements (ES) in April 2012 (BOWL) and July 2012 (MORL) including BOWL's ES Addendum submitted in May 2013 discussions have taken place with Marine Scotland Licensing and Operations Team (MS-LOT) regarding post consent marine mammal monitoring requirements.

A condition of consent related to the submission of a Project Environmental Monitoring Programme ("PEMP") has been attached to the Wind Farm Section 36 Consents (Condition 26 of the Telford, Stevenson and MacColl Wind Farms Section 36 consents).

BOWL has a similar condition of consent related to the submission of a Project Environmental Monitoring Programme ("PEMP") also in relation to the Wind Farm Section 36 Consent (Condition 27)

This condition was included in both project consents "to ensure that appropriate and effective monitoring of the impacts of the Development is undertaken".

As part of this condition it is stated that:

> "The PEMP must set out measures by which the Company must monitor the environmental impacts of the Development. Monitoring is required throughout the lifespan of the Development where this is deemed necessary by the Scottish Ministers. Lifespan in this context includes pre-construction, construction, operational and decommissioning phases."
>
> The PEMP must cover: Section "b". The participation by the Company in surveys to be carried out in relation to marine mammals as set out in the MMMP"
>
> "All the initial methodologies for the above monitoring must be approved, in writing, by the Scottish Ministers and, where appropriate, in consultation with the MFRAG referred to in condition" 27 of the MORL consent and condition 28 of the BOWL consent .

Based on recommendations made by Marine Scotland Science (MSS), BOWL and MORL have agreed in consultation with MS-LOT to contribute to a regional Marine Mammal Monitoring Programme (MMMP) that will be managed by the University of Aberdeen. This document describes the proposed methodologies and associated programme for the pre-construction element of the regional MMMP. The requirement to undertake this work is in light of commitments made by both developments in their respective Environmental Statements to the ongoing engagement and management of issues surrounding marine mammals.

This document builds upon the draft scope for the MMMP submitted to BOWL and MORL on 15/3/13 (Annex I) and provides a more detailed scope of work for the pre-construction period (2014 & 2015).

The Developers' contribution to the regional pre-construction MMMP is two-fold. Firstly, the Developers have committed to fund up to 50% of the scope of the pre-construction element of the regional MMMP as detailed within this document. Secondly, the Developers are providing support to UoA in managing the contract and in sourcing funding for the remaining 50% of the proposed scope.

Both developers are committed to continue with the proposed approach through the construction and post-construction monitoring periods. The scope of these monitoring programmes has not yet been defined, as these will be informed to some extent by the findings of the preceding monitoring stage (although the aims of the MMMP are outlined in the Developers' respective ESs and Annex I.)

Background

The Moray Firth contains internationally important populations of marine mammals. European Union (EU) Special Areas of Conservation (SAC) have been designated for both harbour seals and bottlenose dolphins, and the area is frequented by other protected species such as grey seal, harbour porpoise and minke whale. There has also been a long history of research in the area, and Moray Firth harbour seals and bottlenose dolphins are now two of the most intensively studied marine mammal populations in the world.

The presence of these well studied protected populations provides a unique mix of challenges and opportunities for regulators and industries wishing to undertake new developments in the Moray Firth. The region has long supported a broad range economic activity, including fisheries, oil and gas developments and tourism. For emerging industries such as offshore renewables, however, recent EU legislation has led to a challenging step change in assessment and monitoring requirements. Previous research has provided important baseline, both for site-specific assessments and for more general development of methods to meet new legislative requirements. Unique opportunities now exist for conducting research and monitoring alongside regional developments.

This document describes the first pre-construction phase of a regional MMMP for the Moray Firth. The key driver for this MMMP has been the requirement for monitoring due to the proposed offshore wind farm developments in the Moray Firth namely, BOWL and MORL. The primary purpose of this document is therefore to provide methodological details for the proposed pre-construction MMMP, so that Marine Scotland can consult with relevant stakeholders and approve the pre-construction MMMP on behalf of Scottish Ministers.

The University of Aberdeen, BOWL and MORL are working with other stakeholders to ensure that the pre-construction MMMP maximises the potential to underpin monitoring and research questions of broader interest; both to the offshore renewables industry and other key stakeholders. This MMMP has wider relevance for two reasons:

- First, other stakeholders need the same monitoring data on trends in these protected populations, particularly for the bottlenose dolphins that range widely along the east coast of Scotland. For example, the UK government must provide regular status updates to the EU, and other developers both within (eg. ports and harbours, oil and gas) and outside (eg. other East coast wind farms) the region must consider cumulative impacts on the dolphin population that uses the Moray Firth SAC.

- Secondly, research around these regional developments can be used to test and develop assessment frameworks that are now being used in other areas, particularly those assessing population consequences of disturbance. Thus, whilst BOWL and MORL will provide the core funding for this MMMP, partnership funding is required from other stakeholders to achieve these wider objectives. The broader rationale for partnership funding for an integrated research programme is set out in Annex 1 of this document.

Aims

The pre-construction MMMP aims to provide baseline data on two priority species (harbour seals and bottlenose dolphins) during the two years prior to construction (2014 and 2015). Pre-construction monitoring may stretch into 2016, this is dependent on when the proposed offshore developments commence construction. In this event, an extension to the pre-construction monitoring scope will be prepared and agreed with MS-LOT in consultation with relevant expert consultees.

The proposed scope of works has been agreed in discussion with Marine Scotland and their advisors, following submission of a draft MMMP scope in March 2013 (Annex I). The selection of priority species has been based upon the proximity of EU protected sites (SACs) to the BOWL and MORL sites, and the opportunities to address key questions that can reduce uncertainty in future assessments (Annex 1: Tables 1 & 2).

Specifically, the pre-construction MMMP aims to collect additional data on the distribution, abundance and vital rates of both priority species, thereby providing a baseline against which construction impacts on these populations can be quantified. The draft scope for the MMMP also included baseline studies of variability in the hearing ability of harbour seals from the Moray Firth population. Recent studies have used Auditory Evoked Potentials (AEPs) to assess in-air hearing sensitivity of wild seals. These studies have provided promising results. However, this technique is not yet sufficiently refined to routinely assess seal hearing sensitivity, and further work on hearing is therefore not included within the pre-construction phase of the MMMP.

Programme structure

The proposed MMMP consists of two sets of work packages, the first covering the requirements for harbour seal monitoring, and the second for bottlenose dolphin monitoring.

Harbour Seal Monitoring;

1) Individual based studies of reproduction and survival;
2) Trends in abundance; and
3) Characterisation of foraging areas;

Bottlenose Dolphin Monitoring

1) Individual based studies of reproduction and survival;
2) Trends in abundance; and
3) Baseline occurrence of dolphins in favoured areas.

The following sections outline the proposed objectives, survey design and detailed methodology within each of these work packages. These proposals have been based upon relevant best practice, but the final methodologies for data collection and analysis will be agreed with Marine Scotland following consultation with the relevant statutory and non-statutory consultees, prior to commencing any monitoring work.

Harbour Seal Monitoring Work Packages

WP 1.1: Individual based studies of reproduction and survival

Objectives

This work package will be used to assess baseline variability in harbour seal vital rates and condition. This will permit future comparison with data collected during the construction period. These data will then be used to test and refine assumptions in the Moray Firth harbour seal assessment framework (Thompson et al. 2013) that link noise exposure to changes in vital rates.

Parameters to be measured

- Female fecundity;
- Female pupping dates
- Sex specific survival rates.

Survey Design

Surveys will use land-based photo-identification to recognise individual harbour seals using their distinct facial pelage markings (Thompson & Wheeler 2008). Repeated observations of known females will be used to determine whether or not or different females in the population give birth each year, and data on the timing of births will provide an index of over-winter body condition (see Cordes & Thompson 2013a). Repeated sightings of males and females will be used to estimate sex-specific survival rates (see Cordes & Thompson 2013b).

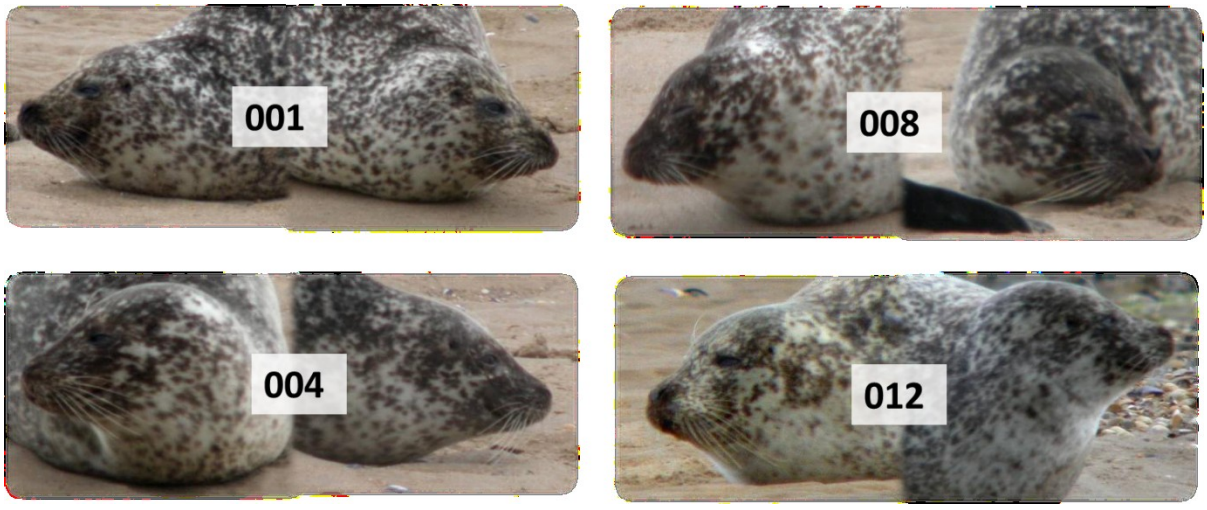

Figure 1. Examples of suitable photographs for individual photo-identification, showing the distinct facial patterns on the left and right hand side of four individuals that regularly use the Loch Fleet haul-out site.

Existing Baseline

Photo-identification studies of harbour seals hauling out in Loch Fleet NNR have been conducted annually since 2006. The existing photo-identification catalogue contains over 170 well-marked individuals, including 75 reproductive females (University of Aberdeen Unpublished Data).

Recent analyses have been used to estimate female fecundity and sex-specific survival using data collected between 2006 and 2011 (Cordes & Thompson 2013b). The additional data collected during the pre-construction monitoring will allow analysis of a 10-year time-series to assess baseline variability in these vital rates.

Sampling Locations

Sampling effort will focus on Loch Fleet NNR, which is the nearest major harbour seal breeding site to the BOWL & MORL developments (Figure 2). Over the last two decades, Loch Fleet has become an increasingly important breeding site for the Moray Firth harbour seal population (Cordes et al. 2011), and the proximity of the haul-out groups to a public road makes it particularly suitable for photo-identification studies.

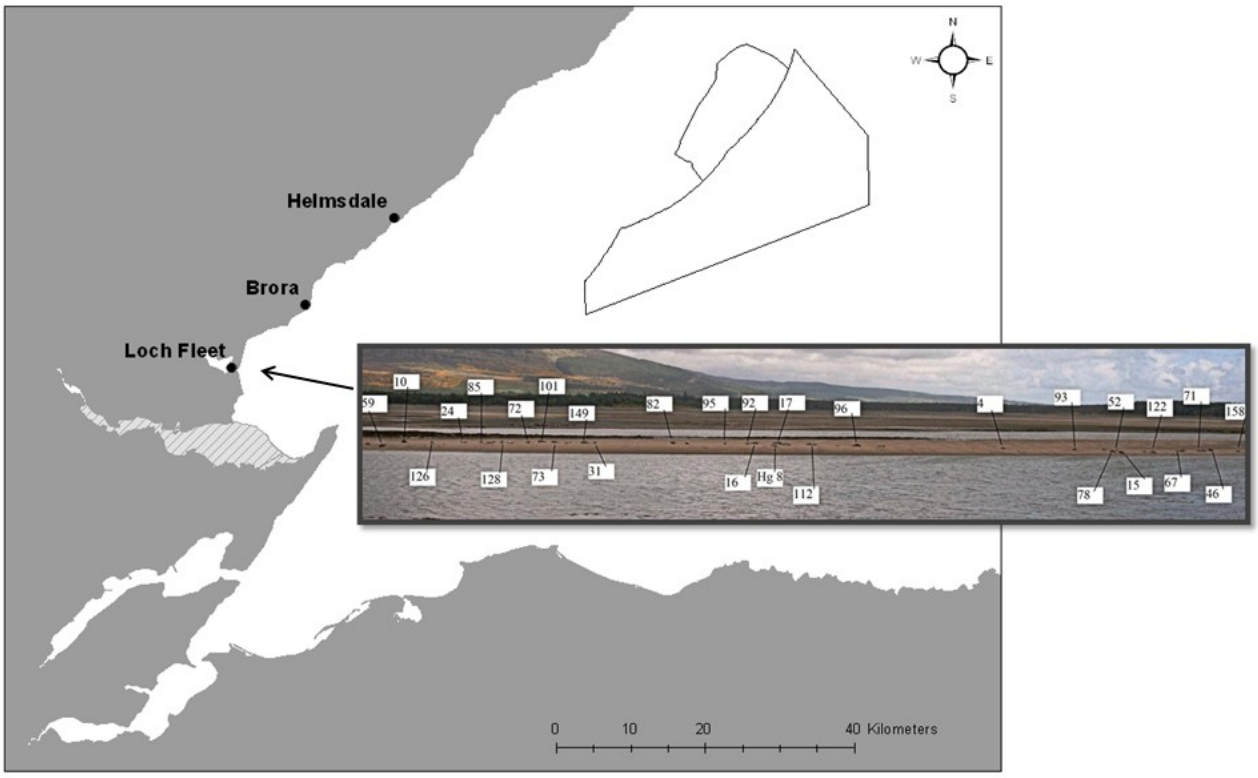

Figure 2. A map of the Moray Firth showing the position of the BOWL and MORL development areas and the three closest harbour seal haul-out sites. The Dornoch Firth and Morrich More SAC is hatched. The inset picture shows a wide-angle view of individually identifiable seals that had been observed from the vantage point used for photo-identification studies.

Sampling Periods

Photo-identification surveys will be made regularly from late May until late July in each year so that data collection covers the complete pupping and lactation periods. Daily surveys will be required during the peak pupping season to determine precise individual pupping dates.

Sampling Technique

Up to 60 visits will be made to Loch Fleet in each year, with daily sampling required during the peak pupping periods. Surveys will be made within 2 hrs of low tide, with observations made from a vehicle parked at a standard vantage point (Grid Ref: NH 791 956). High quality photographic images will be obtained by a trained observer using a Canon 60D SLR camera attached to a 20–60 x 80 mm Swarowski HD-ATS 80 telescope. For adult females, data will also be collected on whether or not the pup was present.

Data Analysis

After each day's survey, all pictures will be graded for photographic quality and archived. The best quality picture from each seal, on each day, will then be matched to the existing photo-identification catalogue by an experienced analyst and archived with associated field data.

At the end of each season, all the initial matches will be confirmed by a second experienced analyst. The resulting observations will be used to create a capture matrix that will be used to provide annual estimates of fecundity and underpin subsequent Capture Mark Recapture (CMR) analyses of survival (see Cordes & Thompson 2013b for statistical approaches used in these analyses).

Repeated sightings of females will be used to estimate individual birth dates, and provide an annual estimate of median birth dates (Cordes & Thompson 2013a).

WP 1.2: Trends in abundance

Objectives

This work package will be used to assess baseline variability in summer and winter abundance at harbour seal haul-out sites along the northern Moray Firth (Figure 2: Loch Fleet and smaller sites near Brora & Helmsdale). These finer–scale summer abundance data from sites that are closest to the BOWL and MORL developments can then be related to broad-scale survey data that are routinely collected by the Sea Mammal Research Unit; ie. Regional Site Condition Monitoring data from the Dornoch Firth & Morrich More SAC and national harbour seal survey data. This will permit future comparison with data collected during the construction and post-construction period, allowing a test of the short term decline and subsequent recovery predicted under the Moray Firth seal assessment framework.

Parameters to be measured

- Summer abundance of harbour seals during the pupping season and moult
- Winter abundance of harbour seals.

Survey Design

Throughout their global range, trends in harbour seal abundance are based upon low-tide counts made during either the pupping season (Thompson et al. 1997; Huber et al. 2001) or moult (Thompson & Harwood 1990; Lonergan et al. 2007), when a higher and more consistent proportion of seals are ashore. A range of counting methods have been used in other studies, including land-based counts (Thompson et al. 1997), aerial photographic survey (Thompson & Harwood 1990) and thermal imagery (Lonergan et al. 2007). In future it is likely that drones may also become a viable survey platform.

Existing Baseline

Annual surveys during both the pupping season (15 June -15 July) and moult (1-31 August) have been made at sites within the inner Moray Firth since 1987.

These surveys were conducted by the University of Aberdeen between 1987 and 2005, involving repeated (n = 3-10) land-based counts (Thompson et al 2007). From 2006 onwards, the Sea Mammal Research Unit started conducting fixed-wing aerial surveys in the region (four to five annually) during the pupping season (Matthiopoulos et al. 2013), supplementing on-going but less frequent aerial surveys during the moult (Lonergan et al. 2007).

In Loch Fleet, the University of Aberdeen has made daily counts during the pupping season since 2008, alongside individual based photo-identification studies (see WP 1.1). Counts at other sites along the northern Moray Firth coast have been made less regularly in previous years but have been routinely covered during SMRU aerial surveys since 2006 (Duck et al. 2012).

Data on winter abundance are sparse. In the Dornoch Firth and Morrich More SAC and Loch Fleet, year round counts were made in 1988, 1989 and 2008 (Thompson et al. 1996; Cordes et al. 2011). No winter data are available from sites in the vicinity of Brora & Helmsdale.

Sampling Locations

Sampling effort will focus on Loch Fleet National Nature Reserve (NNR) and the two other harbour seal haul-out sites along the northern Moray Firth coast near Brora and Helmsdale (Figure 2).

Sampling Periods

Four counts will be made at each of these three sites in the pupping season (15th June – 15th July) moult (1st - 31st August).

Monthly counts will be made at each of these three sites throughout the winter months (Sept – May).

Sampling Technique

Protocols will follow those used by the University of Aberdeen during previous studies of trends in harbour seal abundance (Thompson et al. 1996; 1997, 2007; Cordes at al. 2011).

Land-based counts will be made within 2 hrs of low tide, in the absence of rain and on days with good visibility. Counts will be made from suitable vantage points by a trained observer, using a Swarowski HD-ATS 80 telescope.

In Loch Fleet, these counts will be made as part of the on-going photo-identification studies. Where conditions allow at other sites, opportunistic photographs will also be taken and processed using approaches outlined in WP 1.1.

Data Analysis

Annual data from the pupping season and moult will be used to update the existing time-series that uses mean annual counts in each time period to provide an index of abundance at different haul-out sites. These can, in turn, be related to available broader scale harbour survey data from the East coast of Scotland that are made available through the NERC Special Committee on Seals (eg. SCOS 2012).

Estimates of total abundance will be made using two different approaches. First, counts made during the pupping season can be adjusted using available telemetry data following the approach described in Thompson et al. (1997). Second, the matrix of photographic recaptures used to estimate survival (WP 1.1) can also be used to provide CMR estimates of absolute abundance in Loch Fleet (Cordes 2011) and, potentially, at all three sites.

In addition, data will also be used to underpin on-going collaboration with the University of St Andrews that has used the time series of haul-out counts and photo-identification data within a state-space model for estimating both overall population size and population trends (Matthiopoulos et al. 2013).

WP 1.3: Characterisation of foraging areas

Objectives

This work package will be used to obtain up to data information on baseline variability in the at-sea distribution and foraging patterns of harbour seals breeding at haul-out sites in the northern part of the Moray Firth. This will permit future comparison with data collected from animals that are exposed to piling noise. These data will also be used to characterise the foraging areas used by different identifiable individuals (see WP 1.1). This will, in turn, allow us to evaluate whether individual variation in vital rates is related to the extent of overlap between individual foraging ranges and areas impacted by construction noise. It is hoped that technological developments may allow noise exposure to be measured directly by the tags on subsequent deployments during construction.

Parameters to be measured

- Population distribution at sea during summer and winter;
- Individual home ranges and foraging ranges
- Dive patterns.

Survey Design

A wide range of telemetry devices have previously been used to track harbour seals. The study will use GPS-GSM tags produced by SMRU Instrumentation Ltd, that have been widely used to obtain fine-scale data on distribution and activity on harbour seals in UK waters (Cordes et al. 2011; Sharples et al. 2012).

Tags are expected to last 3-9 months, and the survey has been designed to include two capture periods to maximise the chance of obtaining a balanced dataset across both winter and summer seasons. Given the particular interest in assessing how noise exposure affects reproductive success, tagging will focus on obtaining data from identifiable adult females, with a smaller sample of males selected for comparison.

Existing Baseline

There is a long history of telemetry studies in the Moray Firth, using VHF (Thompson et al 1998), satellite (Sharples et al. 2012) and GPS-GSM tags (Cordes et al. 2011). Existing data were brought together within the Moray Firth Seal Assessment Framework (Thompson et al. 2013), using a state space model to account for the different error structures associated with the various tag types (Bailey et al. 2014).

However, existing data are strongly biased towards the summer months, relatively few animals have been tracked using high resolution GPS devices, and no data have been collected since 2009. These deployments will therefore provide important additional baseline for subsequent comparison with the distribution and behaviour of animals during construction.

Sampling Locations

The primary site for catching harbour seals for tracking will be Loch Fleet (Figure 2), to maximise the chance of linking these data on at-sea distribution and behaviour to the long-

term studies of vital rates. Additional captures will be made at other nearby haul-out sites in the northern part of the Moray Firth if required.

Sampling Periods

The aim is to collect pre-construction data during the winter of 2014/15 and summer of 2015. This will involve deploying tags in two periods; Sept/Oct 2014 and March/April 2015

Sampling Technique

Twenty-five GPS-GSM tags will be deployed on harbour seals. Study individuals will be captured under licence from Marine Scotland, using barrier nets as they leave their haul-out sites. Handling and anaesthesia will be conducted under licence from the Home Office. These procedures all require suitably trained and licenced personnel, and the use of specialist boats and equipment.

GPS-GSM tags will be glued to the hair using established procedures (Fedak et al. 1983) and the seals released following collection of a standardised measurements.

Data Analysis

Data on the locations and activity patterns of individual seals will be regularly transmitted via GSM to the University of St Andrews, where they will be subject to routine error checking and archived.

For the baseline characterization, location data will be used first to update the habitat association analyses presented in Bailey et al. (2014), as used to provide the underlying at-sea distribution for the Moray Firth Seal Assessment Framework.

Individual home ranges will also be characterised using kernel analysis (see Cordes et al. 2011) and these data used to derive estimates of individual and sex-differences in the duration and range of foraging trips.

These data will be used to support the design of additional tracking studies during construction, which are required to the test dose response curves used in the Moray Firth Seal Assessment Framework and identify how long it takes individuals to return to disturbed sites. All finer-scale locational and activity data will therefore be archived as a baseline for more detailed comparison with subsequent data collected during construction.

Bottlenose Dolphin Monitoring Work Packages

WP 2.1: Individual based studies of reproduction and survival

Objectives

This work package will be used to assess baseline variability in bottlenose dolphin vital rates. This will permit future comparison with data collected during the construction period.

Parameters to be measured

- Female fecundity
- Sex specific survival rates.

Survey Design

Surveys will use established boat-based photo-identification techniques to recognise individual bottlenose dolphins using their distinct dorsal fin markings (Wilson et al. 1999; 2004; Cheney et al. 2013). Following agreed methods for monitoring the population that uses the Moray Firth SAC (Cheney 2012), repeated observations will be used to determine whether or not or different females in the population give birth each year. Repeated sightings of known males and females will be used to estimate sex-specific survival rates.

Existing Baseline

Photo-identification studies of bottlenose dolphins in the Moray Firth SAC have been conducted annually since 1989 (Cheney et al., 2012). More recently, surveys have also been conducted in other parts of the population's east coast of Scotland range (Cheney et al. 2013). The existing photo-identification catalogue contains over 193 distinctively marked individuals, including 42 known males and 56 known females (University of Aberdeen & University of St Andrews Unpublished Data).

Initial estimates of adult survival and calving rates were based upon data collected between 1990 and 1997 (Sanders-Reed et al. 1999). Revised estimates of survival were subsequently produced using a state-space modelling approach (Corkrey et al. 2008), and a PhD student at St Andrews is currently using data collected between 1990 and 2012 estimate sex-specific survival rates (Arso In Prep).

The additional data collected during pre-construction monitoring will allow analysis of a 26-year time-series to assess baseline variability in vital rates.

Sampling Locations

Sampling effort will be focussed within the Moray Firth SAC, but analyses will integrate additional data from other parts of the population's range through continued collaboration with other research groups (see Cheney et al. 2013). A map illustrating the areas to be surveyed is shown in Figure 3, which includes the locations of previous encounters with groups of bottlenose dolphins.

Sampling Periods

Photo-identification surveys will be conducted between May and September following established protocols for monitoring the Moray Firth SAC (Cheney et al. 2013).

Sampling Technique

Up to 20 boat-based photo-identification will be made in each summer field season.

Surveys will be conducted from the Lighthouse Field Station in Cromarty using a specialist MCA coded workboat. Standard protocols for this work have been agreed with SNH (Cheney et al. 2013). Surveys aim to target areas that maximise the probability of encountering bottlenose dolphins (Figure 3). Whenever groups are encountered, the boat will be manoeuvred at slow speed around the dolphins to allow dorsal fin photographs to be taken with an SLR camera. Surveys aim to obtain high quality pictures of the left and right hand sides of the dorsal fins of as many individuals as possible, whilst minimising disturbance and ensuring that as many different members of the group were photographed as possible.

All survey work will be conducted under an SNH licence that permits disturbance to dolphins for scientific research. Surveys will require three personnel, including an experienced photographer and a suitably certified boat skipper (DTI Endorsed Advanced Powerboat Handler who has received additional internal training in the handling of small craft around groups of dolphins).

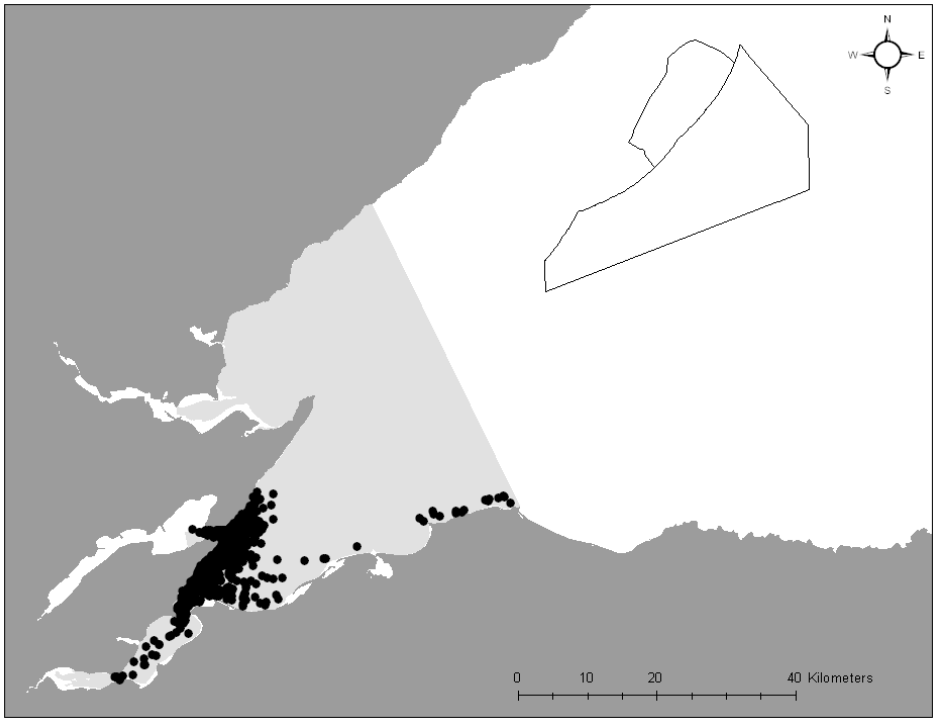

Figure 3. A map of the Moray Firth showing the position of the BOWL and MORL development areas and areas where dolphin groups have been encountered during previous University of Aberdeen photo-identification surveys (Data are from 2001-2013). The location of the Moray Firth SAC is shaded.

Data Analysis

After each day's survey, all pictures will be graded for photographic quality and archived. All high quality pictures are then be matched to the existing photo-identification catalogue by an experienced analyst and archived with associated field data.

The University of Aberdeen will also co-ordinate the archiving and joint analysis of any data collected by collaborators in other parts of the population's range (primarily the University of St Andrews).

At the end of each season, all the initial matches will be confirmed by a second experienced analyst. The resulting observations will be used to create a capture matrix that will be used to provide annual estimates of fecundity and underpin subsequent CMR analyses of survival.

WP 2.2 Trends in abundance

Objectives

This work package will be used to assess baseline variability in the abundance of bottlenose within the Moray Firth SAC and relate these numbers to the overall size of the east coast bottlenose population. This will permit future comparison with data collected during the construction period, allowing an assessment of whether far-field disturbance has led to change in the number of dolphins using the SAC.

Parameters to be measured

- Abundance of dolphins using the Moray Firth SAC in each summer
- Trends in overall population size.

Survey Design

Surveys will use established boat-based photo-identification techniques to recognise individual bottlenose dolphins using their distinct dorsal fin markings (Wilson et al. 1999; 2004; Cheney et al. 2013). Following agreed methods for monitoring the population that uses the Moray Firth SAC (Cheney 2012), repeated observations will be used to provide annual estimates of the abundance of bottlenose dolphins within the Moray Firth.

Existing Baseline

Photo-identification studies of bottlenose dolphins in the Moray Firth SAC have been conducted annually since 1989 (Cheney et al., 2012). More recently, surveys have also been conducted in other parts of the population's east coast of Scotland range (Cheney et al. 2013).

The current best estimate of the size of the east coast population is 195 (Cheney et al. 2013), with over 60% of the population being seen within the Moray Firth SAC in most years.

Although estimates of abundance within the SAC varied between years, no linear trend was detected in an analysis of the 21 year dataset collected between 1990 and 2010 (Cheney et al. 2012). Over this same period, a state space model that uses data from throughout the population's range (Corkrey et al's (2008) indicated that there was a >99% probability that this population is either stable or increasing (Cheney et al. 2012).

The additional data collected during the pre-construction monitoring will allow analysis of a 26-year time-series to assess trends in abundance within the Moray Firth SAC and trends in the overall size of the East coast of Scotland population.

Sampling Locations

Sampling effort will be focussed within the Moray Firth SAC, but analyses will integrate additional data from other parts of the population's range through continued collaboration with other research groups (see Cheney et al. 2013). A map illustrating the areas to be surveyed is shown in Figure 3, which includes the locations of previous encounters with groups of bottlenose dolphins.

Sampling Periods

Photo-identification surveys will be conducted between May and September of 2014 and 2015 following established protocols for monitoring the Moray Firth SAC (Cheney et al. 2013).

Sampling Technique

Sampling will be based upon the same 20 boat based photo-identification surveys that are outlined for WP 2.1..

Data Analysis

Initial data processing is as described for WP 2.1.

Data from Moray Firth SAC surveys will be used to create a capture matrix that will use PROGRAM CAPTURE to provide an annual estimate of the abundance of dolphins within the SAC. This technique is based on the approach described by Wilson et al. (1999), with modifications described in the most recent SAC Site Condition Monitoring report (Cheney et al. 2013).

A second capture matrix incorporating annual sightings from all areas will also be updated, and the state-space model described in Corkrey et al. (2008) used to provide an updated estimate of trends in the total size of the East coast population.

WP 2.3: Baseline occurrence of dolphins in favoured areas

Objectives

This work package will be used to assess baseline variability in the occurrence of bottlenose at key sites within the Moray Firth SAC and along the southern Moray Firth coast. This will permit future comparison with data collected during the construction period, allowing an assessment of whether far-field disturbance has led to a change in the occurrence of dolphins within these areas.

Parameters to be measured

- Presence of dolphin echolocation clicks in given time periods (minutes, hours and days).

Survey Design

Passive acoustic studies using C-PODs will use established techniques for monitoring changes in the occurrence of dolphins in different parts of the SAC. This study design is based on previous studies that have demonstrated that echolocation detections can be used to provide a robust index of occurrence for bottlenose dolphins when compared to visual observations (Philpott et al. 2007; Bailey et al. 2010). These techniques have subsequently been used to compare broad scale spatial variation in the occurrence of bottlenose dolphins around the East coast of Scotland (Thompson et al. 2011) and year to year variation in the occurrence of dolphins at key sites within the Moray Firth SAC (Cheney et al. 2012). These techniques have the advantage that dolphin occurrence at sampling sites can be remotely monitored for 24 hr/day over periods of several months.

Existing Baseline

T-PODS studies were first conducted in the Moray Firth in 2005 (Bailey et al. 2010) and T-PODs and C-PODs have since been used to assess spatial variation in occurrence at both inshore and offshore sites (Pirotta et al. 2013).

Year-round monitoring has been conducted since 2006 at four long-term monitoring sites; (1) Chanonry Narrows, (2) Sutors, (3) Lossiemouth and (4) Spey Bay (Figure 4). Despite occasional data loss due to equipment loss or malfunction, these data have provided a good baseline on seasonal patterns of occurrence in these areas (eg. Thompson et al. 2011).

In addition, summer (May-Sept) data are available from four additional sites along the southern Moray Firth coast following DECC funded studies (Thompson et al. 2013).

This work will result in a 10 year baseline of year-round occurrence at the four long-term monitoring sites for comparison with data during the construction period. In addition, there will be a 5 year baseline of summer occurrence patterns at a broader suite of sites along the southern Moray Firth coast, in those areas that will be most exposed to construction noise.

Sampling Locations

The location of the four long term monitoring sites and additional summer only sites are shown in Figure 4.

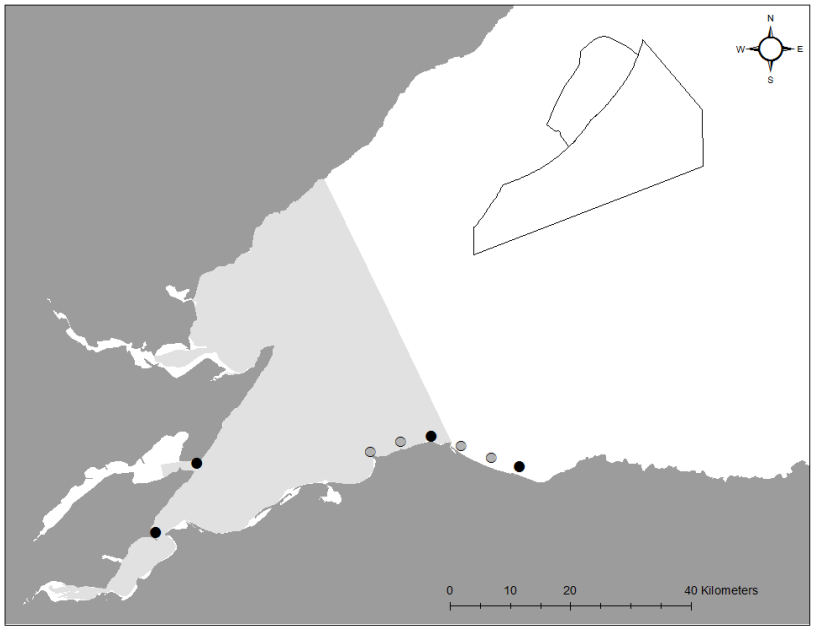

Figure 4. A map showing the position of the BOWL and MORL development areas and the C-POD locations (long-term sites = black circles; summer only sites = grey circles). The location of the Moray Firth SAC is shaded.

Sampling Periods

Sampling will occur year-round at the four long-term monitoring sites, and between May and September of each year at all other sites.

Sampling Technique

Data will be collected using V0 and V1 C-PODS using seabed moorings that have been optimised for deployments at these sites, and licenced for scientific use by Marine Scotland and the Crown Estate.

Deployment and recovery will be made using specialist workboats operated by Moray First Marine, who have extensive experience of these activities through previous work for the University of Aberdeen on DECC funded studies (Thompson et al. 2013) and during baseline data collection for MORL and BOWL.

Deployments will be made for approximately 4 months at a time, requiring three deployment/recovery cycles in each year. Given the multiple years of baseline data available, it is not proposed to deploy duplicate C-PODs to provide redundancy should equipment fail.

Following the recent publication of a method to routinely calibrate C-PODs (Dahne et al. 2013) a test tank will be established at the Lighthouse Field Station to allow devices to be calibrated at the start of each deployment.

Data Analysis

Data will be downloaded using the manufacturer's software, which is also used to identify clicks trains and categorise these as either porpoise or dolphin clicks.

Data will then be processed using established routines and summarised to provide an indication of whether click trains were detected in each minute or hour of the day.

Spatial and temporal variation in occurrence will then be expressed in term of detection positive hours per day, or distributions of waiting times.

Further details of the analysis approaches used are provided in Bailey et al. 2010; Thompson et al. 2010; Brookes et al. 2013; Thompson et al. 2013.

Project management

The MMMP will be co-ordinated by the University of Aberdeen, under the leadership of Professor Paul Thompson. Elements of the MMMP will be carried out under agreements with existing collaborators who have already contributed to the region's long-term research programme.

The MMMP will have a steering group with membership consisting of representatives of each of the funding partners, plus any statutory bodies or external experts required by Marine Scotland. As a minimum, the steering group will meet annually to consider forward plans and draft annual reports. Steering group meetings will be co-ordinated by the University of Aberdeen, and could be held in a number of locations including Glasgow, Aberdeen, Edinburgh or Inverness.

In addition, the University of Aberdeen will co-ordinate annual meetings for a broader group of interested stakeholders. These will be held in July and will involve presentation of the scope of the MMMP (July 2014) and key results from finalised annual reports (July 2015). We anticipate holding stakeholder meetings in the Inverness area to allow participation by regional interest groups. Attendance will be based upon any requirement from Marine Scotland Licensing Operations Team and suggestions from funding partners.

Reporting

The MMMP will produce two reports annually. An interim report will be produced at the end of each summer field season, and an annual report will be presented in April of 2015 and 2016 with more detailed analyses of results.

The reports shall include as a minimum:

- Executive Summary: brief summary of the reporting period highlighting findings and emerging patterns;
- Introduction: brief introduction describing the reporting period and surveys undertaken;
- Methodology: This will reference the standard methodology and any planned or unplanned modifications, including an assessment of the impact of any modification;
- Results: Interim reports will present summary data appropriate to each Work Package, and a short description of the results;
- Annual reports will present more detailed analysis of data as indicated in each Work Package. Where appropriate, these analyses will also incorporate existing baseline to present trends or changing in parameters measured; and
- Interpretation and discussion of the results: Results will be interpreted for a lay audience, focusing on the deliverables of the monitoring aims. Where appropriate, results from the monitoring programme will be placed in the broader context of national schemes (eg. Scottish Strandings Programme, SMRU seal monitoring, MSS East Coast PAM and SCANS III).

Data archiving and dissemination

Survey data will be archived with the lead contractor in line with SSER data standards.

Where appropriate, data will also be archived in appropriate national repositories (e.g. through MEDIN), results disseminated through conference presentations and open access publications in peer-reviewed journals, and key findings and data made publically available through the WWW.

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Annex 1: Scoping document for the BOWL & MORL Marine Mammal Monitoring Programme

Purpose

This document outlines a draft scope for the Marine Mammal Monitoring programme (MMMP) surrounding the construction and operation of the BOWL and MORL wind farms in the Moray Firth.

Background & Rationale

There are five priority species when considering the impacts of offshore wind farm developments in UK waters; harbour seals, grey seals, bottlenose dolphins, harbour porpoises and minke whales. We understand that the requirement for different UK developments to monitor each of these species is likely to vary in relation to the relative importance of local populations (eg. proximity to SACs) or local constraints on the type of monitoring that can be carried out (eg. accessibility of populations that permit individual based studies.)

These proposals have therefore been developed on the assumption that:

1. Different developers will be required to individually adapt their monitoring programmes such that they collectively address higher level UK marine mammal monitoring requirements (eg. linking with ORJIP to gather data to support the development of PCAD based management models).
2. Monitoring programmes should focus on collecting data that can refine and test key assumptions within Environmental Assessments, thereby reducing uncertainty and conservatism in future assessments.
3. The wide-ranging nature of most marine mammals, and the potential for far-field effects of construction noise, will require integration of individual developer's monitoring activities

into broader-scale regional, national or even international research, monitoring and surveillance programmes.

Based upon these assumptions, this draft monitoring programme for Moray Firth sites focuses on three priority species and key questions that aim to reduce uncertainty and the level of conservatism used in assessments of current wind farm consent applications. The rationale for this species prioritisation is outlined in Table 1, and the key monitoring questions for the Moray Firth of which the BOWL and MORL marine mammal monitoring programme will contribute are summarised in Table 2.

Table 1. Rationale for prioritization of monitoring for different marine mammal species.

Harbour seal	**High priority** species for monitoring at Moray Firth sites • Due to proximity to the Dornoch Firth and Morrich More SAC • Because of predictions of significant short-term impacts on this SAC population in the ES under conservative worst case scenarios • To reduce uncertainties and improve predictions of most likely impacts using the Moray Firth Seal Assessment Framework.
Bottlenose dolphin	**High priority** species for monitoring at Moray Firth sites • Due to proximity of Moray Firth SAC • Monitoring is required in the SAC and along southern Moray Firth coast to test worst case predictions of partial displacement and assess whether this influences movements between the SAC and other parts of their East coast range
Harbour porpoise	**Medium priority** species for monitoring at Moray Firth sites • No local SAC population • Predictions of significant short-term impacts through displacement are likely to be common at other sites • Excellent baseline from previous studies in the area provides opportunities to reduce uncertainty over spatial and temporal scale of displacement and potential for habituation.
Grey seal	**Low priority** species for monitoring at Moray Firth sites • No local SAC population • Although some displacement from foraging areas is predicted, local breeding sites are small. • It is anticipated that monitoring of impacts on grey seals will be focused around Firth of Forth developments due to the existence of larger population sizes, local SACs and existing research infrastructure
Minke whale	**Low priority** species for monitoring at Moray Firth sites • Some displacement predicted, but low and variable numbers of animals mean that there is low power to detect impacts • These animals are part of a large mobile population, meaning that any monitoring should be conducted at a broader scale or at other sites (eg Dogger Bank) which hold larger numbers of animals.

Table 2. Key questions that could be addressed through wind farm monitoring programmes.

Harbour seal	*Short-term* 1) To what extent are foraging harbour seals displaced by piling activity compared to worst-case scenarios in the Moray Firth Seal Assessment Framework that used proxy data from harbour porpoises? 2) If displaced during piling, do seals return to foraging areas between piling events; how does this reduce worst-case assumptions that seals are excluded from foraging areas year-round throughout construction? *Medium-term* 3) Does individual condition or reproduction at local sites decline during construction years as predicted under worst case scenarios? *Long-term* 4) Does construction noise cause PTS? 5) Do long-term survival or reproduction rates vary in relation either to variation in noise exposure or variation in hearing thresholds? 6) What are the long-term trends in abundance within the Moray Firth seal management unit in relation to other UK and European populations? 7) Do increases in vessel activity pose any additional threats to harbour seals?
Bottlenose dolphin	*Short-term* 8) Does the occurrence of bottlenose dolphins along the southern Moray Firth coast vary in relation to levels of offshore piling activity? *Medium- and long-term* 9) Are there changes in the vital rates of bottlenose dolphins using the SAC 10) Are there changes in the numbers of bottlenose dolphins using the SAC, or the use of different parts of their overall range, in response to different wind farm construction programmes along the East coast of Scotland?
Harbour porpoise	*Short-term* 11) Can data from Horns Rev II be used as a proxy for the levels of displacement from piling at other sites? 12) How soon do porpoises return to affected areas once piling ends? *Medium-term* 13) Do porpoises become habituated or learn to tolerate piling noise during a prolonged construction period? *Long-term* 14) Are there long-term increases or decreases in porpoise density within the operational wind farm sites?
Generic	15) What are the existing levels of ambient noise and main sources of anthropogenic noise in areas frequented by marine mammals in the Moray Firth? 16) Do acoustic propagation models accurately predict changes in the received noise levels resulting from piling, or other construction and O&M activity?

The approaches required to address these questions include 1) survey based studies that aim to detect changes in density or abundance over different timescales and 2) individual-based studies that can link variation in exposure to particular stressors to longer term changes in vital rates.

In the next sections, we provide indicative plans for how the monitoring programme could be developed, and how it might feed into, and draw from, regional and national monitoring programmes. In taking this forward, there is a requirement for certain underpinning data. However, we also recognise that the programme should be flexible enough to take account of emerging technologies, opportunities to integrate sensors into the wind farm infrastructure, or new analytical procedures that could each lead to more cost-effective data collection in later phases of the programme.

Integration with regional and national research and monitoring programmes

The proximity of the BOWL and MORL development areas led to a joint approach to collecting additional baseline data on marine mammals to support consent applications. Similarly, marine mammal monitoring for the two sites will be developed as a joint programme, and integrated with regional initiatives along the East Coast of Scotland and national programmes that are underway or planned at Scottish and UK levels. Some of the outstanding questions outlined in Table 2 are also being addressed through current or proposed research activity.

It is important to recognise these possible links and interactions at an early planning stage to avoid duplication, to maximise the quality and comparability of data and to improve the cost-effectiveness of survey programmes. Relevant programmes are therefore listed in Table 3, which also indicates how each of these may contribute to answering questions identified in Table 2.

Table 3. Summary of existing and proposed programmes that BOWL and MORL monitoring will be integrated with, with an indication of linkage to the questions identified in Table 2.

Project	Details	Relevance to questions in Table 1
a) Ongoing monitoring & surveillance		
NERC SMRU seal monitoring	Core national monitoring of changes in abundance at grey seal breeding sites and harbour seal moult sites	6
Scottish Marine Animals Strandings Scheme	National surveillance of marine mammal strandings	7
Joint Cetacean Protocol	National integration of survey data that aims to assess the distribution, abundance and population trends of UK cetaceans.	Currently under evaluation, but potentially 10 & 14
b) Ongoing short-term research projects		
DECC SEA funded studies of responses of harbour seals to piling noise	Research, conducted by SMRU, on the movement of harbour seals in relation to construction at sites in the Wash.	1, 2
DECC SEA funded studies of responses of harbour porpoise seals to piling noise	Research, conducted by University of Aberdeen, on the responses of harbour porpoises to piling noise during met mast installation in the Moray Firth.	11, 12
MORL & BOWL funded noise studies	Baseline data collection on variation in ambient noise in key marine mammal habitats (by University of Aberdeen), and comparison of measured and modelled noise during met mast installation (contractor TBC)	15, 16
c) Proposed research, monitoring & surveillance		
Marine Scotland East Coast PAM network	Proposed regional passive acoustic monitoring programme at sentinel sites along the East coast	8, 10
University of Aberdeen marine mammal research and monitoring programme	Maintenance of underpinning individual based studies of Moray Firth harbour seal and bottlenose dolphin populations	5, 6, 9, 10
ORJIP	Includes potential projects that 1) aim to develop a PCAD model to predict impacts of noise on marine mammals and 2) projects on noise mitigation	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

Proposed marine mammal monitoring activity for the MORL & BOWL wind farm developments

Based upon anticipated outcomes from work from existing and proposed marine mammal programmes (outlined in Table 3), it is proposed that BOWL and MORL lead a broader partnership that supports the following core activities to monitor potential impacts on the three highest priority species. For each of these, we provide below an indication of the methodology that could be adopted, recognising that best practice may evolve as a result of ongoing studies, and a note of the monitoring questions (from Table 2) that each activity addresses. We also provide an indicative workplan (Table 4), based upon anticipated start of piling activities in the area (at the BOWL site) in 2016, and completion of construction in the area (at the MORL site in 2020). The start and duration of each survey will depend on MORL and BOWL final construction programmes. Reporting timescales will differ for different components of the programme, and reporting procedures will be developed to meet the needs of different funding partners. Annual reports will be provided for core photo-Id studies of harbour seals and bottlenose dolphins. For other components of the programme, interim reports will be provided once field work is complete, and final reports are expected to be delivered one year after this to allow sufficient time for analysis.

The studies described in this document will form part of MORL's updated Environmental Management Plan (EMP) which was originally submitted as part of supporting documentation for the Telford, Stevenson and MacColl wind farms applications. A final EMP will be submitted as part of pre-construction documentation following discussions with key stakeholders and approval by Marine Scotland Licensing Operations Team.

As above, the finalised and agreed MMMP will form part of BOWL's EMP. The EMP will be further developed once the consenting process progresses and construction of the Project is known. The final version of the EMP will be developed in liaison with consultees and submitted to Marine Scotland Licensing Operations Team for agreement.

1. Harbour seal monitoring

1a) Individual based studies of vital rates Harbour seal monitoring will be underpinned by contributing to the maintenance of annual individual-based photo-ID studies in Loch Fleet, which will provide information on the abundance, survival and reproduction at the breeding site closest to the BOWL and MORL development areas. (Questions 3 & 5)

1b) Trends in abundance Information on long-term trends in abundance at Loch Fleet will be placed in the context of regional and national population trends through comparison with aerial counts routinely made under the SMRU's national seal monitoring programme. (Question 6)

1c) Displacement from foraging areas The level of displacement from foraging areas during construction will be assessed by GPS-GSM tracking a sample of seals in one year before construction and one year during construction. It is expected that, by 2016, technical developments will permit tracking devices to also measure individual differences in noise exposure, and linkage with 1a could permit an assessment of how noise exposure influences reproduction. (Questions 1, 2, 3 & 5)

1d) Impacts on hearing Building upon the DECC SEA work in the WASH, variation in the hearing ability of individual seals will be assessed during the captures required to instrument animals for 1c. This will contribute to baseline understanding of the hearing ability of wild seals in different UK populations, permit an exploration of how hearing ability influences female reproductive success (through 1a), and underpin comparison with repeat measurements of hearing ability at the end of the construction period. (Questions 4 & 5)

Question 7 will be addressed through the 'National survey of marine mammal stranding programme' as highlighted in Table 3.

2. Bottlenose dolphin monitoring

2a) Trends in abundance & survival Bottlenose dolphin monitoring will be underpinned by contributing to the maintenance of annual individual-based photo-ID studies of the East coast population, which will provide information on the abundance, survival and reproductive success of animals using the Moray Firth SAC. (Question 9 & 10)

2b) Displacement from favoured areas An assessment of the extent to which far-field piling noise affects bottlenose dolphin movements along the southern Moray Firth coast will be made using passive acoustic monitoring devices (C-PODS) at six coastal sites proposed for the met mast study (Figure 1), which include three sites for which baseline data exist since 2006. In line with previous monitoring using PAM and photo-ID, studies will focus on a May-September summer period to supplement year-round monitoring that has been maintained at core PAM site since 2006. It is anticipated that studies at all six sites should be carried out during at least one more year pre-construction and for the first two construction years, after which the need for reducing or increasing survey effort can be reviewed. This work complements Marine Scotland proposals for an East coast PAM network (Figure 2) that would provide information on broader scale changes in the use of this population's range. (Questions 8 & 10).

3. Harbour porpoise monitoring

3a) Responses to piling PAM studies using a gradient design (Figure 1) are currently planned to compare levels of response to the met mast piling with data from Horns Rev II, and to assess recovery times after disturbance. Depending upon the outcome of this work, it may be valuable to repeat this design during at least one of the construction years. Such work, conducted during more prolonged periods of piling, would also provide an opportunity to assess whether habituation or increased tolerance of piling noise reduces the likelihood of serious displacement as suggested by studies of responses to seismic air gun noise in the Moray Firth area. (Questions 11, 12 & 13).

3b) Long term changes in the occurrence of harbour porpoises Longer-term changes in the occurrence of porpoises within the windfarm sites can be assessed in relation to high quality baseline information that were collected in two 25 x 25 km study blocks in the summers of 2009, 2010 & 2011 (Figure 3). 2010 data from static PAM, visual and digital aerial surveys and boat based visual aerial surveys were recently compared in a Marine Scotland funded study to evaluate different monitoring options. This comparison highlighted that PAM techniques are likely to provide the most powerful and cost effective method for assessing changes in the relative density of porpoises in different areas or time-periods. Based upon this finding, we propose to monitor long term changes in the occurrence of harbour porpoises by reversing the BACI design used in the seismic study (Figure 3), and deploying C-PODS at a sample of sites in the two sample blocks during June-October of at least two years during both construction and post-construction (Question 14). In addition, baseline data are available from digital aerial surveys flown over these areas in 2010, 2011 and 2012. These techniques could be integrated into this work, particular if this allowed surveys to assess fine-scale changes in distribution of both seabirds and marine mammals around operational turbines.

4. Monitoring variation in environmental variables that might influence target populations

A key requirement for this monitoring programme is to assess whether short term impacts from disturbance during construction have long term population consequences. Assessment methods used in the ES highlight the indirect and often delayed mechanisms by which impacts might occur at the population level. At the same time, these long-lived top predators are potentially influenced by a range of other natural and anthropogenic factors that may influence reproduction, survival and, ultimately, their population dynamics. This constrains the design of monitoring experiments with discrete control populations that could demonstrate cause and effect. Instead, understanding of the factors driving population dynamics in such species are typically based upon models that explore relationships between different candidate drivers (Questions 15 & 16). Here, this should, for example, include information on variation in other anthropogenic stressors (eg. other noise sources, or levels of by-catch), key prey populations or physical processes that might influence prey availability.

To explore the potential role of windfarm construction on these target populations, we will therefore liaise with regulators and their advisors to identify potential candidate drivers, identify where data are already available (eg. from remote sensing or statutory reporting and monitoring) and explore how this information might be supplemented by data resulting from other parts of the MORL and BOWL monitoring programme (eg. benthic, fishery and AIS surveys).

Table 4. Indicative workplan for the different activities proposed in the text, highlighting the annual nature of the underpinning individual based studies, and likely timescales for the focused studies to address other questions. Some pre-construction activities (1c, 1d & 2b) could be conducted in either 2014 or 2015

Activity	Pre-			Construction Period					Post-	
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1a Seal Photo-ID	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1b Seal population trends		✓				✓				✓
1c Seal tracking		✓		✓						
1d Seal hearing		✓		✓			✓	✓		
2a Dolphin Photo-ID	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2b Dolphin displacement		✓		✓	✓					
3a Porpoise responses				✓	✓					
3b Porpoise density					✓	✓			✓	✓

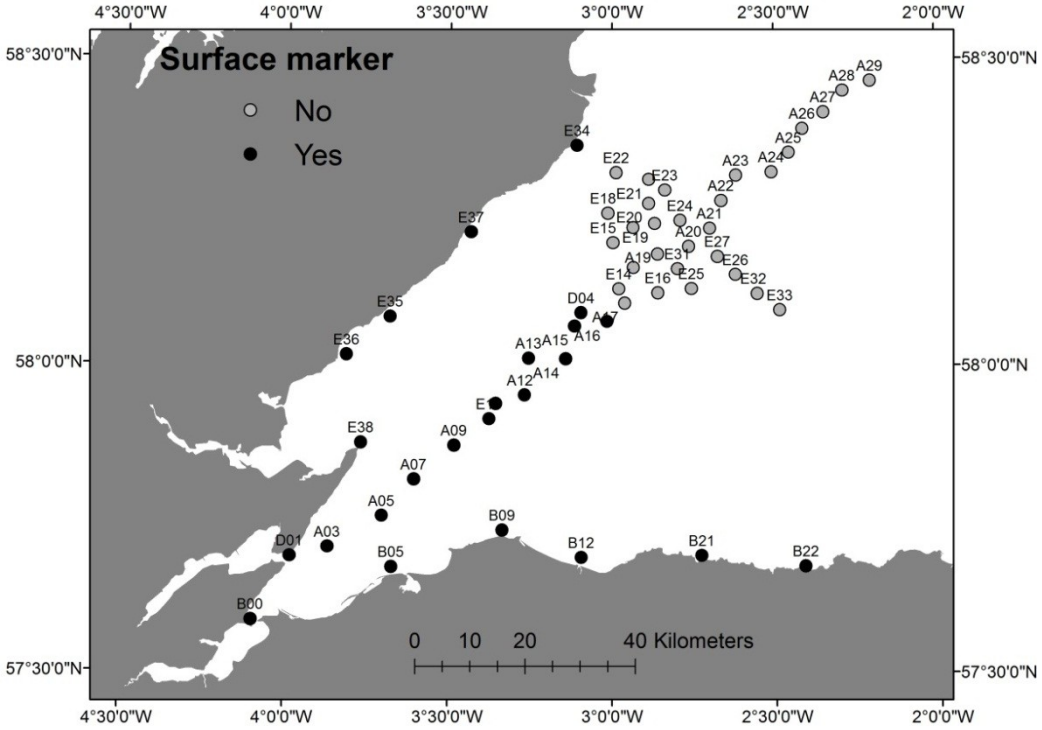

Figure 1. Proposed locations for C-POD sampling sites as part of the gradient design used to assess the spatial and temporal scale of responses of porpoises to piling during the installation of a met mast in the Moray Firth.

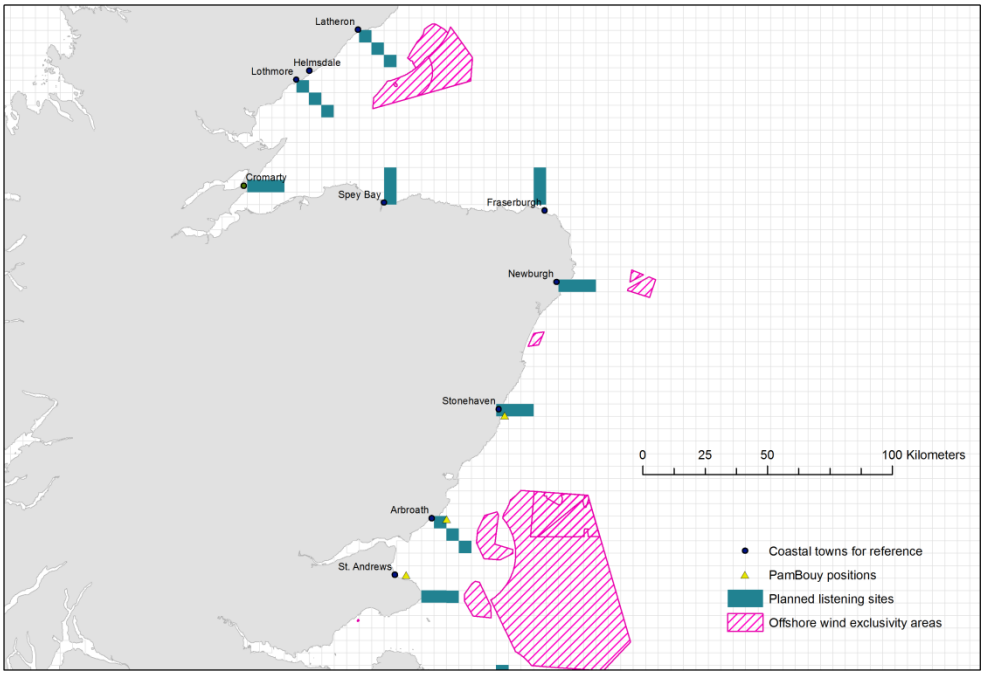

Figure 2. Draft locations for the different passive acoustic devices forming the proposed East Coast PAM network (courtesy of Marine Scotland)

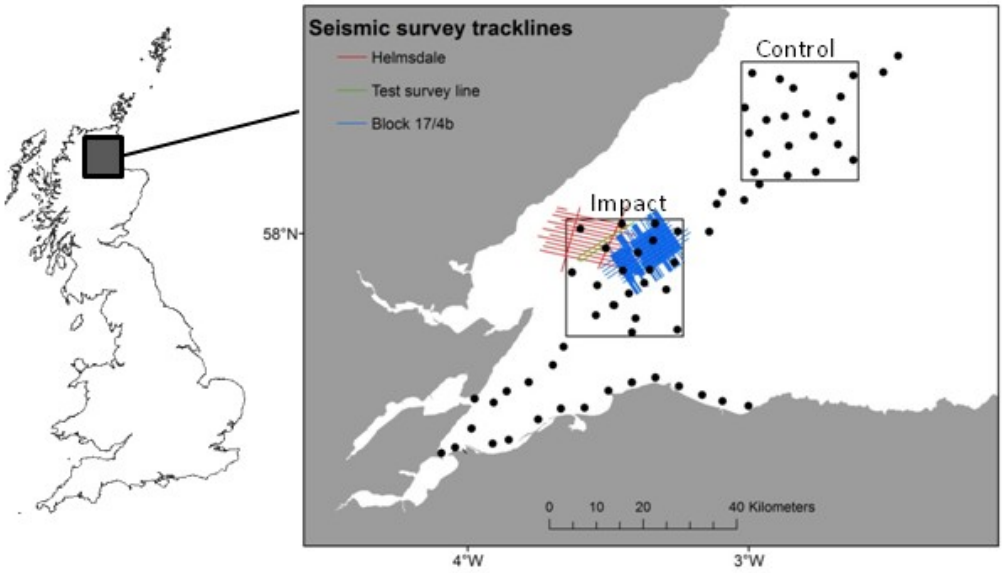

Figure 3. Locations of C-PODs used in the combined BACI and Gradient design to assess responses of porpoises to seismic surveys carried out in the Moray Firth in 2011.