A strategic regional Marine Mammal Monitoring Programme for assessing the population consequences of constructing the BOWL and MORL Wind Farm Developments

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1 Contents

Glossary

BOWL	**Beatrice Offshore Windfarm Ltd**
MS	**Marine Scotland**
MS LOT	**Marine Scotland Licensing Operations Team**
MSS	**Marine Scotland Science**
CMR	**Capture-Mark-Recapture**
CPODs	**Cetacean Porpoise Detectors**
DEVELOPERS	**BOWL & MORL**
MMMP	**Marine Mammal Monitoring Programme**
MFRAG	**Moray Firth Regional Advisory Group**
MORL	**Moray Offshore Renewables Ltd**
NERC	**Natural Environment Research Council**
NNR	**National Nature Reserve**
SAC	**Special Area of Conservation**
SCOS	**Special Committee on Seals**
SSER	**Scottish Southern Energy Renewables**
STAKEHOLDER GROUP	**MS, MSS, SNH and other key stakeholders**
STEERING GROUP	**MS, BOWL, MORL, TCE and other funding parties**

Introduction

The following document outlines the methodologies proposed to undertake the Monitoring Programme for marine mammals during construction of the Beatrice Offshore Windfarm Limited (BOWL) and Moray Offshore Renewables Limited (MORL) wind farm developments (see Figure 1.1).

This monitoring programme has been designed to meet conditions related to the BOWL and MORL Project Environmental Monitoring Programmes ("PEMPs"), as required within the MORL and BOWL Wind Farm Section 36 Consents and Marine Licences;

MORL:

- Condition 26 of MORLs Telford, Stevenson and MacColl Wind Farms Section 36 consents.
- Condition 3.2.1.1 of the MORL Marine Licence for the Modified Offshore Transmission Infrastructure.

BOWL:

- Condition 27 of the BOWL Section 36 Consent.
- Condition 3.2.1.1 of the BOWL Marine Licence for the Offshore Transmission Works.

These conditions were included in consents for both projects "to ensure that appropriate and effective monitoring of the impacts of the Development is undertaken".

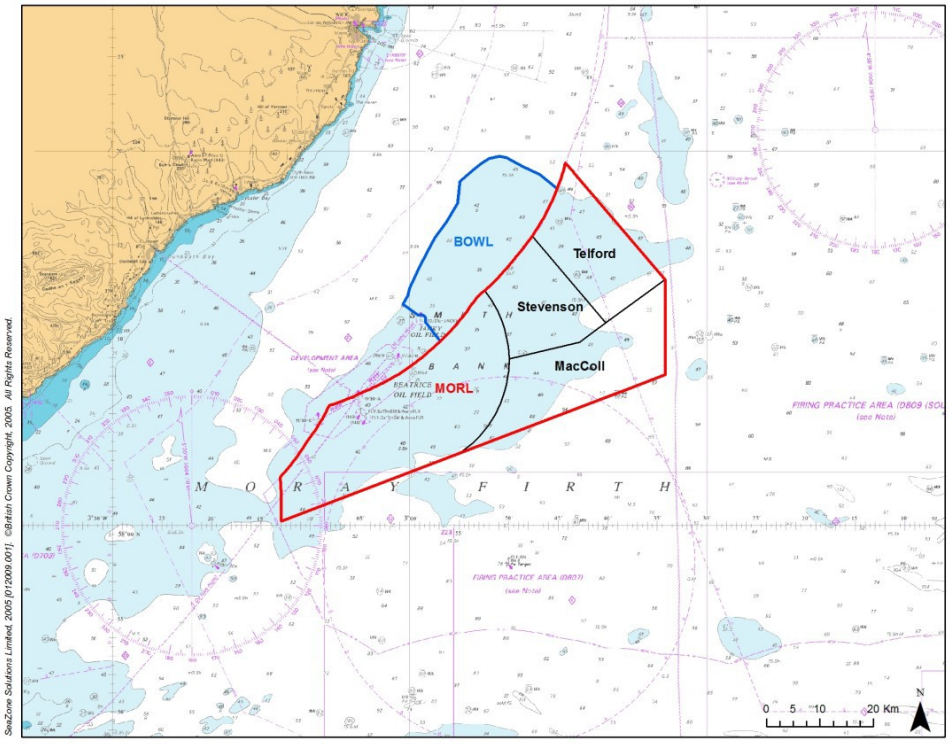

Figure 1.1 BOWL and MORL site locations (Stevenson, Telford and MacColl relate to the three consented MORL wind farms)

As part of the Section 36 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 agreed in consultation with MS-LOT to contribute to a regional Marine Mammal Monitoring Programme (MMMP) that is being managed by the University of Aberdeen.

This document builds upon two previous documents. The first of these was a draft scope for the overall MMMP programme dated 15th March 2013, following consultation meetings between MS-LOT and key stakeholders in March 2013. The second document was a detailed scope of work for the pre-construction period (2014 & 2015), which included the 15/3/13 outline construction / post construction scoping document as an annex. This was submitted to MS-LOT on 25th March 2014 and subsequently provided to stakeholders within the Moray Firth Regional Advisory Group (MFRAG) for comment. The pre-construction elements of this programme are currently in progress, having commenced in 2014 following sign off from MS-LOT.

Rationale

Scoping exercises highlighted that the primary issue when considering the impacts of wind farm developments upon marine mammal populations is construction noise. Assessments made within the BOWL and MORL Environmental Statements indicate that even worst case scenarios for construction noise should not affect the conservation status of either harbour seals or bottlenose dolphins using SACs within the region. Furthermore, these potential risks have been further mitigated through a significant reduction in the size of the consented developments relative to those worst case scenarios. Nevertheless, it is recognized that these assessments are associated with high levels of uncertainty, particularly in relation to the animals' short- and medium-term responses to noise, and to the cumulative impacts of construction and other natural and anthropogenic stressors. Potentially balancing these concerns, there may be ecosystem benefits through reef effects at constructed sites, but the evidence base for this has been insufficient to incorporate these factors into assessments of cumulative impacts.

Extensive stakeholder discussions indicate that there is widespread agreement that the monitoring programmes required for future wind farm projects should address focused research questions related to key uncertainties identified during the consenting process. In

the Moray Firth, consent conditions require these monitoring programmes to be approved by Scottish Ministers, following consultation with the MFRAG. The generic nature of many of the questions being asked requires a strategic research and monitoring programme to understand how Scottish wind farm developments, in combination with other natural and anthropogenic drivers, affect the status of key protected populations. Collectively, wind farm developers have a clear role to play in the development and funding of this programme through their monitoring requirements. However, wind farms are just one of many regulated industries that may cumulatively impact these protected populations. This has been recognised through the development of consortium funding for the pre-construction phase of the MMMP. Elements of the MMMP will also be of relevance for monitoring around any wind farm developments in the Forth and Tay, as well as port developments and oil and gas activities along the east coast of Scotland. However, opportunities to further develop such consortia are currently constrained by uncertainty over the likelihood that particular wind farm sites will be developed. As MORL and BOWL are geographically close, and the timescales for different developments are also uncertain, it is difficult to define pre-construction and construction periods for broader scale impacts such as noise and/or mobile species that move between different development areas.

Whilst the key driver for this MMMP has been to partially discharge conditions within the MORL and BOWL section 36 consents and Marine Licences , this MMMP for the Moray Firth has the potential to support the development of key research areas within a broader scale national monitoring programme. At the same time, given the uncertainties around the construction programme for East coast developments, scoping of the construction phase of the MMMP has had to consider scenarios where only one of these developments is constructed.

Following stakeholder discussion, it was agreed that the pre-construction phase of the MMMP should focus on studies of harbour seals and bottlenose dolphins. In addition, during construction, we suggest that additional shorter-term studies of harbour seals and harbour porpoises may be required if alternative mitigation measures are adopted. The current document provides an outline of a regional programme of monitoring that is considered appropriate if development occurs at both sites. Should construction occur at only one of the consented sites within the Moray Firth, we suggest that studies of harbour seals and mitigation measures should be prioritized. This prioritization is based on several factors. First, the harbour seal population is resident within the Moray Firth, leading to a high degree of overlap with either development site. In contrast, bottlenose dolphins favour areas in the inner and southern Moray Firth and range widely along the east coast of Scotland, resulting in a lower degree of overlap with the BOWL and MORL sites and significant overlap with other east coast developments. Second, the projects' ES's highlighted that these differences indicate that the harbour seal population is the most likely to be affected by construction activity through displacement. In contrast, bottlenose dolphins are less likely to be displaced from favoured areas, and detectable population level impacts are unlikely. Finally, there are better opportunities to study fine-scale changes in the behaviour of harbour seals and link these to any observed changes in vital rates. This offers unique opportunities for the MMMP to address strategic research questions about individual and population level responses to disturbance during the construction period, and meets the requirements of the BOWL and MORL PEMP consent conditions.

Aims

The Pre-construction MMMP aims to collect baseline data on the distribution, abundance and vital rates for two priority species (harbour seals and bottlenose dolphins) during the pre-construction period. This is anticipated to span the period 2014-2016, but construction start date for MORL is yet to be fully confirmed. The scope of these pre-construction works has been agreed in discussion with Marine Scotland and their advisors. The selection of priority species has been based upon the proximity of EU protected sites (Special Areas of Conservation, SACs) to the BOWL and MORL sites, and the opportunities to address key questions that can reduce uncertainty in future assessments.

During construction monitoring, the MMMP aims to use this baseline to underpin studies of the behavioural responses of harbour seals to pile driving noise and any broader scale changes in the distribution of both priority species during the construction period. This work will assess levels of displacement in relation to received noise levels. For harbour seals, observed individual variation in behavioural responses and noise exposure levels will also be related to changes in body condition and vital rates to test assumptions used in the ES assessment framework. Annual estimates of abundance, reproduction and survival of both priority species will be made to compare with worst case impacts predicted in the ES and the pre-construction monitoring baseline.

Additional construction monitoring will be conducted should active acoustics or other alternative mitigation measures be used to minimise risk of injury during piling operations. These studies will focus upon harbour seals and harbour porpoises due to their likely occurrence within the development area, and will monitor the responses of these species to acoustic deterrents and/or alternative soft start procedures deployed prior to piling operations.

Finally, these pre-construction and construction phases of the MMMP aim to support the development of appropriate post-construction monitoring.

Programme structure

The pre-construction and construction phases of the proposed MMMP consist of three work packages. The first covers the requirements for harbour seal monitoring, the second for bottlenose dolphin monitoring, and the third for assessing the performance of alternative measures for mitigating piling injuries.

Harbour Seal Monitoring;

1) Individual based studies of reproduction and survival;
2) Trends in abundance; and
3) Characterisation of foraging areas & responses to piling.

Bottlenose Dolphin Monitoring

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

Monitoring Deployment of Acoustic Deterrent Devices

1) Responses of harbour seals to Acoustic Deterrent Devices (ADD) & piling soft starts;
2) Responses of harbour porpoises to ADD & piling soft starts.

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, however the final methodologies for data collection and analysis will be agreed with Marine Scotland following consultation with the relevant statutory and non-statutory consultees through the MFRAG, prior to commencing each phase of the monitoring work.

Requirements for the post-construction phase of the MMMP will depend both upon the final scale of development, and the extent to which construction impacts are detected. This phase of the work will therefore need be refined in response to forthcoming monitoring results and further discussion with Marine Scotland and the MFRAG. The final section of this document provides a high level indication of the likely scope of this work and how it could relate to broader initiatives to measure cumulative impacts of wind farm construction in Scottish waters.

Harbour Seal Monitoring Work Packages

WP 1.1: Individual based studies of reproduction and survival

Objectives

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

Parameters to be measured

- Female fecundity (birth-rates);
- 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).

Figure1. 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 National Nature Reserve (NNR) have been conducted annually since 2006. At the start of the pre-construction monitoring period, the photo-identification catalogue contained over 170 individuals, including 75 reproductive females. Data collected between 2006 and 2011 have been used to provide initial estimates of female fecundity and sex-specific survival (Cordes & Thompson 2013b). This data, and the data that are being collected during the pre-construction phase of the MORL and BOWL wind farms will provide a 10-year time-series of baseline variability in these vital rates for comparison with estimates obtained during the construction phase.

Sampling Locations

Sampling effort will continue to focus on Loch Fleet NNR, which has become an increasingly important breeding site for the Moray Firth harbour seal population in recent years (Cordes et al. 2011) and is now the nearest major breeding site to the BOWL & MORL developments (Figure 2). Additional baseline data from a haul-out site at Sputie Burn will be collected opportunistically during fieldwork under WP 1.2.

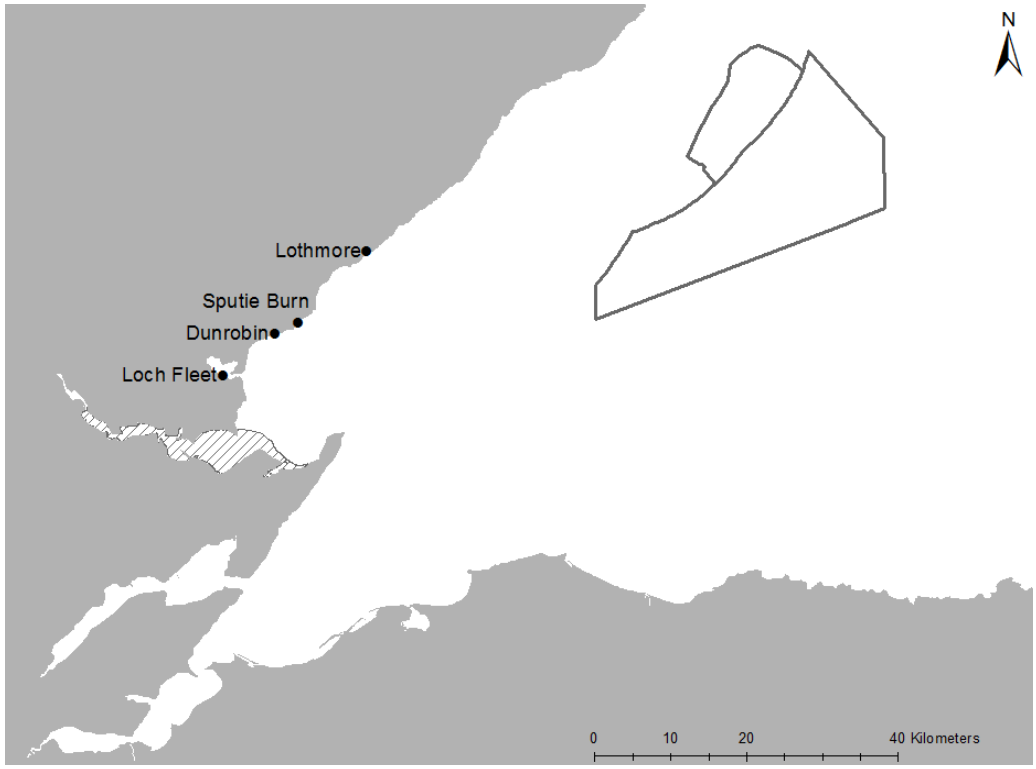

Figure 2. A map of the Moray Firth showing the position of the BOWL and MORL development areas and the four closest harbour seal haul-out sites. The Dornoch Firth and Morrich More SAC is hatched.

Sampling Periods

Photo-identification surveys will be made regularly from late May until late July in each year during pre-construction and construction phases of the projects. This will provide data from 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 around 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 a 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 annual estimates of median birth dates (Cordes & Thompson 2013a).

Once detailed piling schedules are known, these will be incorporated into revised noise exposure models within the seal assessment framework to predict how changes in vital rates may result from disturbance by piling activity. Observed annual rates of reproduction and survival will then be compared for the pre-construction and construction phases of the project, and observed impacts compared with modelled predictions. Variation in individual probabilities of pupping and birth dates will also be related to individual co-variates such as individual estimates of exposure to construction noise that are based upon telemetry data (see WP 1.3).

Proposals are currently being made by the Natural Environment Research Council (NERC) Sea Mammal Research Unit (SMRU) to develop a suite of study sites across Scotland to provide photo-identification based estimates of vital rates. The aim of the SMRU work is to inform MS about the drivers of harbour seal population declines in some Seal Management Units. Every effort will be made to integrate work carried out under the MMMP into these efforts through ongoing MASTS collaborations and Paul Thompson's roles on the Steering Groups for MS funded research at SMRU and the NERC Special Committee On Seals (SCOS).

WP 1.2: Trends in abundance

Objectives

This work package will initially be used to establish variability in summer and winter abundance at harbour seal haul-out sites along the northern Moray Firth (Figure 2: Loch Fleet and smaller sites at Dunrobin, Sputie Burn and Lothmore). 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 SMRU; .i.e. Regional Site Condition Monitoring data from the Dornoch Firth and Morrich More SAC and national harbour seal survey data. These data will be compared with 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 unmanned aerial vehicles 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 SMRU 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). Winter data from sites at Sputie Burn & Lothmore have been collected in 2014/15 as part of the pre-construction phase of the BOWL and MORL MMMP.

Sampling Locations

Sampling effort will focus on the Loch Fleet NNR and the two other harbour seal haul-out sites along the northern Moray Firth coast at Sputie Burn and Lothmore (Figure 2).

Sampling Periods

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

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 around low tide and, where possible, 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 seal survey data from the east coast of Scotland that are made available through the NERC SCOS (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.

The data will be used to inform the BOWL and MORL project environmental monitoring programmes, their post-construction monitoring requirements, and to test assumptions made in the their Environmental Statements.

WP 1.3: Characterisation of foraging areas & responses to piling

Objectives

Data collected during the pre-construction phase of the MMMP will be used to update baseline information on the at-sea distribution and foraging patterns of harbour seals breeding at haul-out sites in the northern part of the Moray Firth. These data will complement other tagging work being conducted as part of MS funded telemetry studies on the connectivity between Moray Firth haul-out sites in relation to ports and harbour developments. Effective integration will be ensured because both the MMMP and the ports and harbour studies are being conducted collaboratively by the University of St Andrews and the University of Aberdeen. The MS study has included some tagging of seals from the Dornoch Firth SAC to assess connectivity with other Moray Firth haul-out sites. Loch Fleet data collected through both studies will also be used to characterise the foraging areas used by different identifiable individuals (see WP 1.1) and assess likely individual variation in noise exposure.

Building upon stakeholder responses to earlier consultation documents, additional tagging deployments will be made immediately prior to the construction period. This work will increase the sample sizes for relating individual variation in noise exposure to changes in vital rates (see WP 1.1), and permit direct studies of behavioural responses at the start of construction phase. Depending upon observed responses and construction schedules, additional tagging deployments may be made in subsequent years to assess whether there is evidence of habituation or tolerance to longer-term piling activity. Individual variation in cumulative noise exposure will be assessed by integrating seal tracks with information on spatial variation in received levels obtained through a combination of field measurements and noise propagation modelling (see Hastie et al. In Press). In addition, technological developments may allow noise exposure to be measured directly by the tags deployed during construction.

Parameters to be measured

- Population distribution at sea during summer and winter;
- Individual home ranges and foraging ranges;
- Individual variation in exposure to piling noise;
- Movement rates and dive patterns.

Survey Design

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. Pre-construction surveys have been designed to include two capture periods to maximise the chance of obtaining a balanced dataset across both winter and summer seasons. The timing of additional deployments which will cover the construction phase will be dependent upon construction timescales.

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. 2013a), using a state space model to account for the different error structures associated with the various tag types (Bailey et al. 2014).

However, these earlier data were strongly biased towards the summer months; relatively few animals were tracked using high resolution GPS devices, and all data had been collected before 2009. Initial deployments during the pre-construction phase in 2014/ 2015 have already provided important additional baseline information. These data have highlighted major individual differences in the extent to which animals forage around the development areas. General patterns from this monitoring also indicate greater use of more inshore areas compared with the historical baseline.

Sampling Locations

The primary site for capturing 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 study 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

Pre-construction data are being collected during the winter of 2014/15 and the summer of 2015. The timing of subsequent data collection will be dependent upon construction timescales.

Sampling Technique

During the pre-construction phase, twenty-five GPS-GSM tags will have been deployed on harbour seals. Final decisions about required sample sizes for construction will be based upon an analysis of the pre-construction data.

In all cases, study individuals will be captured using barrier nets as they flush from their haul-out sites. Capture, handling and anaesthesia will be conducted under licence from the Home Office and Marine Scotland. These procedures all require suitably trained and licenced personnel, and the use of specialist boats and equipment (see Sharples et al. 2012 for full details).

GPS/GSM tags will be attached to the fur at the back of the neck using Loctite® 422 Instant Adhesive and the seals released following collection of standard samples and 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 underlying at-sea distribution used within 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 pre-construction data will be used to design additional tracking studies during construction. Deployments during construction will be used, first, 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. If possible, received noise levels will be measured directly from seal tags and information on final piling schedules will also be used to model sound fields. Known movements of seals through these modelled sound fields will also be used to estimate individual variation in sound exposure levels (see Hastie et al. In Press) for comparison with vital rates (see WP 1.1).

These data will also be used to inform the BOWL and MORL project environmental monitoring programmes, their post-construction monitoring requirements, and to test assumptions in their Environmental Statements.

Bottlenose Dolphin Monitoring Work Packages

WP 2.1: Individual based studies of reproduction and survival

Objectives

This work package will be used to assess year-to-year variability in bottlenose dolphin vital rates. This will permit comparison of Moray Firth data collected during the pre-construction and -construction periods, and will underpin broader scale comparison of vital rates for individuals with different ranging patterns along the east coast of Scotland.

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 2014a), 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.

Figure 3. Examples of suitable photographs for individual photo-identification, showing the distinct nicks and tooth rake marks on the left and right side of four individuals that regularly use the Moray Firth SAC.

Existing Baseline

Photo-identification studies of bottlenose dolphins in the Moray Firth SAC have been conducted annually since 1990 (Cheney et al., 2014b). 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 200 distinctively marked individuals, including 42 known males and 61 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 has recently used data collected between 1990 and 2012 to estimate sex-specific survival rates (Arso 2014).

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 where these are available through continued collaboration with other research groups (see Cheney et al. 2014b). This framework could also be used to underpin data resulting from survey programmes conducted by the Forth and Tay developers. A map illustrating the key areas to be surveyed within the Moray Firth is shown in Figure 4, which includes the locations of previous encounters with groups of bottlenose dolphins.

Sampling Periods

Photo-identification surveys completed during the pre-construction phase will be repeated between May and September during the construction periods of the projects following established protocols for monitoring the Moray Firth SAC (Cheney et al. 2014a).

Sampling Technique

Up to 20 boat-based photo-identification surveys 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 4). 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 sides of the dorsal fins of as many individuals as possible, whilst minimising disturbance and ensuring that as many different members of the group are 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).

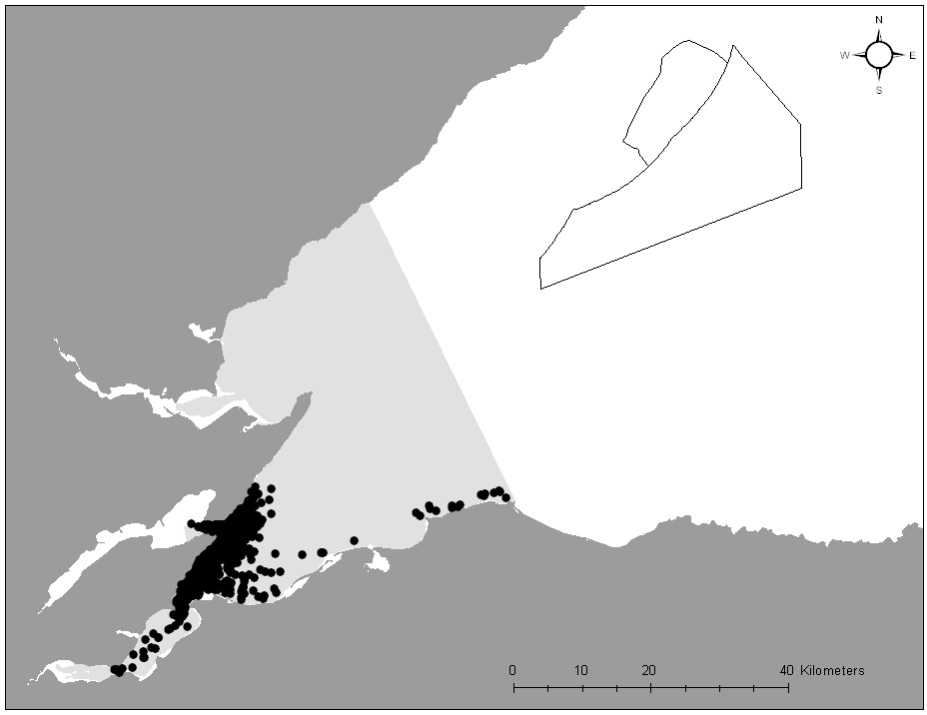

Figure 4. A map of the Moray Firth showing the position of the BOWL and MORL development areas and areas where dolphin groups have been encountered during previous University of Aberdeen photo-identification surveys (Data are from 2001-2013). The location of the Moray Firth SAC is shaded.

Data Analysis

Following the survey, all pictures will be graded for photographic quality and archived as soon as practically possible. All high quality pictures will 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 long-term variability in the abundance of bottlenose dolphins within the Moray Firth SAC and relate these numbers to the overall size of the east coast bottlenose population. This part of the MMMP is therefore fully integrated into ongoing Site Condition Monitoring for the Moray Firth SAC (see Cheney et al. 2014a). These data will permit comparison of data collected during the pre-construction and construction periods, 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 each summer during construction of the projects
- 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 2014a), 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 1990 (Cheney et al., 2014b). 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 individuals (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. 2014b). Over this same period, a state space model that uses data from throughout the population's range (Corkrey et al. 2008) indicated that there was a >99% probability that this population is either stable or increasing (Cheney et al. 2014b).

The additional data collected during the pre-construction monitoring for the BOWL and MORL wind farms 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 any

additional data available from other parts of the population's range through continued collaboration with other research groups (see Cheney et al. 2014b). A map illustrating the areas to be surveyed within the Moray Firth is shown in Figure 4, 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 each year of construction following established protocols for monitoring the Moray Firth SAC (Cheney et al. 2014a).

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 be used to produce annual CMR estimates 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. 2014a).

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. It should be noted that the extent to which this approach can be used to update estimates of total population size will depend upon the availability of data from other parts of the population's range (eg/. the Forth and Tay).

These data will be used to inform the BOWL and MORL project environmental monitoring programmes, their post-construction monitoring requirements, and to test assumptions in their Environmental Statements.

WP 2.3: Baseline occurrence of dolphins in favoured areas and responses to piling

Objectives

This work package will be used to assess variability in the occurrence of bottlenose dolphins at key sites within the Moray Firth SAC and along the southern Moray Firth coast during construction of the projects. This will permit comparisons of data collected during the pre-construction and construction periods, allowing an assessment of whether far-field disturbance leads to a change in the occurrence of dolphins within these areas. Close liaison with MSS will permit integration of these findings with broader scale studies of distributional change that are being underpinned by the East Coast Passive Acoustic Monitoring Project.

Parameters to be measured

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

Survey Design

Passive acoustic studies using existing CPODs 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), across the Moray Firth (Thompson et al. 2015), and year to year variation in the occurrence of dolphins at key sites within the Moray Firth SAC (Cheney et al. 2014a). These techniques have the advantage that dolphin occurrence at sampling sites can be remotely monitored for 24 hr/day over periods of several months.

The final design of a Passive Acoustic Monitoring (PAM) array for construction monitoring will be based upon findings from the MMMP pre-construction monitoring, the MS East Coast Passive Acoustic Monitoring Project, and DECC SEA funded studies of the responses of bottlenose dolphins to coastal piling and harbour construction in 2014. It is anticipated that ongoing data collection and analysis will permit consultation upon this design at the end of 2015. This component of the work would ideally require a nationally co-ordinated programme that integrates fine-scale studies around the Moray Firth and Forth and Tay development areas with the MS East Coast Passive Acoustic Monitoring Project.

Existing Baseline

TPOD studies were first conducted in the Moray Firth in 2005 (Bailey et al. 2010) and TPODs and CPODs 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; Chanonry Narrows, Sutors, Lossiemouth and Spey Bay (Figure 5). 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 (e.g. 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. 2013b; 2015).

The construction MMMP will feed into existing studies to provide a 10 year monitoring baseline for comparison with data to be collected during the construction period. In addition it will feed into 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 5.

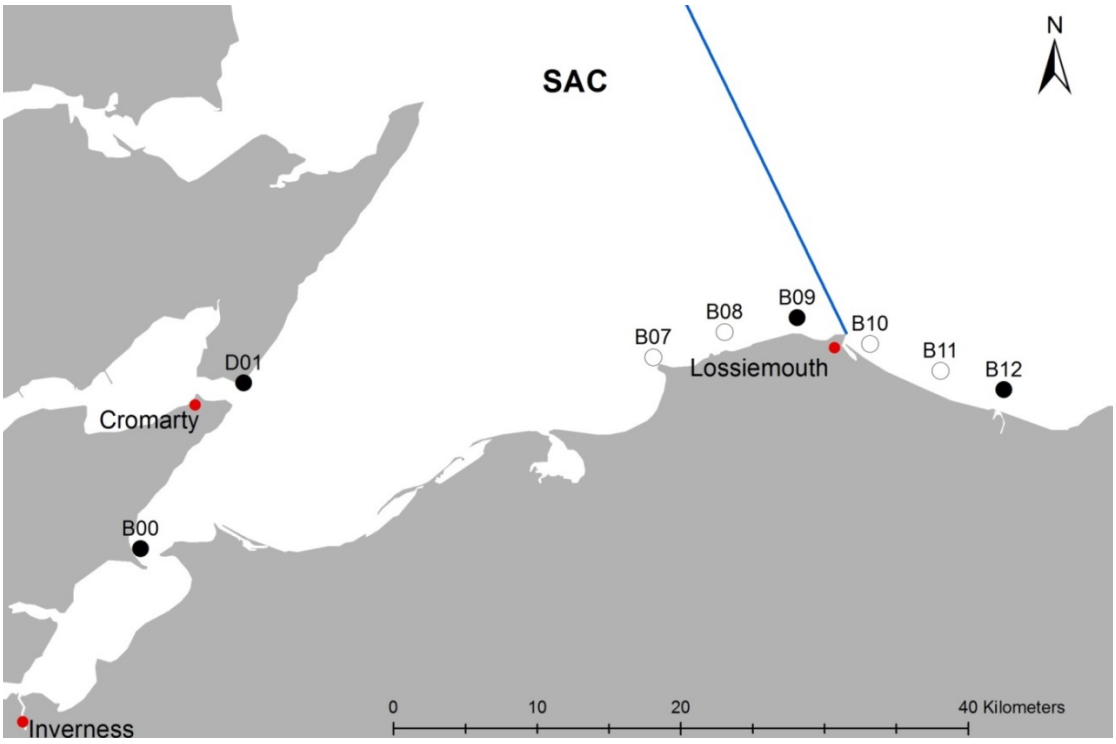

Figure 5. A map showing the CPOD locations (long-term sites = black circles; summer only sites = open circles). The boundary of the Moray Firth SAC is shown in blue.

Sampling Periods

Sampling will occur year-round at the four long-term monitoring sites. During the pre-construction phase, sampling occurs between May and September of each year at all other sites. Based upon these data, and an understanding of the final design, additional sampling periods and locations may be required for the construction period.

Sampling Technique

Data will be collected using V0 and V1 CPODS using seabed moorings that have been optimised for deployments at these sites, and licenced for scientific use by Marine Scotland and consented by 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. 2013b) and during baseline data collection for MORL and BOWL EIAs (Thompson et al. 2015).

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 CPODs to provide redundancy should equipment fail.

Following the recent publication of a method to routinely calibrate CPODs (Dahne et al. 2013a) a test tank has been established at the Lighthouse Field Station to allow devices to be calibrated at the start of each deployment as part of the MMMP. This facility is also being made available to MS for calibration of devices used within their East Coast Passive Acoustic Monitoring Project which will ensure consistency in the data collected.

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 echolocation 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 terms 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. 2013b and Thompson et al. 2015.

Monitoring Mitigation Measures Work Packages

WP 3.1: Responses of harbour seals to ADD & piling soft starts

Objectives

This work package will be used to assess the fine-scale responses of harbour seals to any new mitigation procedures that are used during construction, such the use of ADDs and/or variations in soft start procedures.

Parameters to be measured

- 3 dimensional (3D) distribution;
- Movement rates.

Survey Design

The design of these surveys will be based upon our emerging understanding of the responses of individual harbour seals to ADD playbacks conducted by SMRU as part of MS funded investigations into the interactions between harbour seals and vessels in the inner Moray Firth.

It is anticipated that the work would be based upon tracking of individuals to explore fine-scale behavioural responses to different noise sources. This work could potentially be integrated with studies under WP 1.3. The final design of these studies will depend upon the nature of the mitigation measures to be used which will be agreed with MS-LOT in consultation with the MFRAG, other key stakeholders such as ORJIP, and upon emerging data from both the MMMP pre-construction monitoring programme and the MS funded SMRU studies.

Existing Baseline

By the end of 2015, GPS-GSM data on baseline foraging movements should be available from approximately 30 individual harbour seals from the Loch Fleet study population through the pre-construction MMMP and earlier studies (Cordes et al. 2011). In addition, >30 harbour seals from the Moray Firth have been tracked during 2014 and 2015 using GPS-UHF tags as part of the MS funded SMRU studies. This latter work has under-pinned behavioural response studies to ADD playback that will inform the final study design.

Sampling Locations

It is anticipated that sampling effort would focus upon harbour seals from Loch Fleet and the Dornoch Firth SAC, as these animals are most likely to forage in the vicinity of the wind farm sites. Depending upon the results from the 2014 playbacks and pre-construction monitoring, it may also be appropriate to consider ADD playbacks within more inshore foraging areas that are more intensively used by seals from this population.

Sampling Periods

Studies would aim to assess responses to mitigation procedures during the early phases of construction.

Sampling Technique

Final decisions about the most appropriate tag technology (GPS-GSM or GPS-VHF) and required sample sizes will be based upon an analysis of the pre-construction data and data from MS SMRU ADD playbacks.

Capture, handling and licencing requirements will be as outlined in WP 1.3.

Data Analysis

If GPS-GSM tags are used, 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. Alternatively, we may use GPS-UHF systems that were successfully trialled in this area in 2014, potentially allowing real-time data to be collected using base stations at haul-out sites or on vessels used to deploy the ADD.

Fine-scale changes in behaviour will be determined in relation to information on the known timing and location of piling schedules and associated mitigation. Collaborators at the University of St Andrews have extensive experience of behavioural response studies such as this. Especially as this is such a rapidly expanding field, we suggest that decisions over the most appropriate experimental design and statistical techniques should be made in response to current best practice and the forthcoming analysis of MS-SMRU data from 2014.

WP 3.2: Responses of harbour porpoises to ADD & piling soft starts

Objectives

This work package will be used to assess both broad-scale and fine-scale responses of harbour porpoises to any new mitigation procedures that are used during construction, such the use of ADDs and/or variations in soft start procedures.

Parameters to be measured

- Presence of porpoise echolocation clicks in given time periods (minutes, hours and days) at different distances from piling;
- Movement rates.

Survey Design

The design of these surveys will be based upon previous studies of this species at other European wind farm sites (e.g. Brandt et al. 2013), studies of this species' response to other noise sources within the Moray Firth (Thompson et al. 2013b), and ongoing MS funded work that is using PAM for fine-scale tracking around tidal development sites.

It is anticipated that broad-scale responses (up to 10km) could be based upon dispersed cruciform arrays of C-PODS around piling sites. Fine-scale movement rates could be estimated within more restricted areas (< 1km) using small scale arrays, for example using a system such as PAM Buoy (Gillespie et al. 2013). The final survey design will depend upon the nature of the proposed mitigation and the likely scale of response, which will in turn be determined through additional noise modelling.

Existing Baseline

The MORL and BOWL ESs present the extensive existing baseline on the distribution of harbour porpoises in the outer Moray Firth, with robust estimates of density available within the MORL and BOWL sites and PAM data on porpoise occurrence from multiple locations (see also Brookes et al. 2013). A series of other studies both in the Moray Firth (Thompson et al. 2013b; Pirotta et al. 2014) and at other European wind farm sites (Brandt 2013; Dahne 2013b) have demonstrated how dispersed PAM arrays can be used to measure responses to anthropogenic noise.

Sampling Locations

Effort will be focused at a sample of piling locations. It may also be valuable to consider ADD playbacks at some control sites if information is required on the relative importance of responses to ADDs operating alone vs ADDs being used during active piling operations.

Sampling Periods

Studies would aim to assess responses to mitigation procedures during construction.

Sampling Technique

The primary sampling method for broad scale studies will be using arrays of CPODs as described in WP 2.3. Techniques for studying fine-scale behaviour could include small multi-hydrophone arrays as used on PAMBuoy or other PAM systems.. Decisions on the most appropriate technology for this element of the work will depend on the final study design, a full review of available systems, and logistic and commercial considerations surrounding proposed mitigation and piling schedules.

Data Analysis

CPOD data will be analysed as outlined in WP 2.3, using appropriate train filters for harbour porpoise. Software such as PAMGuard (http://www.pamguard.org) will be used to provide a series of estimates of position using differences in the time of arrival of echolocation clicks to multi-element arrays.

As for WP 3.1, resulting data on changes in occurrence or movement rates will be determined in relation to information on the known timing and location of piling schedules and associated mitigation.

Post-construction Monitoring

Critically, the scope of post-construction monitoring will depend upon whether construction monitoring detects evidence of potential impacts identified under worst case predictions within the BOWL and MORL ES.

For harbour seals, these predictions included declines in reproduction and survival, and a reduced abundance as a result of construction. If this is observed, more intensive post-construction monitoring will be required to assess whether population recovery occurs as predicted. For bottlenose dolphins, small predicted changes in distribution were not expected to have a serious impact at a population level. Nevertheless, post-construction monitoring is anticipated to include some support for ongoing monitoring of vital rates and abundance for both these populations.

An additional component of post construction monitoring could potentially involve assessments of the broader ecosystem impacts of the installation of new turbines. This may, for example, include assessments of the extent to which new structures displace or attract individual marine mammals. Also, there may be a need to understand how these distribution patterns interact with broader change in environmental conditions and management practice. As such, the scale of such studies will depend upon the extent of likely changes due to wind farm construction in relation to other managed activities within the region. Such work could be built upon proposals from the University of Aberdeen and MSS to consider the Moray Firth as a demonstration site for understanding ecosystem impacts of installing and removing man-made structures in the North Sea.

Final decisions about the required scope for post-construction monitoring will be made by MS-LOT following consultation with the MFRAG on the construction monitoring data from the MMMP and taking into account the scale of development in both the Moray Firth and at other east coast sites.

Project management

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

The MMMP has developed a steering group with membership consisting of representatives of each of the funding partners. As a minimum, this steering group will continue to meet at least 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 is working with the Developers to co-ordinate annual meetings for a broader group of interested stakeholders. The first of these meetings was held in December 2014 to provide an overview of the first season's fieldwork under the pre-construction monitoring programme. Attendance has been based upon advice from Marine Scotland Licensing Operations Team and suggestions from funding partners. It is anticipated that the function of this group will in future be developed through the Regional Advisory Group.

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 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).

The timing and content of these reports may in future be modified if required by the MFRAG.

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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