Addendum to the Moray Firth MMMP outlining studies to be conducted during construction of the Moray East Offshore Wind Farm

Paul Thompson, 19th September 2018

1. Introduction

The overall objectives and workplan for the Moray East (previously known as MORL) and BOWL Construction MMMP were outlined in the document dated 27th June 2016 (Thompson, 2016). The details of studies to be conducted at the BOWL Wind Farm were subsequently developed in discussion with key stakeholders and the final workplan presented at the November 2016 meeting of the MFRAG-MM Subgroup (BOWL, 2016). Monitoring carried out during BOWL's 2017 piling campaign has since reduced several key uncertainties encountered during the development of assessment and mitigation protocols for offshore wind farms. In discussing these results, the MFRAG-MM Subgroup recognised that construction monitoring at the Moray East Offshore Wind Farm should be adapted to balance elements of on-going long-term monitoring with more detailed studies exploring remaining areas of uncertainty.

This document provides an addendum to the CMMMP workplans previously approved by MFRAG. It builds, first, upon written comments made by Marine Scotland Science and Scottish Natural Heritage to Moray East, following a request for feedback on monitoring options at the Feb 2018 MFRAG MM-Subgroup meeting. Second, it develops the proposals presented at the July 2018 MFRAG MM-Subgroup meeting at which there was high level agreement for a construction monitoring programme that continued to focus on the responses of the three key receptor populations; harbour seals, bottlenose dolphins and harbour porpoises.

1.1 Overview of the monitoring undertaken during BOWL Construction

Studies undertaken during the previously agreed programme of work in the BOWL Construction Monitoring Programme are summarised in the Annual Report presented to the MFRAG MM-Subgroup in July 2018 (Graham *et al*, 2018). The programme consisted of four work packages, which together aimed to validate and optimise the assessment frameworks and mitigation measures used to support the regulation of offshore wind farm developments.

The first work package (WP1) covered the requirements for harbour seal monitoring. This included maintaining population studies to follow any changes in abundance and vital rates through the pre-construction, construction and post construction phases of these developments. Detailed tracking studies were also conducted in both the preconstruction and construction phases to characterise behavioural responses to piling, with the intention of assessing any population consequences of disturbance.

The second work package (WP2) covered the requirements for bottlenose dolphin monitoring. Like the seal studies, this work package was underpinned by population studies, but also included passive acoustic monitoring (PAM) studies of the occurrence of dolphins on the southern Moray Firth coast using moored echolocation detectors (CPODs).

The third work package (WP3) aimed to monitor the responses of harbour seals and harbour porpoises to acoustic deterrent devices (ADD) and different levels of piling noise. Tagged harbour seals were not observed within the vicinity of the wind farm site, so these studies focussed on the use of a broad-scale array of CPODs to study changes in the occurrence of harbour porpoises in areas experiencing different levels of noise exposure.

Finally, the fourth work package (WP4) involved measuring and modelling levels of noise from ADD and piling to underpin analyses of marine mammal behavioural responses and noise exposure.

1.2 Lessons learned from BOWL construction monitoring

Analyses of data collected during construction activities at the BOWL site are ongoing. However, initial results summarised in the 2018 MMMP Report provide important new findings that can help shape additional construction monitoring during the development of the Moray East Offshore Wind Farm. The five key findings highlighted at the July 2018 MFRAG MM-Subgroup meeting were:

a) ***The abundance and occurrence of key marine mammal receptors during 2017 piling period appears similar to available baseline.*** For example, the abundance of both harbour seals and bottlenose dolphins at monitoring sites was similar during 2017 compared to baseline years.

b) ***Variation in marine mammal occurrence is dominated by inter-annual and seasonal patterns.*** For example, whilst fine-scale responses of harbour porpoises to piling noise were detected, variation in harbour porpoise occurrence over the wind farm site was dominated by strong seasonal peaks in occurrence in late spring and late summer of 2017.

c) ***Environmental Statement predictions of piling impacts were, as consultees intended, conservative.*** For example, the ES assumed that a high proportion of Moray Firth harbour seals would be exposed to noise levels that might lead to risk of hearing damage. In contrast, estimates of noise exposure for the 31 harbour seals tracked during the first phase of piling indicated that no individuals were at risk of a permanent threshold shift. Furthermore, there was no evidence of behavioural displacement of tagged seals from foraging areas used during the pre-construction period.

d) ***More subtle short-term responses to piling are challenging to quantify given interacting effects of vessels and ADD use.*** Results from PAM studies indicated how harbour porpoises responded to pile-driving noise. However, there was also evidence for responses to both ADD use and to vessels in the absence of piling noise. Given that installation of most turbines involved potential disturbance from all three of these sources, it has proved difficult to disentangle their relative importance.

e) ***The use of CPODs to assess finer scale responses is constrained by uncertainty over patterns of piling and local effects of vessels and/or piling noise on detection rates.*** It is recognised that CPOD detection rates may be compromised by high levels of background noise (e.g. from nearby vessels or piling). Additionally, estimates of changes in cetacean occurrence require 1–4 day breaks in piling activity before and after events of interest to compare changes in occurrence during baseline and response periods. This limits our ability to plan experiments using these techniques (e.g. comparing turbines piled with and without ADD) because the

specific events that can be studied are dictated by external factors such as weather conditions and equipment breakdown.

1.3 Remaining areas of uncertainty relevant to consenting decisions

Based upon these initial findings, the following areas were highlighted as key uncertainties for the industry, where additional studies could support future consenting decisions.

a) ***Factors affecting broader scale seasonal and inter-annual variation in occurrence.*** For example, uncertainty over the key drivers influencing recent trends in harbour seal abundance, and of seasonal variation in harbour porpoise occurrence, constrains efforts to place any effects of short-term disturbance in a broader population context.

b) ***The relative importance of piling activity and ADD use.*** Optimisation of mitigation measures requires a better understanding of the relative importance of ADD use and piling noise in shaping observed responses of harbour porpoises to pile installation.

c) ***The extent to which responses to vessels should be considered in assessments of overall construction impacts.*** Evaluation of the benefits of mitigation measures, such as noise reduction using bubble curtains, requires information on the relative importance of vessel traffic and piling noise in determining harbour porpoise responses; particularly given such measures may require additional vessels on site and affect construction schedules.

d) ***The extent to which responses to vessels may reduce the need for ADD use prior to piling soft starts.*** The piling mitigation protocols developed for the BOWL and the Moray East wind farms use ADD to further reduce the extremely low probability that a marine mammal is within a 60m injury zone around each piling site during the first hammer strike. However, the use of ADD may disturb animals over a much broader area. A better understanding of the extent of responsive movements when piling vessels arrive on site would support further evaluation of the potential risks and benefits of varying the extent of ADD use.

e) ***Mechanisms underlying porpoise responses to piling – direct response to noise or indirect response to changes in prey behaviour?*** It is generally assumed that marine mammal responses to piling result from a direct response to either broad-band or weighted noise levels. However, it remains possible that some observed effects result from indirect responses due to changes in the behaviour of their prey. Greater understanding of these mechanisms could be valuable when assessing the value of different mitigation measures (e.g. noise reduction) or responses of marine mammals with different prey preferences.

f) ***Longer-term effects of the wind farm on the distribution and occurrence of marine mammals and their prey.*** There is currently limited understanding of the potential effects of vessel traffic and changing prey fields (e.g. due to reef effects or changes in fishery practice) within operational wind farms. Further studies in these areas are required to support life-cycle impact assessments and to inform future O & M and decommissioning decisions.

Strategic industry-wide studies would be required to investigate the above areas of key uncertainties. Section 2 below provides an overview on how the Moray East CMMMP could contribute to these studies.

2. Proposed MMMP Work Packages

The following amendments are proposed to the MMMP. Work will continue within the same broad areas, presented as four work packages. Slight changes in title and content aim to reflect the lessons learned from BOWL construction monitoring and discussion at the July 2018 MFRAG MM-Subgroup meeting.

WP 1. Harbour seal monitoring work packages.

Previously, this package contained three main areas of work, which collected data on the following parameters.

WP 1.1: Individual based studies of reproduction and survival

- Female fecundity (birth-rates);
- Female pupping dates;
- Sex specific survival rates.

WP 1.2: Trends in abundance

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

WP 1.3: Characterisation of foraging areas & responses to piling

- 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.

It was widely agreed amongst stakeholders that core studies within WP 1.1 and WP 1.2 should be continued, given that these provide strategic demographic data for this key receptor. Proposed data collection within WP 1.1 and WP 1.2 therefore remains largely unchanged. However, five haul-out sites have been surveyed regularly throughout the year, but mean monthly counts at three of these rarely exceeded 5 individuals (Graham et al. 2018, Tables 5 & 6). As a result, we propose to focus future surveys at our two key photo-ID study sites (Loch Fleet and Sputie Burn).

Between 2014 and 2017, fine-scale tracking data collected during 57 GPS-GSM deployments provided a unique dataset for characterising foraging areas under WP 1.3. Analyses of these data are ongoing through a PhD project (Lea Brandes, start date Oct 2017) that will integrate data on individual foraging patterns with available data on reproductive success and condition. As reported to MFRAG, these data have demonstrated that none of the tagged individuals were foraging in areas where behavioural responses or hearing damage were likely to occur during BOWL piling. Further tagging during Moray East construction is unlikely to yield additional insights into the responses of harbour seals to wind farm construction, especially given that the Moray East site is even further from foraging areas used by seals from the main study population.

WP 2. Bottlenose dolphin monitoring work packages.

This package contained three main areas of work, which collected data on the following parameters.

WP 2.1: Individual based studies of reproduction and survival

- Female fecundity (birth-rates);
- Sex specific survival rates.

WP 2.2: Trends in abundance

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

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

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

The first two of these work packages provides strategic demographic data for the second key receptor species identified in the ES. As for harbour seals, there was agreement amongst stakeholders that these core studies should be continued.

PAM data from the third work package has demonstrated that there is strong seasonal and inter-annual variation in the use of the dolphins' favoured areas, both within the Moray Firth SAC and along the southern Moray Firth coast. Dolphins continued to use these areas throughout the 2017 BOWL construction. As seen during earlier offshore seismic surveys, there was some evidence for a slight increase in detections at inshore sampling sites on the southern Moray Firth coast during periods of piling (Graham et al. 2018, Figure 10). One possible explanation for this is that animals travelling along this coast respond to far-field impulsive noise by travelling closer to the shore. To investigate this further during the Moray East piling, the array of CPODs along the south coast will be extended by including six additional sites, three of them located 1 km offshore from three existing sites, and three located 2 km offshore from the other three existing sites (further details on the exact survey design will be provided at a later stage). This will allow us to compare detections at different distances from the coast on piling and non-piling days during 2018 and 2019. The choice of locations 1 - 2 km from existing sites is based on low detections at ECoMASS sites located 5 km from this coast, suggesting that any responsive movement to piling is likely to be happening at a relatively fine spatial scale.

WP 3. Harbour porpoise monitoring work packages.

Originally, work package 3 included two main areas of work to monitor the mitigation measures used during wind farm construction. These aimed to collect data on the responses of harbour seals (WP 3.1) and harbour porpoises (WP 3.2) to ADD use and piling noise. As outlined for WP 1.3, there were no tagged harbour seals within 27 km of any BOWL piling events, meaning that responses of seals could not be measured. Based upon these findings, no further tagging work on harbour seals is proposed, especially given that the Moray East Offshore Wind Farm is located even further from the study population's key feeding areas.

In contrast, harbour porpoises occur regularly over the wind farm areas, and PAM techniques provided better opportunities for assessing the responses of porpoises to turbine installation. To date, these, and most other studies of porpoise responses to wind farm construction, have been based upon CPODs. These devices can be used to assess changes in occurrence between a baseline period before the initiation of piling and a response period after the end of piling. The resulting data have provided a proxy for a porpoise dose-response curve, and have shown that response levels declined through the construction period (Graham et al. 2018, Figure 12). However, this approach requires appropriate baseline and response periods both before and after events of interest. In practice, this is almost entirely dictated by weather conditions and/or unforeseen engineering downtime. In particular, this has constrained efforts to explore the relative importance of ADD use, piling noise levels and vessel activity.

We propose that this work package be revised to focus upon the recognised need to consider responses of harbour porpoises to different phases of wind farm construction. To achieve this, we will extend key components of the existing studies using CPODs, but complement these with new techniques to provide finer scale and direct estimates of porpoise movements around turbine installation sites. The revised objectives and a high level description of the approach to be used are presented below.

WP 3.1: Broad-scale changes in the occurrence of harbour porpoises during different phases of wind farm construction.

The objective of this work package will be to extend the year-round time-series of data from a low density CPOD array across control and impact blocks to explore how the occurrence of porpoises varies in relation to different phases of wind farm construction. The work will focus on maintaining year-round data collection at the eight sites (shown in blue in Figure 1), which have been studied since the start of the BOWL construction period. These will be supplemented in early 2019 (taking into account the predicted start of piling at the Moray East site during mid 2019) by a further four sites (shown in red in Figure 1) that provide additional coverage of the Moray East site. Results will be used to characterise inter-annual and seasonal variation in occurrence, and explore the extent to which these patterns are influenced by different aspects of wind farm construction activity.

WP 3.2: Fine-scale responses of harbour porpoises to construction vessels, ADD and piling.

Previous studies during BOWL construction indicate that the strongest responses to turbine installation occur within 5 km of piling locations. The objective of this work package is to

integrate studies using a long-term CPOD array with focussed short-term deployments of a finer scale array of multi-channel PAM recorders. These devices will allow us to estimate the direction of movement from direct recordings of a series of detections. The work will use a commercially available 4-channel Soundtrap recorder, fitted to a purpose built benthic lander with a 30cm tetrahedral array of hydrophones and a datalogger to record its angle of tilt, depth and compass direction. Data will be analysed using PamGuard to provide 3D pointing vectors that will track individuals as they move past the array.

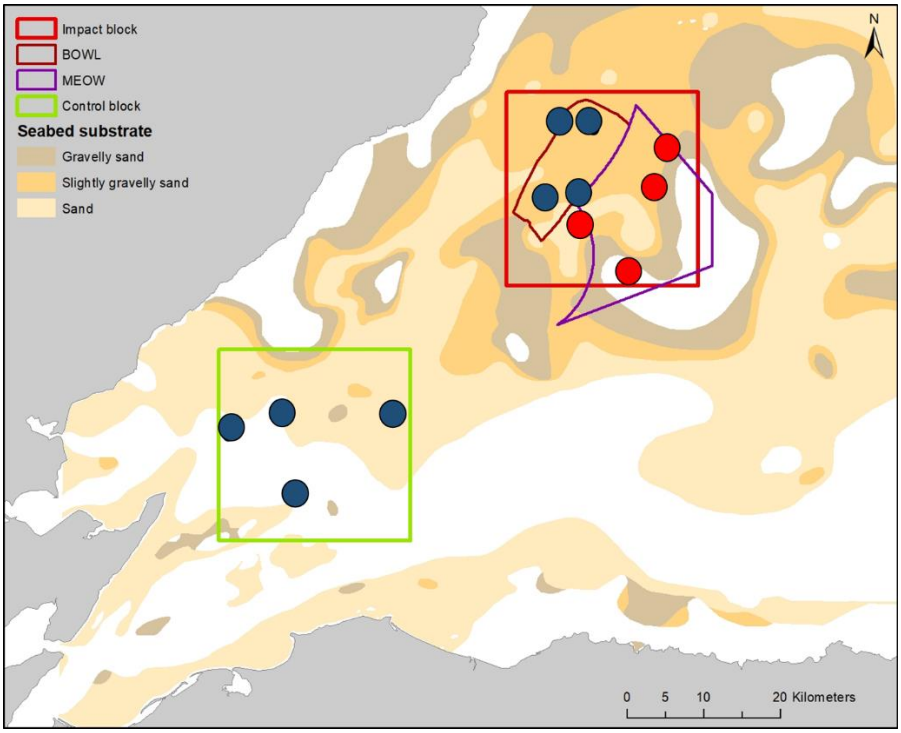

Figure 1. Map of the Moray Firth showing the locations of long-term CPOD monitoring sites within the 25 x 25 km impact (red line) and control (green line) blocks. Blue sites have been maintained since spring 2017. Additional moorings will be deployed at the red sites early in 2019, prior to piling at Moray East Offshore Windfarm.

Analysis of the potential effects of vessel noise on Soundtrap detections during BOWL piling, together with field tests with a 4-channel Soundtrap array, are underway to inform the experimental design. In general, the proposed approach is to deploy the array of CPODs between June and September 2019, sited around Moray East turbine locations that are intended to be piled between July and September. This array will be integrated with deployments made under WP 3.1 to replicate the design used at BOWL during the first two months of piling. In addition, fine-scale arrays (e.g. of six to ten) benthic landers with 4-channel Soundtraps will be deployed for shorter periods of a few days around a series (e.g. 4 - 6) selected turbine locations. Ideally, these should include a balance of sites that will be piled with and without the use of ADD for mitigation, however this will depend on when the phased piling mitigation period will take place at Moray East. Deployment and recovery of these fine-scale arrays will be timed to capture the entire period between the arrival and departure of the piling vessel at each site, with a buffer before and after this. Thus permitting comparison of detections and movements of animals before, during and after different phases of the turbine

installation. These will be related to direct measurements of received noise levels obtained from the Soundtrap recorders, and detailed information on the timing of activities that will be provided by the installation team.

WP 4. Noise measurement and modelling work packages.

The final work package involved field measurements of received levels of piling noise and ADD noise, and the use of these data to refine and test acoustic propagation models used to predict received levels of noise at other sites. The resulting information was primarily aimed to inform analyses undertaken in other work packages (for example to characterise dose-response curves). In addition, the refinement of propagation models is of general value for future environmental assessments.

As outlined in section 1.2 and 1.3, studies during piling at the BOWL wind farm have highlighted the importance of considering other noise sources; both in terms of their potential impact on receptor behaviour and of their potential impact on detection rates of PAM devices.

Discussions at the MFRAG-MM Subgroup indicated that stakeholders considered that there was value both in extending the noise data available on piling noise, and expanding this work to characterise noise levels resulting from other aspects of construction. To reflect this, we propose to amend these work package as follows.

WP 4.1: Temporal variation in noise levels during different phases of wind farm construction.

The objectives of this work package will be to make field measurements to extend our understanding of how near-field noise levels vary in relation to changes in hammer energy and ground conditions. This package also aims to collect further data on received levels of ADD and soft-start piling noise that can be related to behavioural response data from WP 3. Finally, field recordings will be related to operational and AIS data to characterise the noise profiles of vessels involved in different aspects of the wind farm construction, and explore how these profiles vary during different activities.

WP 4.2: Predicting spatial variation in received levels of construction noise.

This work package will use the parabolic equation models developed by CEFAS, and optimised in earlier phases of the MMMP, to provide predictions of received levels of different types of construction noise (piling, ADD and vessel) at key locations of interest. The primary objective of this work will be to inform analyses of behavioural responses in WP 2.3 and WP 3. In addition, received noise level measurements can be compared with predicted received levels that are based on a range of alternative conversion factors. These, in turn, can then inform decisions about the most appropriate conversion factor to be used in future assessments.

Summary

The proposed amendments to each Work Programme are summarised in the Table below.

WP #	Title	Proposed Amendments
WP 1. Harbour seal monitoring		
WP 1.1	Individual based studies of reproduction and survival	Continue core-strategic photo-ID studies
WP 1.2	Trends in abundance	Continue annual monitoring at all sites during breeding season and moult, but reduce surveys at other times of year at peripheral sites where few animals have been observed.
WP 1.3	Characterisation of foraging areas & responses to piling	No additional tagging work proposed
WP 2. Bottlenose dolphin monitoring		
WP 2.1	Individual based studies of reproduction and survival	Continue core-strategic photo-ID studies
WP 2.2	Trends in abundance	Continue annual monitoring in the SAC
WP 2.3	Baseline occurrence of dolphins in favoured areas & responses to piling	Extend summer PAM studies on South coast to compare variation in detection rates at different distances (1 – 3 km) from the coast in relation to offshore piling activity.
WP 3. Responses to ADD and piling		
WP 3.1	Responses of harbour seals	No work possible because harbour seals did not forage close to development sites.
WP 3.2	Response harbour porpoises	Studies to be developed through two new Work Packages. *WP 3.1 Broad-scale changes in the occurrence of harbour porpoises during different phases of wind farm construction* *WP 3.2: Fine-scale responses of harbour porpoises to construction vessels, ADD and piling.*
WP 4. Noise measurement and modelling		
WP 4.1	Temporal variation in source levels of piling noise	Studies to be developed to consider noise sources other than piling and ADD under a revised *WP 4.1 Temporal variation in noise levels during different phases of wind farm construction*
WP 4.2	Spatial variation in received levels of piling & ADD noise	Studies to be developed to consider noise sources other than piling and ADD, and comparison of received levels and predictions made using different conversion factors in a revised *WP 4.2 Predicting spatial variation in received levels of construction noise.*

References

BOWL (2016) Addendum to the BOWL Construction MMMP – details of studies to be conducted during piling, Document Reference: LF000005-REP-1367, available through https://www.gov.scot/Resource/0052/00523491.pdf

Graham, I.M., et al. (2018) Strategic Regional Construction Marine Mammal Monitoring Programme Annual Report 2018 for the Moray Firth Regional Advisory Group, Document Reference: LF000005-REP-13672016.

Thompson, P. (2016) A strategic regional Marine Mammal Monitoring Programme for assessing the population consequences of constructing the BOWL and MORL [Moray East] Wind Farm Developments, University of Aberdeen, 27th June 2016.