UXO Clearance Marine Licence – Environmental Report

September 2016

Beatrice
Offshore Windfarm Ltd

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1 Introduction

1.1 Background

The Beatrice Offshore Wind Farm (the Wind Farm) received consent under Section 36 of the Electricity Act 1989 from the Scottish Ministers on 19 March 2014 (the S.36 Consent) and was granted two Marine Licences from the Scottish Ministers, one for the Offshore Wind Farm (OWF) and one for the Offshore Transmission Works (OfTW) respectively, on 2 September 2014 and as varied on 26 April 2016 (the Marine Licences). The OWF is located in the Moray Firth approximately 13.5 km from the Caithness coastline at its nearest point (Figure 1-1). Construction is scheduled to begin in March 2017 and the Wind Farm is scheduled to become fully operational by October 2019. The project consists of 84 x 7 MW wind turbine generators (WTGs) on piled jacket foundations, with inter-array cables and two Offshore Transformer Modules (OTMs), also on piled jacket foundations. The OfTW cable corridor makes landfall west of Portgordon, in Spey Bay, Moray. Two export cables will be installed.

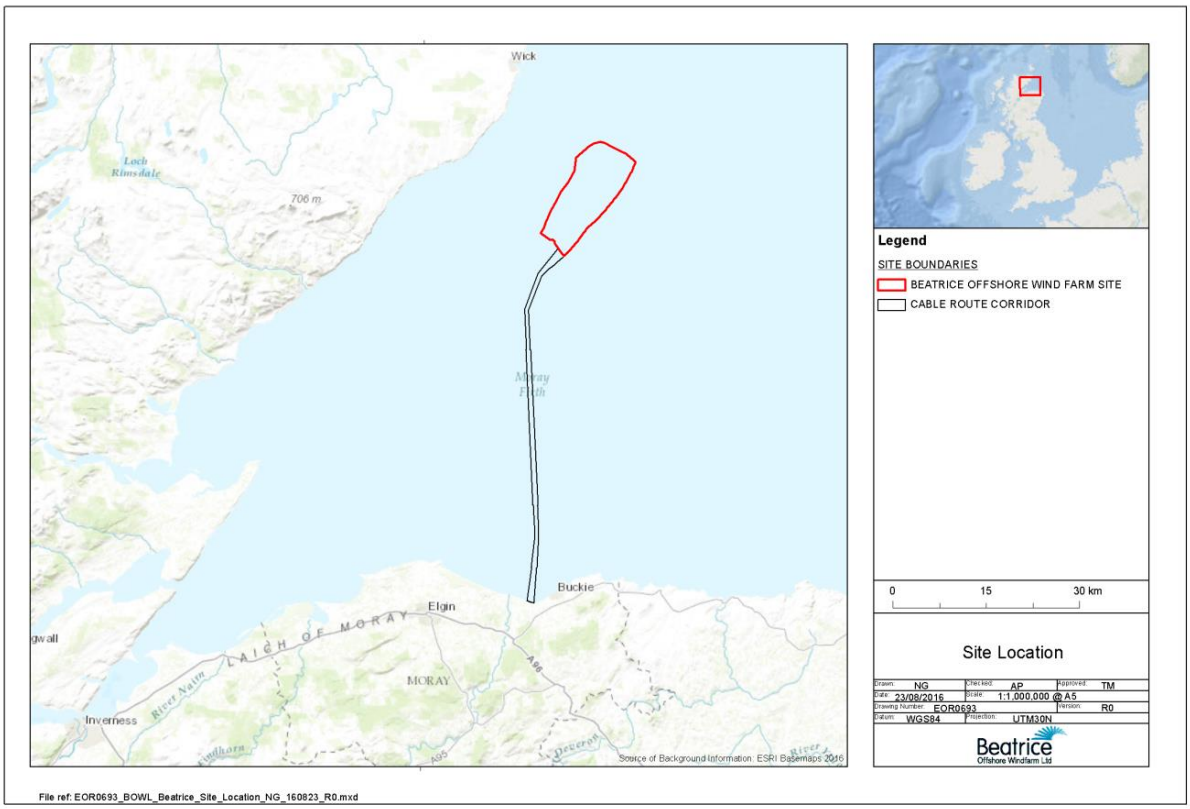

Figure 1-1: Beatrice OWF and OfTW Location

Beatrice Offshore Windfarm Ltd (BOWL) and its contractors are undertaking surveys for unexploded ordnance (UXO) prior to commencement of construction. A UXO survey has been completed along the OfTW cable corridor and another survey is currently taking place in the OWF site. The surveys utilise a towed magnetometer to identify any ferrous objects on the seabed (potential UXO). Any potential UXO identified will then be targeted for a detailed survey by Remotely Operated Vehicle (ROV) to confirm whether or not any objects are UXO hazards and therefore represent a risk to construction activities. If identified as a UXO

hazard BOWL will seek to, in the first instance, avoid the UXO. If this is not possible then BOWL will physically remove the UXO from the area of concern. Detonation by controlled explosion will be used as a last resort should avoidance or removal not be possible. Through this process any risk to subsequent construction activities will be removed.

It should be noted that UXO clearance activities will be limited to the OWF, including the OfTW assets within the boundary of the OWF (hereafter termed 'OWF area'). Based on the results of the completed UXO investigation in the OfTW cable corridor potential UXO identified in the OfTW are to be avoided, with the cable microsited to ensure clearance of UXO along the OfTW is not required. As a result this Environmental Report and Marine Licence and EPS Licence applications only focuses on the OWF area. Further justification for this is provided in Section 2.2.2 below.

Therefore, BOWL is seeking consent to undertake (where necessary) controlled detonation of UXO within the OWF area. If required, BOWL are planning to carry out the UXO clearance activities in November and December 2016 with the aim of ensuring that the development is clear of UXO by the end of 2016 at the latest.

A Marine Licence from the Marine Scotland Licensing Operations Team (MS-LOT), on behalf of the Scottish Ministers, is required if a person or organisation intends to carry out certain activities in Scottish waters. This includes the placement and/or use of explosive at sea, either within the sea itself or on the seabed. Within 12 nm of the coast this is licensable under the Marine (Scotland) Act 2010. Beyond 12 nm of the coast this is licensable under the Marine and Coastal Access Act 2009 (Marine Scotland, 2015). As the scope of the UXO clearance activity is within the OWF area only, which is within 12 nm of the coast, a Marine Licence under the Marine (Scotland) Act 2010 is required in support of the planned UXO clearance activity.

The requirement to consider European Protected Species (EPS) in developments in waters off Scotland derives from the Conservation (Natural Habitats &c.) Regulations 1994 (as amended in Scotland) (hereafter referred to as the Habitats Regulations) and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended) (hereafter referred to as the Offshore Marine Regulations), which transpose the requirements of the Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora). Animals listed in Annex IV(a) of the Habitats Directive, whose natural range includes any area in Great Britain, are also listed in Schedule 2 of the Habitats Regulations and Schedule 1 of the Offshore Marine Regulations as EPS. The marine EPS listed for the UK are dolphins, porpoises and whales (all species); sturgeon; and marine turtles. There are six species of cetacean EPS which have the potential to occur in the vicinity of the BOWL project area: bottlenose dolphin *Tursiops truncatus*, harbour porpoise *Phocoena phocoena*, minke whale *Balaenoptera acutorostrata*, common dolphin *Delphinus delphis*, white-beaked dolphin *Lagenorhynchus albirostris* and Risso's dolphin *Grampus griseus*. As the planned UXO clearance activities have the potential to injure and / or disturb species listed as European Protected Species (see Section 7), an EPS Licence is also required.

This Environmental Report is submitted in support of both the Marine Licence and EPS Licence applications. Consequently, the greater detail provided on marine mammals reflects the information required by an EPS Licence application.

1.2 Consultation

Initial discussions on proposed UXO clearance activity were held during project meetings between BOWL, MS-LOT and Scottish Natural Heritage (SNH) in May 2016. UXO clearance

activity was discussed with MS-LOT during the Execution Commencement Meeting on 20 May 2016, where BOWL outlined the proposed timeframe for undertaking UXO clearance operations. MS-LOT agreed to provide advice to BOWL on how to proceed in gaining consent for undertaking clearance of UXO. A general update meeting was also held with SNH on 31 May 2016 where the timeframe for UXO clearance operations was discussed as one of the agenda items. SNH confirmed that they would need to be consulted on UXO clearance activity.

In August 2016, BOWL undertook consultation with MS-LOT on the approach to gaining consent for the UXO clearance activity through the Consenting Approach document which was submitted on 19 August 2016. The Consenting Approach document set out the scope of the Marine licence application, including this Environmental Report. Following submission of the Consenting Approach document a meeting was held with MS-LOT, Marine Scotland Science (MSS), SNH and the Joint Nature Conservation Committee (JNCC) on 6 September 2016 to agree and further refine the approach in support of the Marine Licence and EPS Licence applications. The Consenting Approach document and the overall approach to undertaking the licence applications was discussed and agreed with MS-LOT during the meeting and it was agreed that the UXO clearance activity itself (i.e. the detonation of UXO) was the only aspect of the UXO clearance activity that is licensable.

A further teleconference was held with SNH on 12 September 2016 to further discuss proposed mitigation and agree the assessment approach for marine mammals. The resulting agreed mitigation measures are provided within the UXO Clearance Mitigation Plan (UXO CMP) in Appendix A and the assessment in Section 5.6.

2 Project Description

The following section provides a description of the UXO clearance activities, including the roles and responsibilities of the key parties involved, the background to the clearance activity, the number, size and location of UXO that may be potentially found and the activities that are licensable under the Marine (Scotland) Act, 2010.

2.1 Roles and Responsibilities

The parties involved in the UXO clearance operations are the following:

- BOWL: Developer, responsible for the construction and operation of the OWF;
- 6alpha: UXO consultants, responsible for the provision of advice to BOWL in relation to UXO disposal;
- Fugro: survey contractors, responsible for the provision of surveys to identify potential UXO; and
- Boskalis: Explosive Ordnance Disposal (EOD) contractor, responsible for the identification and disposal of UXO.

The roles and responsibilities of the parties involved in the implementation of the UXO CMP are further detailed in Appendix A.

2.2 Potential for UXO

2.2.1 Background

Conflicts and military activity within the North Sea in the 20th Century has left a legacy of munitions contamination, such that it is now relatively common to encounter UXO, particularly as, apart from the opening of recognised shipping lanes and the removal of naval mine fields, little ordnance clearance activity has taken place (6alpha, 2016). In addition, enforcement with regard to the positional accuracy of official ordnance dumps has been on the whole substandard (6alpha, 2016) and this, plus widespread unrecorded dumping during WW I and II, which at the time was perceived as inconsequential, has led to the potential for significant UXO contamination. Post WWII military training and especially live firing has also contributed to generic UXO contamination (6alpha, 2016).

According to an assessment of the potential UXO threat and risk across the Beatrice OWF area the key UXO threats which might be encountered include the following (6alpha, 2016):

- Modern live and training munitions;
- WWII live and training munitions;
- Aerially delivered WWII high explosive bombs and torpedoes;
- WWII German and Allied sea mines;
- WWII torpedoes; and
- Artillery projectiles (live and training variants) (e.g. Figure 2-1)

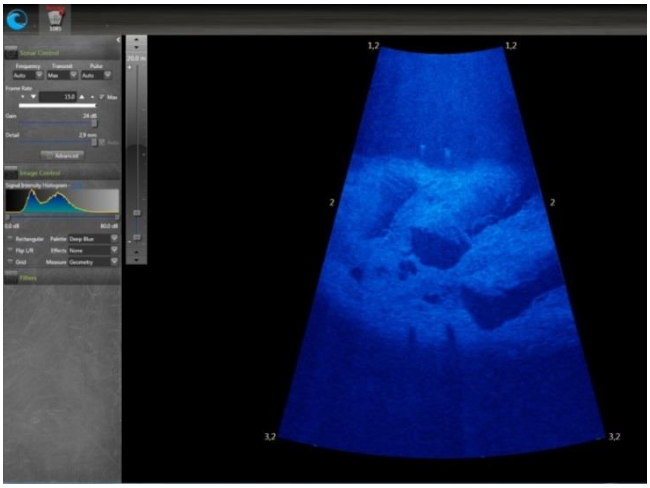

Figure 2-1: Sonar Image of Artillery Shells

6alpha (2016) suggest that the potential for UXO to be present is high, mainly due to the presence of historical and existing live firing training and the potential for munitions from WWII activity to be present.

2.2.2 Number of UXO

As noted in Section 1.1, UXO surveys are currently underway within the OWF area to provide the most up to date information to inform UXO clearance activities. As the data from the OWF area is not yet available, the total number of UXO detonations that may be required is not known. For the purposes of this licence application, BOWL has drawn on the assessment of the potential threat and risk of UXO presence (6alpha, 2016), the number of anthropogenic anomalies identified in previous magnetometer surveys at the BOWL OWF site (MMT, 2015), the preliminary results of the OfTW survey, the numbers of UXO identified and detonated at other wind farms around the UK and the expert judgement of the BOWL UXO consultant (6alpha) to derive an estimate of the number of likely detonations.

From the above sources, and on a precautionary basis, it is estimated that a maximum of 5 detonations may be required within the Beatrice OWF area. However, it should be noted that in many cases while the donor charged placed on the UXO detonates, the UXO itself may be disabled without being detonated. This can often be due to the age of the UXO or due to the contents of the UXO leaching away into the surrounding environment, rendering them inert. In such instances, once the UXO has been declared safe it will be removed to the deck of the vessel and re-located to a predetermined lay down area, as described further in Section 2.3.

The number, size and locations of any UXO to be cleared by detonation will be confirmed with MS-LOT following investigation of the identified targets and prior to any clearance activities.

2.2.3 UXO charge sizes

The assessment of the potential threat and risk of UXO presence by 6alpha provides a basis for understanding the potential size of UXO that might be identified and require detonation. The report suggested that UXO could range from between 10 kg for a mortar or grenade up to 500 kg for a large bomb or sea mine. Based on this data and 6alpha's expert knowledge of the area, derived from analysis of historical records and review of previous BOWL survey

data, it is considered that if any UXO are identified that require clearance, the most likely charge sizes will be up to 50 kg Net Explosive Quantity (NEQ, a measure of the amount of explosive in a UXO), with charges above 50 kg and up to 250 kg NEQ being unlikely and those above 250 kg being very unlikely to occur.

2.2.4 UXO Location

Within the OWF area (Figure 2-2) a 303 m diameter buffer is being surveyed around each WTG, OTM and spare foundation location and an 80 m width corridor is being surveyed along the inter-array cable routes. The two spare foundation locations will also be surveyed to allow for relocation of foundations if piling difficulties are encountered at any of the preferred WTG locations. Additional inter-array cable corridors of 200 m width will also be surveyed to allow for WTG relocation in this event.

The areas being surveyed in Figure 2-2 are those where UXO detonation is most likely to occur, if any disposal is required (i.e. if avoidance or relocation cannot be carried out). However, detonations within the wider OWF area cannot be ruled out as there is the potential need to undertake detonations in locations outside the surveyed area, e.g. when UXOs need to be relocated prior to detonation. Therefore, BOWL are seeking consent to detonate anywhere in the OWF area.

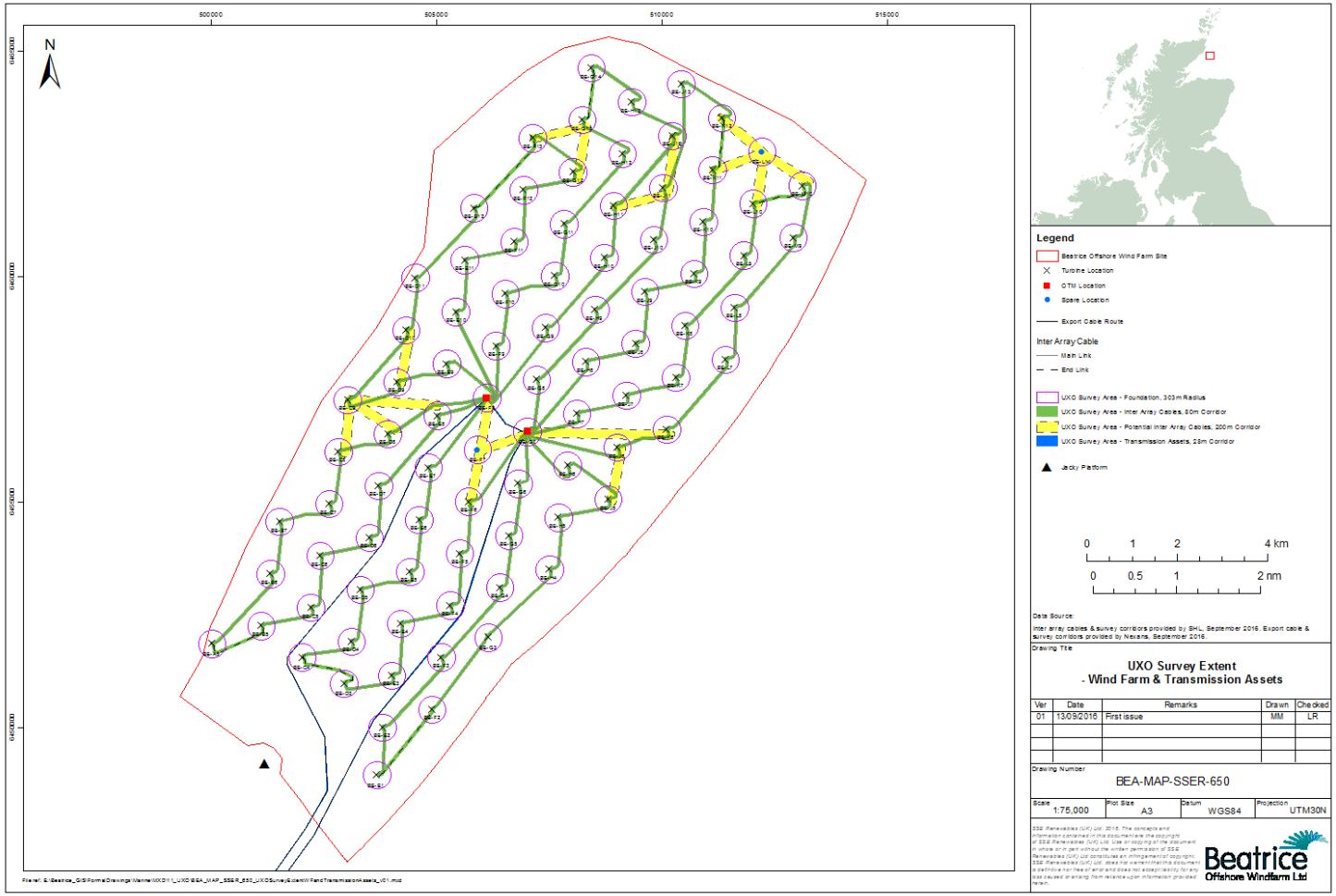

Figure 2-2: Beatrice UXO Clearance Survey OWF Search Area.

2.3 Licensable Activities

The UXO clearance work is divided into two phases, summarised as follows:

Phase 1: UXO survey and investigation (**not a licensable activity**):

A multi-beam echo sounder, side scan sonar and magnetometer survey is underway to examine the seabed for potential UXO across the OWF. The UXO survey data will be processed and quality assured (anticipated end of October 2016) resulting in identification of a number of targets which model as potential UXO. ROV inspections will then take place on those for which the avoidance strategy is impractical to discount those which can be identified as non-UXO. The exact number, type and location of those remaining potential or confirmed UXO items which require clearance will then be confirmed with MS-LOT.

During the meeting with MS-LOT, MSS, SNH and JNCC on the 6th of September 2016 it was agreed that this initial phase of works is not a licensable activity. Therefore, this activity is not considered further in this application.

Phase 2: UXO clearance (**licensable activity**):

The licensable activities that are the subject of the Marine Licence application are presented in Table 2-1. A description of the vessels and equipment to be used during UXO clearance activities is provided in Table 2-2.

It should be noted that the hierarchy of events during the UXO clearance process is that detonation by controlled explosion will be used as a last resort should avoidance or removal not be possible.

Table 2-1: Licensable Activities

Activity	Description
Relocation of non-UXO	In the event a target is identified as non-UXO the Explosive Ordnance Disposal (EOD) expert will classify it as such. At that point a decision will be made regarding the threat of the object to construction activities and the object will either be left in situ or relocated. This may be through re-location on the seabed at a pre-determined lay down area or through recovery to the vessel with subsequent disposal at an onshore disposal facility. In both instances the non-UXO item will be recovered to the deck of the vessel for transport, depending on the size and weight of the target. Items relocated to the seabed will have their coordinates logged. Waste disposal onshore will be undertaken by a suitably registered and licensed contractor. However, the intention is to not recover any UXO to the deck unless absolutely necessary and confirmed as such by the EOD expert.
Clearance of UXO using explosives	It is expected that UXO disposal will predominately be through the use of explosives. This may either be conducted in-situ at the location where the item was discovered or, if safe to do so, moved to a pre-determined position for disposal. Confirmed UXO objects for which disposal is planned fall into one of three categories: **Category A**: Confirmed UXO which are to be disposed of by high-order detonation in-situ utilising a donor charge (used to detonate the UXO)

Activity	Description
	(Figure 2-3) of between 2 and 10 kg.  **Figure 2-3: Cobra Donor Charge** **Category B**: Confirmed UXO which are to be relocated and disposed of by high-order detonation together with other confirmed UXO also relocated to the same location. Only small UXO of up to 50 kg would be disposed of in this manner, with the total being in the range of 250 kg (i.e. 10 x 25 kg, or 5 x 50 kg). The BOWL UXO consultant may request to relocate a target once its identity has been confirmed and it has been determined that it is safe for transport. Lifting of the target will either be undertaken with the WROV manipulators using a basket or with air lift bags. The coordinates of relocated items will be logged. Once all relocated items have been placed and before detonation is undertaken a survey will be conducted of the investigated area to confirm there are no other objects or anomalies which may also be unidentified UXO and require detonation. **Category C**: Confirmed UXO, which are to be recovered onto the vessel and brought ashore for alternative disposal by the contractor. The disposal of transportable UXO will be executed in a destruction facility on land. However, the intention is to not recover any UXO to the deck unless absolutely necessary and confirmed as such by the EOD expert. Detonation will take place during daylight hours only. Each detonation will take approximately 6-8 hours to complete from when the vessels first arrive to set up the detonation to when the removal of debris is complete and the area is declared safe. Therefore, it is anticipated that only a single detonation will be completed in single 24 hour period due the restrictions of daylight during November and December.
Removal of debris	After a detonation has been completed to confirm if it has been successful, a grid of 10 m x 10 m centred around the detonation site will be surveyed by the WROV. Fragmentation scrap with dimensions > 0.3 m from the confirmed UXO or fragmentation scraps which may

Activity	Description
	contain a section of explosive material from the confirmed UXO will be recovered (Figure 2-4). All scrap will be recovered to deck and checked and certified as Free From Explosive (FFE) by the UXO consultant. All certified scrap will be taken ashore and disposed of by a suitably registered and licensed contractor.  **Figure 2-4: ROV recovery of seabed debris following a successful detonation.**

Table 2-2: Vessels and equipment

Type	Description
DP-2 ROV support vessel "*Smit Kamara*" (or similar, Figure 2-5)	Placement of the donor charge is made by the project based ROV support vessel and directly using the WROV. The Marine Mammal Observers (MMOs) and Passive Acoustic Monitoring (PAM) Operator (see Appendix A) will be stationed on board the ROV support vessel, which will be located approximately 100 m from the source during the entire pre-detonation search period. The WROV (see below) will place the charge and then be stored on board the ROV support vessel. The ROV support vessel will then retreat to a distance of 1,500 m once the one hour pre-detonation search period has been completed by the MMOs. The ROV support vessel will then maintain a 1,500 m navigational safety zone to prevent other vessels from approaching the detonation location until the area is declared safe.

Type	Description
	 **Figure 2-5: ROV Support Vessel "*Smit Kamara*"**
Schilling Working Class ROV (WROV) system (Figure 2-6) The WROV system is capable of performing ROV surveys, UXO target investigation, and UXO clearance	The WROV will place the destruction charge on the target object and then return to the surface. The shock tube which is connected to the detonator is then released by the WROV via a sliding float to the surface, the advantage that the explosive material is only dangerous when all three items are in place (i.e. donor charge, detonator and shock tube). Demolitions will be performed by means of bulk charge using plastic explosives approved for civilian use. The ignition takes place by means of shock tube (non-electrical ignition) and is triggered remotely from the guard vessel (see below). Only when the WROV has been recovered, the charge has been set up correctly, the ROV support vessel has transited outside the detonation safety radius (500 m), and pre-detonation mitigation has been implemented will the actual detonation procedure commence. Ignition will take place by means of sending a shockwave through the Shock Tube by the EOD expert on board the guard vessel.  **Figure 2-6: Schilling Working Class ROV (WROV) system**
Guard Vessel (e.g. Figure 2-7)	To secure the blast site and to undertake the detonation a guard vessel will be present approximately 100 m from the target location. The guard vessel will maintain a detonation safety zone set at 500 m to prevent other vessels from approaching the target location (including all other vessels involved in the UXO activities).

Type	Description
	Preparation and implementation of the detonation will be stopped if any vessel (with the exception of vessels conducting detonation operations) enters or appears to approach the navigational safety distance of 1,500 m around the blast site maintained by the ROV support vessel. The area will also be closed down for normal marine vessel traffic in close liaison with the National Maritime Operations Centre of HM Coastguard and the Royal Navy. Only once confirmation that the blast site is clear from other marine traffic and the all clear is given by the guard vessel can preparation for detonation begin. Prior to detonation the guard vessel (stationed at 100 m from the target location) will deploy an Acoustic Deterrent Device (ADD) for 30 mins and several 'soft start' charges which increase in size over a 15 minute period as part of the UXO CMP (see Appendix A).  **Figure 2-7: Guard Vessel Example**

3 Existing Environment

3.1 Overview

A detailed description of the baseline environment for each environmental parameter is available from the original project ES and SEIS (BOWL, 2012; BOWL, 2013). The following sections provide an overview of the key receptors that may be potentially affected by any UXO clearance activity required within the Beatrice OWF. The receptors included in this section have been discussed and agreed with MS-LOT, SNH, JNCC and MSS at the meeting on 6 September 2016. The information utilised to provide details of the key receptors has been drawn from the Beatrice ES and SEIS (BOWL, 2012; 2013), the results of more recent post-consent/pre-construction surveys, and other publically available information.

3.2 Designated Sites

There are a number of nature conservation designations within the Moray Firth and in the vicinity of the Beatrice OWF. Designated sites have been screened into the assessment where there is spatial overlap and/or there are mobile features which may occur within the project area.

A summary of the designated sites that were screened into this assessment as having the potential to interact with the UXO clearance activities is provided in Table 3-1.

Table 3-1: Summary of the nature conservation designations and specific features that have been screened in as having the potential to interact with the UXO clearance activities within the BOWL project area.

Site name	Distance from OWF (km)	Screened in qualifying features	Conservation objectives in relation to screened in qualifying features
Moray Firth SAC	37.2 km south	Primary reason for site selection: ▪ Bottlenose dolphin (*Tursiops truncatus*)	To ensure for the qualifying species that the following are established then maintained in the long term: ▪ Population of the species as a viable component of the site; ▪ Distribution of the species within the site; ▪ Distribution and extent of habitats supporting the species; ▪ Structure, function and supporting processes of habitats supporting the species; ▪ No significant disturbance of the species.
Dornoch Firth and Morrich More SAC	64.6 km southwest	Primary reason for site selection: ▪ Harbour seal (*Phoca vitulina*)	
Loch Fleet National Nature Reserve (NNR)	65 km southwest	Designated for a number of marine, coastal and terrestrial features.	No specific conservation objectives are listed in relation to marine mammals but the overall

Site name	Distance from OWF (km)	Screened in qualifying features	Conservation objectives in relation to screened in qualifying features
		Marine mammal interest feature with potential for interaction with UXO activities is harbour seal, which haul out year round.	objective is to allow natural change to occur with minimal disturbance to habitats and species in the tidal basin.
Berriedale and Langwell Waters SAC	28.6 km north	Primary reason for site selection: ▪ Atlantic salmon (*Salmo salar*)	To ensure for the qualifying species that the following are maintained in the long term: ▪ Population of the species, including range of genetic types for salmon, as a viable component of the site; ▪ Distribution of the species within the site; ▪ Distribution and extent of habitats supporting the species; ▪ Structure, function and supporting processes of habitats supporting the species; ▪ No significant disturbance of the species.
River Spey SAC	55.0 km south southwest	Primary reason for site selection: ▪ Sea lamprey (*Petromyzon marinus*); ▪ Atlantic salmon	

3.3 Physical Processes

The OWF site is located 13.5 km from the coastline at its nearest point. The site is located on Smith Bank, a bathymetric high in the Outer Moray Firth. The bank is comprised of bedrock overlain by poorly sorted stiff clay till sediments, covered by sands and gravels in variable thickness (BOWL, 2015a). Granular surface sediments predominate across Smith Bank, except near the crest where there is little sediment cover, exposing the underlying till. Surface sediments typically comprise medium sands, with negligible content of fines, and generally gravel comprises less than 3% of sediment volume with the exception of some locations where higher volumes were recorded. The OfTW cable route within the OWF area transits across the Smith Bank at approximately 50 m CD.

Most sediment transport likely occurs in pulses associated with (relatively frequent) storm events, although a very weak background transport rate may be associated with stronger (e.g. peak spring) tidal currents. Low current speeds and lack of wave influence in the OWF area were considered in the BOWL ES to be insufficient to frequently transport significant quantities of sediment, with parts of the route greater than 60 to 70 m deep estimated to be largely immobile. Measured levels of suspended sediment concentrations (SSC) are typically low (1 to 10 mgl^{-1}) both near bed and in the upper water column during periods of calm weather. However, during storms, SSC is observed to increase up to the order of 100s to low 1,000s of mgl^{-1} (BOWL, 2012).

In shallower waters near the southern end of the route, wave action will contribute to higher rates of sediment transport, which will be directed east, out of the Moray Firth, due to the underlying tidal asymmetry. These areas may experience levels of SSC of 10s mgl-1 in the upper water column and between 100s to 1,000s mgl^{-1} nearbed (BOWL, 2012a).

3.4 Benthic Ecology

The Beatrice ES identified that the majority of the OWF site was dominated by medium sands and rich infaunal communities predominantly characterised by the SS.SCS.ICS.MoeVen *Moerella* spp. with venerid bivalves in infralittoral gravelly sand biotope (BOWL, 2012c), a priority marine feature (PMF) in Scotland (Howson *et al*., 2012). Pre-construction surveys of the OWF site, undertaken in 2015, noted a shift in the dominant biotope recorded in areas previously identified as MoeVen to the SS.SSa.CFiSa.EpusOborApri *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand biotope (BOWL, 2015b). The changes were ascribed to small changes in the relative abundances of the taxa characteristic of the assigned biotopes (in particular increases in the abundance of *A*. *prismatica*) although the variations in taxon abundance were considered to be within the range of natural variation.

With respect to species of high conservation value, the ocean quahog *Arctica islandica*, a PMF and also a species on the OSPAR (Oslo-Paris Commission) List of threatened and/or declining species for the Greater North Sea, was recorded within the OWF site during EIA characterisation surveys although highest densities were confined to the south west of the OWF site (BOWL, 2012).

3.5 Fish and Shellfish Ecology

The Beatrice ES and SEIS list a number of fish and shellfish species of commercial and conservation importance within the Moray Firth and the Beatrice OWF area. According to fisheries catch data the key commercial species which account for the majority of landings include king scallop (*Pecten maximus*), nephrops (*Nephrops norvegicus*), brown crab (*Cancer pagarus*), squid (e.g. *Loligo* spp.), haddock (*Melanogrammus aeglefinus*), herring (*Clupea harrengus*), monkfish (*Lophius* spp.) and whiting (*Merlangius merlangus*). Other key species include sandeel (*Ammodytes* spp.) and cod (*Gadus morhua*), which also feature in landings to a lesser extent. These species are commercially important as they are either a key prey item for other fish species, birds and marine mammals (sandeels) or are of conservation and regional importance (cod).

Spawning and nursery grounds have been defined for a number of species within and in the immediate vicinity of the OWF (Coull *et al*., 1998; Ellis *et al*., 2010), including for cod, sandeels and herring. Surveys undertaken by BOWL in February and March 2014 confirmed the presence of cod spawning activity at between 19 and 21 locations within the OWF site (BOWL, 2015d). However, results from herring larval surveys undertaken by BOWL (BOWL, 2014a, 2016a, 2016b) suggest that the majority of herring spawning activity occurs within well-established spawning grounds around Orkney and Shetland rather than in the Moray Firth and in the vicinity of the OWF. In addition relatively low sandeel catches recorded in the sandeel survey conducted in 2014 suggest that there are not extensive areas supporting important sandeel populations in the BOWL site (BOWL, 2014b). Spawning activity for cod is concentrated between January and April.

A number of species of conservation importance are found in the Moray Firth and may therefore transit the OWF and/or its vicinity. These include diadromous migratory species, including Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*) and sea trout

(*Salmo trutta*), elasmobranchs (sharks and rays) and a number of commercial fish species. It should be noted that of the diadromous fish species listed above, Atlantic salmon and sea lamprey are of conservation interest in a number of SAC rivers in the Moray Firth area. In general Atlantic salmon are of greatest concern due to the large distances they travel, their conservation status and their sensitivity to sound. Migration activity takes place throughout the year with smolt activity from rivers occurring between April and June, peaking in the latter half of April and in May (BOWL, 2012). Adult salmon are thought to migrate into the rivers of the Moray Firth during most months of the year, peaking in the summer between May and October (BOWL, 2012).

3.6 Marine Mammals

Bottlenose dolphin (*Tursiops truncatus*)

The Moray Firth bottlenose dolphin population generally occurs in coastal areas, with the majority of sightings occurring within the Moray Firth SAC and along the southern coast of the Moray Firth (BOWL, 2012). Bottlenose dolphins occur year round in the Moray Firth with a similar range and distribution, albeit with lower occupancy rates in winter compared to summer. These findings are consistent with the findings of the Phase III Joint Cetacean Protocol (JCP) report, which highlighted that the Moray Firth was a region with consistent high densities of bottlenose dolphin (Paxton *et al*., 2016). Modelled abundance estimates using the JCP data also found lower densities in the winter and autumn months compared to spring and summer (Paxton *et al*., 2016). The reference population for bottlenose dolphin is the Moray Firth Management Unit (MU) and is based upon the population estimate of the Moray Firth SAC of 195 individuals (see Moray Firth SAC below; Cheney *et al*., 2012).

Since bottlenose dolphins often occur in large groups, it is more accurate to describe their distribution in terms of probability of occurrence rather than average density (Figure 3-1). The potential for bottlenose dolphin to occur within the BOWL OWF site is very low, with a maximum estimate for probability of occurrence of just 1% in the southwest corner of the OWF (Figure 3-1).

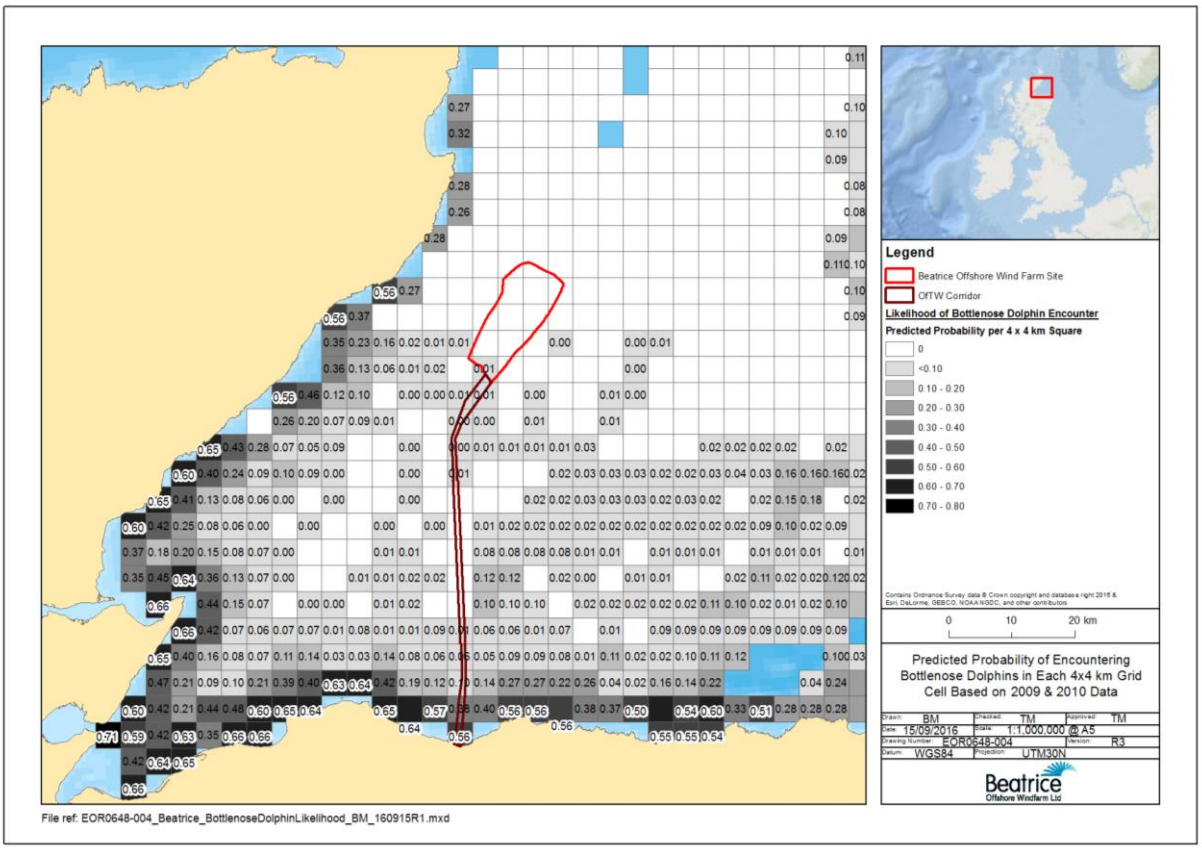

Figure 3-1 Modelled probability of occurrence of bottlenose dolphin in each 4x4 km grid cell within the Moray Firth.

Moray Firth SAC

Bottlenose dolphin is the primary reason for designation of the Moray Firth SAC which lies 37.3 km from the OWF. The most recent population estimate for bottlenose dolphin in the Moray Firth SAC, based on photo-identification work collected between 2006 and 2007, is 195 individuals (95% Confidence Interval: 162 - 253) (Cheney *et al*., 2012). Bottlenose dolphins using the Moray Firth range as far afield as the Firths of Forth and Tay, and sometimes even as far south as the Tyne Estuary (Wilson *et al*., 2004; Thompson *et al*., 2011). The bottlenose dolphins throughout this range are referred to as the Scottish East Coast population. The current status assessment of the bottlenose dolphin Moray Firth SAC population is “Stable (increasing)” (Cheney *et al*., 2014), which is no change from the previous assessment (Cheney *et al*., 2012). Similarly, the Natura 2000 data form for the Moray Firth SAC (updated in December 2015) records the conservation status of the population as “Good” (JNCC, 2016a).

Harbour porpoise (*Phocoena phocoena*)

Harbour porpoise is widespread around UK waters and was the most commonly encountered species in all the Moray Firth studies, both inshore and offshore (BOWL, 2012). Habitat association modelling predicted that the highest densities were in the offshore waters of the Moray Firth, including the BOWL site, where up to 1.25 animals per km^2 may occur (Figure 3-2). Harbour porpoise also occurs regularly around coastal waters, and particularly during the warmer months (May to July) when observed seasonal increases along the coast

may be due to a movement inshore by lactating females and their calves, followed thereafter by males (Robinson *et al*., 2007). However, the densities of harbour porpoise in general tend to be lower where bottlenose dolphins are prevalent, possible because bottlenose dolphins are known to attack porpoises where they occur in the same area (Spitz *et al*., 2006; Evans *et al*., 2015).

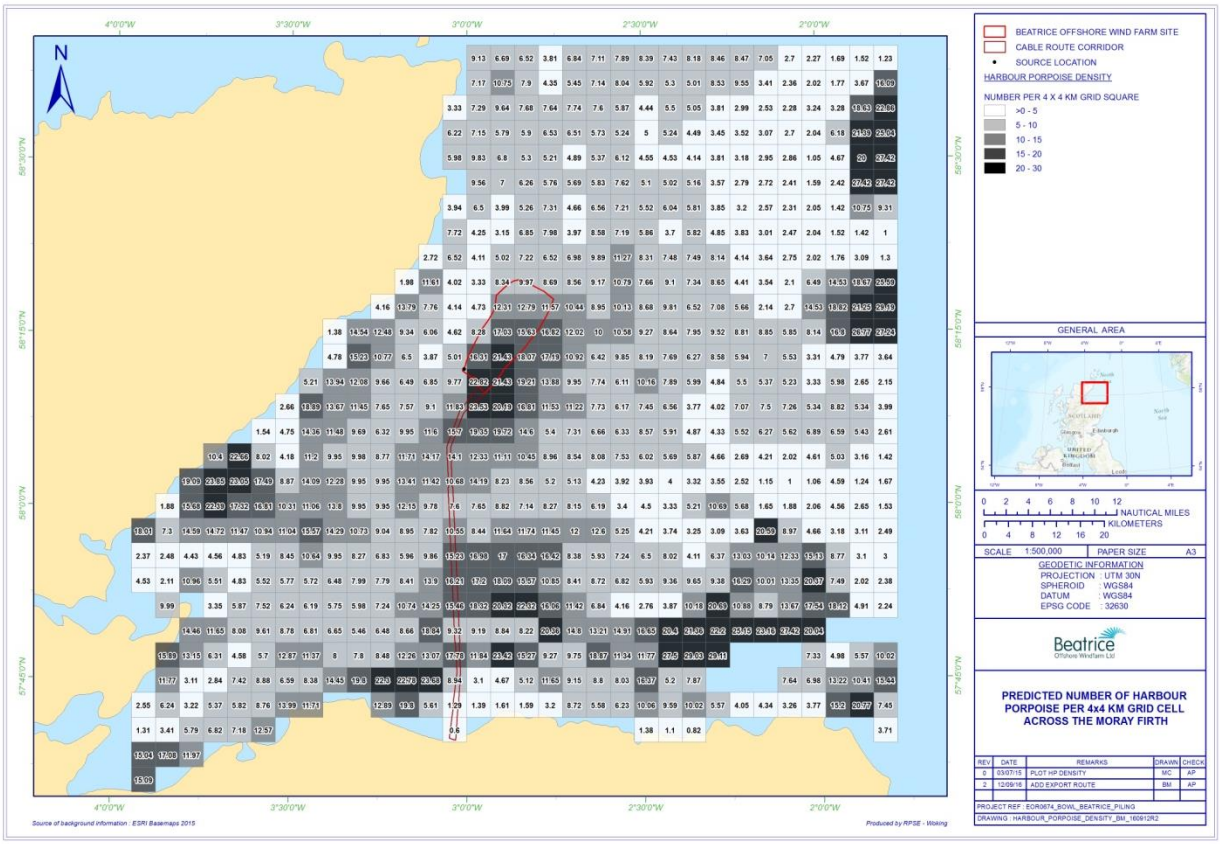

Figure 3-2 Modelled number of harbour porpoise in each 4x4 km grid cell

Seasonal changes in density have also been demonstrated using the Phase III JCP data, which showed that the Outer Moray Firth has high persistent densities of harbour porpoise during the summer months and lower densities during winter (Heinänen and Skov, 2015). Harbour porpoise exploit a wide range of prey items and studies of porpoises off the east coast of Scotland have shown that dominant prey items include whiting (*Merlangius merlangus*) during winter months and sandeels (*Ammodytidae*) during the summer months (Santos *et al*., 2006).

The reference population for harbour porpoise is the North Sea MU (IAMMWG, 2015) and the most recent estimate is given as 227,298 animals (95% CI=176,360 – 292,948) based on SCANS II modelled abundance estimates (Hammond *et al*., 2013).

Minke whale (*Balaenoptera acutorostrata*)

Minke whale is widely distributed along the Atlantic coastline of Britain and Ireland as well as in the northern and central North Sea (Reid *et al*., 2003). Site-specific data collected during boat-based surveys in the Moray Firth showed that minke whales occurred predominantly between April and October. Along the southern Moray coast there are peaks in sightings in June, July and August, when minke whales are associated with feeding on their preferred

prey item, sandeels, in areas of upwelling along this southern coastline (Robinson and Tetley, 2005).

This finding is corroborated by the Phase III JCP data which estimates higher abundances of minke whale in the Moray Firth during the summer months (210 animals) compared to autumn (20), winter (20) and spring (30), when numbers are much lower (Paxton *et al*., 2016). This represents approximately 0.085% (autumn/winter) to 0.89% (spring) of the Celtic and Greater North Seas MU reference population (23,528 animals; IAMMWG, 2015).

Estimated densities of minke whale in the summer, when numbers are peaking, are on average 0.04 animals per km^2, with 0.08 animals per km^2 in the upper 95% confidence limit (Figure 3-3; Paxton *et al*., 2016). Therefore, it can be deduced that winter densities will be lower than those estimated for summer months.

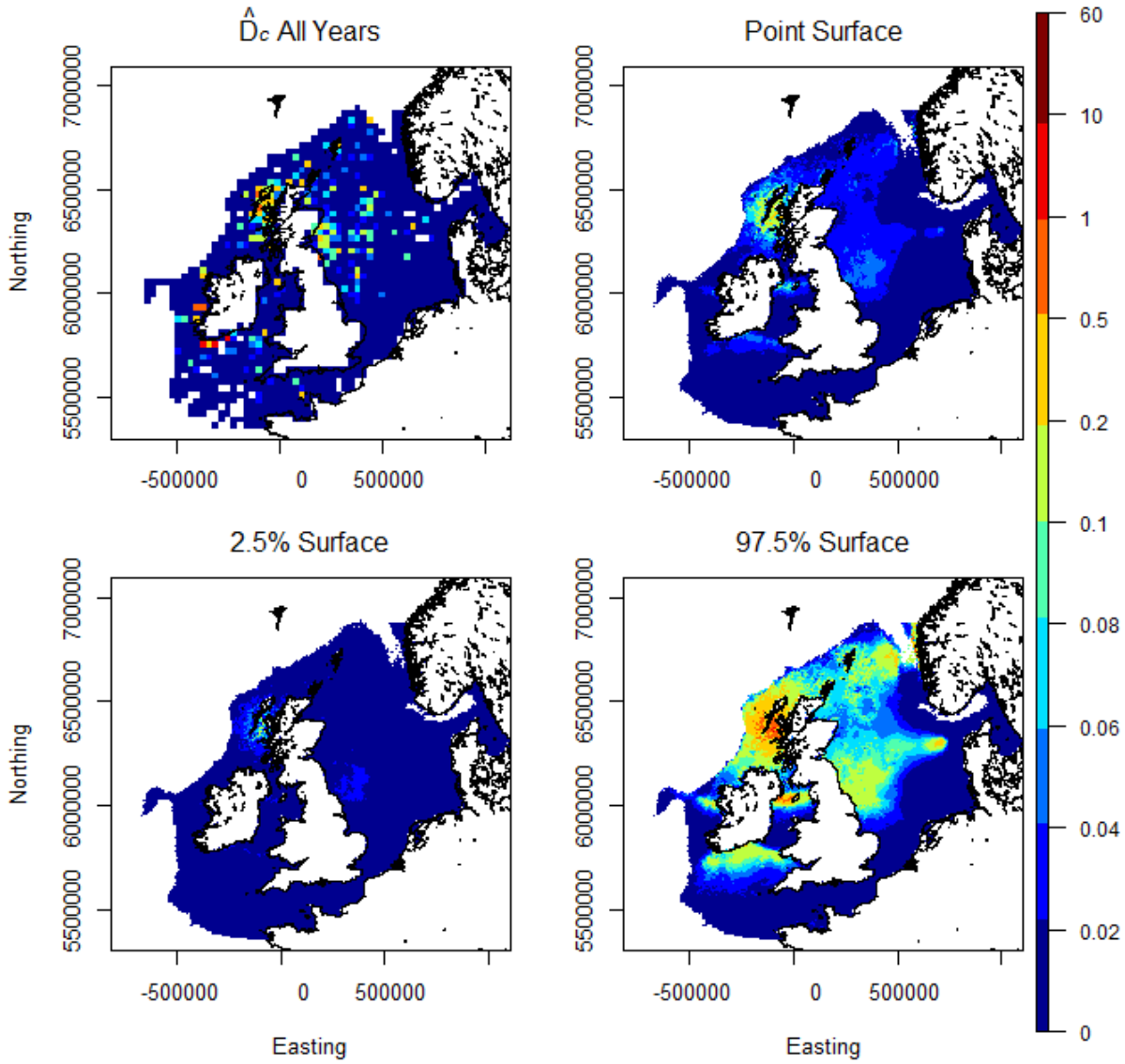

Figure 3-3 Predicted minke whale densities for summer 2010. Top left: input densities for all summers. Top right: point estimate of cell densities. Bottom left: lower 2.5% CI

on densities. Bottom right: upper 95% CI on cell densities (animals/km^2). Source: Paxton *et al*., (2016).

White-beaked dolphin (*Lagenorhynchus albirostris*)

White-beaked dolphin occur over a large part of the northern European continental shelf but are recorded most frequently in the western part of the central and northern North Sea and off northern and western Scotland (Reid *et al*., 2003). White-beaked dolphin, occur primarily in offshore waters of 50 to 100 m deep. Temperature is also an important factor in determining their distribution since this species is only common in waters cooler than 14°C and is absent in regions where the temperature exceeds 18°C (MacLeod *et al*., 2008; Parsons *et al*., 2012a). During the warmer summer months it is likely that white-beaked dolphin in the North Sea will be restricted to more northerly areas (Canning *et al*., 2008).

During the site-specific surveys most sightings of white-beaked dolphin were in offshore waters, with only occasional sightings in the inner Moray Firth (Thompson and Brookes, 2011). Seasonal variation was not possible to determine from site-specific data due to there being too few sightings. However, the Phase III JCP data, suggests that numbers may be highest in the Moray Firth during the spring, with an estimated abundance of 180 animals, compared to 70 in the summer, 60 in the autumn and 40 in the winter (Paxton *et al*., 2016). This represents 0.25 (winter) to 1.1% (spring) of the reference population for white-beaked dolphin in the Celtic and Greater North Seas (CGNS) MU (15,895 animals) (IAMMWG, 2015). Due to the low abundance of this species within the Moray Firth, density estimates are very low with <0.1 animals per km^2 estimated using the JCP data (data scaled from 0 at 0.1 intervals), and the most recent SCANS II block J (Moray Firth, Orkney and Sheltand) predicting a mean density of 0.0182 (CV=0.82).

Other cetaceans

Small numbers of other cetaceans, including common dolphin (*Delphinus delphis*) and Risso's dolphin (*Grampeus griseus*) were recorded during surveys in the Moray Firth (Thompson and Brookes, 2011).

In the UK common dolphins are more regularly sighted in waters off the west coast than in the North Sea (Reid *et al*., 2003). Site-specific surveys undertaken in the Moray Firth found that most common dolphin sightings (15 in total) were along the north coast of the Moray Firth with seasonal peaks in June and July during the calving period (Thompson and Brookes, 2011). Sightings were also made along the south coast of the Moray Firth between May and August during the Cetacean Research and Rescue Unit (CRRU) surveys in 2006 – 2009 (Robinson *et al*., 2010).

Like the common dolphin, Risso's dolphins were recorded in offshore waters of the Moray Firth during the site-specific surveys and again in very low numbers (total of two sightings) (Thompson and Brookes, 2011). During the CRRU surveys, only five individuals were sighted in total along the southern Moray coastline between 2001 and 2005, and all between the 20 to 50 m isobaths (Robinson *et al*., 2007).

Recent JCP Phase III data suggests that densities of both species are low within the Moray Firth with <0.5 common dolphin per km^2 (data scaled from 0 at 0.5 intervals) and <0.1 Risso's dolphin per km^2 (data scaled from 0 at 0.1 intervals) (Paxton *et al*., 2016). There is no MU population assessment available for Risso's dolphin but the Celtic and Greater North Seas MU for common dolphin gives a total population estimate of 56,556 animals (IAMMWG, 2015).

Harbour seal (*Phoca vitulina*)

Harbour seals are present in the Moray Firth all year round and use haul-out sites to rest between foraging trips, during the pupping and breeding season in June/July and to moult in August (Bailey and Thompson, 2011). The annual moult counts undertaken by the Sea Mammal Research Unit (SMRU) in 2014 found the lowest ever numbers recorded for the Moray Firth MU, with a total of 733 animals (Figure 3-4; Duck *et al*., 2015). Scaling this by the proportion of the population hauled out (approximately 72%; Lonergan *et al*., 2011) gives a population estimate of 1,018 animals (95% CI= 833 - 1,357) for the Moray Firth (SCOS, 2015). This is the reference population against which impacts are assessed in this Environmental Report. Population modelling (Smout *et al*., 2015) suggests that the population is sensitive to changes in the survival of adult females with additional effects on survival based on the abundance of both sandeels (as in important prey resource for harbour seal in the Moray Firth; Wilson *et al*., 2014) and local grey seals (since adult grey seal cause additional mortality on harbour seal pups; Thompson *et al*., 2015).

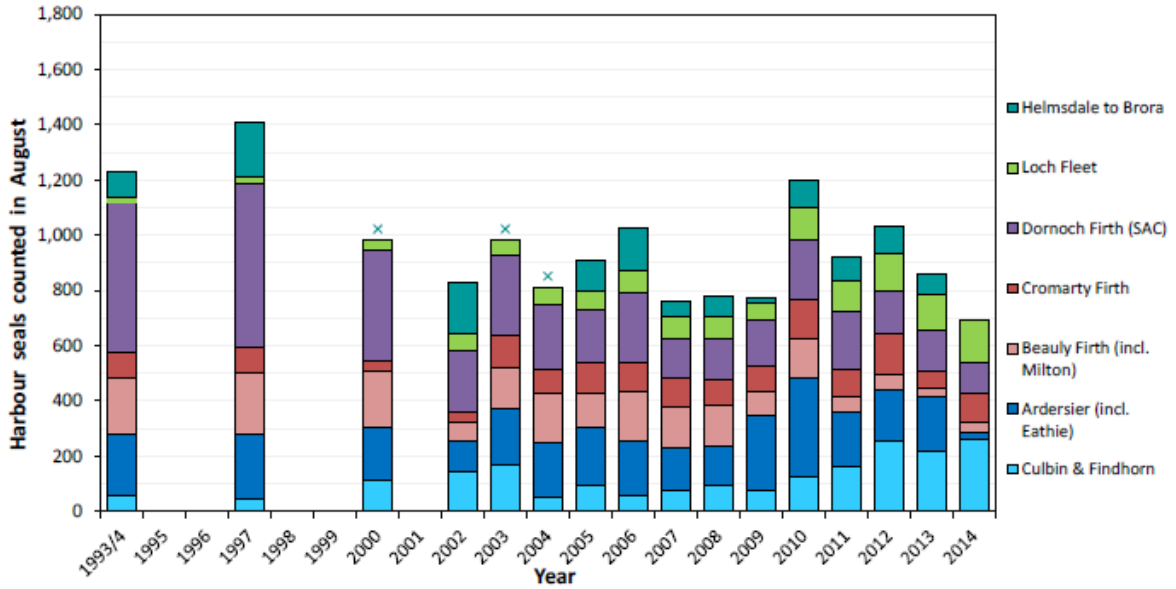

Figure 3-4 August counts of harbour seals in different areas of the Moray Firth, 1994 – 2014. Data recorded by SMRU. x: Helmsdale to Brora not surveyed in 2000, 2003 or 2004. Source: Duck *et al*. (2015).

At sea distribution maps (based on tagging studies of harbour seal) show that densities are higher closer to haul-out sites although animals are distributed throughout the Moray Firth, including within the OWF (Figure 3-5). The distribution varies seasonally in relation to haul-out periods with females likely to be closer to shore during the pupping and lactation period in June and July (Thompson *et al*., 2004). In contrast, male harbour seals travel widely during the early pupping season, but once females have come into oestrus (heat), the males restrict their range (Van Parijs *et al*., 1997). As mating takes place in the water, it is likely that during the June/July breeding season, adult males will spend time in areas of water where they are more likely to encounter females (Thompson and Miller, 1990).

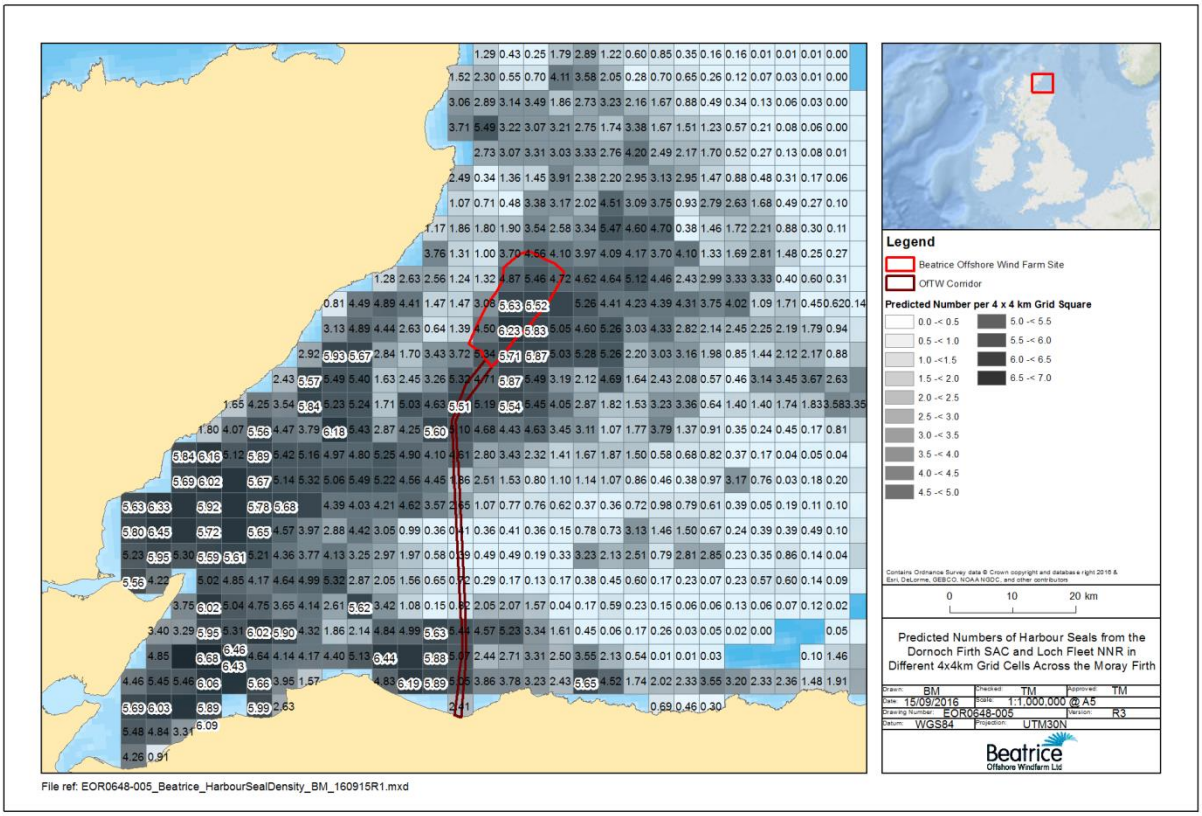

Figure 3-5 Modelled at-sea densities of harbour seals in the Moray Firth

Dornoch Firth and Morrich More SAC

Harbour seal is a primary reason for designation of the Dornoch Firth and Morrich More SAC, since this site supports a breeding population of harbour seals that represent almost 2% of the UK breeding population (JNCC, 2011). The main harbour seal haul-out site in the Dornoch Firth and Morrich More SAC lies within the inner Moray Firth and is 67 km to the southwest of the Beatrice OWF. The most recent August haul-out count for the Dornoch Firth is 111 animals (SCOS, 2015). This is a 20 year low for the Dornoch Firth, although noting that the population appears to have shifted to other parts of the Moray Firth (see paragraph below). Although the last condition assessment for the SAC determined that the population of seals within the SAC was “unfavourable (recovering)” (SNH, 2005) the latest Natura 2000 data form (updated in December 2015) assesses the conservation status of the harbour seal population as “Good” with an estimated population of 251 to 500 animals (JNCC, 2016b).

Loch Fleet NNR

To the north of the Dornoch Firth and Morrich More SAC, is the Loch Fleet NNR, which lies approximately 65 km southwest of the OWF. Harbour seal use the intertidal habitat to haul-out throughout the year and over the last 20 years Loch Fleet appears to have become increasingly important as a breeding site, relative to the Dornoch Firth and Morrich More SAC. Although the population of harbour seal has increased in Loch Fleet over the last 20 years, there has been a general trend of decreasing numbers of harbour seal in the Moray Firth over the same period (Figure 3-4). The 2014 August haul-out count for Loch Fleet was 156 animals (SCOS, 2015). Finer-scale counts are currently also being made of harbour

seals during the pupping and moulting season as part of the BOWL Marine Mammal Monitoring Programme (MMMP) in order to allow a test of any short-term decline and recovery predicted under the Moray Firth seal assessment framework (Thompson *et al*., 2013).

Grey seal (*Halichoerus grypus*)

Approximately 90% of the British population of grey seal breeds in Scotland and in contrast to harbour seals, pup production has risen steadily since the 1960s (SCOS, 2015). Grey seals are found year-round within the Moray Firth and haul out between foraging trips at intertidal sites around the coast. Key haul-out sites occur along northern coastlines within the Dornoch Firth, Brora and Duncansby Head (Duck, 2009). Brora is the site closest to the Wind Farm and is approximately 53 km away (BOWL, 2012). In winter, grey seals aggregate between October and December at preferred haul-out sites on beaches (or in caves) above the high water mark to give birth and subsequently to breed (three weeks after the female has given birth). Moulting occurs in January to early April.

Grey seal pup production counts are made every five years across the UK and subsequently a population model is applied in order to estimate the population size. In the Moray Firth, the majority of grey seal pups are born between Helmsdale and Duncansby Head on the northwest coast and the most recent count data from this area (in 2012) was 1,588 pups (Callan Duck, pers. comm.). The ratio of the total population to the number of pups born for the UK as a whole (based on SCOS, 2014) was 1.958, thus the Moray Firth population estimate can be scaled using this ratio (Callan Duck, pers. comm.) to 3,110 animals.

Telemetry data from individual grey seals shows that animals make long distance movements from haul-out sites in the Moray Firth to other locations further afield (e.g. Orkney islands to the north and Firth of Forth to the south) (Jones and Matthiopoulos, 2011). Thus, whilst an estimate has been made for the population of the Moray Firth above, this is, in fact, not a discrete population but part of a wider regional population. Telemetry data were subsequently combined with aerial survey data to produce maps of the estimated usage in the Moray Firth and Figure 3-6 illustrates the distribution of grey seals (at-sea usage) within the region (Jones and Matthiopoulos, 2011).

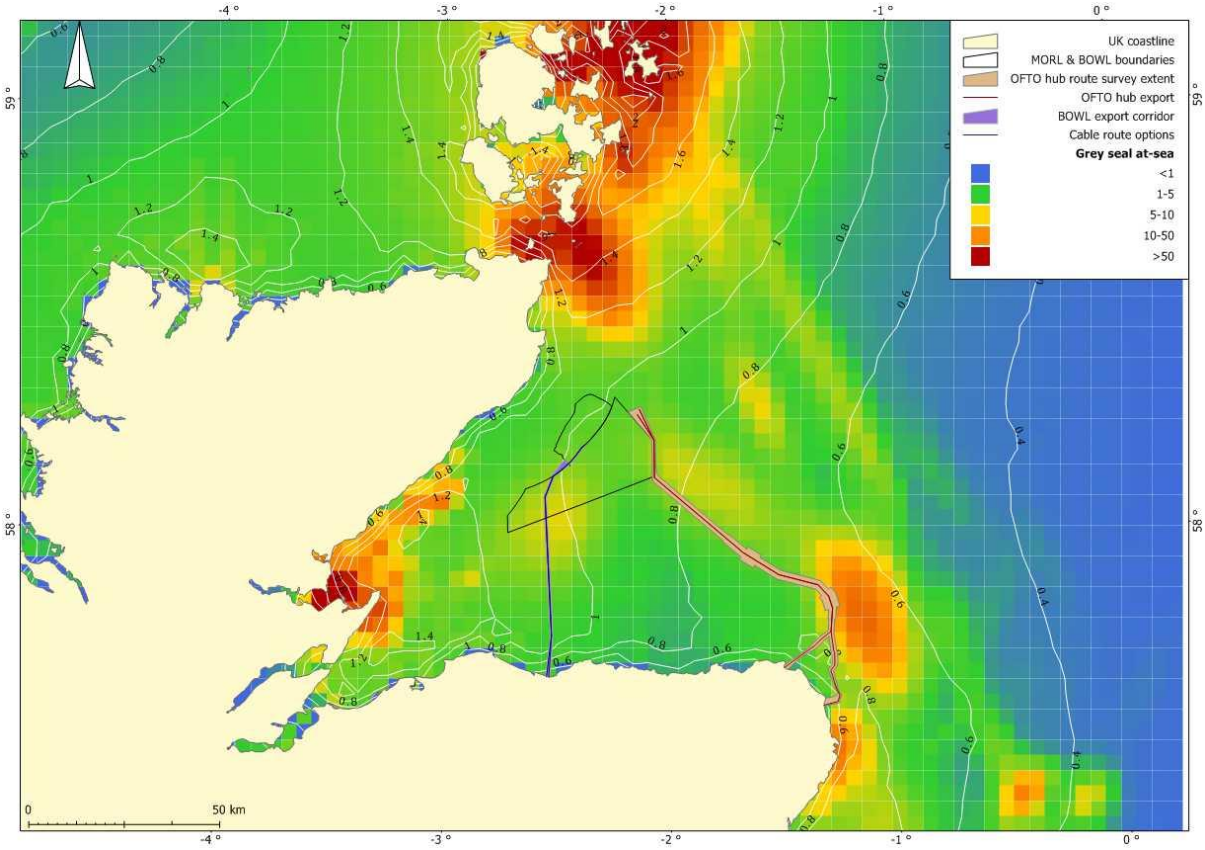

Figure 3-6 Estimated grey seal at-sea usage around the proposed BOWL development site. Source: Jones and Matthiopoulous (2011).

Favourable Conservation Status of EPS

Regulation 44(3)(b) of the Habitat Regulations 1994 requires the Scottish Ministers to be satisfied that the Licensed Operations must not be detrimental to the maintenance of the population of species concerned, which is this case relates to cetacean EPS. Under the Habitats Directive, the overarching objective is to ensure that the species covered reach, what is known as 'Favourable Conservation Status' (FCS) and that the viability of the population is secured over the long-term survival. Article 1(i) of the Habitats Directive defines the conservation status of a species as:

"*the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within its natural range*."

The conservation status is considered to be 'favourable' when:

- "*population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and*
- *the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and*
- *there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis*."

Table 3-2 provides a summary of the conservation status of the key cetacean EPS

considered in this assessment. The data provided in this table is based on the most recent condition assessment (2007 to 2012) (JNCC, 2012). An estimate of the population is also provided for the relevant UK MU for each species (IAMMG, 2015), as the reference population against which impacts are assessed.

Table 3-2: Conservation status of key cetacean species

Species	UK Conservation Status Assessment	Management Unit and population[1]	Population estimate of MU
Bottlenose dolphin	Favourable	Coastal East Scotland (CES)	195 (95% CI= 162 – 253)[2]
Harbour porpoise	Favourable	North Sea (NS)	227,298 (95% CI= 176,360 – 292,948)[3]
Minke whale	Favourable	Celtic and Greater North Seas (CGNS)	23,528 (95% CI: 13,989 – 39,572)[3,4]
White-beaked dolphin	Favourable	Celtic and Greater North Seas (CGNS)	15,895 (95% CI= 9,107 – 27,743)
Common dolphin	Favourable	Celtic and Greater North Seas (CGNS)	56,556 (95% CI=8,700 – 21,234)
Risso's dolphin	Unknown	No abundance estimate available	

[1]Source: IAMMWG (2015)
[2]Source: Cheney *et al*. (2014)
[3]Source: Hammond *et al*. (2013)
[4]Source: Macleod *et al*. (2009)

For the UK as a whole, the most recent condition assessment (2001 to 2012) assesses the UK bottlenose dolphin population as "favourable" for range, habitat, population and overall (JNCC, 2012).

The most recent condition assessment (2007 to 2012) assesses the UK harbour porpoise population as a whole as "stable" for range, habitat, population and overall (JNCC, 2012). The UK reference population of harbour porpoise has been estimated as 177,567 (CV=0.15).

3.7 Commercial Fisheries

The ICES Rectangle within which the Beatrice OWF is located (45E7) was considered in the BOWL ES as being of moderate importance on a national and regional scale. Landings values for all species from rectangle 45E7 are generally at their highest between May and September, although moderate catches have also been recorded in April and October. The majority of vessels operating in the rectangle that covers the OWF are over 15 m in length with a low proportion of vessels below 15 m active in this area. Fishing activity within the OWF itself is generally low with activity mostly occurring on the fringes of the array location, confirmed by available data and consultation (BOWL, 2012). Principal target species in the vicinity of the OWF include king scallop, nephrops, whitefish (principally haddock, but also

whiting, cod, monkfish, herring and other species), squid and crabs and lobsters. Pelagic fishing activity is negligible across the OWF.

Gear types utilised depend on the target species. King scallops are mainly targeted by boat dredges, towing one or more commonly two beams onto which dredges are attached. Nephrops are principally targeted by demersal otter trawlers. Finfish are generally targeted using Scottish seine nets and demersal trawlers. Bottom otter trawlers targeting Nephrops or finfish may also reconfigure their gear to target squid, operating nets with a smaller mesh size and higher headline heights. The species is often targeted on rough ground and vessels may employ protective gear, such as rockhoppers. Crabs and lobsters are mainly targeted by full time static gear vessels setting pots/creels. Pots may also be used to target whelks, although this activity is centred around areas outside the OWF.

Fishing occurs all year round although there are seasonal variations in landings. Nephrops catches peak in the summer months (June to August), haddock catches decline during the summer months, and peak activity for lobster and crab is between June and September. The peak in lobster and crab fishing activity is determined by the size of vessels in the area and weather conditions are a significant factor in determining levels of activity in the winter months. In addition to full time vessels, there are also a number of part time vessels that will set a small number of creels in inshore areas during the summer months, increasing the activity levels in the summer. Peak landings for squid occur in August and September, although fishermen have reported the fishery to be lengthening, with vessels beginning to target the species in June and continuing into February.

3.8 Shipping and Navigation

According to the Beatrice ES (BOWL, 2012) and SEIS (BOWL, 2013) the main navigational features in the area include the Beatrice Oil and Gas Development Area and Jacky platform (approximately 1.5 nm and 0.2 nm south west of the OWF, respectively), the two Beatrice demonstrator turbines (approximately 5.7 nm to the south by south west of the OWF) and Wick harbour (approximately 9.6 nm north west of the OWF).

Maritime traffic surveys carried out in 2010 and 2011 (BOWL, 2012) indicated that the number of vessels within 10 nm of the OWF area averaged between 10 and 11 per day. The majority of vessel tracks associated with the OWF were vessels travelling the Pentland Firth route, approximately 5 nm north by north east of the OWF. Offshore support traffic were recorded heading to the Beatrice and Jacky fields, with on average one vessel every four days. Within the OWF an average of just over one vessel every two days was recorded by the surveys. The most common vessel type recorded were cargo ships, which tended to be small to medium sized coasters headed to ports within the Moray Firth (Wick, Invergordon and Buckie).

The surveys tracked 23 fishing vessels (an average of one fishing vessel every five days) and 7 recreational sailing vessels passing through the OWF site.

3.9 Marine Archaeology

There are no designated archaeological or cultural heritage assets within the OWF area, or within a 1 km buffer. The marine geophysical survey carried out in 2011 identified nine unidentified targets within the OWF, and a further three within a 1 km buffer of the OWF (BOWL, 2015f) which were considered to be of medium archaeological potential. One wreck of high potential was also identified within a 1 km buffer of the OWF site which is charted by the United Kingdom Hydrographic Office (UKHO) (BOWL, 2015a).

A total of 39 Archaeological Exclusion Zones (AEZs) were identified in the Written Scheme of Investigation (WSI) and Protocol for Archaeological Discoveries (PAD); 32 which have been ascribed AEZs of 50 m radius and seven which have been ascribed AEZs of 100 m radius (BOWL, 2015f). In July 2015, BOWL commissioned a ground truthing survey of 13 of the 39 AEZs because these targets could potentially impact on the design and construction of the OWF. Following this survey it was recommended that the AEZs associated with these 13 targets be removed (BOWL, 2015g).

3.10 Aviation, Military and Communications

Aviation, Military and Communications were scoped out of the assessment in agreement with Marine Scotland and their advisors at the meeting held on 6 September 2016.

3.11 Infrastructure and Other Users

The main oil and gas activity in the Moray Firth area is the Beatrice oil field (Block 11/30a). Key structures include the Beatrice Alpha, Bravo and Charlie platforms; the Jacky platform; and seabed cables and pipelines linking the platforms (BOWL, 2012).

The Beatrice OWF site is adjacent to the consented Moray Offshore Renewables Ltd (MORL) wind farms and the proposed MORL Western Development Area. The OWF site is also approximately 11 km to the northeast of the two-turbine Beatrice Demonstrator Project, owned by Talisman and SSE, which has been operational since 2007. Due to the distance from the proposed UXO clearance activity potential effects to the existing Beatrice demonstration turbines have been scoped out.

The Shefa Ltd fibre-optic telecommunications cable, which runs from the Faroe Islands to Banff in Moray, runs north to south, to the east of the OWF site. The proposed SHE Transmission (SHE-T) High Voltage Direct Current (HVDC) link between Caithness and Moray will lie approximately 7 km to the east of the OWF, making landfall at Wick in the north and Buckie in the south (SSE, 2015). On the basis that there is no existing cable infrastructure within the OWF site, effects on existing cable infrastructure were scoped out in agreement with MS-LOT on 6 September 2016.

In terms of recreational activity there are a number of clubs, training centres and marinas located on the coastline around Moray, Aberdeenshire, Caithness and Sutherland. A range of facilities are also located at Inverness, popular for vessels passing through the Caledonian Canal. There is one Medium Use route from Wick to Peterhead and a Light Use route between the Northern Isles and the Moray Firth that pass through the OWF. Survey data indicates that recreational vessels generally head to and from Wick using coastal and cross Firth cruising routes.

4 Embedded Mitigation Measures

There are a number of embedded mitigation measures that will be implemented for the UXO clearance activities, which reduce the potential for certain impacts. These measures are listed in Table 4-1 below and are referred to in the individual assessments where relevant.

Table 4-1: Embedded Mitigation Measures

Measure	Description
Communications and awareness	

Measure	Description
Notification of UXO locations to MS-LOT and Coastguard	Before detonation of UXO begins, all positively identified UXO Items will be documented and reported according to OSPAR requirements, with notification sent to HM Coastguard and the Royal Navy. Notification of the location and size of any UXO to be detonated will also be made to Marine Scotland. Following completion of the surveys to identify potential UXO, further inspection of suspected UXO locations and confirmation of which UXO require detonation, a log of the location, type and size of each UXO will be compiled and e-mailed to HM Coastguard, the Royal Navy and Marine Scotland as soon as possible prior to the first detonation, but no later than 24 hours. Once confirmation that the information has been received and the planned detonation can take place has been given by these organisations, the detonation process of all UXO will begin. The detonation of any UXO will be undertaken after consultation between BOWL, 6alpha, Boskalis, the Royal Navy, Marine Scotland and HM Coastguard.
Notices to Mariners	BOWL will issue Notices to Mariners in advance of any UXO clearance activities to alert vessels and other interests of the timing and location of UXO clearance activity. Radio navigation warnings will be broadcast prior to the commencement of UXO clearance activities stating the nature and timescale of the work to be carried out.
Consultation with asset owners	BOWL will liaise closely with the Beatrice and Jacky platform owners (Talisman and Ithaca) regarding the UXO clearance activity and discuss potential measures to ensure the assets are protected. BOWL will liaise with MORL to discuss survey activities that may be taking place during UXO clearance activities and to ensure safe operation of MORL activities.
Fisheries Liaison	The BOWL Fisheries Liaison Officer (FLO) will maintain dialogue with fishermen prior to the UXO clearance activities to ensure that fishermen are informed of the activity and are aware of restricted areas where UXO clearance activity is being undertaken. The fishing community can raise issues regarding the activity with the FLO. Information regarding the operations will be provided to the fishing industry through appropriate bulletins, publications and Notices to Mariners. BOWL will provide an FLO on board the ROV support vessel to provide fisheries liaison during the UXO clearance activity.
Safety	
Relocation	If it is deemed unsafe to detonate the UXO safely in situ, for

Measure	Description
	example due to its proximity to a sensitive asset, the UXO will be moved using the WROV and/or airbags (the latter only if required to help achieve neutral buoyancy) and relocated to the closest site which would enable its safe detonation. Whether detonation of the relocated UXO is undertaken or not will depend on the advice of Boskalis.
Safety distances	A 1,500 m safety distance will be implemented during UXO clearance activities, including inspection and detonation, to ensure safe operation of clearance activities and to ensure the safety of vessels and other interests operating in the vicinity. Preparation and implementation of the detonation will be stopped when any vessel (with the exception of vessels conducting detonation operations) enters or appears to approach within a safety distance of 1,500 m around the blast site. The area (i.e. the 1,500 m safety distance) will also be closed down for normal marine vessel traffic in agreement with the HM Coastguard National Maritime Operations Centre and the Royal Navy and via a Notice to Mariners. Only once confirmation that the blast site is clear from other marine traffic and the all clear is given by the guard vessel can preparation for detonation begin.
Guard Vessel	To secure the blast site, a guard vessel will be present at 100m from the target location to prevent other vessels (including other vessels involved in the UXO activity) from entering the 500m detonation safety zone. “Securite” broadcasts will be made on VHF Ch16 in the hour or so prior to detonation to warn other vessels of the detonation activity and to ensure vessels in the vicinity stay clear of the location during the detonation process. As soon as the charge has been positioned correctly, the ROV recovers to deck and the ROV support vessel will transit outside the detonation safety zone of 500 m. The safety zone will be shown on the ROV, “*Smit Kamara*” and Guard vessel navigation screens. Once the “*Smit Kamara*” is outside the 1,500 m navigational safety zone the EOD Expert on board the guard vessel will begin with the ADD and ‘soft start’ charges. Once completed the EOD Expert will do a communications check and acknowledge that all vessels are outside the navigational safety zone. A visual search will also be made to ensure no smaller vessels are within the detonations safety zone. When the EOD Expert is confident that the demolition area is safe he will do a final communication call to all vessels on VHF Ch16 with the words “Firing now”. Once this final call to neutralise the targets has been given the detonation is initiated.

Measure	Description
Post-clearance survey	Once successful detonation has been undertaken the blast site is surveyed by WROV to verify that the object and donor charge are both destroyed. Only when this is unequivocally confirmed, the detonation safety zone be lifted and the operation confirmed as completed. If the detonation should fail or be incomplete, the entire procedure will be repeated. The detonation and navigation safety distances will continue to remain closed to marine traffic until the operation has been completed successfully.
Marine mammal mitigation	
UXO Clearance Mitigation Plan (CLMP)	A UXO Clearance Mitigation Plan (CLMP) has been developed for the UXO clearance activities. This is presented in Appendix A. The measures to mitigate any potential impacts will adhere to the JNCC guidelines: "JNCC guidelines for minimising the risk of injury to marine mammals from using explosives" (JNCC, 2010). Additional mitigation over and above that recommended by the JNCC guidance includes the following: • All detonations will occur during daylight hours, in good visibility and ideally in sea states of less than three, to provide good conditions for conducting the pre- and post-detonation searches using MMOs. • An ADD will be employed for 30 minutes as part of the UXO Mitigation Plan in order to ensure animals move beyond the 1 km search zone and also beyond a pre-determined 'deterrence' zone (based on predicted PTS injury radius from a 50 kg UXO) of ~4 km. • Before the main detonation is initiated, a total of three separate small explosive charges, spaced at five minute intervals, will be detonated to ensure marine mammals continue to move beyond the 4 km deterrence zone. • The total duration of 'deterrence activities' (ADD + small charges) will be 45 minutes, after which time marine mammals are predicted to be clear of the injury zone. • In the unlikely event of UXOs greater than 50 kg requiring detonation, the soft start sequence will be extended with additional slightly larger charges and in agreement with the statutory authorities.
Environment	
Pollution Prevention	Pollution prevention measures will be in place on board vessels involved in undertaking the UXO clearance activity. No refuelling of vessels will take place at sea. Storage facilities on board vessels will be suitable to contain and prevent the accidental release of fuel,

Measure	Description
	oils and chemicals associated with any of the tools used on board the vessel. Secondary containment (e.g. bunds) will be used with a capacity of not less than 110% of the containers storage capacity so that in the case of a spill, 100% of liquid will be retained.
Archaeological mitigation	The vessel master and UXO contractor will be briefed on the exact locations of Archaeological Exclusion Zones (AEZ) and a chart of these locations provided to ensure limited interference with AEZs. UXO clearance works will avoid AEZs unless absolutely necessary and otherwise agreed with MS-LOT in consultation with Historic Environment Scotland. BOWL's WSI and PAD (LF000005-REP-416 Marine Written Scheme of Investigation and Protocol for Archaeological Discoveries) will be followed during the UXO clearance works. Any object that is identified as potential archaeology will be reported to the project Archaeologist. A reporting form will be completed by the Client Rep on board the vessel and photographs of the object will be issued to the Project Archaeologist. If a stray archaeological target is deemed to be of potentially high importance (from the real-time ROV check), then the Archaeologist will be consulted and advice sought.

5 Assessment of Effects

5.1 Approach

The following sections provide an assessment of the potential environmental impacts of the UXO clearance activities in relation to the following environmental topics: Physical Processes; Benthic Ecology; Fish and Shellfish; Marine Mammals; Commercial Fisheries; Shipping and Navigation; Marine Archaeology; and Infrastructure and Other Users. Birds and Aviation, Military and Communications have been screened out of assessment, as agreed with MS-LOT and their advisors.

Each assessment concludes whether the UXO clearance activities are likely to result in a negligible, minor, moderate or major effect on the receptor.

5.2 Designated Sites

Further information on potential effects to Atlantic salmon as qualifying features of the Berriedale and Langwell Waters SAC and River Spey SAC are provided in Section 5.5. Details of the potential effects on bottlenose dolphin as the qualifying feature for the Moray Firth SAC and for harbour seals as the qualifying feature for the Dornoch Firth and Morrich More SAC are provided in Section 5.6. Consideration of Likely Significant Effects (LSE) is given in Section 6.

5.3 Physical Processes

UXO clearance activities may lead to increases in suspended sediment concentrations (SSC) and deposition on the seabed

There is likely to be an increase in suspended sediment concentrations within the vicinity of the detonation location due to the blast mobilising sediment into the water column. Following suspension the sediment will start to re-settle on the seabed. The duration of the disturbance will be instantaneous (very short duration) and once the detonation has completed the sediment will immediately start to re-settle on the seabed. The effect will be localised to the blast site and with an estimated maximum of 5 UXO detonations the total area affected will be small in the context of the wider area. The disturbance may result in increases of SSC above that of background concentrations but it is unlikely to be of the magnitude experienced during storm events. Given any disturbance will be of highly limited duration sediment will settle back down to background concentrations very quickly. Any craters created during detonation are expected to be backfilled by natural processes with the rate at which this occurs varying spatially according to sediment transport regimes in the local area. However, it is also worth noting that the donor charges used to detonate the UXO will not create a crater in instances where the UXO fails to detonate but is still made safe.

Due to the short term duration and localised nature of the impact and the low number of UXO expected to require detonation, the effects of increased SSC and deposition on the seabed is considered to be **minor**. No mitigation is considered necessary.

5.4 Benthic Ecology

UXO clearance activities may result in temporary habitat loss and/or disturbance

The clearance of UXO within the OWF has the potential to result in the loss of benthic habitat and associated fauna within the vicinity of the blast site. This impact is, however, predicted to be highly localised. Sandy and coarse sand sediments, and their associated annelid and

mollusc dominated communities, prevail across the OWF site and as similar sediments and communities are widely distributed throughout the Moray Firth, recovery from surrounding unaffected areas is likely to be rapid.

Due to the localised nature of the impact, coupled with the high recoverability of the communities present, the impact of temporary habitat loss and/or disturbance on benthic ecology within the OWF is considered to be **minor**. No mitigation is considered necessary.

UXO clearance activities may lead to increases in suspended sediment concentrations (SSC) and deposition on the seabed

The sensitivity of the benthic communities across the OWF site to seabed disturbance and increases in suspended sediments was assessed as low in the Beatrice ES (BOWL, 2012). Many of the component species of the sandy and coarse sand sediments across the OWF are infaunal and therefore not typically susceptible to increases in suspended sediments and sensitivity to smothering is considered to be very low with affected species likely to be able to reposition to preferable depths (Tillin, 2016). The dominant species in the Beatrice OWF site are, in most cases, rapid colonisers, capable of rapid growth and early reproduction. Therefore, as similar sediments and communities (i.e. those dominated by polychaetes and venerid bivalves) are widely distributed throughout the OWF site and in the wider Moray Firth, recovery from surrounding unaffected areas is likely to be rapid.

Due to the low sensitivity of the benthic communities present and the dispersive nature of the environment, the impacts of increased SSC and sediment deposition on benthic ecology within the OWF are considered to be **negligible**.

UXO clearance activities may result in release of sediment contaminants

During the EIA characterisation surveys, no raised levels of any hydrocarbon or metals in the sediments were found across the OWF site (BOWL, 2012). As a result of this, and the dispersive and dilutive nature of the environment, any minor elevated levels of contaminants in the water column that may arise in association with the elevated SSC following UXO clearance are unlikely to result in adverse effects on benthic ecology.

Due to the low level of contaminants in sediments across the project area, the effect of resuspension of sediment contaminants on benthic ecology within the OWF is considered to be **negligible**.

5.5 Fish and Shellfish Ecology

UXO clearance activities may result in behavioural disturbance during key sensitive periods

Herring spawning activity occurs further to the north around the Orkney and Shetland islands between August and September (Coull *et al*., 1998). Spawning activity is known to be variable between years and is likely to be more temporally limited than the commonly reported two month period. Cod spawning, while located in the immediate vicinity of the OWF area, takes place between January and April, peaking during February and March. As a result spawning activity for these two species will not be affected by the clearance activity taking place during November and December.

Atlantic salmon are considered to be sensitive to noise emissions when they migrate through the Moray Firth either as smolts on their way out form rivers into the Firth, or as adults returning to rivers to spawn. Smolt migration from rivers generally takes place between April and June (BOWL, 2012), peaking during the latter half of April and in May. Adult salmon

migration into the rivers of the Moray Firth occurs during most months of the year with peak numbers seen between May and October (BOWL, 2012). Therefore, while adult salmon may be present within the Moray Firth and potentially the OWF in November and December, their peak migration season will have passed. Based on the migration periods for smolts they are unlikely to be present. As a result there is the potential for adult salmon to be affected during their migrations, although not during the peak migration period, and it is unlikely that smolts will be present in the Firth during UXO clearance activity.

The detonation of UXO within the Beatrice OWF area has the potential to cause injury and physical disturbance to fish species in the vicinity of the detonation. Physical injury / trauma would occur in close proximity to the detonation with behavioural effects occurring much further afield. Given the short duration of the activity (probable worst case scenario of 5 days), the intermittent nature of the noise produced (i.e. anticipated one UXO detonation per day) and that noise production is likely to occur at a different location each time the potential for a large proportion of the fish populations present in the Moray Firth is low Therefore, it is not expected that population level effects will occur.

Due to the short duration and localised nature of the impact and the activity occurring outside the peak spawning and migration periods for key species the effects of physical injury and behavioural disturbance before the application of mitigation are considered to be **minor**.

Mitigation

While there is no specific measures that can be applied to mitigate potential effects on fish populations, the mitigation measures employed for marine mammals should encourage fish species to move away from the area prior to the detonation of any UXO (see Table 4-1 and Section 5.6). The implementation of a 'soft start' approach before detonation of the UXO involves the detonation of three small charges of 50g, 100g and 150g spaced at 5 minute intervals with a further five minutes before the UXO is detonated. This should trigger avoidance reactions in mobile fish species in the immediate vicinity of the detonations. It should also be noted that detonation will only occur if the UXO cannot be avoided (through re-siting of infrastructure) or removed, as a result there is the potential that the number of UXO detonated will be much lower than considered in this assessment.

Residual Impact

The short duration and intermittent nature of the activity, the lack of temporal overlap with key spawning and peak migration periods coupled with the application of mitigation measures for marine mammals will ensure that any effects are minimised. Therefore, the UXO detonations are considered not to have any population level effects. As a result, the residual effects of physical injury and behavioural disturbance after the application of mitigation are considered to be **negligible**.

UXO clearance activities may result in temporary loss and/or disturbance of spawning, nursery or feeding habitat

The clearance of UXO within the OWF has the potential to result in the loss of benthic habitat within the vicinity of the blast site which is of importance to fish species. This impact is, however, predicted to be highly localised and therefore will not result in significant areas of seabed being disturbed.

Following disturbance, levels of suspended sediment in the water column are not expected to be significantly higher than background levels and the sandy and coarse sand sediments will settle back to the seabed relatively rapidly. Given the relatively high susceptibility of

eggs and larvae to suspended and resettling sediment, there is the potential for early life stages to be affected. However, the spawning and nursery areas present in the vicinity of the project are extensive and given the highly localised area affected by each detonation it is unlikely that large proportions of any nursery and spawning grounds will be affected. Benthic spawning activity (i.e. from herring) occurs further to the north around the Orkney and Shetland islands and is therefore highly unlikely to be impacted. In addition, the activity will avoid the migratory and spawning seasons of key fish species in the vicinity of the OWF area (see Section 3.5).

Mobile fish species are able to avoid localised areas disturbed by increased SSC. Juveniles and adults would be able to move to adjacent undisturbed areas within their normal distribution range and avoid any areas of increased SSC.

Due to the localised nature of the impact, the activity occurring outside the spawning periods for key species, the lack of benthic spawning activity and the extensive feeding, nursery or spawning habitat available in the wider area, the effects of temporary habitat loss and/or disturbance is considered to be **negligible**. No mitigation is considered necessary.

UXO clearance activities may result in release of sediment contaminants

As discussed in Section 5.4, levels of hydrocarbon and metals in sediments across the OWF did not show significant levels of contamination (BOWL, 2012). As a result of this, and the dispersive and dilutive nature of the environment, any minor elevated levels of contaminants in the water column that may arise in association with the elevated SSC following UXO clearance are unlikely to result in adverse effects on fish species in the vicinity of UXO clearance activity.

Due to the low level of contaminants in sediments across the project area, the effect of resuspension of sediment contaminants on fish ecology within the OWF is considered to be **negligible**. No mitigation is considered necessary.

5.6 Marine Mammals

UXO clearance activities may result in injury or disturbance to marine mammal receptors

As described in Section 2, an estimated maximum of up to five UXO detonations could occur across the Beatrice OWF site as a worse case, with the most likely charge sizes being up to 50 kg NEQ, charges above 50 kg and up to 250 kg NEQ being unlikely and those above 250 kg being very unlikely to occur. Therefore, the noise assessment has been based on the most likely worst case of 50 kg.

As part of the project-design mitigation, the contractor will use a 'soft start' approach before detonation of the UXO. This is described above (Section 2) and will involve detonation of three small charges of 50 g, 100 g, and 150 g spaced at five minute intervals, with a final five minute interval before the detonation of the UXO. In estimating the SEL dose received by marine mammals, the noise assessment has taken into account the detonation of these small charges first.

Subsea noise assessment approach

A noise assessment was undertaken to determine the potential effects of subsea noise arising from UXO detonations on sensitive marine mammal receptors. The assessment, presented in Appendix B, considered the potential for physical injury/trauma, auditory injury, and behavioural disturbance to occur in marine mammals based on published noise criteria. The potential for physical injury/trauma (lethality), was assessed using the peak sound pressure level (SPL) threshold of 240 dB re. 1µPa for all marine mammals (Yelverton *et al*., 1973). For auditory injury leading to a permanent threshold shift (PTS) or temporary threshold shift (TTS) the noise assessment applied dual metrics of SPL and cumulative sound exposure levels (SEL) to understand the potential range of effects (Table 2.1 in Appendix B). The noise thresholds applied in this instance were derived from the widely applied Southall *et al*. (2007) guidelines and the more precautionary NOAA guidelines (NMFS, 2016). The potential for behavioural effects to occur were also considered, and based on the very short term nature of behavioural responses, and likely recoverability of animals that may be affected (within a few hours), it was concluded that behavioural effects could be scoped out of the detailed noise assessment.

The criteria and approach for the noise assessment were discussed and agreed with the Regulators and their consultees (meeting dated 6th September, 2016). A detailed account of the metrics, noise thresholds and approach to the subsea noise assessment is provided in Appendix B.

The potential for negative effects on marine mammals from subsea noise arising from UXO detonation was estimated for different hearing groups of marine mammals: high frequency cetaceans, mid-frequency cetaceans, low frequency cetaceans and pinnipeds in water.

The noise assessment found that, of the dual noise criteria (SPL and SEL), the peak pressure levels resulted in the greatest effect ranges for marine mammals and therefore, these are the focus of this sensitivity assessment as providing the more precautionary evaluation. Information from other studies of UXOs has also been used to inform this assessment, particularly where empirical measurements have been made. A literature review of the published studies looking at effects of UXOs on marine mammals is provided in Appendix B.

Effects on marine mammal receptors

The potential for negative effects on marine mammals from subsea noise arising from UXO detonation has been estimated for the different hearing groups of marine mammals. Hearing is the primary sense for marine mammals and therefore subsea noise introduced into the marine environment has potential for negative consequences on animals within the ensonified range.

The noise assessment has considered the effect ranges for physical injury/trauma, auditory injury, and TTS/onset of fleeing response from peak pressure (SPL) and dose SEL. In addition, information from other studies of UXOs has been considered in this assessment, particularly where empirical measurements have been made. The noise assessment found that, of the dual noise criteria (SPL and SEL), the peak pressure levels resulted in the greatest effect ranges for marine mammals and therefore, these are the focus of this sensitivity assessment as providing the more precautionary evaluation.

For all marine mammals, peak pressure levels for the most likely 50 kg UXO could result in injury/trauma out to a maximum of 81 m without mitigation (Table 3.1 in Appendix B). Von Benda-Beckmann et al., (2015) provided empirical measurements of 263 kg UXOs and from these injury/trauma was predicted (for harbour porpoise) out to 500 m. Thus, it is considered likely that the potential for physical injury to occur will be relatively localised and within 500 m of the source, even in the unlikely event that detonations larger than 50 kg will be required.

For permanent auditory damage, or PTS, the effect ranges were predicted using the widely applied Southall et al., (2007) criteria and the recent, more precautionary, NOAA criteria (NMFS, 2016). Using the Southall criteria, auditory damage was predicted to occur out to a range of 225 m for all cetaceans, and to a range of 764 m for pinnipeds (Table 3.1 in Appendix B). Whilst these ranges have typically been considered to be conservative, it is acknowledged that more recent evidence suggests that high frequency cetaceans and low frequency cetaceans may be more sensitive to the effects of subsea noise than previously understood. Therefore, the effect ranges quoted below are based on the more precautionary NOAA thresholds.

The most sensitive group is the high frequency cetaceans for which the assessment found that, without mitigation, auditory damage could occur out to a distance of 3.9 km (Table 3.2 in Appendix B). The dominant part of the shock wave is contained in low frequencies (<1 kHz) and whilst high frequency cetaceans echolocate at frequencies above 100 kHz, they also produce sounds below 1 kHz that have been attributed to communication (Verboom and Kastelein, 1997). Harbour porpoise, a high frequency cetacean, occurs throughout the Moray Firth, particularly in offshore waters, at average densities of approximately 1.25 animals per km^2. Therefore, during UXO detonations within the BOWL site, there is a high likelihood of encountering harbour porpoise and the potential for auditory damage to occur, in the absence of mitigation, is considered to be **high.**

For minke whale, a low frequency cetacean, the potential for PTS to occur from the UXO clearance activities is predicted up to a range of 690 m metres (Table 3.2 in Appendix B). During marine mammal surveys, most minke whale were observed between April and October and therefore in November and December, when the UXO clearance activities are planned, the densities are likely to be lower than the 0.04 animals per km^2 estimated as the summer peak. The potential for auditory damage to occur in minke whale, in the absence of mitigation, is considered to be **moderate.**

For the mid-frequency cetaceans, including bottlenose dolphin, white-beaked dolphin, common dolphin and Risso's dolphin, the potential auditory injury range is predicted to be

225 m (Table 3.2 in Appendix B). The bottlenose dolphin population have been recorded in coastal waters of the Moray Firth and the probability of occurrence within the BOWL site is predicted to be very low (just 1% in the southwest corner of the BOWL site). This species is the primary citation feature of the Moray Firth SAC, and therefore injury to any animals is likely to have negative consequences for the population, which is relatively small (~195 individuals) and highly site faithful. Other mid-frequency cetaceans were recorded in low numbers within the Moray Firth, i.e. white-beaked, common and Risso's dolphin. The potential of auditory damage to occur in all mid-frequency cetaceans, in the absence of mitigation, is considered to be **moderate.**

For pinnipeds, the noise assessment predicted auditory injury out to a range of 764 m from the UXO detonation (Table 3.2 in Appendix B). Harbour and grey seal occur within the Moray Firth year-round and are abundant in offshore waters including within the BOWL site. The closest haul-out site for harbour seal in the Dornoch Firth and Morrich More SAC is approximately 67 km from the BOWL site, and whilst animals may stay closer to their haul-outs during the pupping and breeding season (June/July) and moult (August), during November and December when the UXO clearance activities are planned their distribution is likely to be more widespread. The closest haul-out site for grey seal, at Brora, lies 53 km from the BOWL site and animals haul-out on land between October to December in the Moray Firth to give birth and breed. The potential for auditory damage to occur in harbour and grey seals, is therefore considered to be **high.**

In summary, during UXO clearance activities, the potential for injury or auditory damage to occur in marine mammals in the Moray Firth ranges from moderate to high in the absence of mitigation. Based on the sensitivities of receptors, the subsea noise from UXO clearance activities is considered to result in **moderate** to **major** effects on marine mammals. Therefore, mitigation has been designed to ensure animals are deterred beyond the potential injury zones and this is presented in Appendix A (UXO CMP) of this report, and summarised below.

Mitigation

A UXO Clearance Mitigation Plan (UXO CMP) has been devised, in consultation with Scottish Natural Heritage (SNH), to mitigate the potential for physical and auditory injury to occur in marine mammals. The UXO CMP sets out the procedure for undertaking the mitigation, the roles and responsibilities of personnel in the mitigation team, and the reporting requirements to Marine Scotland -Licensing Operations Team (MS-LOT) (Appendix A).

The mitigation follows the JNCC (2010) guidelines for minimising the risk of injury to marine mammals from using explosives through the use of two Marine Mammal Observers (MMOs) and one Passive Acoustic Monitoring (PAM) Operator to carry out monitoring over a 1 km 'search' zone for a minimum one hour period prior to the UXO detonation.

The next phase of the mitigation has been designed to encourage marine mammals to flee beyond a ~4 km 'deterrence' zone, which is based on the largest predicted auditory injury zone for marine mammals for a 50 kg UXO (i.e. 3.89 km based on the injury range for high-frequency cetaceans using the precautionary NOAA threshold). The first step in this deterrence phase will be the deployment and activation of an Acoustic Deterrent Device (ADD) for a period of 30 minutes. This will be followed by a 'soft start' procedure, involving the detonation of three small charges (50 g, 100 g and 150 g) spaced at 5 minute intervals, also from the guard vessel.

The total deterrent mitigation phase prior to the UXO detonation event will be 45 minutes, during which time marine mammals are estimated to flee over a deterrence zone of >4 km

(based on a swim speed of 1.5 m/s; Otani *et al*., 2000).

A careful balance must be achieved between ensuring that marine mammals flee the injury zone and minimising the additional noise introduced into the marine environment. The sequencing of the ADD and soft start charges was therefore based upon the predicted injury ranges from the most likely scenario of detonation of a 50 kg UXO. Noting that there is the potential (albeit with a low likelihood) for larger UXOs to require detonation, the UXO CMP allows for an extension to the soft start phase through the deployment of slightly larger charges, in order to elicit a fleeing response in marine mammals over a greater distance. Therefore, as agreed through consultation with SNH, for the less likely scenario of UXOs of 50 kg to 250 kg requiring detonation, one additional small charge of 200 g will be added to the soft start sequence, and for the unlikely scenario of UXOs >250 kg requiring detonation, two additional small charges of 200 g and 250 g will be added to the soft start sequence.

Residual Impact

In this way, the UXO CMP can be adapted to the particular UXO size and it is therefore considered that the extension of the soft start phase will be appropriate for mitigation up the largest possible UXO size of 700 kg (a very unlikely scenario). The UXO CMP is provided in Appendix A. Due to the application of the UXO CMP, particularly the use of the ADD and 'soft start' charges, the potential effects of UXO clearance activities will be reduced to **minor**.

UXO clearance activities may result in indirect effects to marine mammals due to sediment disturbance, localised increases in suspended sediment concentrations (SSC) and release of sediment contaminants

The clearance of UXO within the OWF area has the potential to result in disturbance of the seabed and subsequent increases in SSC in the water column. This impact is, however, predicted to be highly localised and therefore will not result in significant areas of seabed being disturbed or significant levels of sediments being released into the water column.

Following disturbance, levels of suspended sediment are not expected to be significantly higher than background levels and the sandy and coarse sand sediments will settle back to the seabed relatively rapidly. Mobile marine mammal species are able to avoid localised areas disturbed by increased SSC. In addition, the embedded mitigation measures to address potential impacts from noise (see Table 2.2) will cause animals to flee the area such that they are unlikely to be exposed to elevated levels of suspended sediment concentrations.

As discussed in Section 5.4, levels of hydrocarbon and metals in sediments across the OWF did not show significant levels of contamination (BOWL, 2012). As a result of this, and the dispersive and dilutive nature of the environment, any minor elevated levels of contaminants in the water column following UXO clearance are unlikely to result in adverse effects on marine mammals.

Due to the localised nature of the impact, the low level of contaminants in sediments across the project area and the mitigation for noise impacts causing animals to flee the area, the effects of seabed disturbance, subsequent increases in SSC and resuspension of sediment contaminants are considered to be **negligible**. No mitigation is considered necessary.

UXO clearance activities may result in indirect effects to marine mammals from changes in fish and shellfish prey resources

Given that impacts to fish species are considered to be negligible following mitigation, any potential secondary effects to marine mammals that target these species are also expected

to be **negligible**.

5.7 Commercial Fisheries

UXO clearance activities may lead to interference, restriction and displacement of fishing activity

Temporary safety distances of 1,500 m radius will be implemented around UXO clearance activities which may result in the restriction of access to fishing grounds. Any exclusion zone will be implemented over a short period of time (a few hours) and across a small area (approximately 7 km^2) in relation to the wider available fishing area, and is required for safety purposes. It is considered that the impact would be short term, temporary and reversible.

Once the area has been deemed safe following detonation then fishing activity will be able to resume within the previously restricted area. There are a number of existing embedded mitigation measures which will reduce the magnitude of any impact to commercial fisheries receptors. Notices to Mariners and communication with the fishing industry through the BOWL and BOWL FLO will ensure that the fishing industry is aware of the location and timing of any activity and will be able to plan in order to minimise disruption. Due to the very small area of seabed that will be unavailable for fishing, the short duration that any restrictions will be in place and as an estimated maximum of 5 events are expected, disruption to fishing activity is expected to be minimal. In addition, evidence shows that fishing vessels operate across the project area at very low frequency so the likelihood that any fishing activity is affected is low. As a result, any increased steaming times, interference and displacement of fishing activity is considered to be minimal.

Due to the short duration of impact and the measures in place to ensure that the fishing industry is aware of the UXO clearance activity, the effects of interference, restriction and displacement is considered to be **minor**. Therefore, additional mitigation over and above the embedded mitigation is not required.

5.8 Shipping and Navigation

UXO clearance activities may result in interference to shipping and navigation

UXO clearance activities have the potential to result in obstructions to shipping and navigation in the vicinity of the detonation location. Temporary safety distances of 1,500 m radius will be implemented around UXO clearance activities, which will be closed to all normal marine traffic. UXO clearance activities will involve the use of an ROV support vessel and guard vessel, which will likely transit to and from the detonation location from ports around the Moray Firth, or from a previous operational location.

As described in Section 3.8, between 10 and 11 vessels per day were recorded in the vicinity (10 nm) of the OWF during the maritime traffic surveys, with an average of just over one vessel every two days within the OWF site itself.

There are a number of embedded mitigation measures which will reduce the magnitude of any impact to shipping and navigation receptors (see Table 4-1). The safety distances and presence of a guard vessel are designed to ensure the safety of other mariners. Notices to Mariners, combined with radio navigation broadcasts, will ensure that mariners are aware of the location and nature of the works, including the details of the safety distances.

The impact would be short term, temporary, reversible and localised to the UXO detonation location. Due to the low level of commercial vessel traffic recorded in the OWF site and due to the embedded mitigation measures which are designed to ensure the safety of mariners

during UXO clearance activities, it is considered that the effect on shipping and navigation receptors will be **minor**.

5.9 Marine Archaeology

UXO clearance activities may affect marine archaeology

UXO clearance activities have the potential to affect marine archaeology through direct and indirect impact to the seabed. It is also possible that finds of archaeologist interest may be identified as a result of UXO investigation activities.

As specified in Table 4-1, UXO clearance works will avoid AEZs, in accordance with the Beatrice Marine Archaeological WSI and PAD (LF000005-REP-416), unless absolutely necessary and otherwise agreed with MS-LOT in consultation with Historic Environment Scotland. Seabed disturbance may cause secondary physical effects to marine archaeology assets through settlement of SSC out of the water column, however the increases in SSC from the detonation activities are anticipated to be short term and localised with the associated sediment deposition also localised and discrete. Any object that is identified as potential archaeology during UXO investigation activities will be reported to the project Archaeologist in accordance with the Marine Archaeological WSI and PAD (LF000005-REP-416).

Due to the planned avoidance of AEZs, implementation of the embedded mitigation measures for archaeology, and the short term and localised nature of increased SSC, the effects of UXO clearance on marine archaeology is considered to be **negligible**.

5.10 Infrastructure and Other Users

UXO clearance activities may affect the activities of other oil and gas, offshore wind and recreational receptors in the vicinity

UXO clearance activities have the potential to temporarily affect existing oil and gas receptors in the vicinity of the OWF site through for example interference with oil support vessel activity in the area and any seismic surveys. UXO clearance activities may also have potential safety implications for the existing oil and gas activity in the Moray Firth. There are a number of embedded mitigation measures in place to reduce the impact to oil and gas receptors (see Table 4-1), including close liaison with the Beatrice platform owners (Talisman) regarding potential measures to ensure the assets are protected; implementation of a 1,500 m safety zone, to ensure safe operation of clearance activities and to ensure the safety of other activity (e.g. oil and gas activity) in the vicinity of the operations; and Notices to Mariners, to alert other users of the timing and location of UXO clearance activity.

UXO clearance activities also have the potential to affect activities at the adjacent MORL OWF sites. As above, impacts will be minimised through the implementation of the embedded mitigation measures, including close liaison with MORL to discuss any survey activities that may be taking place during UXO clearance activities; implementation of a 1,500 m safety zone, to ensure the safety of MORL activity in the vicinity of the operations; and Notices to Mariners, to alert other users of the timing and location of UXO clearance activities.

Recreational receptors may also be affected by UXO clearance activities, although noting that the maritime traffic survey recorded no recreational vessels during the winter survey (BOWL, 2012), it is anticipated that recreational activity will be reduced in the winter months when UXO clearance activity is scheduled to take place. The embedded mitigation measures of Notices to Mariners combined with radio navigation broadcasts will ensure that

recreational receptors are aware of the location and nature of the works, and the implementation of a 1,500 m safety zone, combined with a guard vessel, is designed to ensure the safety of other marine users.

The UXO clearance activities will be temporary and of short duration. Due the implementation of the above embedded mitigation measures, the effects of UXO clearance activities on other marine users in the Moray Firth is considered to be **negligible**. No additional mitigation is considered necessary.

6 Consideration of Likely Significant Effect

6.1 Moray Firth SAC

The bottlenose dolphins of the Moray Firth SAC are largely coastally distributed and therefore have a low incidence of occurrence in the BOWL OWF site. Bottlenose dolphin, as a mid-frequency cetacean, has a lower sensitivity to subsea noise from UXO detonations than other hearing groups of cetaceans. The noise assessment predicted that, in the absence of mitigation, physical injury/trauma could occur out to a maximum distance of 81 m and auditory injury could occur out to 225 m from the detonation of a 50 kg UXO. Mitigation for injurious effects will include deployment of an ADD device for 30 minutes, followed by the detonation of three small charges as a 'soft start'. During this 45 minute mitigation phase, animals are predicted to flee out to a range of greater than 4 km from the source. Therefore, with this mitigation applied the potential for physical or auditory injury is considered to be negligible. Behavioural reactions to subsea noise are likely to occur as a startle response during detonation and whilst animals may flee further from the ensonified area, the effects are short-lived, and expected to be reversible with hours of cessation of the detonation.

Based on the above, there is not predicted to be a population-level effect on bottlenose dolphins in the Moray Firth and therefore there is considered to be no Likely Significant Effect (LSE) on the Moray Firth SAC.

6.2 Dornoch Firth and Morrich More SAC

Harbour seals of the Dornoch Firth and Morrich More SAC are distributed throughout the Moray Firth and are likely to occur within the BOWL OWF site during the UXO clearance activities. The planned UXO activities in November and December do not coincide with the key haul-out periods for harbour seal in the Moray Firth. The noise assessment predicted that, in the absence of mitigation, physical injury/trauma could occur out to a maximum distance of 81 m and auditory injury could occur out to 764 m from the detonation of a 50 kg UXO. Mitigation for injurious effects using ADD deployment and 'soft start' detonations will ensure that harbour seal move beyond the 764 m auditory injury zone and therefore the risk of injury will be negligible. As described for bottlenose dolphin of the Moray Firth SAC (Section 6.1), behavioural effects are predicted to occur as short-term events during detonation, with recovery of animals immediately following cessation of the activity.

Based on the above, there is not predicted to be a population-level effect on harbour seal in the Moray Firth and therefore there is considered to be no Likely Significant Effect (LSE) on the Dornoch Firth and Morrich More SAC.

6.3 Berriedale and Langwell Waters SAC

The Berriedale and Langwell Waters SAC is the closest salmon SAC to the OWF area and supports an Atlantic salmon population that is considered to be of high quality. Salmon catches are generally highest during the period between June and September, suggesting this is when adult populations generally migrate into the river towards spawning areas, although peak timing within the Moray Firth is generally considered to be May to October (Annex 16B: BOWL, 2012). Smolt migration occurs between the middle of April and the middle of May with some earlier running smolts and a good number through June also.

Atlantic salmon, without a connection between the swim bladder and the inner ear, has lower sensitivity to subsea noise from UXO detonations than other groups of fish (e.g. cod and herring). In the absence of mitigation, physical injury/trauma could occur within a few metres

from the detonation of a 50 kg UXO with behavioural effects occurring at much greater distances. While there is no specific mitigation employed for fish species, mitigation employed for marine mammals including the deployment of an ADD device for 30 minutes, followed by the detonation of three small charges as a 'soft start' should also be effective for fish species. During this 45 minute mitigation phase, animals are predicted to flee beyond the range at which potential effects could occur. Therefore, with this mitigation applied the potential for physical or auditory injury is considered to be negligible. Behavioural reactions to subsea noise are most likely to occur as a startle response during detonation and whilst animals may flee further from the ensonified area, any noise generated will be intermittent, the effects are short-lived and localised and expected to be reversible with hours of the detonation being completed. In addition smolts are unlikely to be present in the vicinity of the detonation and the peak period for adult salmon migration will have passed.

Based on the above, there is not predicted to be a population-level effect on Atlantic salmon in the Moray Firth and therefore there is considered to be no Likely Significant Effect (LSE) on the Berriedale and Langwell Waters SAC.

6.4 River Spey SAC

The River Spey SAC enters the Moray Firth 8 km west of Buckie, and supports an Atlantic salmon population that is considered to be of high quality, considered to be of international significance (JNCC, 2010). Salmon catches are generally highest during the period between June and September, suggesting this is when adult populations generally migrate into the river towards spawning areas, although peak times in the Moray Firth are between May and September (Annex 16B: BOWL, 2012). Smolt migration occurs between April and May, sometimes stretching into early June.

Atlantic salmon, without a connection between the swim bladder and the inner ear, has lower sensitivity to subsea noise from UXO detonations than other groups of fish (e.g. cod and herring). In the absence of mitigation, physical injury/trauma could occur within a few metres from the detonation of a 50 kg UXO with behavioural effects occurring at much greater distances. While there is no specific mitigation employed for fish species, mitigation employed for marine mammals including the deployment of an ADD device for 30 minutes, followed by the detonation of three small charges as a 'soft start' should also be effective for fish species. During this 45 minute mitigation phase, animals are predicted to flee beyond the range at which potential effects could occur. Therefore, with this mitigation applied the potential for physical or auditory injury is considered to be negligible. Behavioural reactions to subsea noise are most likely to occur as a startle response during detonation and whilst animals may flee further from the ensonified area, any noise generated will be intermittent. The effects are short-lived and localised and expected to be reversible with hours of the detonation being completed. In addition smolts are unlikely to be present in the vicinity of the detonation and the peak period for adult salmon migration will have passed.

Based on the above, there is not predicted to be a population-level effect on Atlantic salmon in the Moray Firth and therefore there is considered to be no Likely Significant Effect (LSE) on the River Spey SAC.

7 EPS Licence Requirements

An EPS Licence can only be granted for specific purposes set out in Regulation 44 of the 1994 Regulations. If an EPS Licence is required, the Application should be made for the following purpose: "imperative reasons of overriding public interest including those of a social or economic nature" within the terms of Regulation 44(2)(e). For the Application to be granted, the relevant regulations provide that the Scottish Ministers will need to be satisfied that (within the terms of Regulation 44(3) of the Habitats Regulations the following criteria are met:

- Test 1 (Overriding Public Interest Test) pertaining to Regulation 44(2) - The Licensable Operations are for a purpose which constitutes "imperative reasons of overriding public interest including those of a social or economic nature";
- Test 2 (No Satisfactory Alternatives Test) pertaining to Regulation 44(3)(a) - There are no satisfactory alternative methods for the Licensable Operations); and
- Test 3 (Favourable Conservation Status Test) pertaining to Regulation 44(3)(b) - The Licensable Operations will not be detrimental to the maintenance of the population of the species concerned at a Favourable Conservation Status (FCS) in their natural range.

7.1 Test 1 - Overriding Public Interest Test

With regard to Test 1, there is an overarching European, UK and Scottish policy requirement for sustainable energy supply from renewables. That need is the subject of national planning and energy policy. The consented Beatrice Offshore Wind Farm Development has been consented on this basis and has been subject to a detailed and rigorous EIA in support of the application for consent.

This EPS licence application for UXO clearance is founded on IROPI identified in the policy requirement to achieve (or exceed) the set targets for energy from renewables. Considering the Scottish Government guidance principles on IROPI, the consented Beatrice Offshore Wind Farm Development is clearly of national importance, in relation to delivering the policy requirements, and delivery of the development will make a vital contribution to the economic development of the Moray Firth area. It is also argued that there is a clear and demonstrable, direct environmental benefit from delivery of the project through the reduction in carbon emissions that will be achieved and the contribution of this to climate change mitigation efforts.

Applying the relevant guidance, it is evident that renewable energy developments (of which the Beatrice Offshore Wind Farm Development is a significant example) are also specifically recognised by SNH as the types of development which can fulfil the requirements of the IROPI Test.

It is also clear the Beatrice Offshore Wind Farm Development meets all the objectives set out in the SNH Guidance in that it will make a significant contribution to the desired reduction in Scotland and the UK's greenhouse gas emissions (required to meet UK and Scottish targets) and will provide a significant and secure supply of electricity. This is fundamental to the nationally important aim of delivering and supporting sustainable economic growth in Scotland and the UK and reducing reliance on other forms of energy generation.

The overriding public importance of the Beatrice Offshore Wind Farm Development is further supported by the UK and Scottish policy support for renewables in general, and the Development in particular. The EPS application and Supporting Information Document submitted in respect of Licensable Operations during construction of the BOWL Wind Farm

and OfTW provided a detailed account of the requirement to proceed with the Development on the basis of imperative and overriding public interest (BOWL, 2015h).

BOWL therefore considers that the UXO clearance operations will facilitate the sustainable and safe construction of the Beatrice Offshore Wind Farm Development, and therefore clearly meet the IROPI Test.

7.2 Test 2 - Satisfactory Alternatives Test

Regulation 44(3)(a) of the Habitat Regulations 1994 requires the Scottish Ministers to be satisfied that there is no satisfactory alternative before an EPS Licence can be issued for the Licensable Operations. Potential alternatives to the proposed UXO clearance survey have been considered by the Applicant and the project engineers as outlined previously in Section 2.3. In deciding how to best deal with UXOs identified within the OWF area, first consideration will be given is to whether it is possible to micro-site infrastructure around these targets. In the event that this is not possible (due to engineering constraints for example), second consideration will be given to moving the UXO. Only when these two options are not possible for engineering or safety reasons would the last, less preferred, option be implemented (i.e. detonation of the UXO). The proposed methods outlined within this Environmental Report are the only viable way to achieve the required UXO clearance to enable the safe construction of the offshore wind farm.

BOWL therefore considers that, on the basis of health and safety, the no satisfactory alternatives test is clearly met.

7.3 Test 3 – Favourable Conservation Status

Regulation 44(3)(b) of the Habitat Regulations 1994 requires the Scottish Ministers to be satisfied that the Licensed Operations must not be detrimental to the maintenance of the population of species concerned at a FCS in their natural range. The EU Habitats Directive (which is given effect in the UK by, among others, the 1994 Habitats Regulations) includes the definitions for FCS below:

The "conservation status" of a species means, "the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations […]"

The "favourable conservation status" of a species means:

- *"population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and*
- *the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and*
- *there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis."*

As outlined in Section 3.6, there are five cetacean species which have the potential to occur in the vicinity of the Beatrice OWF site, and therefore vicinity of the UXO clearance activities for which effects must be assessed on FCS. However, as discussed in Section 5.6, significant behavioural effects are considered likely to occur only in the very short term due to the very short duration of the acoustic event, associated with each UXO clearance, and the small number of discrete events that are likely to occur. Following cessation of each explosion event, it is considered likely that any behavioural effects will be reversible and animals will resume normal behaviour within the short term.

As injurious effects will be mitigated by the implementation of the UXO CMP and given that any behavioural effects will be very short term and reversible, the populations of all marine mammals are likely to continue “maintaining itself on a long-term basis as a viable element of its natural habitats”, as defined by the first FCS test. Similarly, the UXO clearance activities will not reduce the range of populations of marine mammals, with the “natural range of the species neither being reduced nor likely to be reduced for the foreseeable future”, as defined by the second FCS status test. As disturbance will constitute discrete, short term, reversible events only, with animals returning to the area in the short term, it is predicted that the third FCS test, namely that “there is, and will probably continue to be, a sufficiently large habitat to maintain populations on a long-term basis”, will also be satisfied.

The information provided within this document demonstrates that the three tests detailed above have been satisfied in line with the requirements of the Regulation 44 of the Habitats Regulations, fulfilling the requirement for issuing an EPS licence for the clearance of UXO within the Beatrice OWF area.

8 Summary

BOWL and its contractors are undertaking surveys for UXO prior to commencement of construction. A UXO survey is currently taking place in the OWF site utilising a towed magnetometer to identify any ferrous objects on the seabed (potential UXO). Any potential UXO identified will then be targeted for a detailed survey by ROV to confirm whether or not any objects are UXO hazards and therefore represent a risk to construction activities. If identified as a UXO hazard BOWL will seek to, firstly, avoid the UXO by micrositing around it, or, secondly, move the UXO. Detonation by controlled explosion to remove the UXO hazard will be used as a last resort should avoidance or removal not be possible. Through this process any risk to subsequent construction activities will be removed.

This Environmental Report has been prepared in support of both a Marine Licence application and EPS Licence application for the UXO clearance activities and has provided an assessment of the potential environmental impacts of the licensable activities. A summary of the environmental effects is presented in Table 8-1 below.

The key receptors potentially affected by the detonation of UXO are marine mammals. The UXO detonations have the potential to cause injury to marine mammals if they are in the vicinity of the location when the UXO detonated. However, through the application of the UXO CMP (Appendix A) which adheres to the JNCC guidelines for minimising the risk of injury to marine mammals (JNCC, 2010) and the additional use of ADD and soft start charges in the 45 minutes prior to detonation, it is considered that the potential effects will be Minor. It is predicted that through the use of these additional measures no injury will occur to marine mammals in the vicinity of the UXO detonation.

It is considered that there will be no population level effects on qualifying features of the Moray Firth, Dornoch Firth and Morrich More, Berriedale and Langwell Waters and River Spey SACs from UXO clearance activities and no LSE.

Table 8-1: Summary of Environmental Effects

Receptor	Potential Impact	Assessment of Effect after Mitigation
Physical Processes	UXO clearance activities may lead to increases in suspended sediment concentrations (SSC) and deposition on the seabed	Minor
Benthic Ecology	UXO clearance activities may result in temporary habitat loss and/or disturbance	Minor
	UXO clearance activities may lead to increases in suspended sediment concentrations (SSC) and deposition on the seabed	Negligible
	UXO clearance activities may result in release of sediment contaminants	Negligible
Fish and Shellfish	UXO clearance activities may result in behavioural disturbance during key sensitive periods	Negligible

Receptor	Potential Impact	Assessment of Effect after Mitigation
	UXO clearance activities may result in temporary loss and/or disturbance of spawning, nursery or feeding habitat	Negligible
	UXO clearance activities may result in release of sediment contaminants	Negligible
Marine Mammals	UXO clearance activities may result in injury or disturbance to marine mammal receptors	Minor
	UXO clearance activities may result in indirect effects to marine mammals due to sediment disturbance, localised increases in suspended sediment concentrations (SSC) and release of sediment contaminants	Negligible
	UXO clearance activities may result in indirect effects to marine mammals from changes in fish and shellfish prey resources	Negligible
Commercial Fisheries	UXO clearance activities may lead to interference, restriction and displacement of fishing activity	Minor
Shipping and Navigation	UXO clearance activities may result in interference to shipping and navigation	Minor
Marine Archaeology	UXO clearance activities may affect marine archaeology through direct disturbance and secondary effects	Negligible
Infrastructure and Other Users	UXO clearance activities may affect the activities of other oil and gas, offshore wind and recreational receptors in the vicinity	Negligible

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Appendix A: UXO Clearance Mitigation Plan (UXO CMP)

Project Title	Beatrice Offshore Wind Farm
Date:	SEPTEMBER 2016

Beatrice Offshore Wind Farm

UXO Clearance Mitigation Plan

Rev	Prepared By	Signed	Checked By	Signed	Approved By	Signed	Date of Issue
01	RPS		Lis Royle	Lis Royle	J. WILSON		19/9/16

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1 Introduction

This UXO Clearance Mitigation Plan (UXO CMP) has been prepared in support of a Marine Licence application by Beatrice Offshore W indfarm Ltd (BO WL) for unexploded ordnance (UXO) clearance activities within the Beatrice Offshore W ind Farm (OWF) area. Full detai ls of the proposed UXO clearance activities, and an assessment of the potential effects on marine mammal receptors, are provided in the supporting Environmental Report (document ref LF000005-REP-1326) to which this UXO CMP forms an Appendix.

This document presents the methods and procedures for mitigating the potential effects identified in the Environmental Report. In developing this UXO CMP, the JNCC guidance for minimising the risk of injury to marine mammals from using explosives has been consulted to determine the best approach for mitigation (JNCC, 2010). In addition, this UXO CMP has been informed by previous work undertaken for BOW L's Piling Strategy consent plan with respect to the application of Acoustic Deterrent Devices (ADD) for mitigating the effects of subsea noise during pile -driving (BOW L, 2015). The outline sequence of events of the mitigation described in this UXO CMP is summar ised in Figure 1.1. The approach to mitigation has been discussed with Scottish Natural Heritage (SNH). Detailed Task Plans are provided in Figures 3.1 and 3.2.

This UXO CMP applies to each detonation as a separate event, on the basis that only a single main detonation is likely to be completed in single 24 hour period (assuming they are not clustered) due the restrictions of daylight during November. This would allow for hearing recovery between the main detonations.

This UXO CMP is structured into the following sections:

- Roles and Responsibilities;
- Methods and Procedures; and
- Reporting.

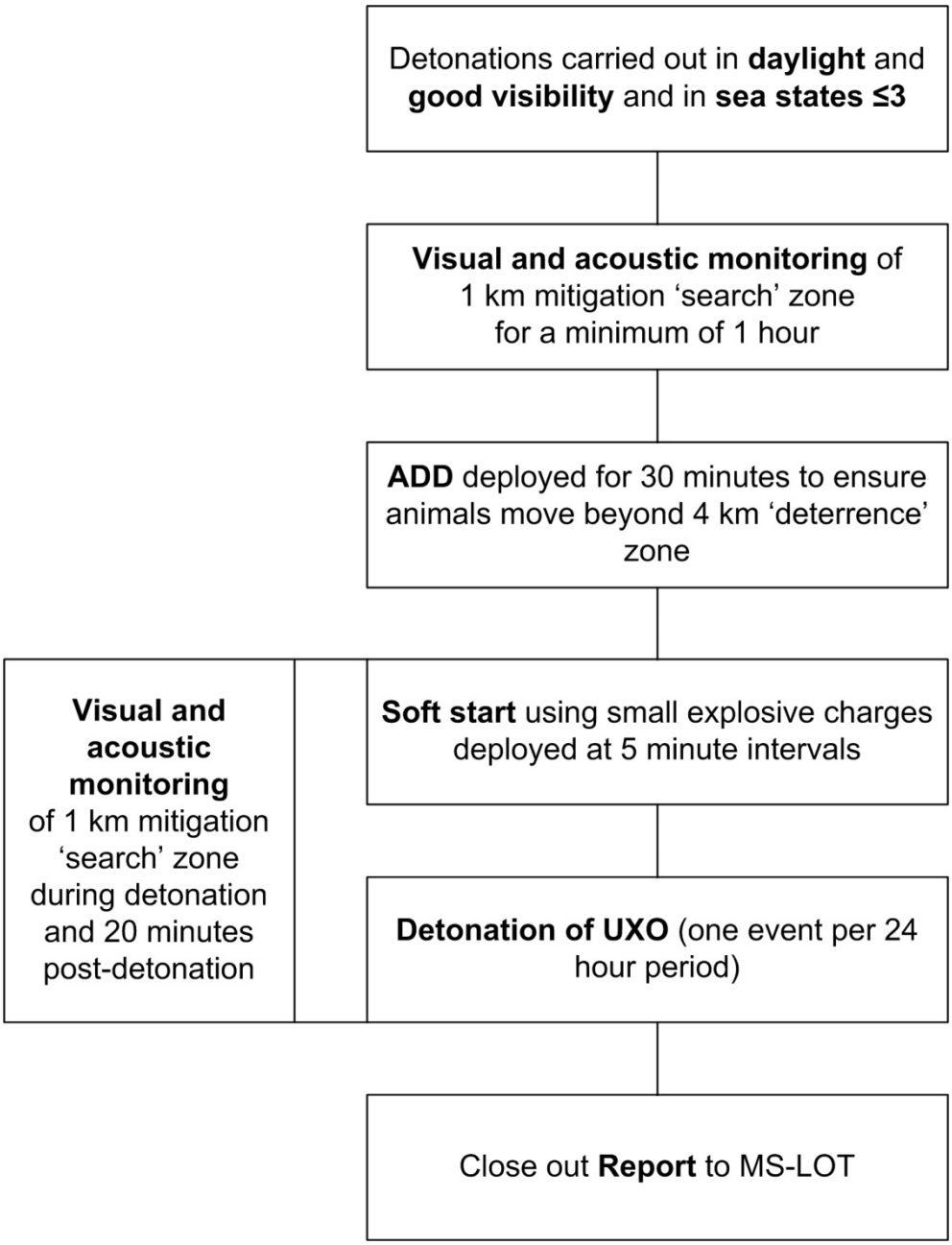

Figure 1.1: Sequence of events for UXO clearance marine mammal mitigation

2 Roles and Responsibilities

2.1 Mitigation Team

The UXO clearance mitigation team will comprise the following roles:

- Marine Mammal Observers (MMO);
- Passive Acoustic Monitoring (PAM) Operator;
- Acoustic Deterrent Device (ADD) Operator;
- Explosive Ordnance Disposal (EOD) Technical Advisor; and
- EOD Team.

The responsibilities of the mitigation team are discussed below.

2.1.1 MMOs

Two dedicated MMOs will be appointed, and will be responsible for carrying out the pre-detonation search, recording the observations on a JNCC marine mammal recording form, and liaising with the EOD Technical Advisor to advise whether a delay to detonation is necessary if any marine mammals are detected. The MMOs will be in direct contact with the EOD Technical Advisor and PAM Operator via radio.

The MMOs will be trained to JNCC standards as Marine Mammal Observers (by a JNCC approved course provider) and will have an appropriate level of field experience.

The MMOs will be responsible for recording all marine mammal sightings in the appropriate format, and together with the PAM Operator, will be responsible for compiling all the data on marine mammal observations, mitigation activities and detonations, including ADDs and 'soft start' (see Section 3.3.2), for reporting to MS-LOT.

The MMOs will be based on the ROV support vessel, which will be located approximately 100 m from the source during the pre-detonation search period.

2.1.2 PAM Operator

The dedicated PAM Operator, appointed by BOWL, will be responsible for deployment, maintenance and operation of the PAM hydrophone, including spares. The PAM Operator will be required to liaise with the EOD Technical Advisor and MMOs in order to confirm timings for detonations and start of the pre-detonation search period. In addition, the PAM Operator will be in communication with the ADD Operator to advise if there are any issues with functioning of the ADD device that have been picked up via the computer interface monitored by the PAM Operator. The PAM Operator will be in direct contact with the EOD Technical Advisor, MMOs and ADD Operator via radio. Any recordings of marine mammals using PAM can be communicated immediately to the EOD Technical Advisor to delay the commencement of the 'soft start' detonations.

The PAM Operator will be responsible for recording all marine mammal detections in the appropriate format, and together with the MMOs, will be responsible for compiling all the data on mitigation activities and detonations, including ADDs and 'soft start', for reporting to MS-LOT.

The PAM Operator will be suitably trained in passive acoustic monitoring and the use of PAMGuard with training provided by an appropriate organisation and will have an

appropriate level of field experience.

The PAM Operator will be based on the ROV support vessel, which will be located approximately 100 m from the source during the pre-detonation search period.

2.1.3 ADD Operator

The ADD Operator will be a member of the Boskalis guard vessel crew, and will be responsible for deployment, maintenance and operation of the ADD device, including spares. The ADD Operator will be required to liaise with the EOD Technical Advisor in order to confirm timings for detonations and therefore when to commence the ADD deployment period. In addition, the ADD Operator will be in communication with the PAM Operator to check that the ADD is functioning correctly. The ADD Operator will be in direct contact with the EOD Technical Advisor and PAM Operator via radio.

The ADD Operator duties will be to undertake maintenance and preparation of the ADD device, including ensuring batteries are fully charged, initial testing, deployment and operation prior to any detonations, communication with all parties, and recording and reporting of all ADD activity.

The ADD Operator will be suitably trained in the use of the selected ADD device and will have an appropriate level of field experience.

The ADD Operator will be based on the guard vessel which will be positioned 100 m from the source during the ADD deployment period.

2.1.4 EOD Technical Advisor

The EOD Technical Advisor has overall responsibility for the detonations programme and is based on the ROV support vessel. The EOD Technical Advisor is the main point of communication between the mitigation team (MMOs, PAM Operator and ADD Operator) and the EOD support teams (responsible for carrying out the UXO clearance activities) on board the ROV support vessel and guard vessel. The EOD Technical Advisor will be in control of initiating, delaying or pausing the detonation activities.

2.1.5 EOD Team

The EOD team are responsible for carrying out the UXO clearance activities and are based on board the ROV support vessel and guard vessel. Crew on board the ROV support vessel may be required to assist the MMOs and PAM Operator e.g. through deployment of the hydrophone. Similarly, crew on board the guard vessel will support the ADD Operator in deployment of the ADD device. The EOD team, on board both vessels, has extensive experience of carrying out UXO clearance operations and has worked with many marine mammal mitigation teams in this respect. Therefore, the EOD team will provide support where possible, by reporting any sightings to the MMOs and PAM Operators during the mitigation period.

3 Methods and Procedures

3.1 Mitigation zone

The 'mitigation zone' is the area within which mitigation measures are implemented to ensure avoidance of injury. For the purposes of this UXO CMP, there are two separate zones identified as described below.

3.1.1 Search Zone

The 'search zone' is defined as the zone over which the MMO and PAM searches will take place prior to any detonations. Since the noise assessment presented in the Environmental Report predicted that auditory injury, in the form of a Permanent Threshold Shift (PTS), in marine mammals could occur out to 748 m from the initial small 'soft start' detonation charge size of 50 g (see Section 3.3.2), the search zone has been determined as having a precautionary radius of 1 km from the source, and therefore follows the JNCC guidelines on explosives (JNCC, 2010) in this respect.

3.1.2 Deterrence Zone

The second mitigation zone is defined here as the 'deterrence zone'. The noise assessment presented in the Environmental Report predicted, using the precautionary NOAA guidelines (NMFS, 2016), that PTS could occur out to 3.89 km from the most likely worst case UXO charge size of 50 kg and therefore the mitigation strategy has been designed such that measures will be taken to deter animals beyond this zone to ensure the likelihood of injury is minimised. The size of the deterrence zone is therefore determined as ~4 km and mitigation deterrence activities have been designed to ensure that animals flee beyond this distance (Section 3.3).

3.2 Pre-detonation visual and acoustic search

Following the JNCC (2010) recommendation, visual monitoring of the 1 km search zone will be undertaken by the two dedicated MMOs for a minimum of one hour prior to detonation, and observations will continue during detonation and for a minimum of 20 minutes post-detonation. PAM monitoring of the search zone will be undertaken by the dedicated PAM Operator for minimum of 1 hour prior to detonation, and monitoring will continue during detonation and for a minimum of 20 minutes post-detonation.

The MMOs and PAM Operator will be stationed on board the ROV support vessel, which will be located approximately 100 m from the source during the entire pre-detonation search period. Since all detonations will occur during daylight hours, in good visibility and ideally in sea states of less than three, this will provide suitable conditions for conducting the pre- and post- detonation searches using MMOs.

The MMOs will be suitably equipped with binoculars and marine mammal reporting forms, and be capable of determining the extent of the mitigation zone in relation to their viewing platform (the wheelhouse/bridge on board the Smit Kamara at ~ 30 m height). The MMOs will scan the search zone systematically with the unaided eye. Binoculars will be used to aid the search and identification to species level of any sightings. A range stick may be used to aid the estimation of distance of the sighting from the observation vessel. Sightings will be recorded and a JNCC Marine Mammal Recording and Sightings Form will be completed subsequently.

Information on the survey effort (i.e. start and end times) and survey conditions (e.g. weather and sea state) will be recorded by the MMOs. When a marine mammal sighting is made, the following information will be recorded:

- Species, group size, age/size/sex categories (e.g. adult/juvenile, if determinable);
- Physical description of features of animals which cannot be identified to species level;
- Behaviour when first sighted including direction of travel and speed category where appropriate;
- Bearing and distance from observer;
- Time;
- Vessel position;
- Vessel speed, including speed over ground and speed through water if known;
- Vessel activity;
- Water depth;
- Sea state, visibility, and sun glare; and
- Positions of other vessel(s) in the vicinity of the observer location.

The PAM Operator will acoustically track marine mammals using a hydrophone deployed to a suitable depth from the ROV support vessel. The hydrophone data will be monitored by the PAM Operator via a computer interface using the software PAMGuard. This allows the operator to detect vocalisations and signal strengths give an indication of the position of the animal relative to the hydrophone (i.e. the signal becomes weaker as the animal moves further away). The PAM Operator can communicate with the MMOs to 'ground truth' any detection of marine mammals in order to validate species identification and determine approximate position.

The MMOs and PAM Operator will communicate with the EOD Technical Advisor to confirm that the 1 km search zone is clear of marine mammals, and that the detonation operation can commence. The lines of communication and sequencing of events are shown in the task plan below (Figure 3.1).

If marine mammals are detected within the search zone during the pre-detonation survey the MMOs and PAM Operator will immediate notify the EOD Technical Advisor that detonation must be delayed. The search zone must be clear of marine mammals for a period of not less than 20 minutes prior to detonation. Any animal detected within the search zone during the pre-detonation search will be tracked or monitored to ensure it has moved beyond the 1 km range. Any uncertainty in the presence of marine mammals within the search zone will be treated as a positive detection and detonation will be delayed until the MMOs and PAM Operator are certain that no animals are present.

Following the one hour pre-detonation search period, the ROV support vessel will move to the edge of the 1,500 m safety zone and, once the EOD Technical Advisor notifies the mitigation team of the intention to commence 'soft start' detonations in 30 minutes, the ADD deployment period will commence from the guard vessel (see Section 3.3.1). Due to the short delay between the end of the pre-detonation search period (as the vessel moves to the edge of the safety zone) and the start of the ADD deployment period, the MMOs and PAM Operator will continue to monitor the search zone for marine mammals. In addition, monitoring will continued during ADD deployment and soft start charge detonations (Section

3.3), with the MMOs and PAM Operator noting reactions to the ADD device and soft start and tracking individuals, as far as possible.

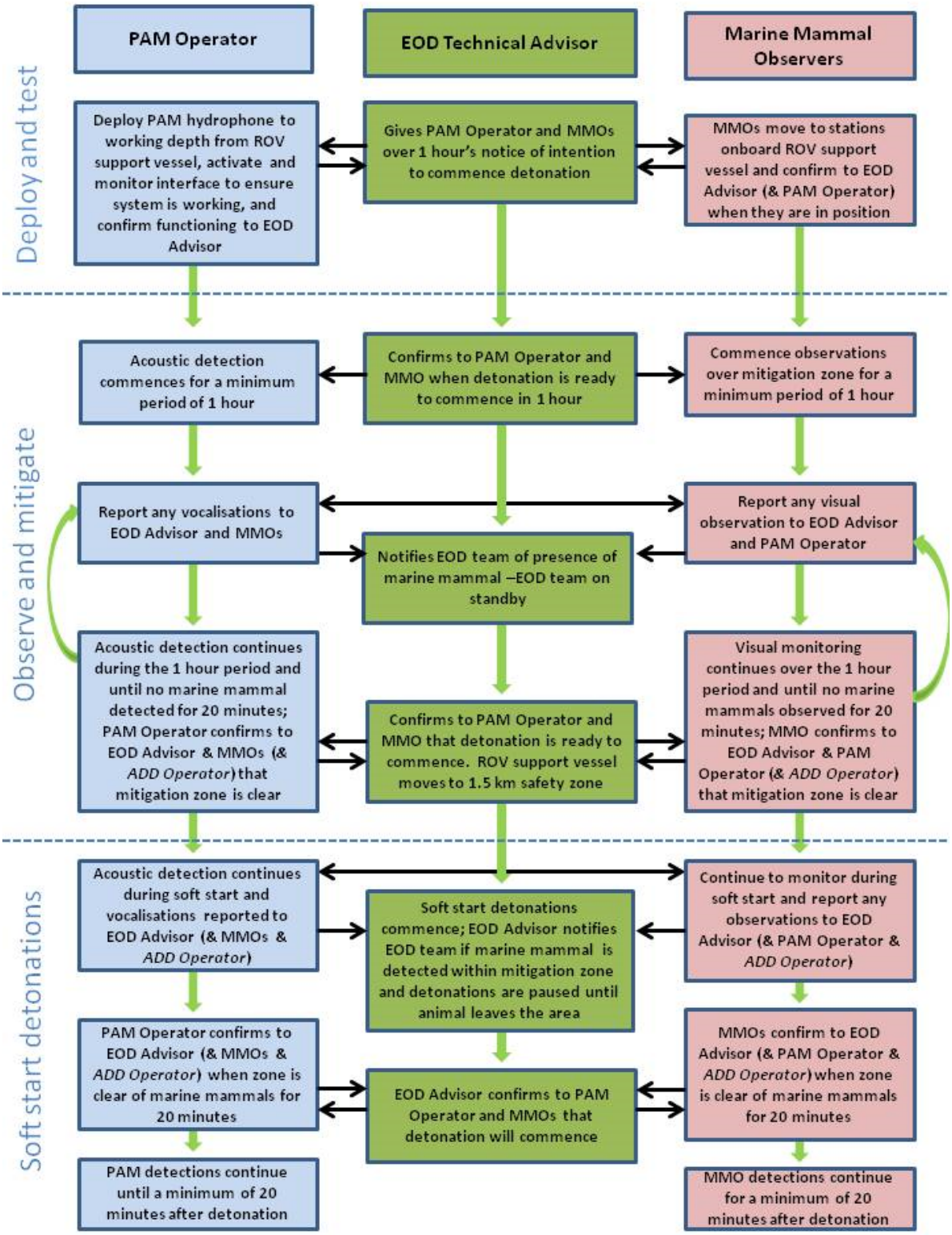

Figure 3.1: Task plan for undertaking the pre-detonation search period within the 1 km mitigation 'search' zone, sho wing th e lines of communication between the MMOs, PAM Operator and EOD Technical Advisor.

3.3 Deterrence activities

3.3.1 ADD deployment

An ADD device will be deployed from the guard vessel by the crew, 30 minutes prior to the 'soft start' detonations. The guard vessel will be located approximately 100 m from the UXO detonation source. The ADD selected for this UXO CMP is the same as proposed for carrying out the Pile-driving Mitigation Protocol and is the Lofitech Seal Scarer (Lofitech AS, Leknes, Norway). The technical specification for this device and procedure for deployment has been presented by BOWL as part of the Piling Strategy (Appendix C - ADD Deployment Protocol; BOWL, 2015).

In agreement with SNH, the 30 minute ADD deployment period is considered to be sufficient to allow marine mammals to flee beyond the potential range of injury, which as a minimum should be beyond the injury range for the first small charge 'soft start' detonation (i.e. 748 m). Further information on timing of the ADD is provided below (Section 3.3.2) and information on the sequencing of events and communications is provided in the task plan below (Figure 3.2).

The ADDs will be tested for operation before being activated. This will be done in collaboration with the PAM Operator using the hydrophone deployed over the side of the ROV support vessel before the vessel moves to the edge of the 1.5 km safety zone in order to ensure the ADD is working *in situ*. The PAM Operator, through monitoring the hydrophone computer interface, will be able to determine whether there are any issues with the functioning of the ADD device. If the device is found to be malfunctioning, a backup device will be deployed and re-tested. During the 30 minute ADD activation period, the device must be working for the full 30 minutes. If there are any pauses in the ADD deployment of >10 minutes (e.g. due to malfunctioning of the device) the 30 minute activation will be re-started.

As described previously (Section 3.2), there may be a short delay between the end of the pre-detonation search period and the start of the 30 minute ADD deployment, but, as agreed with SNH, it was determined that the use of the ADD would be more effective if it were to be deployed just prior to the soft start. The reason for this is that the sequencing of the ADD followed by the soft start would allow a greater period of time for marine mammals to flee beyond the potential range of injury, and also minimise the deployment time of the ADD (i.e. because if it were to be deployed too early then it may be necessary to activate intermittently until the soft start is ready to commence).

3.3.2 Sequencing of the detonations

A 'soft-start' procedure will be implemented involving the use of very small explosives with charges of 50 g, 100 g, and 150 g, detonated in a sequence of small to large charge size in order to allow additional time for marine mammals to leave the area of potential impact. The noise assessment presented in the Environmental Report predicts that detonation of the small charges will result in the onset of a fleeing response (based on TTS threshold) at ranges of 1.4 km, 1.6 km and 1.8 km for the 50 g, 100 g, and 150 g charge sizes respectively. Thus, it is considered likely that marine mammals will continue to move away from the possible injury range at distances greater than these. The timings of the detonations following the ADD are discussed below (Section 3.3.3).

The soft start charge sequence is based upon the most likely scenario of UXOs of up to 50 kg requiring detonation. In the unlikely event that charges greater than 50 kg require detonation, additional smaller charges will be added to the soft start sequence. Therefore,

for the unlikely scenario of UXOs of 50 to 250 kg requiring detonation, one additional small charge of 200 g will be added to the soft start sequence, and for the unlikely scenario of UXOs >250 kg requiring detonation, two additional small charges of 200 g and 250 g will be added to the soft start sequence. It is important that the introduction of additional small detonations to the soft start sequence ensures a balance between deterrence of marine mammals beyond the potential range of injury and minimising the additional noise introduced into the environment.

Following the JNCC guidelines, consideration will also be given to sequencing of the UXO detonations where the survey has identified that groups of charges must be detonated together. In this case, fusing of the second and subsequent charges will be sequenced to allow for a few millisecond delay between UXO detonations in order to reduce the cumulative effect of the shock wave.

3.3.3 Duration of the deterrence activities

As discussed previously, the duration of ADD deployment followed by the soft start detonations must be sufficient to deter animals beyond the potential range of injury, but not be too long so as to cause more than the necessary noise disturbance on marine mammal receptors. Conservatively, the sequencing of the ADD and soft start charges was based on deterring animals over the largest predicted auditory injury range for marine mammals (i.e. 3.89 km based on the injury range for high-frequency cetaceans using the precautionary NOAA threshold).

After notification from the EOD Technical Advisor that the soft start is due to commence in 30 minutes the ADD device will be deployed for a period of 30 minutes followed by the small charge detonations at five minute intervals, including an interval of five minutes before the detonation of the UXO. This gives a total deterrence time of 45 minutes and based on a swimming speed of 1.5 m/s (Otani *et al.* 2000), marine mammals should clear a radius of ~4.05 km over this duration.

As described previously, there may be a requirement for additional small charge detonations to be deployed in the unlikely event that UXOs greater than 50 kg are discovered. If these are required they will be deployed in five minute intervals following the soft start sequence and in this way both the TTS (onset of fleeing) range is increased and the duration over which mitigation occurs is increased, thereby allowing marine mammals to flee further beyond the potential injury range.

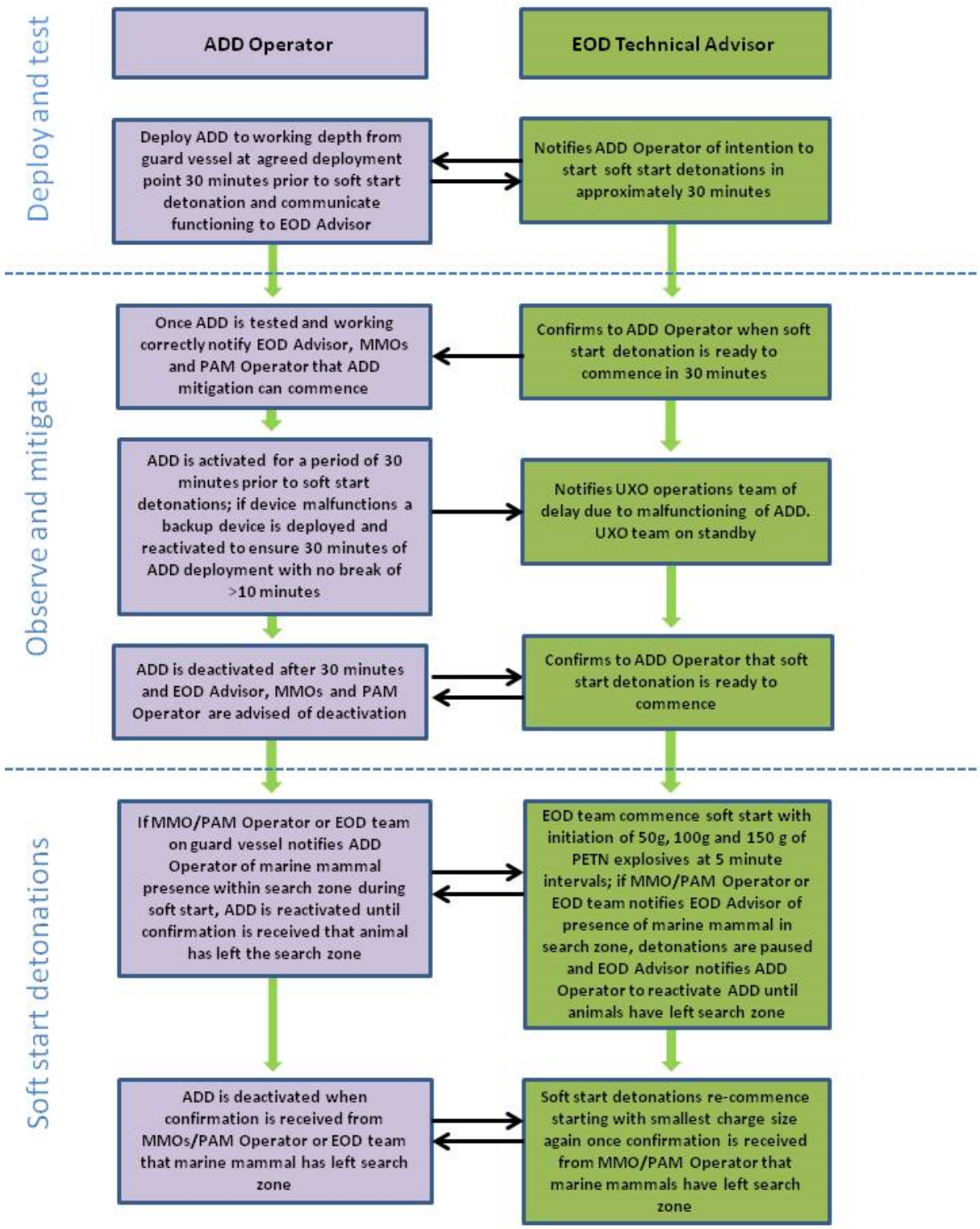

Figure 3.2: Task plan for deploy ment of the A DD device, w hich occurs 30 minutes prior to the soft start detonations.

3.4 Post-detonation search

Following detonation, the ROV support vessel will return to the detonation site (within approximately 5 minutes) , and the MMOs and PAM Operator will continue to monitor the search zone for a minimum period of 20 minutes at the detonation site. Any observations will be noted and details provided within the report.

4 Reporting

A close out report will be prepared detailing the UXO operations, marine mammal mitigation activities and any marine mammal observations and/or detections, and will be sent to MS-LOT, and their consultees if required, following completion of the UXO clearance activities at the BOWL site.

The report will include:

- Date and location of the activity;
- Details of the operation, including: information on the size of c harges used; the start times of explosive detonations; the start and end times of watches by MMOs; the start and end times of any acoustic monitoring using PAM; the start and end times of ADD deployment and details of all explosive activity during the relevant watches;
- Details of marine mammal encounters and any mitigation actions taken;
- A record of any marine mammal encounters (sightings and detections) as recorded in the completed Marine Mammal Recording Forms (adapted from seismic survey forms), including any behaviour observed;
- Detailed description of any technical problems encountered and what, if any, actions were taken; and
- The report will also discuss the protocols followed and put forward any recommendations based on the project and any marine mamma l sightings/behaviour encountered during the UXO operations which could benefit future projects.

5 References

BOWL (2015) LF000005-PLN-142 Beatrice Offshore W ind Farm Consent Plan: Piling Strategy. November 2015.

Joint Nature Conservation Committee (JNCC) (2010) Guidelines for minimising the risk of injury to marine mammals from using explosives. August 2010.

National Marine Fisheries Service (NMFS) (2016) Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwa ter Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

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Appendix B – Subsea Noise Assessment

1. Introduction

A subsea noise assessment was undertaken to determine the range of potential effects on key marine mammal receptors during the soft start detonations and UXO detonations. The results have been used to inform the mitigation strategy that will be applied during UXO detonations as described in Section 2, and detailed in the UXO Clearance Mitigation Plan (UXO CMP, Appendix A).

2. Methodology

2.1 Noise metrics

There is considerable literature on the peak pressures that arise due to underwater explosive operations (e.g. Richardson, 1995, Barrett, 1996, Urick, 1983, Nedwell & Edwards, 2004, Nedwell & Howell, 2004). Richardson *et al*. (1995) describes the underwater pressure signature from an explosion as comprising an initial shock pulse followed by a succession of oscillating bubble pulses, assuming the explosion is at a sufficient depth so as to not vent through the surface. The rise time of the blast wave is so short that the passage of the blast front may occupy less than a metre (Parvin *et al*., 2007). The peak pressure value (in Pa), which occurs around a microsecond after detonation is given by the empirical equation (Urick, 1983):

Equation 1

$$P_{\max} = 5 \times 10^{7} \times \frac{W^{0.27}}{r^{1.13}}$$

where W is the TNT charge weight in kilograms and r is the range from the explosive in metres.

At greater distances from the explosion the propagation of the pressure wave is similar to other sound waves but, since the high frequency components are absorbed and scattered, and the waveform extended over time, the resulting pressure is dominated by low frequency energy. This is consequently perceived as a “rumble” at distance. The peak pressure received will depend on the charge mass and range from the source and typically the metric used to describe this is the sound pressure level (SPL), which represents the difference between the lowest pressure variation (rarefaction) and highest pressure variation (compression).

The frequency, or pitch, of the sound is the rate at which the oscillations occur and is measured in cycles per second, or Hertz (Hz). It is important to understand how an animal’s hearing varies over the entire frequency range in order to assess the effects of sound on marine life. Consequently use can be made of frequency weighting scales to determine the level of the sound in comparison with the auditory response of the animal concerned. A marine mammal M-weighting function (Southall *et al*., 2007) is designed to represent the bandwidth for each marine mammal group within which acoustic exposures can have auditory effects. The categories include: low-frequency cetaceans (e.g. minke whale); mid-frequency cetaceans (e.g. dolphins); high-frequency cetaceans (e.g. harbour porpoises) and

pinnipeds in water (e.g. seals). Recently, the frequency weighting bands for each hearing group have been refined, and subsequently narrowed, by NOAA (NMFS, 2016). The following figure shows the refinements made for development of a new set of marine mammal noise criteria (Figure 2.1).

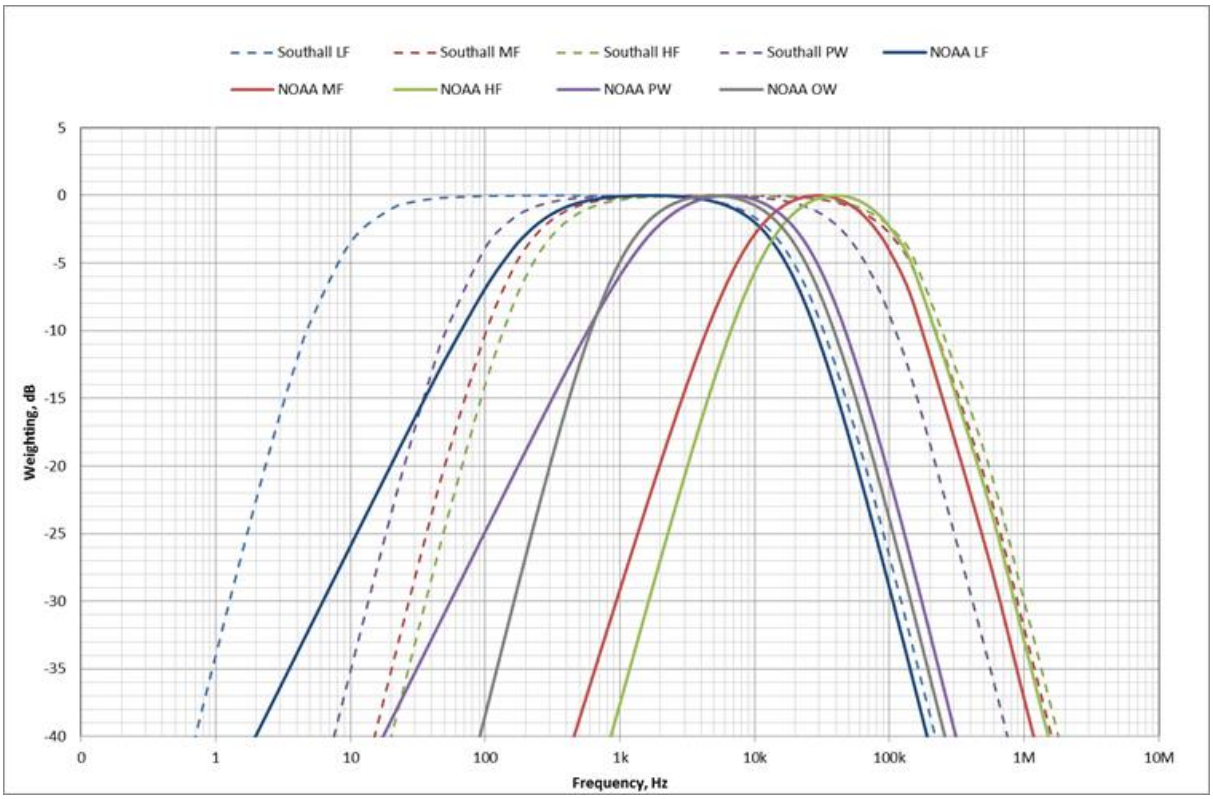

Figure 2.1 Revised frequency weightings published by NOAA (NMFS, 2016) compared to the previously published weightings derived by Southall *et al*. (2007).

Another metric used to describe subsea noise is the sound exposure level (SEL) and is a measurement of the total sound energy of an event or number of events over time, normalised to one second. Whilst peak noise levels (SPL) are based on un-weighted overall levels, and so there is no need to take the frequency content into account, for assessing physiological damage using the weighted SEL criteria it is, however, necessary to account for frequency. For this purpose, a reference frequency spectrum has been taken from Nedwell & Howell (2004) and applied to the calculated source levels. Attenuation due to molecular absorption in the water at various distances was also taken into account (this being frequency dependant).

The only (known) reference to date that gives a specific relationship between values of underwater SEL and peak pressure is that associated with the Hay Point Coal Terminal (Duncan & McCauley, 2009). This document, prepared by Curtin University, Centre for Marine Science and Technology, sets forward a best-fit curve between SEL and L_{peak} for the development based upon measurements made by the University using “small explosive charges” made in 6 – 11 m water depth.

The specific relationship is given by the expression:

Equation 2

$SEL = K \times L_{peak}$

where K = 0.8859 and L_{peak} = Peak pressure level in dB re 1 µPa. This reference advises the standard deviation in the estimate of K as 0.0143.

The potential effects on marine mammals, at a given range, can be determined by estimating the received noise levels (SPL and SEL) against the published thresholds for a given species. These are described in more detail below.

2.2 Subsea noise thresholds

2.2.1 Injury

There are two types of injury considered in this assessment. Physical injury, or trauma, can result from direct or indirect effects of the blast wave potentially causing injury to body tissues. Such effects usually occur close to the source and the threshold at which physical injury can occur on all marine mammals is a peak to peak sound pressure level (SPL) of 240 dB re. 1µPa (Yelverton *et al*., 1973).

High levels of exposure can also cause an instantaneous auditory injury resulting in a permanent threshold shift (PTS) that persists even after the noise has ceased. PTS can also result from a long duration of exposure at lower levels. Lower levels of sound exposure, in this instance, are those that can cause a temporary threshold shift (TTS), from which an animal can ordinarily recover. Sound levels that cause TTS are also known as those which cause the onset of fleeing behaviour and thus the potential for damage will depend on the level of exposure that an animal receives as it flees the ensonified area.

Thresholds for PTS and TTS are commonly presented as un-weighted peak SPL and mammal hearing weighted (M-weighted) sound exposure levels (SELs). The peak SPL is the maximum level the animal may experience and this is relevant because it assesses the potential for injury to occur instantaneously. SEL allows the assessment to consider whether the total energy that the animal receives as it flees the area will cumulatively lead to an effect over the period of time assessed. As dual criteria, the onset of PTS or TTS is considered to have occurred when either one of the two metrics is exceeded (JNCC, 2010; NMFS, 2016).

Typically, noise assessments for UXO clearance are undertaken using the injury criteria proposed by Southall *et al*. (2007) following the draft Joint Nature Conservation Committee (JNCC) guidance (JNCC, 2010)[1]. Southall *et al*. (2007) proposed thresholds for the functional marine mammal groups for the onset of PTS for SPL and SEL. Given that PTS cannot be ethically or legally induced in animals to determine the threshold, Southall *et al*. (2007) proposed that noise exposure criteria for PTS-onset should be extrapolated from the onset of TTS based on the assumed relationships between the relative levels of noise likely to cause TTS and PTS. Thus, the onset of PTS is derived by the addition of 6 dB to the TTS threshold for peak pressure and 15 dB to the TTS threshold for SEL. For cetaceans, the data were based on studies of bottlenose dolphin and beluga and therefore Southall *et al*. (2007) recommended the use of mid-frequency cetaceans as surrogates for the other two

[1] Although notably, the JNCC guidance highlighted the new data emerging on thresholds for harbour porpoise from the work by Lucke *et al.* which was presented at the Effects of Noise on Marine Life Conference in Nyborg, Denmark.

cetacean groups (high and low frequency cetaceans).

Later, based on exposure experiments on harbour porpoise to single airgun transients, Lucke *et al*., (2009) suggested that the onset of TTS in harbour porpoise may be at a lower threshold than other cetaceans. These experiments resemble the sound stimuli from explosions (i.e. impulsive and low frequency) and therefore provide a useful comparison for understanding the effects of explosives. This work has been supported by other more recent studies (e.g. Kastelein *et al*., 2012; Tougaard *et al*., 2014) and most recently has been used to derive the new guidelines for injury thresholds for marine mammals from the National Oceanic and Atmospheric Administration (NOAA) (NMFS, 2016).

This assessment for the potential for auditory injury to occur from explosions considers both the more commonly applied Southall *et al*. (2007) thresholds and the more precautionary, and recently published NOAA guidelines (NMFS, 2016) (Table 2.1). Note that for harbour porpoise, the threshold for SEL from the NOAA guidelines is much lower than the 179 dB re. 1μPa^2.s recommended by Lucke *et al*. (2009). However, the Lucke *et al*. (2009) threshold was not frequency weighted (using Southall M-weighting bands would bring this down to 177 dB re. 1μPa^2.s) and in any case the frequency weighting bands for all cetaceans have also been refined by NOAA. So whilst the NOAA threshold is more precautionary compared to Lucke *et al*., (2009), the narrower frequency weighting bands counters this to some extent.

Table 2.1: Proposed permanent auditory injury criteria (PTS) and TTS criteria (in parentheses) for marine mammal functional hearing groups exposed to a discrete noise event (single pulse exposure) within a 24 hour period. Thresholds shown are those published by Southall *et al*. (2007) and more recently by NOAA (NMFS, 2016).

Hearing group	Southall *et al.* (2007)		NOAA (NMFS, 2016)	
	Unweighted peak SPL dB re 1μPa	M-weighted cumulative SEL dB re 1μPa^2.s	Unweighted peak SPL dB re 1μPa	M-weighted cumulative SEL dB re 1μPa^2.s
Low frequency cetaceans	230 (224)	198 (183)	219 (213)	183 (179)
Mid frequency cetaceans	230 (224)	198 (183)	230 (224)	185 (178)
High frequency cetaceans	230 (224)	198 (183)	202 (196)	155 (153)
Phocid pinnipeds in water	218 (212)	186 (171)	218 (212)	185 (181)

2.2.2 Behavioural effects

Studies of the behavioural response of marine species to sound describe a variety of different behavioural reactions. At lower levels, anthropogenic noise may temporarily impair hearing, cause stress or disturbance to behaviour by disrupting communication, echolocation or threat detection. At the higher levels, animals may also actively avoid an ensonified area

and may therefore be displaced from important habitat (i.e. feeding, breeding or nursing grounds). Based on this, JNCC (2010) define disturbance in terms of animals incurring a sustained or chronic disruption of behaviour or undergoing a significant change from their expected distribution.

Whilst the sensitivity of a species may be a key factor in understanding behavioural effects, the context of the exposure is also important. For example, the baseline characteristics of the environment, exposure history of an animal, and importance of the area for a given species relative to the wider area, all play a part in determining the extent of possible effects.

Significant behavioural effects, as described above, may occur in the very short term due to the very short duration of the acoustic event and the small number of events that are likely to occur during the UXO clearance activities. A study looking at the effects of seismic surveys on cetaceans in the Moray Firth found that fine-scale behavioural responses from harbour porpoise to noise from seismic airguns occurred during the surveys but that animals were typically detected again at affected sites within a few hours (Thompson *et al*., 2013). Therefore, following cessation of each detonation event, it is considered likely that any behavioural effects will be reversible and animals will resume normal behaviour within the short term. Therefore, for this assessment further consideration of behavioural effects has been scoped out.

3. Assessment of Effects

As described in Section 2.2.2 of the Environmental Report, it is estimated that a maximum of five UXO detonations could occur across the Beatrice OWF area, with the most likely charge sizes being up to 50 kg NEQ, charges above 50 kg and up to 250 kg NEQ being unlikely and those above 250 kg being very unlikely to occur. Therefore, the noise assessment has been based on the most likely worst case of 50 kg, however, as a precautionary measure the mitigation described in the UXO Clearance Mitigation Plan (UXO CMP, Appendix A) provides mitigation options for larger UXOs also.

As part of the project-design mitigation, the soft start detonations will involve detonation of three small charges of 50 g, 100 g, and 150 g spaced at 5 minute intervals, with a final five minute interval before the detonation of the UXO. In estimating the SEL dose received by marine mammals, the noise assessment has taken into account the detonation of these small charges.

The assessment indicates that potential physical injury/trauma would be localised, occurring within a range of <100 m from the detonation site for all cetaceans up to the 50 kg charge size (Table 3.1). Instantaneous auditory injury arising from peak pressure levels could occur further afield and the range of effects depends on the threshold applied. Using the Southall *et al*. (2007) criteria, the effect ranges are relatively small, with injury occurring at a maximum of 225 m for all cetaceans and 764 m for pinnipeds (Table 3.1). Applying the more precautionary NOAA guidelines suggests that injury from peak pressure could occur over much larger ranges, with PTS occurring out to 690 m for Low Frequency (LF) cetaceans and 3,898 m for High Frequency (HF) cetaceans for the 50 kg charge size (Table 3.2). The effect ranges for Mid Frequency (MF) cetaceans and pinnipeds in water (Pw) remain the same as predicted using Southall *et al*., (2007) criteria since the recommended peak pressure thresholds have not changed in the NOAA guidelines.

Table 3.1: Estimation of effect ranges (in metres) from peak pressure levels for injury/trauma, PTS and TTS to occur in marine mammals as a result of explosives (including small charges) at the BOWL site. Thresholds (in dB re 1µPa) are based on Yelverton *et al*. (1973) for injury/trauma and on Southall *et al*. (2007) for PTS and TTS.

Charge size (kg)	All cetaceans	All cetaceans		Pinnipeds in water	
Threshold	Injury/trauma 240 dB re 1µPa	TTS 224 dB re 1µPa	PTS 230 dB re 1µPa	TTS 212 dB re 1µPa	PTS 218 dB re 1µPa
0.05	16	80	43	270	147
0.1	18	94	51	319	173
0.15	20	103	56	351	191
50	81	414	225	1407	764

Table 3.2: Estimation of effect ranges (in metres) from peak pressure levels for injury/trauma, PTS and TTS to occur in marine mammals as a result of explosives (including small charges) at the BOWL site. Thresholds (in dB re 1µPa) are based on NOAA (NMFS, 2016) for PTS and TTS.

Charge size (kg)	LF cetaceans		MF cetaceans		HF cetaceans		Pinnipeds in water	
Threshold	TTS 213 dB re 1µPa	PTS 219 dB re 1µPa	TTS 224 dB re 1µPa	PTS 230 dB re 1µPa	TTS 196 dB re 1µPa	PTS 202 dB re 1µPa	TTS 212 dB re 1µPa	PTS 218 dB re 1µPa
0.05	244	132	80	43	1,379	748	270	147
0.1	288	156	94	51	1,627	883	319	173
0.15	317	172	103	56	1,793	973	351	191
50	1271	690	414	225	7,184	3,898	1,407	764

For the soft start charge sizes (50 g, 100 g and 150 g) the potential range over which PTS is predicted to occur in the HF cetaceans (as the most sensitive hearing group) is 748 m, 883 m and 973 m respectively. The onset of TTS is predicted out to distances of 1,379 m, 1,627 m, and 1,793 m for the 50 g, 100 g and 150 g charge sizes respectively (Table 3.2). TTS is important to consider as this gives an estimate of the distances at which animals start to flee (i.e. to avoid possible injury) when the small charges are deployed, and it is considered likely

that the fleeing effect will occur beyond this TTS zone.

The ranges at which animals would need to be to receive dose SEL that may elicit the onset of PTS for the 50 kg charge size and including the soft start charges was predicted to be smaller than the auditory injury ranges for peak sound pressure. The SEL dose received over distance from the source is shown illustratively in Figure with NOAA thresholds overlaid to illustrate where PTS may occur for different hearing groups. The results from this are summarised in

Table .

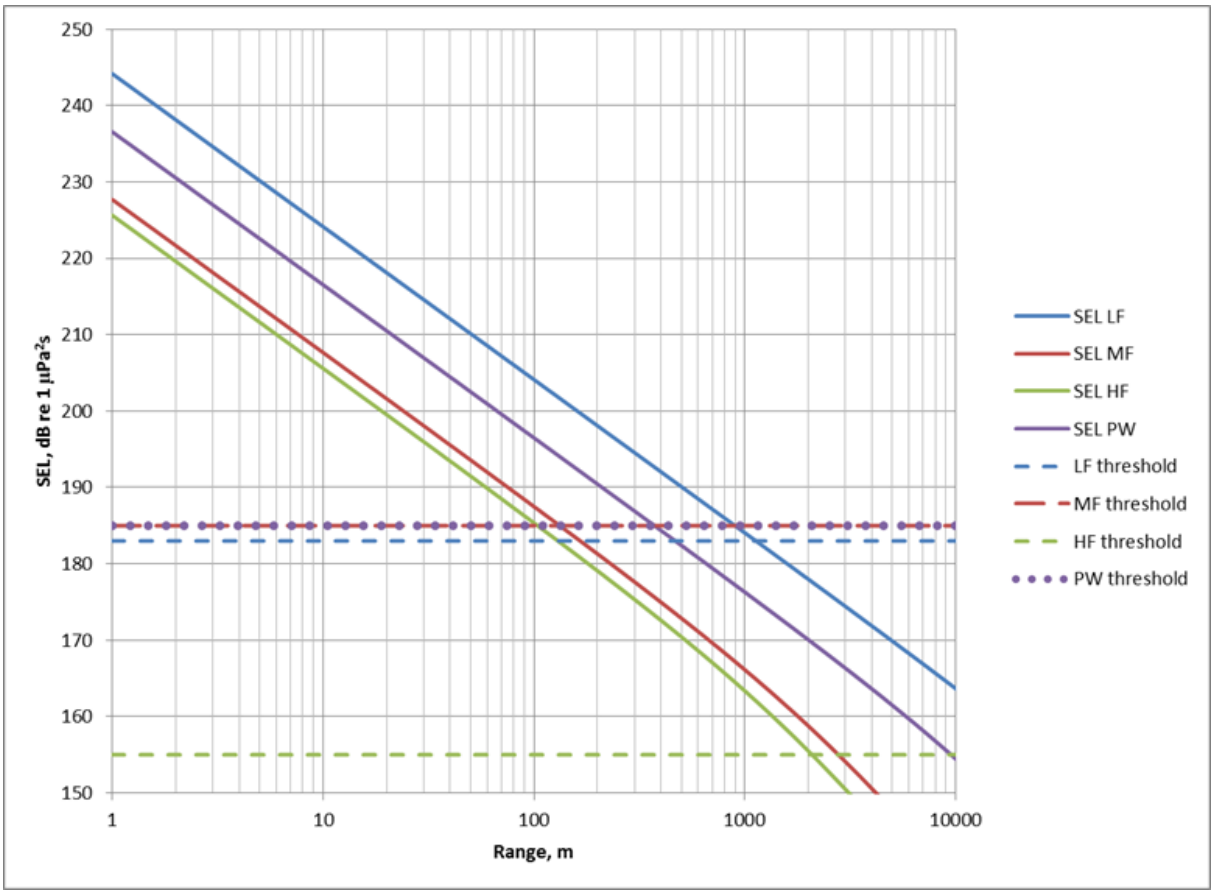

Figure 3.1 Modelled effect ranges for the onset of PTS for marine mammal hearing groups based on a soft start of three small charges (50 g, 100 g, and 150 g) at five minute intervals plus a 50 kg UXO detonation.

Table 3.3: Estimation of effect ranges (in metres) from cumulative SEL for PTS to occur in marine mammals as a result of UXO detonation (including soft start) at the BOWL site. Thresholds (in dB re 1μPa^2.s) are based on NOAA (NMFS, 2016).

Charge size (kg)	LF cetaceans	MF cetaceans	HF cetaceans	Pinnipeds in water
Threshold	183 dB re 1μPa^2.s	185 dB re 1μPa^2.s	155 dB re 1μPa^2.s	185 dB re 1μPa^2.s
Soft start (0.05+0.1+0.15) +50	1,000	125	2,000	350

The results above were subsequently compared with published studies looking at the effects of subsea noise from explosives on marine mammals, with a particular focus on those studies that present empirical measurements of the received noise levels in the field.

Von Benda-Beckmann *et al*., (2015) investigated the range of effects of explosives on harbour porpoise in the southern North Sea. The study measured SEL and peak overpressure2 (in kPa) at distances up to 2 km (and over a range of depths) from the explosions of seven aerial bombs (six with charge masses of 263 kg and one with a charge mass of 121 kg) detonated at ~26-28 m depth. The study considered the potential for noise-induced PTS to occur based on a threshold of 190 dB re. 1μPa^{2}s (PTS very likely to occur) and an onset threshold of 179 dB re. 1μPa^{2}s (SEL) (Lucke *et al*. 2009 criteria) (PTS increasingly likely to occur). In addition, the study looked at the potential for injury to occur as an ear trauma caused by the blast wave (at a peak overpressure of 172 kPa ≡ 190 dB re. 1μPa). The results suggested that the largest distance at which a risk of ear trauma could occur was at 500 m and that noise-induced PTS was likely to occur greater than the 2 km range that was measured during the study since the SEL recorded at this distance was 191 dB re. 1μPa^{2}s (i.e. 1 dB above the 'likely to occur' threshold). Whilst this study looked at a much larger explosive than considered for the Beatrice site, the results are largely in agreement with the noise assessment and suggest that for the most likely charge size of 50 kg, the physical injury range would be less than 500 m whilst auditory injury from dose SEL could occur over the JNCC standard 1 km mitigation range.

Von Benda-Beckmann *et al*., (2015) also modelled possible effect ranges for 210 explosions (of up to 1,000 kg charge size) that had been logged by the Royal Netherland Navy (RNLN) and the Royal Netherlands Meteorological Institute (KNMI) over a two year period (2010 and 2011). The model was validated using the empirical measurements of SEL out to 2 km (as described above). The authors found that the effect distances (based on onset of PTS from dose SEL) ranged between hundreds of metres and just over 10 km (for charges ranging from 10 kg up to 1,000 kg) (Figure 3.2). Near the surface, where porpoises are known to spend a large proportion of time (e.g. 55% based on Teilmann *et al*., 2007; 30 – 60% based on Westgate *et al*., 1995) the SELs were predicted to be lower with effect distances for the onset of PTS just below 5 km. The authors caveat these results as whilst the model could

[2] Peak compressional pressure defined as the maximum value of the positive overpressure (pressure minus ambient pressure).

provide a reasonable estimate of the SEL within 2 km (since the empirical measurements were made out to this point), estimates above this distance required further validation since the uncorrected model systematically overestimated SEL. There were no charges around 50 kg but extrapolating from the graph below (Figure 3.2) suggests that the effect distance could be between 2-3 km for a 50 kg charge size. The results of this modelling, which uses a similar onset threshold for PTS in harbour porpoise to the NOAA threshold, suggests that for the most likely charge size that could occur within the Beatrice site, the onset of PTS for harbour porpoise could occur beyond the 1 km JNCC (2010) recommended mitigation zone.

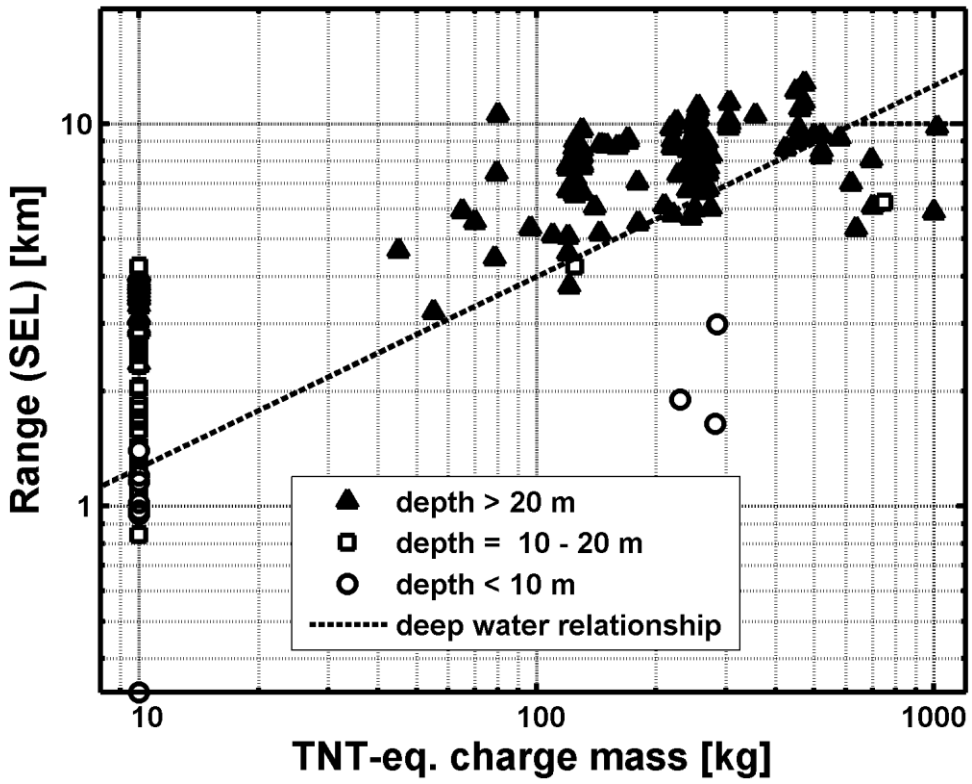

Figure 3.2 Modelled effect distances for a harbour porpoise at 1 m from the bottom as a function of charge mass for the lower limit of PTS (179 dB re. 1μPa^{2}s). Lower effect distances are seen for shallower water depths. The dashed line shows a deep-water prediction using the Weston (1960) model. (Source: von Benda-Beckmann, 2015).

Parvin *et al*., (2007) estimated lethal and injury ranges from various, freely suspended, explosive sources including a very large underwater explosion with a charge size of 4,540 kg, a blast from wellhead severance with a charge size of 40 kg and a smaller charge of 2.27 kg. Source levels were estimated following Urick (1983) (*Equation 1*) and subsequently the ranges at which effects could occur (based on thresholds determined following a review of a wide range of exposure experiments in terrestrial and marine mammals and humans), are presented in Table 3.4. These data suggest that the lethal range falls within the 1 km JNCC (2010) recommended mitigation distance but that auditory injury could occur beyond this point for larger explosives. Notably, the injury criteria presented in this Parvin *et al*., (2007) are different than those presented in the recent NOAA criteria (Table 3.4). Therefore, it could be deduced that the injury ranges presented in the table below would be smaller for MF cetaceans (using the NOAA threshold of 230 dB re 1μPa), and larger for other cetaceans (particularly HF cetaceans) and pinnipeds.

Table 3.4 Onset of lethality and injury for all marine mammal species based on thresholds of 240 dB re 1µPa and 220 dB re 1µPa respectively (source Nedwell *et al*., 2007)

Source (freely suspended)	Source level (dB re 1µPa)	Lethal range (m) 240 dB re 1µPa	Injury range (m) 220 dB dB re 1µPa
Underwater blast 4,540 kg	300	520	4000
Wellhead severance 40 kg	285	110	900
Underwater blast 2.27 kg	276	43	350

Ward (2015) reviewed a case study of an air-dropped 'GC' mine containing 680 kg of explosives at Sheerness. The peak pressure (in µPa) was estimated at increasing distance from the source using the empirical equation in Urick (1983). Ward (2015) estimated that the distances at which animals would need to be to survive the blast (i.e. radius of physical injury) would be 633 m for harbour porpoise, 505 m for harbour seal and 447 m for grey seal (based on the average body weight of adults in each species). As with the noise assessment for the BOWL UXO clearance activities, the physical injury range falls within the 1 km standard JNCC mitigation zone.

4. Conclusion

In summary, based on the calculated effect ranges (Table 3.2) and evidence from the literature, it is considered that the thresholds for physical injury/mortality will not be exceeded beyond the 1 km mitigation zone, but that PTS could occur beyond this point. The range over which PTS could occur depends on the species, but for the most hearing sensitive species – harbour porpoise – the range over which the onset of PTS could occur is estimated as up to 3.9 km for the most likely scenario of 50 kg of explosive. A UXO Clearance Mitigation Plan (CMP) has therefore been devised, in consultation with the statutory consultees, to ensure that marine mammals avoid injury by being deterred beyond this distance (Appendix A).

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