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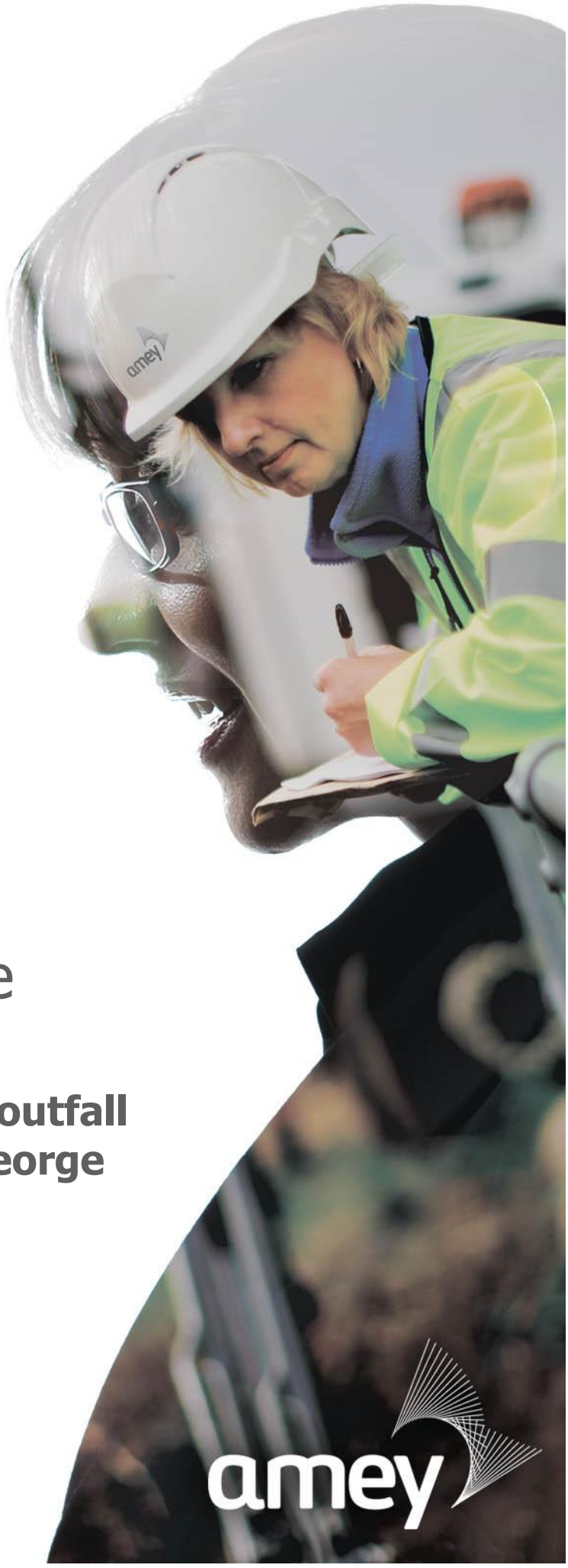

Construction marine noise assessment

Extension to existing sea outfall – Ardersier East of Fort George

CO07430197/NV Revision 0.2

May 2017

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Document Control Sheet

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Executive summary

Scottish Water submitted a marine licence application for an extension to the existing sea outfall at Ardersier, east of Fort George. Marine Scotland Science (MSS) and Scottish Natural Heritage (SNH) provided stakeholder responses to the application requesting further methodological information on noise sources and the potential effects on salmon and marine mammals.

The purpose of this report is to address the outstanding issues raised by MSS and SHN in relation to the effects of the construction underwater noise on diadromous fish and marine mammals. The scope includes the potential effects of noise during piling once the piling technique has been defined.

The chosen piling methodology is Odex piling. Odex piling is a percussive drilling technology where the excentric drill bit swings out creating a hole with a diameter greater than that of the steel casing. This allows the steel casing to traverse down behind the drill bit without having to first remove the drill bit in order to insert the casing. The hammer is driven by air. The percussion rate by the hammer is 1235 blows per minute at a pressure of 17 bar. This high rate of percussion means that the noise produced by the source is continuous rather than impulsive and therefore similar to vibratory piling.

The assessment concludes that no significant adverse effects to diadromous fish, such as salmon, are expected. Permanent significant adverse effects to mid-frequency cetaceans (bottlenose dolphin), high-frequency cetaceans (harbour porpoise) and phocid pinnipeds (harbour seal and grey seal) are not expected beyond 2, 20 and 13m of the piling works respectively. Temporary significant adverse effects may occur up to 28, 430 and 263m of the piling works for mid-frequency cetaceans (bottlenose dolphin), high-frequency cetaceans (harbour porpoise) and phocid pinnipeds (harbour seal and grey seal) respectively.

The following management and mitigation procedures are recommended to be included into contract documentation:

- A marine mammal exclusion zone of 500m radial distance of the piling works;
- The use of trained MMO's;
- 30 min pre-start search area. During early morning and evening when it is expected to still be dark, passive acoustic monitoring systems (PAMS) will be used instead of direct observation of mammals;
- Use of soft start/ramp up;

- The construction period should take place between January and April;
- The initial piling noise shall be monitored with an hydrophone to ensure that noise levels at around 10m from the source are at around 154dB,RMS,re: 1µPa with no relevant impulsive noise; and
- The contractor will produce and retain a compliance and sighting report which will made available on request.

No residual significant adverse effects are expected if the mitigation measures above are followed.

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1 Introduction

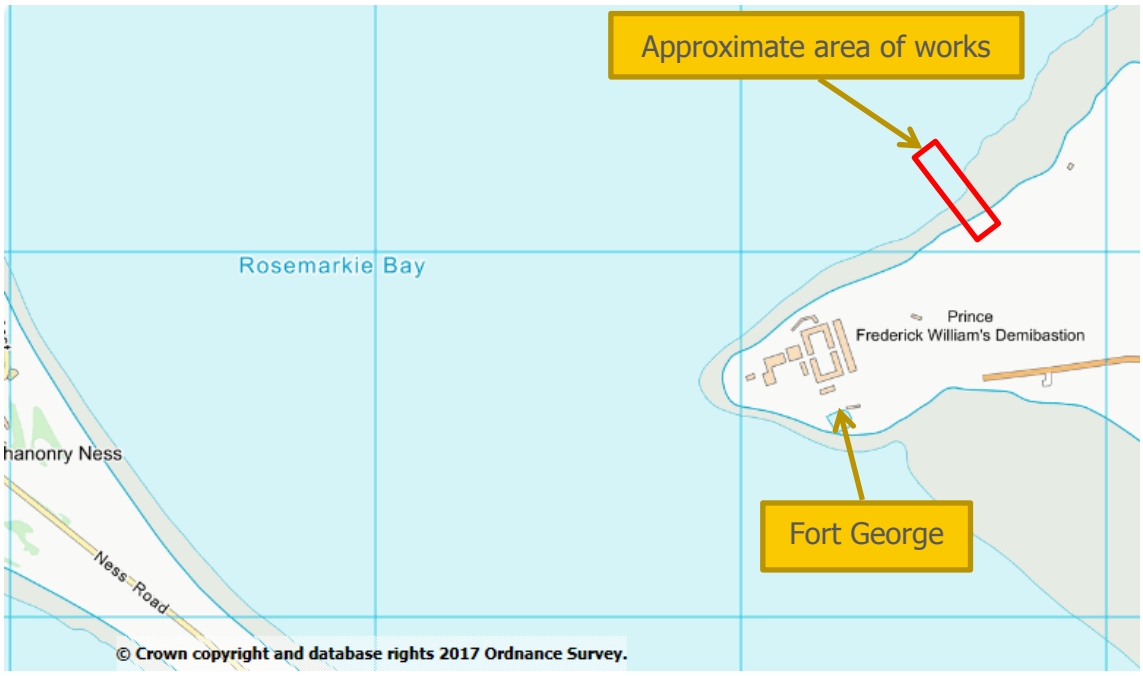
1.1 Background

1.1.1 Scottish Water is proposing to utilise an existing outfall to discharge effluent from a new waste water treatment works. The scheme involves the extension and upsizing of the existing Ardersier outfall at the Fort George Beach, Ardersier, to lowest astronomical tide (LAT) in the Moray Firth (see Figure 1).

Figure 1: Existing outfall photographed at low tide (left). Existing outfall discharge point and pipe restraint (centre). Along the existing outfall line (right). Source: Mott MacDonald.

1.1.2 The site is located just to the east of Fort George, Ardersier, Inverness (see Figure 2).

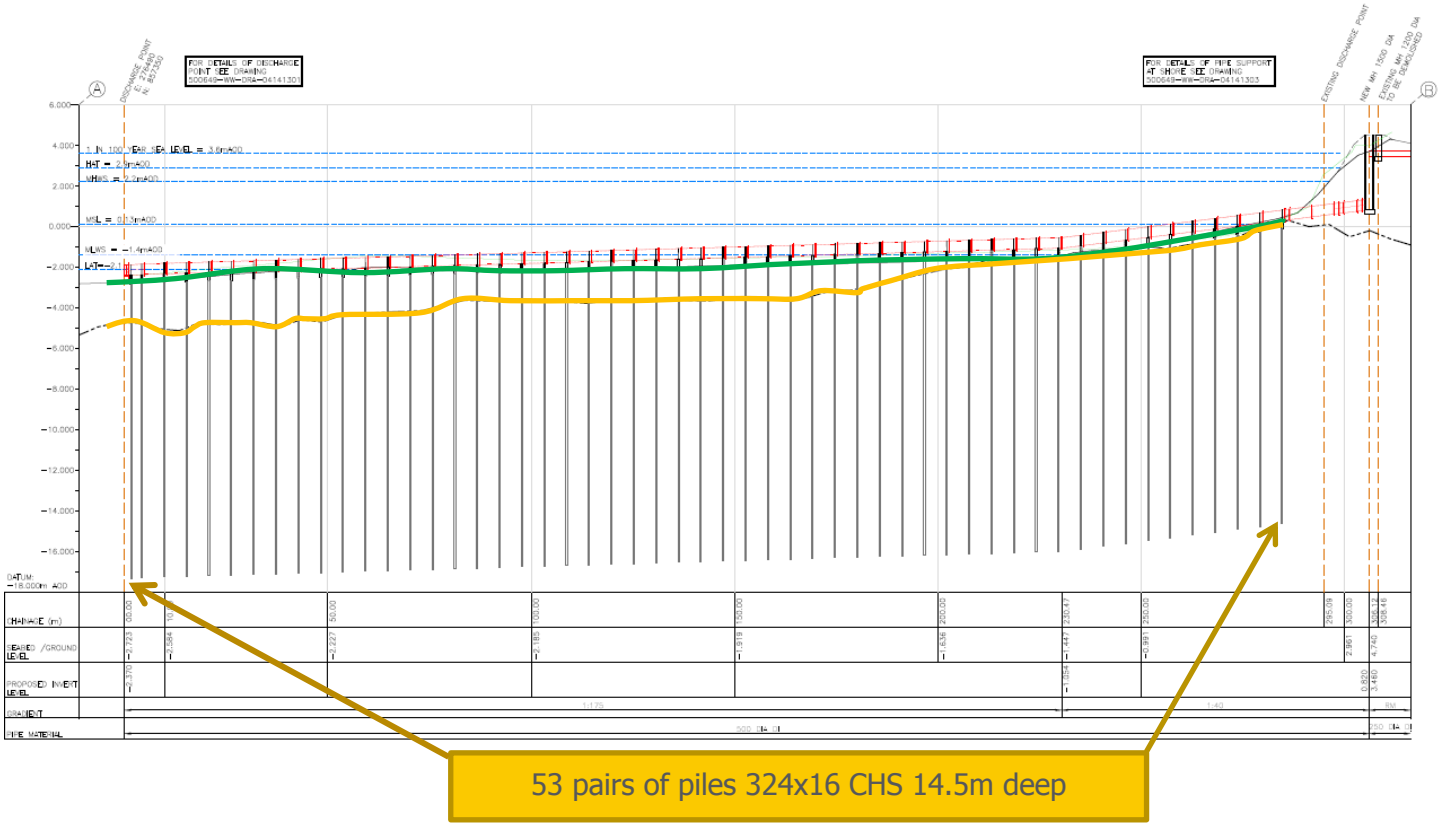
Figure 2: Approximate location of the works (highlighted in red)



1.2 The proposed works

1.2.1 The outfall pipe is 500mm diameter and formed of 5.5m lengths. Each length needs to be supported, so piles are proposed to be driven in pairs, 5.5m apart. Each pair would be connected by a cradle which would carry the pipe. The first 17 to 20m of the 300m long outfall is buried in the slope above the beach and it is not part of the scope of this report. Piling is then required for the remaining 283m of pipeline. This is 53 pairs of piles, a total of 106 piles which are planned to be driven to a depth of 14.5 below current sea bed level (see Figure 3). The two piles of each pair should be 1.0m centre to centre, each 0.5m from the pipe centreline. The pile heads should be at the same level so that a precast concrete cradle can be placed across them to carry the pipe. The proposed piles are steel piles 324x16 CHS (see Figure 4 below).[1]

Figure 3: Longitudinal section (Dwg No 500649-WW-DRA-04141200-0A)

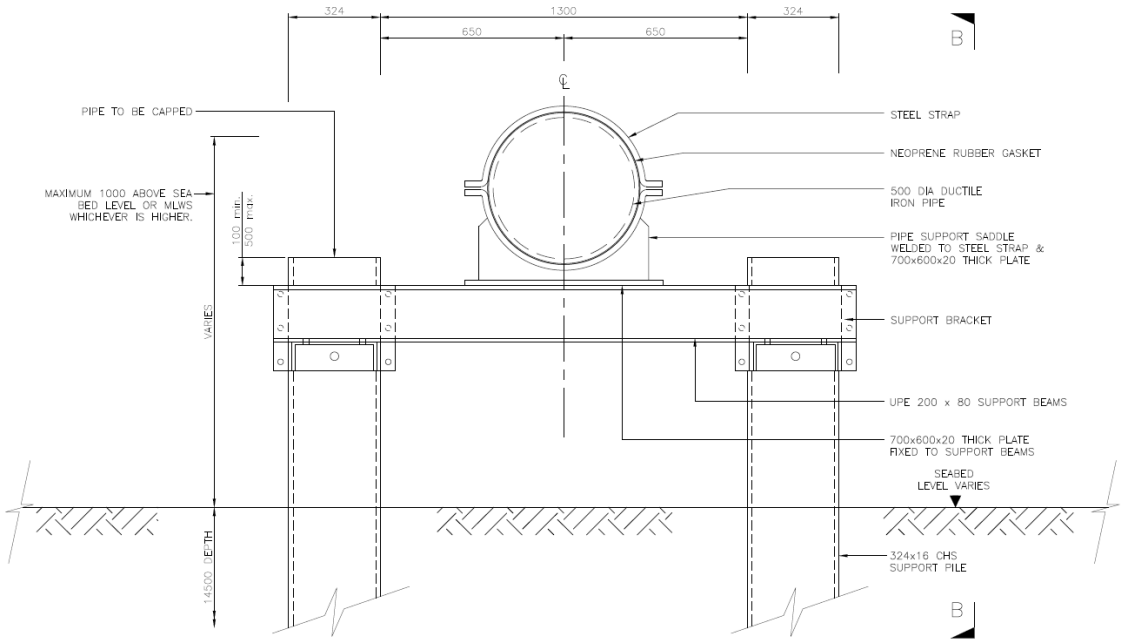


[1] 324x16 CHS – Circular Hollow Sections with an outside diameter of 324mm and a wall thickness of 16mm.

1.2.2 The outfall alignment runs across the beach to just below mean low water springs (MLWS), a distance of 300m. In the area of proposed piling, the bed level falls from +0.2m OD to -2.3m OD.[2] The whole length of the exposed outfall is covered at high tide, which occurs at +2.2m OD.[3] At MLWS the alignment is dry for the first 120m. Beyond that, the alignment is covered at all states of the tide but water depths are shallow.

1.2.3 Marine piling plant will be required to drive the piles, particularly at the seaward end. The shallow water depths may preclude easy movement of floating plant except at high tide. This could significantly delay construction. The use of land based plant is also limited to low tide. As noted all the works will take place in shallow waters (4.5m deep in the worst case of the last pile at -2.3m OD combined with a MHWS of +2.2m OD).

Figure 4: Pipe support detail (Dwg No 500649-WW-DRA-04141302-0A)



1.3 Stakeholder responses to the Marine Application

1.3.1 On 5 September 2016, Scottish Water submitted a marine licence application for the piled outfall.[4] Marine Scotland Science (MSS) and Scottish Natural Heritage (SNH) provided stakeholder responses to the application on 8 December and on 21 December 2016 respectively (see Appendix A).

[2] OD – Ordnance datum Newlyn, defined as the mean sea level at Newlyn in Cornwall between 1915 and 1921.
[3] The mean high water springs (MHWS) is at +2.2m OD.
[4] Application reference 06167 – Scottish Water – Extension to existing sea outfall – Ardersier, East of Fort George.

1.3.2 The Marine Licensing Officer from Marine Scotland drew attention to the following outstanding issues regarding the topic of this report:

- The request for further methodological information on noise sources by MSS.
- The potential noise effects on salmon as stated by MSS and SNH.
- The potential noise effects on marine mammals as stated by MSS and SNH.

1.3.3 Further methodological information on noise sources and specifically piling is provided in section 4 of this report.

1.3.4 Salmon is included in the group of diadromous fish. The concern is centred on the transit of salmon through the area of works rather than on the permanent presence of the fish. MSS (see paragraphs 1.3.5 and 1.3.6) and SNH (see paragraphs 1.3.7 and 1.3.8) highlighted the following:[5]

1.3.5 *Diadromous fish, including salmon, sea trout and eels will be present at or in the vicinity of the site. The site is at a narrow point on the inner Moray Firth. Two important salmon rivers, the River Ness and the River Beauly, lie up-estuary of the site and salmon smolts leaving these rivers and adult salmon returning to these rivers will therefore pass close to or through the site.*

1.3.6 *Diadromous fish should be given consideration by the developer in relation to best timing of the work, but MSS would note that, although some returning adult salmon and spawned salmon (kelts) may be present in the proposed period (9 January to 31 March) that this period will avoid the main runs of returning adult salmon, which take place later in spring and in summer, and the main runs of emigrating salmon smolts which are likely to take place in late April and May.*

1.3.7 *The River Moriston (NB special protection area SPA) is designated for Atlantic salmon and freshwater pearl mussel. Fish that access the River Moriston will use the inner Moray Firth. Freshwater pearl mussels rely on Atlantic salmon to fulfil their life history; therefore there is connectivity between the River Moriston SAC and this proposal.*

1.3.8 *The River Moriston smolt run occurs between March to July. There could therefore be a possibility that the work would coincide with the beginning of the smolt run and if the proposed work is delayed, it may coincide with a greater proportion of post-smolts migrating to sea. The degree to which Atlantic salmon might be affected by the underwater sound emissions depends on a number of factors, such the level of sound received by the fish and its frequency and duration. Atlantic salmon are categorised as hearing generalists with moderate sensitivity. Small fish i.e. smolts and exceptionally small grilse may be the most vulnerable to noise impacts.*

[5] See full context of the paragraphs in the MSS and the SNH responses in Appendix A.

1.3.9 The reference to marine mammals is mainly in relation to the bottlenose dolphin, since the works take place within the Moray Firth Special Area of Conservation (SAC) and the bottlenose dolphin is the primary reason for the designation of the site.[6] However, reference is also made to other marine mammals such as harbour porpoise (which is also a cetacean) and, both harbour seal and grey seal. MSS (see paragraph 1.3.10) and SNH (see paragraph 1.3.11) highlighted the following:

1.3.10 *This location lies just over 2 km from one of the most regularly used foraging locations for the Moray Firth SAC bottlenose dolphin population… bottlenose dolphins and harbour porpoise… are protected from intentional or reckless disturbance as European Protected Species... Both harbour seal and grey seal… haul out on the sandbanks near Ardersier and are known to use the waters of the inner Moray Firth… the region surrounding Ardersier and Chanonry Point, is a particularly sensitive area for marine mammals.*

1.3.11 *The underwater noise impacts on cetaceans from piling are well documented. We therefore conclude that there will be a likely significant effect on the bottlenose dolphin feature of the Moray Firth SAC. Consequently, Marine Scotland is required to carry out an appropriate assessment in view of the site's conservation objectives for the dolphins.*

1.3.12 MSS and SNH responses state that other species or aspects, such as marine fish ecology, commercial fisheries, aquaculture sites and, the common eider, long-tailed duck and diver interests of the Moray Firth proposed Special Protection Area (pSPA) are unlikely to be significantly affected by the works.

1.3.13 SNH advised that the proposal could be progressed with appropriate mitigation which is detailed as follows:

- *The construction period should take place between January to March.*
- *Vibro piling is used rather than impact piling (as per the 'noise assessment' document submitted with the application).*
- *A bubble curtain is used (as per the 'noise assessment' document).*
- *Adherence to JNCC's piling guidance (as per the 'noise assessment' document and outline methodology submitted with the application). This should include:*
    - *the use of trained MMO's;*
    - *a marine mammal exclusion zone of 500m radial distance of the sound source;*
    - *use of soft start/ ramp up;*
    - *30 min pre-start search of area.*[7]

[6] See the site details of the Moray Firth SAC on http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0019808.

[7] SNH notes in their response *"the suggestion to deploy a continuous noise source to avoid having to undertake full restart procedures following any breaks in construction activities and to facilitate working at night."* SNH states that *"Due to the lack of detail about this aspect of the proposal and its intended use we are unable to advise on the implications for the dolphins or if it represents suitable, alternative*

- *Construction of activities at night should use PAMs (as per Appendix 7 Marine traffic management plan submitted with the application).*

1.3.14 The proposed mitigation measures are discussed in section 7 below, some of which follow the proposals from SNH and some others are proposed alternatives once the piling methodology has been defined.

1.4 Purpose and scope

1.4.1 The purpose of this report is to address the outstanding issues raised by Marine Scotland Science (MSS) and Scotland Natural Heritage (SHN) in relation to the effects of the construction underwater noise on diadromous fish and marine mammals.

1.4.2 The scope includes the potential effects of noise during piling once the piling technique has been defined.

1.4.3 It is not part of the scope of this document to assess the noise from the multibeam echosounder which was used during the geological survey[8] or the deployment of a continuous sound source as a measure to ensure the no presence of animals near the works.[9]

mitigation. We therefore advise that any deviation from JNCC's piling guidance, including amendment of soft start times, pre-search times or use of 'scarers', will require further dialogue and agreement."

[8] A site investigation was conducted by Environmental Scientifics Group (ESG) on behalf of Amey – Black and Veatch to provide information on the ground conditions at the site. The site investigation comprised sonic bored boreholes and marine geophysical surveys. The fieldwork was carried out between 18 and 22 February 2016. The echosounder used during the survey is detailed in the appendixes (ESG's Ardersier Outfall Land & Marine Geophysical Survey ref. L6028-16 Rev. 2 of May 2016) of the Amey's Geotechnical Design Report ref. CO07430197 rev. 1 of September 2016.

[9] Acoustic Deterrent Devices (ADDs) as stated in JNCC's piling guidance are mentioned in the mitigation section (Joint Nature Conservation Committee – JNCC. *Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise.* August 2010). This assessment is not proposing the use of ADDs (see section 7 below).

2 Methodology

2.1 Guidance

2.1.1 This report follows the methodology in the NOAA Technical Memorandum NMFS-OPR-55 of July 2016 for effects on marine animals.[10,11] For effects on fish, it also follows the methodology in the NOAA Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities.

2.2 Sensitivity of receptors

2.2.1 Sensitive receptors (fish and marine mammals) are classified in different groups according to their hearing ranges. Since the effects of noise in fish is less known and it is still object of further research, this report considers a single sensitivity for all fish. However, marine mammals are divided in five groups: i. Low-Frequency (LF) Cetaceans, ii. Mid-Frequency (MF) Cetaceans, iii. High-Frequency (HF) Cetaceans, iv. Phocid Pinnipeds (PW) (Underwater) and v. Otariid Pinnipeds (OW) (Underwater).

2.3 Magnitude of impact

2.3.1 The magnitude of impact (ie level of noise from the source) is expressed in three acoustic parameters:

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[10] U.S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. *NOAA Technical Memorandum NMFS-OPR-55 – Technical Guidance for Assessing the Effects of Anthropogenic Sound and Marine Mammal Hearing – Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts.* July 2016.

[11] The NOAA's methodology uses three noise levels to describe the effects of noise on fish and marine mammals. These are peak sound pressure level (Lpk), sound exposure level (SEL) and sound pressure level (SPL) which is usually expressed in terms or root mean square (RMS). When detailed data of all three parameters are not available, the guidance from the Department of Transport of Washington State (WSDOT. *Biological Assessment Preparation. Advanced Training Manual Version 4-2017.* April 2017. Section 7.2 Construction Noise Impact Assessment – Underwater Noise) states the following:

> *It is not possible to convert peak levels to RMS levels directly, but a conservative rule of thumb can be applied in noise assessments. Peak levels are generally 10 to 20dB higher than RMS levels. To convert from peak to RMS, subtract 10dB. This likely overestimates the RMS value, but enables the assessment to remain as conservative as possible.*
> *Likewise, to convert from RMS to peak, add 20dB. This again may overestimate the actual peak noise level, but will provide a conservative estimate. Sound Exposure Level (SEL) is often used as a metric for acoustic events and is often used as an indication of the energy dose. SEL is calculated by summing the cumulative pressure squared (p^2), integrating over time, and normalizing to 1second. This metric accounts for both negative and positive pressures because p^2 is positive for both, and both are treated equally in the cumulative sum of p^2. The units for SEL are dB re:1µPa^{2}Sec.*

Other guidance uses a specific acoustic weighting for marine mammals called M-weighting. This is not used in this report. Conversely the Weighting Factors Adjustments (WFAs) from the NOAA's memorandum are used instead.

- Peak sound pressure level (Lpk);
- Sound exposure level (SEL); and
- Sound pressure level (SPL) expressed as root mean square (RMS).

2.3.2 The first parameter (Lpk) is a good descriptor of the physical damage caused by impulsive noise. The second parameter (SEL) is a good descriptor of the physical damage caused by cumulative noise. The third parameter (SPL) is usually described to define changes in behaviour.

2.4 Significance of effects

2.4.1 To assess the significance of effects, the following zones of impact can be defined.

Area of hearing injury (PTS and TTS) – significant adverse effects

2.4.2 The effects on the area of hearing injury are considered disturbing and therefore significant adverse effects.

2.4.3 PTS Permanent threshold shift (PTS) is a permanent reduction in hearing sensitivity caused by irreversible damage to the sensory hair cells of the ear. Given the source noise characteristics, a model that predicts the propagation of sound away from the source, and the noise exposure criteria, the radii within which impacts are expected to occur can be predicted.

2.4.4 TTS Temporary threshold shift (TTS) is a temporary reduction in hearing sensitivity as a result of exposure to sound. Exposure to high levels of sound over relatively short time periods can cause the same amount of TTS as exposure to lower levels of sound over longer time periods. The duration of TTS varies depending on the nature of the stimulus.

Area of responsiveness (Change of behaviour) – adverse effects

2.4.5 The effects on the zone of responsiveness may be considered intrusive and therefore adverse effects however non-significant.

2.4.6 The area of responsiveness is the area within which the considered marine mammal or fish might react behaviourally to the noise source. This zone can be smaller than the zone of audibility as marine mammals or fish usually do not show significant behavioural responses to noises that are faint but audible.

Area of audibility – non-adverse effects

2.4.7 The area of audibility is the area within which marine mammal or fish might hear the source noise but not show any significant behavioural response. The size of the zone of audibility is highly dependent on the ambient noise environment.

Other factors to be considered to define the significance of effect

2.4.8 The areas of impact define the likely environmental footprint of a noise source and indicate how far away a noise source is expected to have an impact on a marine mammal species, either behaviourally or physiologically. This information, together with information on the biological importance of the marine site as a habitat for the considered species, e.g. breeding, calving or resting areas, or confined migratory routes or feeding areas, is used to assess the likely impact of a noise source.

3 Sensitivity of receptor

3.1 Diadromous fish

Fish hearing

3.1.1 The main sensory organ in fish is the lateral-line system that detects low-frequency (<100Hz) particle motion in water. Audiograms developed for various fish species are based on noise pressure (see Figure 5 below). However, fish do not hear with noise pressure.[12] They hear with particle motion. Therefore, the thresholds and frequency ranges listed Figure 5 will likely be revised when those data are available. The sensitivity of salmon (see orange line in Figure 5) is relatively low.

3.1.2 Scottish Natural Heritage (SNH) stated in their response that *Small fish i.e. smolts and exceptionally small grilse may be the most vulnerable to noise impacts.* However, there seems to be no agreement in this and the guidance of Washington State citing Anderson (1992) suggests that juvenile fish may have less developed hearing abilities so the distance at which they could detect pile driving noises might be much less than adults.[13]

Potential behavioural impacts

3.1.3 The guidance from Washington State DOT citing Mueller et al. (1998) and Knudsen et al. (1992, 1997) indicates that noise intensity level must be 70 to 80 dB above the hearing threshold at 150 Hz to obtain a behaviour response for salmon. Citing Feist et al. (1992) states that broad - band pulsed noise (e.g., pile driving noise) rather than continuous, pure tone noises are more effective at altering fish behaviour. However, the noise level must be at least within the minimum audible field of the fish for the frequencies of interest (1 to 100 Hz for pile driving).

3.1.4 Behavioural sensitivity is lowest in flatfishes that have no swim bladder and also in salmonids (brown trout) in which the swim bladder is present but somewhat remote from the inner ear.

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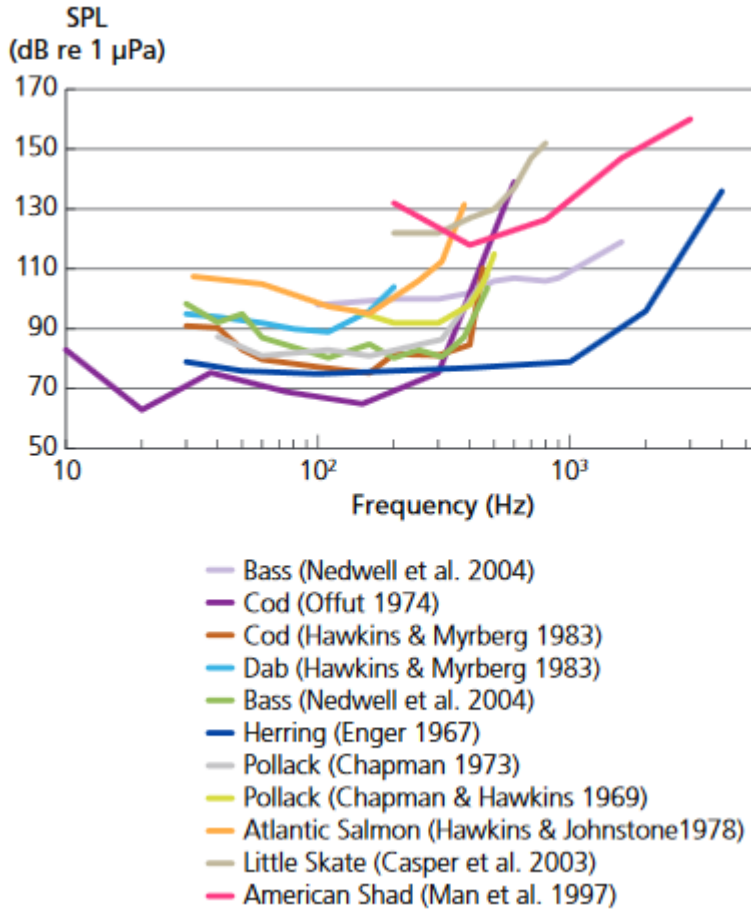
[12] In the Scotland's Marine Atlas – Clean and Safe Seas – 3.8 Underwater Noise, it is stated that *The issue of underwater noise is of concern and urgently requires more research. Future studies should focus on mapping and/or modelling ambient noise, observational and experimental studies, and the further development of frameworks for assessing noise related risks.*

[13] See more detailed discussion on the effects of noise on fish on Washington State Department of Transport, *Biological Assessment Preparation. Advanced Training Manual Version 4-2017.* Section 7 Construction Noise Assessment. Section 7.2.4.3 How Aquatic Species Hear. Section 7.2.4.4 Thresholds Levels and Section 7.2.4.5 Extent of Project-Related Noise and Effect Determinations.

Potential physiological impacts

3.1.5 High-intensity noises may temporarily or permanently damage the hearing of fish. Therefore, when evaluating potential injury impacts to fish, peak sound pressure (Lpk) is often used. This is usually related to underwater impulse-type noise. Impacts on fishes or other aquatic organisms have not been observed in association with vibratory hammers. This may be due to the slower rise time and the fact that the energy produced is spread out over the time it takes to drive the pile. As such, vibratory driving of piles is generally considered less harmful to aquatic organisms and is the preferred method.[14,15]

Figure 5: Audiograms of fish regularly occurring in UK waters. Source: Scotland's Marine Atlas – Clean and Safe Seas – 3.8 Underwater Noise



[14] The wave form may also need to be considered. Although peak sound levels may be similar, a slower rise time means that the shock wave produced with each impulse is not as severe presumably resulting in less damage to fish. The effect is similar to the difference between a push and a punch.
[15] Lethal impacts associated with noise risk of injury or mortality for aquatic species and fish associated with noise, in general, is related to the effects of rapid pressure changes, especially on gas filled spaces in the body. Rapid volume changes of the swim bladder may cause it to tear, reducing hearing sensitivity in some hearing specialist species, and loss of hydrostatic control.

3.1.6 This document follows the NOAA model. The criteria used for the onset of physical injury and adverse behavioural effects are listed in the table below. The onset of physical injury uses dual criteria - peak pressure and SEL. The onset of physical injury is expected if either of these criteria are exceeded. The criterion for accumulated SEL is based upon the mass of the fishes under consideration. If fishes smaller than 2 grams are present, then the more conservative 183 dB SEL criterion may be required.

Table 1: Onset of physical injury and behavioural effects for fish

Effect	Metric	Fish mass	Threshold
Onset of physical injury	Peak pressure	N/A	206 dB (re: 1 µPa)
	Accumulated Sound Exposure Level (SEL)	≥ 2 g	187 dB (re: $1\mu Pa^2 \cdot sec$)
		< 2 g	183 dB (re: $1\mu Pa^2 \cdot sec$)
Adverse behavioural effects	Root Mean Square Pressure (RMS)	N/A	150 dB (re: 1 µPa)

3.2 Marine mammals

Marine mammals hearing

3.2.1 Figure 6 shows the different sensitivity of different marine mammals to sound. Different marine mammals are sensitive to different frequencies of sound. The frequencies ranges are much higher than for fish.

Potential behavioural impacts

3.2.2 Marine mammals produce sounds in various contexts and use sound for various biological functions including social interactions, foraging, orientation, and predator detection. Interference with producing or receiving sounds could have negative consequences including impaired foraging efficiency from masking, altered movement of prey, increased energetic expenditures, and temporary or permanent hearing threshold shifts due to chronic stress from noise.

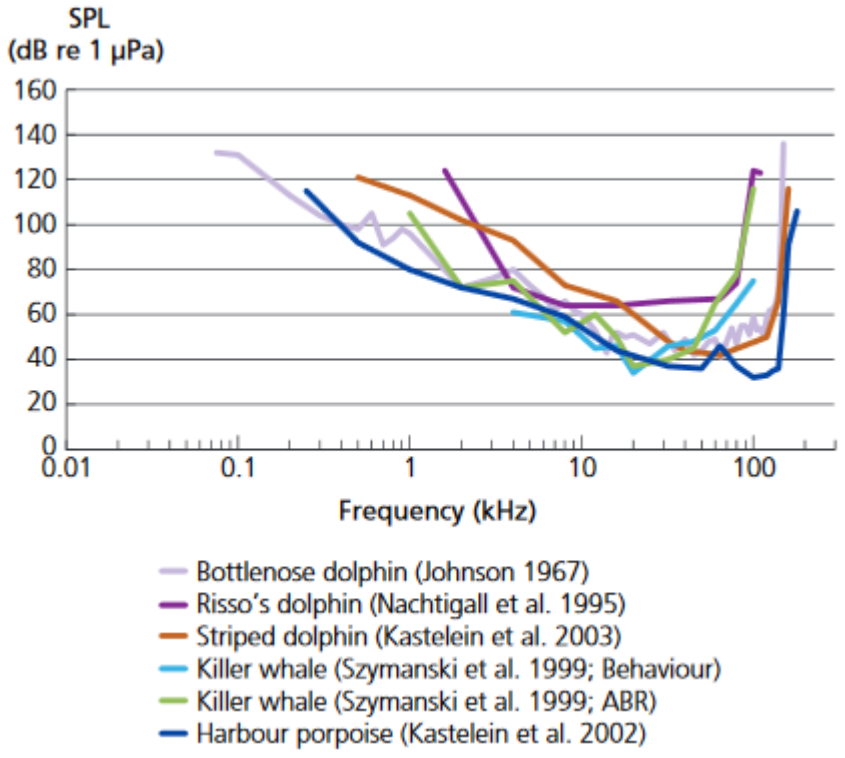
Potential physiological impacts

3.2.3 Exposure to chronic or high levels of sound may result in physiologic effects to hearing or, in extreme cases tissue damage or stranding. Temporary threshold shift (TTS) occurs when the auditory system is exposed to a high sound level over a duration that causes the cochlear cilia cells to fatigue and results in a temporary decrease in hearing sensitivity. The hearing sensitivity returns when the cilia cells return to their normal

3.2.4 Permanent threshold shift (PTS) is the term used when hearing sensitivity is permanently altered from high levels of sound exposure due to damage of the cochlear cilia cells. High levels of sound exposure may result in haemorrhaging around the brain and ear bones. Other results from intense acoustic exposure, such as naval sonar, may lead to stranding of cetaceans, either from behavioural reactions or injury.

3.2.5 A sound source's frequency compared to a species hearing frequency range, as well as the intensity and energy from the source that are received by an animal, affect the potential for sound to cause masking, a behavioural response, or physical injury. Washington State guidance, citing Southall et al. (2007) notes, that even in well controlled studies, behavioural responses in marine mammals and conditions which elicit the response are highly variable and strongly dependent upon the context of exposure and by an individual subject's prior experience, motivation, and conditioning.

Figure 6: Audiograms of some marine mammals. Source: Scotland's Marine Atlas – Clean and Safe Seas – 3.8 Underwater Noise



3.2.6 As said, different mammals have different sensitivity to noise. The NOAA's guidance divides marine mammals into five different groups as shown in the table below.

Table 2: Onset of physical injury and behavioural change for marine mammals

Hearing group	PTS		TTS[16]	Behavioural change
	dB Peak SPL	dB SEL_{cum}	dB SEL_{cum}	dB RMS
Low-Frequency (LF) Cetaceans	219	199	179	120
Mid-Frequency (MF) Cetaceans	230	198	178	120
High-Frequency (HF) Cetaceans	202	173	153	120
Phocid Pinnipeds (PW) (Underwater)	218	201	181	120
Otariid Pinnipeds (OW) (Underwater)	232	219	199	120

3.2.7 Of the species of concern in this report, bottlenose dolphin is classified as a mid-frequency (MF) cetacean, harbour porpoise as a high-frequency (HF) cetacean and, both harbour seal and grey seal as a phocid pinnipeds (PW).[17]

[16] Estimated as 20 dB lower than the PTS. This is considered a robust assumption.
[17] The later referred to hearing thresholds underwater.

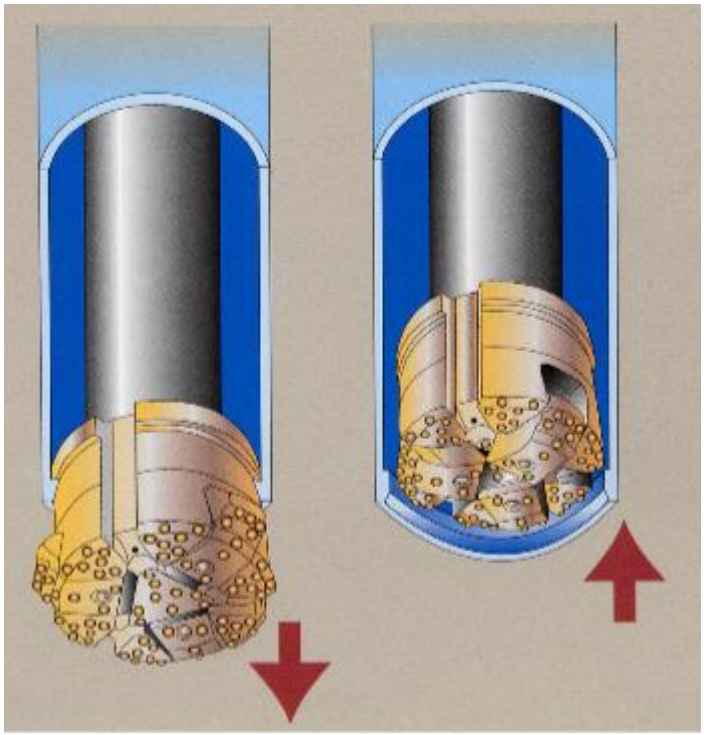
4 Magnitude of impact

4.1 Odex piling

4.1.1 The chosen piling methodology is Odex piling (see Figure 7).[18] Odex piling is a percussive drilling technology where the excentric drill bit swings out creating a hole with a diameter greater than that of the steel casing. This allows the steel casing to traverse down behind the drill bit without having to first remove the drill bit in order to insert the casing.

4.1.2 Once desired depth has been reached, the drill bit wings swing back in allowing the drill to be removed back up through the casing. It has advantages in unstable soil since it leaves the surrounding ground undisturbed.

Figure 7: Overburden drill bits in drilling position (left) and in retract position (right)



4.1.3 The hammer is driven by air. The percussion rate by the hammer is 1235 blows per minute at a pressure of 17 bar. This high rate of percussion means that the noise produced by the source is continuous rather than impulsive and therefore similar to vibratory piling.

[18] Odex stands for Overburden Drilling Excentric.

4.2 Noise levels from Odex piling

4.2.1 There is limited guidance on the underwater noise levels caused by Odex piling (i.e. percussive drilling piling) with most of the guidance referring to driven piling or to vibratory piling. Therefore, this report does not use actual underwater noise levels from Odex piling. The underwater noise produced by Odex piling used in this report has been estimated from measurements taken in air. It is recognised that the approach of converting noise levels in air to noise levels in water is preferably avoided however it has not been possible in this case.[19]

4.2.2 The noise levels used as a reference were measured by the company Van Elle using similar Odex machinery than the one proposed in this document. The piling advanced at an average speed of 2.5m per minute. The reported noise level of 107dB(C) at the operator were transformed to 111dB(Z) at 1m from the source in air and at the same time this level was converted to 173dB,RMS,re:1µPa at 1m from the source. Peak levels have been estimated as 15dB above the RMS level whereas the SEL has been estimated as 10dB below the RMS level (see Table 3 below).[20,21]

Table 3: Estimated magnitude of impact of Odex piling

	Acoustic Metric		
	Peak	**SEL[22]**	**RMS**
Estimated level (dB)	188	163	173
Distance (m)	1	1	1

4.2.3 As said above, Odex piling is a percussive technique. However, the high rate of percussion has as a consequence that the noise from Odex piling may be defined as non-impulsive continuous sound. Around 60% of the acoustic energy is concentrated between 1,000 and 2,000Hz and around 75% of the acoustic energy is concentrated between 500Hz and 2,000Hz.

[19] This report recommends recording underwater noise measurements during the installation of the first piles part of the works to overcome the lack of direct underwater sound levels.
[20] We used the approximation of adding 62dB to the noise levels in air. This accounts for the conversion between dB re: $20x10^{-6}$Pa and dB re $1x10^{-6}$Pa and for the different speed of sound and density for water and air.
[21] The 173dB,RMS have been estimated to produce a peak level of 188dB Lpk and a SEL of 163dB.
[22] Estimated SEL for impact piling per strike.

5 Assessment

5.1 Diadromous fish

5.1.1 Table 4 shows the expected results of the Odex piling at different distances in terms of noise.[23] Since Odex piling is more similar to vibratory piling than to impulsive driven piling, it is not expected to produce impulsive Lpk noise at relevant levels. Moreover, as noted in paragraph 4.2.3, the Odex piling is expected to produce most of the energy between 500Hz and 2,000Hz in a range where according to Figure 5 it is beyond the area of audibility of salmon.

Table 4: Potential zones of impact by species without mitigation

Species	PTS	TTS	Behavioural response	Audible
Salmon	0m	0m	34m	---

5.1.2 Consequently, it is likely that the Odex piling will not produce either significant or non-significant adverse effects on diadromous fish.

5.2 Marine mammals

5.2.1 Table 5 shows the assumptions for a non-impulsive stationary continuous noise such as the considered for the Odex piling. Table 6 shows the expected results of the Odex piling at different distance in terms of noise.[24]

Table 5: Assumptions made to estimate the areas of impacts to marine mammals

Source Level (RMS SPL)	173
Activity Duration (hours) within 24-h period	12
Activity Duration (seconds)	43200
10 Log (duration)	46.35
Propagation (xLogR)	15
Distance of source level measurement (meters)	1

[23] Spreadsheet available on http://www.wsdot.wa.gov/NR/rdonlyres/1C4DD9F8-681F-49DC-ACAF-ABD307DAEAD2/0/BA_NMFSpileDrivCalcs.xls
[24] Spreadsheet available on http://www.wsdot.wa.gov/NR/rdonlyres/673DC5DA-013E-41A3-B4A7-2B25DD7C9E5A/0/MMspreadsheet.xlsx

Table 6: Potential zones of impacts by hearing groups without mitigation

Hearing Group	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds
SEL_{cum} Threshold	198	173	201
PTS Isopleth to threshold (meters)	1.3	19.9	12.2
TTS Isopleth to threshold (meters)[25]	28.0	428.7	262.8

5.2.2 In the worst-case scenario Odex piling noise without mitigation is expected to be disruptive up to around 430m for harbour porpoise (high-frequency cetacean). The impact would be lower for dolphins (mid-frequency cetaceans) and seals (phocid pinnipeds). Therefore, the marine mammal exclusion zone of 500m proposed by SNH is appropriate.

5.3 Cumulative effects

5.3.1 As the area with potential disruption is limited to up to around 430m from the piling works it is considered that there will be no cumulative adverse effect from other developments such as the Beatrice offshore wind farm and the Aberdeen Harbour Expansion Project.

[25] Assumption of TTS 20dB lower than PTS.

6 Assumptions and limitations

6.1.1 The noise levels from Odex piling used in this assessment are based on noise measurements in air. The data used (noise levels and frequency spectrum) was gathered from different sources where the type of ground was not specified and no detail of the peak sound pressure level was provided. The ground in the area is described as a layer of sand for the first 1.6m on average followed by dense and very dense gravel. No bedrock is expected. Therefore, the actual noise levels on site may vary (either increase or decrease) from the ones assumed in this report. The same applies to the frequency spectrum.

7 Mitigation

7.1 Reduction of noise at the source

7.1.1 As described above, some of the piling may occur in the dry and some in very shallow waters.[26] In addition, the point of more transmission into the water will be at the first contact point where most of the ground will be sands and therefore when the noise levels will be potentially lower.[27]

7.1.2 Therefore, to reduce the noise at the source we would recommend the following:

1. As far as practicable, piling for each pile should start in the dry or in low tide when the water is at the shallowest.[28]

7.2 Reduction of noise during the transmission path

7.2.1 SNH advice is to use a bubble curtain (as per the 'noise assessment' document). Use of bubble curtain is usually effective in reducing peak sound pressure levels for impulsive noise. However, it is not clear whether their use would be effective in the case of reducing noise from Odex piling where the relevance of peak sound pressure levels may be limited. Therefore, the use of bubble curtains is not recommended in this report.

7.3 Reduction of noise at the receptor

7.3.1 To reduce the noise received by aquatic species the following is proposed:

2. A marine mammal exclusion zone of 500m radial distance of the piling works;
3. The use of trained MMO's;

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[26] It is usually considered that no acoustic energy is transmitted in waters shallower than 2 feet/0.7m.
[27] The paper Willis, MR, Broudic, M, Bhurosah, M and Masters, I, *Noise Associated with Small Scale Drilling Operations,* 6 October 2010; shows that the noise level from percussive drilling is smaller the deeper the drill bit into the ground likely due to the abortion of the ground above (e.g. noise transmitted and absorbed by the sands and gravels that will surround the drill bit at deeper depths). This is called sound flaking.
[28] Impact driving in the dry can also generate underwater noise in adjacent aquatic habitats. Sound flanking occurs when a pressure wave travels down the pile, is transmitted into the soil, and then travels back up through the soil and into the water column. Pile driving in the dry is a minimization measure designed to reduce the amount of sound that is transmitted through the water. There are methods for calculating transmission loss from pile driving in the air and a method for calculating transmission loss from pile driving in the water. There is no method for calculating transmission loss through soil outside of the water, and then calculating the loss in the water. What it is not known is how much transmission loss occurs within the soil – the assumption is that it is greater than what occurs in water or air due to the denseness of the soil. It is known that soil type - density and composition can affect transmission loss. It is impossible to predict what the transmission loss in soil will be and what the sound level will be at when it enters the water column.

4. 30 min pre-start search area. During early morning and evening when it is expected to still be dark, PAMs will be used instead of direct observation of mammals;
5. Use of soft start/ramp up;
6. The construction period should take place between January and April.

7.3.2 Since the piling noise is not expected to be disruptive for diadromous fish, it is proposed not to use ADDs.

7.4 Reduction of the uncertainty of the results of this assessment

7.4.1 As previously indicated, the findings of this report are made with some caution due to the limited availability of monitoring data from Odex piling underwater.. Therefore, we would recommend that for the initial piling noise is monitored with an hydrophone to ensure that noise levels at around 10m from the source are at around or below 154 dB,RMS,re: 1µPa with no relevant impulsive noise. If this is not the case, the findings of this report and therefore the proposed mitigation measures should be revisited.

8 Summary and conclusions

8.1 Potential effects

8.1.1 No significant adverse effects to diadromous fish (ie physical damage) are expected.

8.1.2 Permanent significant adverse effects to mid-frequency cetaceans (bottlenose dolphin), high-frequency cetaceans (harbour porpoise) and phocid pinnipeds (harbour seal and grey seal) are not expected beyond 2, 20 and 13m of the piling works respectively. Temporary significant adverse effects may occur up to 28, 430 and 263m of the piling works for mid-frequency cetaceans (bottlenose dolphin), high-frequency cetaceans (harbour porpoise) and phocid pinnipeds (harbour seal and grey seal) respectively.

8.2 Mitigation measures

8.2.1 The following management and mitigation procedures are recommended to be included into contract documentation:

- A marine mammal exclusion zone of 500m radial distance of the piling works;
- The use of trained MMO's;
- 30 min pre-start search area. During early morning and evening when it is expected to still be dark, PAMS will be used instead of direct observation of mammals;
- Use of soft start/ramp up;
- The construction period should take place between January and April.
- For the initial piling noise shall be monitored by the use of an hydrophone to ensure that levels at around 10m from the source are no greater than around 154dB,RMS,re: 1µPa with no relevant impulsive noise; and
- The contractor will produce and retain a compliance and sighting report which will made available on request.

8.3 Residual effects

8.3.1 No residual significant adverse effects are expected if the mitigation measures above are followed.

9 Marine Noise Registry Service

9.1.1 Defra and JNCC have developed the Marine Noise Registry (MNR) to record human activities in UK seas that produce loud, low to medium frequency (10Hz – 10kHz) impulsive noise.[29] Developing the MNR was a commitment made in the UK Marine Strategy.

9.1.2 The Monitoring Guidance for Underwater Noise in European Seas[30] states the following:

- The emphasis of the register is not on "impulsive sounds" as such, but on sound of "short duration", of which impulsive sounds are mentioned as an example.
- Whereas sounds produced by piling (NB impact pile driven), airguns and explosions typically are short (less than one second), sonar sounds may be of longer durations, i.e. several seconds. To cover all sources of concern TSG Noise[31] proposes that all loud sounds of duration less than 10 seconds should be included.
- The most important sound-sources that should be considered for inclusion in the register are airguns, pile-driving, explosives, sonar working at relevant frequencies and some acoustic deterrent devices. Additional sources that could also be of concern include boomers, sparkers and scientific echo sounders.

9.1.3 It is our opinion, that the Odex piling is not included within the definition of impulsive (or short term) noise as described above and therefore the works would not need to be registered in the Marine Noise Registry Service.

9.1.4 However, since the Marine Noise Registry Service is a new service (the website is still as a beta version), the authority may want to register the works as a precautionary measure.

[29] https://mnr.jncc.gov.uk/
[30] https://ec.europa.eu/jrc/sites/jrcsh/files/lb-na-26555-en-n.pdf
[31] TSG Noise stands for Technical Sub-Group on Underwater Noise and other forms of Energy, established in 2010 by the Marine Directors of the European Union (EU).

Appendix A Scottish Natural Heritage and Marine Scotland Science response to the original application

A.1 Scottish Natural Heritage response

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

By email only to: ms.marinelicensing@scotland.gsi.gov.uk

Our ref: CNS/MSA/HI/ML-IMF/A2169403

21st December 2016

Dear Jessica

MARINE (SCOTLAND) ACT 2010, PART 4 MARINE LICENSING
06167 - SCOTTISH WATER - EXTENSION TO EXISTING SEA OUTFALL - ARDERSIER WWTW OUTFALL, EAST OF FORT GEORGE

Thank you for your e-mail dated 9th December 2016 inviting our comments on the above consultation and for granting us a two-week extension within which to respond.

SUMMARY

This proposal could be progressed with appropriate mitigation. However, because it could affect internationally important natural heritage interests, we object to this proposal unless it is made subject to conditions so that the works are done strictly in accordance with the mitigation detailed below.

BACKGROUND

The applicant, Scottish Water, proposed to start the work in January 2017 but we were notified by them on 16th December 2016 that they now intend to defer the proposed works to January 2018. Scottish Water have stated they would like to continue to progress this application, noting the change to the construction programme, but with all other details as per information already provided.

APPRAISAL OF THE IMPACTS OF THE PROPOSAL AND ADVICE

The proposal is within the Moray Firth Special Area of Conservation (SAC) and the Moray Firth proposed Special Protection Area (SPA). It is close to the Inner Moray Firth SPA and it could affect the Dornoch Firth and Morrich More SAC and the River Moriston SAC. Further information on these designated sites can be seen at http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=8488.

The status of these sites mean that the requirements of the Conservation (Natural Habitats, &c.) Regulations 1994 as amended (the "Habitats Regulations") apply. The SNH website has a summary of the legislative requirements (http://www.snh.gov.uk/docs/A423286.pdf).

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Tel: 01349 865333 Website: www.snh.gov.uk

Dualchas Nàdair na h-Alba, Slighe Fodhraitidh, Pàirc Gnìomhachas Inbhir Pheofharain, Inbhir Pheofharain, Siorrachd Rois. IV15 9XB
Fòn: 01349 865333 Làrach-lìn: www.snh.gov.uk/gaelic

APPRAISAL OF THE IMPACTS OF THE PROPOSAL AND ADVICE

Moray Firth SAC - dolphins

We understand that the proposal is for 106 piles to be constructed between January and May 2018. The construction will be 24 hours a day but the piles/piling technique has not been finalised. We note the suggestion to use vibro piling which will reduce noise levels.

The underwater noise impacts on cetaceans from piling are well documented. We therefore conclude that there will be a likely significant effect on the bottlenose dolphin feature of the Moray Firth SAC. Consequently, Marine Scotland is required to carry out an appropriate assessment in view of the site's conservation objectives for the dolphins. To help you do this, we advise that in our view, on the basis of the information provided, if the proposal is undertaken strictly in accordance with the following mitigation then it will not adversely affect the integrity of the SAC.

- The construction period should take place between January to March.
- Vibro piling is used rather than impact piling (as per the 'noise assessment' document submitted with the application).
- A bubble curtain is used (as per the 'noise assessment' document).
- Adherence to JNCC's piling guidance (as per the 'noise assessment' document and outline methodology submitted with the application). This should include:
    - the use of trained MMO's;
    - a marine mammal exclusion zone of 500m radial distance of the sound source;
    - use of soft start/ ramp up;
    - 30min pre-start search of area.
- Construction of activities at night should use PAMs (as per Appendix 7 Marine traffic management plan submitted with the application).

We note the suggestion to deploy a continuous noise source to avoid having to undertake full restart procedures following any breaks in construction activities and to facilitate working at night. Due to the lack of detail about this aspect of the proposal and its intended use we are unable to advise on the implications for the dolphins or if it represents suitable, alternative mitigation. We therefore advise that any deviation from JNCC's piling guidance, including amendment of soft start times, pre-search times or use of 'scarers', will require further dialogue and agreement.

Mention that sandbank feature won't be significantly affected?

Moray Firth pSPA

In our view, this proposal will have a likely significant effect on the common eider, long-tailed duck and diver interests of the pSPA. Survey data used for identifying the features of the SPA show that the immediate area of the proposal has a low density of eider use, a moderate to high density of long-tailed duck use and a high density of diver use. There is therefore the potential for these species to be disturbed and/or displaced by the construction phase. Increased turbidity from mobilised sediment resulting from the works may also deter divers from feeding in the area. Consequently, Marine Scotland, as competent authority, is required to carry out an appropriate assessment in view of the site's conservation objectives for these qualifying interests.

To help you do this we advise that, in our view, based on the information provided, the proposal will not adversely affect the integrity of the site. This is because only a small area of the pSPA will be impacted by these works and the main wintering areas with the highest densities for these three species are all in other parts of the site. It is therefore very likely that

any birds displaced from the immediate area of the works will be able to use alternative feeding areas within the pSPA. Furthermore, the proposal is temporary and time limited and therefore it will not result in a permanent displacement of these qualifying interests. The possibility of the loss of a small area of foraging habitat is dependent on the substrate present and the existing in sediment fauna. Even if there is feeding suitable habitat present, the area is a tiny proportion of the pSPA as a whole.

Inner Moray Firth SPA

In our view, it is unlikely that the proposal will have a likely significant effect on any qualifying interests either directly or indirectly. This is because the works are approximately 700m from the SPA boundary. An appropriate assessment for the features of this site is therefore not required.

Dornoch Firth and Morrich More SAC – common seal

Significant numbers of common seals haul out at Whiteness Head approximately 3km away. This is less than 50km from the Dornoch Firth and Morrich More SAC and common seals are a qualifying interest of that site. There is therefore connectivity between that SAC and the common seals that occur at Whiteness Head.

As far as this feature is concerned, we are of the view that the proposal is unlikely to have a significant effect. The proposal is short lived and temporary in nature, it is some distance from the haul out site at Whiteness Head and it is outwith the common seal breeding season (June – August). Adherence to JNCC's piling guidance will also help to minimise disturbance to seals.

River Moriston SAC

The River Moriston is designated for Atlantic salmon and freshwater pearl mussel. Fish that access the River Moriston will use the inner Moray Firth. Freshwater pearl mussels rely on Atlantic salmon to fulfil their life history; therefore there is connectivity between the River Moriston SAC and this proposal.

In our view, this proposal is likely to have a significant effect on the Atlantic salmon and freshwater pearl mussel interests of this SAC. The works are proposed to be carried out between January and May 2018. The spring stock component will be approaching rivers at that time of year and may pass near to the development. The River Moriston smolt run occurs between March to July. There could therefore be a possibility that the work would coincide with the beginning of the smolt run and if the proposed work is delayed, it may coincide with a greater proportion of post-smolts migrating to sea. The degree to which Atlantic salmon might be affected by the underwater sound emissions depends on a number of factors, such the level of sound received by the fish and its frequency and duration. Atlantic salmon are categorised as hearing generalists with moderate sensitivity. Small fish i.e. smolts and exceptionally small grilse may be the most vulnerable to noise impacts. Increased turbidity associated with the works may also affect migrating fish. Consequently, Marine Scotland, as competent authority, is required to carry out an appropriate assessment in view of the site's conservation objectives for these qualifying interests.

To help you do this, we advise that in our view, on the basis of the information provided, if the proposal is undertaken strictly in accordance with the following mitigation, then it will not adversely affect the integrity of the SAC.

- Vibro piling is used rather than impact piling (as per the 'noise assessment' document submitted with the application).
- A bubble curtain is deployed (as per the 'noise assessment' document).

- Soft start/ramp up procedures are deployed (in accordance with JNCC's piling guidance).

OTHER COMMENTS

European Protected Species

We note that MS-LOT have asked Scottish Water to submit an EPS licence application for disturbance of dolphins associated with the proposed outfall construction.

The 'noise mitigation' document submitted with the application states that the multibeam surveys will be undertaken at 455kHz although the noise monitoring section 4.5.4 in the 'Outline Methodology' document states that it will be between 10-500kHz. If the multibeam survey is above 200kHz then it should be outwith the hearing capabilities of harbour porpoise (species which can hear the highest frequencies) and thus will not require any mitigation. If it is below 200kHz then it will be detected by porpoise and an EPS licence should also be sought for this species. Furthermore, we would advise that an MMO should be present during these surveys.

CONCLUSION

Please contact Ben Leyshon (ben.leyshon@snh.gov.uk) if you have any questions or require further clarification on any points raised in this letter.

Yours sincerely,

STEVE NORTH
Operations Manager
South Highland
Email: steve.north@snh.gov.uk

Cc: Kirsty Windle – Scottish Water - kirsty.windle2@scottishwater.co.uk

A.2 Marine Scotland Science response

marinescotland science

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The Scottish Government

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SCOTTISH WATER - EXTENSION TO EXISTING SEA OUTFALL - ARDERSIER WWTW OUTFALL, EAST OF FORT GEORGE – MSS COMMENTS

Marine Scotland Science (MSS) has reviewed the submitted marine licence application and has provided the following comments.

benthic ecology
MSS notes that there is very little information provided on most ecological impacts from this development. In Preliminary Surveys, Section 3.2 of the Outline Methodology document mention is made of possible topographic and hydrographic surveys; these could be extended to include observations on intertidal and shallow subtidal benthic ecology. Baseline data on benthic habitats in the area of the proposed outfall extension would be welcome.

physical environment
MSS has no comments on physical environment.

marine mammals
MSS welcome the opportunity to review this application, and we have various comments on the documents.

This location lies just over 2 km from one of the most regularly used foraging locations for the Moray Firth SAC bottlenose dolphin population. The primary aim of the SAC is to maintain the favourable conservation status of the local bottlenose dolphin population (Habitats Directive Annex II). Additionally, bottlenose dolphins and harbour porpoise (and all other cetaceans in EU waters) are protected from intentional or reckless disturbance as European Protected Species (Habitats Directive Annex IV). Both harbour seal and grey seal (protected under the Marine (Scotland) Act 2010) haul out on the sandbanks near Ardersier and are known to use the waters of the inner Moray Firth.

For these reasons the inner Moray Firth, specifically the region surrounding Ardersier and Chanonry Point, is a particularly sensitive area for marine mammals.

The applicant states intention to use trained and experienced Marine Mammal Observers, working within the JNCC guidelines, to ensure no marine mammals are in the vicinity of noisy activities (e.g.multibeam echosounder, piling) during surveys and construction. This is welcomed, however, MSS consider that further details of the construction methodology are required before we can provide an opinion on the likely effects to marine mammals, and bottlenose dolphins in particular, and whether the proposed mitigation us sufficient. In particular, we seek additional clarity on the following issues:

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In section 4.5.4 of construction methodology:

- The applicant mentions the deployment of a continuous sound source. MSS seek clarification on what this might be, and its intended use.
- Multibeam echosounder average source level reported as 176.7 dB. This is of limited value as the highest source level that will be used should be reported so MSS can assess the possible impacts on marine mammals.
- Multibeam echosounder frequency range reported as 10 – 500 kHz. This is of limited value, as no appraisal on the risks to marine mammals can be made from such a large range of sound frequencies. We seek clarification on what frequency will be used during MBES surveys.
- Piling technique has not been finalised. We request further details on the piling method to be used as this is likely to influence the levels of noise produced.

Because of the location of this development within a Natura site we suggest that there may be a requirement for an Appropriate Assessment on impacts to the Moray Firth SAC. This will have to take into account cumulative effects of other developments that may impact on the SAC population, e.g. Beatrice offshore wind farm, Aberdeen Harbour Expansion Project. SNH will be able to advise if this is necessary.

Given the information provided we cannot rule out the risk of disturbance to EPS. For this reason an EPS licence to disturb may be required for hydrographic surveys, piling operations and deployment of a continuous sound source.

marine fish ecology
MSS has no comments on marine fish ecology.

commercial fisheries
MSS has no comments on commercial fisheries.

diadromous fish
Diadromous fish, including salmon, sea trout and eels will be present at or in the vicinity of the site. The site is at a narrow point on the inner Moray Firth. Two important salmon rivers, the River Ness and the River Beauly, lie up-estuary of the site and salmon smolts leaving these rivers and adult salmon returning to these rivers will therefore pass close to or through the site.

The potential effects of the survey and construction work involved, which include noisy and disturbing activities, and the finished structure itself, and the likely effectiveness of the proposed mitigation measures will need to be given consideration by the developer in relation to diadromous fish receptors. In addition, part of the River Ness system, the River Moriston, is a SAC of salmon, so HRA in respect of this will also be required. MSS notes that SNH was consulted by the developer and would have expected SNH to have pointed this out.

Consideration may need to be given to whether this element of the HRA should be done jointly with the other regulator which is involved in aspects which could affect salmon – SEPA, which is particularly concerned with the water quality aspects, including in relation to the discharge itself. Diadromous fish should be given consideration by the developer in relation to best timing of the work, but MSS would note that, although some returning adult salmon and spawned salmon (kelts) may be present in the proposed period (9 January to 31 March) that this period will avoid the main runs of returning adult salmon, which take place later in spring and in summer, and the main runs of emigrating salmon smolts which are likely to take place in late April and May. MSS also notes that the applicant sees no requirement for a licence for sea disposal of excavated material. It will be for MS-LOT to determine whether this is correct.

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aquaculture
MSS aquaculture planning has no specific comments to make on the Scottish Water application for an extension to the existing sea outfall at Ardersier Wastewater Treatment Works Outfall (WwTW) Outfall, East of Fort George.

There are no aquaculture sites within the immediate vicinity of the Ardersier WwTW (see map in annex 1).

There are four active shellfish sites within the Moray Firth area, three in Cromarty Bay - a mussel long line site operated by Cromarty Mussels, a pacific oyster trestle site operated by Black Isle Seafood Ltd. and another pacific oyster trestle site operated by MacKenzie Oysters. There is also a wild bed of common mussels in the Dornoch Firth operated by the Highland Council. There are no other marine aquaculture sites on the east coast of Scotland to the south of the proposed development until North Berwick, and to the north, the next closest aquaculture sites would be around Orkney ~150km from the proposed works.

There are several land based freshwater sites displayed on the map but these are not expected to be affected by this development.

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Annex 1

Aquaculture sites within the vicinity of the proposed extension to the existing sea outfall at Ardersier WwTW Outfall, East of Fort George by Scottish Water

Hopefully these comments are helpful to you. If you wish to discuss any matters further contact the MSS Renewables in-box MS_Renewables@scotland.gsi.gov.uk.

Yours sincerely

Paul Stainer

Marine Scotland Science

08 December 2016

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Appendix B JNCC's protocol for minimising the risk of injury to marine mammals from piling noise

Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise

August 2010

To find out more about offshore renewable energy or piling visit
http://www.jncc.gov.uk/page-4274

To learn more about JNCC visit http://www.jncc.gov.uk/page=1729

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Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise

August 2010

Introduction

This document, which has been produced by Natural England, the Countryside Council for Wales and the Joint Nature Conservation Committee, outlines a protocol for the mitigation of potential underwater noise impacts arising from pile driving during offshore wind farm construction. This protocol may also be useful to other industries in the marine environment which use pile driving. The agencies recommend that all operations that include pile driving should consider producing an Environmental Management Plan (EMP), or an equivalent document that meets the requirements of the relevant regulator.

The nature conservation agencies' policies support appropriately sited offshore renewable energy developments because they can provide environmental benefits to species of conservation concern, including marine mammals, by reducing greenhouse gas emissions and mitigating adverse climate change impacts. However, these developments can adversely affect species and features of conservation importance, including those protected by European and domestic Law. Mitigation of such impacts forms an intrinsic part of the Environmental Impact Assessment (EIA) process required as part of the consenting process for offshore windfarms.

The installation of driven piles in the marine environment without mitigation is likely to produce noise levels capable of causing injury and disturbance to marine mammals. Such effects, although incidental to consented activities, have the potential to conflict with the legislative provisions of The Conservation of Habitats and Species Regulations 2010 (the 'Habitats Regulations', HR), which applies to English and Welsh waters inside 12 nautical miles (nm), and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (the 'Offshore Marine Regulations', OMR, as amended 2009 and 2010), which apply on the United Kingdom Continental Shelf.

JNCC, NE and CCW have produced guidance on 'the protection of marine European protected species from injury and disturbance'. The piling protocol forms part of that more general guidance and the recommendations should be considered as 'best practice' for piling operations.

JNCC notes that other protected fauna, for example turtles, occur in waters where these guidelines may be used, and would suggest that, whilst the appropriate mitigation may require further investigation, the protocols recommended for marine mammals would also be appropriate for marine turtles and basking sharks[1].

Scientific understanding of the issues discussed in this piling protocol is incomplete, but improving. It is therefore important to note that the piling protocol is not considered to be static policy and will be subject to regular revision following on from experience of its use, and the development of a better understanding of the efficacy of certain mitigation measures recommended in the protocol.

Pile driving in the marine environment without mitigation is likely to produce noise levels capable of inducing adverse avoidance reactions at a considerable distance from the activity, which could constitute disturbance under the Regulations (HR and OMR depending on the area). Pile driving is also likely to cause injuries (e.g. hearing impairment) and there remains the possibility of causing death in marine mammals that are in very close proximity.

This protocol does not document measures to mitigate disturbance effects, but has been developed to reduce to negligible levels the potential risk of injury or death to marine mammals in close proximity to piling operations.

If the risk of disturbance cannot be avoided or reduced to negligible levels, the developers need to obtain a licence under regulations 53/49 (HR/OMR respectively) in order to avoid the application of regulations 41(1)(b) and 39(1)(b) of the HR/OMR.

[1] Basking sharks are protected from intentional capture or disturbance in British waters (up to 12 miles offshore) under a 1998 listing on the Wildlife and Countryside Act (1981), Schedule 5.

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Terminology

Marine European Protected Species: These are marine species in Annex IV(a) of the Habitats Directive that occur naturally in the waters of the United Kingdom. These consist of several species of cetaceans (whales, dolphins and porpoises), turtles, and the Atlantic Sturgeon.

Marine Mammal Observer (MMO): Individual responsible for conducting visual watches for marine mammals. It may be requested that observers are trained, dedicated and/or experienced. The MMO may also be a PAM operative.

- **Trained MMO**: Has been on a JNCC recognised course

- **Dedicated MMO**: Trained observer whose role on board is to conduct visual watches for marine mammals (although it could double up as a PAM operative)
- **Experienced MMO**: Trained observer with 3 years of field experience observing for marine mammals, and practical experience of implementing the JNCC guidelines
- **PAM Operative**: Person experienced in the use of PAM software and hardware and marine mammal acoustics

Mitigation Zone: The area where a Marine Mammal Observer keeps watch for marine mammals (and delays the start of activity should any marine mammals be detected).

Passive Acoustic Monitoring (PAM): Software system that utilises hydrophones to detect the vocalisations of marine mammals.

Section 1 - The Standard Piling Protocol

The standard protocol should be recommended to developers as a minimum level of good practice to mitigate the potential for causing injury or death to marine mammals in close proximity to piling operations.

Many of the techniques in the standard piling protocol have their origins in the 'JNCC seismic guidelines'. As the levels of noise associated with seismic survey can, in some cases, be similar to those likely to arise from piling operations, it is appropriate to adopt comparable mitigation measures. Additionally, many of the elements of the protocol have already been incorporated as FEPA licence conditions for Round 1 and 2 offshore windfarms, following advice provided by the statutory nature conservation agencies (Section 5).

1.1 The planning stage

The developer should consult JNCC, NE and CCW guidance on 'the *protection of marine European Protected Species from injury and disturbance*' to assist in environmental impact assessment.

The recommendations detailed below should be considered by the developer during the planning stage and be incorporated into the project's Environmental Management Plan or the equivalent document required by the relevant regulator.

1.1.1 Developer to demonstrate that Best Available Technique (BAT) is being used

BAT, which incorporates the previous concept of BATNEEC (Best Available Technique Not Entailing Excessive Cost), is an established approach in environmental management. It seeks to balance the highest level of environmental protection against commercial affordability and practicality.

The demonstration of BAT may require developers to submit commercially sensitive information to the agencies. For example, the costing of different pile construction

techniques is likely to be confidential. There may, understandably, be concerns about this process and, in such cases, the agencies will agree an approach with the developers and the regulators (currently the MMO for offshore windfarm developments covered by this protocol) to regulate this process.

Techniques such as hammer modifications, sleeving or muffling, the use of vibratory hammers and gravity based piling may all reduce noise levels. The developer may be able to demonstrate that certain installation approached do not amount to BAT, and this can be achieved by submitting a detailed business case involving analysis of cost and impact on margins. The use of gravity base piles is particularly notable, because potential noise impacts area likely to be much reduced. In contrast, the COWRIE work has gone some way to demonstrate that the use of unenclosed bubble curtains, bubble trees[2] or enclosure coffer dams[3] is currently ineffective or uneconomical.

1.1.2 Consideration of the local environment

The developer must determine what marine mammal species are likely to be present in the area and assess if there are any seasonal considerations that need to be taken into account. Seasonal restrictions on piling operations may be necessary. For example this may be appropriate during periods of seal pupping, and when there is clear seasonal demarcation in animal occurrence and seasonal restrictions would have practical application[4]. The interaction with other potential spatial and temporal restrictions on construction times (for example in spring to mitigate impacts on commercial fish spawning or during winter to reduce impacts on certain seabirds) would also need to be considered.

1.2 Role of the Marine Mammal Observer (MMO)

Operators should seek to provide dedicated MMOs and Passive Acoustic Monitoring (PAM) operatives. Piling activities should be monitored by MMOs and PAM operatives whose primary role is to detect marine mammals and to potentially recommend a delay in the commencement of piling activity if any marine mammals are detected. In addition, the MMO / PAM operatives should be able to advise the crew on the implementation of the procedures set out in the agreed mitigation protocol, to ensure compliance with those procedures.

1.2.1 Training requirements for MMOs

MMOs should be appropriately trained and understand the mitigation procedures within the piling protocol. MMOs should be present in sufficient numbers to ensure that monitoring is not compromised by fatigue. They should ensure they receive a copy of the mitigation procedures requested by the regulating authority as they may

[2] Bubble curtains and bubble trees release streams of bubbles into the water column - because of tidal flows such bubbles are likely to dissipate in the environments associated with offshore windfarms.
[3] Not commercially feasible currently because of the time taken to install them, particularly in the offshore environment.
[4] Seasonal restrictions which would restrict piling for large parts of the year and which might therefore make a project uneconomic may not be welcomed by the operator. In such cases where the impact assessments showed risk of a disturbance offence, the operator may wish to consider alternative methods, for example such as the use of gravity piles.

vary between activities. JNCC has approved a number of MMO course providers[5] – although the courses they run deal primarily with the seismic guidelines, the skills are easily transferable to the monitoring of piling activities.

1.2.2 Equipment required by the MMO

MMOs should be equipped with binoculars, a copy of the agreed monitoring protocol and the 'Marine Mammal Recording Form', which is an Excel spreadsheet containing embedded worksheets named 'Cover Page', 'Operations', 'Effort' and 'Sightings'. A Word document named 'Deck forms' is also available, and MMOs may prefer to use this when observing before transferring the details to the Excel spreadsheets. Although these forms were developed for seismic surveys, they can be used for piling operations, although many columns will not be applicable.

The ability to determine range of marine mammals is a key skill for MMOs, and a useful tool is a range finding stick. All MMO forms, including a guide to completing the forms, and instructions on how to make and use a range finding stick, are available on the JNCC website.

1.3 Passive Acoustic Monitoring (PAM) and PAM operatives

PAM systems consist of hydrophones that are deployed into the water column, and the detected sounds are processed using specialised software. PAM operatives are needed to set up and deploy the equipment, and to interpret the detected sounds. A PAM operative could also be a trained MMO, and this would allow them to switch roles, if required, between acoustic and visual monitoring (providing that there is another trained PAM operative available). Switching roles between acoustic and visual monitoring could help alleviate observer fatigue.

In its current state of development, PAM systems are particularly useful in detecting harbour porpoises within a 500 metre mitigation zone, although the systems have their limitations and can only be used to detect vocalising species of marine mammals.

PAM can provide a useful supplement to visual observations undertaken by MMOs and the agencies may recommend that it is used as a mitigation tool when commenting on applications for piling consents. However, in many cases it is not as accurate as visual observation for determining range, and this will mean that the mitigation zone will reflect the range accuracy of the system. For example, if the range accuracy of a system is estimated at +/-300 metres, animals detected and calculated to be within 500 metres from the source could, in reality, be 500 + 300 = 800 metres, but their detection would still lead to a delay in the soft-start. Although, at present it is not possible to express the range accuracy of most PAM systems in numerical terms, this example serves to illustrate that it is in the developer's best interests to use the most accurate system available, and for the PAM operative to factor in a realistic estimate of the range accuracy.

[5] The JNCC website has a list of MMO course providers: http://www.jncc.gov.uk/page-4703

1.4 Communication

At the planning stage the communication channels between those providing the mitigation service and the crew working on the piling are to be established. The MMO and PAM operatives also have to ensure there is a workable communication procedure in place so that any visual and acoustic detections can be corroborated by both. In addition, a formal chain of communication from the MMO or PAM operative to the person who can start/stop piling operations must be established. This is important, because construction contractors working to a tight timetable may not fully appreciate the roles and responsibilities of the MMO and PAM operatives. In order to establish the chain of communication and command MMOs and PAM operatives should attend any relevant pre-mobilisation meetings.

1.5 Mitigation zone

It is necessary to establish a "mitigation zone" of a pre-agreed radius around the piling site prior to any piling. This is an area in which the MMO / PAM operative will monitor either visually and/or acoustically for marine mammals before piling commences. The extent of this zone should be considered during the environmental impact assessment and agreed with the regulatory authority.

The extent of this zone represents the area in which a marine mammal could be exposed to sound that could cause injury and will be determined by factors such as the pile diameter, the water depth, the nature of the activities (for example whether drilling will also take place) and the effect of the substrate on noise transmission. The radius of the mitigation zone should be no less than 500 metres, and this is measured from the pile location (figure 1). The MMO and PAM operative should be located on the most appropriate viewing platform (e.g. vessel) to ensure effective coverage of the mitigation zone. The MMO will also require a platform that provides a good all-round view of the sea.

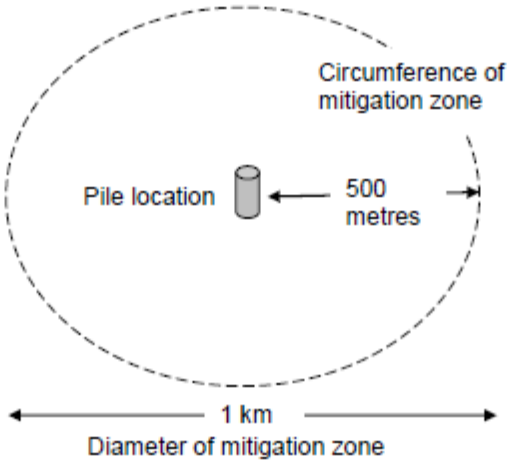

Figure 1: A representation of the mitigation zone, this is measured from the location of the pile to be installed out to a distance of 500 metres.

Section 2 – Advice during the piling activity

The following recommendations are relevant during piling operations.

2.1 Piling at night or poor visibility

Piling should not be commenced during periods of darkness or poor visibility (such as fog), or during periods when the sea state is not conducive to visual mitigation (above Sea State 4[6]), as there is a greater risk of failing to detect the presence of marine mammals. Variations to this restriction on commercial grounds are discussed in section 4.

2.2 Pre-Piling Search

The mitigation zone should be monitored visually by MMOs and/or acoustically using PAM for an agreed period prior to the commencement of piling. It is recommended that the pre-piling search duration should be a minimum of 30 minutes[7].

2.3 Delay if marine mammals detected within mitigation zone

Piling should not be commenced if marine mammals are detected within the mitigation zone or until 20 minutes[8] after the last visual or acoustic detection. The MMO and PAM operative should track any marine mammals detected and ensure they are satisfied the animals have left the mitigation zone before they advise the crew to commence piling activities.

2.4 Soft-Start of pile driver

The soft-start is the gradual ramping up of piling power, incrementally over a set time period, until full operational power is achieved. The soft-start duration should be a period of not less than 20 minutes[9]. It is believed that by initiating piling at a lower power this will allow for any marine mammals to move away from the noise source, and reduce the likelihood of exposing the animal to sounds which can cause injury. Soft-start noise levels will vary according to hammer and pile design and other factors, and should be assessed as part of the environmental impact assessment process. Developers might want an alternative soft-start duration depending upon the

[6] Detection of marine mammals, particularly porpoises, will decrease as sea-state increases. While ideally sea-states of 2 or less, are required for optimal visual detection the risks of not detecting individuals within the MZ should be reduced by the combined use of visual monitoring and PAM.
[7] This 30 minute period is used in the JNCC seismic survey guidance
[8] A 20 minute period is adopted by the JNCC seismic survey guidance. Issues of swimming speed and noise dosage are considered in the Thame Developer report - it is considered that twenty minutes is a sufficient period of time to allow individuals to be at a distance where risk of injury or death is minor.
[9] The details of soft-start will vary according to substrate type, pile design and the hammer utilised. Measurements from the Lynn and Inner Dowsing test pile suggest that while "soft-start" levels are considerably lower than those occurring during full power piling they are still capable of giving rise to injury. Details of the soft-start procedure should be obtained for each project (see draft FEPA conditions Section 5).

specifics of the project and outcomes of the EIA process; any requested variation from a 20 minute soft-start should be agreed with the relevant agency and regulator.

If a marine mammal enters the mitigation zone during the soft-start then, whenever possible, the piling operation should cease, or at the least the power should not be further increased until the marine mammal exists the mitigation zone, and there is no further detection for 20 minutes. The feasibility of this approach should be agreed with the relevant agency and regulator as part of the approval process. It is recognised that the ability to cease operations may be constrained by the substrate type or pile design.

When piling at full power, there is no requirement to cease piling or reduce the power if a marine mammal is detected in the mitigation zone (it is deemed to have entered "voluntarily"[10]). It is also acknowledged that, for engineering reasons, it may not be possible to stop piling at full power until the pile is in final position.

2.5 Break in piling activity

If there is a pause in the piling operations for a period of greater than 10 minutes, then the pre-piling search and soft-start procedure should be repeated before piling recommences. If a watch has been kept during the piling operation, the MMO or PAM operative should be able to confirm the presence or absence of marine mammals, and it may be possible to commence the soft-start immediately. However, if there has been no watch, the complete pre-piling search and soft-start procedure should be undertaken.

2.6 Acoustic Deterrent Devices (ADDs)

The use of devices that have the potential to exclude animals from the piling area should be considered. Acoustic Deterrent Devices (ADDs) should only be used in conjunction with visual and / or acoustic monitoring.

In theory, ADDs have the potential to reduce the risk of causing injury to marine mammals, and are relatively cost effective. However, evidence relating to the efficacy of acoustic deterrents such as "scrammers" or "pingers" is currently limited and there is a need for studies to quantify the efficacy of candidate devices to determine their applicability as suitable mitigation measures.

When planning to use ADDs, the potential effectiveness of candidate devices on the key marine mammal species likely to be present in the area should be assessed as part of the EIA process for the activity. This assessment should feed into the site specific Environmental Management Plan (EMP) or equivalent. It is expected that these devices would always be used in accordance with recommended conditions that would prevent the exposure of animals to disturbance that would constitute an offence under regulations 41 and 39 of the Habitats Regulations and the Offshore Marine Regulations, respectively. It should be noted that a wildlife licence under the

[10] Please note that there is no scientific evidence for this "voluntary" hypothesis, instead it is based on a common sense approach. Note, however, that other factors, such as food availability, may result in marine mammals approaching piling operations. In particular, the availability of prey species stunned by loud underwater noise may attract seals into the vicinity of piling operations.

Wildlife and Countryside Act 1981 (within 12nm) might be required to authorise a potential intentional disturbance.

The use of ADDs will be subject to a number of recommended conditions, for example:

- ADDs should be positioned in the water in close proximity to the pile to be installed; the vessel with the MMOs and PAM operatives may not necessarily be a suitable mooring location for these devices.
- ADDs should be switched on throughout the pre-piling search and turned off immediately after the piling activity has started.

Section 3 – After the piling activity

3.1 Reporting Requirements

Reports detailing the piling activity and marine mammal mitigation, the 'MMO and PAM reports', should be sent to the relevant conservation agency after the end of the piling activity. Reports should include:

- Completed Marine Mammal Reporting Forms
- Date and location of the piling operations
- A record of all occasions when piling occurred, including details of the duration of the pre-piling search and soft-start procedures, and any occasions when piling activity was delayed or stopped due to presence of marine mammals
- Details of watches made for marine mammals, including details of any sightings, details of the PAM equipment and detections, and details of the piling activity during the watches
- Details of any Acoustic Deterrent Devices (ADDs) used, and any relevant observations on their efficacy
- Details of any problems encountered during the piling process including instances of non-compliance with the agreed piling protocol
- Any recommendations for amendment of the protocol

Section 4 - Variation of standard piling protocol

The above protocol is considered to represent current best practice for a typical windfarm piling operation. Developers may, however, feel that the protocol is unduly restrictive, particularly in respect of restrictions on night-time/low visibility piling. In such cases, the burden of proof lies with the developer to demonstrate that effective mitigation can be delivered using an amended protocol.

A distinction should be made here between piling which commences during times of good visibility (and subject to the above provisions) and continues into a period of poor visibility/ night-time, and piling that commences during times of poor visibility (including night-time conditions).
Assuming that the operations are continuous the first scenario would not need additional mitigation. The second, scenario would, however, require enhanced

mitigation measures. For example, a developer wishing to commence piling at night might need to demonstrate that:

- Such piling is essential for commercial viability.
- The developer will provide enhanced detection of marine mammals (e.g. increased number of PAM systems and PAM operatives for commencement of piling during night-time.

Each request for variations from the protocol should be considered on its merits and, to ensure consistency across projects and other marine industries, in close liaison with JNCC and other statutory nature conservation agencies.

Section 5 - Securing of mitigation package through legally-binding consent conditions and Environmental Management Plan (EMP)

Under current arrangements the mitigation package relating to windfarm developments is likely to be secured under FEPA conditions, rather than under the Electricity Act s.36 consent. Conditions drafting is likely to vary according to project specific issues and will evolve as our understanding of the issues improves. Conditions imposed by the MMO (formerly MFA, formerly MCEU Defra) in respect of the Thames windfarms are set out below as an example of possible consent requirements only.

9.20 Conditions 9.20 to 9.22 shall only apply where driven or drilled pile foundations are to be installed.

9.21 Construction activities shall not commence until the Licence Holder has agreed with the Licensing Authority and [insert relevant nature conservation agency name] a scheme for the mitigation of potential impacts on marine mammals. The scheme must be submitted to the Licensing Authority by the date specified in the timetable required under condition 9.35. Such a scheme shall include, inter alia:

- *A requirement on the Licence Holder to ensure that suitably qualified and experienced Marine Mammal Observers are appointed and [insert relevant nature conservation agency name(s)] notified of their identity and credentials before any construction work commences.*

- *A requirement on the Licence holder must ensure that piling activities do not commence until half an hour has elapsed during which marine mammals have not been detected in or around the site. The monitoring should be undertaken both visually (by Marine Mammal Observers) and acoustically appropriate passive acoustic monitoring equipment. Both the observers and equipment must be deployed at a reasonable time before piling is due to commence.*

- *A requirement on the Licence Holder to ensure that at times of poor visibility (night-time, foggy conditions, sea state greater than that associated with force*

4 winds, etc.) enhanced acoustic monitoring[11] of the zone is carried out prior to commencement of relevant construction activity.

- *A requirement that piling may only commence using an agreed soft start procedure. The duration and nature of this procedure must be discussed and agreed prior to commencement of operations[12].*
- *A requirement that the Licence Holder must make provision for a reporting methodology to be in place before works commence to enable efficient communication between the MMOs and the skipper of the piling vessel.*

9.22 Piling activities shall not take place other than in accordance with the scheme agreed at 9.21 above

In addition to be involved in the drafting of such conditions, it is likely that statutory nature conservation agencies will want to check that a project's Environmental Management Plan contains appropriate protocols relating to the pile driving operations, such as how the MMOs will interact with the piling crew. Drafting of a potential template condition requiring approval of the EMP following consultation with the agencies is set out below:

X: The Licence Holder must submit a copy of a project Environmental Management Plan for the approval of the Licensing Authority, in consultation with CEFAS, and the [insert relevant nature conservation agency name(s)], at least 4 months prior to the proposed commencement of construction works. To ensure that satisfactory arrangements are in place for liaison on environmental issues. Construction shall not commence until such time as the Environmental Management Plan has been approved by the Licensing Authority.

Y: The Licence Holder must ensure that a suitably qualified and experienced liaison officer, Marine Mammals Observer(s) and other officers are appointed (for fisheries and environmental liaison) and that the Licensing Authority is notified of their identity and credentials before any construction work commences, to establish and maintain effective communications between the Licence Holder, contractors, fishermen, conservation groups and other users of the sea during the course of the project.

Z: The Licence Holder must ensure that the liaison officer's environmental remit includes:

i) Monitoring compliance with the commitments made in the Environmental Statement and the Environmental Management Plan (as agreed under condition Y above).

[11] The details of any enhanced acoustic monitoring scheme would need to be agreed in advance with the regulator as advised by the relevant nature conservation agency however they might include the provision of additional hydrophones and/or T-Pods together with extra PAM operators

[12] As discussed at footnote 9 above there is potential for "soft-start" levels to be of a sufficient volume to give rise to injury or significant disturbance. Information on possible noise levels will therefore need to be provided as part of the EIA and the process will need to be agreed with the regulator as advised by the relevant nature conservation agency. An excessive level for soft-start procedures might be that capable of giving rise to TTS to an individual in close proximity (metres) to the piling operation

ii) Providing a central point of contact for the Monitoring Programme and Ornithological Monitoring Programmes required under relevant conditions
iii) Liaison with fishermen, conservation groups and other users of the sea concerning any amendments to the method statement and site environmental procedures.
iv) Inducting site personnel on site / works environmental policy and procedures.

Section 6 - References

Collaborative Offshore Wind Research into the Environment (COWRIE):
http://www.offshorewindfarms.co.uk