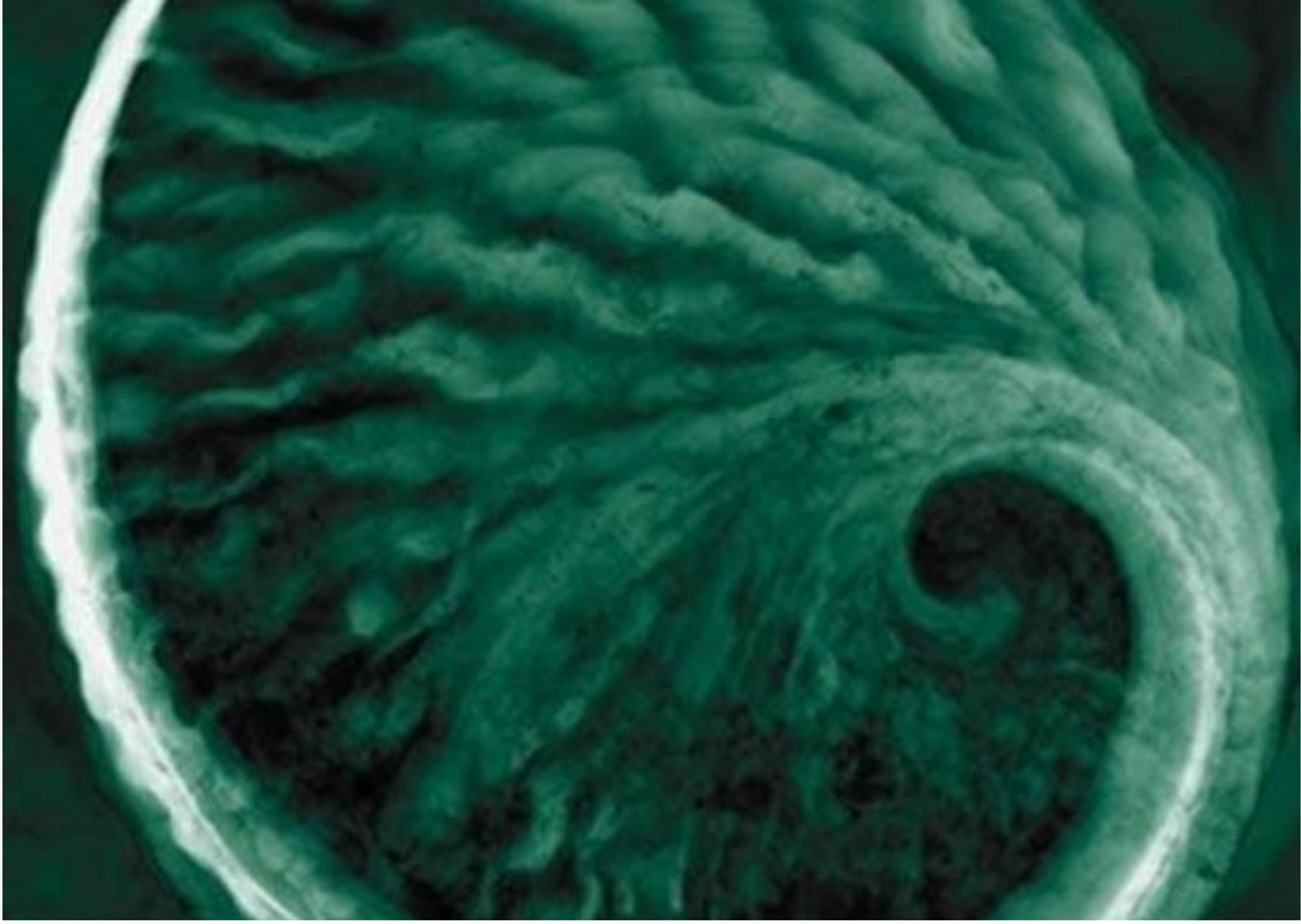

Appendix 13.1

Jetty Piling Underwater Noise Modelling Report

2 August 2023

Project No.: 0697804

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Appendix 13.1

Jetty Piling Underwater Noise Modelling Report

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Acronyms and Abbreviations

Name	Description
Decibels (dB)	Unit to measure the intensity of a sound by comparison of a given level on a logarithmic scale.
Permanent Threshold Shift (PTS)	A permanent change in the auditory threshold which results in permanent hearing loss.
Sound Exposure Level (SEL)	The time integral of the square pressure over a time window long enough to include 90% of the energy of a sound pulse expressed as a decibel relative to a standard reference.

Sound Exposure Level (SEL(single strike))	The SEL of one hammer strike event.
SEL(cum)	Cumulative Sound Exposure Level (cum). The logarithmic sum of received sounds from events which are individually quantified in terms of their SEL.
Peak Sound Pressure SPL(peak)	The pressure values above expressed as decibel (dB) values relative to stated reference pressure values. The peak, referred to in this report as SPL(peak), and also referred to as Lpeak or sometimes Lpk in other documents, is the maximum value reached by the sound pressure. There is no time-constant applied and the signal has not passed through an RMS circuit or calculator. This is the true Peak of the sound pressure wave.
Source Level (SL)	The apparent strength of a sound source at a reference distance, usually 1m, from the source.
Temporary Threshold Shift (TTS)	A temporary change in the auditory threshold resulting in temporary hearing impairment.

1. INTRODUCTION

This Appendix relates to the proposed sustainable aviation fuel production facility at Crown Wharf, Port Talbot docks (the Proposed Scheme) and specifically the development of two wharves/jetties required for the Proposed Scheme. The document forms an Appendix to, and informs, the Environmental Impact Assessment (EIA) Chapter 13: Marine Ecology.

This Appendix identifies the key sources of underwater noise that are likely to occur and predicts the underwater noise levels from these activities, which comprise the driven piling activities associated with the Proposed Scheme. The noise levels are then compared with suitable noise impact criteria and the distances at which aquatic fauna are likely to be affected are reported. A quantitative analysis of removal of the existing wooden piles associated with a disused wharf (required to be removed for the purpose of the new wharves/jetties) has not been undertaken as this is likely to be less noisy than the piling installation activities above, and it is not considered further in this assessment.

Underwater noise during operation is expected to be limited to vessel movements, which are not expected to result in underwater noise which is any higher than those that are already produced during the vessel movements using the docks presently.

The location of the EIA Study Area and the Marine Ecology Study Area are shown in Figure 1 which is also shown as **Figure 13.1** in Chapter 13.

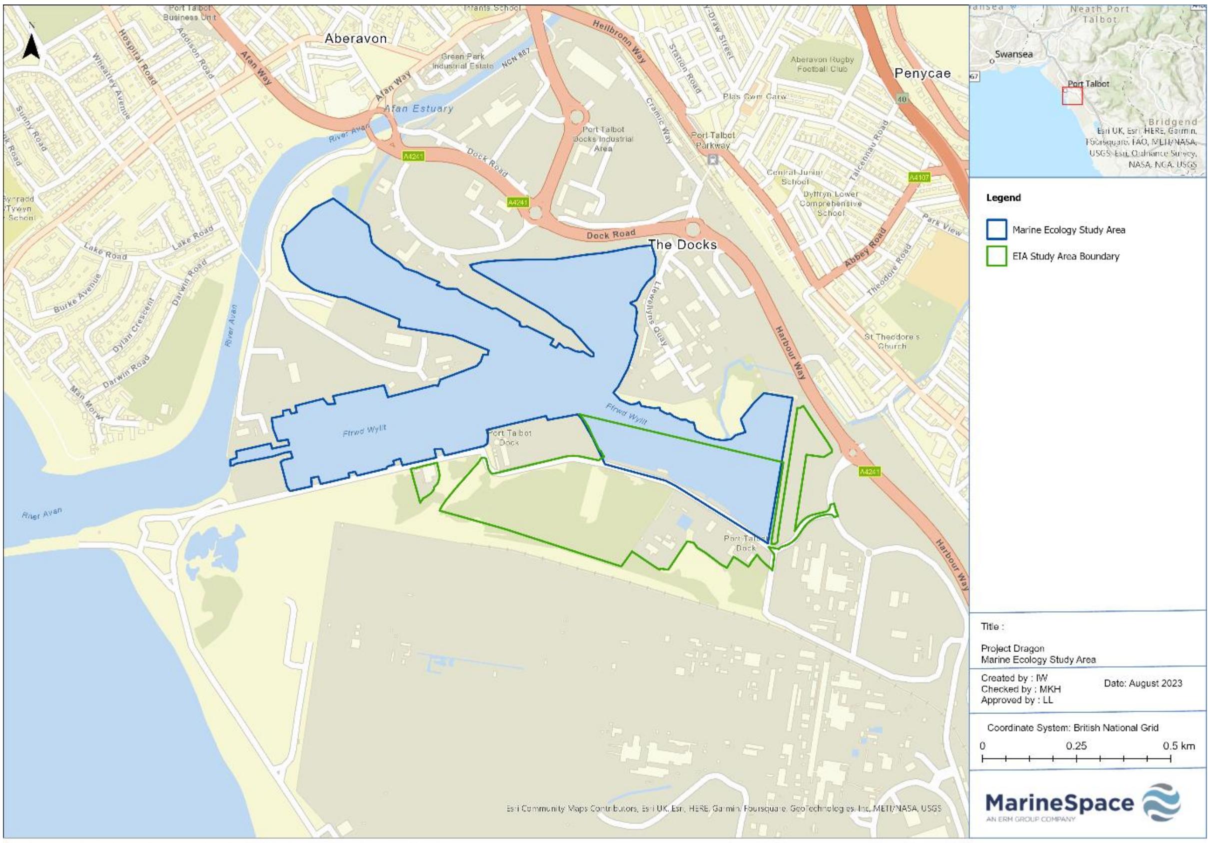

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Figure 1 Study Area Boundaries

The Marine Ecology Study Area for this assessment has been limited to the enclosed area within the dock. The dock is enclosed by land and the opening to the River Afan by the lock which is fitted with two sets of steel lock gates (one set at each end of the lock). There is no direct path from the piling location to the lock gates, and any sound rays that reach the gates would be reflected from the banks of the dock area, which are expected to be highly effective in attenuating underwater noise.

In addition to the lack of a direct sound path to the lock gates it is noted that the lock gates will act as embedded mitigation in terms of reducing underwater noise propagation to any areas outside of the dock area. Both sets of lock gates will remain closed at all times other than when locking vessels when one set will remain closed. The introduction of steel barrier materials is often used as a method of reducing underwater noise from piling (e.g. when a steel pipe is used to enclose the pile being driven).

Underwater noise levels from the Proposed Scheme have been predicted, and subsequently assessed using criteria based on studies into the potential effects on fish in terms of injury (which are discussed in Section 2). Injury is defined in this case as auditory injury in the form of potential physical injury including injury to auditory functions on a permanent basis which is termed as Permanent Threshold Shift (PTS). It is also anticipated that some temporary effects on hearing may occur Temporary Threshold Shift (TTS) and these effects have also been considered. Displacement of fish is likely to occur due to the noise generated from piling which is assessed using typical guidance for this effect, although evidence for this type of effect is limited.

1. NOISE MODELLING METHODOLOGY

1.1 Source

1.1.1 Assumed Piling Details

The detailed piling programme has not been established at this stage of the Proposed Scheme. Therefore, assumptions have been made based on data from other projects, robust publicly available reference material and initial estimates from the project team as described in Sections 1.1.3 for tubular piles and 1.1.4 for sheet piles. Inevitably these are approximate at this stage of the assessment, but the assumptions represent the typical range of piling noise levels generated during impact piling of tubular piles and sheet piles which are included in the current design of the Proposed Scheme. As established in the ES in **Chapter 1: Introduction** and **Chapter 2: Approach to EIA**, it is expected that the Marine Licence application will consider the final detail of the proposed wharves/jetties and where necessary revise the outputs of this assessment, albeit it is expected that the assumptions are sufficiently conservative that any further assessment would result in lower impact/effect, or at a minimum no worse and impact/effect than reported in the ES.

To check compliance with the impact assessment criteria in Section 2 two noise metrics are required; SPL(Peak) which is the sound level based on the highest pressure level during the piling noise event, and the SEL which is a measure of the energy of the piling noise for a single strike or cumulatively over the piling sequence (SELcum). The latter value is based on a combination of the SEL(single Strike) experienced during an individual hammer blow, and the number of hammer blows that occur during a 24 hour period. The adopted values and the source of the data used are described in the following sections.

It is noted that the predictions have not included mitigation such as soft-start procedures in the calculated values, which represents a worst case approach.

1.1.2 Total Number of Piles

Several options are still being considered with numbers of piles between approximately 40 and 60 piles in total based on feasibility design study information. An installation rate one to two piles per day has been assumed for tubular piles which indicates a typical maximum duration of approximately 60 days. It is anticipated that sheet piles are likely be faster to install.

The noise calculations in this report consider noise experienced over a 24 hour period in line with the relevant underwater noise criteria, and therefore the data below show the maximum assumed for each type of piling below.

1.1.3 Tubular Piles

The following assumptions have been made for tubular piling:

- approximately 400 mm diameter steel tubular piles;
- maximum number per day 2 (from ABP estimate);
- assumed strike rate (ERM estimate based on other projects) 60 per minute; and
- number of minutes to install one pile 5 minutes (ERM estimate from source measurement data discussed below).

The noise levels for the piling have been based on a database of reliable noise measurement data for piling activities which has been used in the United States for regulation of the effects of piling noise on fish (Caltrans, 2020). As a close approximation for piling under similar conditions, measured data from the Richmond-San Rafael Bridge project has been used. The piling in this example data was 356 mm diameter rather than 400 mm diameter but is likely to result in similar noise levels. Longer installation times (five minutes per pile) have been assumed for driving each pile than the short times suggested in the example in order to take a conservative approach. Based on the pile diameter, the SPL(peak), and SEL(single strike) level from pile driving are estimated to be 198 dB re μPa, and 170 dB re 1 μPa2s at 22 metres respectively from the source for tubular pile installation.

1.1.4 Sheet Piles

The following assumptions have been made for sheet piling:

- piles: 24” (0.6 m) sheet piles;
- number of minutes to install one pile 10 minutes (from measured example in reference data);
- number per day 10 (higher value chosen compared to tubular piles to reflect higher speed of installation and 10 min drive time as measured in example measured data); and
- assumed strike rate (ERM estimate based on other projects) 60 per minute.

The measured noise data are based sheet piling on the Napa flood control project in the United States from the same Caltrans reference data set which is described in Section 1.1.3. Based on the dimensions, the SPL(peak), and SEL(single strike) level from pile driving are estimated to be 209 dB re μPa, and 166 dB re 1 μPa2s at 10 metres respectively from the source for monopile installation.

1.2 Noise Propagation Modelling

Noise propagation has been modelled assuming the log relationship:

$$\mathrm{TL} = -\mathrm{N}\log_{10}\left(\frac{\mathrm{R}}{\mathrm{R_0}}\right) - \mathrm{aR}$$

where TL is the transmission loss, N is the underwater noise spreading term, R is the distance from the source in metres, $\mathrm{R0}$ is the reference distance from the source (which is 10 m or 22 m in the examples above) and a is the water absorption (in dB/m). This transmission loss is then added to the noise source level at 1 m to predict the noise level at any particular distance (R) from the source.

Typically, the underwater noise spreading term (N) ranges between 10 (for spherical spreading) and 20 (for cylindrical spreading) depending on the water depth and distance from the noise source. In this study, N has been set equal to 15 in order to simulate typical noise spreading in the Marine Ecology Study Area which is in relatively shallow water (Nedwell & Howell, 2004). This has been applied when extrapolating beyond the initial reference distance. In order to take a conservative approach a higher spreading rate (N=20) has been applied when calculating noise levels that are closer to the source than the reference distance at which measurements were taken.

The water absorption is not a significant factor over the calculation ranges that are considered in this study, and therefore it has not been included in the calculations. This approach provides a good estimate of spreading and is based on empirical data (Caltrans, 2020) as a practical way of assessing the potential effect of piling projects when detailed information is not available from the piling contractor to enable a more detailed study to be carried out.

1.3 Receiver Assumptions

The assessment criteria and the parameters that need to be calculated are discussed fully in Section 2, and the way in which they affect the modelling methodology are described in this section. For peak noise level predictions, the distances at which noise level thresholds are predicted to be been met are calculated. For the cumulative SEL (SELcum) criterion, the location of the animal in the sound field is important and noise levels from each hammer strike reduce with distance. In this case a worst case assumption has been made that animals would not swim away from the piling, and therefore that noise would be accumulated assuming a constant sound level for each strike.

2. NOISE ASSESSMENT CRITERIA

For piling numerical criteria apply to the potential for permanent injury to fish. Popper et al 2014 (Popper, 2014) sets out noise criteria at which mortality and potential mortal injury, and recoverable injury (which includes hearing damage) are predicted to occur. The thresholds at which temporary threshold shift occurs are also noted. Criteria are set for fish at different stages of life (i.e. as adults, larvae and eggs) for these effects. The injury criteria are shown in Table 2.1.

Table 2.1 Popper et al Criteria for Injury for Fish for Piling Noise

Type of Animal	Mortality and Potential Mortal Injury	Recoverable Injury	Temporary Threshold Shift (TTS)
Fish: no swim bladder (particle motion detection)	>219 dB SELcum or >213 dB SPL(Peak)	>216 dB SELcum or >213 dB SPL(Peak)	186 dB SELcum
Fish: swim bladder not involved in hearing (particle motion)	210 SELcum or >207 dB SPL(Peak)	203 dB SELcum or >207 dB SPL(Peak)	186 dB SELcum
Fish: swim bladder involved in hearing (primary pressure detection)	207 SELcum or >207 dB SPL(Peak)	203 dB SELcum or >207 dB SPL(Peak)	186 dB SELcum

Fish: Eggs and Larvae	210 SELcum or >207 dB SPL(Peak)	(N/A – moderate potential near to source)	(N/A Moderate potential within tens of metres, and low beyond)

Source: Popper et al 2014.

Popper et al give qualitative advice on distances at which the most noise-sensitive fish species might exhibit behavioural changes. They conclude that high reactions might occur as far as hundreds of metres from the source, but that only moderate reactions would be likely at kilometres from the source.

The potentially affected fish within the Study Area are discussed in Chapter 13 of the EIA. It is relevant to note here that although distances are calculated for all categories of fish here, there are only species with swim bladders within the study area.

3. RESULTS

3.1 Predicted Ranges for Acoustic Injury (Without Mitigation)

This section reports the results of the underwater noise study for both of the impact piling techniques that are considered in this study and which are likely to be the main sources of underwater noise (tubular piling and sheet piling).

Based on the prediction methods described above, the results of the noise predictions of underwater noise levels from impact piling of tubular piling are presented in Table 3.1**Error! Reference source not found.**. The table presents a summary of the results in terms of the distances at which the relevant criteria are met.

The calculated SELcum noise level assuming no mitigation and a stationary animal. The effect of a bubble curtain or other mitigation such as soft start piling procedures have not been included in this section.

Table 3.1 Calculated Distances at which Underwater Noise Levels for Jetty Piling Meet the Injury Criteria for Fish – Tubular Piling

Type of Animal	Metric	Distance to Mortality and Potential Mortal Injury (m)	Distance to Recoverable Injury (m)	Distance to Temporary Threshold Shift - TTS (m)
Fish: no swim bladder (particle motion detection)	SELcum	2	3	134
	SPL(Peak)	4	4	NA
Fish: swim bladder not involved in hearing (particle motion)	SELcum	5	12	134
	SPL(Peak)	8	8	NA
Fish: swim bladder involved in hearing (primary pressure detection)	SELcum	8	12	134
	SPL(Peak)	8	8	NA

Fish: Eggs and Larvae	SELcum	5	(N/A – Moderate potential near to source)	(N/A Moderate potential within tens of metres, and low beyond)
	SPL(Peak)	8	(N/A – Moderate potential near to source)	(N/A Moderate potential within tens of metres, and low beyond)

Source: ERM

Based on the prediction methods described above, the results of the noise predictions of underwater noise levels from impact piling of sheet piling are presented in Table 3.2. The table presents a summary of the results in terms of the distances at which the relevant criteria are met.

The calculated SELcum noise level assuming no mitigation and a stationary animal. The effect of a bubble curtain or other mitigation such as soft start piling procedures have not been included in this section.

Table 3.2 Calculated Distances at which Underwater Noise Levels for Jetty Piling Meet the Injury Criteria for Fish – Sheet Piling

Type of Animal	Metric	Distance to Mortality and Potential Mortal Injury (m)	Distance to Recoverable Injury (m)	Distance to Temporary Threshold Shift - TTS (m)
Fish: no swim bladder (particle motion detection)	SELcum	2	2	153
	SPL(Peak)	6	6	NA
Fish: swim bladder not involved in hearing (particle motion)	SELcum	5	11	153
	SPL(Peak)	14	14	NA
Fish: swim bladder involved in hearing (primary pressure detection)	SELcum	7	11	153
	SPL(Peak)	14	14	NA

Type of Animal	Metric	Distance to Mortality and Potential Mortal Injury (m)	Distance to Recoverable Injury (m)	Distance to Temporary Threshold Shift - TTS (m)
Fish: Eggs and Larvae	SELcum	5	(N/A – Moderate potential near to source)	(N/A - Moderate potential within tens of metres, and low beyond)
	SPL(Peak)	14	(N/A – Moderate potential near to source)	(N/A - Moderate potential within tens of metres, and low beyond)

Source: ERM

3.2 Predicted Ranges for Behavioural Effects (Without Mitigation)

In terms of behavioural effects, high reactions are likely to occur as far as hundreds of metres from the source, but only moderate reactions would be likely at kilometres from the source. As discussed in Section 5, given the size of the dock there is likely to be some behavioural reaction to the piling noise over the piling period.

4. MITIGATION MEASURES

4.1 Introduction

As stated above, the noise calculations have been undertaken assuming no noise mitigation around the source. Since the calculations are based on preliminary design information the potential effects and any subsequent need for noise mitigation will need to be reviewed once the details of the Proposed Scheme are developed further. However, it is noted that noise mitigation measures are commonly available for use during the construction phase. These are normally needed where high energy piling takes place to reduce the risk of displacement, altered behaviour and direct physical harm in marine fauna. Commonly included methods are avoiding construction during sensitive times of the year (e.g., during migration, foraging, mating), noise reduction gear (e.g., bubble curtains) as well as noise source modifications (e.g., “soft starts”) (Nehls, Rose, Diederichs, Bellmann, & Pehlke, 2016), (Erbe, et al., 2019); (Thompson, et al., 2020).

4.2 Noise source modifications

“Soft start” techniques involve driving the piles with a reduced piling energy and blow rate that is gradually increasing over a pre-defined timeframe (e.g., 20 minutes). This allows noise sensitive, mobile species to escape the area which reduces the likelihood of mortality and severe physiological damage and avoidable stress ((JNCC, NE, & CCW, 2010)).

4.3 Bubble curtains

A bubble curtain is a device which emits a constant stream of large and small air bubbles around the construction site of the piled foundation. It is often used in offshore wind projects, but can be used in jetty projects as well. A weighted nozzle pipe or tube connected to a large compressor is laid around the foundation on the seafloor. The “wall of bubbles” that is created is absorbing part of the physical energy of emitted sound waves generated during the impact of the hydraulic hammer on a pile. Effectiveness is relatively high: A reduction of 8-21 dB peak-to-peak measured at 750 m distance to the noise source. Effectiveness is dependent on water depth and other physical parameters

(Defingou, Bils, Horchler, Liesenjohann, & Nehls, 2019); (Koschinski & Lüdemann, 2020). A more cautious approach is adopted in calculations in the US where a standard assumption of 5 dB is made for a bubble curtain.

4.4 Exclusion zones

The use of exclusion zones is used to reduce the effects of noise on marine mammals, but in this case marine mammals are not within the study area, and it would not be practical to observe exclusion zones for fish species. Therefore, this method is not considered appropriate in this case.

5. CONCLUSION

Underwater noise levels have been predicted based on piling works for the construction of the two wharves/jetties associated with the Proposed Scheme. The modelling was based on typical calculated noise levels for the proposed activities and design. A worst case view has been taken assuming no mitigation. However, it is noted that any effects are likely to be limited to within the dock area due to the presence of the lock gates and this will form an inherent mitigation measure.

The predicted noise levels for adult fish have been assessed against relevant criteria for potential injury. All fish within the dock have a swim bladder and therefore the most stringent criteria proposed by Popper et al have been applied.

Underwater noise modelling, based on typical noise propagation rates and initial project information, suggests there is potential for injury of fish during piling, but that this is predicted to be only within approximately 15 m of the piles. It is likely that implementing a soft-start would result in this being avoided.

Temporary threshold shift (TTS) and general disturbance effects to fish would be expected over a larger area than injury effects. TTS is predicted to occur at up to approximately 130 m for stationary fish for tubular piling, and approximately 150 m for sheet piling.

Any eggs and larvae are predicted to experience potential or actual mortality within 15 m based on conservative assumptions and a numerical prediction of piling noise. Qualitative conclusions are provided by the adopted criteria for recoverable injury, which suggest that only a moderate potential exists “near” to source.. In a similar way, TTS is said to be likely to be moderate within tens of metres and low beyond.

In terms of behavioural effects, high reactions are likely to occur as far as hundreds of metres from the source, but only moderate reactions would be likely at kilometres from the source. Given the size of the dock there is likely to be some behavioural reaction to the piling noise.

A detailed assessment is recommended before construction (e.g., once a piling contractor has been appointed), taking into account site specific features which will affect how sound will propagate in the study area and detailed design of the piles. The assessment will identify the need for suitable noise mitigation including soft start procedures or secondary mitigation such as bubble curtains if necessary.

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