LLŶR FLOATING OFFSHORE WIND PROJECT

Llŷr 1 Floating Offshore Wind Farm

Environmental Statement

Volume 6: Appendix 21B - Underwater Noise Impact Study

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Prepared by: Llŷr Floating Wind Ltd

FLOVENTIS ENERGY

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Acronyms and abbreviations

Acronym or abbreviation	Definition	Acronym or abbreviation	Definition
2D	Two dimensional	OWF	Offshore Wind Farm
AECL	Award Environmental Consultants Ltd	P	Primary
AIS	Automated Information System	Pa	Pascals
ANSI	American National Standards Institute	PCoD	Population Consequences of Disturbance
AUV	Autonomous Underwater Vehicle	PCW	Phocid Pinniped in Water
BRSS	Behavioural Response Severity Scale	PETN	Pentaerythritol Tetranitrate
CR	Cable Route	PL	Propagation Loss
Cum	Cumulative	PTS	Permanent Threshold Shift
dB	Decibel	R	Range
DP	Dynamic Positioning	RAM	Rapid Acoustic Model
DWT	Deadweight	RANDI	Research Ambient Noise DIrectionality
EIA	Environmental Impact Assessment	Ref	Reference
EMODnet	European Marine Observation and Data Network	RL	Received Level
EU	European Union	RMS	Root-mean-square
F	Far	ROV	Remotely Operated Vehicle
FHG	Functional Hearing Group	S	Secondary
GEBCO	General Bathymetric Chart of the Oceans	SBP	Sub-bottom profiler
HF	High frequency (cetacean)	SE	Sound Exposure
Hz	Hertz	Sec	Second
I	Intermediate	SEL	Sound Exposure Level
IOS	International Organisation for Standardisation	SL	Source Level
JNCC	Joint Nature Conservation Committee	SPL	Sound Pressure Level
JOMOPANS	Joint Monitoring Programme for Ambient Noise in the North Sea	SS	Single Strike
Kg	Kilogram	SSP	Sound Speed Profile
kHz	KiloHertz	SSS	Side scan sonar
LF	Low frequency (cetacean)	T	Time
M-weight	Marine mammal weighting	TL	Transmission Loss
M	Metre	TNT	Trinitrotoluene
MBES	Multi beam echo sounder	TTS	Temporary Threshold Shift
Mm	Millimetre	UK	United Kingdom
MMO	Marine Management Organisation	USA	United States of America
N	Geometric spreading factor	USBL	Ultra-short baseline positioning sonar
N	Near	USFWS	United States Fish and Wildlife Service
N	Newton	UXO	Unexploded ordnance

Acronym or abbreviation	Definition	Acronym or abbreviation	Definition
NMFS	National Marine Fisheries Service	VHF	Very High Frequency (cetacean)
NRW	Natural Resources Wales	WOA	World Ocean Atlas
OTO	One third octave	WTG	Wind Turbine Generator
		WWII	World War Two

Glossary of Project Terms

Term	Definition
The Applicant	The developer of the Project, Llŷr Floating Wind Limited
Array	All wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure within the Array Area, as defined, when considered collectively, excluding the offshore export cable(s).
Array Area	The area within which the wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure will be located
Floventis Energy	A joint venture company between Cierco Ltd and SBM Offshore Ltd of which Llŷr Floating Wind Limited is a wholly owned subsidiary.
Landfall	The location where the offshore export cable(s) from the Array Area, as defined, are brought onshore and connected to the onshore export cables (as defined) via the transition joint bays (TJB).
Llŷr 1	The proposed Project, for which the Applicant is applying for Section 36 and Marine Licence consents. Including all offshore and onshore infrastructure and activities, and all project phases.
Marine Licence	A licence required under the Marine and Coastal Access Act 2009 for marine works which is administered by Natural Resources Wales (NRW) Marine Licensing Team (MLT) on behalf of the Welsh Ministers.
Offshore Development Area	The footprint of the offshore infrastructure and associated temporary works, comprised of the Array Area and the Offshore Export Cable Corridor, as defined, that forms the offshore boundary for the S36 Consent and Marine Licence application
Offshore Export Cable	The cable(s) that transmit electricity produced by the WTGs to landfall.
Offshore Export Cable Corridor (OfECC)	The area within which the offshore export cable circuit(s) will be located, from the Array Area to the Landfall.
Onshore Development Area	The footprint of the onshore infrastructure and associated temporary works, comprised of the Onshore Export Cable Corridor and the Onshore Substation, as defined, and including new access routes and visibility splays, that forms the onshore boundary for the planning application.
Onshore Export Cable(s)	The cable(s) that transmit electricity from the landfall to the onshore substation
Onshore Export Cable Corridor (OnECC)	The area within which the onshore export cable circuit(s) will be located.
proposed Project	All aspects of the Llŷr 1 development (i.e. the onshore and offshore components).
Onshore Substation	Located within the Onshore Development Area, converts high voltage generated electricity into low voltage electricity that can be used for the grid and domestic consumption.
Section 36 consent	Consent to construct and operate an offshore generating station, under Section 36 (S.36) of the Electricity Act 1989. This includes deemed planning permission for onshore works.

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EXECUTIVE SUMMARY

1. The assessment has been undertaken by Award Environmental Consultants Ltd for AECOM Group, UK and Ireland on behalf of the Llŷr 1 Floating Offshore Windfarm project - hereafter referred to as the 'proposed Project' located off the southwest coast of Wales. Further details of the proposed Project Team's competency are provided in **Appendix 1A: Statement of Competence**. This appendix is concerned with the construction and operation of the proposed Project.

2. The construction of the proposed Project is a complex task requiring a number of separate activities relevant to this report, including pre-construction geophysical surveys using sonar-type devices, cable installation using dredging and trenching procedures, drilling and piling operations as well as the potential detonation of any unexploded ordnance (UXO) found in the vicinity of the Offshore Development Area. Once commissioned, the proposed Project becomes operational.

Acoustic source levels and thresholds

3. Marine construction activities for offshore wind developments generate levels of underwater noise which have the potential to impact on various species of marine mammal and fish found in and around the Offshore Development Area. The key objective of the work discussed in this report is to carry out acoustic propagation and impact modelling at specific study areas within the wider Offshore Development Area, for the underwater noise generated during the construction and operational phases. This allows distances at which underwater noise levels associated with each activity fall below thresholds for potential injury, hearing damage and behavioural responses for species of marine mammal, fish and sea turtle, to be established.

4. Published literature was reviewed in order to obtain representative acoustic source levels for each of the activities identified above and these were agreed with Applicant. These acoustic source levels are used during the underwater noise propagation modelling process to determine noise levels over the wider Offshore Development Area, which has been used in this report as the Study Area. Relevant guidance on acoustic impact criteria for exposure of noise-sensitive species likely to be present in the Offshore Development Area to the noise-generating construction activities occurring as part of the proposed Project, have also been determined from literature. Noise-sensitive species considered are marine mammals (specifically minke whale, common dolphin, bottlenose dolphin, and harbour porpoise), fish and sea turtle (see **Chapter 20: Fish and Shellfish** and **Chapter 21: Marine Mammals**).

5. Thresholds have been used in terms of both peak sound pressure level (SPL_{peak}), root-mean-square (rms) sound pressure level ($SPL_{rms)}$, and sound exposure level (SEL) metrics.

6. For cetaceans and phocid pinnipeds, dual exposure criteria for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) were based on the work undertaken by Southall *et al*. (2019) where the marine mammals were divided into a number of functional hearing groups (FHG) based on similarities in hearing bandwidth and audiological sensitivity. Where appropriate, M-weighting functions relating to the auditory sensitivity of marine mammals were used.

7. Behavioural impacts in RMS metrics have also been assessed in this report using the Level B Harassment criterion as given by the National Marine Fisheries Service (NMFS, 2018). Behavioural disturbance impacts can also be assessed using a dose-response function, which estimates the numbers of cetaceans and seals potentially impacted by piling noise using a dose-response curve and animal distribution data. This report has provided the dose-response function isopleths / contours (created using unweighted SEL associated with a single strike of the piling hammer, generated at 5 dB steps between 120-180 dB re 1 µPa2.sec) but has not taken the analysis further to determine the numbers of animals likely to be disturbed. The isopleths / contours are provided for the Applicant to undertake the investigation elsewhere.

8. For potential impacts on fish, dual exposure criteria representing Mortality and Potential Mortal Injury; Recoverable Injury; and TTS were based on thresholds developed by Popper *et al*. (2014) and given in terms of both SPL_{peak} and SEL. Behavioural impacts for fish, given using SPL_{rms} metrics, were based on work reviewed by United States Fish and Wildlife Service (USFWS) (Stadler and Woodbury, 2009). It is acknowledged that the threshold levels derived are unreliable however, in the absence of any other guidance, the threshold representing the onset of Low-Level Behavioural Responses in fish species are used in the current report for the purpose of conducting the analysis. Threshold levels representing the onset of Aversive Behavioural Responses in sea turtles were based on data derived from a review conducted by Finneran and Jenkins (2012).

9. For marine mammal FHGs, acoustic impact thresholds in SPL and SEL metrics (are given for impulsive-type noise such as that generated by piledriving and for non-impulsive type noise such as that generated by dredging, trenching, vessels movements and operational wind turbines. The SEL thresholds for marine mammals are M-weighted (which modifies the frequency spectrum of the impacting noise so that it represents the noise as it is perceived by a marine mammal) while those for the fish groupings are unweighted.

Acoustic Modelling

10. Underwater acoustic propagation modelling was undertaken using the RAM and the BELLHOP acoustic models both of which require site- and time-specific environmental data relating to two nominal modelling sites, nominated as Site WTG and Site CR.

11. Propagation modelling was carried out over a total of 36 transects radiating from each modelling site using sound speed profiles for the months of February and August, to account for seasonal variability in oceanographic parameters which can affect acoustic propagation. Using February and August conditions are considered to be representative of the extremes of acoustic propagation conditions that are likely to arise in the proposed Project Study Area. The subsequent propagation modelling results were applied to the acoustic source data for each of the noise-generating activities in order to yield propagated sound pressure levels at depth and range for both modelling sites (WTG and CR).

12. Acoustic impact modelling was carried out by comparing the results of the acoustic propagation modelling with the threshold levels for each impact, using two modelling scenarios. The first scenario assumed both noise source and receptor are stationary in the water. The impact distances were determined using both peak SPL and RMS metrics. Acoustic impact modelling was also carried out using energy level or SEL metrics. The second modelling scenario considered here was based on an extension to the Moving-Receptor scenario where, in this case, both noise source and animal are moving in various directions and at various speeds. The instantaneous SPL on the receptor varies according to the distance from the noise source and hence the SEL builds up on the receptor over a period of time as the animal moves around in the sound field.

13. Several overarching conclusions have been drawn from the acoustic impact modelling carried out in respect of the noise likely to be generated during the construction and operational phases on the proposed Project and these are summarised in the main text.

APPENDIX 21B: UNDERWATER NOISE IMPACT STUDY

21.1 Introduction

14. Llŷr Floating Wind Limited (hereafter the Applicant) is proposing to develop the Llŷr 1 Floating Offshore Wind Farm (hereafter referred to as the proposed Project), located approximately 35 km off the coast of Pembrokeshire in the Celtic Sea.

15. The proposed Project is a test and demonstration wind farm development, comprising up to 10 wind turbine generators (WTGs). The proposed Project will make landfall at Freshwater West before connecting into Pembroke Dock power station and the national grid network.

16. The Applicant is seeking a Section 36 consent and Marine Licence for Llŷr 1, and this chapter forms part of the Environmental Statement (ES) which is submitted in support of those consent applications. This appendix discusses the underwater noise modelling which has been conducted to assess the impacts of underwater noise generated by the proposed Project on marine ecological receptors.

17. The location of the proposed Project is indicated in **Figure 21B-1**.

18. The construction phase of the proposed Project involves a number of activities which generate underwater noise. Each floating platform is held in place by anchors which require piles inserted into the seabed. These may be driven pile anchors; drilled and grouted anchors; or micropile anchors. Other construction noise sources comprise cable laying; rock placement; and associated vessel movements. When complete, the wind turbine generators (WTGs) generate operational noise.

19. The activities identified above generate levels of underwater noise which have the potential to impact on various species of marine mammal and fish found in and around the Offshore Development Area. This report provides a study of the propagation and impact on the marine environment of man-made underwater noise arising during the construction. Subsequently, it is required to establish distances at which underwater sound levels generated by each activity meet relevant underwater sound thresholds developed for the protection of marine fauna.

20. This study comprises the following:

- An introduction to terms and units relevant to this work;
- A discussion of the acoustic source parameters relating to each of the construction activities proposed for the works;
- A review of threshold levels of sound relating to acoustic impacts on species of marine mammal, fish and sea turtles;
- A description of the noise propagation modelling undertaken;
- Application of the acoustic impact models to determine the distances at which predicted sound levels are below relevant threshold criteria associated with potential acoustic impacts on marine mammals, fish and sea turtles;
- A discussion of the results obtained; and
- A review of missing and incomplete knowledge associated with this study.

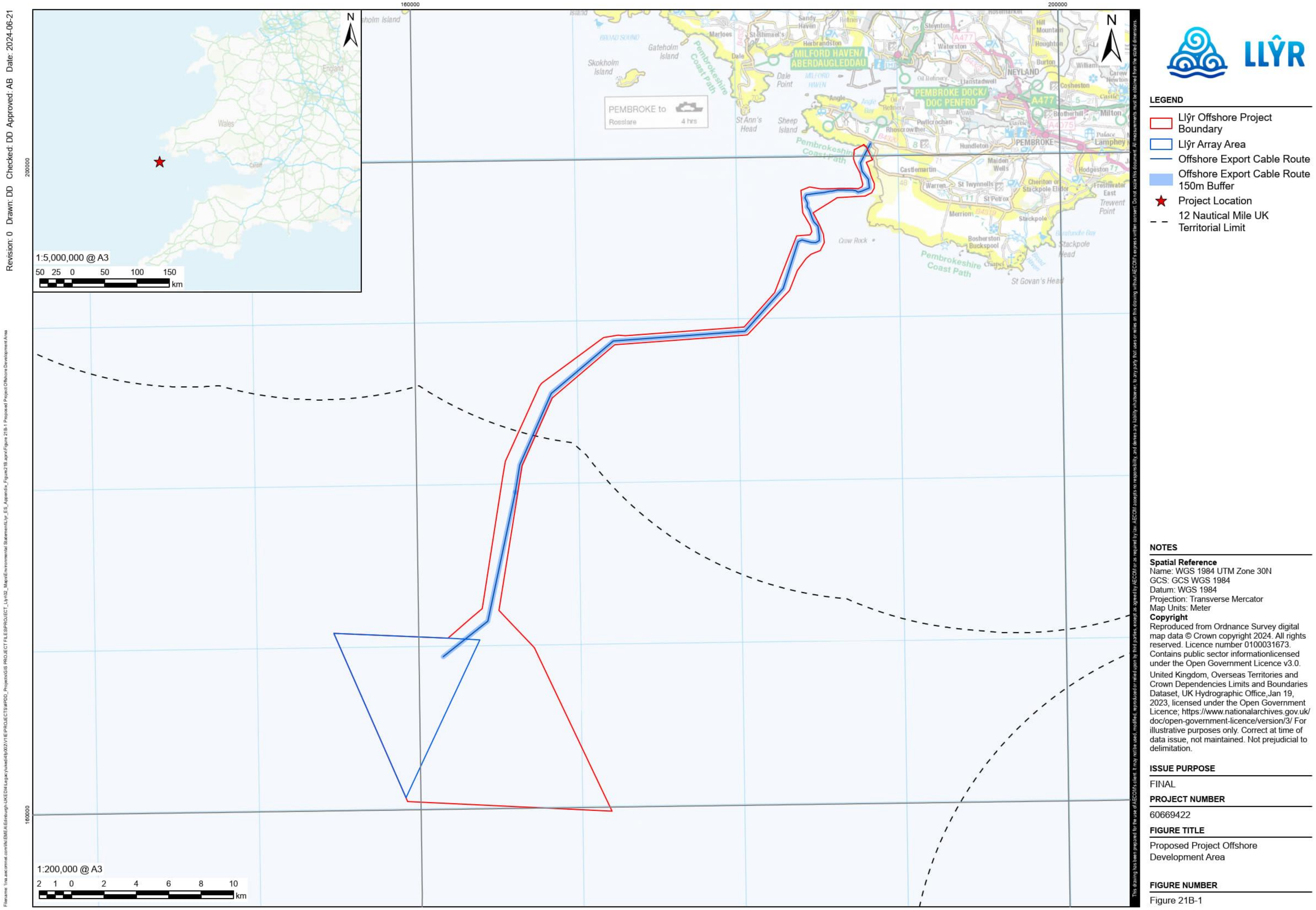


Figure 21B-1: Location of proposed Project area, Wales

21.2 Study Area

21. For the purposes of the modelling assessment conducted for this report, the Study Area is the Offshore Development Area and surrounding waters. Two sound propagation modelling sites were selected (which can be seen in **Figure 21B-13**) to be representative of the depth range and conditions of the Offshore Development Area. Thus, one modelling point was located in the deeper waters of the Array Area where installation of the wind turbines will take place (point WTG) and one in nearshore waters, to be reflective of the cable route in shallower areas (point CR). The underwater sound modelling is then undertaken in a number of transects around each point, to account for variations in bathymetry across the Celtic Sea and Bristol Channel (see Section 21.5).

22. Description of underwater noise and assessment units

21.2.1. Introduction

23. Studies by Thomsen *et al*. (2006) and Southall *et al*. (2007 and 2019), amongst others, provide detailed reviews of the metrics used to measure and assess the impact of underwater noise in the marine environment. A detailed discussion has not therefore been provided here, although a brief overview is provided to assist the reader. It is noted that a number of these definitions and parameters draw on the advice given in American National Standards Institute (ANSI) S12.7-1986 (ANSI, 1986).

24. Sound may be defined as the periodic disturbance in pressure from some equilibrium value. The unit of pressure is given in Pascals (Pa) or Newton per square metre (N/m^2). The measurements however cover a very wide range of pressure values, typically from 1×10^{-3} Pa for the hearing threshold value of a human diver at 1 kHz to 1×10^{7} Pa for the sound of a lightning strike on the sea surface. For convenience therefore, sound levels are expressed in decibels (dB) relative to a fixed reference pressure commonly 1 μPa for measurements made underwater. The decibel is therefore a logarithmic way of describing a ratio of sound relative to a specified reference value. Further elucidation on this, often misunderstood concept, is provided by Chapman and Ellis (1998) in their short but seminal paper 'The Elusive Decibel'.

21.2.2. Peak Sound Level

25. For transient pressure pulses such as an explosion or a single strike from a piledriving hammer, the peak sound level is the maximum absolute value of the instantaneous sound pressure recorded over a given time interval. Hence:

$$\text{Peak Level (zero-to-peak)} = 20 \times \log_{10}(|P_{peak}| / P_{ref})$$

Equation 21B.1

26. where P_{peak} is the maximum zero-to-peak positive or negative acoustic pressure in Pascals and P_{ref} is the reference pressure of 1 microPascal (μPa).

27. When the pulse has approximately equal positive and negative parts to the waveform (as shown in **Figure 21B-2**), the peak-to-peak level is often quoted and this is equal to twice the peak level or 6 dB higher.

21.2.3. RMS Sound Pressure Level

28. The Root-Mean-Square (RMS or rms) Sound Pressure Level (SPL) is used to quantify noise of a continuous nature. Underwater sound sources of this type include shipping, sonar transmissions,

drilling or cutting operations, and background sea noise. The RMS SPL is the mean square pressure level measured over a given time interval (t) (illustrated in **Figure 21B-2**), and hence represents a measure of the average sound pressure level over that time. It is expressed as:

$$\text{RMS Sound Pressure Level} = 20 \times \log_{10}(P_{RMS}/P_{ref})$$

Equation 21B.2

29. When RMS SPLs are used to quantify the transient noise arising from an impact piling strike, the time period over which the measurements are averaged must be quoted as the RMS value will vary with the averaging time period. When the noise is continuous, as in the examples given above, the time period over which measurements are taken is not relevant as the measurement will give the same result regardless of the period over which the measurements are averaged.

30. Peak SPLs may be converted to equivalent RMS SPL following consideration of the nature of the signal. For a sinusoidal signal, the relationship between peak level signal and the RMS equivalent is given by peak level – 3 dB. For signals having non-equal positive and negative parts of the waveform such as those from impact piledriving or from seismic airguns, this conversion is not valid. Furthermore, during propagation the outgoing source signal stretches out in time (see e.g., Urick, 1983) and this is attributed to the sound travelling along multiple paths and each arriving at a given location at a slightly different time. As a result, the difference between peak level and RMS varies with distance. Strictly, a conversion factor at any given distance from the piling site can only be determined following analysis of the pressure-time waveforms recorded during the piledriving activity. Without access to such data, it is necessary to obtain a best-estimate from available data. Various studies (e.g. Madsen (2005), Greene (1996), McCauley *et al*. (2000)), suggest a range of values between 2 dB and 20 dB. The lower the conversion factor, the greater the overestimation of RMS SPL for any given non-sinusoidal signal. For the purpose of the subsequent analysis discussed herein, it is recommended that, based on the range of values above, a distance-invariant value of 11 dB be used to convert all peak level metrics to RMS metrics.

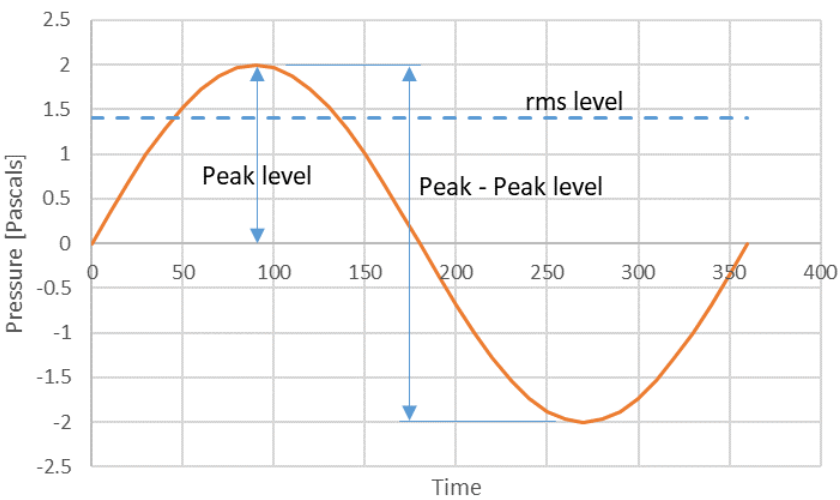


Figure 21B-2: Comparison of three matrices used to characterise the loudness of a sinusoidal sound wave

21.2.4. Sound Exposure Level

31. The problems associated with the time period over which the Sound Pressure Levels are averaged, as highlighted above, can be overcome by describing a transient pressure wave in terms of its Sound Exposure Level (SEL). The SEL is the time integral of the square pressure over a time window

long enough to include the entire pressure-time history. Greene (1996) gives a practical definition of the duration of the time window based on the interval over which 90% of the sound energy arrives at the receptor location and this seems now to be a widely accepted approach (Southall *et al*. (2007), Madsen (2005)). The SEL is therefore the sum of the acoustic energy over a measurement period, and effectively takes account of both the level of the sound, and the duration over which the sound is present in the acoustic environment. Sound Exposure (SE) is defined by the equation:

$$\mathrm{SE} = \int_0^T P^2(t)\, dt$$

Equation 21B.3

32. where T is the overall duration of the sound in seconds and t is time. The SE is a measure of the acoustic energy and therefore has units of Pascal squared seconds (Pa^2.sec).

33. To express the Sound Exposure as a logarithmic decibel, it is compared with a reference acoustic energy level of 1 µPa2.sec. The SEL is then defined by:

$$\mathrm{SEL} = 10 \log_{10} \int_0^T \frac{p^2(t)dt}{p_{ref}^2}$$

Equation 21B.4

34. When the time period is less than 1 second, the SPL is greater than the SEL. When the time period is 1 second, SPL is equal to SEL. For signals of more than 1 second duration, the SEL will be greater than the SPL where:

$$\mathrm{SEL} = \mathrm{SPL}_{90\%} + 10 \times \log_{10}(T)$$

Equation 21B.5

35. Extending the concept of including a time exposure component, SEL can be computed for a single pulse or signal, which in studies of pile driving is often referred to as single-strike SEL (SELss).

21.2.5. Cumulative Sound Exposure Level

36. Where multiple noise events occur, the total or cumulative SEL can be calculated by summing the SEL from the individual events. The events themselves may be separated in time or space or both. For instance, the events could be either consecutive in time from seismic airgun array emissions at a given location or else concurrent from two piling operations taking place in close physical proximity at the same time.

37. For multiple events, the cumulative SEL is computed by summing the SEL (in linear units) of N individual events thus:

$$\mathrm{SEL}_{cum} = 10 \log_{10} \sum_{i=1}^{N} 10^{\frac{\mathrm{SEL}}{10}}$$

Equation 21B.6

21.2.6. Source Level

38. The source level (SL) is the apparent strength of a noise source at a reference distance, usually 1 m, from the source. For example, a noise source may be quoted as having a source SPL of 180 dB re 1µPa at 1 m. In practice, the parameters of the source are rarely measured at such a close range and the source level is inferred by back-propagating the noise from a number of far-field measurements. Back-propagation in this way is most effective when the noise source is compact i.e., where the dimensions of the noise source are small compared with the wavelength of the emitted noise. For this scenario, the noise source is described as a point-source. The process falls down for the opposite case where the sound source is dimensionally large compared with the wavelength. For instance, piledriving noise cannot be approximated as a point source hence the source level thus obtained may only be considered as a notional source level. Hence under these circumstances, back-propagation can lead to an over-estimate of source level.

21.2.7. Propagation Loss and Transmission Loss

39. The propagation loss (PL) represents the loss in intensity or pressure of the acoustic field strength as the noise propagates from source to a receptor. In general terms, the propagation loss is given by:

$$PL = N \log(r) + \alpha r$$

Equation 21B.7

40. where r is the distance in metres from the source to the receptor, N is a factor representing attenuation due to geometric spreading, and α (in $dB.km^{-1}$) is a factor for the absorption of sound in water. Propagation loss is rarely described as simply as this: the subject is discussed further in **Section 21.5**.

41. It is noted that the terms propagation loss and transmission loss (TL) have previously been declared synonymous (Ainslie, 2005) and are often used as such. However, the ISO Standard on underwater acoustic terminology (ISO, 2017) defines transmission loss as being the difference in sound pressure level at two different locations:

$$TL(r_2,r_1) = SPL(r_2) – SPL(r_1)$$

Equation 21B.8

42. where r_2 and r_1 are the distances from a source location and that r_2 is larger than r_1 so that the resulting TL is usually a positive number.

21.2.8. Received Level

43. The Received level (RL) is the strength of the acoustic field at a given depth and range relative to the source. At a range r from a source, this is given by:

$$RL = SL - PL$$

Equation 21B.9

44. From Equation 21B.7, this can be written in the form:

$$RL = SL – N \log(r) - \alpha r$$

Equation 21B.10

45. As the received level varies with range, it is important to state the range at which the measurement has been taken or the estimate has been made.

21.3 Sound Source characterisation

21.3.1. Introduction

46. Due to the range of parameters which are included in the proposed Project Design Envelope at this stage, it is not possible to assign unambiguous acoustic characterisation data such as source sound levels and frequency spectra to each activity. In order to address this, a review of the international published literature was undertaken. From this, each task was discussed in terms of the acoustic characteristics of the noise likely to arise. Representative worst case scenario sound levels for each operation were established and these are discussed below.

21.3.2. Pre-construction geophysical surveys

47. Prior to the commencement of any construction work, it is necessary to undertake geophysical surveys to ascertain the nature of the seabed structure; the water depths over a fine scale commensurate with the subsequent positioning of the piling sites; to determine the presence of any obstructions on the seabed including UXO; and to track the position of remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs) or divers.

48. The physical resolution of the sonar devices is directly related to the frequency of the transmitted signals while the effective range over which the signals carry is related to the frequency, the acoustic source level and the beamwidth or angular spread of the transmitted energy. For each device, a pulse of acoustic energy of typical duration ~milliseconds, followed by a quiet period where signals reflected from the target are detected and recorded. The duty cycle, the ratio of the pulse duration relative to the quiet period, is typically around 10% although this varies from sonar to sonar. The geophysical surveys at the Study Area thus draw on a range of sonar devices whose transmissions consist of varying frequency content and acoustic source level.

49. **Table 21B-1** shows the acoustic characteristics, agreed by the client, for a number of sonar devices which may be used during the pre-construction surveys.

Table 21B-1: Acoustic source levels and frequencies for geophysical sonar devices deployed at Llŷr array area (data taken from Genesis (2011))

Activity	Operating frequency (kHz)	Source level (dB re 1 µPa @ 1 m)	Typical pulse duration and duty cycle	Sound source data reference & Notes
Swathe or multi-beam echo sounder (MBES)	170 - 450	221 SPL_{peak}	3 msec @ 10%	Kongsberg Equipment specification sheet (2023a)
Side scan sonar (SSS)	300 - 600	226 SPL_{peak}	0.17 msec @ 1%	EdgeTech Equipment specification sheet (2023)
Sub-bottom profiler (SBP)	0.5 – 12	238 SPL_{peak}	1.3 msec @ 7.5%	Innomar Equipment specification sheet (2023)

Activity	Operating frequency (kHz)	Source level (dB re 1 µPa @ 1 m)	Typical pulse duration and duty cycle	Sound source data reference & Notes
Ultra-short baseline (USBL) positioning sonar	21 - 31	207 SPL_{peak}	0.17 msec @ 10%	Kongsberg Equipment specification sheet (2023b)

21.3.3. Vessel movements

Acoustic source levels

50. Vessel noise is a combination of broadband sound superimposed with tonals at specific frequencies corresponding to propeller blade rate, engine cylinder firing and crankshaft rotation. Southall *et al*. (2019) classifies vessel noise as being non-impulsive in nature.

51. A limited set of acoustic data for noise-ranged vessels are available (Ricardson *et al*. (1995), Hannay (2004), JASCO (2011), Johansson and Andersson (2012), Götz (2009)), none of which are likely to include the vessels expected to be contracted for activities on behalf of the proposed Project. It is assumed that vessel noise is proportional to overall vessel size and hence vessel power (Li *et al*., 2011). It is necessary therefore to use acoustic characterisation data from similarly sized vessels to those anticipated for proposed Project activities.

52. Client-supplied data provide some limits to the vessels that might be expected to be deployed on the proposed Project. These consist of a cable-lay vessel, around 140 m in length, operating with dynamic positioning (DP) and generating noise levels in the range 180-197 dB re 1 µPa rms, and two classes of project support vessel - medium (in the length range 50 m to 100 m); and small (length <50 m) where noise levels will be in the range 160 – 180 SPL dB re 1 µPa rms. These are likely to be the largest vessels (hence generating the highest underwater noise levels) involved in Project activities. Any other vessels such as survey boats or those providing movement of personnel throughout the Offshore Development Area are assumed to be much smaller thus generating lower underwater noise levels.

Source spectra

53. The shape of the frequency spectrum across the bandwidth of the noise emitted by a vessel is key to determining the significance of any ensuing acoustic impacts.

54. Wales and Heitmeyer (2002) proposed a source spectra model for merchant ship-radiated noise, based on the Research Ambient Noise Directionality (RANDI) 3.1 model (Breeding *et al*. (1994)). As part of the Joint Monitoring Programme for Ambient Noise in the North Sea (JOMOPANS) project, RANDI 3.1 was validated using acoustic data from a hydrophone located in Haro Strait, British Columbia, Canada together with Automated Information System (AIS) broadcasts from passing vessels (MacGillivray and de Jong, 2021). Subsequent analysis was necessary in order to determine vessel source levels and frequency content. The ensuing model, drawing on vessel type, approximate length, breadth and depth; and a representative transit speed, was used in order to derive representative frequency spectra for various classes of vessel proposed for use in the proposed Project and these are given in **Figure 21B-3**.

55. No data are available on the directionality of vessel noise. It is assumed therefore that the sound radiates equally in all directions.

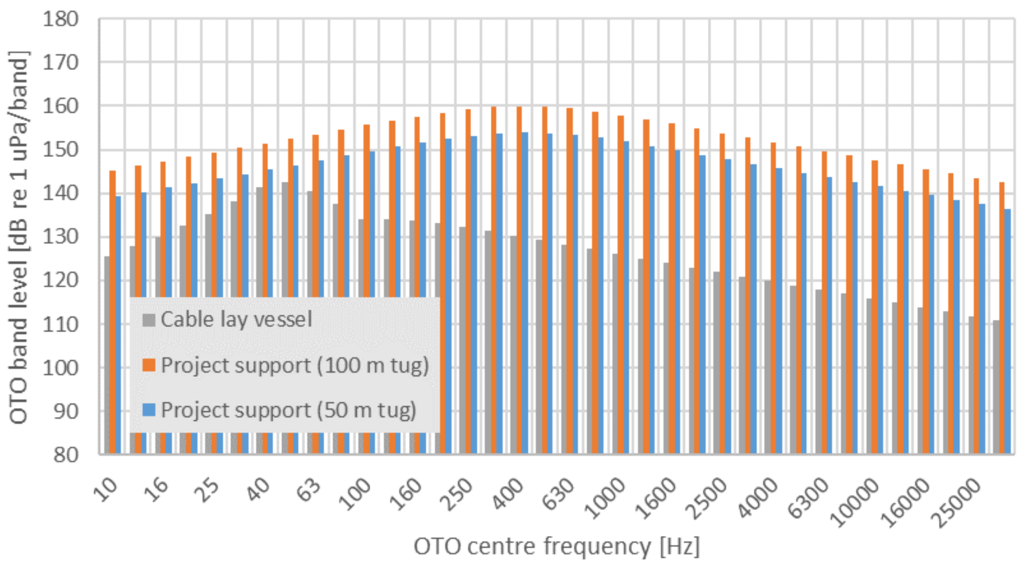


Figure 21B-3: One third octave (OTO) band level spectra for vessels proposed for use on the proposed Project

21.3.4. Cable installation activities

Dredging, jetting and rock placement noise

56. A number of seabed preparation activities may be required prior to construction of infrastructure. These activities include levelling the seabed. For the proposed Project, a backhoe dredger and a suction dredger are proposed to be deployed from specialist vessels to carry out seabed levelling activities. For the dredging operations, noise is generated as the backhoe is dragged over the seabed or else as the seabed material is sucked up the drag head. It is understood that the noise recorded during dredging operations is principally the noise made by the vessel. Source levels of 165 dBrms re 1 µPa at 1 m and 186 dBrms re 1 µPa at 1 m have been agreed by the client for backhoe and suction dredging respectively.

57. Jetting or jet trenching is an operation whereby powerful water jets dig a trench in the seabed within which the export cable is laid. Immediately afterwards, additional water jets are involved in the cable burial process. It is understood that noise source levels are generally low: Nedwell *et al*. (2003) determined a source level of 178 dBrms re 1 µPa at 1 m and this is the value agreed by the client for the subsequent analysis.

58. Additional mechanical protection to the cable, if required, can be provided through a number of different protection methods, including by rock placement. Only one set of acoustic data relating to rock placement operations was found in the published literature (Royal Haskoning, 2011). Measurements of the fall-pipe vessel *Rollingstone*, placing rock at a depth of 60-70 m near the Shetland Islands, UK, showed no evidence that rock placement itself contributed to the noise level. It is assumed that noise levels associated with rock placement operations were equal to background underwater noise levels (thus see **Section 21.5.7**). Any noise arising therefore during rock placement activities is likely to be largely attributable to the noise generated by the vessels involved in the activity. An acoustic source level of 172 dBrms re 1 µPa has thus been established for the purpose of this model.

59. Source spectra for each cable installation activity in the Study Area have been obtained from the reference spectrum model discussed above (MacGillivray and de Jong, 2021) and these are given in **Figure 21B-4.**

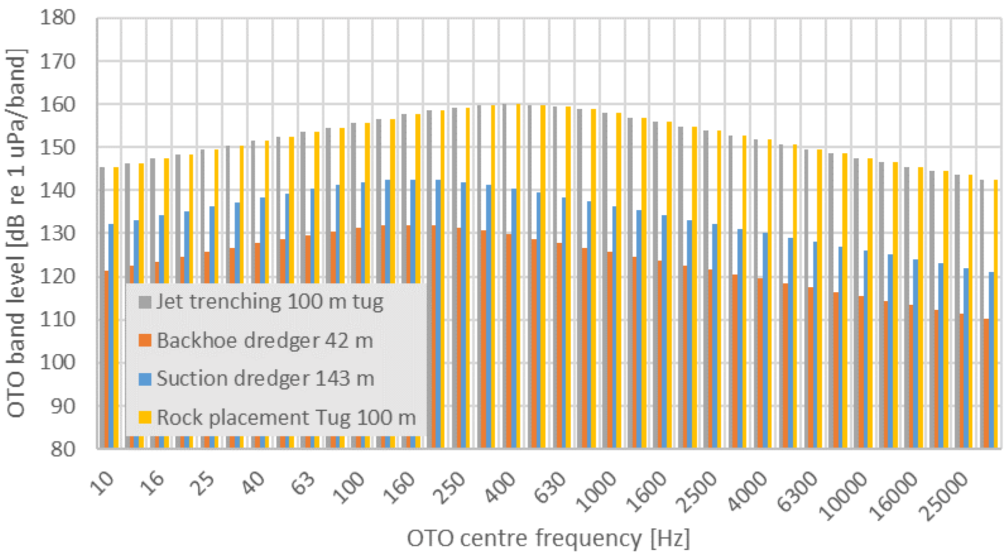


Figure 21B-4: One third octave (OTO) band level spectra for vessels proposed for use on the proposed Project

Impact piling

Acoustic source levels

60. Underwater piling noise is generated through the impacting of a hydraulically powered hammer onto the end surface of the pile. The noise is dependent on the force applied and the dimensions of the impacting hammer which, in turn, are related to the diameter of the pile and the engineering properties of the sediment into which piling is taking place. It is to be intuitively expected that the larger the pile the greater the force required to drive it and the louder the noise subsequently generated. However, the geotechnical properties of the underlying sediment affect the energy levels required to drive the pile to the design depth: for instance, less energy is required to drive a pile through a clay substrate than through a sand layer hence for the same diameter pile, it is likely that noise levels in the first case will be lower than those in the second case. Dahl *et al*. (2015) reviews a number of observational and numerical studies where it is suggested that ~0.5% of the energy delivered to the hammer finds its way into the water as acoustic energy.

61. The energy levels required to drive the piling rig may be estimated through a modelling procedure known as wave equation analysis of pile driving (Smith, 1960). This is a complex numerical analysis on the behaviour of driven piles. The piling hammer and associated equipment are modelled as a series of lumped springs and masses while the sedimentary layers are modelled as a series of viscoelastic-plastic masses. The underlying models are realised in various software packages however, these all require as input, advanced geotechnical data relating to the sediments through which the pile is to be driven. When such data are not available, an alternative method must be approached in order to estimate likely noise levels.

62. To address this knowledge shortfall, the international published literature has been reviewed in order to determine whether noise levels recorded from other construction activities can be used as proxy noise levels for the current Llŷr project. Key parameters to be considered for comparison are pile-size, water depth and sediment type. It is important to ensure that each comparator is as close as possible in dimension or type to those used in the project activity.

63. Underwater sound pressure level data were obtained from reviews of piling noise undertaken by Bellman (2014) and Rumes *et al.* (2015). These data were noise levels recorded at a distance of 750 m from the piling site acquired predominantly (but not exclusively) during piling in the North Sea and Baltic Sea for various offshore wind farm projects. Water depths were in the range 15-40 m which is somewhat shallower than those across the Llŷr FOWF sites. Pile diameters were in the

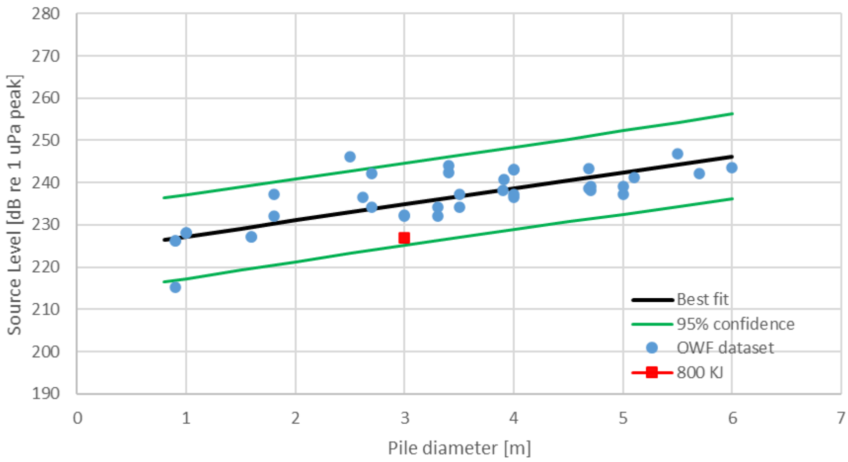
range 0.9 m to 6 m and thus encompassed those proposed for the Llŷr project being 2.5-3 m. These data were back-propagated to the source position using a 15 $\log_{10}$[R] relationship[1], where R=750 m, and the resulting source levels are shown in **Figure 21B-5** as a function of pile diameter.

64. The source level data given in the figure supports the contention that the larger the pile diameter, the greater the force required to drive it into the sediment and the louder the underwater noise thus generated. It is also seen that there is a considerable variation in source level for any given pile diameter. The ensuing scatter is attributed to the varying seabed geotechnical conditions at each pile site however this level of detail is rarely reported in the underlying literature. Nevertheless, in the absence of more precise information, these data are taken forward for use in the analysis discussed in this report.

65. A trendline fitted to the combined dataset was subsequently used to estimate an acoustic source level likely to arise during piling with a 3 m pile diameter at the Llŷr array area. The 95% confidence limits were determined in order to capture the data variation at any given pile diameter and these are included in **Figure 21B-5**. At a pile diameter of 3 m, it is expected that acoustic source levels are likely to fall in the range 235 ± 9.5 dB re 1 μPa at 1 m.

66. An alternative approach may be followed in order to estimate acoustic source level associated with piledriving. De Jong and Ainslie (2008) provide an energy conversion model that estimates the noise level given the hammer energy and an assumed energy conversion factor of 0.5% (see above). For a hammer energy of 800 kJoules (Hill, Pers. comm), the expected acoustic source level is 227 dB re 1 μPa at 1 m and this value is also included in **Figure 21B-5**: . It will be seen that this value lies within the range of values that might be expected for a 3 m pile. In line with the precautionary principle, the acoustic source level of 235 dB re 1 μPa at 1 m is therefore deemed appropriate.

67. A pulse duration of 0.022 seconds was estimated from the waveform data contained in the aforementioned datasets (Bellman, 2014; Rumes *et al*., 2015). Subsequently, the SEL for a single strike of the piling hammer was obtained. The acoustic source levels are given in **Table 21B-2**.



[1] Given the range of water depths in the North Sea and Baltic Sea, a propagation constant of 15, midway between spherical (20) and cylindrical (10), is deemed appropriate.

Figure 21B-5: Scatter plot of acoustic source levels as a function of pile diameter for impact piling

Table 21B-2: Estimated acoustic source level for impact piling at Llŷr array area

Pile diameter	SPLpeak	$SEL_{single\ strike}$
3 m	235 dB re 1 µPa @ 1 m	218 dB re 1 µPa^2.sec @ 1 m

Source spectrum

68. A review of the published reports on the underwater noise impacts of piling noise reveals that there is relatively little data on the spectral content of the noise generated during piling activity. Two potential sources for this parameter are discussed below.

69. Underwater sound pressure levels were recorded from pile driving activities at many marine construction sites throughout Northern California, USA (CDOT, 2007). These provide an empirical database which may be accessed in order to obtain estimated underwater noise levels elsewhere. At each site, noise levels were recorded underwater where the water depths generally varied in the range 2-10 m and were rarely greater than 15 m. The piles were thin-walled, steel tubes varying in diameter from 0.3 to 2.4 m. This range of pile sizes are smaller than those proposed for use in the Llŷr Project and furthermore, the water depths in the California dataset are rather shallower than those found across the Llŷr site. It is accepted that the frequency spectrum of the piling noise is governed in part by the water depth (see Section 5). In shallow waters, the spectrum is likely to show considerable reductions in low-frequency noise compared with noise levels acquired in deeper water. It is necessary to access spectral data obtained from piling activities in deeper water. The Belwind OWF lies in the Belgian sector of the North Sea where foundation piles 4 m diameter were driven into the seabed through water depths around 29 m (Norro *et al*., 2010). Although this is still considerably shallower than at the Llŷr sites, no other data are available thus a spectrum based on measurements made at Belwind OWF are taken forward for use in the current work and the results are caveated accordingly.

70. The source spectrum data at Belwind were recorded as 1/3rd octave band levels in units of dB re 1 µPa^{2}m^2 over the frequency range 10 Hz to 80 kHz. (Acoustic SPLs for point sources are given in units of dB re 1µPa. For directional noise sources that are not small in relation to the wavelength of the noise they generate, SPLs are given in units of dB re 1 µPa^2 m^2. Ainslie (2011) states that the numerical value of the energy source SPL in each case is numerically the same. Individual band levels were adjusted in order to give the same overall acoustic source level matching that given in **Table 21B-2** and the resulting 1/3rd octave band spectrum, representing source noise levels generated from piling a 3 m diameter pile, is shown in **Figure 21B-6**.

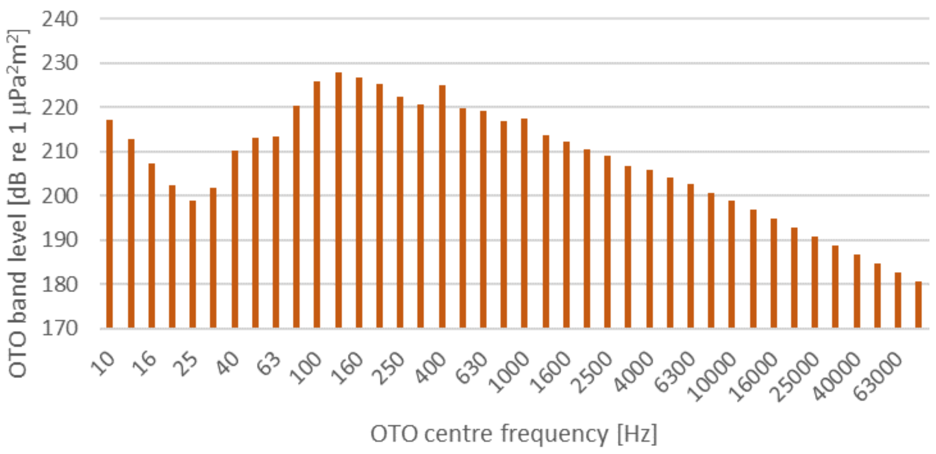


Figure 21B-6: One third octave (OTO) band level source spectrum proposed for the Llŷr impact piling hammer

21.3.5. Drilling

71. During drilling, noise is generated principally through the action of the drill bit on the substrate. The level of noise created is dependent therefore not only on the size of the drill bit but also on the degree to which the substrate is consolidated; a soft clay will produce lower levels of sound compared to that generated by a granite layer.

72. Noise generated at the drill head is likely to be transmitted into the water through two mechanisms. The first is where the noise is transmitted from the drill bit-sediment interface and into the surrounding seabed layers before becoming refracted back into the water column while the second is where vibrations travel up the drill shaft and then become transmitted into the water.

73. A review of the literature on underwater drill noise revealed that there is little useful data that has been released into the public domain: invariably the noise measurement units are ambiguous; the drill diameter is not quoted; or there is no information on sediment or seabed rock type. Despite this, three reports were identified where they contained sufficient data such that useful source levels and frequency spectra for underwater drilling could be estimated. The first report (Ward & Needham, 2012) discussed underwater noise recordings made in the vicinity of a site where a 4.2 m diameter foundation socket was being drilled through a metamorphic basement rock having little or no sediment cover. For this scenario, the source level was estimated at 153.4 dB peak re 1 µPa at 1 m. The second report (Willis *et al*., 2010) related to small scale drilling off southwest Wales using a 20 cm diameter drill. Measurements of noise were made at distances of 7.5 m, 23 m and 179 m from the site while drilling into sedimentary mudstone or shale. Analysis of the data led to an estimated source level of 135.8 dB peak re 1 µPa at 1 m. The last report (Erbe & McPherson, 2017) discussed a geotechnical site investigation using an 83 mm diameter drill bit drilling through sand and mudstone. Source levels were reported in the range 142-145 dBrms re 1 µPa over the frequency range 30-2000 Hz.

74. The source frequency spectrum shown in **Figure 21B-7** is based on the data given by Willis *et al*. (2010) with spectral levels adjusted to give the requisite source level of 170.1 dB re 1 µPa at 1 m as given by Barham and Mason (2021) in connection with the nearby project, ErebusOWF which lies ~5 km to the northwest of the Llŷr Array Area.

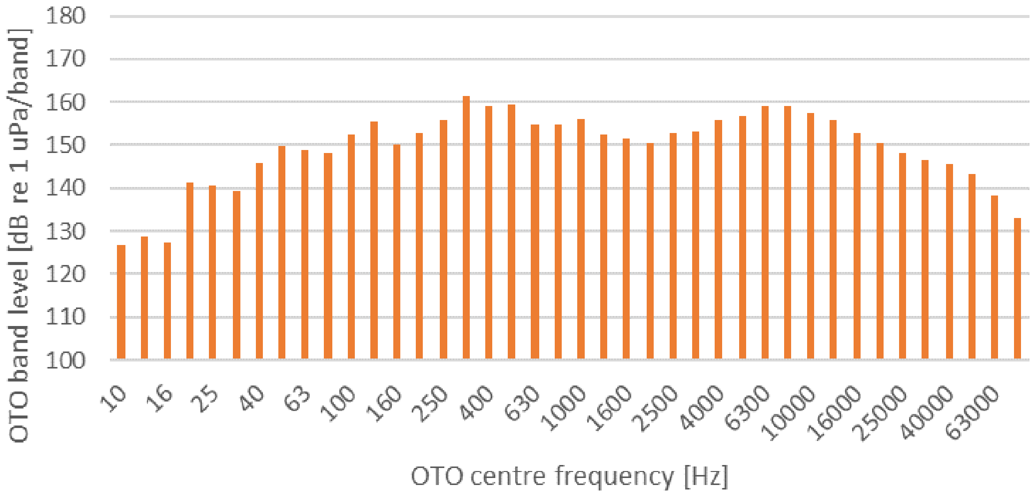


Figure 21B-7: One third octave (OTO) band level source spectrum proposed for Llŷr drilling

21.3.6. Wind turbine operational activity

75. During normal operation, underwater noise generated by wind turbines is expected to be low and measurements largely support this contention. Tougaard *et al*. (2009) report that noise at windfarms in Denmark and Sweden was only measurable above ambient background noise at frequencies below 500 Hz. More recent measurements by Tougaard *et al*. (2020) indicate that acoustic source levels are at least 10-20 dB lower than ship noise in the same low frequency range. Barham and Mason (2021) suggest an acoustic source level of 161 dBrms re 1 μPa based on measurements of operational underwater noise made at the Hywind Floating Offshore Windfarm off the east coast of Scotland for wind speeds in the range 5 knots to 25 knots (Burns *et al*., 2022). At Hywind, tonal noise below 500 Hz, associated with rotating rotor and generator components, was evident and showed correlation with wind speed. The data showed that broadband source levels varied from 158.9 dB re 1 μPa^2m^2 to 172.0 dB re 1 μPa^2m^2. For the analysis contained in the current report, an acoustic source level based on the 75th percentile for a 20-knot wind, viz. 167.2 dB re 1 μPa^2m^2 was subsequently taken forward. The spectrum based on this noise level is shown in **Figure 21B-8.**

76. Intermittent snapping or clicking noise was recorded at the Hywind site in 2011 (Martin *et al*., 2011) and 2022 (Burns *et al*., 2022). In each case, the noise was attributed to tension release in the mooring system. Subsequent analysis of the HYWIND 1 data by Xodus (2015) for the HYWIND Scotland Pilot Park Project predicted a potential cumulative SEL of up to 157 dB re 1 μPa^2sec over 24 hours caused by snapping chains from six turbines. No spectral data are available for this artefact hence it is not possible to include this feature in the noise analysis conducted herein.

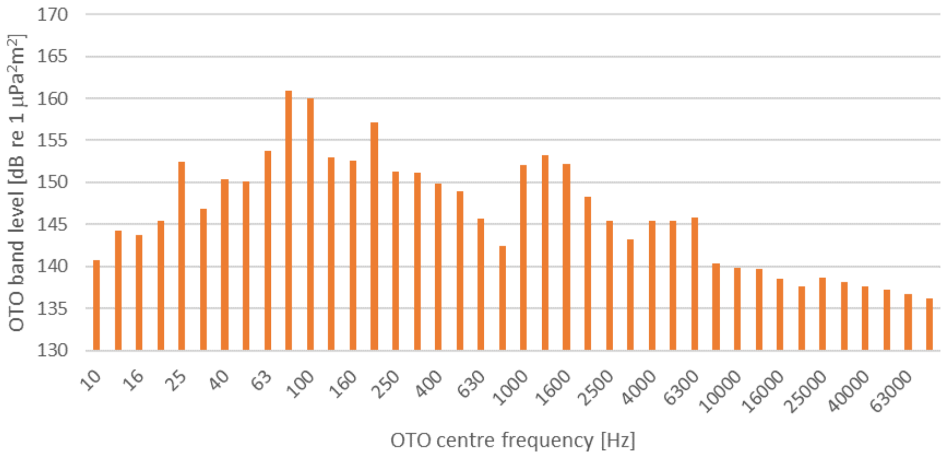


Figure 21B-8: One third octave (OTO) band level source spectrum proposed for Llŷr operational noise

21.3.7. Unexploded ordnance

Introduction

77. The potential exists for quantities of unexploded ordnance (UXO) to be discovered in the Offshore Development Area. These need to be rendered harmless before any construction work continues and the safest option is through detonation at the site of discovery. It is likely that there will be a range of explosive types and charge weights and these may have been subject to degradation and burying in the seabed over time. As a result, two UXO devices having the same type and weight could conceivably yield different blasts on detonation. For the nearby Erebus OWF, a range of charge weights (25-794 kg), were used in the underwater noise impact study and these were based on site surveys and following consultation with various Statutory Bodies. Given the geographical proximity of the two developments, it is deemed appropriate therefore to work with the same charge weights that were agreed for the Erebus Project in the analysis undertaken for the proposed Project. A number of detonation techniques are available (EODEX, 2023; Cook & Banda, 2021):

- High order detonation – this is a technique where a small counter charge is placed next to the UXO. The counter charge is detonated and this causes the UXO to detonate in turn. A blast wave equivalent to full detonation of the device is likely to occur.
- Low order clearance – this is also referred to as 'deflagration'. The technique requires an initial shaped explosive charge, typically 250 grammes but sometimes larger, to breach the casing of the UXO and to ignite the explosive material but without causing detonation of same. The blast wave from the shaped charge is much smaller than would arise from the high order detonation of the same explosive. The technique is not without risk: depending on the stability of the explosive material, deflagration may inadvertently lead to a high order event.
- Low yield disposal – this technique also relies on small, shaped charges to break open the casing. Thereafter, a high-pressure water jet washes the explosive material out of the casing where it subsequently dissipates in the water. Again, the stability of the explosive material may be such that a high order detonation results before the material has had the chance to dissipate.

78. Regardless of the intended detonation technique, the unintended consequence is that a high order detonation might arise while, at best, a smaller low order detonation prevails. The discussion in this report will focus on these two methods of dealing with UXO. Modelling the key acoustic characteristics draws on the same techniques and is discussed below.

Acoustic source level

79. An explosive charge contains a chemical compound such as trinitrotoluene (TNT) or pentaerythritol tetranitrate (PETN). The explosion commences with a chain reaction throughout the charge which generates gas at very high temperature and pressure (Urick, 1987; DOSITS, 2023). A shock wave is formed at the gas-water boundary, and this propagates through the water. The shock wave creates a near instantaneous rise in pressure which then decays rapidly. The hot gasses also create a large oscillating gas bubble in the water. Between them, the gas bubble and the shock wave contain around half of the energy produced by the explosion. The bubble expands until its internal pressure is less than that in the surrounding water, at which point it begins to collapse until the internal pressure has increased. A series of bubble oscillations ensue where each successive pulse is weaker than the preceding one: the peak pressure of the second bubble pulse is only about 20% that of the first bubble pulse. The subsequent pressure-time history is illustrated in **Figure 21B-9.**

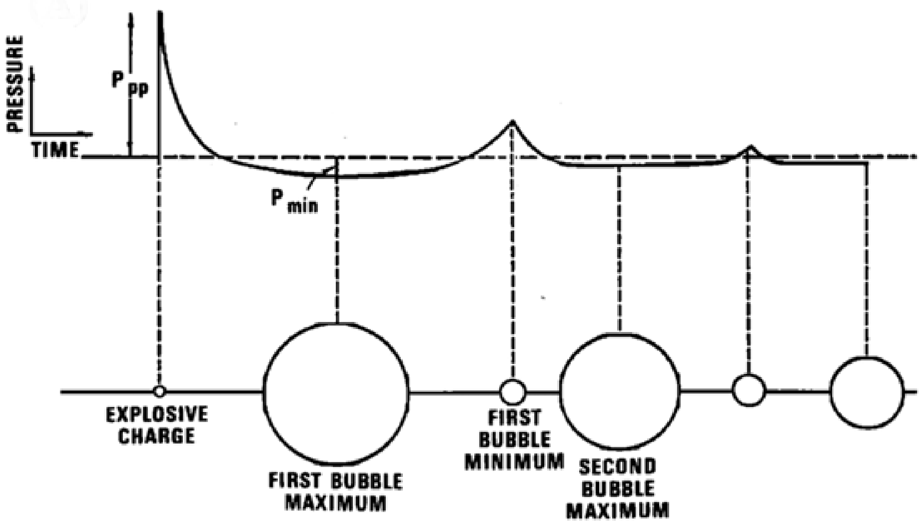


Figure 21B-9: Idealised pressure-time curves for underwater blasts. Adapted with permission from Gaspin et al. (1979) Copyright 1979, Acoustical Society of America.

80. The peak pressure value, which occurs around a microsecond after detonation, is given by the semi-empirical expression derived by Cole (1948):

$$SPL_{peak} = 5.24 \text{ x } 10^{13} \left[\frac{W^{1/3}}{R}\right]^{1.13} \text{ Pa}$$

Equation 21B.11

81. where W is the charge weight of explosive in kg; and R is the distance from the blast site in metres. From extensive measurements of blast in the shallow waters off the east coast of the USA, Soloway and Dahl (2014) developed an expression for the sound exposure level following a single detonation:

$$SEL_{ss} = 6.14 \text{ x } \log_{10}\left[W^{1/3}\left(\frac{R}{W^{1/3}}\right)^{-2.12}\right] + 219 \text{ dB re 1 } \mu\text{Pa}^2\text{.sec}$$

Equation 21B.12

82. The resulting acoustic source level for a range of charge weights is given in **Table 21B-3**.

Table 21B-3: Acoustic source levels in unweighted SPLpeak and SELss as a function of charge weight for low order and high order detonations

Detonation type	Charge weight [kg]	SPL_{peak} [dB re 1 µPa at 1 m]	SEL_{ss} [dB re 1 µPa^2.sec]
Low-order	0.1	266.7	212.6
	0.25	269.9	215.2
	0.5	272.1	217.1
	2	276.7	220.9
High-order	25	284.9	227.9
	55	287.5	230.1
	120	290.1	232.3
	240	292.3	234.2
	525	294.9	236.4
	794	296.2	237.5

Source spectrum

83. The frequency content of a signal generated by an explosive blast is related to the characteristics of the initial shock pulse and the subsequent oscillation of the detonation gas bubble as reviewed above. The noise generated by an underwater detonation is broadband in characteristic with a bandwidth of several hundred kHz (Robinson *et al*., 2022) although peak levels are found over the range 10 – 1000 Hz (Salomons *et al*., 2021). The resulting energy source level contained in the explosion is determined using a technique described by Urick (1971) where a series of energy source level spectral density curves for underwater explosions at various depths are defined in terms of a normalised frequency. The technique is illustrated by Hannay and Zykov (Hannay & Zykov, 2022) and is drawn on for the analysis contained herein.

84. Chapman (1988) developed an expression for the first bubble frequency:

$$f_{b1} = \left(2.11\ \mathrm{w}^{1/3} \mathrm{z}_0^{-5/6}\right)^{-1}$$

Equation 21B.13

85. where w is the charge weight in kg, z_0 is the hydrostatic depth in metres of the charge and is given by $z_0 = z_s + 10.1$ metres, where z_s is the charge depth.

86. On the basis that water depths over the array area vary between 45 m and 70 m, a representative charge depth of 54 m is used thus giving a hydrostatic depth of 64 m. Normalised energy spectral data are read from the appropriate curve in **Figure 21B-10.**

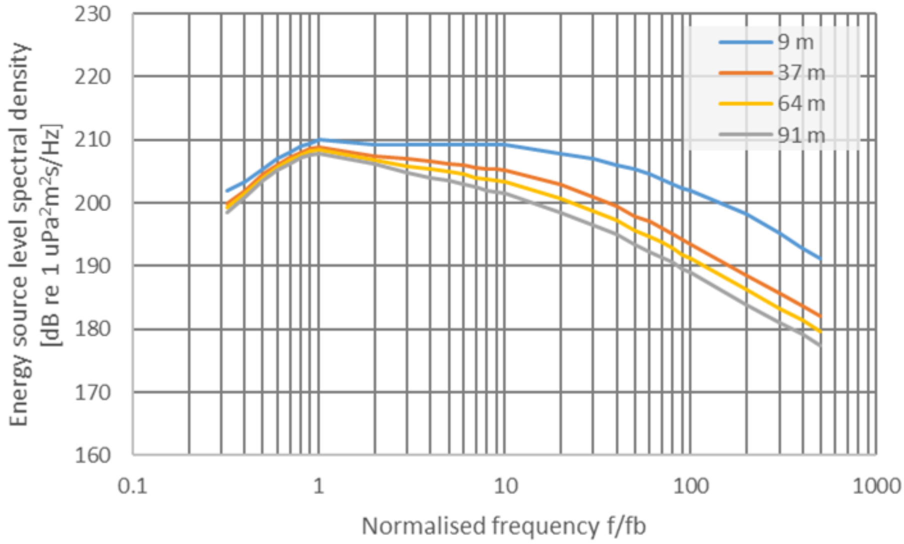


Figure 21B-10: Explosive energy flux density spectrum curves at a range of hydrostatic depths for a 1 kg charge

87. The first bubble pulse frequency is calculated from Equation 21B.13 and absolute frequencies across the spectrum are determined by multiplying the normalised frequencies by f_{b1}. The spectral levels are then corrected by the addition of a scaling factor D given by

$$\Delta = 13.3 \log_{10}(w)$$

Equation 21B.14

88. The corresponding energy frequency spectrum calculated across 1/3rd octave centre frequencies, for an example 240 kg explosive charge, is shown in **Figure 21B-11**.

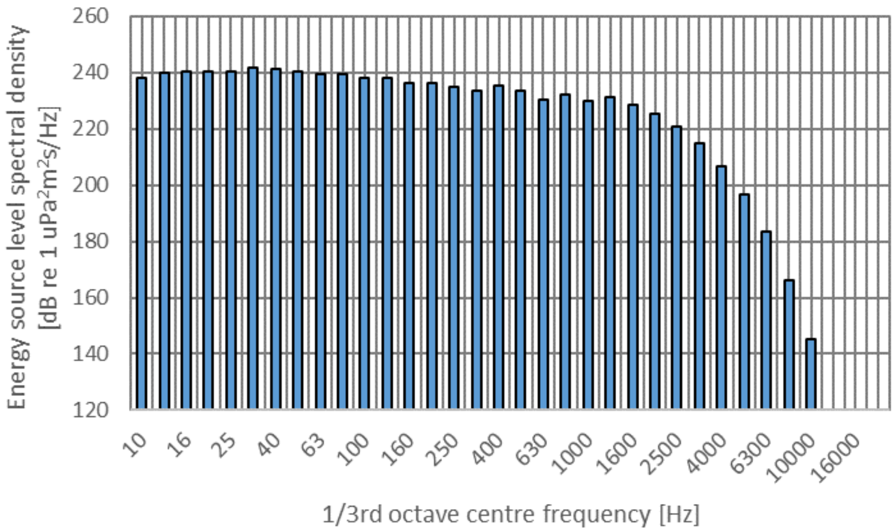


Figure 21B-11: One third octave band level source spectrum generated by the detonation of a 240 kg explosive charge

21.3.8. Summary

89. The noise sources for the activities undertaken within the Study Area are characterised using the acoustic data presented above. These are taken forward for use in the acoustic modelling section discussed in **Section 21.6** of this report.

21.4 Marine Fauna and Acoustic Impact Criteria

21.4.1. Introduction

90. A number of species of marine mammal, fish and sea turtle have been identified as potentially being present in and around the Offshore Development Area. This section provides a discussion of the assessment criteria against which the impact of man-made underwater noise on various marine species is quantified. These criteria are used to estimate the size of impact zones centred about each source of noise using the results from underwater sound propagation modelling.

21.4.2. Acoustic impact thresholds

Introduction

91. The derivation of appropriate threshold levels of noise on marine life exposed to impulsive- and non-impulsive-type noise draws on the methodologies developed by Southall *et al*. (2007; 2019) for cetaceans and pinnipeds; and Popper *et al*. (2014) for fish and sea turtles. An overview of the salient points is given below.

21.4.3. Marine mammals

Physiological impacts

92. Southall *et al*. (2007) commenced by reviewing work undertaken over previous decades on animal audiology and noted that marine mammals could be assigned to one of a number of functional hearing groups where each group depended on differences and similarities in the animal's audiological physiology and behavioural psychophysics. To illustrate this, it was noted that although marine mammals possess the typical mammalian 3-stage ear, there are subtle differences that indicate specific adaptations to pressure, hydrodynamics and sound reception in water. For instance, the outer ear, denoted by the pinna, has been eliminated in all cetacean species and some pinniped species while gas spaces in the middle ear of some marine mammals have been reduced substantially thus indicating that bone conduction may be an important means by which sound is transferred to the inner ear. In addition, cetaceans were further subdivided on the basis of their hearing sensitivity.

93. The latest functional hearing group (FHG) classification for species relevant to the proposed Project are given in **Table 21B-4**.

Table 21B-4: Function hearing groups for marine mammal species known or likely to be present within the vicinity of the Offshore Development Area

Functional hearing group	Note
Low-frequency cetaceans (LF)	Baleen whales e.g., minke
High-frequency cetaceans (HF)	Toothed whales and dolphins e.g., common dolphin, bottlenose dolphin
Very high-frequency cetaceans (VHF)	Toothed whales and dolphins e.g., harbour porpoise
Phocid pinnipeds (PCW)	Grey seal, harbour seal

94. It is acknowledged that, like humans, marine mammals do not hear equally well across all frequencies. In order to account for this, Southall *et al*. (2007) proposed a series of frequency-dependent weightings that were derived from the hearing sensitivity curves for animals in each functional hearing group. These have the effect of emphasising the frequencies over which the animals are most sensitive and de-emphasising the remaining frequencies. For each FHG (species of which are listed in **Table 21B-4**), passband functions with specified roll-offs were developed by Southall *et al*. (2007) and have been subsequently refined a number of times since (Southall *et al*.,

2019). The frequency-weighting curves, (collectively known as M-weightings), for each functional hearing group representing marine mammals found in and around the Study Area are shown in **Figure 21B-12**. The M-weighting curves are used to modify the frequency spectrum of the impacting noise so that it more closely represents the noise as perceived by the target species. From these data, weighting values are extracted for each functional hearing group and applied to the frequency band levels for the sound source given in **Section 21.3**.

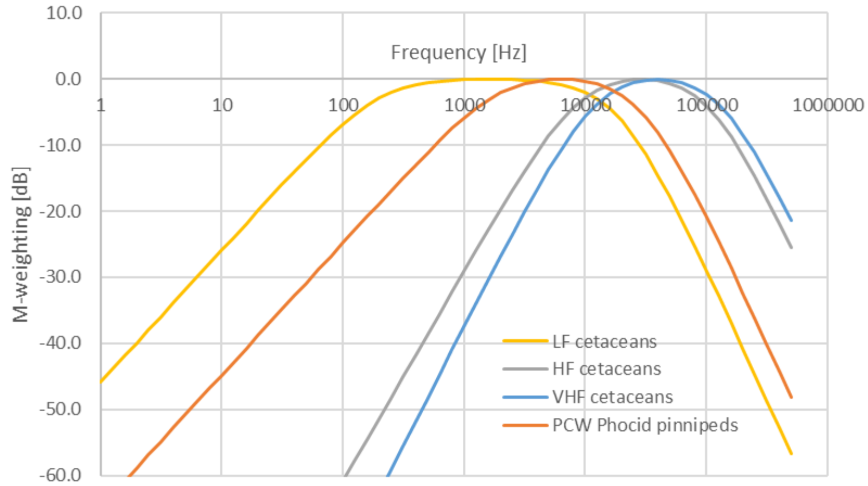


Figure 21B-12: M-weighting curves for low-, high- and very high-frequency cetaceans and for pinnipeds

95. Given the frequency dependent M-weightings, it is possible to determine the apparent source levels of the underwater noise type as perceived by each of the FHGs following the technique demonstrated by Houser *et al*. (2017). The M-weighting curves are applied to the noise spectra as given in **Section 21.3** and the results are summarised in **Table 21B-5** using SPL_{peak} metrics. For reference, the column headed 'Un' provides the unweighted noise source level. It is seen that LF cetaceans are most sensitive to the noises generated during the construction activities at the proposed Project due to the relatively high levels of low-frequency noise in the outgoing signals. By comparison, VHF cetaceans are much less sensitive to the various noise types as the higher frequency components of the signals generated contain much less energy than those at lower frequencies.

Table 21B-5: Apparent source levels perceived by each marine mammal functional hearing group

Impacting noise type	Far-field apparent source level dB_{Peak} re 1 µPa				
	Un	LF	HF	VHF	PCW
Drilling	170.1	168.7	161.8	159.5	166.4
Wind turbine operational	167.2	162.9	148.7	147.1	156.7
Impact piling	234.8	231.6	205.7	202.3	220.8
Cable laying	197.0	189.3	170.8	168.9	179.9
Project vessel (large)	180.0	178.4	163.8	161.9	172.4
Project vessel (medium)	170.0	168.4	153.8	151.9	162.4
Jet trenching	181.0	179.4	164.8	162.9	173.4
Backhoe dredging	165.0	161.6	144.7	142.8	153.7
Suction dredging	186.0	182.6	165.7	163.8	174.7

Impacting noise type	Far-field apparent source level dB_{Peak} re 1 µPa				
	Un	LF	HF	VHF	PCW
Rock emplacement	172.0	170.4	155.8	153.9	164.4

96. From reviewing available data derived from extensive tests involving marine mammals, Southall *et al*. (2007) proposed thresholds representing the onset of permanent threshold shift (PTS) for marine mammals (based on measurements relating to the onset of temporary threshold shift (TTS)) which were expressed in terms of SPL and SEL, where the latter metric (expressed as dB re 1 μPa^2.s) takes note not only of the period of time over which the receptor is exposed but also the sensitivity of the animal to the impacting sound. For impulsive type noises such as that emitted by impact piling or explosions, the thresholds are given using both SPL metrics using unweighted source levels; and SEL metrics where the appropriate M-weighting has been applied to the source spectrum. For continuous type noise such as trenching or vessel noise, the thresholds are given using only SEL metrics. The resulting impact thresholds, subsequently refined by Southall *et al*. (2019) for both PTS and TTS, are given in **Table 21B-6.**

Table 21B-6: Summary of acoustic impact threshold criteria for PTS and TTS in SPL_{peak} and M-weighted SEL metrics for each functional hearing group when exposed to impulsive and non-impulsive noise.

Functional hearing group	Impulsive noise				Non-impulsive noise	
	Unweighted SPL_{peak} thresholds dB re 1 µPa		M-weighted SEL thresholds dB re 1 μPa^2.sec		M-weighted SEL thresholds dB re 1 μPa^2.sec	
	PTS	TTS	PTS	TTS	PTS	TTS
LF cetaceans	219	213	183	168	199	179
HF cetaceans	230	224	185	170	198	178
VHF cetaceans	202	196	155	140	173	153
PCW pinnipeds	218	212	185	170	201	181

Behavioural impacts

97. To arrive at threshold levels of noise giving rise to behavioural effects in animals when exposed to man-made underwater sound, Southall *et al*. (2007) noted that the responses varied according to the sound level on the animal as well as the frequency and duration of the perturbing noise. Observations of the resulting behavioural response were standardised by being quantified on a Behavioural Response Severity Scale (BRSS) ranging from 0 (No observable response) through to 9 (Outright panic, flight, stampede, stranding). On such a scale, responses referred to herein as 'Weak Responses' have a BRSS rating of 1-3 indicating brief and/or minor changes in e.g., vocal behaviour, respiration and locomotion. By contrast, responses referred to herein as 'Strong Responses' are represented by extensive and/or prolonged changes in the behavioural traits mentioned above as well as aggressive behaviour amongst individuals and brief or minor separations of females and dependent offspring.

98. Having defined a BRSS, Southall *et al*. (2007) provided a range of sound pressure levels on the animal over which each behavioural response had been observed. The ensuing data were categorized into 10-dB SPL bins and then ranked by the severity of the behavioural response

observed over that SPL range. This tended to show that the higher the SPL on the animal the greater the BRSS score and the more severe the behavioural response.

99. It is noted that frequently, the data on which the BRSS is based is somewhat sparse, consisting as it does of relatively few observations of animal behaviour; behavioural responses being variable, context-dependent (i.e., costs or benefits of fight or flight) and less predictable than physical/physiological effects; and there being a considerable overlap in the range of sound pressure levels over which a given mode of behaviour might be prevalent. Some degree of interpretation and extrapolation is thus required when applying the data in the manner required for the current study. For instance, Southall *et al*. (2007) show that for a given severity response score the BRSS may indicate that more animals were observed giving a strong response to noises having low SPLs than at higher SPLs. This challenges the idea behind the continuum represented by the BRSS that low SPLs produce weak responses and high SPLs always lead to stronger responses. Digging deeper into the data reveals that some of the observations may relate to a species of marine mammal not found in the Study Area hence these data can reasonably be overlooked.

100. Behavioural impacts are defined by a threshold which was set following observations of low-frequency cetaceans reacting to multiple pulses (predominantly seismic airgun array discharges (Malme *et al*., 1983; Malme *et al*., 1984)). Southall *et al*. (2007) shows that for a BRSS of 6, low-frequency cetaceans were observed as giving more identifiable behavioural responses at received levels of 120-130 dBrms re 1 μPa than over any other SPL-bin. Similarly, for a BRSS of 1, responses were seen predominantly over the SPL range of 110-130 dBrms re 1 μPa. A couple of points may be concluded from this:

- There does not appear to be a clear distinction in received sound levels for a BRSS of 6 and a BRSS of 1; and
- Southall *et al*. (2007) emphasised that the relevance of this threshold to high-frequency cetaceans was not well established.

101. Later work published by Southall e*t al*. (2021) identifies the inherent weaknesses in the approach discussed in the 2007 paper. A revised experimental protocol is recommended whereby the earlier anomalies are addressed with the objective of deriving probabilistic response functions for various modes of behaviour. It will likely take some years to collect sufficient data on which a rigorous analysis may be made. In the meantime, it is proposed to draw on guidance given by the US National Marine Fisheries Service (NMFS) (2018) where it considers that the threshold likely to cause '*behavioral disruption for impulsive sounds [Level B harassment] is 160 dB re 1 µPa (rms)*'[2]. Similarly, for continuous sounds, the threshold is set at 120 dB re 1 µPa (rms).

102. NMFS regards a Level B Harassment as a response that occurs '*to a point where such behavioral patterns are abandoned or significantly altered*.' It is subject to interpretation as to how long a given behaviour (e.g., foraging) has to be interrupted before meeting the definition of being abandoned. Similarly, '*significantly altered*' could be interpreted in a statistically significant sense or in a biologically significant sense. Despite this, for the purpose of the current study, a threshold

[2] Level B Harassment is defined as having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.

level of 160 dBrms re 1 μPa is proposed as representing a noise which results in the onset of a strong behavioural reaction in marine mammals when exposed to impulsive type noise (NOAA, 2023). For non-impulsive type noise, the threshold lies close to background noise levels (see **Section 21.4**) and is thus considered unreliable.

103. In a further development, Natural Resources Wales (NRW) (2023) suggest an alternative approach to quantifying the impact of impulsive noise on marine animals. They state that '*When a competent authority carries out a Habitats Regulations Assessment (HRA), behavioural disturbance is assessed through area thresholds, whereas for an Environmental Impact Assessment (EIA) the aim is to quantify the magnitude of the impact in terms of the number of harbour porpoise disturbed*'. To meet these requirements, and underpinned by work carried out by Brandt *et al*. (2018) and Heinis *et al*. (2019), where behavioural response in harbour porpoise were observed following exposure to impact piling noise, two thresholds were defined. These are given in **Table 21B-7.** Although these are specifically derived from harbour porpoise related studies, they may also be used to define thresholds for animals in the LF and HF FHGs.

Table 21B-7: Unweighted and m-weighted SEL thresholds representing the onset of behavioural response in harbour porpoise

FHG	Impact	Threshold
VHF cetacean	Behavioural response	143 dB re 1 mPa^2.sec unweighted
		103 dB re 1 mPa^2.sec m-weighted

104. The approaches outlined above suggest that there is a threshold level above which a particular behavioural response is apparent while below this, the response is absent. In reality, the onset of any particular mode of behaviour is by no means so clear cut (as Southall *et al*. indicate in the 2007 and 2021 papers). The dose-response approach (Graham *et al*., 2019) proposes a more statistically-based methodology where a response amongst a group of animals becomes increasingly apparent as noise levels rise but is not necessarily absent even at low noise levels. The implementation of the dose-response model requires a series of isopleths or contours of unweighted SEL generated by a single strike of the pile driving hammer (this being the most impactful noise source) over the range 120-180 dB re 1 μPa^2.sec in 5 dB steps. Together with information on the likely distribution of animals in any given geographical area, it becomes possible to estimate the numbers of animals that may be impacted by the construction activity. The analysis around the dose-response function is not discussed in the current report: the isopleth data are provided for the client to undertake the investigation elsewhere.

21.4.4. Fish and sea turtles

Physiological impacts

105. Popper *et al*. (2014) conducted a similar process for fish as Southall *et al*. (2007) had completed for marine mammals. They reviewed a number of studies and subsequently suggested various noise thresholds related to potential acoustic impacts that were a function of the hearing sensitivity of fish species and of the noise type. The functional hearing groups refer back to studies of either the internal physiology of the fish or else to their auditory sensitivity (see **Section 21.4.2** above). The latest groupings (Popper & Hawkins, 2019) are summarised in **Table 21B-8.**

Table 21B-8: Fish and sea turtle hearing groups

Functional hearing group	Description	Characteristics
Group 1	Fish with no swim bladder	Generally, these fish have no swim bladder or other gas chamber. They are relatively unsusceptible to barotrauma[3] and are sensitive only to particle motion rather than sound pressure[4]. This class includes flatfish, sharks and rays.
Group 2	Fish with swim bladders in which hearing does not involve the swim bladder	Although fish in this class have a swim bladder and thus the organ is able to respond to sound pressure, the swim bladder is not connected to the inner ear hence the hearing ability of fish depends only on particle motion. Fish in this class are relatively sensitive to only a narrow range of frequencies.
Group 3	Fishes with swim bladders that are close, but not intimately connected, to the ear	Fish in this class are sensitive to both particle motion and sound pressure. They are sensitive to a wider range of frequencies compared with Groups 1 and 2. This group includes members of the Gadidae, Anguillidae and Sciaenidae families.
Group 4	Fish where hearing involves a swim bladder	Fish in this class have a connection between the swim bladder and the inner ear and are sensitive to both particle velocity and sound pressure. Species in this class are sensitive to sounds over a wide frequency range (~several kHz) and have a higher sensitivity than fish in the preceding groups. The group includes members of the Holocentridae, Sciaenidae, Clupeidae families and the large group of otophysan fishes.
Group 5	Fish eggs and larvae	Studies show that the hearing abilities are similar to those of the adult of the species. Swim bladders may develop during the larval stage hence those species are particularly sensitive to barotrauma. Popper *et al*. (2014) shows that there is very little data on the effects of sound or vibration on fish eggs.
Group 6	Sea turtles	There is relatively limited data on sea turtle hearing therefore the area is poorly understood. Studies of the auditory physiology of sea turtles indicate that the ear structure is closer to that found in fish than sea mammals but that they are adapted to detect sound pressure changes underwater. Popper *et al*. (2014) maintains that until more data become available, fish hearing, rather than mammalian hearing, is the better model to use for sea turtles.

106. In attempting to provide a range of acoustic thresholds at which various impacts might occur, Popper *et al*. (2014) reviewed data from tests where various fish species had been exposed to impulsive and non-impulsive sound and their resulting response observed. Impacts were described in terms of:

[3] Barotrauma is tissue injury caused by a difference in pressure between a gas-filled space inside an organ and the surrounding tissues. Low levels of damage involve stretching of the tissue in tension or shear. Higher levels involve rupture of the tissues which can lead to fatalities.

[4] Hitherto, nearly all audiological investigations on fish have focussed on sound pressure as a metric. Very little data have been acquired on the responses of fish to particle motion. Attempts are being made by the international research community to address this major knowledge shortfall, see Popper & Hawkins, (2018).

- Mortality and Potential Mortal Injury – where the acoustic-related injury is so severe that death follows either immediately or shortly very afterwards.
- Recoverable Injury – where the injury, including hair-cell damage, minor internal or external haematoma, is not likely to result in death.
- TTS – temporary hearing damage which is recoverable over time.
- Masking – where the man-made sound is sufficiently loud enough that it drowns out *e.g.*, vocalisations made by conspecifics or hunting noises made by predators.
- Behavioural effects – where there is a discernible change in behaviour of the animal when exposed to the sound. Such responses include large-scale and long-lasting movements away from feeding and breeding sites; or cessation of breeding or spawning activity.

107. Subsequently, Popper *et al*. (2014) provides threshold levels of noise for fish of all functional hearing groups and these are given using, where appropriate, both SPL peak and SEL metrics in **Table 21B-9** for explosive noise;

108. **Table** 21B-10 for piling noise and **Table 21B-11** for vessel and continuous noise.

109. It is noted that threshold levels representing the onset of Recoverable Injury; and TTS in fish eggs; and sea turtles do not currently exist due to insufficient data. Popper *et al*. (2014) acknowledges the difficulty in ascribing specific distances or a range of distances to the risk of an impact given the number of variables that underpin such a decision. They suggest that *'… 'near' might be considered to be in the tens of metres from the source, 'intermediate' in the hundreds of metres, and 'far' in the thousands of metres'*.

Table 21B-9: Summary of acoustic impact threshold criteria in SPL_{peak} for fish functional hearing groups exposed to explosive noise (N: Near; I: Intermediate; F: Far) (Popper et al. 2014)

Functional hearing group	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Fish Group 1	229 - 234 dB re 1 µPa SPL_{peak}	(N) High (I) Low (F) Low	(N) High (I) Moderate (L) Low
Fish Group 2	229 - 234 dB re 1 µPa SPL_{peak}	(N) High (I) High (F) Low	(N) High (I) Moderate (F) Low
Fish Group 3/4	229 - 234 dB re 1 µPa SPL_{peak}	(N) High (I) High (F) Low	(N) High (I) High (F) Low
Fish eggs and larvae Group 5	>13 mm/sec peak velocity	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low
Sea turtles Group 6	229 - 234 dB re 1 µPa SPL_{peak}	(N) High (I) High (F) Low	(N) High (I) High (F) Low

Table 21B-10: Summary of acoustic impact threshold criteria in SPL_{peak} and unweighted SEL metrics for fish functional hearing groups exposed to piling noise (N: Near; I: Intermediate; F: Far) (Popper et al. 2014)

Functional hearing group	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Fish Group 1	>213 dB re 1 µPa SPL_{peak}	>213 dB re 1 µPa SPL_{peak}	186 dB re 1 µPa^2.sec SEL
	>219 dB re 1 µPa^2.sec SEL	216 dB re 1 µPa^2.sec SEL	
Fish Group 2	>207 dB re 1 µPa SPL_{peak}	>207 dB re 1 µPa SPL_{peak}	186 dB re 1 µPa^2.sec SEL
	210 dB re 1 µPa^2.sec SEL	203 dB re 1 µPa^2.sec SEL	
Fish Group 3/4	>207 dB re 1 µPa SPL_{peak}	>207 dB re 1 µPa SPL_{peak}	186 dB re 1 µPa^2.sec SEL
	207 dB re 1 µPa^2.sec SEL	203 dB re 1 µPa^2.sec SEL	
Fish eggs and larvae Group 5	>207 dB re 1 µPa SPL_{peak}	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low
	210 dB re 1 µPa^2.sec SEL		
Sea turtles Group 6	>207 dB re 1 µPa SPL_{peak}	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low
	210 dB re 1 µPa^2.sec SEL		

Table 21B-11: Summary of acoustic impact threshold criteria in SPL_{peak} and unweighted SEL metrics for fish functional hearing groups exposed to vessel and continuous noise (N: Near; I: Intermediate; F: Far) (Popper et al. 2014)

Functional hearing group	Mortality and Potential Mortal Injury	Recoverable Injury	TTS
Fish Group 1	(N)Low (I)Low (F) Low	(N)Low (I)Low (F) Low	(N)Moderate (I)Low (F) Low
Fish Group 2	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low
Fish Group 3/4	(N) Low (I) Low (F) Low	170 dB rms for 48 h	158 dB rms for 12 h
Fish eggs and larvae Group 5	(N) Low (I) Low (F) Low	(N)Low (I)Low (F) Low	(N) Moderate (I) Low (F) Low
Sea turtles Group 6	N) Low (I) Low (F) Low	(N)Low (I)Low (F) Low	(N) Low (I) Low (F) Low

Behavioural impacts

110. Threshold levels may be assigned to the onset of behavioural response in fish species but current guidance appears somewhat ambiguous. The US Fish and Wildlife Service (USFWS) works with a level of 150 dB re 1 μPa as a threshold for behavioural responses in fish[5] (Stadler & Woodbury, 2009). Popper *et al*. (2014) state that it is not clear whether this is a peak or rms metric. They also affirm that the corresponding criterion does not specify a particular behavioural response or whether it merely assumes that at that sound level, there is the potential to experience a behavioural reaction. Furthermore, Hastings (2008) declares that the scientific origin of this threshold is unknown and thus the validity of the criterion is uncertain. However, in the absence of any data in addition to the guidelines provided by USFWS and for the purpose of continuing the analysis contained in the current study, it is decided that a 150 dB_{rms} re 1 μPa threshold be used to represent the onset of Low-Level Behavioural Responses in fish.

111. With regards to behavioural responses in sea turtles, Finneran and Jenkins (2012) reviewed a number of studies reporting the responses of caged sea turtles when exposed to impulsive-type noises. They report that behavioural responses first become evident at received sound levels of 166 dB_{rms} re 1 μPa. When sound levels are increased to lie in the range 175-179 dB_{rms} re 1 μPa, the reactions are more erratic and avoidance behaviour becomes apparent. Accordingly, for the current study, a threshold of 175 dB_{rms} re 1 μPa is used to represent the onset of avoidance behaviour in sea turtles.

21.4.5. Summary

112. This section has provided an overview of the marine animal species found in and around the proposed Project noting their susceptibility to noise. The international published literature has been accessed in order to determine levels of noise that have the potential to give rise to impacts on each species. Threshold levels are given in units of SPL using peak level and RMS metrics (using Level B Harassment criterion); while SEL thresholds are M-weighted which considers the relative audiological sensitivity of each generic species grouping. These data are subsequently taken forward for use in the acoustic impact modelling discussed in detail further on in this report.

21.5 Underwater Acoustic Propagation Modelling

21.5.1. Introduction

113. The following sections describe the acoustic propagation modelling undertaken in order to estimate received level variation with distance from the source, specifically the acoustic models used and the oceanographic and geo-acoustic parameters required as input data for the models.

21.5.2. Description of the models for non-explosive sources

114. These include such noise sources as dredging, piling and shipping. Numerous computer models are available to predict acoustic propagation in the marine environment. Each model has its own strengths and weaknesses in terms of input requirements and calculation methods, but all include some form of description of various environmental parameters, such as the water column sound speed profile (SSP) and sediment acoustic properties.

[5] The 150 dBrms threshold is given for Low Level Behavioural Disturbance and is widely credited to USFWS but no original reference for this may be found.

115. Reviews of a number of acoustic propagation computer programs are given by Buckingham (1992), Jensen *et al*. (2000), and Etter (2013). A number of these are included in the online repository funded by the US Office of Naval Research known as the Ocean Acoustics Library (OALIB, 2024). The computer programs are based on ray-trace, normal mode, parabolic equation and fast field techniques. Not all programs are equally suitable for use: due consideration must be made to the nature of the problem to be addressed and this will guide the user to the most appropriate model.

116. It is required to carry out a two-dimensional (2D) (in depth and distance) frequency-dependent analysis for a given sound speed profile in a varying-depth ocean waveguide which overlies a range-dependent, acoustically absorbent seabed sediment. In addition, the water depth is an important factor to be taken into account. The programs used for the analysis undertaken in this report are BELLHOP (Porter, 2011) – based on the ray-trace method; and RAM (Collins, 1989; 1993) – based on the parabolic equation. Both programs provide a solution that is valid over a limited frequency, water depth and range regime: parabolic-equation models are optimised for use at lower frequencies while ray-trace models tend to be most suitable for high frequencies.

117. The non-explosive noise sources discussed in **Section 21.3**, each generate noise over a wide range of frequencies hence it is considered acceptable to use both the BELLHOP and RAM models such that the whole frequency range of interest is covered. The transition frequency at which it is appropriate to switch from one to the other is related to the wavelength of the noise compared with the water depth. Buckingham (1992) declares that ray modelling is satisfactory when the wavelength is very much less than any of the length scales in the problem. Etter (2013) quantifies this by using a factor of 8-10. Appropriate switchover frequencies are thus defined for each of the WTG and CR modelling locations within the Offshore Development Area.

118. The two propagation models are classed as range-dependent which is to say they can deal with changes in water depth or SSP over increasing distance from the point of origin. The quality of the modelling results is therefore highly dependent on obtaining site- and time-specific data. The sources of data used as inputs to the propagation modelling process are discussed below.

21.5.3. Description of the models for explosive sources

119. The acoustic propagation models discussed in the previous section are all ultimately derived from the wave equation (Kinsler *et al*. 1999). This starting point requires that the underlying acoustics should be linear in nature i.e., all fluctuations in pressure and displacement are of small amplitude. By contrast, the outgoing waves of acoustic energy from an explosive source are non-linear especially in the acoustic near-field. Fundamentally, the change in density of water caused by pressure fluctuations from a passing sound wave is not linearly proportional to the change in pressure. The wave equation as a basis for further analysis is no longer valid and some other mathematical treatment is necessary. (A number of techniques have been explored for analysing the propagation of non-linear waves but these are necessarily complex and time-consuming and do not easily lend themselves for inclusion in the current study (Cotaras, 1985; Novikov *et al*., 1987; Beaujean *et al*., 2003; Castor *et al*., 2004; Maestas *et al*., 2014).

120. The propagation of sound from explosive source in open water is represented by a number of semi-empirical equations developed from experiments undertaken in the immediate post WWII period. Commencing with the expression for peak pressure (given in Equation 21B.1), Arons *et al*. (1949) showed that the instantaneous pressure at a time t after the onset of the shock wave, P(t) is given by

$$P(t) = P_{peak} e^{-t/tc} \ \mu Pa$$

Equation 21B.15

$$t_c = 92.5\ w^{1/3}\left(w^{1/3}/R\right)^{-0.22}\ \mu sec$$

Equation 21B.16

121. Gaspin derived a limiting range R_0 beyond which the preceding equations no longer applied where

$$R_0 = 4.76\ w^{1/3}\ \text{metres}$$

Equation 21B.17

122. Beyond this range, Rogers (1977) applied weak-shock theory to derive expressions for peak pressure P_m and the time constant t of an exponentially decaying pressure wave where

$$P_m(R) = P_0\ \{[1 + 2(R_0/L_0)\ln(R/R_0)]^{1/2} - 1\}/[(R/L_0)\ln(R/R_0)]\ \ \mu Pa$$

Equation 21B.18

$$\tau(R) = t_0\ [1 + 2(R_0/L_0)\ln(R/R_0)]^{1/2}\ \mu seconds$$

Equation 21B.19

$$\text{For } L_0 = (\rho_0\ c_0^3\ t_0)/(P_0\ \beta)$$

Equation 21B.20

123. where sea water density r_0 = 1026 kg/m^3, nominal sound speed in water c_w = 1500 m/s, β = 3.5 and P_0 and t_0 are calculated from Equations 21B.1 and 21B.5 for distance R_0.

124. By comparison with the acoustic propagation models discussed in **Section 21.5.2**, the expressions are fairly rudimentary and require little in the way of environmental data. Nonetheless, they are used widely when modelling explosive blast and are used for the blast analysis discussed in the current report.

21.5.4. Transect bathymetry

125. Water depth data was taken from the bathymetry database GEBCO 2023 (GEBCO, 2023). This is a database of water depths having global coverage and a resolution of 15 arc-seconds (corresponding to a spatial separation of around 0.45 km in the vicinity of the Study Area).

126. Navigation charts (UKHO 2008) show that water depths over the Array Area is fairly uniform being around 60-70 m. The depths over the Offshore Export Cable Corridor (OfECC) increase from 0 m at landfall to 30-40 m within a few km of the coast and thereon, gradually increase to 60 m or so on the edge of the defined Array Area.

127. In order to capture the depth variation over the wider project area, a set of 36 equally spaced transects were used at each of two modelling sites. These are referred to as Sites Wind Turbine Generator (WTG) and Cable Route (CR): their respective locations within the larger proposed Project Study Area are indicated in Figure 21B-15 while the corresponding site coordinates are given in **Table 21B-12**. The length of each modelling transect varies from approximately 40 km for some of the easterly going transects through to 150 km for the southerly- and westerly-going transects.

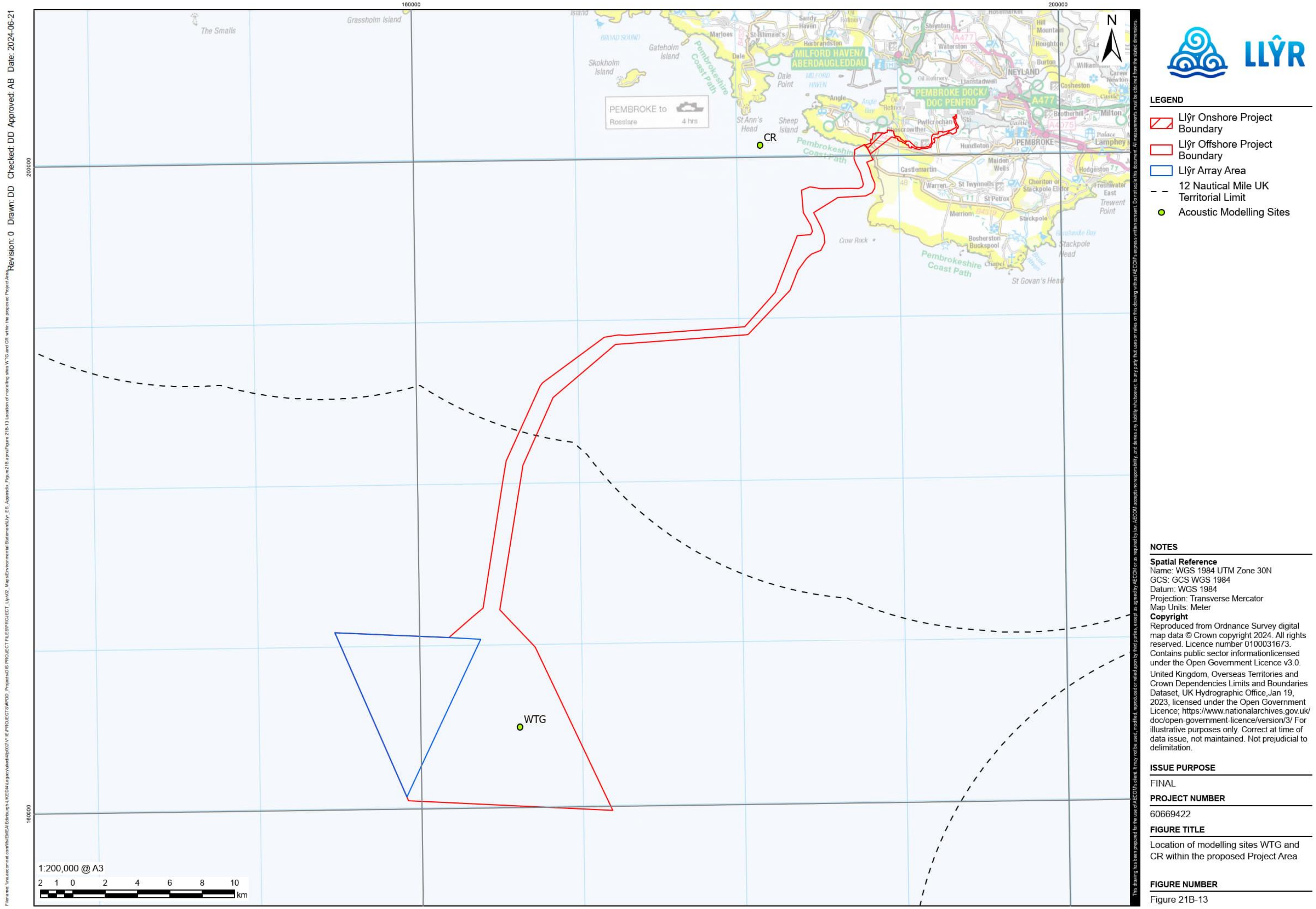


Figure 21B-13: Location of modelling sites WTG and CR within the Offshore Development Area.

Table 21B-12: Locations of acoustic propagation modelling sites in the Offshore Development Area

Acoustic Modelling Site	Latitude	Longitude	Water depth (m)
WTG	51° 20.112'N	005° 21.48'W	67
CR	51° 39.75'N	005° 9.63'W	34

21.5.5. Oceanographic data

128. Oceanographic data was obtained through the World Ocean Atlas (WOA, 2009). This consists of gridded monthly samples of temperature, salinity and depth and from which, sound speed profiles in the vicinity of the Offshore Development Area may be reconstructed with the aid of the Chen-Millero relationship (Chen & Millero, 1977).

129. Thus far in the Project timeline, although an indicative period for construction has been defined (Q1 2027-Q4 2028), exact dates have not been set over which any specific construction activity may take place. To address this, the monthly sound speed profiles were reviewed in order to determine which profiles are most likely to give rise to maximum and minimum acoustic propagation conditions over the course of the year. During the winter months, the sea surface temperature is at its lowest and this results in a profile where the sound speed increases with increasing depth over the whole of the water column. The spring and early summer months see a warming of the topmost layers so that the sound speed increases. The warming effect extends to a depth of around 50 m or so and this gives rise to a profile that has a combination of a surface duct near the surface, a downwardly refracting profile indicative of the seasonal thermocline below followed by an increasing sound speed down to the seabed. During autumn and early winter, seasonal storms and decreasing levels of solar heating result in both the surface duct and seasonal thermocline decaying with time until the winter profile is reached. In the temperate waters of the UK therefore, the months of February and August provide sound speed profiles that lead to extremes of sound propagation and these are illustrated in **Figure 21B-14**.

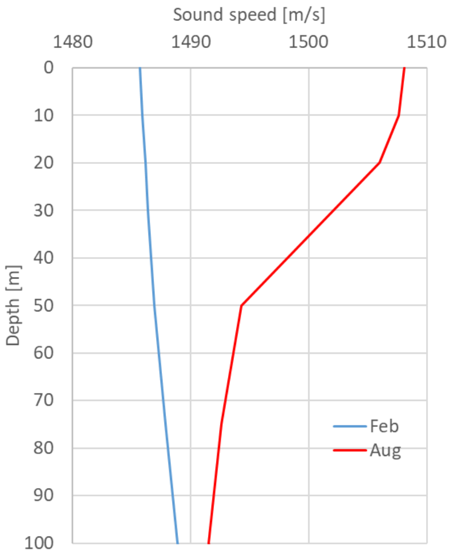


Figure 21B-14: Sound speed profiles for the months of February and August for the Offshore Development Area

130. During February the sound speed profile is upwardly refracting over the entire water column. In this profile, sound will be directed away from the seabed and towards the sea surface. Any losses due to reflection off the sea surface are much less than the losses that would arise during reflection off the seabed hence sound pressure levels at a given location in the water column tend

to be somewhat higher during the winter months compared with later on in the year. By August, heating of the surface layers during spring and summer has led to a downwardly refracting profile over the entire water column. At this time the energy will tend to be directed down towards the seabed where it becomes absorbed in the lossy sedimentary layers. Sound will tend therefore not to propagate to such long distances during August compared with earlier on in the year.

131. Subsequently, SSPs for the months of February and August are taken forward for use in the propagation modelling discussed in this report.

21.5.6. Seabed geoacoustics

132. Seabed data are taken from the European Marine Observation and Data Network (EMODnet) website (EMODNet, 2022). EMODnet is a network of marine-related organisations supported by the European Union's (EU) integrated maritime policy. The seabed substrate portal indicates that over the proposed Project, the seabed is largely coarse sand. This overlies a bedrock of largely mudstone with patches of shale and sandstone (Tappin *et al*. 1994). Sediment thickness ranges from 10 m or less in the upper reaches of the Bristol Channel to greater than 100 m further out in the Celtic Sea. It is not possible to ascertain sediment thickness closer to the Array Area however an intermediate 60 m sediment thickness is deemed to be a reasonably representative value.

133. Hamilton (1963; 1970; 1972) provides advice on geoacoustic parameters and from this, a corresponding geoacoustic property profile through the sediment layer is obtained and this is summarised in **Table 21B-13** below. It is pointed out that both the sediment layer and the underlying semi-infinite bedrock are treated as elastic solids where both compressional (or primary (P)) waves and shear (or Secondary (S)) waves are supported.

Table 21B-13: Seabed sediment and bedrock properties for the Offshore Development Area

Depth below seafloor m	Layer	P-wave velocity Vp m/s	S-wave velocity Vs m/s	Density kg/m³	P-wave attenuation dB/m/kHz	S-wave attenuation dB/m/kHz
0-10	Coarse sand	1836-1849	490-497	2.030-2.044	0.874-0.871	6.463
10-20		1849-1862	497-505	2.044-2.057	0.871-0.868	6.565
20-40		1862-1887	505-521	2.057-2.084	0.868-0.861	6.668
40-60		1887-1912	521-537	2.084-2.110	0.861-0.854	6.876
>60	Mudstone	3500	1768	2.274	1.015	23.338

21.5.7. Background noise

134. Background noise or oceanic ambient noise is considered to be a composite of a number of overlapping components (Wenz, 1962):

- At very low frequencies (1 Hz to 100 Hz) the dominant source is due to earthquake noise from distant activity and from turbulent pressure fluctuations caused by large-scale movements of bodies of water;
- At low frequencies (10 Hz to 1 khz) vessel noise is dominant;
- At mid-range frequencies (50 Hz to 20 khz) weather-related noise as prevails while biological activity such as animal vocalisations are also present;
- At high frequencies (> 20 khz), thermal noise becomes apparent.

135. In deep water regions which are generally remote from centres of population, the overarching characteristic of the noise field is that it is isotropic and homogenous, that is, it has more or less

the same noise level and frequency content regardless of the direction in which the observer is listening. To clarify, vessel noise, for instance, may be heard but it is not significantly louder in one direction than another. In shallow water coastal regions by contrast, background noise levels are very variable being dependent on shipping activity and marine industrial activity as well as wind speed and rainfall (Urick, 1983). Shipping activity in particular is denoted by clearly marked shipping lanes inside which noise levels are significantly louder than at locations outside (Neenan *et al*., 2016; Jalkanan *et al*., 2018).

136. By virtue of their relative accessibility, noise levels are more likely to have been recorded in coastal regions (Neenan *et al*., 2016). However, no data on underwater background sound levels have been found for the Study Area. In order to address this shortfall, comparisons may be made with other shallow water sites in which similar levels of shipping and construction-related activity takes place.

137. The North Sea contains a number of oil and gas fields that are being developed and commissioned; in full operation; or are in the process of being decommissioned. In addition, a number of ports and harbours are serviced by vessels transiting the region. Measurements of background sound in the coastal fringe of the North Sea by Nedwell *et al.* (2003) indicate a background sound level range of 100-135 dB re 1 μPa with a modal value of 120 dB re 1 μPa[6]. The report however fails to explain whether the SPL data are given using RMS or peak values. As it is common practice to present background sound levels in RMS units, it is assumed that the data provided in the report follow this convention.

138. It is noted that the proposed Project is close to shipping lanes associated with the oil and gas refineries at Milford Haven while slightly further afield are ferry routes between Wales and Ireland. It is proposed therefore that background sound levels in the vicinity of the proposed Project are considered to be in the range of 100-120 dB re 1 μPa (rms). It must be emphasised that the North Sea data is the best estimate available but nevertheless may not be wholly representative of sound levels in the sea area to the southwest of Wales.

21.5.8. Source modelling parameters for non-explosive sources

139. Noise generated by the impact piling activity may be characterised as consisting of short pulses of finite duration and covering a wide range of frequencies (see **Section 21.3**). At emission, the pulse has a typical duration of a few tens of milliseconds (CDOT, 2007). For this scenario, a broadband, time-domain propagation model ideally should be used to represent the source and underwater acoustic environment. However, these tend to be difficult to use, they often have a considerable time overhead associated with them (Jensen *et al*., 2000) and are therefore deemed unsuitable for use in environmental impact assessment-related work such as the current study. In addition, and most importantly, there is insufficient engineering and geological data available that would permit a detailed simulation of the propagation of an acoustic pulse in the given environment for the current study.

140. An alternative approach is to divide the source frequency spectrum into 1/3rd octave bands (Kinsler *et al*., 1999) where each band has a given spectral level, centre frequency and bandwidth; and then to use a frequency-domain type program (such as those discussed above) for subsequent propagation modelling. This specific approach works also for modelling the propagation from

[6] It is likely that these are broadband noise measurements made over a specific frequency bandwidth. However, the report fails to provide the necessary data on this matter.

continuous type noise sources generated by e.g., trenching and vessel activity etc. The 1/3rd octave centre frequencies thus selected cover the frequency range of interest and are listed in **Table 21B-14** while the corresponding 1/3rd octave band levels are obtained from **Section 21.3** for the noise created by each of the proposed Project construction activities.

Table 21B-14: Acoustic modelling frequencies

Parameter	Value		
Noise source	Vessel inc. cablelay	Piling/Drilling	Dredging/Material disposal
Source depth [m]	5	At seabed	5
Frequency [Hz]	10, 12.5, 16, 20, 25, 31, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1k, 1.25k, 1.6k, 2k, 2.5k, 3.15k, 4k, 5k, 6.3k, 8k, 10k, 12.5k, 16k, 20k, 25k, 31.5k, 63k, 80k, 100k, 125k		
Summer (Aug)	✓	✓	✓
Winter (Feb)	✓	✓	✓

21.5.9. Sound propagation modelling scenarios

141. Using the bathymetric and geoacoustic data given in the preceding sections, propagation loss data was generated along a total of 36 transects radiating from each modelling site using SSPs representing oceanography for the months of February and August.

142. For all the non-explosive noise sources, the propagation loss data is generated at each of the 1/3rd octave band frequencies given in **Table 21B-14**. The frequency-dependent propagation loss (indicated by PL in Equation 21B.7) is subtracted from the corresponding 1/3rd octave band source levels for each noise source (provided in **Section 21.3**) in order to derive propagated SPL data as a function of distance from the activity site. A discussion of the results generated by this stage is given in the following section.

21.6 Underwater Acoustic Propagation Modelling Results

*21.6.1. I*ntroduction

143. This section of the report describes the results of some of the acoustic propagation modelling undertaken in **Section 21.5**. Unweighted sound levels as a function of depth and distance for a number of noise sources are discussed below.

21.6.2. Impact piling noise

144. The results from the acoustic propagation modelling indicate that sound pressure levels at any given depth and distance are very dependent upon the nature of the SSP and the underlying bathymetry. In order to illustrate this, the impact piling noise modelled over three transects and two seasons are discussed below.

145. **Figure 21B-15** shows contoured SPL for impact piling noise modelled using the February SSP along the 0° bearing at Site WTG (see **Table 21B-12**). The transect length is approximately 150 km and displays a maximum water depth of approximately 100 m. It will be seen that the water depth decreases from 67 m to around 25 m where a sub-surface seamount is encountered at a distance of 60 m. The decreasing water depth over the first 60 km has the effect of rapidly stripping energy out of the water column. At a distance of 60 km, SPLs are down to around 140 dB re 1 μPa. Thereafter, a definite structure to the acoustic field in the water column becomes evident where it will be seen that propagation occurs preferentially at depths around 50-60 m. Within this duct, SPLs are around 30 dB higher than at greater or lesser depths. This feature is attributed to the nature of the SSP together with the increasing water depths beyond a distance of 60 km.

146. **Figure 21B-16** shows the piling hammer noise propagating along the 40° transect over a distance of approximately 38 km. This is one of the shortest modelling transects where it will be seen that water depths generally decrease from 67 m at the piling site to 0 m at the coastline. Over the first 8 km or so, water depths generally vary in the range 8 - 60 m. A seamount at 24 km has a water depth around 40 m and the figure shows that acoustic energy is stripped out of the water column at this feature is approached. Beyond the seamount, sound levels fall to around 155 dB re 1 μPa as the transect meets the coastline.

147. **Figure 21B-17** shows the piling hammer noise propagating along the 240° transect where water depths gradually increase over the entire modelling transect to a maximum depth of 100 m. Now, it will be seen that there is no feature to strip acoustic energy from the water column. There is evidence of preferential propagation taking place along a sub-surface channel over depths in the range 50 – 60 m. Within this channel, sound levels remain above 150 dB re 1 μPa at a distance of 150 km from the piling site.

148. The effect of the SSP on the acoustic propagation of piling noise is significant and this is discussed as follows.

149. **Figure 21B-18** shows the propagation of piling noise over the 0° bearing transect modelled using the August SSP. It will be seen from **Section 21.4** that this profile is downward refracting hence the transmitted acoustic energy is directed towards the seabed. The effect of this is clear in the figure where sound levels at the sub-surface seamount are down to 140 dB re 1 μPa while thereafter, sound levels fall rapidly to background noise levels at a distance of approximately 110 km.

150. The 40° bearing transect is too short to show any substantial difference in modelled acoustic propagation at any given depth and distance. Sound levels are around 155 dB re 1 μPa as the transect meets the coastline.

151. Propagation along the sub-surface channel, which was apparent during February, is no longer in evidence. Sound is clearly directed to the seafloor and falls to around 135 dB re 1 μPa at 150 km.

152. These six figures indicate that the SPL at any given distance is very dependent on the nature of the bathymetry where sills, sandbanks and other seabed features prevent high levels of noise propagating to any considerable distance. In addition, it must be emphasised that the bathymetry sections as displayed above relate uniquely to the given modelling points and to the specific transects radiating therefrom. As the impact piling locations progress through the Array Area, the nature of the bathymetry will vary from location to location, and this will subsequently affect the propagation of piling noise through the water. Accordingly, the distances over which each acoustic impact is met will vary along each modelled transect radiating from each modelled point. Impact distances are summarised in the next Section.

21.6.3. Geophysical sonar noise

153. Each of the geophysical sonar devices transmit at a single relatively high frequency or else over a very narrow band of high frequencies. The dominant cause of acoustic absorption is due to ionic relaxation of various salts dissolved in the sea water. This is absorptive effect is proportional to frequency and, over the frequencies transmitted by the geophysical sonar source, has a considerable effect. In addition, the acoustic energy is contained within a narrow beam and is directed predominantly towards the seabed. The resulting distribution of energy, transmitted by the USBL operating at a frequency of 25 kHz (being a representative geophysical sonar example) is shown in the below figures modelled for the months of February and August respectively.

154. It will be seen that SPLs fall rapidly with distance. At a distance of approximately 5 km, SPLs are down to background levels. There is a small but noticeable effect attributed to the nature of the

SSP where, when modelled using August oceanography, the SPLs fall to background levels at a slightly shorter distance compared with that in February.

21.6.4. UXO detonation noise

155. The Figures below show the modelled SPL_{peak} as a function of distance for high order detonation and low-order clearance respectively.

156. In the event that a 794 kg TNT-equivalent charge in the range 25 kg to 794 kg are fully detonated, 21B-21 shows maximum SPLs vary between 285 and 296 dB_{peak} re 1 μPa at 1 m and remain above 180 dB_{peak} re 1 μPa out to a distance in excess of 230 km.

157. A low-order clearance, is achieved by the detonation of much smaller shaped charges that split the casing and allow for the slow burning of the explosive material. In this case, for a maximum likely charge weight of 2 kg, SPLs fall to 180 dB_{peak} re 1 μPa at a maximum distance of 30 km.

21.6.5. Summary

158. **Figure 21B-15** to **Figure 21B-24** and as discussed above show the variation of unweighted SPLs with respect to distance for a number of noise sources. Given the relative auditory sensitivity of each FHG, it is to be expected that, given the apparent source levels as perceived by each FHG (see **Section 21.4.2**), overall SPLs will be slightly lower in the case of LF cetaceans and pinnipeds and significantly lower in the case of HF and VHF cetaceans.

159. The next section discusses the impact of each noise generating activity on the various groups of marine fauna when exposed to the noise over extended periods of time.

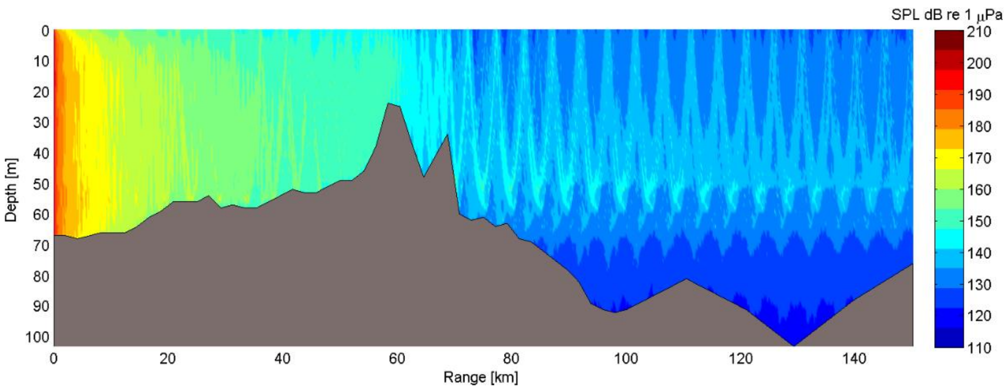


Figure 21B-15: Contour plot of SPL as a function of depth and distance from the piling site within the Array Area generated by the proposed Project impact piling hammer modelled along a bearing of 0° using February oceanographic conditions

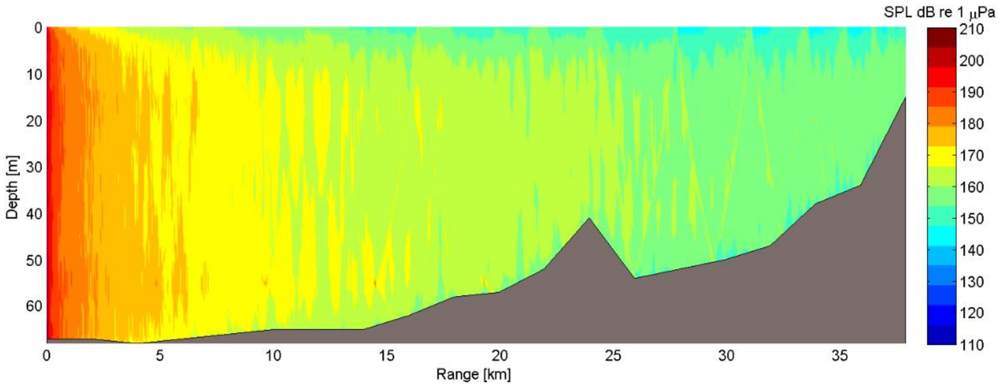


Figure 21B-16: Contour plot of SPL as a function of depth and distance from the piling site within the Array Area generated by the proposed Project impact piling hammer modelled along a bearing of 40° using February oceanographic conditions

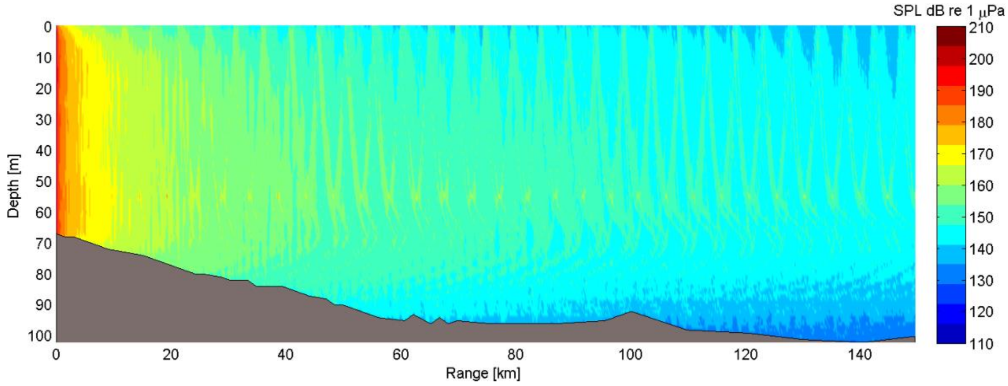


Figure 21B-17: Contour plot of SPL as a function of depth and distance from the piling site within the Array Area generated by the proposed Project impact piling hammer modelled along a bearing of 240° using February oceanographic conditions

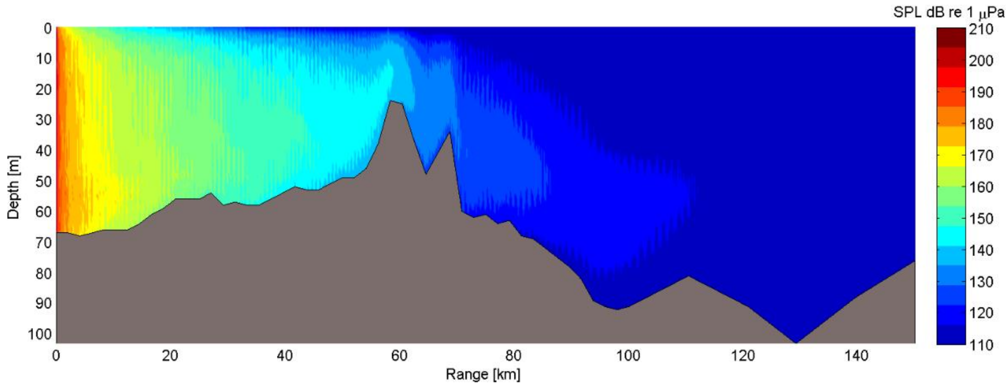


Figure 21B-18: Contour plot of SPL as a function of depth and distance from the piling site within the Array Area generated by the proposed Project impact piling hammer modelled along a bearing of 0° using August oceanographic conditions

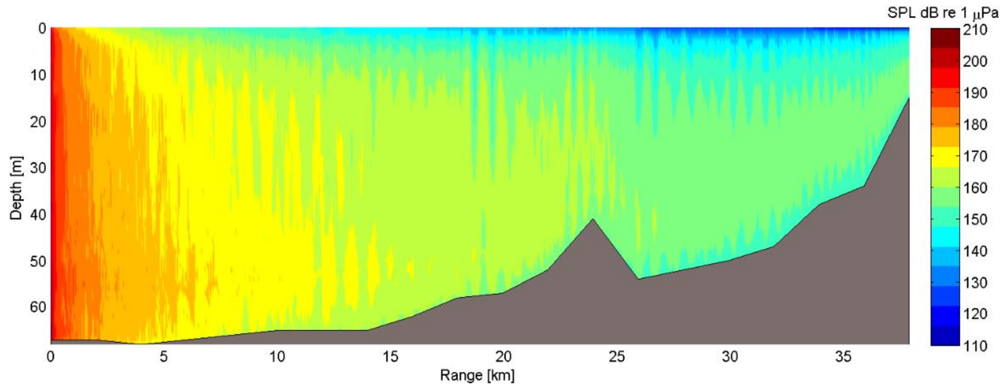


Figure 21B-19: Contour plot of SPL as a function of depth and distance from the piling site within the Array Area generated by the proposed Project impact piling hammer modelled along a bearing of 40° using August oceanographic conditions

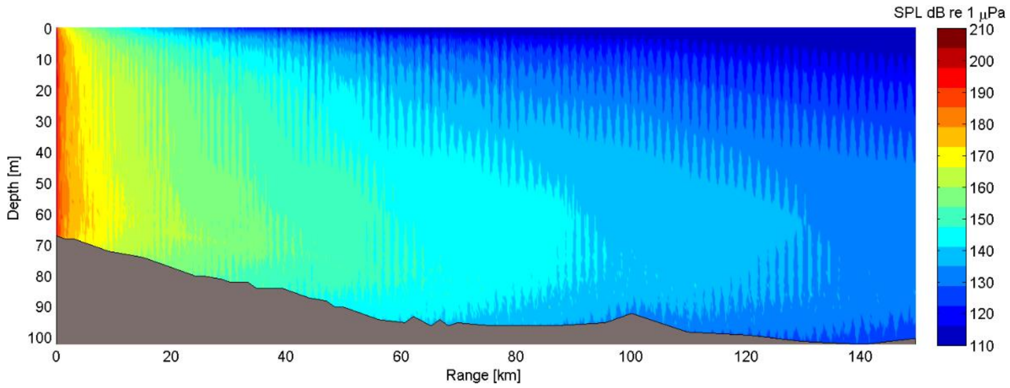


Figure 21B-20: Contour plot of SPL as a function of depth and distance from the piling site within the Array Area generated by the proposed Project impact piling hammer modelled along a bearing of 240° using August oceanographic conditions

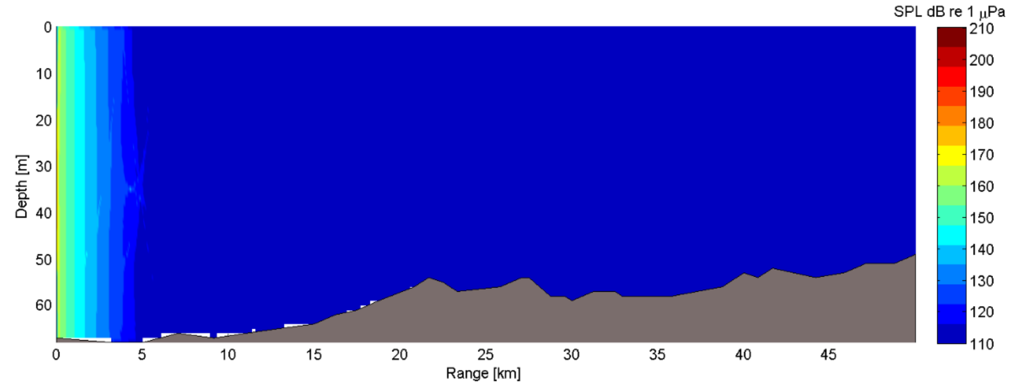


Figure 21B-21: Contour plot of SPL as a function of depth and distance from the geophysical sonar deployed at Site WTG along a bearing of 0° using February oceanographic conditions

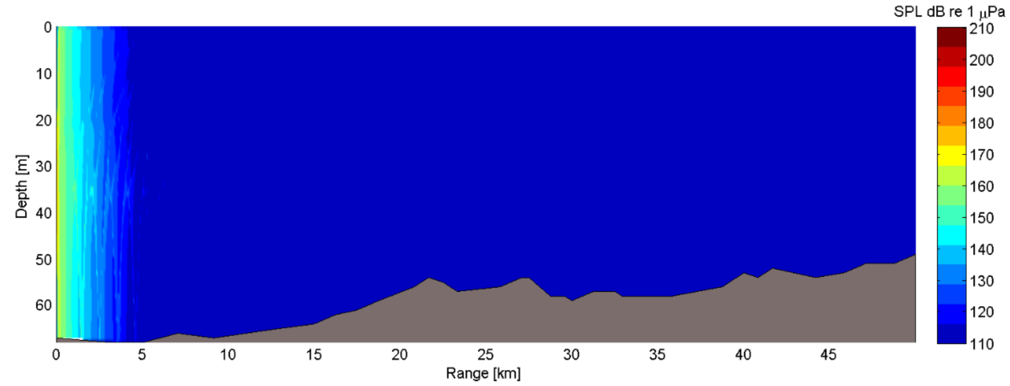


Figure 21B-22: Contour plot of SPL as a function of depth and distance from the geophysical sonar deployed at Site WTG along a bearing of 0° using August oceanographic conditions

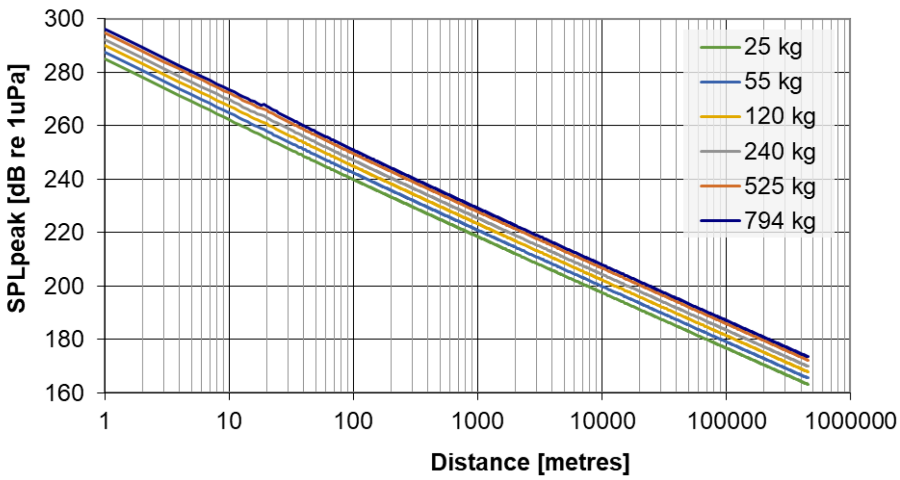


Figure 21B-23: Plot of SPL as a function of distance from source origin for high-order clearance of UXO for various TNT-equivalent charge weights

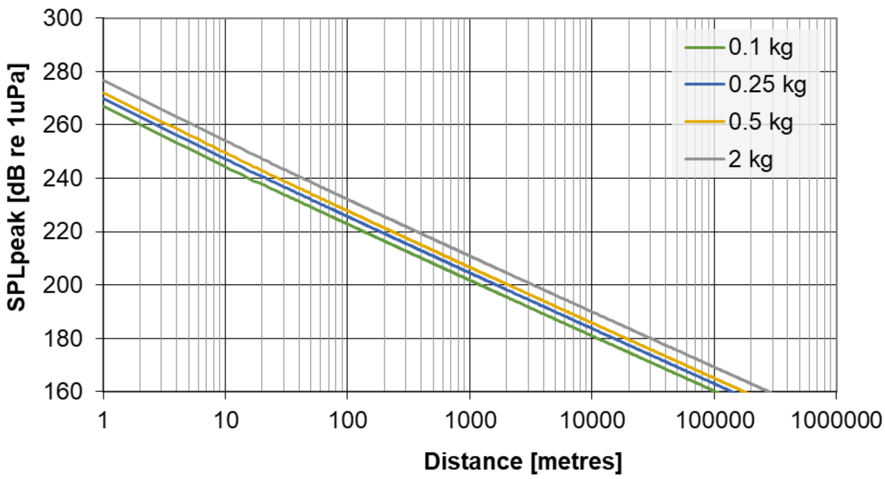


Figure 21B-24: Plot of SPL as a function of distance from source origin for low-order clearance of UXO for various TNT-equivalent charge weights

21.7 Acoustic Impact Modelling Results

21.7.1. Introduction

160. The previous section discussed the propagation of noise through the marine environment that is generated by various construction activities within the Offshore Development Area. This section determines the distances at which noise levels fall to below the threshold levels associated with each of the potential impacts discussed in **Section 21.4**. There are a number of procedures where this approach is followed. The discussion commences on the assumption that the receptor is stationary. This is followed up with a discussion of the impacts arising when the receptor is transiting through the sound fields generated by moving or stationary noise sources. In each case, a binary approach is followed with regards to quantifying the impact where the impact criterion corresponding to the onset of e.g., PTS, is either met or not met. This contrasts with a probabilistic approach to modelling acoustic impacts where the inherent uncertainty in setting a threshold defining the onset of a behavioural response is assessed by combining a dose-response function

with information on the underwater acoustic noise levels and animal distributions. Each procedure is discussed below.

21.7.2. Stationary receptor scenario: Physiological and behavioural impacts

Non-explosive noise sources

161. This section presents a summary of the potential impacts arising during construction activities within Site WTG and Site CR involving non-explosive noise sources.

162. Acoustic impacts can arise on a receptor following a single exposure to a loud noise or following continued exposure to a lower-level of noise but over an extended period of time. For this latter consideration, NMFS guidance (2018) recommends a baseline accumulation period of 24 hours for comparative purposes. However, the guidance also acknowledges that there may be exposure situations where this accumulation period requires adjustment hence shorter or longer exposure durations may also be specified. Accordingly, a range of exposure durations are considered varying from a single-strike exposure duration up to a 24-hour exposure duration. The range of time exposures considered take into account the various periods over which an animal may be exposed to the impactful noise. The shorter exposure durations are appropriate for animals transiting rapidly through the Offshore Development Area while the longer periods are deemed more appropriate for slower moving animals and for those species which are habitat-constrained.

163. Summaries of maximum impact distances for physiological and behavioural impacts on each marine mammal, fish and sea turtle FHG assessed using SPL and SEL metrics are given in 0 for each of the modelling scenarios at Site WTG for the modelling scenarios at Site CR.

164. Impact distances modelled at the proposed Project piling site, using variously, SPL metrics and unweighted and M-weighted SEL metrics for a range of exposure durations, are given **Table 21B-15** through to **Table 21B-20.**

Table 21B-15: Summary of maximum distances in metres at which SPL has fallen to threshold levels for PTS, TTS and behavioural reactions for stationary marine mammals exposed to piling hammer noise at the Offshore Development Area († denotes at Site WTG only)

Activity	Impact	LF cetacean	HF cetacean	VHF cetacean	PW pinniped
Impact piling†	PTS	< 10 m	< 10 m	39 m	< 10 m
	TTS	< 10 m	< 10 m	84 m	< 10 m
	Behavioural	9.3 km			

Table 21B-16: Summary of maximum distances in metres at which SEL has fallen to threshold levels for PTS and TTS for stationary marine mammals exposed to piling hammer noise over a maximum exposure of 4 hours at the Offshore Development Area († denotes at Site WTG only)

Activity	Impact	LF cetacean	HF cetacean	VHF cetacean	PW pinniped
Impact piling†	PTS	29.6 km	168 m	5.8 km	3.3 km
	TTS	149.7 km	2.0 km	29.4 km	34.1 km

Table 21B-17: Summary of maximum distances in metres at which SPL has fallen to threshold level for mortality, recoverable injury and behavioural reactions for stationary fish groups exposed to piling hammer noise at proposed Project († denotes at Site WTG only)

Activity	Impact	Gp 1	Gp 2	Gp 3/4	Fish eggs & larvae	Sea turtle
Impact piling†	Mortality	< 10 m	< 10 m	< 10 m	< 10 m	< 10 m
	Recov Inj	< 10 m	< 10 m	< 10 m	N/A	N/A

Activity	Impact	Gp 1	Gp 2	Gp 3/4	Fish eggs & larvae	Sea turtle
	Behavioural	30.6 km			N/A	710 m

Table 21B-18: Summary of maximum distances in metres at which SEL has fallen to threshold level for mortality, recoverable Injury and TTS for stationary fish groups exposed to piling hammer noise over a maximum exposure of 4 hours at proposed Project († denotes at Site WTG only)

Activity	Impact	Gp 1	Gp 2	Gp 3/4	Fish eggs & larvae	Sea turtle
Impact piling†	Mortality	135 m	906 m	1.2 km	906 m	906 m
	Recov Inj	245 m	2.7 km	2.7 km	N/A	N/A
	TTS	29.6 km			N/A	N/A

Table 21B-19: Summary of maximum distances in metres at which SEL has fallen to threshold level for PTS and TTS for stationary marine mammals exposed to continuous type noise generating activities over a maximum exposure of 24 hours at proposed Project († denotes at Site WTG only)

Activity	Impact	LF cetacean	HF cetacean	VHF cetacean	PW pinniped
Geophysical survey SBP (500-12500 Hz)	PTS	82	< 10	< 10	< 10
	TTS	221	< 10	50	< 10
Geophysical survey USBL (25 kHz)	PTS	100	< 10	< 10	< 10
	TTS	100	< 10	< 10	< 10
Geophysical survey MBES (170 kHz)	PTS	87	< 10	< 10	< 10
	TTS	187	< 10	< 10	< 10
Geophysical survey SSS (300 kHz)	PTS	50	< 10	< 10	< 10
	TTS	50	< 10	< 10	< 10
Project support vessel (large)	PTS	41	< 10	164	< 10
	TTS	1451	101	2010	286
Project support vessel (medium)	PTS	< 10	< 10	< 10	< 10
	TTS	251	< 10	649	50
Cable lay vessel	PTS	328	< 10	421	< 10
	TTS	6950	307	4703	1051
Jet trenching	PTS	47	< 10	177	< 10
	TTS	1651	123	2247	328
Backhoe dredging	PTS	< 10	< 10	< 10	< 10
	TTS	101	< 10	177	< 10
Suction dredging	PTS	101	< 10	219	< 10
	TTS	3352	133	3300	409
Rock placement	PTS	< 10	< 10	47	< 10
	TTS	352	44	800	50
Drilling†	PTS	< 10	< 10	93	< 10
	TTS	157	50	2901	82
Turbine operation†	PTS	< 10	< 10	< 10	< 10
	TTS	50	< 10	250	< 10

Table 21B-20: Summary of maximum distances in metres at which SPL has fallen to threshold level for mortality, recoverable injury and behavioural reactions for stationary fish groups exposed to continuous type noise generating activities at proposed Project († denotes at Site WTG only)

Activity	Impact	Gp 1	Gp 2	Gp 3	Gp 4	Sea turtle
Geophysical survey Sub-bottom profiler (500-12500 Hz)	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Geophysical survey USBL (25 kHz)	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Geophysical survey MBES (170 kHz)	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Geophysical survey SSS (300 kHz)	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Project support vessel (large)	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Project support vessel (medium)	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Cable lay vessel	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	133	
	Behavioural	700				< 10
Jet trenching	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Backhoe dredging	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Suction dredging	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	101				< 10
Rock placement	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Drilling†	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10
Turbine operation†	Recov Inj	N/A	N/A	< 10	N/A	
	TTS	N/A	N/A	N/A	< 10	
	Behavioural	< 10				< 10

Explosive noise sources

165. This section presents a summary of the potential impacts arising during detonation of explosive charges in the proposed Project Area.

166. The modelling indicates that when assessed using SPL metrics, VHF cetaceans are the most sensitive marine mammals FHG to explosive noise. In the event that a high order detonation takes place involving a maximum likely charge weight of 794 kg, the PTS impact criterion is met at a distance of 19.3 km while the TTS criterion extends over a distance of 37.5 km. By contrast, HF cetaceans are the least sensitive: the PTS and TTS impact criteria are met at maximum distances of 915 m and 1750 m respectively. When assessed using SEL metrics, LF cetaceans are the most sensitive FHG. The PTS impact criterion extends to a distance of 10.8 km while the TTS impact criterion is met at a distance of 155 km. HF cetaceans are the least sensitive where the PTS and TTS impact criteria are met at distances of 11 m and 156 m respectively.

167. When all fish groups are exposed to the blast from a 794 kg charge weight, the Mortality and Potential Mortal Injury impact criterion is met at distances in the range 596-1019 m from the blast site.

168. A low order clearance involving the detonation of a maximum charge weight of 2 kg generates a significantly smaller blast. When assessed using SPL metrics, for VHF cetaceans, the impact distance for the PTS and TTS thresholds are reduced to 2.6 km and 5.1 km respectively. For HF cetaceans, the corresponding distances are 124 m and 238 m. When assessed using SEL metrics, for LF cetaceans, the PTS impact criterion is met at 579 m and the TTS impact criterion is met over a distance of 8.2 km. For HF cetaceans, both the PTS and TTS criteria are met within a distance of 10 m from the blast site.

169. When fish are exposed to the blast from a 2 kg charge weight, the Mortality and Potential Mortal Injury impact criterion is met at distances in the range 81-138 m from the blast site.

170. Summaries of maximum impact distances for physiological and behavioural impacts on each marine mammal, fish and sea turtle FHG assessed using SPL and SEL metrics when exposed to explosive blast are given in Section 21.9.

21.7.3. Moving receptor scenario: Physiological and behavioural impacts

171. The analysis discussed above assumes the animal remains stationary in the water for a fixed period of time. For all operational periods greater than the shortest one considered, this assumption becomes increasingly unlikely and can be considered very implausible in a ‘real-world’ scenario. To address this unrealistic rationale, a more realistic, Moving-Receptor (sometimes referred to as a Fleeing-Animal) scenario (Theobald *et al*., 2009) has been adapted for use to take into account a moving source – where relevant.

172. In the context of a noise generating activity at a marine construction site, the Moving-Receptor schema models over elapsed time the positions of a marine receptor (marine mammal or fish) with respect to the noise site while taking into account the receptor transit speeds and directions. At each position, the sound exposure on the receptor is computed and this builds up over a period of time until the cumulative SEL (SEL_{cum}) reaches a level representing the onset of TTS or even PTS. The cumulative dose on an animal is dependent therefore not only on its audiological sensitivity to the noise but also on its proximity and duration of exposure to the noise source. It is emphasised that any result arising from a Moving-Receptor scenario is unique to that specific model scenario only. Nevertheless, the results from such models provide some boundary conditions for possible real-world receptor movement scenarios and these can inform an assessment that draws on a SEL_{cum} threshold criterion.

173. It is important to note the limitations of the Moving-Receptor model. It assumes the animal transits in a straight line at a constant speed and does not allow for deviations in either parameter due to meeting e.g., the coastline or other unsuitable habitat. This is deemed to be a very idealised model. In a real-world scenario when an animal is exposed to a potentially impactful sound field, depending on the animal's current activity (feeding, breeding, nursing etc.) and motivation, it may or may not move away to a less-impactful location. Equally, it may or may not move at a fixed speed and/or direction including diving to depth. In order to model such scenarios, it is necessary to draw on a comprehensive animal movement model (Houser, 2006) which samples the predicted 3-D sound fields with movement rules derived from animal observations. The likelihood of impacts arising are assessed accordingly. This requires specialist complex, computer intensive modelling and is beyond the terms of reference for this project.

174. For the Moving-Receptor scenarios considered below, it is assumed that the animal swims from a given start location relative to the noise site on a constant bearing and at a constant speed. Representative swim speeds for various species of marine mammal are derived from guidance given by UK-based regulatory organisations. In Welsh waters, advice is provided by NRW (Natural Resources Wales, 2023) and the Marine Management Organisation (MMO, 2023). The swim speeds are given in **Table 21B-21.** For representative fish species, typical swim speeds are taken from the open literature and these are included in the table. It is noted that fleeing speeds are likely to be somewhat greater than typical swim speeds however there are very limited data on these.

Table 21B-21: Summary of representative swim speeds for each FHG

FHG	Representative species	Modelled swim speeds	References
LF cetacean	Minke whale	2.3 m/s	Boisseau *et al*. (2014)
HF cetacean	Bottlenose dolphin	1.52 m/s	Bailey *et al*. (2010)
VHF cetacean	Harbour porpoise	1.5 m/s	Otani *et al*. (2001)
PCW pinniped	Grey seal	1.8 m/s	Thompson (2015)
Fish Group 1	Basking shark	1.10 m/s	Sims (2000)
Fish Group 2	Salmon	0.97 m/s	Hvas & Oppedal (2017)
Fish Group 3/4	Juvenile fish (bream)	0.11 m/s	Clough *et al*. (2004)
Sea turtle	Generic	1.5 m/s	Ocean Life (2023)

175. A typical animal/noise site layout is illustrated in **Figure 21B-25.** Given an initial animal offset from the noise site (500 m in the example shown), the positions of the animal with respect to the noise site are computed at successive, regularly-spaced distance intervals where the time interval corresponds to an interval of 1 second. The model was run over a total operational period of 10,000 seconds. The Applicant estimates that it will take approximately 3 hours to drive 1 pile to the design depth. It is expected that 1 piling operation will be undertaken over a 24-hour period. For all other construction activities, 'round-the-clock' operations are likely to be followed. It is worth noting that the SEL_{cum} as given by the Moving-Receptor model was seen to asymptote to a final value well within a period of 10,000 seconds for all the scenarios subsequently considered. Running the model beyond this time limit was therefore deemed nugatory.

176. Both the variation of instantaneous SEL over time and the build-up of SEL_{cum} over a period of time were calculated. The underlying SPL data were generated by using the acoustic modelling discussed in **Section 21.5**. A typical result is shown in **Figure 21B-26:** for an LF cetacean moving through the Offshore Development Area using the positional scenario shown in **Figure 21B-25** where the animal commences moving at a constant transit speed of 1.4 m/s from an initial offset

of 500 m from the noise site (in this example, the noise is impact piling). The figure indicates that as the noise-receptor distance increases, the instantaneous SPL decreases (although not monotonically given the nature of acoustic propagation in the area (see **Section 21.6**)). The figure shows that the SEL_{cum} increases over time, reaching the TTS threshold after 6 seconds and meeting the PTS threshold after 200 seconds. By an elapsed time of 4,500 seconds, it is seen that the SEL_{cum} has asymptoted to its final value. The Moving-Receptor model is repeatedly run with increasing initial offsets until, over the duration of the model simulation, the SEL_{cum} fails to meet either the PTS or TTS thresholds. The area corresponding to this critical initial offset, represents a region of the sea within which animals are unlikely to be impacted by the noise. Given a representative animal density in the given area, it becomes possible to determine the numbers of animals that are not impacted by the given construction activity. This forms the basis of the Population Consequences of Disturbance (PCoD) model which is a framework used to assess the potential for population-level consequences following exposure of animals to a disturbance activity (Dunlop *et al*. 2021). Full implementation of the PCoD model is not undertaken in the current report.

177. **Table 21B-22** through to **Table 21B-31** gives the minimum offset (or starting position) of a marine mammal relative to a construction activity in order for the SEL_{cum} to remain below the PTS impact threshold. It is seen that the impact piling task generates highest levels of noise and these are most impactful for the LF cetacean. The results indicate that if piling occurs when the animal is within a distance of 5,490 m from the piling site during February, the SEL_{cum} would meet the PTS impact threshold. By August, the critical minimum offset is reduced to 3300 m. For piling operations taking place in all other months, the critical distances will lie between these two extremes. By contrast, fleeing HF and VHF cetacean; and PCW pinniped, may be as close as 100 m from the piling site at the commencement of piling yet the SEL_{cum} remains below the threshold representing the onset of PTS. It is important to note that standard industry practice as given by the Joint Nature Conservation Committee (JNCC) is to delay the commencement of impact piling if receptors are seen within a radius of 500 m of the piling site (JNCC, 2017). In the event that an animal appears within this critical monitoring zone, the modelling results in **Table 21B-22** indicates that HF and VHF cetaceans and PCW pinnipeds will avoid the situation where the SEL_{cum} reaches the PTS impact threshold. However, additional mitigation, over and above that stipulated by JNCC must be applied in the case of the LF cetacean.

178. When exposed to impact piling noise, the Fleeing Animal modelling results given in **Table 21B-22** show that, in order that the SEL_{cum} does not meet the PTS impact criterion, the LF cetacean must be at least 5.5 km from the piling site in February and at least 3.3 km in August. By contrast, the critical minimum distance from the piling site for PCW pinnipeds is 60 m.

179. For all construction activities except impact piling, the modelling results given in **Table 21B-23** through to **Table 21B-31** indicate that, in order for the SEL_{cum} to avoid meeting the PTS impact threshold, VHF cetaceans may be as close as 50 m from the noise site at the commencement of operations. All other animal groupings may be as close as 10 m.

180. Summaries of minimum offset distances for the PTS impact criterion on each marine mammal FHG assessed using SPL and SEL metrics following exposure to pile driving noise, the most impactful activity during construction, are given in **Table 21B-39** for the modelling at Site WTG.

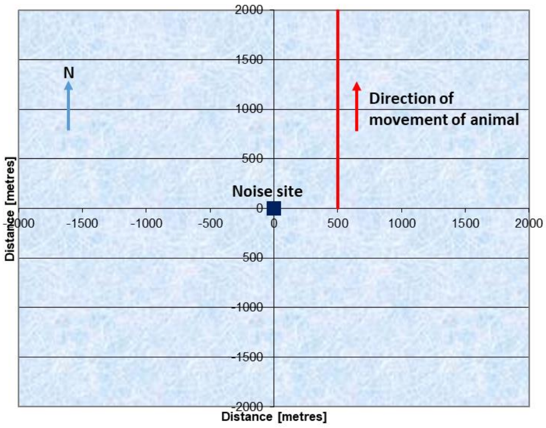


Figure 21B-25: Schematic showing transit line for an animal (red line) moving due North with an initial offset position of 500 m with respect to a stationary noise site (blue square) located at (0, 0)

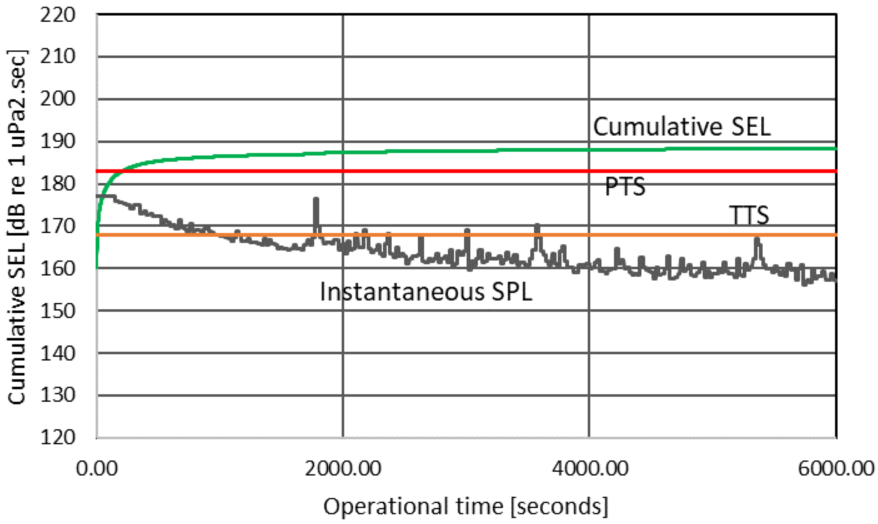


Figure 21B-26: Instantaneous SPL and Cumulative SEL on an LF cetacean transiting through the Offshore Development Area as a function of elapsed time

Table 21B-22: Summary of minimum offset in metres from piling at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 µPa^2.sec	5490
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	100
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	100
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	60
Aug	LF cetacean	PTS	183 dB re 1 µPa^2.sec	3300
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	100
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	100
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	60

Table 21B-23: Summary of minimum offset in metres from a project support vessel (large) at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10

Table 21B-24: Summary of minimum offset in metres from a project support vessel (medium) at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	< 10
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	< 10
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10

Table 21B-25: Summary of minimum offset in metres from cable-laying at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 µPa^2.sec	50
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 µPa^2.sec	50
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10

Table 21B-26: Summary of minimum offset in metres from jet-trenching at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 μPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 μPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 μPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 μPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 μPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 μPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 μPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 μPa^2.sec	< 10

Table 21B-27: Summary of minimum offset in metres from backhoe dredging at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 μPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 μPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 μPa^2.sec	< 10
	PCW pinniped	PTS	185 dB re 1 μPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 μPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 μPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 μPa^2.sec	< 10
	PCW pinniped	PTS	185 dB re 1 μPa^2.sec	< 10

Table 21B-28: Summary of minimum offset in metres from suction dredging at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 μPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 μPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 μPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 μPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 μPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 μPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 μPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 μPa^2.sec	< 10

Table 21B-29: Summary of minimum offset in metres from rock emplacement at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 μPa^2.sec	< 10

	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	< 10
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	< 10
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10

Table 21B-30: Summary of minimum offset in metres from drilling at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	50
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10

Table 21B-31: Summary of minimum offset in metres from the turbine at site WTG that a marine mammal FHG must be in order to avoid meeting the PTS impact criterion when exposed to operational noise

Month	FHG	Impact	Threshold	Min offset to avoid PTS [m]
Feb	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	< 10
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10
Aug	LF cetacean	PTS	183 dB re 1 µPa^2.sec	< 10
	HF cetacean	PTS	185 dB re 1 µPa^2.sec	< 10
	VHF cetacean	PTS	155 dB re 1 µPa^2.sec	< 10
	PCW pinniped	PTS	185 dB re 1 µPa^2.sec	< 10

21.7.4. Dose response scenario: Behavioural impacts

181. The results generated by the impact modelling indicate that the most potentially impactful noise stressor is that that due to pin piledriving; all other noise sources generate noise levels which are considerably more benign.

182. There is considerable uncertainty over modelling the significance of a noise that gives rise to a behavioural response. The animal reactions are frequently context-dependent and contradictory at any given receptor noise level (see **Section 21.3** for an overview on behavioural responses to underwater noise). It is thus recognised that a single threshold value representing the onset of a given behavioural response is considered unreliable (Tyack & Thomas, 2019). An alternative methodology acknowledges the uncertainty in assigning a threshold level corresponding to a given behavioural response by, instead, applying a dose-response function. This provides a threshold

range over which 50% of a group of animals are expected to show a given response to the disturbing noise. The dose-response function is derived from observations of animals responding (or otherwise) to a specific noise type. This is combined with the actual distribution of animals in a given geographical area together with data showing how the impacting noise reduces in intensity with increasing distance. The implementation of a dose-response model requires a series of isopleths or contours of unweighted SEL generated by a single strike of the impact piling hammer over the range 120-180 dB re 1 µPa^2.sec in 5 dB steps. These are shown in **Figure 21B-27** and **Figure 21B-28** modelled for the months of February and August respectively.

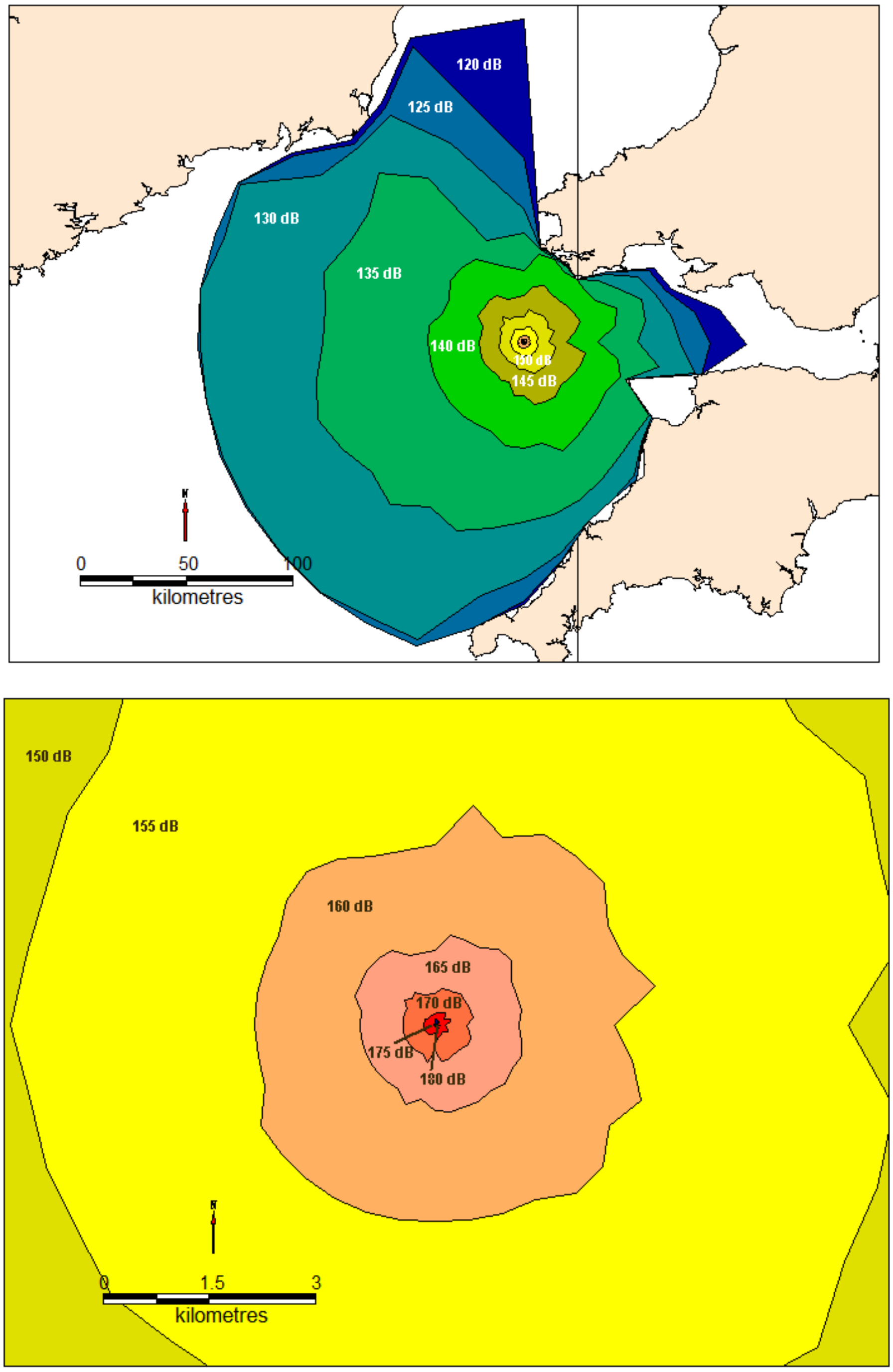


Figure 21B-27: Isopleths showing unweighted SELss for impact piling noise at the Offshore Development Area modelled for the month of February

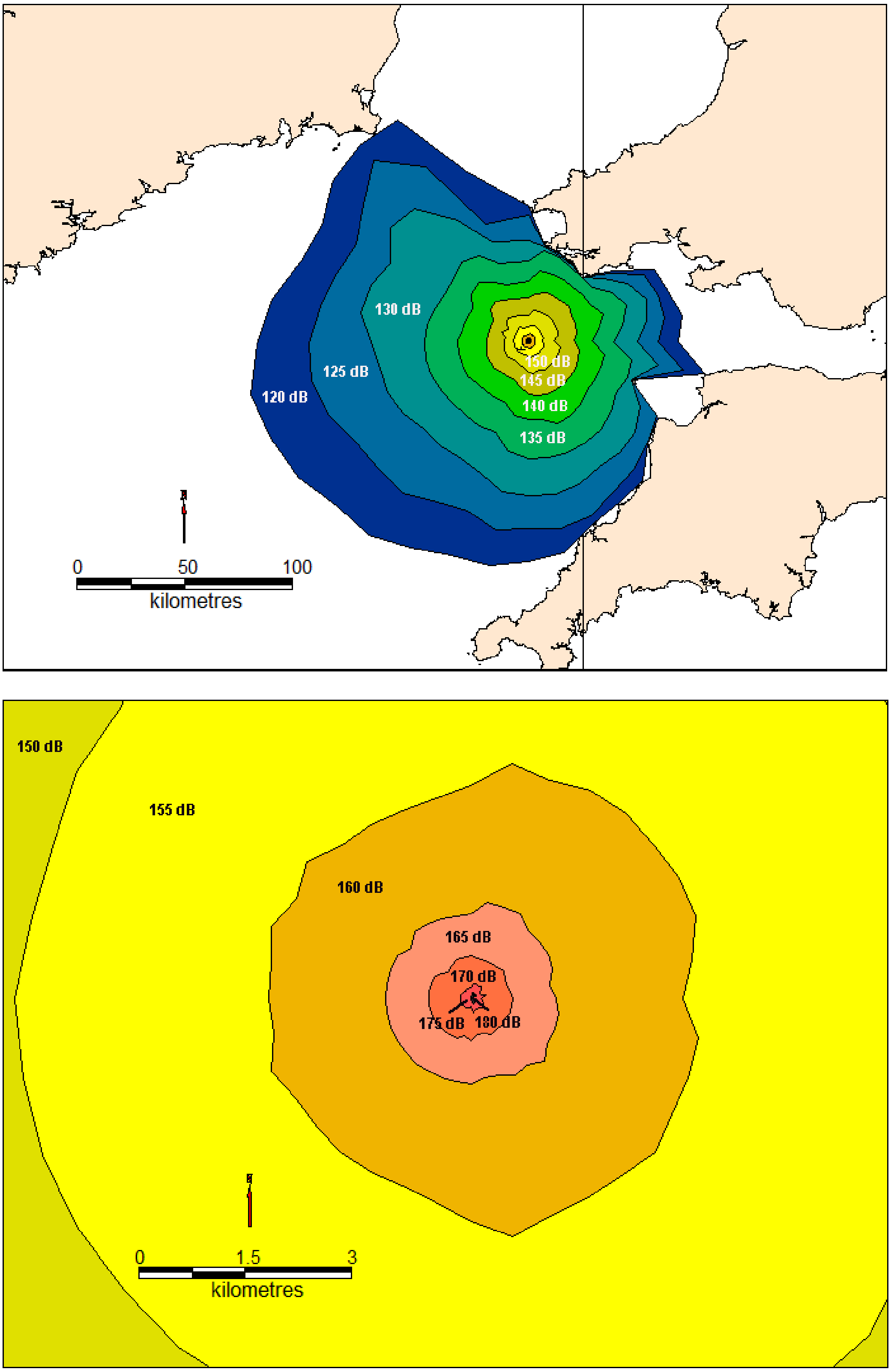


Figure 21B-28: Isopleths showing unweighted SELss for impact piling noise at Llyr Project Area modelled for the month of August

21.8 Missing or Incomplete Knowledge

21.8.1. Introduction

183. The aim of this section is to identify areas where knowledge is incomplete or where data have been unavoidably extrapolated beyond their reliable scope. Conclusions of the underwater noise study should be seen in the context of the reliability of the contributing information.

184. In order to complete this study, it has been necessary to utilise information from a wide variety of sources covering a range of topics. Wherever possible, use has been made of peer-reviewed articles or papers published in the open scientific literature. Where this has not been possible, an effort has been made to state the limitations of the data or to indicate inferences drawn from the available references.

21.8.2. Noise source acoustic characteristics and operating procedures

185. In order to obtain an estimate of the likely acoustic source level associated with impact piling at the proposed Project, a review of the international published literature was undertaken. It is known that acoustic source levels are related to the pile diameter where the larger the pile, the greater the acoustic energy required to drive it to depth; and the nature of the seabed substrate i.e., piling in coarse sand is likely to give rise to higher noise levels than piling in soft clay. It was found that available data related to piling in shallower waters using pile diameters commensurate with those proposed for the proposed Project gave a considerable spread of acoustic source levels. There were no data that captured more precisely the use of piles of 3 m diameter in waters of depth around 60-70 m. In addition, most of the literature failed to provide much detail on the nature of the seabed sediments in a way that was scientifically rigorous.

186. Given these shortcomings, a scatterplot was generated from all the available data and a best-fit trendline along with 95% confidence limits were generated. It is assumed therefore that the acoustic source level thus derived is representative of that likely to arise at the proposed Project piling site however, a degree of uncertainty must be apportioned to this parameter. The energy conversion model showed that the resulting estimate of acoustic source level lay within the range of data expected at the 95% confidence limit. This provided additional certainty over the source level subsequently used in the analysis.

187. Similarly, a frequency spectrum for the piling noise was taken from the published literature. For the current case, the selected spectrum assumes that most of the acoustic energy is carried at frequencies around 1 kHz but, as with the acoustic source level, the actual distribution of energy over the noise spectrum generated by the proposed Project hammer may be different. The lack of sufficient published data on this aspect prevents any further comparison.

188. Operational data, namely the overall piling time per pile, the strike rates, and the soft-start protocol were all taken from the noise study carried out for the Erebus Environmental Impact Assessment (EIA). These are considered representative of operational parameters but nevertheless may not align precisely with operating conditions during piling carried out on the proposed Project.

189. Data on all other noise sources e.g. vessel type, construction activities such as dredging or trenching; and drilling, were derived from data used to support the modelling undertaken for the nearby Erebus OWF project. Data on the characteristics of wind turbine noise at the operational stage were taken from the Hywind OWF project. In each case, the construction activities at the proposed Project may not necessarily generate the same levels of noise as those from the comparison projects.

21.8.3. *Marine fauna and thresholds*

190. A list of marine fauna of environmental relevance to the Offshore Development Area has been provided by the client.

191. The impact of sound on marine mammals has been reported extensively in the literature. Impact thresholds representing the onset of PTS and TTS are widely accepted given the limits of current knowledge. It is accepted that, as more information on audiology and audiological responses become available, the functional hearing groups may be revised along with the acoustic impact threshold levels themselves.

192. It is particularly difficult to assess behavioural changes and habituation to aquatic noise and also to cumulative effects from noises. The results reported in the literature are highly context dependent and often contradictory. It is likely that an animal's reaction to a noise will depend on the nature and intensity of the noise, as well as the animal's motivation to respond. Much published work gives qualitative rather than quantitative information concerning marine mammal distributions, marine mammal behaviour, the reaction of marine mammals to sound, and hearing threshold shifts caused by underwater sound. Currently, the Level B 'Harassment; impact criterion is used across all marine mammal groupings and for all classes of noise. Additionally, the dose response function based on unweighted SEL is used for all marine mammal groupings. Southall *et al*. (2019) have provided a framework for future marine mammal behavioural response studies. It is expected that, as more detailed information becomes available, revised thresholds representing the onset of behavioural responses will be developed.

193. For fish and sea turtle species, threshold levels of sound representing Mortality and Potential Mortal Injury, Recoverable Injury and TTS are derived from studies representing only a small fraction of all fish species (i.e., a few dozen species out of more than 32,000 (Popper & Hawkins, 2018). Many classes of marine benthos are not currently included such as polychaete annelids (e.g., segmented worms), molluscs (e.g., snails, slugs, limpets, whelks, conchs, periwinkles), crustaceans (e.g., crabs, lobsters, crayfish, shrimp, krill and barnacles), and echinoderms (e.g., starfish, brittle stars, sea urchins, sand dollars, sea cucumbers, sea lilies). Quantitative threshold values are only available for impulsive type noise such as that emitted by explosives or impact piling. For non-impulsive noise such as that emitted by vessels, thresholds are described qualitatively in terms of the probability of the impact arising. It is expected that as the underlying knowledge of acoustic impacts on fish species becomes further developed, these data shortfalls will be addressed.

194. Furthermore, many fish species are responsive to a greater or lesser degree to the particle motion of sound waves in addition to the pressure component. So far, there is very limited data on fish responses to particle motion hence this parameter is not currently included in any acoustic impact model.

21.8.4. *Acoustic propagation loss modelling*

195. Modelling the propagation of the noise generated by each of the sources was undertaken using rigorous and proven computer models. Time- and site-specific environmental data were used to populate the models. These are expected to be reliable within the resolutions of the data provided.

196. Southall *et al*. (2019) provide a brief qualitative discussion on the change in acoustic characteristics as an impulsive noise propagates through the undersea environment. After a sufficient distance, the noise may no longer be recognisable as an impulsive event. Hence from an acoustic impact perspective, the acoustic thresholds on the receptor should be based on those for non-impulsive noises. The distance over which this occurs depends on the propagation characteristics of the

undersea environment and can only be determined through detailed and extensive modelling. Southall *et al*. (2019) are currently developing guidance on estimating the distance over which the transition from impulsive to non-impulsive noise takes place.

21.8.5. Acoustic impact modelling

197. The acoustic impact modelling is based on applying threshold levels of noise discussed above to the modelled propagation loss data. For a static source and receptor, impact distances are derived using SPL and SEL metrics. For the latter measure, a number of exposure durations are considered ranging from single strike through to 24 hours. Based on data provided by the client, it is likely that 1 pile may be driven to the design depth over a 4-hour period. All other construction activities have the potential to take place over a 24-hour period.

198. In addition to the environmental data used to populate the acoustic propagation model, the received levels at any given depth and range are related to the acoustic source level. As discussed above, there is a degree of uncertainty attached to this parameter. If it is assumed that the acoustic source level has been underestimated, the distances over which each acoustic impact are met will also be underestimated. Any changes in the distribution of acoustic energy over the transmitted frequency may have a variable effect on impact distances. For instance, if peak energy levels are shifted into a higher frequency band this might have an advantageous impact on fish species and LF cetaceans but less so on HF and VHF cetaceans. The specific changes in distances are unquantifiable without rerunning the models once specific engineering data on source level and spectra.

199. Impact modelling using the Moving-Receptor scenario is an established technique. The swim speeds for the receptors are taken from the open literature. However, they are unlikely to be representative for all species of marine mammal or fish. Furthermore, when stressed, animals may swim at somewhat faster speeds over shorter periods of time. This scenario has not been modelled.

200. With regards to the impact piling procedure itself, there are a number of soft-start protocols available. The one selected for this study, i.e., an initial source level 13 dB down on maximum level, increasing in discrete steps of approximately 3.5 dB every 5 minutes, may not be the one selected during the Project activity itself. Nevertheless, the results derived using the soft-start model are deemed indicative and representative of soft-start models in general.

21.9 Summary

201. Man-made underwater noise will be generated during construction and operational activities undertaken in relation to the proposed Project. The noise thus produced has the potential to impact on various species of marine fauna found in and around the Offshore Development Area. The scale of any acoustic impacts arising was determined by comparing the propagated noise levels with threshold values representing physiological and behavioural impacts for marine mammals, fish and sea turtles. The results are summarised as follows.

21.9.1. Marine mammals – Stationary receptor

202. For piledriving noise, when marine mammals are assessed using SPL metrics, the PTS impact criterion is met at a maximum distance of 39 m while the TTS impact criterion extends to a distance of 84 m. The Level B Harassment criterion is met at a maximum distance of 9.3 km for all marine mammal groupings.

203. When exposed to piling noise and assessed using SEL metrics over a maximum duration of 4 hours, the PTS impact criterion extends to a distance of 29.6 km and the TTS impact is met at a distance of approximately 150 km.

204. For the noise transmitted by the geophysical sources, when assessed using SEL metrics for a duration of 24 hours, the PTS and TTS impact criteria are met at distances of 87 m and 221 m respectively.

205. Over a 24-hour period, for vessel noise, including that emitted during cable-laying, when assessed using SEL metrics the PTS impact criterion extends over a distance of 328 m while the TTS impact criterion reaches a distance of 7 km. For all other construction noise activities involving trenching, drilling and rock placement, the PTS impact criterion applies over a maximum distance of 219 m while the TTS impact criterion is met at a distance of 3.3 km. Underwater operational noise generated by the wind turbines is likely to result in the PTS impact criterion extending to no more than 10 m from each turbine while the TTS zone covers a maximum distance of 250 m.

206. When explosive sources are assessed using the SPL metric, for marine mammals exposed to a high-order detonation of a 794 kg charge weight, the PTS impact criterion is met at a distance of 19.3 km while the TTS criterion extends over a distance of 37.5 km. A low-order detonation of a 2 kg charge weight results in the impact distances for the PTS and TTS thresholds being reduced to 2.6 km and 5.1 km respectively. When assessed using SEL metrics for a single explosive event, the high order detonation indicates that the PTS impact criterion extends to a distance of 10.8 km while the TTS impact criterion is met at a distance of 155 km.

21.9.2. Fish and sea turtles – Stationary receptor

207. For piling noise, when fish and sea turtle species are assessed using SPL metrics, the Mortality and Potential Mortal Injury; and the Recoverable Injury impact criteria are met at distances within 10 m from the piling site. For fish species, the Low-level Behavioural Response criterion extends to 30.6 km while the Aversive Response criterion covers a distance of 710 m.

208. When exposed to piling noise over a 4-hour duration, the Mortality and Potential Mortal Injury; and the Recoverable Injury impact criteria extend over maximum distances of 1.2 km and 2.7 km respectively. The zone over which the TTS impact criterion is met covers a maximum distance of 29.6 km from the piling site.

209. All fish species appear insensitive to the noise transmitted by the geophysical sources. When assessed using SEL metrics for a duration of 24 hours, the PTS and TTS impact criteria are both met within distances of 10 m from the noise source.

210. For Fish Group 3, the Recoverable Injury criterion is met at a distance of less than 10 m when exposed to all the construction activities as well as the noise generated by the wind turbines at the operational stage. For Group 4 Fish, cable-laying activities are likely to lead to the TTS impact criterion extending out to a distance of 133 m. For all other activities, the corresponding distance is less than 10 m. For all Fish Groups, cable-laying sees the Low-Level Behavioural Response impact criterion being met over a distance of 700 m. Again, for all other activities, the corresponding distance is less than 10 m.

211. When all fish groups are exposed to the blast from a 794 kg charge weight, the Mortality and Potential Mortal Injury impact criterion is met at distances in the range 596-1019 m from the blast site.

212. When fish are exposed to the blast from a 2 kg charge weight, the Mortality and Potential Mortal Injury impact criterion is met at distances in the range 81-138 m from the blast site.

21.9.3. Marine mammals – Moving receptor

213. A moving receptor scenario was modelled whereby each marine mammal FHG transits at a constant speed and on a constant bearing through the noise field generated by a given construction activity. For the piling operations, a soft-start was modelled in which the piling

energy is increased incrementally over a 20-minute period until the full force is being applied and hence maximum noise levels are being generated. The build-up of SEL_{cum} over a period of time was calculated. The modelling indicated that when exposed to impact piling noise, the SEL_{cum} fails to meet the PTS impact criterion provided that the LF cetacean (being the most audiologically sensitive) is at least 5.5 km from the piling site. By contrast, the critical minimum distance from the piling site for PCW pinnipeds (being the least sensitive) is 60 m.

214. For all other construction activities, the modelling results indicate that, in order for the SEL_{cum} to avoid meeting the PTS impact threshold, VHF cetaceans may be as close as 50 m from the noise site at the commencement of operations. Animals in all other FHG may be as close as 10 m.

Annex A. Summary of Impact distances - Site WTG

Impact piling

Table A 21B-1: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to piling noise at site WTG during the months of February and August
(† Behavioural threshold for all FHG excluding VHF cetacean)

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
LF	PTS	219 dB re 1 μPa peak	0	0	0	0	0	0
	TTS	213 dB re 1 μPa peak	0	0	0	0	0	0
HF	PTS	230 dB re 1 μPa peak	0	0	0	0	0	0
	TTS	224 dB re 1 μPa peak	0	0	0	0	0	0
VHF	PTS	202 dB re 1 μPa peak	0	0	0	0	39	1
	TTS	196 dB re 1 μPa peak	0	84	26	0	84	26
PCW	PTS	218 dB re 1 μPa peak	0	0	0	0	0	0
	TTS	212 dB re 1 μPa peak	0	0	0	0	0	0
All MM	Level B†	160 dB re 1 μPa rms	6449	7477	6905	7171	9271	7998

Table A 21B-2: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to piling noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
Single Strike	LF	PTS	183 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	168 dB re 1 μPa^2.s	297	419	350	297	419	350
	HF	PTS	185 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	170 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	155 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	140 dB re 1 μPa^2.s	84	158	138	84	158	138
	PCW	PTS	185 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	170 dB re 1 μPa^2.s	0	41	3	0	41	3
0.5 hours	LF	PTS	183 dB re 1 μPa^2.s	5690	7035	6269	6275	7151	6653
		TTS	168 dB re 1 μPa^2.s	37795	63210	51898	24597	38944	31220
	HF	PTS	185 dB re 1 μPa^2.s	0	41	3	0	41	3
		TTS	170 dB re 1 μPa^2.s	363	450	428	363	450	428
	VHF	PTS	155 dB re 1 μPa^2.s	1692	1812	1776	2026	2247	2118
		TTS	140 dB re 1 μPa^2.s	10104	10256	10187	9341	9911	9560

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	PCW	PTS	185 dB re 1 μPa^2.s	594	710	637	594	735	650
		TTS	170 dB re 1 μPa^2.s	5795	6285	6001	6289	7019	6629
1 hour	LF	PTS	183 dB re 1 μPa^2.s	8767	11198	10139	8399	12176	10109
		TTS	168 dB re 1 μPa^2.s	39266	97029	74183	29246	46649	38270
	HF	PTS	185 dB re 1 μPa^2.s	0	70	9	0	70	9
		TTS	170 dB re 1 μPa^2.s	594	710	637	675	1040	772
	VHF	PTS	155 dB re 1 μPa^2.s	2377	2513	2430	2971	3310	3046
		TTS	140 dB re 1 μPa^2.s	14076	15089	14879	11680	12448	12199
	PCW	PTS	185 dB re 1 μPa^2.s	945	1062	1027	1046	1348	1170
		TTS	170 dB re 1 μPa^2.s	10033	10488	10205	8767	9929	9516
2 hours	LF	PTS	183 dB re 1 μPa^2.s	12578	19867	15865	12036	15964	13881
		TTS	168 dB re 1 μPa^2.s	39634	145077	95294	33446	54773	45232
	HF	PTS	185 dB re 1 μPa^2.s	0	84	26	0	84	26
		TTS	170 dB re 1 μPa^2.s	945	1062	1027	1046	1348	1211
	VHF	PTS	155 dB re 1 μPa^2.s	3511	3637	3596	3893	4034	3974
		TTS	140 dB re 1 μPa^2.s	18897	19986	19741	14510	15530	15094
	PCW	PTS	185 dB re 1 μPa^2.s	1485	1603	1533	1643	2084	1892
		TTS	170 dB re 1 μPa^2.s	15148	19867	18936	12578	14141	13377

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
3 hours	LF	PTS	183 dB re 1 μPa^2.s	18897	24655	20986	14998	19952	16834
		TTS	168 dB re 1 μPa^2.s	39798	148812	100559	37645	60507	50535
	HF	PTS	185 dB re 1 μPa^2.s	0	139	57	0	139	57
		TTS	170 dB re 1 μPa^2.s	1200	1350	1330	1329	1430	1368
	VHF	PTS	155 dB re 1 μPa^2.s	4591	5193	4775	4930	5052	4962
		TTS	140 dB re 1 μPa^2.s	22922	24776	24328	16345	18055	17194
	PCW	PTS	185 dB re 1 μPa^2.s	1932	2129	2015	2080	2533	2280
		TTS	170 dB re 1 μPa^2.s	19947	29348	24599	14998	18055	15944
4 hours	LF	PTS	183 dB re 1 μPa^2.s	20697	29557	24935	16198	24120	19220
		TTS	168 dB re 1 μPa^2.s	39920	149740	101745	39471	66782	54897
	HF	PTS	185 dB re 1 μPa^2.s	121	168	148	121	168	148
		TTS	170 dB re 1 μPa^2.s	1485	1571	1510	1494	2026	1688
	VHF	PTS	155 dB re 1 μPa^2.s	5318	5434	5378	5132	5849	5393
		TTS	140 dB re 1 μPa^2.s	23290	29434	27554	17398	19519	18737
	PCW	PTS	185 dB re 1 μPa^2.s	2377	2452	2414	2971	3310	3069
		TTS	170 dB re 1 μPa^2.s	23208	34141	28354	16621	19449	17817

Table A 21B-3: Summary of impact ranges in metres at which unweighted and M-weighted SEL for a single strike has fallen to threshold level for VHF cetaceans exposed to piling noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
Single Strike	VHF	Behavioural	143 dB re 1 μPa^2.s unweighted	25047	39279	30816	20547	28726	25059
			103 dB re 1 μPa^2.s m-weighted	15124	19728	18089	13177	14097	13589

Table A 21B-4:Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to piling noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 1	Mort, Reco	213 dB re 1 μPa peak	0	0	0	0	0	0
Fish 2/3/4	Mort, Reco	207 dB re 1 μPa peak	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 μPa rms	23547	30672	26050	19273	27257	22749
Sea turtle	Aver. Beh	175 dB re 1 μPa rms	540	710	618	540	631	599

Table A 21B-5: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for fish species exposed to piling noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
Single Strike	Fish 1	Mort	219 dB re 1 µPa².s	0	0	0	0	0	0
		Reco	216 dB re 1 µPa².s	0	0	0	0	0	0
	Fish 2	Mort	210 dB re 1 µPa².s	0	0	0	0	0	0
		Reco	203 dB re 1 µPa².s	0	0	0	0	0	0
	Fish 3/4	Mort	207 dB re 1 µPa².s	0	0	0	0	0	0
		Reco	203 dB re 1 µPa².s	0	0	0	0	0	0
	Fish 1/2/3/4	TTS	186 dB re 1 µPa².s	0	0	0	0	0	0
	Sea turtle	Mort	210 dB re 1 µPa².s	0	0	0	0	0	0
	Eggs & larvae	Mort	210 dB re 1 µPa².s	0	0	0	0	0	0
	Mackerel	Beh 50%	142 dB re 1 µPa².s	27746	43801	33529	23509	32555	27297
	Sprat	Beh 50%	135 dB re 1 µPa².s	39471	96967	72339	36145	53058	44461
0.5 hours	Fish 1	Mort	219 dB re 1 µPa².s	0	0	0	0	0	0
		Reco	216 dB re 1 µPa².s	0	41	3	0	41	3
	Fish 2	Mort	210 dB re 1 µPa².s	0	123	40	0	123	40
		Reco	203 dB re 1 µPa².s	363	558	464	448	599	539
	Fish 3/4	Mort	207 dB re 1 µPa².s	121	245	161	135	245	178
		Reco	203 dB re 1 µPa².s	363	558	464	448	599	539
	Fish 1/2/3/4	TTS	186 dB re 1 µPa².s	6574	9520	7310	7321	9427	8419
	Sea turtle	Mort	210 dB re 1 µPa².s	0	123	40	0	123	40
	Eggs & larvae	Mort	210 dB re 1 µPa².s	0	123	40	0	123	40
1 hour	Fish 1	Mort	219 dB re 1 µPa².s	0	41	3	0	41	3
		Reco	216 dB re 1 µPa².s	0	82	19	0	84	26

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	Fish 2	Mort	210 dB re 1 µPa².s	121	245	161	135	245	178
		Reco	203 dB re 1 µPa².s	598	789	676	789	1022	902
	Fish 3/4	Mort	207 dB re 1 µPa².s	297	419	350	363	450	428
		Reco	203 dB re 1 µPa².s	598	789	676	789	1022	902
	Fish 1/2/3/4	TTS	186 dB re 1 µPa².s	10159	14908	11990	10049	14353	11669
	Sea turtle	Mort	210 dB re 1 µPa².s	121	245	161	135	245	178
	Eggs & larvae	Mort	210 dB re 1 µPa².s	121	245	161	135	245	178
2 hours	Fish 1	Mort	219 dB re 1 µPa².s	0	82	19	0	84	26
		Reco	216 dB re 1 µPa².s	0	135	51	0	123	40
	Fish 2	Mort	210 dB re 1 µPa².s	297	419	350	363	450	428
		Reco	203 dB re 1 µPa².s	1195	1430	1295	1189	1394	1265
	Fish 3/4	Mort	207 dB re 1 µPa².s	594	710	637	586	906	689
		Reco	203 dB re 1 µPa².s	1195	1430	1295	1189	1394	1265
	Fish 1/2/3/4	TTS	186 dB re 1 µPa².s	15090	21084	17608	15148	20030	16967
	Sea turtle	Mort	210 dB re 1 µPa².s	297	419	350	363	450	428
	Eggs & larvae	Mort	210 dB re 1 µPa².s	297	419	350	363	450	428
3 hours	Fish 1	Mort	219 dB re 1 µPa².s	0	84	26	0	84	26
		Reco	216 dB re 1 µPa².s	121	168	148	121	168	148
	Fish 2	Mort	210 dB re 1 µPa².s	446	572	492	540	627	589
		Reco	203 dB re 1 µPa².s	1620	1814	1744	2026	2208	2103
	Fish 3/4	Mort	207 dB re 1 µPa².s	743	1022	891	892	1104	1003
		Reco	203 dB re 1 µPa².s	1620	1814	1744	2026	2208	2103
	Fish 1/2/3/4	TTS	186 dB re 1 µPa².s	18718	29396	22107	17370	24204	19922

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	Sea turtle	Mort	210 dB re 1 μPa^2.s	446	572	492	540	627	589
	Eggs & larvae	Mort	210 dB re 1 μPa^2.s	446	572	492	540	627	589

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
4 hours	Fish 1	Mort	219 dB re 1 µPa^2.s	0	135	51	0	123	40
		Reco	216 dB re 1 µPa^2.s	121	245	161	135	245	178
	Fish 2	Mort	210 dB re 1 µPa^2.s	594	710	637	586	906	689
		Reco	203 dB re 1 µPa^2.s	1947	2329	2183	2161	2681	2337
	Fish 3/4	Mort	207 dB re 1 µPa^2.s	1040	1215	1119	1080	1226	1186
		Reco	203 dB re 1 µPa^2.s	1947	2329	2183	2161	2681	2337
	Fish 1/2/3/4	TTS	186 dB re 1 µPa^2.s	21447	29696	25490	19273	25551	22350
	Sea turtle	Mort	210 dB re 1 µPa^2.s	594	710	637	586	906	689
	Eggs & larvae	Mort	210 dB re 1 µPa^2.s	594	710	637	586	906	689

Geophysical sources: Sub-bottom profiler

Table A 21B-6: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to sub-bottom profiler noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	78	100	98	78	100	98
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	78	100	98	78	100	98
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	93	133	103	93	133	103
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	123	157	148	123	157	148
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 µPa².s	39	50	49	39	50	49
		TTS	179 dB re 1 µPa².s	150	187	153	150	187	153
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
12 hours	LF	PTS	199 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	179 dB re 1 µPa^2.s	176	204	198	176	204	198
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
24 hours	LF	PTS	199 dB re 1 µPa^2.s	44	82	51	44	82	51
		TTS	179 dB re 1 µPa^2.s	187	221	201	187	221	201
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49

Table A 21B-7: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to sub-bottom profiler noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	78	100	98	78	100	98
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	176	204	198	176	204	198
All Fish	Low Level Beh	150 dB re 1 µPa rms	286	327	301	300	327	302
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	47	88	54	47	88	54

Geophysical sources: USBL

Table A 21B-8: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to USBL noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	44	5	0	44	5
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	41	78	50	41	78	50
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0

Table A 21B-9: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to USBL noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	39	50	49	39	50	49
All Fish	Low Level Beh	150 dB re 1 µPa rms	187	221	201	187	221	201
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Geophysical sources: Multi beam echo sounder

Table A 21B-10: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to MBES noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	47	6	0	44	5
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	41	78	50	41	78	50
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	78	100	98	78	100	98
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	100	140	104	100	140	104
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	132	163	149	132	163	149

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
24 hours	LF	PTS	199 dB re 1 µPa^2.s	0	39	1	0	39	1
		TTS	179 dB re 1 µPa^2.s	150	187	153	150	187	153
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0

Table A 21B-11: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to MBES noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	47	6	0	47	6
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	123	157	148	123	157	148
All Fish	Low Level Beh	150 dB re 1 µPa rms	187	221	201	187	221	201
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	39	1	0	39	1

Geophysical sources: Side scan sonar

Table A 21B-12: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to side scan sonar noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
24 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0

Table A 21B-13: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to side scan sonar noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	44	82	51	41	78	50
All Fish	Low Level Beh	150 dB re 1 µPa rms	78	100	98	78	100	98

Sea turtle	Aver. Beh	175 dB re 1 μPa rms	0	0	0	0	0	0

Project support vessel (large) noise

Table A 21B-14: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to project support vessel (large) noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 μPa rms	3627	3702	3663	2551	2952	2859

Table A 21B-15: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to project support vessel (large) noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	176	204	198	176	204	198
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	41	78	50	41	78	50
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	274	310	299	265	300	296
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
2 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	100	140	104	100	140	104
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	420	450	448	420	450	448
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	44	5	0	44	5
4 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	187	221	201	187	221	201
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	44	5	0	44	5
		TTS	153 dB re 1 µPa².s	627	663	650	650	666	651
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	39	50	49	39	50	49
8 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	350	373	351	327	368	350
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	44	5	0	44	5
	VHF	PTS	173 dB re 1 µPa².s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa².s	900	941	905	926	951	948

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	50	93	55	50	93	55

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	485	513	500	450	490	454
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa^2.s	41	78	50	41	78	50
		TTS	153 dB re 1 µPa^2.s	1120	1151	1149	1147	1185	1152
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	88	123	100	88	123	100
24 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	794	823	801	794	823	801
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	44	82	51	44	82	51
	VHF	PTS	173 dB re 1 µPa^2.s	88	123	100	88	123	100
		TTS	153 dB re 1 µPa^2.s	1550	1651	1646	1588	1751	1633
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	187	221	201	187	221	201

Table A 21B-16: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to project support vessel (large) noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Project support vessel (medium) noise

Table A 21B-17: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to project support vessel (medium) noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	600	666	626	600	627	602

Table A 21B-18: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to project support vessel (medium) noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	39	50	49	39	50	49
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	39	50	49	39	50	49
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	78	100	98	78	100	98
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	47	6	0	47	6
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	132	163	149	132	163	149
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	233	265	250	233	265	250
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	47	88	54	47	88	54
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	300	327	302	300	327	302
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
24 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	123	157	148	123	157	148
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	467	509	498	450	490	454
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	47	6	0	47	6

Table A 21B-19: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to project support vessel (medium) noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Cablelay vessel noise

Table A 21B-20: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to cablelay noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 μPa rms	16500	19558	17942	12697	13305	12942

Table A 21B-21: Summary to impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to cablelay noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	300	368	333	286	327	301
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	485	513	500	467	500	497
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	39	50	49	39	50	49
1 hour	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	500	619	563	529	619	597
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	39	50	49	39	50	49
		TTS	153 dB re 1 μPa^2.s	700	735	702	700	745	703
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	39	50	49	39	50	49
2 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	973	1014	998	840	882	851

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa².s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa².s	1017	1058	1048	1050	1074	1052
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	88	123	100	88	123	100
4 hours	LF	PTS	199 dB re 1 µPa².s	39	50	49	39	50	49
		TTS	179 dB re 1 µPa².s	1599	1801	1621	1587	1801	1610
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa².s	78	100	98	78	100	98
		TTS	153 dB re 1 µPa².s	1489	1511	1500	1447	1651	1471
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	176	204	198	176	204	198
8 hours	LF	PTS	199 dB re 1 µPa².s	50	100	91	50	100	77
		TTS	179 dB re 1 µPa².s	2241	3302	2579	2051	2599	2276
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	78	100	98	78	100	98
	VHF	PTS	173 dB re 1 µPa².s	132	163	149	132	163	149
		TTS	153 dB re 1 µPa².s	1951	3301	2643	2001	2502	2158
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	300	327	302	300	327	302

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	88	123	100	88	123	100
		TTS	179 dB re 1 µPa^2.s	3299	3702	3598	2600	2952	2836
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	100	140	104	100	140	104
	VHF	PTS	173 dB re 1 µPa^2.s	187	221	201	187	221	201
		TTS	153 dB re 1 µPa^2.s	2567	3351	3223	2351	2901	2652
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	400	442	404	400	450	410
24 hours	LF	PTS	199 dB re 1 µPa^2.s	150	200	189	150	196	154
		TTS	179 dB re 1 µPa^2.s	4371	5150	4667	3641	4719	4038
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	200	235	203	200	235	203
	VHF	PTS	173 dB re 1 µPa^2.s	300	327	302	300	327	302
		TTS	153 dB re 1 µPa^2.s	3649	3950	3897	2901	3300	3047
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	650	694	653	650	666	651

Table A 21B-22: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to cablelay noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	78	100	98	78	100	98
All Fish	Low Level Beh	150 dB re 1 µPa rms	350	400	368	300	400	338
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Jet trenching noise

Table A 21B-23: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to jetting noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	3892	4002	3939	2901	3253	3168

Table A 21B-24: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to jetting noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	200	235	203	200	235	203
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	47	88	54	47	88	54
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	309	350	345	300	327	302
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	179 dB re 1 µPa^2.s	132	163	149	132	163	149
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	485	513	500	467	509	498
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
4 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	233	265	250	233	265	250
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa^2.s	700	735	702	700	750	705
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
8 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	400	449	405	400	467	405
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa^2.s	1027	1062	1051	1050	1074	1052
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	181 dB re 1 μPa^2.s	78	100	98	78	100	98

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	588	619	601	588	619	601
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 μPa^2.s	47	88	54	47	88	54
		TTS	153 dB re 1 μPa^2.s	1250	1301	1255	1250	1401	1303
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	118	150	147	118	150	147
24 hours	LF	PTS	199 dB re 1 μPa^2.s	0	41	2	0	41	2
		TTS	179 dB re 1 μPa^2.s	887	929	901	882	901	899
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	47	88	54	47	88	54
	VHF	PTS	173 dB re 1 μPa^2.s	100	140	104	100	140	104
		TTS	153 dB re 1 μPa^2.s	1750	1801	1794	1797	2001	1853
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	221	250	247	221	250	247

Table A 21B-25: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to jetting noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 μPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 μPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 μPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 μPa rms	0	0	0	0	0	0

Backhoe dredging noise

Table A 21B-26: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to backhoe dredging noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	250	286	253	250	286	253

Table A 21B-27: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to backhoe dredging noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	39	50	49	39	50	49
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	39	50	49	39	50	49
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	181 dB re 1 $\mu Pa^2.s$	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	47	88	54	47	88	54
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
24 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	100	140	104	100	140	104
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0

Table A 21B-28: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to backhoe dredging noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 μPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 μPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 μPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 μPa rms	0	0	0	0	0	0

Suction dredging noise

Table A 21B-29: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to suction dredging noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	7230	9854	8720	5702	6453	6234

Table A 21B-30: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to suction dredging noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	78	100	98	50	100	93
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	221	250	247	221	250	247
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	150	187	153	140	177	152
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	350	400	369	350	392	353
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	39	1	0	39	1
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	179 dB re 1 µPa^2.s	274	310	299	250	300	255
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	39	1	0	39	1
		TTS	153 dB re 1 µPa^2.s	549	575	552	549	575	552
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
4 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	500	531	503	450	490	454
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	39	1	0	39	1
	VHF	PTS	173 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa^2.s	794	823	801	800	840	805
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	44	82	51	44	82	51
8 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	882	901	899	794	858	846
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa^2.s	44	82	51	44	82	51
		TTS	153 dB re 1 µPa^2.s	1144	1176	1151	1167	1201	1198
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	181 dB re 1 μPa^2.s	100	140	104	100	140	104

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	41	2	0	41	2
		TTS	179 dB re 1 µPa^2.s	1100	1151	1146	1100	1151	1117
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa^2.s	78	100	98	78	100	98
		TTS	153 dB re 1 µPa^2.s	1400	1451	1446	1389	1600	1418
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	150	187	153	140	177	152
24 hours	LF	PTS	199 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	179 dB re 1 µPa^2.s	1838	1900	1852	1838	1901	1855
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	78	100	98	78	100	98
	VHF	PTS	173 dB re 1 µPa^2.s	132	163	149	132	163	149
		TTS	153 dB re 1 µPa^2.s	1879	3300	2341	1900	2502	2075
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	280	314	300	274	310	299

Table A 21B-31: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to suction dredging noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	39	50	49	39	50	49
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Rock placement noise

Table A 21B-32: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to rock placement noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	882	901	899	838	862	850

Table A 21B-33: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to rock placement noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	39	50	49	39	50	49
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	50	93	55	50	93	55
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	41	2	0	41	2

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	118	150	147	100	140	104
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	200	235	203	200	235	203
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	47	88	54	47	88	54
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	309	350	345	300	327	302
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	93	133	103	93	133	103
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	400	442	404	400	442	404
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	41	2	0	41	2
24 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	187	221	201	187	221	201
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	44	5	0	44	5
		TTS	153 dB re 1 µPa^2.s	600	627	602	607	650	645
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49

Table A 21B-34: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to rock placement noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Drilling noise

Table A 21B-35: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to drilling noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 μPa rms	600	627	602	1050	1106	1098

Table A 21B-36: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to drilling noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	100	140	104	100	140	104
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	200	235	203	200	245	204
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	327	354	349	350	373	351
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	513	550	547	1000	1050	1008
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	50	43	0	50	43
		TTS	153 dB re 1 µPa^2.s	776	800	799	1144	1900	1172
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	41	2	0	41	2

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	50	93	55	50	100	65
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	44	5	0	44	5
	VHF	PTS	173 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa^2.s	950	1001	987	1350	1951	1482
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
24 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	123	157	148	123	157	148
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa^2.s	47	88	54	50	93	55
		TTS	153 dB re 1 µPa^2.s	1351	1450	1385	1999	2901	2147
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	44	82	51	44	82	51

Table A 21B-37: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to drilling noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Operational noise

Table A 21B-38: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to operational noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	550	588	553	529	560	549

Table A 21B-39: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to operational noise at site WTG during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	39	50	49	39	50	49
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	44	82	51	44	82	51
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	88	123	100	88	123	100
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	41	2	0	39	1
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	132	163	149	132	163	149
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
24 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	200	250	227	221	250	247
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0

Table A 21B-40: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to operational noise at site WTG during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 μPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 μPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 μPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 μPa rms	0	0	0	0	0	0

Annex B. Summary of Impact distances- Site CR

Project support vessel (large) noise

Table B 21B-1: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to project support vessel (large) noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 μPa rms	1683	4503	3300	1584	4051	2926

Table B 21B-2: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to project support vessel (large) noise at site cable route during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	200	252	225	200	252	221
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	88	123	100	88	123	100
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	346	374	352	346	374	352
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	148	205	193	148	205	176
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	153 dB re 1 µPa².s	500	599	527	495	600	523
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	47	6	0	47	6
4 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	299	352	316	299	352	314
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	47	6	0	47	6
		TTS	153 dB re 1 µPa².s	700	800	749	696	800	742
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	41	78	50	41	78	50
8 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	499	704	547	448	600	519
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	47	6	0	47	6
	VHF	PTS	173 dB re 1 µPa².s	41	78	50	41	78	50
		TTS	153 dB re 1 µPa².s	995	1188	1075	896	1101	1016
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	88	132	102	88	132	102
12 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	619	804	727	575	850	695

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa².s	78	101	98	78	101	98
		TTS	153 dB re 1 µPa².s	1194	1401	1273	1053	1401	1222
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	140	177	152	132	164	149
24 hours	LF	PTS	199 dB re 1 µPa².s	0	41	2	0	41	2
		TTS	179 dB re 1 µPa².s	953	1451	1176	834	1351	1073
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	78	101	98	78	101	98
	VHF	PTS	173 dB re 1 µPa².s	132	164	149	132	164	149
		TTS	153 dB re 1 µPa².s	1650	2010	1856	1304	2001	1662
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	247	286	253	234	286	252

Table B 21B-3: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to project support vessel (large) noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Project support vessel (medium) noise

Table B 21B-4: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to project support vessel (medium) noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	697	1100	949	697	1100	902

Table B 21B-5: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to project support vessel (medium) noise at site cable route during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	39	50	49	39	50	49
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	47	88	54	47	88	54
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
2 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	99	149	105	99	140	104
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	39	50	49	39	50	49
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	187	221	201	187	221	201
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	78	101	98	78	101	98
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	153 dB re 1 μPa².s	297	328	302	297	328	302
	PCW	PTS	201 dB re 1 μPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa².s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	99	151	125	99	151	114
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	350	421	391	350	421	385
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
24 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	198	251	209	187	251	207
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	547	649	580	527	649	572
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49

Table B 21B-6: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to project support vessel (medium) noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Cablelay vessel noise

Table B 21B-7: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to cablelay noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	1930	21854	10498	1930	18507	8828

Table B 21B-8: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to cablelay noise at site cable route during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	432	649	505	395	600	483
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	550	649	595	547	650	589
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	647	1051	864	619	951	814
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa^2.s	796	901	843	746	900	822
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	78	101	98	78	101	98
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	39	1	0	41	2

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	179 dB re 1 µPa^2.s	885	1601	1270	824	1451	1192
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa^2.s	47	88	54	47	88	54
		TTS	153 dB re 1 µPa^2.s	1095	1287	1184	1000	1301	1125
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	132	164	149	132	164	149
4 hours	LF	PTS	199 dB re 1 µPa^2.s	49	100	56	49	94	55
		TTS	179 dB re 1 µPa^2.s	1194	2552	1867	1106	2401	1723
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	47	88	54	47	88	54
	VHF	PTS	173 dB re 1 µPa^2.s	99	149	105	99	140	104
		TTS	153 dB re 1 µPa^2.s	1395	1990	1709	1254	1751	1525
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	246	281	252	234	275	251
8 hours	LF	PTS	199 dB re 1 µPa^2.s	88	133	102	88	123	100
		TTS	179 dB re 1 µPa^2.s	1584	3602	2634	1491	3502	2387
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	100	151	121	100	151	114
	VHF	PTS	173 dB re 1 µPa^2.s	187	221	201	187	221	201
		TTS	153 dB re 1 µPa^2.s	1831	3152	2360	1597	2400	2004

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	398	468	423	395	468	411

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	132	177	151	123	177	149
		TTS	179 dB re 1 µPa^2.s	1633	4453	3169	1584	4051	2891
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	150	201	163	148	201	157
	VHF	PTS	173 dB re 1 µPa^2.s	247	286	253	234	286	252
		TTS	153 dB re 1 µPa^2.s	1831	3452	3003	1648	2902	2367
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	500	649	561	498	600	545
24 hours	LF	PTS	199 dB re 1 µPa^2.s	247	328	273	247	301	260
		TTS	179 dB re 1 µPa^2.s	1732	6950	4395	1683	6102	3877
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	250	307	271	250	303	269
	VHF	PTS	173 dB re 1 µPa^2.s	350	421	391	350	421	385
		TTS	153 dB re 1 µPa^2.s	1831	4703	3477	1732	3601	2918
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	752	1051	891	697	1001	843

Table B 21B-9: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to cablelay noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	88	133	102	88	133	102
All Fish	Low Level Beh	150 dB re 1 µPa rms	432	700	573	402	655	560
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Jet trenching noise

Table B 21B-10: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to jetting noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	1732	5451	3728	1633	4403	3216

Table B 21B-11: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to jetting noise at site cable route during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	49	94	55	49	100	56
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	247	300	256	247	286	253
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	100	157	143	100	157	127
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	395	448	403	392	450	403
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	179 dB re 1 µPa^2.s	198	252	214	200	251	214
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	550	649	598	547	650	589
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
4 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	350	450	380	346	409	372
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa^2.s	796	901	850	746	900	824
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	47	88	54	47	88	54
8 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	550	749	643	550	749	618
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa^2.s	47	88	54	47	88	54
		TTS	153 dB re 1 µPa^2.s	1095	1298	1191	1000	1301	1126

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	100	157	147	100	157	127

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	697	1051	862	619	1001	831
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	41	78	50	41	78	50
	VHF	PTS	173 dB re 1 µPa^2.s	88	123	100	88	123	100
		TTS	153 dB re 1 µPa^2.s	1273	1766	1410	1146	1751	1368
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	176	205	198	150	205	175
24 hours	LF	PTS	199 dB re 1 µPa^2.s	0	47	6	0	47	6
		TTS	179 dB re 1 µPa^2.s	1009	1651	1353	929	1451	1238
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	88	123	100	88	123	100
	VHF	PTS	173 dB re 1 µPa^2.s	140	177	152	140	177	152
		TTS	153 dB re 1 µPa^2.s	1748	2247	1961	1455	2101	1791
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	297	328	302	297	328	302

Table B 21B-12: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to jetting noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Backhoe dredging noise

Table B 21B-13: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to backhoe dredging noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	392	550	449	350	550	405

Table B 21B-14: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to backhoe dredging noise at site cable route during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February Min	February Max	February Mean	August Min	August Max	August Mean
		TTS	179 dB re 1 µPa².s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	0	0	0	0	0	0
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	39	50	49	39	50	49
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	47	88	54	47	88	54

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	0	41	2	0	41	2
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	88	123	100	88	123	100
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0
24 hours	LF	PTS	199 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa².s	49	101	65	49	101	65
	HF	PTS	198 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa².s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa².s	140	177	152	140	177	152
	PCW	PTS	201 dB re 1 µPa².s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa².s	0	0	0	0	0	0

Table B 21B-15: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to backhoe dredging noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Suction dredging noise

Table B 21B-16: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to suction dredging noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	1782	10704	5930	1732	8453	5070

Table B 21B-17: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to suction dredging noise at site cable route during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	132	164	149	123	157	148
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	297	328	302	297	328	302
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	200	328	255	200	328	251
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	445	498	455	400	499	451
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	41	2	0	41	2
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	179 dB re 1 µPa^2.s	400	550	452	392	550	425
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	41	2	0	41	2
		TTS	153 dB re 1 µPa^2.s	643	700	660	602	700	661
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	39	50	49	39	50	49
4 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	619	983	797	619	899	766
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	41	2	0	41	2
	VHF	PTS	173 dB re 1 µPa^2.s	39	50	49	39	50	49
		TTS	153 dB re 1 µPa^2.s	896	1001	940	846	1001	915
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	82	118	99	82	118	99
8 hours	LF	PTS	199 dB re 1 µPa^2.s	0	39	1	0	39	1
		TTS	179 dB re 1 µPa^2.s	902	1501	1240	840	1451	1186
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	39	50	49	39	50	49
	VHF	PTS	173 dB re 1 µPa^2.s	78	101	98	78	101	98
		TTS	153 dB re 1 µPa^2.s	1194	1435	1289	1053	1401	1233

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	148	201	160	148	201	157

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 µPa^2.s	0	50	7	0	50	7
		TTS	179 dB re 1 µPa^2.s	1103	2201	1584	1017	1801	1436
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	47	88	54	47	88	54
	VHF	PTS	173 dB re 1 µPa^2.s	94	133	103	94	133	103
		TTS	153 dB re 1 µPa^2.s	1345	1909	1660	1238	1751	1488
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	200	263	229	200	252	228
24 hours	LF	PTS	199 dB re 1 µPa^2.s	78	101	98	78	101	98
		TTS	179 dB re 1 µPa^2.s	1498	3352	2298	1354	2952	2107
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	94	133	103	94	133	103
	VHF	PTS	173 dB re 1 µPa^2.s	177	219	200	176	205	198
		TTS	153 dB re 1 µPa^2.s	1831	2752	2195	1505	2400	1953
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	350	409	388	350	409	384

Table B 21B-18: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to suction dredging noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 µPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 µPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 µPa rms	78	101	98	78	101	98
Sea turtle	Aver. Beh	175 dB re 1 µPa rms	0	0	0	0	0	0

Rock placement noise

Table B 21B-19: Summary of impact ranges in metres at which SPL has fallen to threshold level for marine mammals exposed to rock placement noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
All MM	Level B	120 dB re 1 µPa rms	929	1501	1254	840	1451	1184

Table B 21B-20: Summary of impact ranges in metres at which M-weighted SEL has fallen to threshold level for marine mammals exposed to rock placement noise at site cable route during the months of February and August

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
0.5 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	41	78	50	41	78	50
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
1 hour	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	0	0	0	0	0
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	88	123	100	88	123	100
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
2 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	0	47	6	0	47	6
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	148	201	160	148	199	156
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 µPa^2.s	0	0	0	0	0	0
4 hours	LF	PTS	199 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 µPa^2.s	49	94	55	49	100	56
	HF	PTS	198 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 µPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 µPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 µPa^2.s	250	301	260	247	299	255
	PCW	PTS	201 dB re 1 µPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0
8 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	123	157	148	100	157	133
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	395	450	404	392	450	403
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	0	0	0	0	0

Operational period	FHG	Impact	Threshold	February			August		
				Min	Max	Mean	Min	Max	Mean
12 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	148	205	175	148	201	171
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	153 dB re 1 μPa^2.s	495	599	516	483	599	514
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	0	44	5	0	44	5
24 hours	LF	PTS	199 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	179 dB re 1 μPa^2.s	299	352	308	299	352	307
	HF	PTS	198 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	178 dB re 1 μPa^2.s	0	0	0	0	0	0
	VHF	PTS	173 dB re 1 μPa^2.s	0	47	6	0	47	6
		TTS	153 dB re 1 μPa^2.s	697	800	728	647	800	726
	PCW	PTS	201 dB re 1 μPa^2.s	0	0	0	0	0	0
		TTS	181 dB re 1 μPa^2.s	39	50	49	39	50	49

Table B 21B-21: Summary of impact ranges in metres at which SPL has fallen to threshold level for fish species exposed to rock placement noise at site cable route during the months of February and August

FHG	Impact	Threshold	February			August		
			Min	Max	Mean	Min	Max	Mean
Fish 3	Recoverable Injury	170 dB re 1 μPa rms for 48 hr exposure	0	0	0	0	0	0
Fish 4	TTS	158 dB re 1 μPa rms for 12 hr exposure	0	0	0	0	0	0
All Fish	Low Level Beh	150 dB re 1 μPa rms	0	0	0	0	0	0
Sea turtle	Aver. Beh	175 dB re 1 μPa rms	0	0	0	0	0	0

Annex C. UXO detonation

High order detonation

Table C 21B-1: Summary of PTS and TTS impact distances based on impulsive SPLpeak thresholds given by Southall et al. (2019)

FHG	Impact [dB re 1 μPa peak]	25 kg (NEQ)	55 kg (NEQ)	120 kg (NEQ)	240 kg (NEQ)	525 kg (NEQ)	794 kg (NEQ)
LF cetacean	PTS 219 dB	951	1237	1600	2000	2600	3000
	TTS 213 dB	1830	2350	3050	3850	5000	5700
HF cetacean	PTS 230 dB	289	376	487	614	797	915
	TTS 224 dB	552	719	932	1174	1520	1750
VHF cetacean	PTS 202 dB	6100	7900	10250	13000	16750	19250
	TTS 196 dB	11750	15250	20000	25000	32500	37500
	PTS 218 dB	1061	1375	1780	2250	2900	3350

PCW pinniped	TTS 212 dB	2000	2650	3400	4300	5600	6400

Table C 21B-2: Summary of PTS and TTS impact distances based on impulsive SELss m-weighted thresholds given by Southall et al. (2019)

FHG	Impact [dB re 1 µPa² s m-weight]	25 kg (NEQ)	55 kg (NEQ)	120 kg (NEQ)	240 kg (NEQ)	525 kg (NEQ)	794 kg (NEQ)
LF cetacean	PTS 183 dB	2000	2900	4300	6000	8900	10750
	TTS 168 dB	28250	41500	61000	86000	126000	155000
HF cetacean	PTS 185 dB	< 10	< 10	< 10	< 10	< 10	11
	TTS 170 dB	28	42	62	87	128	156
VHF cetacean	PTS 155 dB	55	82	120	169	248	304
	TTS 140 dB	792	1166	1710	2400	3500	4300
PCW pinniped	PTS 185 dB	330	486	713	1003	1470	1800
	TTS 170 dB	4650	6900	10000	14000	20750	25500

Table C 21B-3: Summary of the impact distances based on the unweighted SPLpeak explosive noise criteria given by Popper et al. (2014)

FHG	Impact [dB re 1 µPa peak]	25 kg (NEQ)	55 kg (NEQ)	120 kg (NEQ)	240 kg (NEQ)	525 kg (NEQ)	794 kg (NEQ)
All fish groups	Mortality and Potl Mortal Injury 234 dB	188	244	317	400	519	596
All fish groups	Mortality and Potl Mortal Injury 229 dB	322	418	543	684	888	1019

Low order clearance

Table C 21B-4: Summary of PTS and TTS impact distances based on impulsive SPLpeak thresholds given by Southall et al. (2019)

FHG	Impact [dB re 1 µPa peak]	0.1 kg (NEQ)	0.25 kg (NEQ)	0.5 kg (NEQ)	2.0 kg (NEQ)
LF cetacean	PTS 219 dB	151	205	258	410
	TTS 213 dB	290	394	497	789
HF cetacean	PTS 230 dB	45	62	78	124
	TTS 224 dB	87	119	150	238
VHF cetacean	PTS 202 dB	972	1315	1660	2600
	TTS 196 dB	1880	2550	3200	5100
PCW pinniped	PTS 218 dB	168	228	288	457
	TTS 212 dB	324	440	554	880

Table C 21B-5: Summary of PTS and TTS impact distances based on impulsive SELss m-weighted thresholds given by Southall et al. (2019)

FHG	Impact [dB re 1 µPa² s M-weight]	0.1 kg (NEQ)	0.25 kg (NEQ)	0.5 kg (NEQ)	2.0 kg (NEQ)
LF cetacean	PTS 183 dB	133	209	293	579
	TTS 168 dB	1890	2950	4150	8200
HF cetacean	PTS 185 dB	< 10	< 10	< 10	< 10
	TTS 170 dB	1	3	4	8
VHF cetacean	PTS 155 dB	3	5	8	16
	TTS 140 dB	52	82	116	229
PCW pinniped	PTS 185 dB	22	34	48	95
	TTS 170 dB	312	490	689	1360

Table C 21B-6: Summary of the impact distances based on the unweighted SPLpeak explosive noise criteria given by Popper et al. (2014)

FHG	Impact [dB re 1 µPa peak]	0.1 kg (NEQ)	0.25 kg (NEQ)	0.5 kg (NEQ)	2.0 kg (NEQ)
All fish groups	Mortality and Potl Mortal Injury 234 dB	29	40	51	81
All fish groups	Mortality and Potl Mortal Injury 229 dB	51	69	87	138

Annex D. Summary of Fleeing Animal modelling at Site WTG

Piling noise

Table D 21B-1: Summary of minimum offset in metres from the WTG piling site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria

FHG PTS/TTS dB re 1 µPa^2.s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa^2.s] at 6000 sec
			Time (sec) to meet threshold	Distance Travelled (metres)	Time (sec) to meet threshold	Distance Travelled (metres)	
LF cetacean (183/168 dB)	Feb	1	<1	1	<1	1	228.0
		10	<1	10	<1	10	228.0
		50	<1	50	<1	50	214.6
		100	23	112	<1	100	191.2
		200	64	247	1	200	189.9
		500	211	695	6	500	188.3
		1000	631	1761	15	1001	186.9
		2000	1648	4286	39	2002	185.5
		4000	1450	5208	68	4003	185.3
		5000	3698	9866	85	5004	183.8
		5490	5954	14754	47	5491	183.0
		6000	6000	15048	159	6011	182.7
	Aug	1	<1	1	<1	1	228.0
		10	<1	10	<1	10	228.0
		50	<1	50	<1	50	214.6
		100	23	112	<1	100	191.2
		200	60	242	1	200	190.0
		500	243	748	4	500	188.3
		1000	297	1210	14	1001	187.6
		2000	1246	3495	43	2002	185.0
		3000	2504	6494	76	3005	183.8
		3290	4690	11278	24	3290	183.2

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance Travelled (metres)	Time (sec) to meet threshold	Distance Travelled (metres)	
		3300	6000	14189	24	3300	182.9
HF cetacean (185/170 dB)	Feb	1	<1	1	<1	1	203.9
		10	<1	10	<1	10	203.9
		50	<1	50	<1	50	191.7
		60	NR	9120	NR	9120	160.8
		100	NR	9121	NR	9121	159.3
	Aug	1	<1	1	<1	1	203.9
		10	<1	10	<1	10	203.9
		50	<1	50	<1	50	191.7
		60	NR	9120	NR	9120	161.3
		100	NR	9119	NR	9119	160.0
VHF cetacean (155/140 dB)	Feb	1	<1	1	<1	1	200.6
		10	<1	10	<1	10	200.5
		50	<1	50	<1	50	188.3
		80	NR	9000	3	80	155.0
		100	NR	9001	3	100	153.8
	Aug	1	<1	1	<1	1	200.6
		10	<1	10	<1	10	200.5
		50	<1	50	<1	50	188.3
		90	2411	3618	3	90	155.2
		100	NR	8999	3	100	154.5

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance Travelled (metres)	Time (sec) to meet threshold	Distance Travelled (metres)	
PCW pinniped (185/170 dB)	Feb	1	<1	1	<1	1	218.3
		10	<1	10	<1	10	218.3
		50	<1	50	<1	50	203.8
		60	NR	10800	9	62	180.6
		100	NR	10800	20	106	179.3
	Aug	1	<1	1	<1	1	218.3
		10	<1	10	<1	10	218.3
		50	<1	50	<1	50	203.8
		60	NR	10800	9	62	180.9
		100	NR	10800	20	106	179.6

Project support vessel (large) noise

Table D 21B-2: Summary of minimum offset in metres from the project support vessel (large) at the WTG site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	1	3	190.4
		10	NR	19500	1	11	190.4
		50	NR	19500	NR	19500	178.6
		100	NR	19500	NR	19500	163.9
		200	NR	19501	NR	19501	162.8
		500	NR	19506	NR	19506	161.5
		1000	NR	19526	NR	19526	160.7
	Aug	1	NR	19500	1	3	190.4
		10	NR	19500	1	11	190.4
		50	NR	19500	NR	19500	178.6
		100	NR	19500	NR	19500	162.6
		200	NR	19501	NR	19501	160.9
		500	NR	19506	NR	19506	158.7
		1000	NR	19526	NR	19526	157.2
HF cetacean (198/178dB)	Feb	1	NR	9000	26	39	179.1
		10	NR	9000	26	40	179.0
		50	NR	9000	NR	9000	167.0
		100	NR	9001	NR	9001	150.3

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
		200	NR	9002	NR	9002	148.4
		500	NR	9014	NR	9014	145.9
		1000	NR	9055	NR	9055	144.3
	Aug	1	NR	9000	26	39	179.1
		10	NR	9000	26	40	179.0
		50	NR	9000	NR	9000	167.0
		100	NR	9001	NR	9001	149.9
		200	NR	9002	NR	9002	147.7
		500	NR	9014	NR	9014	144.7
		1000	NR	9055	NR	9055	142.4
VHF cetacean (173/153dB)	Feb	1	12	18	0	1	177.1
		10	12	21	0	10	177.1
		50	NR	9180	0	50	165.0
		100	NR	9181	NR	9181	147.7
		200	NR	9182	NR	9182	145.5
		500	NR	9194	NR	9194	142.5
		1000	NR	9234	NR	9234	140.6
	Aug	1	12	18	0	1	177.1
		10	12	21	0	10	177.1
		50	NR	9180	0	50	165.0
		100	NR	9181	NR	9181	147.4
		200	NR	9182	NR	9182	145.0
		500	NR	9194	NR	9194	141.5
		1000	NR	9234	NR	9234	138.8

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	7	19	185.0
		10	NR	16680	7	22	185.0
		50	NR	16680	NR	16680	172.7
		100	NR	16680	NR	16680	158.0
		200	NR	16681	NR	16681	156.8
		500	NR	16687	NR	16687	155.3
		1000	NR	16710	NR	16710	154.6
	Aug	1	NR	16680	7	19	185.0
		10	NR	16680	7	22	185.0
		50	NR	16680	NR	16680	172.6
		100	NR	16680	NR	16680	156.9
		200	NR	16681	NR	16681	155.2
		500	NR	16687	NR	16687	153.0
		1000	NR	16710	NR	16710	151.5

Project support vessel (medium) noise

Table D 21B-3: Summary of minimum offset in metres from the project support vessel (medium) at the WTG site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	11	36	180.4
		10	NR	19500	11	37	180.4
		50	NR	19500	NR	19500	168.6
		100	NR	19500	NR	19500	153.9
		200	NR	19501	NR	19501	152.8
		500	NR	19506	NR	19506	151.5
		1000	NR	19526	NR	19526	150.7
	Aug	1	NR	19500	11	36	180.4
		10	NR	19500	11	37	180.4
		50	NR	19500	NR	19500	168.6
		100	NR	19500	NR	19500	152.6
		200	NR	19501	NR	19501	150.9
		500	NR	19506	NR	19506	148.7
		1000	NR	19526	NR	19526	147.2

FHG PTS/TTS dB re 1 μPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	NR	9000	169.1
		10	NR	9000	NR	9000	169.0
		50	NR	9000	NR	9000	157.0
		100	NR	9001	NR	9001	140.3
		200	NR	9002	NR	9002	138.4
		500	NR	9014	NR	9014	135.9
		1000	NR	9055	NR	9055	134.3
	Aug	1	NR	9000	NR	9000	169.1
		10	NR	9000	NR	9000	169.0
		50	NR	9000	NR	9000	157.0
		100	NR	9001	NR	9001	139.9
		200	NR	9002	NR	9002	137.7
		500	NR	9014	NR	9014	134.7
		1000	NR	9055	NR	9055	132.4
VHF cetacean (173/153dB)	Feb	1	NR	9180	1	2	167.1
		10	NR	9180	1	10	167.1
		50	NR	9180	1	50	155.0
		100	NR	9181	NR	9181	137.7
		200	NR	9182	NR	9182	135.5
		500	NR	9194	NR	9194	132.5
		1000	NR	9234	NR	9234	130.6
	Aug	1	NR	9180	1	2	167.1
		10	NR	9180	1	10	167.1
		50	NR	9180	1	50	155.0
		100	NR	9181	NR	9181	137.4
		200	NR	9182	NR	9182	135.0
		500	NR	9194	NR	9194	131.5
		1000	NR	9234	NR	9234	128.8

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	NR	16680	175.0
		10	NR	16680	NR	16680	175.0
		50	NR	16680	NR	16680	162.7
		100	NR	16680	NR	16680	148.0
		200	NR	16681	NR	16681	146.8
		500	NR	16687	NR	16687	145.3
		1000	NR	16710	NR	16710	144.6
	Aug	1	NR	16680	NR	16680	175.0
		10	NR	16680	NR	16680	175.0
		50	NR	16680	NR	16680	162.6
		100	NR	16680	NR	16680	146.9
		200	NR	16681	NR	16681	145.2
		500	NR	16687	NR	16687	143.0
		1000	NR	16710	NR	16710	141.5

Cable laying noise

Table D 21B-4: Summary of minimum offset in metres from the WTG cable-laying site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	9	29	0	1	201.3
		10	9	31	0	10	201.3
		50	NR	19500	0	50	189.5
		100	NR	19500	NR	19500	175.2
		200	NR	19501	NR	19501	173.4
		500	NR	19506	NR	19506	171.9
		1000	NR	19526	NR	19526	170.9
	Aug	1	9	29	0	1	201.3
		10	9	31	0	10	201.3
		50	NR	19500	0	50	189.5
		100	NR	19500	NR	19500	174.3
		200	NR	19501	NR	19501	172.0
		500	NR	19506	NR	19506	169.9
		1000	NR	19526	NR	19526	168.0

FHG PTS/TTS dB re 1 µPa²s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	5	8	186.1
		10	NR	9000	5	13	186.0
		50	NR	9000	NR	9000	174.0
		100	NR	9001	NR	9001	157.3
		200	NR	9002	NR	9002	155.3
		500	NR	9014	NR	9014	152.8
		1000	NR	9055	NR	9055	151.3
	Aug	1	NR	9000	5	8	186.1
		10	NR	9000	5	13	186.0
		50	NR	9000	NR	9000	174.0
		100	NR	9001	NR	9001	156.8
		200	NR	9002	NR	9002	154.7
		500	NR	9014	NR	9014	151.6
		1000	NR	9055	NR	9055	149.4
VHF cetacean (173/153dB)	Feb	1	2	3	0	1	184.1
		10	2	10	0	10	184.1
		50	NR	9180	0	50	172.0
		100	NR	9181	180	293	154.7
		200	NR	9182	NR	9182	152.5
		500	NR	9194	NR	9194	149.5
		1000	NR	9234	NR	9234	147.5
	Aug	1	2	3	0	1	184.1
		10	2	10	0	10	184.1
		50	NR	9180	0	50	172.0
		100	NR	9181	186	302	154.4
		200	NR	9182	NR	9182	152.0
		500	NR	9194	NR	9194	148.5
		1000	NR	9234	NR	9234	145.8

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	1	3	192.4
		10	NR	16680	1	10	192.4
		50	NR	16680	NR	16680	180.1
		100	NR	16680	NR	16680	165.6
		200	NR	16681	NR	16681	164.3
		500	NR	16687	NR	16687	162.8
		1000	NR	16710	NR	16710	162.0
	Aug	1	NR	16680	1	3	192.4
		10	NR	16680	1	10	192.4
		50	NR	16680	NR	16680	180.1
		100	NR	16680	NR	16680	164.5
		200	NR	16681	NR	16681	162.7
		500	NR	16687	NR	16687	160.5
		1000	NR	16710	NR	16710	158.9

Jet trenching noise

Table D 21B-5: Summary of minimum offset in metres from the WTG jet-trenching site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	0	1	191.4
		10	NR	19500	0	10	191.4
		50	NR	19500	0	50	179.6
		100	NR	19500	NR	19500	164.9
		200	NR	19501	NR	19501	163.8
		500	NR	19506	NR	19506	162.5
		1000	NR	19526	NR	19526	161.7
	Aug	1	NR	19500	0	1	191.4
		10	NR	19500	0	10	191.4
		50	NR	19500	0	50	179.6
		100	NR	19500	NR	19500	163.6
		200	NR	19501	NR	19501	161.9
		500	NR	19506	NR	19506	159.7
		1000	NR	19526	NR	19526	158.2

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	20	30	180.1
		10	NR	9000	20	32	180.0
		50	NR	9000	NR	9000	168.0
		100	NR	9001	NR	9001	151.3
		200	NR	9002	NR	9002	149.4
		500	NR	9014	NR	9014	146.9
		1000	NR	9055	NR	9055	145.3
	Aug	1	NR	9000	20	30	180.1
		10	NR	9000	20	32	180.0
		50	NR	9000	NR	9000	168.0
		100	NR	9001	NR	9001	150.9
		200	NR	9002	NR	9002	148.7
		500	NR	9014	NR	9014	145.7
		1000	NR	9055	NR	9055	143.4
VHF cetacean (173/153dB)	Feb	1	10	15	0	1	178.1
		10	10	18	0	10	178.1
		50	NR	9180	0	50	166.0
		100	NR	9181	NR	9181	148.7
		200	NR	9182	NR	9182	146.5
		500	NR	9194	NR	9194	143.5
		1000	NR	9234	NR	9234	141.6
	Aug	1	10	15	0	1	178.1
		10	10	18	0	10	178.1
		50	NR	9180	0	50	166.0
		100	NR	9181	NR	9181	148.4
		200	NR	9182	NR	9182	146.0
		500	NR	9194	NR	9194	142.5
		1000	NR	9234	NR	9234	139.8

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	5	14	186.0
		10	NR	16680	5	17	186.0
		50	NR	16680	NR	16680	173.7
		100	NR	16680	NR	16680	159.0
		200	NR	16681	NR	16681	157.8
		500	NR	16687	NR	16687	156.3
		1000	NR	16710	NR	16710	155.6
	Aug	1	NR	16680	5	14	186.0
		10	NR	16680	5	17	186.0
		50	NR	16680	NR	16680	173.6
		100	NR	16680	NR	16680	157.9
		200	NR	16681	NR	16681	156.2
		500	NR	16687	NR	16687	154.0
		1000	NR	16710	NR	16710	152.5

Backhoe dredging noise

Table D 21B-6: Summary of minimum offset in metres from the WTG backhoe dredging site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	NR	19500	173.6
		10	NR	19500	NR	19500	173.6
		50	NR	19500	NR	19500	161.8
		100	NR	19500	NR	19500	147.6
		200	NR	19501	NR	19501	146.3
		500	NR	19506	NR	19506	144.9
		1000	NR	19526	NR	19526	144.1
	Aug	1	NR	19500	NR	19500	173.6
		10	NR	19500	NR	19500	173.6
		50	NR	19500	NR	19500	161.8
		100	NR	19500	NR	19500	146.4
		200	NR	19501	NR	19501	144.5
		500	NR	19506	NR	19506	142.4
		1000	NR	19526	NR	19526	140.7

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	NR	9000	160.1
		10	NR	9000	NR	9000	159.9
		50	NR	9000	NR	9000	147.9
		100	NR	9001	NR	9001	131.2
		200	NR	9002	NR	9002	129.3
		500	NR	9014	NR	9014	126.8
		1000	NR	9055	NR	9055	125.2
	Aug	1	NR	9000	NR	9000	160.1
		10	NR	9000	NR	9000	159.9
		50	NR	9000	NR	9000	147.9
		100	NR	9001	NR	9001	130.8
		200	NR	9002	NR	9002	128.6
		500	NR	9014	NR	9014	125.6
		1000	NR	9055	NR	9055	123.3
VHF cetacean (173/153dB)	Feb	1	NR	9180	10	15	158.0
		10	NR	9180	10	18	158.0
		50	NR	9180	NR	9180	146.0
		100	NR	9181	NR	9181	128.6
		200	NR	9182	NR	9182	126.4
		500	NR	9194	NR	9194	123.4
		1000	NR	9234	NR	9234	121.5
	Aug	1	NR	9180	10	15	158.0
		10	NR	9180	10	18	158.0
		50	NR	9180	NR	9180	146.0
		100	NR	9181	NR	9181	128.3
		200	NR	9182	NR	9182	125.9
		500	NR	9194	NR	9194	122.4
		1000	NR	9234	NR	9234	119.7

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	NR	16680	166.2
		10	NR	16680	NR	16680	166.2
		50	NR	16680	NR	16680	153.9
		100	NR	16680	NR	16680	139.4
		200	NR	16681	NR	16681	138.1
		500	NR	16687	NR	16687	136.7
		1000	NR	16710	NR	16710	135.9
	Aug	1	NR	16680	NR	16680	166.2
		10	NR	16680	NR	16680	166.2
		50	NR	16680	NR	16680	153.9
		100	NR	16680	NR	16680	138.2
		200	NR	16681	NR	16681	136.5
		500	NR	16687	NR	16687	134.3
		1000	NR	16710	NR	16710	132.8

Suction dredging noise

Table D 21B-7: Summary of minimum offset in metres from the WTG suction dredging site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	0	1	194.6
		10	NR	19500	0	10	194.6
		50	NR	19500	0	50	182.8
		100	NR	19500	NR	19500	168.6
		200	NR	19501	NR	19501	167.3
		500	NR	19506	NR	19506	165.9
		1000	NR	19526	NR	19526	165.1
	Aug	1	NR	19500	0	1	194.6
		10	NR	19500	0	10	194.6
		50	NR	19500	0	50	182.8
		100	NR	19500	NR	19500	167.4
		200	NR	19501	NR	19501	165.5
		500	NR	19506	NR	19506	163.4
		1000	NR	19526	NR	19526	161.7

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	16	24	181.1
		10	NR	9000	16	26	180.9
		50	NR	9000	NR	9000	168.9
		100	NR	9001	NR	9001	152.2
		200	NR	9002	NR	9002	150.3
		500	NR	9014	NR	9014	147.8
		1000	NR	9055	NR	9055	146.2
	Aug	1	NR	9000	16	24	181.1
		10	NR	9000	16	26	180.9
		50	NR	9000	NR	9000	168.9
		100	NR	9001	NR	9001	151.8
		200	NR	9002	NR	9002	149.6
		500	NR	9014	NR	9014	146.6
		1000	NR	9055	NR	9055	144.3
VHF cetacean (173/153dB)	Feb	1	8	12	0	1	179.0
		10	8	16	0	10	179.0
		50	NR	9180	0	50	167.0
		100	NR	9181	NR	9181	149.6
		200	NR	9182	NR	9182	147.4
		500	NR	9194	NR	9194	144.4
		1000	NR	9234	NR	9234	142.5
	Aug	1	8	12	0	1	179.0
		10	8	16	0	10	179.0
		50	NR	9180	0	50	167.0
		100	NR	9181	NR	9181	149.3
		200	NR	9182	NR	9182	146.9
		500	NR	9194	NR	9194	143.4
		1000	NR	9234	NR	9234	140.7

FHG PTS/TTS dB re 1 µPa^2.s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa^2.s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	4	11	187.2
		10	NR	16680	4	15	187.2
		50	NR	16680	NR	16680	174.9
		100	NR	16680	NR	16680	160.4
		200	NR	16681	NR	16681	159.1
		500	NR	16687	NR	16687	157.7
		1000	NR	16710	NR	16710	156.9
	Aug	1	NR	16680	4	11	187.2
		10	NR	16680	4	15	187.2
		50	NR	16680	NR	16680	174.9
		100	NR	16680	NR	16680	159.2
		200	NR	16681	NR	16681	157.5
		500	NR	16687	NR	16687	155.3
		1000	NR	16710	NR	16710	153.8

Rock emplacement noise

Table D 21B-8: Summary of minimum offset in metres from the WTG rock emplacement site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa^2.s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa^2.s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	7	23	182.4
		10	NR	19500	7	25	182.4
		50	NR	19500	NR	19500	170.6
		100	NR	19500	NR	19500	155.9
		200	NR	19501	NR	19501	154.8
		500	NR	19506	NR	19506	153.5
		1000	NR	19526	NR	19526	152.7
	Aug	1	NR	19500	7	23	182.4
		10	NR	19500	7	25	182.4
		50	NR	19500	NR	19500	170.6
		100	NR	19500	NR	19500	154.6
		200	NR	19501	NR	19501	152.9
		500	NR	19506	NR	19506	150.7
		1000	NR	19526	NR	19526	149.2

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	NR	9000	171.1
		10	NR	9000	NR	9000	171.0
		50	NR	9000	NR	9000	159.0
		100	NR	9001	NR	9001	142.3
		200	NR	9002	NR	9002	140.4
		500	NR	9014	NR	9014	137.9
		1000	NR	9055	NR	9055	136.3
	Aug	1	NR	9000	NR	9000	171.1
		10	NR	9000	NR	9000	171.0
		50	NR	9000	NR	9000	159.0
		100	NR	9001	NR	9001	141.9
		200	NR	9002	NR	9002	139.7
		500	NR	9014	NR	9014	136.7
		1000	NR	9055	NR	9055	134.4
VHF cetacean (173/153dB)	Feb	1	NR	9180	0	1	169.1
		10	NR	9180	0	10	169.1
		50	NR	9180	0	50	157.0
		100	NR	9181	NR	9181	139.7
		200	NR	9182	NR	9182	137.5
		500	NR	9194	NR	9194	134.5
		1000	NR	9234	NR	9234	132.6
	Aug	1	NR	9180	0	1	169.1
		10	NR	9180	0	10	169.1
		50	NR	9180	0	50	157.0
		100	NR	9181	NR	9181	139.4
		200	NR	9182	NR	9182	137.0
		500	NR	9194	NR	9194	133.5
		1000	NR	9234	NR	9234	130.8

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	NR	16680	177.0
		10	NR	16680	NR	16680	177.0
		50	NR	16680	NR	16680	164.7
		100	NR	16680	NR	16680	150.0
		200	NR	16681	NR	16681	148.8
		500	NR	16687	NR	16687	147.3
		1000	NR	16710	NR	16710	146.6
	Aug	1	NR	16680	NR	16680	177.0
		10	NR	16680	NR	16680	177.0
		50	NR	16680	NR	16680	164.6
		100	NR	16680	NR	16680	148.9
		200	NR	16681	NR	16681	147.2
		500	NR	16687	NR	16687	145.0
		1000	NR	16710	NR	16710	143.5

Drilling noise

Table D 21B-9: Summary of minimum offset in metres from the WTG drilling site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance Travelled (metres)	Time (sec) to meet threshold	Distance Travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	10	33	180.8
		10	NR	19500	10	34	180.8
		50	NR	19500	NR	19500	168.9
		100	NR	19500	NR	19500	152.7
		200	NR	19501	NR	19501	151.0
		500	NR	19506	NR	19506	148.7
		1000	NR	19526	NR	19526	147.0
	Aug	1	NR	19500	10	33	180.8
		10	NR	19500	10	34	180.8
		50	NR	19500	NR	19500	169.0
		100	NR	19500	NR	19500	154.9
		200	NR	19501	NR	19501	154.0
		500	NR	19506	NR	19506	153.1
		1000	NR	19526	NR	19526	152.3

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance Travelled (metres)	Time (sec) to meet threshold	Distance Travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	NR	9000	177.2
		10	NR	9000	NR	9000	177.0
		50	NR	9000	NR	9000	165.0
		100	NR	9001	NR	9001	148.1
		200	NR	9002	NR	9002	145.9
		500	NR	9014	NR	9014	142.7
		1000	NR	9055	NR	9055	139.9
	Aug	1	NR	9000	NR	9000	177.2
		10	NR	9000	NR	9000	177.0
		50	NR	9000	NR	9000	165.1
		100	NR	9001	NR	9001	150.1
		200	NR	9002	NR	9002	148.8
		500	NR	9014	NR	9014	147.6
		1000	NR	9055	NR	9055	146.4
VHF cetacean (173/153dB)	Feb	1	22	34	0	1	174.7
		10	22	35	0	10	174.7
		50	NR	9180	0	50	162.6
		100	NR	9181	NR	9181	145.5
		200	NR	9182	NR	9182	143.1
		500	NR	9194	NR	9194	139.7
		1000	NR	9234	NR	9234	136.7
	Aug	1	22	34	0	1	174.7
		10	22	35	0	10	174.7
		50	NR	9180	0	50	162.7
		100	NR	9181	NR	9181	147.3
		200	NR	9182	NR	9182	145.9
		500	NR	9194	NR	9194	144.5
		1000	NR	9234	NR	9234	143.2

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance Travelled (metres)	Time (sec) to meet threshold	Distance Travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	NR	16680	178.9
		10	NR	16680	NR	16680	178.9
		50	NR	16680	NR	16680	166.6
		100	NR	16680	NR	16680	150.6
		200	NR	16681	NR	16681	148.6
		500	NR	16687	NR	16687	146.0
		1000	NR	16710	NR	16710	143.8
	Aug	1	NR	16680	NR	16680	178.9
		10	NR	16680	NR	16680	178.9
		50	NR	16680	NR	16680	166.6
		100	NR	16680	NR	16680	152.8
		200	NR	16681	NR	16681	151.7
		500	NR	16687	NR	16687	150.8
		1000	NR	16710	NR	16710	149.8

Operational noise

Table D 21B-10: Summary of minimum offset in metres from the WTG operational site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	NR	19500	175.0
		10	NR	19500	NR	19500	175.0
		50	NR	19500	NR	19500	163.1
		100	NR	19500	NR	19500	148.4
		200	NR	19501	NR	19501	147.0
		500	NR	19506	NR	19506	145.3
		1000	NR	19526	NR	19526	144.1
	Aug	1	NR	19500	NR	19500	175.0
		10	NR	19500	NR	19500	175.0
		50	NR	19500	NR	19500	163.1
		100	NR	19500	NR	19500	148.4
		200	NR	19501	NR	19501	147.0
		500	NR	19506	NR	19506	145.5
		1000	NR	19526	NR	19526	144.8

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	NR	9000	164.0
		10	NR	9000	NR	9000	163.9
		50	NR	9000	NR	9000	151.8
		100	NR	9001	NR	9001	134.5
		200	NR	9002	NR	9002	132.2
		500	NR	9014	NR	9014	129.2
		1000	NR	9055	NR	9055	126.9
	Aug	1	NR	9000	NR	9000	164.0
		10	NR	9000	NR	9000	163.9
		50	NR	9000	NR	9000	151.8
		100	NR	9001	NR	9001	134.9
		200	NR	9002	NR	9002	133.0
		500	NR	9014	NR	9014	130.7
		1000	NR	9055	NR	9055	130.3
VHF cetacean (173/153dB)	Feb	1	NR	9180	3	5	162.3
		10	NR	9180	3	11	162.3
		50	NR	9180	NR	9180	150.2
		100	NR	9181	NR	9181	132.2
		200	NR	9182	NR	9182	129.6
		500	NR	9194	NR	9194	125.9
		1000	NR	9234	NR	9234	123.0
	Aug	1	NR	9180	3	5	162.3
		10	NR	9180	3	11	162.3
		50	NR	9180	NR	9180	150.2
		100	NR	9181	NR	9181	132.5
		200	NR	9182	NR	9182	130.2
		500	NR	9194	NR	9194	127.4
		1000	NR	9234	NR	9234	126.7

FHG PTS/TTS dB re 1 μPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	NR	16680	169.3
		10	NR	16680	NR	16680	169.3
		50	NR	16680	NR	16680	156.9
		100	NR	16680	NR	16680	141.6
		200	NR	16681	NR	16681	140.1
		500	NR	16687	NR	16687	138.4
		1000	NR	16710	NR	16710	137.1
	Aug	1	NR	16680	NR	16680	169.3
		10	NR	16680	NR	16680	169.3
		50	NR	16680	NR	16680	156.9
		100	NR	16680	NR	16680	142.0
		200	NR	16681	NR	16681	140.6
		500	NR	16687	NR	16687	139.2
		1000	NR	16710	NR	16710	139.1

Annex E. Summary of Fleeing Animal modelling at Site CR

Project Support vessel (large) noise

Table E 21B-1: Summary of minimum offset in metres from the project support vessel (large) at the cable route site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 μPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	1	3	190.5
		10	NR	19500	1	11	190.5
		50	NR	19500	NR	19500	178.7
		100	NR	19500	NR	19500	165.7
		200	NR	19501	NR	19501	164.2
		500	NR	19506	NR	19506	162.5
		1000	NR	19526	NR	19526	161.6
	Aug	1	NR	19500	1	3	190.4
		10	NR	19500	1	11	190.4
		50	NR	19500	NR	19500	178.6
		100	NR	19500	NR	19500	164.9
		200	NR	19501	NR	19501	163.0
		500	NR	19506	NR	19506	160.7
		1000	NR	19526	NR	19526	159.0
HF cetacean (198/178dB)	Feb	1	NR	9000	26	39	179.1
		10	NR	9000	26	40	179.0
		50	NR	9000	NR	9000	167.0
		100	NR	9001	NR	9001	151.9
		200	NR	9002	NR	9002	149.8
		500	NR	9014	NR	9014	147.5
		1000	NR	9055	NR	9055	146.3
	Aug	1	NR	9000	26	39	179.1
		10	NR	9000	26	40	179.0
		50	NR	9000	NR	9000	167.0
		100	NR	9001	NR	9001	151.4
		200	NR	9002	NR	9002	149.1
		500	NR	9014	NR	9014	146.2
		1000	NR	9055	NR	9055	144.0
VHF cetacean (173/153dB)	Feb	1	12	18	0	1	177.1
		10	12	21	0	10	177.1
		50	NR	9180	0	50	165.1
		100	NR	9181	NR	9181	149.3
		200	NR	9182	NR	9182	146.9
		500	NR	9194	NR	9194	144.2
		1000	NR	9234	NR	9234	142.6
	Aug	1	12	18	0	1	177.1
		10	12	21	0	10	177.1
		50	NR	9180	0	50	165.1

FHG PTS/TTS dB re 1 μPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
		100	NR	9181	NR	9181	148.9
		200	NR	9182	NR	9182	146.3
		500	NR	9194	NR	9194	143.0
		1000	NR	9234	NR	9234	140.5

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	7	19	185.0
		10	NR	16680	7	22	185.0
		50	NR	16680	NR	16680	172.7
		100	NR	16680	NR	16680	159.5
		200	NR	16681	NR	16681	158.1
		500	NR	16687	NR	16687	156.6
		1000	NR	16710	NR	16710	156.0
	Aug	1	NR	16680	7	19	185.0
		10	NR	16680	7	22	185.0
		50	NR	16680	NR	16680	172.7
		100	NR	16680	NR	16680	158.4
		200	NR	16681	NR	16681	156.6
		500	NR	16687	NR	16687	154.3
		1000	NR	16710	NR	16710	152.7

Project support vessel (medium) noise

Table E 21B-2: Summary of minimum offset in metres from the project support vessel (medium) at the cable route site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	11	36	180.5
		10	NR	19500	11	37	180.5
		50	NR	19500	NR	19500	168.7
		100	NR	19500	NR	19500	155.7
		200	NR	19501	NR	19501	154.2
		500	NR	19506	NR	19506	152.5
		1000	NR	19526	NR	19526	151.6
	Aug	1	NR	19500	11	36	180.4
		10	NR	19500	11	37	180.4
		50	NR	19500	NR	19500	168.6
		100	NR	19500	NR	19500	154.9
		200	NR	19501	NR	19501	153.0
		500	NR	19506	NR	19506	150.7
		1000	NR	19526	NR	19526	149.0
HF cetacean (198/178dB)	Feb	1	NR	9000	NR	9000	169.1
		10	NR	9000	NR	9000	169.0
		50	NR	9000	NR	9000	157.0
		100	NR	9001	NR	9001	141.9
		200	NR	9002	NR	9002	139.8
		500	NR	9014	NR	9014	137.5
		1000	NR	9055	NR	9055	136.3

FHG PTS/TTS dB re 1 μPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
	Aug	1	NR	9000	NR	9000	169.1
		10	NR	9000	NR	9000	169.0
		50	NR	9000	NR	9000	157.0
		100	NR	9001	NR	9001	141.4
		200	NR	9002	NR	9002	139.1
		500	NR	9014	NR	9014	136.2
		1000	NR	9055	NR	9055	134.0
VHF cetacean (173/153dB)	Feb	1	NR	9180	1	2	167.1
		10	NR	9180	1	10	167.1
		50	NR	9180	1	50	155.1
		100	NR	9181	NR	9181	139.3
		200	NR	9182	NR	9182	136.9
		500	NR	9194	NR	9194	134.2
		1000	NR	9234	NR	9234	132.6
	Aug	1	NR	9180	1	2	167.1
		10	NR	9180	1	10	167.1
		50	NR	9180	1	50	155.1
		100	NR	9181	NR	9181	138.9
		200	NR	9182	NR	9182	136.3
		500	NR	9194	NR	9194	133.0
		1000	NR	9234	NR	9234	130.5

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_cum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	NR	16680	175.0
		10	NR	16680	NR	16680	175.0
		50	NR	16680	NR	16680	162.7
		100	NR	16680	NR	16680	149.5
		200	NR	16681	NR	16681	148.1
		500	NR	16687	NR	16687	146.6
		1000	NR	16710	NR	16710	146.0
	Aug	1	NR	16680	NR	16680	175.0
		10	NR	16680	NR	16680	175.0
		50	NR	16680	NR	16680	162.7
		100	NR	16680	NR	16680	148.4
		200	NR	16681	NR	16681	146.6
		500	NR	16687	NR	16687	144.3
		1000	NR	16710	NR	16710	142.7

Cable-laying noise

Table E 21B-3: Summary of minimum offset in metres from the cable route cable-laying site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_cum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	9	29	0	1	201.3
		10	9	31	0	10	201.3
		50	NR	19500	0	50	189.6
		100	NR	19500	NR	19500	176.8
		200	NR	19501	NR	19501	174.9
		500	NR	19506	NR	19506	173.1
		1000	NR	19526	NR	19526	171.4
	Aug	1	9	29	0	1	201.3
		10	9	31	0	10	201.3
		50	NR	19500	0	50	189.6
		100	NR	19500	NR	19500	176.4
		200	NR	19501	NR	19501	174.2
		500	NR	19506	NR	19506	172.3
		1000	NR	19526	NR	19526	170.1
HF cetacean (198/178dB)	Feb	1	NR	9000	5	8	186.1
		10	NR	9000	5	13	186.0
		50	NR	9000	NR	9000	174.0

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
		100	NR	9001	NR	9001	158.8
		200	NR	9002	NR	9002	156.8
		500	NR	9014	NR	9014	154.5
		1000	NR	9055	NR	9055	153.2
	Aug	1	NR	9000	5	8	186.1
		10	NR	9000	5	13	186.0
		50	NR	9000	NR	9000	174.0
		100	NR	9001	NR	9001	158.4
		200	NR	9002	NR	9002	156.0
		500	NR	9014	NR	9014	153.1
		1000	NR	9055	NR	9055	150.9
VHF cetacean (173/153dB)	Feb	1	2	3	0	1	184.1
		10	2	10	0	10	184.1
		50	NR	9180	0	50	172.1
		100	NR	9181	77	155	156.3
		200	NR	9182	922	1425	153.9
		500	NR	9194	NR	9194	151.2
		1000	NR	9234	NR	9234	149.6
	Aug	1	2	3	0	1	184.1
		10	2	10	0	10	184.1
		50	NR	9180	0	50	172.1
		100	NR	9181	79	157	155.9
		200	NR	9182	1179	1815	153.3
		500	NR	9194	NR	9194	150.0
		1000	NR	9234	NR	9234	147.4

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	1	3	192.5
		10	NR	16680	1	10	192.5
		50	NR	16680	NR	16680	180.2
		100	NR	16680	NR	16680	167.0
		200	NR	16681	NR	16681	165.6
		500	NR	16687	NR	16687	164.0
		1000	NR	16710	NR	16710	163.3
	Aug	1	NR	16680	1	3	192.4
		10	NR	16680	1	10	192.4
		50	NR	16680	NR	16680	180.1
		100	NR	16680	NR	16680	166.1
		200	NR	16681	NR	16681	164.2
		500	NR	16687	NR	16687	161.9
		1000	NR	16710	NR	16710	160.3

Jet trenching noise

Table E 21B-4: Summary of minimum offset in metres from the cable route jet-trenching site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	0	1	191.5
		10	NR	19500	0	10	191.5
		50	NR	19500	0	50	179.7
		100	NR	19500	NR	19500	166.7
		200	NR	19501	NR	19501	165.2
		500	NR	19506	NR	19506	163.5
		1000	NR	19526	NR	19526	162.6
	Aug	1	NR	19500	0	1	191.4
		10	NR	19500	0	10	191.4
		50	NR	19500	0	50	179.6
		100	NR	19500	NR	19500	165.9
		200	NR	19501	NR	19501	164.0
		500	NR	19506	NR	19506	161.7
		1000	NR	19526	NR	19526	160.0

FHG PTS/TTS dB re 1 μPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	20	30	180.1
		10	NR	9000	20	32	180.0
		50	NR	9000	NR	9000	168.0
		100	NR	9001	NR	9001	152.9
		200	NR	9002	NR	9002	150.8
		500	NR	9014	NR	9014	148.5
		1000	NR	9055	NR	9055	147.3
	Aug	1	NR	9000	20	30	180.1
		10	NR	9000	20	32	180.0
		50	NR	9000	NR	9000	168.0
		100	NR	9001	NR	9001	152.4
		200	NR	9002	NR	9002	150.1
		500	NR	9014	NR	9014	147.2
		1000	NR	9055	NR	9055	145.0
VHF cetacean (173/153dB)	Feb	1	10	15	0	1	178.1
		10	10	18	0	10	178.1
		50	NR	9180	0	50	166.1
		100	NR	9181	NR	9181	150.3
		200	NR	9182	NR	9182	147.9
		500	NR	9194	NR	9194	145.2
		1000	NR	9234	NR	9234	143.6
	Aug	1	10	15	0	1	178.1
		10	10	18	0	10	178.1
		50	NR	9180	0	50	166.1
		100	NR	9181	NR	9181	149.9
		200	NR	9182	NR	9182	147.3
		500	NR	9194	NR	9194	144.0
		1000	NR	9234	NR	9234	141.5

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	5	14	186.0
		10	NR	16680	5	17	186.0
		50	NR	16680	NR	16680	173.7
		100	NR	16680	NR	16680	160.5
		200	NR	16681	NR	16681	159.1
		500	NR	16687	NR	16687	157.6
		1000	NR	16710	NR	16710	157.0
	Aug	1	NR	16680	5	14	186.0
		10	NR	16680	5	17	186.0
		50	NR	16680	NR	16680	173.7
		100	NR	16680	NR	16680	159.4
		200	NR	16681	NR	16681	157.6
		500	NR	16687	NR	16687	155.3
		1000	NR	16710	NR	16710	153.7

Backhoe dredging noise

Table E 21B-5: Summary of minimum offset in metres from the cable route backhoe dredging site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	NR	19500	173.6
		10	NR	19500	NR	19500	173.6
		50	NR	19500	NR	19500	161.9
		100	NR	19500	NR	19500	149.5
		200	NR	19501	NR	19501	147.7
		500	NR	19506	NR	19506	145.9
		1000	NR	19526	NR	19526	144.6
	Aug	1	NR	19500	NR	19500	173.6
		10	NR	19500	NR	19500	173.6
		50	NR	19500	NR	19500	161.9
		100	NR	19500	NR	19500	149.0
		200	NR	19501	NR	19501	146.9
		500	NR	19506	NR	19506	144.8
		1000	NR	19526	NR	19526	142.9

FHG PTS/TTS dB re 1 µPa^2.s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 mPa^2.s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	NR	9000	160.1
		10	NR	9000	NR	9000	159.9
		50	NR	9000	NR	9000	147.9
		100	NR	9001	NR	9001	132.8
		200	NR	9002	NR	9002	130.7
		500	NR	9014	NR	9014	128.4
		1000	NR	9055	NR	9055	127.1
	Aug	1	NR	9000	NR	9000	160.1
		10	NR	9000	NR	9000	159.9
		50	NR	9000	NR	9000	147.9
		100	NR	9001	NR	9001	132.3
		200	NR	9002	NR	9002	130.0
		500	NR	9014	NR	9014	127.1
		1000	NR	9055	NR	9055	124.8
VHF cetacean (173/153dB)	Feb	1	NR	9180	10	15	158.0
		10	NR	9180	10	18	158.0
		50	NR	9180	NR	9180	146.0
		100	NR	9181	NR	9181	130.2
		200	NR	9182	NR	9182	127.8
		500	NR	9194	NR	9194	125.1
		1000	NR	9234	NR	9234	123.5
	Aug	1	NR	9180	10	15	158.0
		10	NR	9180	10	18	158.0
		50	NR	9180	NR	9180	146.0
		100	NR	9181	NR	9181	129.9
		200	NR	9182	NR	9182	127.2
		500	NR	9194	NR	9194	123.9
		1000	NR	9234	NR	9234	121.3

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	NR	16680	166.2
		10	NR	16680	NR	16680	166.2
		50	NR	16680	NR	16680	154.0
		100	NR	16680	NR	16680	140.8
		200	NR	16681	NR	16681	139.4
		500	NR	16687	NR	16687	137.9
		1000	NR	16710	NR	16710	137.2
	Aug	1	NR	16680	NR	16680	166.2
		10	NR	16680	NR	16680	166.2
		50	NR	16680	NR	16680	153.9
		100	NR	16680	NR	16680	139.8
		200	NR	16681	NR	16681	138.0
		500	NR	16687	NR	16687	135.7
		1000	NR	16710	NR	16710	134.1

Suction Dredging noise

Table E 21B-6: Summary of minimum offset in metres from the cable route suction dredging site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	0	1	194.6
		10	NR	19500	0	10	194.6
		50	NR	19500	0	50	182.9
		100	NR	19500	NR	19500	170.5
		200	NR	19501	NR	19501	168.7
		500	NR	19506	NR	19506	166.9
		1000	NR	19526	NR	19526	165.6
	Aug	1	NR	19500	0	1	194.6
		10	NR	19500	0	10	194.6
		50	NR	19500	0	50	182.9
		100	NR	19500	NR	19500	170.0
		200	NR	19501	NR	19501	167.9
		500	NR	19506	NR	19506	165.8
		1000	NR	19526	NR	19526	163.9

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL$_{cum}$ [dB re 1 mPa^2.s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	16	24	181.1
		10	NR	9000	16	26	180.9
		50	NR	9000	NR	9000	168.9
		100	NR	9001	NR	9001	153.8
		200	NR	9002	NR	9002	151.7
		500	NR	9014	NR	9014	149.4
		1000	NR	9055	NR	9055	148.1
	Aug	1	NR	9000	16	24	181.1
		10	NR	9000	16	26	180.9
		50	NR	9000	NR	9000	168.9
		100	NR	9001	NR	9001	153.3
		200	NR	9002	NR	9002	151.0
		500	NR	9014	NR	9014	148.1
		1000	NR	9055	NR	9055	145.8
VHF cetacean (173/153dB)	Feb	1	8	12	0	1	179.0
		10	8	16	0	10	179.0
		50	NR	9180	0	50	167.0
		100	NR	9181	NR	9181	151.2
		200	NR	9182	NR	9182	148.8
		500	NR	9194	NR	9194	146.1
		1000	NR	9234	NR	9234	144.5
	Aug	1	8	12	0	1	179.0
		10	8	16	0	10	179.0
		50	NR	9180	0	50	167.0
		100	NR	9181	NR	9181	150.9
		200	NR	9182	NR	9182	148.2
		500	NR	9194	NR	9194	144.9
		1000	NR	9234	NR	9234	142.3

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 mPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	4	11	187.2
		10	NR	16680	4	15	187.2
		50	NR	16680	NR	16680	175.0
		100	NR	16680	NR	16680	161.8
		200	NR	16681	NR	16681	160.4
		500	NR	16687	NR	16687	158.9
		1000	NR	16710	NR	16710	158.2
	Aug	1	NR	16680	4	11	187.2
		10	NR	16680	4	15	187.2
		50	NR	16680	NR	16680	174.9
		100	NR	16680	NR	16680	160.8
		200	NR	16681	NR	16681	159.0
		500	NR	16687	NR	16687	156.7
		1000	NR	16710	NR	16710	155.1

Rock placement noise

Table E 21B-7: Summary of minimum offset in metres from the cable route rock placement site that a marine mammal FHG must be in order to avoid meeting the PTS and TTS impact criteria (NR – threshold not reached)

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 µPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
LF cetacean (199/179dB)	Feb	1	NR	19500	7	23	182.5
		10	NR	19500	7	25	182.5
		50	NR	19500	NR	19500	170.7
		100	NR	19500	NR	19500	157.7
		200	NR	19501	NR	19501	156.2
		500	NR	19506	NR	19506	154.5
		1000	NR	19526	NR	19526	153.6
	Aug	1	NR	19500	7	23	182.4
		10	NR	19500	7	25	182.4
		50	NR	19500	NR	19500	170.6
		100	NR	19500	NR	19500	156.9
		200	NR	19501	NR	19501	155.0
		500	NR	19506	NR	19506	152.7
		1000	NR	19526	NR	19526	151.0

FHG PTS/TTS dB re 1 µPa².s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SELcum [dB re 1 µPa².s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
HF cetacean (198/178dB)	Feb	1	NR	9000	NR	9000	171.1
		10	NR	9000	NR	9000	171.0
		50	NR	9000	NR	9000	159.0
		100	NR	9001	NR	9001	143.9
		200	NR	9002	NR	9002	141.8
		500	NR	9014	NR	9014	139.5
		1000	NR	9055	NR	9055	138.3
	Aug	1	NR	9000	NR	9000	171.1
		10	NR	9000	NR	9000	171.0
		50	NR	9000	NR	9000	159.0
		100	NR	9001	NR	9001	143.4
		200	NR	9002	NR	9002	141.1
		500	NR	9014	NR	9014	138.2
		1000	NR	9055	NR	9055	136.0
VHF cetacean (173/153dB)	Feb	1	NR	9180	0	1	169.1
		10	NR	9180	0	10	169.1
		50	NR	9180	0	50	157.1
		100	NR	9181	NR	9181	141.3
		200	NR	9182	NR	9182	138.9
		500	NR	9194	NR	9194	136.2
		1000	NR	9234	NR	9234	134.6
	Aug	1	NR	9180	0	1	169.1
		10	NR	9180	0	10	169.1
		50	NR	9180	0	50	157.1
		100	NR	9181	NR	9181	140.9
		200	NR	9182	NR	9182	138.3
		500	NR	9194	NR	9194	135.0
		1000	NR	9234	NR	9234	132.5

FHG PTS/TTS dB re 1 µPa^2.s	Month	Initial Offset (metres)	PTS		TTS		M-weighted SEL_{cum} [dB re 1 µPa^2.s] at 6000 sec
			Time (sec) to meet threshold	Distance travelled (metres)	Time (sec) to meet threshold	Distance travelled (metres)	
PCW pinniped (201/181dB)	Feb	1	NR	16680	NR	16680	177.0
		10	NR	16680	NR	16680	177.0
		50	NR	16680	NR	16680	164.7
		100	NR	16680	NR	16680	151.5
		200	NR	16681	NR	16681	150.1
		500	NR	16687	NR	16687	148.6
		1000	NR	16710	NR	16710	148.0
	Aug	1	NR	16680	NR	16680	177.0
		10	NR	16680	NR	16680	177.0
		50	NR	16680	NR	16680	164.7
		100	NR	16680	NR	16680	150.4
		200	NR	16681	NR	16681	148.6
		500	NR	16687	NR	16687	146.3
		1000	NR	16710	NR	16710	144.7

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