Addendum to the
Natura Impact Statement

NISA
North Irish Sea Array

Volume 2: Appendices

Appendix A13
North Irish Sea Array: Underwater Noise Assessment

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Appendix A13: North Irish Sea Array: Underwater noise assessment

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Units

Unit	**Definition**
dB	Decibel (sound pressure)
Hz	Hertz (frequency)
kg	Kilogram (mass)
kJ	Kilojoule (energy)
kHz	Kilohertz (frequency)
km	Kilometre (distance)
km^2	Square kilometres (area)
m	Metre (distance)
mms^{-1}	Millimetres per second (particle velocity)
ms^{-1}	Metres per second (speed)
MW	Megawatt (power)
Pa	Pascal (pressure)
Pa^2s	Pascal squared seconds (acoustic energy)
μPa	Micropascal (pressure)

Glossary

Term	Definition
Decibel (dB)	A customary scale commonly used (in various ways) for reporting levels of sound. A difference of 10 dB corresponds to a factor of 10 in sound power. The actual sound measurement is compared to a fixed reference level and the "decibel" value is defined to be *10* log_{10}*(actual/reference)* where *(actual/reference)* is a power ratio. Because sound power is usually proportional to sound pressure squared, the decibel value for sound pressure is *20* log_{10}*(actual pressure/reference pressure)*. The standard reference for underwater sound is 1 micro pascal (µPa). The dB symbol is followed by a second symbol identifying the specific reference value (e.g., re 1 µPa).
Peak pressure	The highest pressure above or below ambient that is associated with a sound wave.
Peak-to-peak pressure	The sum of the highest positive and negative pressures that are associated with a sound wave.
Permanent Threshold Shift (PTS)	A permanent total or partial loss of hearing caused by acoustic trauma. PTS results in irreversible damage to the sensory hair cells of the air, and thus a permanent reduction of hearing acuity.
Root Mean Square (RMS)	The square root of the arithmetic average of a set of squared instantaneous values. Used for presentation of an average sound pressure level.
Sound Exposure Level (SEL)	The constant sound level acting for one second, which has the same amount of acoustic energy, as indicated by the square of the sound pressure, as the original sound. It is the time-integrated, sound-pressure-squared level. SEL is typically used to compare transient sound events having different time durations, pressure levels, and temporal characteristics.
Sound Exposure Level, cumulative (SEL_{cum})	Single value for the collected, combined total of sound exposure over a specified time or multiple instances of a noise source.
Sound Exposure Level, single strike (SEL_{ss})	Calculation of the sound exposure level representative of a single noise impulse, typically a pile strike.
Sound Pressure Level (SPL)	The sound pressure level is an expression of sound pressure using the decibel (dB) scale; the standard frequency pressures of which are 1 µPa for water and 20 µPa for air.
Sound Pressure Level Peak (SPL_{peak})	The highest (zero-peak) positive or negative sound pressure, in decibels.
Temporary Threshold Shift (TTS)	Temporary reduction of hearing acuity because of exposure to sound over time. Exposure to high levels of sound over relatively short time periods could cause the same level of TTS as exposure to lower levels of sound over longer time periods. The mechanisms underlying TTS are not well understood, but there may be some temporary damage to the sensory cells. The duration of TTS varies depending on the nature of the stimulus.
Unweighted sound level	Sound levels which are "raw" or have not been adjusted in any way, for example to account for the hearing ability of a species.
Weighted sound level	A sound level which has been adjusted with respect to a "weighting envelope" in the frequency domain, typically to make an unweighted level relevant to a particular species. Examples of this are the dB(A), where the overall sound level has been adjusted to account for the hearing ability of humans in air, or the filters used by Southall *et al*. (2019) for marine mammals.

Acronyms

Acronym	Definition
ADD	Acoustic Deterrent Device
BGS	British Geological Survey
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data Network
FPSO	Floating Production Storage and Offloading
GIS	Geographic Information System
HE	High Explosive
HF	High-Frequency Cetaceans (from Southall *et al*., 2019)
IB	Infrastructure Boundary
LF	Low-Frequency Cetaceans (from Southall *et al*., 2019)
MTD	Marine Technology Directorate
NISA	North Irish Sea Array
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
NPL	National Physical Laboratory
OWF	Offshore Wind Farm
PCW	Phocid Carnivores in Water (from Southall *et al*., 2019)
PPV	Peak Particle Velocity
PTS	Permanent Threshold Shift
RLB	Red Line Boundary
RMS	Root Mean Square
SBJ	Suction Bucket Jacket
SE	Sound Exposure
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SEL_{ss}	Single Strike Sound Exposure Level
SPL	Sound Pressure Level
SPL_{peak}	Peak Sound Pressure Level
$SPL_{peak\text{-}to\text{-}peak}$	Peak-to-peak Sound Pressure Level
SPL_{RMS}	Root Mean Square Sound Pressure Level
TNT	Trinitrotoluene (explosive)
TTS	Temporary Threshold Shift
UXO	Unexploded Ordnance
VHF	Very High-Frequency Cetaceans (from Southall *et al*., 2019)
WTG	Wind Turbine Generator

North Irish Sea Array Windfarm Ltd (NISA, hereafter referred to as 'the Developer') has been considering the Request for Further Information (RFI) issued by An Bord Pleanála (now An Coimisiún Pleanála) as well as the third-party submissions received following public consultation. At An Coimisiún Pleanála's behest, the Developer has also continued to consult with stakeholders in respect of the 2024 planning application throughout 2024-2026. The Developer has refined elements of the design to respond to the third-party submissions, the continued public and stakeholder consultation and the RFI. Amendments are therefore required to Appendix 6: Underwater Noise Modelling Report of the 2024 Natura Impact Statement (NIS). Full details of consultation undertaken can be found in Appendix A2: Consultation Report of the SISAA.

For the purposes of clarity, this document shall be read in conjunction with Appendix 6: Underwater Noise Modelling Report submitted as part of the 2024 NIS.

Any cross reference to a chapter, section, table, image, figure or appendix within this document is to another location within the Addendum to the NIS unless explicitly stated otherwise. Any cross reference to anything included in the 2024 NIS will be clearly labelled as such.

Text in bold is only used throughout this document to indicate where changes are required, and what is subsequently driving them. Text in italics is text from a section of the 2024 NIS which is deleted, or quotations from other documents (as explicitly stated). Replacement text is in normal font.

Tables which have been updated from the 2024 NIS, or entirely new tables, have been included in the Addendum to the NIS. These can be identified by the "A" prefix in the caption. Any changes within an updated table, in comparison to tables within the 2024 NIS, are indicated by grey shading in the relevant cell, column or row, as necessary. The exception to this is when a table has changed in its entirety.

The sections relevant to Appendix 13: Underwater Noise Modelling Report in the RFI are included below.

RFI Section	RFI	Relevance to Chapter
1 (b)	The scientific information provided as part of the planning application documentation should be based on up-to-date survey reports and data. Accordingly, the applicant is requested to confirm/provide justification/verification that the information submitted in support of the planning application remains relevant and appropriate at the point of submitting further information or to update same as required.	The timeframes associated with the RFI have necessitated a review of the datasets previously used in the 2024 NIS to ensure any necessary updates to the baseline environment are captured. Therefore, a review of the baseline environment has been undertaken to comply with RFI Section 1 (b).
3 (c)	Assess the results obtained from modelled impulsive (with and without abatement) and continuous noise in a) to be assessed against	This Appendix provides underwater noise modelling however, it removes modelled impulsive noise from the

	the relevant thresholds values for impulsive and continuous noise set out in the above referenced Commission Notice.	assessment (to reflect the design refinements presented in Appendix A5.1: Design refinements including the removal of piling). It contains an assessment of continuous noise.
10 (a) ii.	The applicant must also consider and draw on the best available technology and thresholds, including as applied in other EU jurisdictions (e.g. Germany; Belgium; Netherlands; Denmark), to identify and provide for suitable noise abatement to reduce the level and extent of potential noise impacts arising from the proposed development. Examples include the German 160 dB re 1 µPa²s SELss and 190 dB re 1 µPa SPLpeak thresholds that must not be exceeded at a distance of 750m from a piling site; or the frequency weighted SELcum PTS thresholds (e.g. harbour porpoise 155 dB re 1µPa2s) that must not be exceeded for a fleeing animal with a starting distance of 200m in Denmark.	This Appendix provides an update of underwater noise criteria for marine mammals from Southall et al. (2019) to NMFS (2024) (except that the use of PTS is replaced by Auditory Injury (‘AUD INJ’), which includes PTS) which relates to the RFI to draw upon the best available thresholds.
10 (b)	The applicant is invited to submit any details of monitoring/reporting available from previous experience of offshore development in other EU jurisdictions which demonstrates the efficacy of mitigation measures adopted in relation to underwater noise.	This Appendix includes a summary of outcomes of monitoring of SBJs to demonstrate low levels of underwater noise being produced during installation. and conclude that minimal underwater noise is produced by SBJ installation.

1 Introduction

The key change in this section is that Suction Bucket Jackets (SBJ) are now selected as the only foundation type for wind turbines; as a result Section 3 and 4 can be deleted. Therefore, the following bullets in Section 1 shall be deleted:

- *"Discussion of the modelling approach, input parameters and assumptions for the detailed noise modelling undertaken (section 3);*
- *Presentation and interpretation of the detailed subsea noise modelling for impact piling with regards to its effect on marine mammals and fish (section 4)"*

And be replaced with,

- Background information covering the units used for measuring and assessing underwater noise and a review of the underwater noise metrics and criteria used to assess the possible environmental effect in marine receptors (section 2);
- Noise modelling of the other noise sources expected to be present around the construction and operation of the proposed development, including cable laying, trenching, dredging, rock placement, vessel movements, drilling, operational WTG noise and unexploded ordnance (UXO) clearance (section 5); and
- Summary and conclusions (section 6).

There are no further changes to this section. Refer to Section 1 of Appendix 6 in the 2024 NIS.

2 Background to underwater noise metrics

2.1 Underwater noise

There are no changes to this section. Refer to Section 2.1 of Appendix 6 in the 2024 NIS.

2.2 Analysis of environmental effects

The key change in this section relates to the update of underwater noise criteria for marine mammals from Southall *et al.* (2019) to NMFS (2024), which relates to Section 10.a) ii) of the RFI, to draw upon the best available thresholds. The following bullet in Section 2.2 shall be deleted:

- *"Southall et al. (2019) marine mammal exposure criteria; and"*

And replaced with

- NMFS (2024) marine mammal exposure criteria; and

And followed by the following text:

While Southall *et al.* (2019) has been the most widely used and recognised source of guidance for the assessment of noise impact on marine mammals since its publication, the recent publication of NMFS (2024) provides an update including the influence of latest research on this guidance.

2.2.1 Marine mammals

Section 2.2.1 is updated to include a description of changes brought in by NMFS 2024 relating to Section 10.a) ii) of the RFI, to draw upon the best available thresholds. In general, for the purposes of this assessment, the naming, structure and general principles of NMFS 2024 follow those in Southall et al. (2019), except that the use of PTS is replaced by Auditory Injury ('AUD INJ'), which includes PTS. The hearing range (Table A2-1) and weighting functions (Figure A2-1) are slightly modified, as below.

Table A2-1 Marine mammal hearing groups (from Southall et al., 2019) (Replaces Table 2-1 in Appendix 6 of the 2024 NIS.)

Hearing group	Generalised hearing range	Example species
Low-frequency cetaceans (LF)	7 Hz to 36 kHz	Baleen whales
High-frequency cetaceans (HF)	150 Hz to 160 kHz	Dolphins, toothed whales, beaked whales, bottlenose whales (including bottlenose dolphin)
Very high-frequency cetaceans (VHF)	200 Hz to 165 kHz	True porpoises (including harbour porpoise)
Phocid carnivores in water (PCW)	40 Hz to 90 kHz	True seals (including harbour seals)

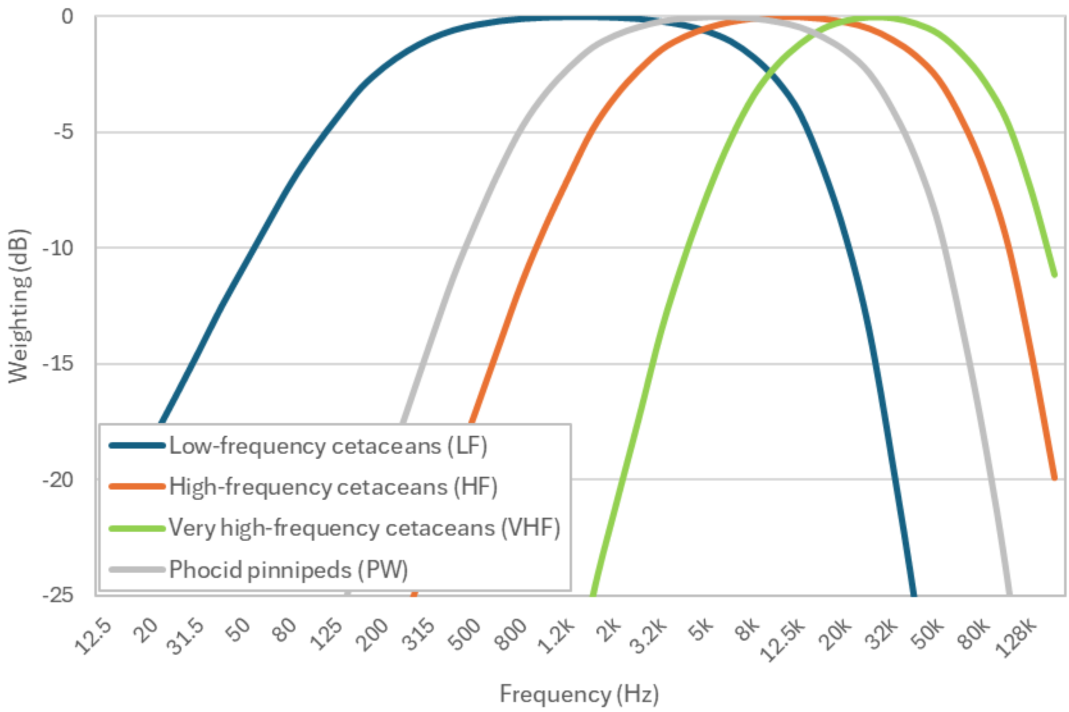

Figure A2-1 Auditory weighting functions for low-frequency cetaceans (LF), high-frequency cetaceans (HF), very high-frequency cetaceans (VHF), and phocid carnivores in water (PCW) (from NMFS, 2024). (Replaces Figure 2-1 in Appendix 6 of the 2024 NIS.)

Table A2-2 and

Table A2-3 present the unweighted SPL_{peak} and weighted SEL_{cum} criteria for marine mammals from NMFS (2024) covering both impulsive and non-impulsive noise.

Table A2-2 Single strike SPL_{peak} criteria for AUD INJ and TTS in marine mammals (NMFS, 2024). (Replaces Table 2-2 in Appendix 6 of the 2024 NIS.)

Southall *et al.* (2019)	**Unweighted SPL_{peak} (dB re 1 µPa)**	
	Impulsive	
	AUD INJ	**TTS**
Low-frequency cetaceans (LF)	222	216
High-frequency cetaceans (HF)	230	224
Very high-frequency cetaceans (VHF)	202	196
Phocid carnivores in water (PCW)	223	217

Table A2-3 Impulsive and non-impulsive SEL_{cum} criteria for AUD INJ and TTS in marine mammals (NMFS, 2024). (Replaces Table 2-3 in Appendix 6 of the 2024 NIS.)

Southall *et al.* (2019)	**Weighted SEL_{cum} (dB re 1 µPa²s)**			
	Impulsive		**Non-impulsive**	
	AUD INJ	**TTS**	**AUD INJ**	**TTS**
Low-frequency cetaceans (LF)	183	168	197	177
High-frequency cetaceans (HF)	193	178	201	181
Very high-frequency cetaceans (VHF)	159	144	181	161
Phocid carnivores in water (PCW)	183	168	195	175

Due to the use of SBJ and elimination of impact piling, the results for impulsive noise are now only relevant for the UXO assessment in section 5.3. The following two paragraphs in section 2.2.1 shall be deleted.

"Where SEL_{cum} thresholds are required for marine mammals, a fleeing animal model has been used. This assumes that a receptor, when exposed to high noise levels, will swim away from the noise source. A constant fleeing speed of 3.25 ms^{-1} has been assumed for the low-frequency cetaceans (LF) group (Blix and Folkow, 1995), based on data for minke whale, and for other receptors, a constant rate of 1.5 ms^{-1} has been assumed for fleeing, which is a cruising speed for a harbour porpoise (Otani et al., 2000). These are considered highly precautionary assumptions as marine mammals are expected to be able to swim much faster under stress conditions (Kastelein et al. 2018), especially at the start of any noisy process when the receptor will be closest.

Limited data is available for behavioural disturbance on species of marine mammal. To take this into account, the NOAA (2005) Level B (behavioural disturbance) harassment criterion for impulsive noise on marine mammals, 160 dB unweighted SPL_{RMS}, has been included to cover disturbance effects."

2.2.2 Fish

There are no changes to this section. Refer to Section 2.2.2 of Appendix 6 in the 2024 NIS.

3 Modelling methodology

As a result of the use of SBJ and elimination of impact piling as a noise generating activity, the whole of Section 3 of Appendix 6 in the 2024 NIS shall be deleted.

4 Modelling results

As a result of the use of SBJ and elimination of impact piling as a noise generating activity, the whole of Section 4 of Appendix 6 in the 2024 NIS shall be deleted.

5 Other noise sources

Section 5 of Appendix 6 in the 2024 NIS will be retained. Table 5-1 of the 2024 NIS has been updated to include a line for SBJ (Table A5-1). An additional section has been added regarding SBJ, see section 5.1.1 below.

Table A5-1 Summary of the possible noise making activities at the proposed development. (Replaces Table 5-1 in Appendix 6 of the 2024 NIS.)

Activity	Description
SBJ	Noise from vacuum pumps to extract water from within the bucket, forcing it into the soil to secure a wind turbine foundation, typically as part of a jacket structure.
Cable laying	Noise from the cable laying vessel and any other associated noise during the offshore cable installation.
Dredging	Dredging may be required on site for seabed preparation work for certain foundation options, as well as for the export cable, array cables and interconnector cable installation. Suction dredging has been assumed as a worst-case.
Drilling	There is the potential for WTG and offshore substation platform foundations to be installed using drilling depending on seabed type.
Rock placement	Potentially required on site for installation of offshore cables (cable crossings and cable protection) and scour protection around foundation structures.
Trenching	Plough trenching may be required during offshore cable installation.
Vessel noise	Jack-up barges for foundation substructure and WTG installation. Other large and medium sized vessels to carry out other construction tasks and anchor handling. Other small vessels for crew transport and maintenance on site.
Operational WTG	Noise transmitted through the water from operational WTG. The project options give WTGs with rotor diameters of between 250 and 276 m, in line with expected power output.
UXO clearance	Should Unexploded Ordnance (UXO) exist within the proposed development area, this would need to be cleared before construction can begin.

5.1 Non-impulsive noise-making activities

Section 5.1 of the 2024 NIS is retained, however a minor update to the paragraph below has been updated to revise the results for weightings and thresholds as per guidance in NMFS (2024).

Tables 5-1, 5-3, 5-4, 5-5 and Figure 5-1 have also been updated as per guidance in NMFS (2024).

The following paragraph is deleted:

"To account for the weightings required for modelling using the Southall et al. (2019) criteria (see section 2.2.1), reductions in source level have been applied to the various noise sources; Table A5-1 shows the representative noise measurements used for this, which have been adjusted for the source levels given in Table 5-2. Details of the reductions in sources levels for each of the weightings used for modelling are given in Table 5-3."

And replaced with:

To account for the weightings required for modelling using the NMFS (2024) criteria (see section 2.2.1), reductions in source level have been applied to the various noise sources; Table A5-1 shows the representative noise measurements used for this, which have been adjusted for the source levels given in Table 5-2 of the 2024 NIS. Details of the reductions in sources levels for each of the weightings used for modelling are given in Table A5-2.

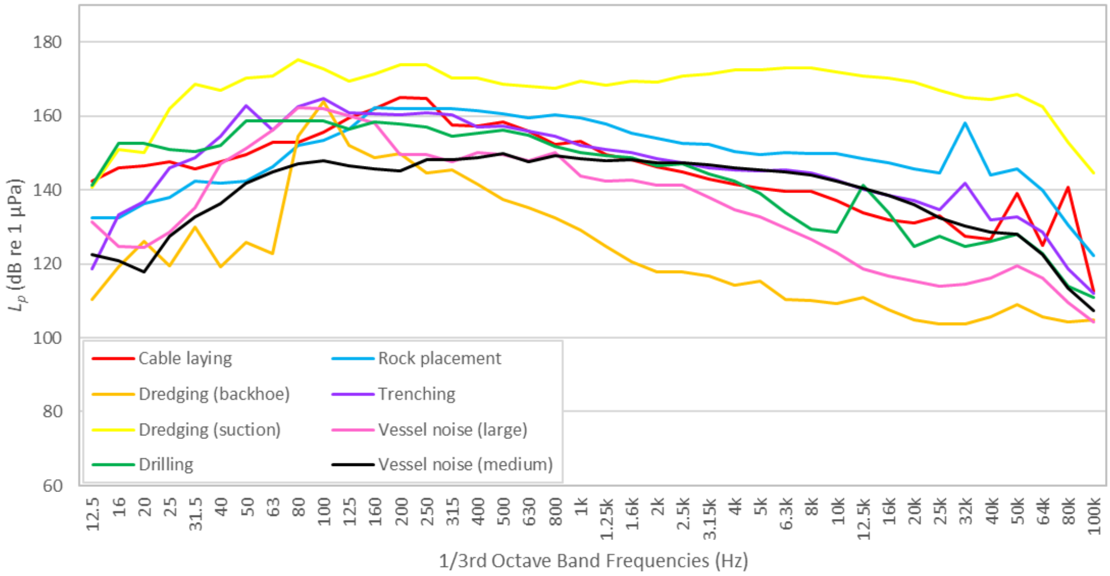

Figure A5-1 Summary of the 1/3rd octave frequency bands to which the NMFS (2024) weightings have been applied. (Replaces Figure 5-1 in the 2024 NIS.)

Table A5-2 Reductions in source level for the different construction noise sources considered when the Southall et al. (2019) weightings are applied. (Replaces Table 5-3 in the 2024 NIS.)

Source	Reduction in source level from the unweighted level (NMFS, 2024)			
	LF	**HF**	**VHF**	**PCW**
Cable laying	2.0 dB re 1 µPa	17.3 dB re 1 µPa	25.4 dB re 1 µPa	12.4 dB re 1 µPa
Dredging (backhoe)	5.2 dB re 1 µPa	32.4 dB re 1 µPa	46.9 dB re 1 µPa	24.7 dB re 1 µPa
Dredging (suction)	2.4 dB re 1 µPa	4.1 dB re 1 µPa	7.4 dB re 1 µPa	3.6 dB re 1 µPa
Drilling	3.5 dB re 1 µPa	15.8 dB re 1 µPa	25.5 dB re 1 µPa	11.7 dB re 1 µPa
Rock placement	1.4 dB re 1 µPa	8.9 dB re 1 µPa	11.7 dB re 1 µPa	6.7 dB re 1 µPa
Trenching	3.5 dB re 1 µPa	15.9 dB re 1 µPa	22.5 dB re 1 µPa	12.4 dB re 1 µPa
Vessel noise	4.7 dB re 1 µPa	20.9 dB re 1 µPa	34.4 dB re 1 µPa	16.2 dB re 1 µPa

Under the NMFS (2024) non-impulsive criteria for marine mammals, the results change slightly which requires replacing Tables 5-4 and 5-5 in the 2024 NIS with Tables A5-3 and A5-4.

Table A5-3 Summary of the impact ranges for the different noise sources related to construction using the non-impulsive criteria from NMFS (2024) for marine mammals assuming a fleeing animal. (Replaces Table 5-4 in the 2024 NIS.)

Southall *et al.* (2019) Weighted SEL_{cum}	**AUD INJ (non-impulsive)**				**TTS (non-impulsive)**			
	LF 197 dB	**HF** 201 dB	**VHF** 181 dB	**PCW** 195 dB	**LF** 177dB	**HF** 181 dB	**VHF** 161 dB	**PCW** 175 dB
Cable laying	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m
Dredging (Backhoe)	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m
Dredging (Suction)	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	60 m	< 50 m
Drilling	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m
Rock placement	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m
Trenching	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m
Vessel noise (large)	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m
Vessel noise (medium)	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m

Table A5-4 Summary of the impact ranges for the different noise sources related to construction using the non-impulsive criteria from NMFS (2024) for marine mammals assuming a stationary animal. (Replaces Table 5-5 in the 2024 NIS.)

Southall *et al.* (2019) Weighted SEL_{cum}	**AUD INJ (non-impulsive)**				**TTS (non-impulsive)**			
	LF 197 dB	**HF** 201 dB	**VHF** 181 dB	**PCW** 195 dB	**LF** 177dB	**HF** 181 dB	**VHF** 161 dB	**PCW** 175 dB
Cable laying	< 50 m	< 50 m	< 50 m	< 50 m	1.5 km	50 m	400 m	340 m
Dredging (Backhoe)	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m	< 50 m
Dredging (Suction)	80 m	< 50 m	280 m	80 m	800 m	410 m	2.5 km	870 m
Drilling	< 50 m	< 50 m	< 50 m	< 50 m	220 m	< 50 m	100 m	90 m
Rock placement	70 m	< 50 m	270 m	< 50 m	2.5 km	490 m	4.0 km	1.7 km
Trenching	< 50 m	< 50 m	< 50 m	< 50 m	1.2 km	80 m	770 m	400 m
Vessel noise (large)	< 50 m	< 50 m	< 50 m	< 50 m	700 m	< 50 m	70 m	140 m
Vessel noise (medium)	< 50 m	< 50 m	< 50 m	< 50 m	400 m	80 m	820 m	350 m

There are no changes to the results for fish as stated in Table 5-6 of the 2024 NIS.

A new Section 5.1.1 has been added to focus on the noise from suction bucket jackets.

5.1.1 Suction bucket jackets

An alternative method for installation of turbine foundations is SBJs, which are expected to be suitable for the seabed conditions at the NISA site. SBJs consist of inverted, closed cylinders at the base of a framework, which, when placed on the seabed, use suction pumps to remove the water from inside the buckets and create a pressure difference that forces them into the seabed. These pumps are then removed after installation is complete.

Weilgart *et al.* (2023) state that SBJ installation noise "barely exceeds background levels", which is plausible due to the absence of any use of impulsive force (such as seen in impact piling). However, empirical evidence is limited, with only one study by Koschinski and Ludemann (2020) publicly available, providing measurement data from Borkum Riffgrund 2 OWF in Germany which used SBJs. This study reports that underwater noise monitoring at 750 m found no detectable noise from the pumps on the suction buckets above a background noise level of 137 dB $L_{eq,50}$ (equivalent to $L_{p,\mathrm{RMS}}$). It was also noted that the background noise recorded during the installation was influenced by construction activities.

More recently, 114 WTGs were installed on three-legged steel jackets using suction bucket caissons at Seagreen between 2021 and 2023. It should be noted that the aim of this study was to look at regional scale changes and therefore smaller scale impacts may not have been recorded. Underwater noise monitoring showed that PAM sites within the Seagreen array area detected a 3-5 dB median increase the 0.1 – 1 kHz frequency band during hours of suction compared to baseline (Chudzinska et al., 2026). However, the data also showed that when comparing suction and non-suction hours within a construction day, the differences were relatively minor suggesting that vessel traffic, mobilisation, and ancillary operations contribute substantially to the overall increase in underwater noise on construction days. There was no evidence of a change in dolphin or porpoise detections as a result of SBJ construction activities.

Previous underwater noise assessments for offshore wind developments have therefore used 137 dB $L_{p,\mathrm{RMS}}$ at 750 m as a worst-case scenario for SBJ installation, making it appear as one of the loudest continuous noise sources during wind farm construction compared to other sources such as dredging, trenching etc. It should be noted that this noise level is an over-precautionary prediction, as a measurement of 137 dB represents a combination of existing background noise, vessel and vessel-based machinery noise, as well as noise from the suction bucket pumps. Assuming that the combination of vessel noise and pumps exceeds background (as was reported in Koschinsky and Ludemann (2020), and the contribution of these two noise sources to the overall noise level is equal, each source would be 134 dB, as a theoretical doubling in noise would add 3 dB.

However, it should be noted that since the suction buckets were inaudible at this distance, their true noise level is likely at least 5-10 dB quieter than the measured level. Since suction bucket pumps were inaudible against the vessel noise, they are not themselves considered as a significant noise source, and instead, vessel operations should be considered the main contributor of noise during SBJ installation.

5.2 Operational WTG noise

There are no changes to this section. Refer to Section 5.2 of Appendix 6 in the 2024 NIS.

5.3 UXO clearance

There are no changes to this section. Refer to Section 5.3 of Appendix 6 in the 2024 NIS.

5.3.1 *Estimation of underwater noise levels*

There are no changes to this section. Refer to Section 5.3.1 of Appendix 6 in the 2024 NIS.

5.3.2 *Estimation of underwater noise propagation*

There are no changes to this section. Refer to Section 5.3.2 of Appendix 6 in the 2024 NIS

5.3.3 *Impact ranges*

Impact ranges change in this section to account for the updated NMFS (2024) criteria and the use of a bubble curtain for all high order (25 kg or greater) charge weights ("+BC"), providing -10 dB attenuation. Tables 5-10, 5-11 and 5-12 of Appendix 6 in the 2024 NIS shall be deleted and replaced with Tables A5-5, A5-6 and A5-7 respectively.

Table A5-5 Summary of the AUD INJ. and TTS impact ranges for UXO detonation using the impulsive, unweighted SPL_{peak} noise criteria from NMFS (2024) for marine mammals. (Replaces Table 5-10 in Appendix 6 of the 2024 NIS.)

Southall *et al.* (2019) Unweighted SPL_{peak}	**AUD INJ (impulsive)**				**TTS (impulsive)**			
	LF 222 dB	**HF** 230 dB	**VHF** 202 dB	**PCW** 223 dB	**LF** 216 dB	**HF** 224 dB	**VHF** 196 dB	**PCW** 217 dB
Low order (0.25 kg)	130 m	60 m	990 m	110 m	230 m	100 m	1.8 km	210 m
25 kg +donor +BC	210 m	100 m	1.6 km	190 m	400 m	170 m	3.1 km	360 m
55 kg +donor +BC	280 m	120 m	2.1 km	250 m	520 m	230 m	4.0 km	470 m
120 kg +donor +BC	360 m	160 m	2.8 km	330 m	670 m	300 m	5.1 km	610 m
240 kg +donor +BC	460 m	200 m	3.5 km	410 m	850 m	370 m	6.5 km	770 m
525 kg +donor +BC	600 m	260 m	4.6 km	540 m	1.1 km	490 m	8.4 km	1.0 km

Table A5-6 Summary of the AUD INJ. and TTS impact ranges for UXO detonation using the impulsive, weighted SEL_{ss} noise criteria from NMFS (2024) for marine mammals. (Replaces Table 5-11 in Appendix 6 of the 2024 NIS.)

Southall *et al.* (2019) Weighted SEL_{ss}	**AUD INJ (impulsive)**				**TTS (impulsive)**			
	LF 183 dB	**HF** 193 dB	**VHF** 159 dB	**PCW** 183 dB	**LF** 168 dB	**HF** 178 dB	**VHF** 144 dB	**PCW** 168 dB
Low order (0.25 kg)	130 m	< 50 m	170 m	< 50 m	1.8 km	< 50 m	1.2 km	380 m
25 kg +donor +BC	210 m	< 50 m	260 m	< 50 m	3.0 km	< 50 m	1.6 km	630 m
55 kg +donor +BC	310 m	< 50 m	360 m	70 m	4.4 km	< 50 m	1.9 km	920 m
120 kg +donor +BC	460 m	< 50 m	490 m	100 m	6.4 km	< 50 m	2.2 km	1.3 km
240 kg +donor +BC	640 m	< 50 m	630 m	130 m	8.9 km	50 m	2.5 km	1.8 km
525 kg +donor +BC	950 m	< 50 m	820 m	190 m	13 km	80 m	2.9 km	2.7 km

Table A5-7 Summary of the AUD INJ. and TTS impact ranges for UXO detonation using the non-impulsive, weighted SEL_{ss} noise criteria from NMFS (2024) for marine mammals. (Replaces Table 5-12 in Appendix 6 of the 2024 NIS.)

Southall *et al.* (2019) Weighted SEL_{ss}	**AUD INJ (non-impulsive)**				**TTS (non-impulsive)**			
	LF 197 dB	**HF** 201 dB	**VHF** 181 dB	**PCW** 195 dB	**LF** 177 dB	**HF** 181 dB	**VHF** 161 dB	**PCW** 175 dB
Low order (0.25 kg)	< 50 m	< 50 m	< 50 m	< 50 m	370 m	< 50 m	120 m	110 m
25 kg +donor +BC	< 50 m	< 50 m	< 50 m	< 50 m	620 m	< 50 m	190 m	180 m
55 kg +donor +BC	< 50 m	< 50 m	< 50 m	< 50 m	910 m	< 50 m	270 m	270 m
120 kg +donor +BC	< 50 m	< 50 m	< 50 m	< 50 m	1.3 km	< 50 m	370 m	390 m
240 kg +donor +BC	50 m	< 50 m	< 50 m	< 50 m	1.8 km	< 50 m	480 m	550 m
525 kg +donor +BC	80 m	< 50 m	< 50 m	< 50 m	2.7 km	< 50 m	640 m	810 m

5.3.4 Summary

The following paragraph shall be deleted:

"Should UXO be identified across the offshore development area, the maximum PTS range calculated UXO is 12 km for the VHF cetacean category, when considering the unweighted SPL_{peak} criteria for the largest high-order clearance. For SEL_{ss} criteria, the largest PTS range is calculated for LF cetaceans with a predicted impact of 9.5 km using the impulsive noise criteria. As explained earlier, this assumes no degradation of the UXO and no smoothing of the pulse over that distance, which is very precautionary. Although an assumption of non-pulse could under-estimate the potential impact (Martin et al., 2020) (the equivalent range based on LF cetacean non-pulse criteria is 570 m), it is likely that the long-range smoothing of the pulse peak would reduce its potential harm and the maximum 'impulsive' range for all species is very precautionary."

And will be replaced as follows, to revise the impact ranges as per the results in section 5.3.3:

Should UXO be identified across the offshore development area, the maximum AUD INJ range calculated UXO is 4.6 km for the VHF cetacean category, when considering the unweighted SPL_{peak} criteria for the largest high-order clearance. For SEL_{ss} criteria, the largest AUD INJ range is calculated for LF cetaceans with a predicted impact of 950 m using the impulsive noise criteria. As explained earlier, this assumes no degradation of the UXO and the use of a bubble curtain for all high order detonations.

6 Summary and conclusions

The summary and conclusions have changed to reflect the elimination of impulsive underwater noise from impact piling, the introduction of SBJ and change of impact range for UXO as a result of the update to NMFS (2024) impact criteria for marine mammals and use of a bubble curtain. Section 6 shall therefore be deleted, and be replaced with the following:

Subacoustech Environmental have undertaken a study on behalf of the Developer to assess the potential underwater noise and its effects during the construction and operation of the proposed development.

The level of underwater noise from the installation of WTG foundations during construction has been considered for the use of a suction bucket installation technique. The data available for noise generated during suction bucket jacket installation indicates that at 750 m from the foundation, the noise is inaudible against background noise and thus is not considered a significant source of noise in the context of marine mammal or fish impacts.

Noise sources other than from suction bucket installation were considered using a high-level, simple modelling approach, including cable laying, dredging, drilling, rock placement, trenching vessel movements, and operational WTG noise. The risk of any potentially injurious effects to fish or marine mammals from these sources are expected to be minimal as the noise emissions from these are close to, or below, the appropriate injury criteria even when very close to the source of the noise.

UXO clearance has also been considered at the site, and for the expected low order UXO clearance noise, there is a risk of auditory injury at up to 990 m from the UXO for VHF cetaceans. In the event that low order clearance is not possible, there is a risk of AUD INJ up to 4.6 km from the largest UXO device considered, 525 kg, using the unweighted SPL_{peak} criteria for VHF cetaceans. Any high order clearance will include the use of a bubble curtain to reduce noise levels.

The outputs of this modelling have been used to inform analysis of the impacts of underwater noise on marine mammals and fish in their respective reports.

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Additional references:

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2. Koschinski S and Lüdemann K (2020). Noise mitigation for the construction of increasingly large offshore wind turbines. Technical options for complying with noise limits. Commissioned by the Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN).
3. National Marine Fisheries Service (NMFS) (2024). *2024 update to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 3.0): Underwater and in-air criteria for onset of auditory injury and temporary threshold shifts.* U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-71.
4. Weilgart L (2023). Best Available Technology (BAT) and Best Environmental Practice (BEP) for Mitigating Three Noise Sources: Shipping, Seismic Airgun Surveys, and Pile Driving. 53 Pages. CMS Technical Series No. 46

Appendix A Additional modelling results

As a result of the use of SBJ and elimination of impact piling as a noise generating activity, the whole of Appendix A of Appendix 6 in the 2024 NIS shall be deleted.

Report documentation page

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P291R2000	01	24/04/2023	Initial writing and internal review
P291R0201	-	12/05/2023	Update following new parameters
P291R0202	-	19/01/2024	Further updates following client review
P291R0203	-	14/02/2024	Issue to client
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