

**Moray Offshore Windfarm (West) Limited
Addendum to existing EPS Risk Assessment for UXO
clearance**



8460005-DG0207-MWW-REP-000003

MORAY OFFSHORE WINDFARM (WEST) LIMITED

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Prepared by:	Review by:	Approved by:	Approved by:
[Redacted]	[Redacted]	[Redacted]	[Redacted]

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1 Introduction

In order to safely undertake unexploded ordnance (UXO) clearance at the Development Site, a European Protected Species (EPS) Licence is required and an application for a licence to disturb or injure marine EPS has been applied for and issued by the Marine Scotland Licensing Operations Team (MS-LOT). This Risk Assessment (Document: 8460005-DG0207-MWW-REP-000002) was submitted in support of the EPS Licence application submitted by Moray West for UXO clearance and the use of acoustic deterrent devices (ADDs).

A Licence to Injure Marine Species and Disturb Marine Species (EPS/BS-00010265) was issued on the 30th March 2023. This licence is valid from 31st March, 2023 to 31st May, 2023 and covers the clearance of up to 30 UXO's through High Order or Low order (through deflagration) clearance in either the Wind Farm Site or cable corridor.

Additional clearance of up to 51 UXO has been identified following the completion of the potential UXO (pUXO) Investigation works carried out between February and April 2023. Further information on the location and types of UXO that require clearing has also been identified. This has led to the potential duration of the clearance activities being extended until the 31st August 2023.

As such further assessment has been undertaken to present a more realistic worst case effects for the for High order or Low order clearance taking in to account the updated UXO sizes and the timing and duration of the works.

A variation of the EPS Licence (EPS/BS-00010265) is required to cover the following:

- 30 UXO clearance in the Moray West Site and OfTI Corridor through high order or low order clearance between 31st March and 31st August 2023 (Marine Licence Number: MS-00010264) for the extended duration; and
- The additional 51 UXO clearance identified in the Moray West Site through Low order clearance (deflagration) between 30th April and 31st August (Marine Licence in application).

The findings from this risk assessment are in line with those assessed in the UXO EPS Risk Assessment (Document: 8460005-DG0207-MWW-REP-000002 Rev 04, dated 7 February 2023), thus, no changes to mitigation outlined in the MMMP (Document: 8460005-DG0207-MWW-REP-000002; Appendix B) are required.

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1.1 Purpose of the Addendum

The purpose of this addendum is to provide further information for the application of a license variation to the existing marine license (MS-00010264) and EPS Licence (EPS/BS-00010265) (Supporting documents Moray West Environmental Report (document reference: 8460005-DG0207-MWW-REP-000001) and the European Protected Species Risk Assessment (document reference: 8460005-DG0207-MWW-REP-000002)). With regards to the recent progress of the UXO ID Campaign at Moray West, a significant number of confirmed UXOs have been identified, exceeding the number of UXOs stated in the marine license (30 UXOs). The map in Figure 1 shows where these UXOs are within Moray West Site and Table 1 summarises the UXO items that have been found.

The disposal works would commence following the completion of the ID works (15th April 2023). However in light of the recent findings it is now anticipated that the disposal works would be completed by the end of August 2023 (accounting for weather downtime) instead of end of May 2023, as per marine licence and EPS licence variation. Thus, Moray West requests a variation to the existing EPS licence (EPS/BS-00010265) to:

- Extend it to the **31st August 2023**, and
- Increase the number of UXO clearance up to a maximum of 81 instead of 30. The additional 51 cUXO are located in the Moray West Site and will be disposed by deflagration, this risk assessment will however assess using donor charges as the worst case.

Table 1: Summary of UXO items found within Moray West Site

Count	UXO item	NEQ (kg)	Ferrous mass (kg)	Dimensions
2	6" projectile	6	39.4	582mm x 152mm
1	60" Anti-submarine projectile	16	29.5	1,448mm x 305mm
74	15" projectile	20.7	879	1,300mm x 381mm
1	Air dropped 250lb mine	51	115	699mm x 254mm
2	Air dropped 500lb mine	89	226	900mm x 300mm
1	10" projectile	105	250	1000mm x 254mm

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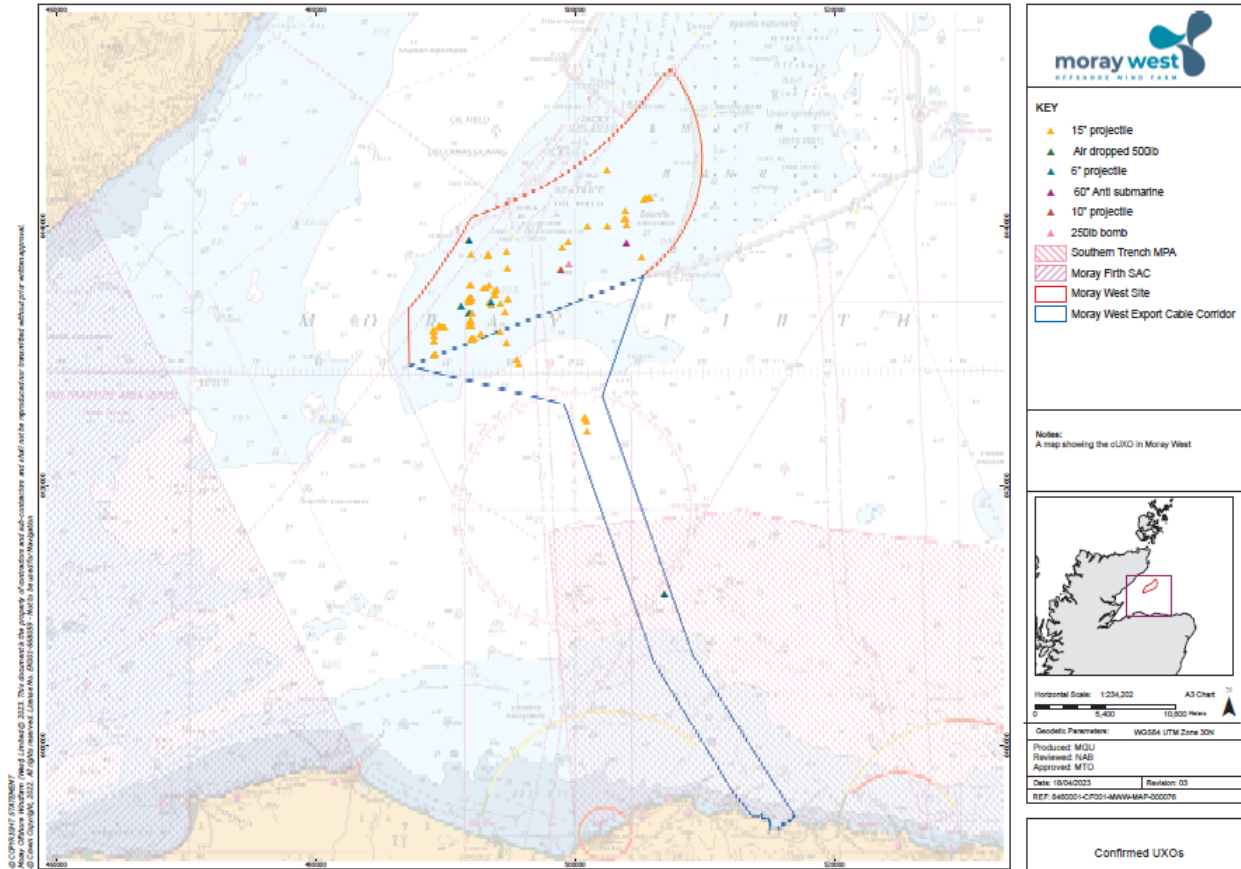


Figure 1 Map showing the findings of the confirmed UXO at the Development Site (73 cUXO in the Moray West Site and 8 cUXO in the OfTI Corridor).

Moray West will prioritise clearance operations of the 8 cUXOs within the OfTI Corridor to be completed between April and 31st May 2023.

2 High-Order Clearance

The density and abundance of the cetacean species which regularly occur in the Moray Firth are summarised in Table 2. Reference population for harbour porpoise is the North Sea MU (Hammond *et al.*, 2021). The reference population for bottlenose dolphin is the CES MU, the reference population for common dolphin, white-beaked dolphin and minke whale is CGNS MU (IAMMWG, 2021; Table 2).

Table 2: Density and abundance estimates for the five regularly occurring cetacean species in the Moray Firth			
Species	Density estimates (individuals/km ²)	Estimated population abundance in the relevant MU	References
Harbour porpoise	1.468*	346,601	Moray West (2018); IAMMWG (2021)
Bottlenose dolphin	0.0037	224	Hammond <i>et al.</i> (2021); Arso Civil <i>et al.</i> (2021); IAMMWG (2022)
White-beaked dolphin	0.123	43,951	Waggitt <i>et al.</i> (2019); IAMMWG (2022)
Common dolphin	0.074	102,656	Hammond <i>et al.</i> (2021); IAMMWG (2022)
Minke whale	0.023	20,118	Waggitt <i>et al.</i> (2019); IAMMWG (2022)

* Maximum density cell within the Moray West Site

The information received from the UXO ID Works provides a real-life scenario, upon which the worst-case can be modelled. The following risk assessment uses the impact ranges from the underwater noise modelling that is available for the UXO items that have been found at the Development Site (Moray West Site and OfTI Corridor). The heaviest items that have been found are an air dropped 250lb mine, an air dropped 500lb mine and a 10" projectile with an NEQ of 51kg, 89kg and 105 kg (+ donor charge), respectively. However, no impact ranges have been previously modelled for these sizes, thus a precautionary approach of using a 166kg NEQ from the Moray West Underwater Noise (UWN) modelling report (see Table 3).

The remaining items that have been found at Development Site are of smaller ordnance (max. 22kg NEQ). UXOs of 25kg (+ donor charge) have been assessed for Moray West but also for Erebus OWF and SEP/DEP (Equinor New Energy Ltd, 2022). A comparison of modelled impact ranges is provided in Table 4. The comparison allows the identification of the worst-case, which are highlighted in bold and carried forward for further risk assessment to marine mammals in this addendum (Table 5 and Table 7 for permanent auditory injury (PTS); Table 11 and Table 13 for temporary auditory injury (TTS)).

As a worst-case scenario, the UXO clearance is modelled under the assumption that a high-order clearance will be required. More realistically, these items are very likely to be deflagrated, causing only a fraction of the impact and would be short-lived.

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2.1 PTS from UXO clearance

The maximum predicted impact ranges for PTS in harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale, from a 25kg and 166kg (+ donor charge) UXO are presented in Table 3 and Table 4 based on the underwater noise modelling for high-order detonation. It must be noted that the assessment for the 166kg (+ donor charge) UXO is overly precautionary whereas the remaining items (below 22kg) represent a more realistic scenario.

Table 3: The maximum predicted impact ranges (km) for PTS in marine mammals, based on the underwater noise modelling for high-order detonation for a 166 kg NEQ (+ donor charge)		
Species	PTS Criteria and Threshold (Southall <i>et al.</i> , 2019)	166 kg
Harbour porpoise (VHF)	PTS SPL _{peak} 202 dB re 1 µPa Unweighted Impulsive criteria	8.86 km (246.6 km ²)
	PTS SEL 155 dB re 1 µPa ² s Weighted Impulsive criteria	0.96 km (2.9 km ²)
Bottlenose dolphin, white-beaked dolphin and common dolphin (HF)	PTS SPL _{peak} 230 dB re 1 µPa Unweighted Impulsive criteria	0.51 km (0.8 km ²)
	PTS SEL 185 dB re 1 µPa ² s Weighted Impulsive criteria	0.035 km (0.004 km ²)
Minke whale (LF)	PTS SPL _{peak} 219 dB re 1 µPa Unweighted Impulsive criteria	1.57 km (7.7 km ²)
	PTS SEL 183 dB re 1 µPa ² s Weighted Impulsive criteria	2.74 km (23.6 km ²)

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Table 4: The maximum predicted impact ranges (km) for PTS in marine mammals, based on the underwater noise modelling for high-order detonation for 25-30 kg NEQ (+donor charge).				
Species	PTS Criteria and Threshold (Southall <i>et al.</i> , 2019)	Projects that assessed for 25-30 kg UXO including charge weights NEQ and maximum predicted impact range (km) and area (km ²)		
		Erebus Offshore Wind (25kg)	Moray West UWN modelling 30kg (NEQ+ charge)	SEP/DEP UWN modelling 25.5kg (NEQ+ charge)
Harbour porpoise (VHF)	PTS SPL _{peak} 202 dB re 1 µPa Unweighted Impulsive criteria	4.6 km (66.5 km ²)	4.96 km (77.3 km ²)	4.6 km (66.5 km ²)
	PTS SEL 155 dB re 1 µPa ² s Weighted Impulsive criteria	0.56 km (1 km ²)	0.41 km (0.5 km ²)	0.57 km (1.0 km ²)
Bottlenose dolphin, white-beaked dolphin and common dolphin (HF)	PTS SPL _{peak} 230 dB re 1 µPa Unweighted Impulsive criteria	0.26 km (0.2 km ²)	0.29 km (0.3 km ²)	0.26 km (0.2 km ²)
	PTS SEL 185 dB re 1 µPa ² s Weighted Impulsive criteria	0.01 km 0.02 km ²)	0.015 km km ²)	<0.05 km (0.008 km ²)
Minke whale (LF)	PTS SPL _{peak} 219 dB re 1 µPa Unweighted Impulsive criteria	0.81 km (2.1 km ²)	0.88 km (2.4 km ²)	0.82 km (2.1 km ²)
	PTS SEL 183 dB re 1 µPa ² s Weighted Impulsive criteria	2.1 (13.9 km ²)	1.2 km (4.5 km ²)	2.2 km (15.2 km ²)

2.1.1 PTS Assessment of 25kg UXO

The maximum number of harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale that could potentially be at risk of PTS during a 25kg (+ donor charge) UXO clearance, based on the maximum potential PTS impact ranges for a UXO high-order detonation are presented in Table 5.

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The magnitude for bottlenose dolphin, white-beaked dolphin, common dolphin has been assessed as negligible for the PTS SPL_{peak} and weighted SEL criteria, based on the worst-case impact ranges identified in Table 4. A low magnitude was assessed for PTS (SPL_{peak}) in harbour porpoise and for minke whale for the weighted SEL criteria.

Table 5: The maximum number of animals that could be at risk of PTS from high-order clearance of a 25kg (+ donor charge) UXO			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
Harbour porpoise	PTS SPL _{peak} (77.3 km ²) unmitigated	113 harbour porpoise (0.03% of North Sea MU) based on site survey density 1.468/km ²	Low magnitude (i.e. 0.01%-0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (1.02 km ²) unmitigated	1.5 harbour porpoise (0.00043% of North Sea MU) based on site survey density 1.468/km ²	Negligible magnitude (i.e. 0.001% or less of the North Sea MU reference population anticipated to be exposed to the permanent impact).
Bottlenose dolphin	PTS SPL _{peak} (0.3 km ²) unmitigated	0.001 bottlenose dolphin (0.00005% of CES MU) based on the density estimate of 0.0037/km ²	Negligible magnitude (i.e. 0.001% or less of the CES MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (0.008 km ²) unmitigated	0.00003 bottlenose dolphin (0.000002% of CES MU) based on the density estimate of 0.0037/km ²	Negligible magnitude (i.e. 0.001% or less of the CES MU reference population anticipated to be exposed to the permanent impact).
White-beaked dolphin	PTS SPL _{peak} (0.3 km ²) unmitigated	0.04 white-beaked dolphin (0.0001% of CGNS MU) based on the density estimate of 0.123/km ²	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (0.008 km ²) unmitigated	0.001 white-beaked dolphin (0.000002% of CGNS MU) based on the density estimate of 0.123/km ²	Negligible magnitude (i.e. 0.001% or less of the CES MU reference population anticipated to be exposed to the permanent impact).

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Table 5: The maximum number of animals that could be at risk of PTS from high-order clearance of a 25kg (+ donor charge) UXO			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
Common dolphin	PTS SPL _{peak} (0.3 km ²) unmitigated	0.02 common dolphin (0.00002% of CGNS MU) based on the density estimate of 0.074 /km ²	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (0.008 km ²) unmitigated	0.0006 common dolphin (0.000001% of CGNS MU) based on the density estimate of 0.074 /km ²	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
Minke whale	PTS SPL _{peak} (2.4 km ²) unmitigated	0.06 minke whale (0.0003% of CGNS MU) based on the density estimate of 0.023/km ²	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (15.2 km ²) unmitigated	0.35 minke whale (0.002% of CGNS MU) based on the density estimate of 0.023/km ²	Low magnitude (i.e. 0.01%-0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).

2.1.1.1 Assessment of Significance

The impact significance for any PTS in marine mammals has been assessed in for 25kg UXO in Table 6. Considering the high sensitivity and the negligible to low magnitude for harbour porpoise and minke whale the potential impact significance for any PTS, is assessed as minor to moderate adverse. For the dolphin species with a high sensitivity the potential impact significance is likely to be less than minor adverse.

Taking into account the proposed mitigation in the MMMP, the impact significance of the potential risk of PTS to marine mammals as a result of underwater UXO clearance is **minor adverse (not significant)**.

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Table 6: Assessment of impact significance for PTS in the marine mammal species during high-order UXO detonation of 25kg (+ donor charge)						
Species	Potential Impact	Sensitivity	Magnitude without mitigation	Significance	Mitigation	Residual impact
Harbour porpoise	Risk of PTS during underwater high-order UXO detonation of 25 kg	High	Negligible to low	Minor to moderate adverse	MMMP	Minor adverse (not significant)
Bottlenose dolphin			Negligible	Minor adverse		
White-beaked dolphin			Negligible	Minor adverse		
Common dolphin			Negligible	Minor adverse		
Minke whale			Negligible to low	Minor to moderate adverse		

2.1.2 PTS Assessment of 166kg UXO

The maximum number of harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale that could potentially be at risk of PTS during a 166kg UXO (+ donor charge) clearance, based on the maximum potential PTS impact ranges for a UXO high-order detonation are presented in Table 7.

The magnitude for bottlenose dolphin, white-beaked dolphin, common dolphin has been assessed as negligible for the PTS SPL_{peak} and weighted SEL criteria, based on the worst-case impact ranges identified in Table 3. A low magnitude was assessed for PTS (SPL_{peak}) in harbour porpoise and for minke whale for the weighted SEL criteria.

Table 7: The maximum number of animals that could be at risk of PTS from high-order clearance of a 166kg UXO (+ donor charge)			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
Harbour porpoise	PTS SPL_{peak} (246.6 km ²) unmitigated	362 harbour porpoise (0.1% of North Sea MU) based on site survey density 1.468/km ²	Medium magnitude (i.e. 0.01%-1% of the North Sea MU reference population anticipated to be exposed to the permanent impact).

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Table 7: The maximum number of animals that could be at risk of PTS from high-order clearance of a 166kg UXO (+ donor charge)			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
	PTS weighted SEL impulsive criteria (2.9 km ²) unmitigated	4.3 harbour porpoise (0.001% of North Sea MU) based on site survey density 1.468/km ²	Negligible magnitude (i.e. 0.001% or less of the North Sea MU reference population anticipated to be exposed to the permanent impact).
Bottlenose dolphin	PTS SPL _{peak} (0.8 km ²) unmitigated	0.003 bottlenose dolphin (0.0001% of CES MU) based on the density estimate of 0.0037/km ²	Negligible magnitude (i.e. 0.001% or less of the CES MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (0.004 km ²) unmitigated	0.00001 bottlenose dolphin (0.0000007% of CES MU) based on the density estimate of 0.0037/km ²	Negligible magnitude (i.e. 0.001% or less of the CES MU reference population anticipated to be exposed to the permanent impact).
White-beaked dolphin	PTS SPL _{peak} (0.8 km ²) unmitigated	0.01 white-beaked dolphin (0.0002% of CGNS MU) based on the density estimate of 0.123/km ²	Low magnitude (i.e. 0.01%-0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (0.004 km ²) unmitigated	0.0005 white-beaked dolphin (0.000001% of CGNS MU) based on the density estimate of 0.123/km ²	Negligible magnitude (i.e. 0.001% or less of the CES MU reference population anticipated to be exposed to the permanent impact).
Common dolphin	PTS SPL _{peak} (0.8 km ²) unmitigated	0.06 common dolphin (0.0001% of CGNS MU) based on the density estimate of 0.074 /km ²	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (0.004 km ²) unmitigated	0.0003 common dolphin (0.0000003% of CGNS MU) based on the density estimate of 0.074 /km ²	Negligible magnitude (i.e. 0.001% or less of the CGNS MU reference population anticipated to be exposed to the permanent impact).

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Table 7: The maximum number of animals that could be at risk of PTS from high-order clearance of a 166kg UXO (+ donor charge)			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
Minke whale	PTS SPL _{peak} (7.7 km ²) unmitigated	0.2 minke whale (0.0009% of CGNS MU) based on the density estimate of 0.023/km ²	Low magnitude (i.e. 0.01%-0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).
	PTS weighted SEL impulsive criteria (23.6 km ²) unmitigated	0.5 minke whale (0.003% of CGNS MU) based on the density estimate of 0.023/km ²	Low magnitude (i.e. 0.01%-0.001% of the North Sea MU reference population anticipated to be exposed to the permanent impact).

2.1.2.1 Assessment of Significance

The impact significance for any PTS in marine mammals has been assessed for a 166kg UXO in Table 8. Considering the negligible to medium magnitude for harbour porpoise, the potential impact significance for any PTS, is assessed as minor to major adverse. The significance of effect for minke whale, with a low magnitude, is likely to be moderate adverse, and the dolphin species, negligible to low magnitude, have the potential impact significance of less than minor adverse.

Taking into account the high sensitivity, proposed mitigation in the MMMP, the impact significance of the potential risk of physical injury and PTS to marine mammals a result of underwater UXO clearance is **minor adverse (not significant)**.

Table 8: Assessment of impact significance for PTS in the marine mammal species during high-order UXO detonation of a 166kg UXO (+ donor charge)						
Species	Potential Impact	Sensitivity	Magnitude without mitigation	Significance	Mitigation	Residual impact
Harbour porpoise	Risk of PTS during underwater high-order UXO detonation of 25-30 kg	High	Negligible to medium	Minor to major adverse	MMMP	Minor adverse (not significant)
Bottlenose dolphin			Negligible	Minor adverse		Minor adverse (not significant)

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Table 8: Assessment of impact significance for PTS in the marine mammal species during high-order UXO detonation of a 166kg UXO (+ donor charge)

Species	Potential Impact	Sensitivity	Magnitude without mitigation	Significance	Mitigation	Residual impact
White-beaked dolphin			Negligible to low	Minor to moderate adverse		Minor adverse (not significant)
Common dolphin			Negligible	Minor adverse		Minor adverse (not significant)
Minke whale			Low	Moderate adverse		Minor adverse (not significant)

2.2 TTS from UXO clearance

The maximum predicted impact ranges for TTS in harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale, from a 25kg and 166kg (+ donor charge) UXO are presented in Table 9 and Table 10 based on the underwater noise modelling for high-order detonation. This is very precautionary as the impact ranges are based on the worst-case scenario for the 89kg and 105 kg UXO (+ donor charge) device and the items that fall below the 25kg UXO (+ donor charge) that is present and that it is cleared using high-order detonation.

Table 9: The maximum predicted impact ranges (km) for TTS in marine mammals, based on the underwater noise modelling for high-order detonation for a 166 kg NEQ (+ donor charge)

Species	PTS Criteria and Threshold (Southall <i>et al.</i> , 2019)	166 kg
Harbour porpoise (VHF)	TTS SPL _{peak} 196 dB re 1 µPa Unweighted Impulsive criteria	16.3 km (836.7 km ²)
	TTS SEL 140 dB re 1 µPa ² s Weighted Impulsive criteria	5.1 km (80.1 km ²)
Bottlenose dolphin, white-beaked dolphin and common dolphin (HF)	TTS SPL _{peak} 224 dB re 1 µPa Unweighted Impulsive criteria	0.9 km (2.8km ²)
	TTS SEL 170 dB re 1 µPa ² s Weighted Impulsive criteria	0.2 km (0.1 km ²)
Minke whale (LF)	TTS SPL _{peak} 213 dB re 1 µPa Unweighted Impulsive criteria	2.9 km (26.2 km ²)

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Table 9: The maximum predicted impact ranges (km) for TTS in marine mammals, based on the underwater noise modelling for high-order detonation for a 166 kg NEQ (+ donor charge)		
Species	PTS Criteria and Threshold (Southall <i>et al.</i> , 2019)	166 kg
	TTS SEL 168 dB re 1 $\mu\text{Pa}^2\text{s}$ Weighted Impulsive criteria	14.4 km (653.3 km ²)

Table 10: The maximum predicted impact ranges (km) for TTS in marine mammals, based on the underwater noise modelling for high-order detonation for a 25 – 30 kg NEQ (+donor charge).				
Species	PTS Criteria and Threshold (Southall <i>et al.</i> , 2019)	Projects that assessed for 25 kg UXO (+ charge) NEQ and maximum predicted impact range (km) and area (km ²)		
		Erebus Offshore Wind (25kg)	Moray West UWN modelling 30kg (NEQ+ charge)	SEP/DEP UWN modelling 25.5kg (NEQ+ charge)
Harbour porpoise (VHF)	TTS SPL _{peak} 196 dB re 1 μPa Unweighted Impulsive criteria	8.5 km (227 km ²)	8.5 km (227 km ²)	9.1 km (260.2 km ²)
	TTS SEL 140 dB re 1 $\mu\text{Pa}^2\text{s}$ Weighted Impulsive criteria	2.4 km (18.1 km ²)	2.1 km (13.9 km ²)	2.4 km (18.1 km ²)
Bottlenose dolphin, white-beaked dolphin and common dolphin (HF)	TTS SPL _{peak} 224 dB re 1 μPa Unweighted Impulsive criteria	0.53 km (0.9 km ²)	0.49 km (0.8 km ²)	0.49 km (0.8 km ²)
	TTS SEL 170 dB re 1 $\mu\text{Pa}^2\text{s}$ Weighted Impulsive criteria	0.015 km (0.001 km ²)	0.08 km (0.02 km ²)	0.2 km (0.13 km ²)
Minke whale (LF)	TTS SPL _{peak} 213 dB re 1 μPa Unweighted Impulsive criteria	1.5 km (7.1 km ²)	1.5 km (7.1 km ²)	1.6 km (8.2 km ²)
	TTS SEL 168 dB re 1 $\mu\text{Pa}^2\text{s}$	29 km (2624.1 km ²)	6.1 (117.1 km ²)	29 km (2624.1 km ²)

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Table 10: The maximum predicted impact ranges (km) for TTS in marine mammals, based on the underwater noise modelling for high-order detonation for a 25 – 30 kg NEQ (+donor charge).

Species	PTS Criteria and Threshold (Southall <i>et al.</i> , 2019)	Projects that assessed for 25 kg UXO (+ charge) NEQ and maximum predicted impact range (km) and area (km ²)		
		Erebus Offshore Wind (25kg)	Moray West UWN modelling 30kg (NEQ+ charge)	SEP/DEP UWN modelling 25.5kg (NEQ+ charge)
	Weighted Impulsive criteria			

2.2.1 TTS Assessment of 25kg UXO

The maximum number of harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale that could potentially be at risk of TTS during a 25kg UXO (+ donor charge) clearance, based on the maximum potential TTS impact ranges for a UXO high-order detonation are presented in Table 11.

The magnitude for bottlenose dolphin, white-beaked dolphin, common dolphin has been assessed as negligible for the TTS SPL_{peak} and weighted SEL criteria, based on the worst-case impact ranges identified in Table 10. A low magnitude was assessed for PTS (SPL_{peak}) in harbour porpoise and for minke whale for the weighted SEL criteria.

Table 11: The maximum number of animals that could be at risk of TTS from high-order clearance of a 25kg (+ donor charge) UXO

Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
Harbour porpoise	TTS SPL _{peak} 196 dB re 1 µPa Unweighted Impulsive criteria (260.2 km ²)	382 harbour porpoise (0.1% of North Sea MU) based on site survey density 1.468/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 140 dB re 1 µPa ² s Weighted Impulsive criteria (18.1 km ²)	16.6 harbour porpoise (0.008% of North Sea MU) based on site survey density 1.468/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).

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Table 11: The maximum number of animals that could be at risk of TTS from high-order clearance of a 25kg (+ donor charge) UXO			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
Bottlenose dolphin	TTS SPL _{peak} 224 dB re 1 μPa Unweighted Impulsive criteria (0.9 km ²)	0.003 bottlenose dolphin (0.0002% of CES MU) based on the density estimate of 0.0037/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 170 dB re 1 μPa ² s Weighted Impulsive criteria (0.1 km ²)	0.0004 bottlenose dolphin (0.00002% of CES MU) based on the density estimate of 0.0037/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
White-beaked dolphin	TTS SPL _{peak} 224 dB re 1 μPa Unweighted Impulsive criteria (0.9 km ²)	0.1 white-beaked dolphin (0.0003% of CGNS MU) based on the density estimate of 0.123/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 170 dB re 1 μPa ² s Weighted Impulsive criteria (0.1 km ²)	0.01 white-beaked dolphin (0.00003% of CGNS MU) based on the density estimate of 0.123/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
Common dolphin	TTS SPL _{peak} 224 dB re 1 μPa Unweighted Impulsive criteria (0.9 km ²)	0.07 common dolphin (0.0001% of CGNS MU) based on the density estimate of 0.074 /km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 170 dB re 1 μPa ² s Weighted Impulsive criteria (0.1 km ²)	0.01 common dolphin (0.00001% of CGNS MU) based on the density estimate of 0.074 /km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).

Table 11: The maximum number of animals that could be at risk of TTS from high-order clearance of a 25kg (+ donor charge) UXO			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
Minke whale	TTS SPL _{peak} 213 dB re 1 µPa Unweighted Impulsive criteria (8.2 km ²)	0.2 minke whale (0.0009% of CGNS MU) based on the density estimate of 0.023/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 168 dB re 1 µPa ² s Weighted Impulsive criteria (2642.1 km ²)	61 minke whale (0.3% of CGNS MU) based on the density estimate of 0.023/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).

2.2.1.1 Assessment of Significance

The impact significance for any TTS in marine mammals has been assessed for a 25kg UXO in Table 12. Considering the high sensitivity and the negligible magnitude for all marine mammals the potential impact significance for any TTS is assessed as minor adverse. With the proposed mitigation in the MMMP, the impact significance of the potential risk of TTS to marine mammals a result of underwater UXO clearance is **minor adverse (not significant)**.

Table 12: Assessment of impact significance for TTS in the marine mammal species during high-order UXO detonation of a 25kg (+ donor charge) UXO						
Species	Potential Impact	Sensitivity	Magnitude without mitigation	Significance	Mitigation	Residual impact
All marine mammals	Risk of TTS during underwater high-order UXO detonation of 25-30 kg	High	Negligible	Minor Adverse	MMMP	Minor adverse (not significant)

2.2.2 TTS Assessment of 166kg UXO

The maximum number of harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale that could potentially be at risk of TTS during a 166kg UXO (+ donor charge) clearance, based on the maximum potential TTS impact ranges for a UXO high-order detonation are presented in Table 13.

The magnitude for all marine mammal species have been assessed as negligible for the TTS SPL_{peak} and weighted SEL criteria, based on the worst-case impact ranges identified in Table 9.

Table 13: The maximum number of animals that could be at risk of TTS from high-order clearance of a 166kg UXO (+ donor charge)			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
Harbour porpoise	TTS SPL _{peak} 196 dB re 1 µPa Unweighted Impulsive criteria (836.7 km ²)	1228 harbour porpoise (0.35% of North Sea MU) based on site survey density 1.468/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 140 dB re 1 µPa ² s Weighted Impulsive criteria (80.1 km ²)	118 harbour porpoise (0.034% of North Sea MU) based on site survey density 1.468/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
Bottlenose dolphin	TTS SPL _{peak} 224 dB re 1 µPa Unweighted Impulsive criteria (2.8 km ²)	0.01bottlenose dolphin (0.005% of CES MU) based on the density estimate of 0.0037/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 170 dB re 1 µPa ² s Weighted Impulsive criteria (0.1 km ²)	0.0004 bottlenose dolphin (0.0002% of CES MU) based on the density estimate of 0.0037/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
White-beaked dolphin	TTS SPL _{peak} 224 dB re 1 µPa Unweighted Impulsive criteria (2.8 km ²)	0.3 white-beaked dolphin (0.0008% of CGNS MU) based on the density estimate of 0.123/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).

Table 13: The maximum number of animals that could be at risk of TTS from high-order clearance of a 166kg UXO (+ donor charge)			
Species	PTS criteria and maximum impact area	Maximum number of harbour porpoise and % of reference population based on maximum potential impact area	Magnitude
	TTS SEL 170 dB re 1 $\mu\text{Pa}^2\text{s}$ Weighted Impulsive criteria (0.1 km ²)	0.01 white-beaked dolphin (0.00003% of CGNS MU) based on the density estimate of 0.123/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
Common dolphin	TTS SPL _{peak} 224 dB re 1 μPa Unweighted Impulsive criteria (2.8 km ²)	0.2 common dolphin (0.0002% of CGNS MU) based on the density estimate of 0.074 /km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 170 dB re 1 $\mu\text{Pa}^2\text{s}$ Weighted Impulsive criteria (0.1 km ²)	0.007 common dolphin (0.00001% of CGNS MU) based on the density estimate of 0.074 /km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
Minke whale	TTS SPL _{peak} 213 dB re 1 μPa Unweighted Impulsive criteria (26.1 km ²)	0.6 minke whale (0.003% of CGNS MU) based on the density estimate of 0.023/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).
	TTS SEL 168 dB re 1 $\mu\text{Pa}^2\text{s}$ Weighted Impulsive criteria (653.3 km ²)	15 minke whale (0.07% of CGNS MU) based on the density estimate of 0.023/km ²	Negligible magnitude (i.e. less than 1% of the North Sea MU reference population anticipated to be exposed to the temporary impact).

2.2.2.1 Assessment of Significance

The impact significance for any TTS in marine mammals has been assessed for a 166kg UXO in Table 14. Considering the high sensitivity and the negligible magnitude for all marine mammals the potential impact significance for any TTS is assessed as minor adverse. With the proposed mitigation in the MMMP, the impact significance of the potential risk of TTS to marine mammals a result of underwater UXO clearance is **minor adverse (not significant)**.

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Table 14: Assessment of impact significance for TTS in the marine mammal species during high-order UXO detonation of a 166kg (+ donor charge) UXO						
Species	Potential Impact	Sensitivity	Magnitude without mitigation	Significance	Mitigation	Residual impact
All marine mammals	Risk of TTS during underwater high-order UXO detonation of 166 kg	High	Negligible	Minor Adverse	MMMP	Minor adverse (not significant)

3 Low-Order Clearance

Alternative techniques to high-order clearance are emerging. One of these is low-order deflagration, intended to result in a ‘low order’ burn of the explosive material in a UXO, which destroys but does not detonate the internal explosive. Where the UXO device cannot be moved, deflagration represents the best-case scenario in respect to environmental effects.

A risk assessment for low-order clearances with an explosive charge of 0.25kg and 2kg has been assessed for all marine mammals in the UXO Clearance EPS Risk Assessment (document reference: 8460005-DG0207-MWW-REP-000002 Rev 04 dated 7 February 2023). Refer to Section 4.2 PTS from UXO Clearance and Section 4.3 TTS from UXO Clearance to find a detailed risk assessment for PTS and TTS, respectively. In summary, the assessment showed that the risk of PTS during underwater low-order UXO clearance was **negligible to low** (see Table 15).

The MMMP (document reference: 8460005-DG0207-MWW-REP-000002 Rev04 dated 7 February; Appendix B) outlines the mitigation measures to reduce the risk of PTS in marine mammals which would result in a residual impact of **minor (not significant)** and also reduces the number of animals at risk of TTS. Using low-order clearance such as deflagration would further reduce the impact ranges for marine mammals.

Table 15: Summary of impact significance for PTS in marine mammals during low-order UXO clearance						
Species	Potential Impact	Sensitivity	Magnitude	Significance	Mitigation	Residual impact
Harbour porpoise	Risk of PTS during underwater low-order UXO clearance	High	Low to Negligible	Moderate to Minor adverse	MMMP	Minor (not significant)
Dolphin species			Negligible	Minor		
Minke whale			Negligible	Minor		

4 Potential Effects on Designated Sites

The UXO Clearance EPS Risk Assessment (document reference: 8460005-DG0207-MWW-REP-000002 Rev04 dated 7 February 2023; Section 5) details the potential effects on designated sites. In summary, the assessments indicated that through the application of mitigation as outlined in the MMMP (8460005-DG0207-MWW-REP-000002 Rev04 dated 7 February, Appendix B) there is **no potential Adverse Effect on Site Integrity (AEoSI) of the Moray Firth SAC in relation to the conservation objectives for bottlenose dolphin** as a result of any disturbance from underwater noise during UXO clearance. Furthermore, there is **no potential AEoSI of the Dornoch Firth and Morrich More SAC in relation to the conservation objectives for harbour seal** as a result of any disturbance from underwater noise during UXO clearance.

In the case of the Southern Trench NCMMPA, the number of minke whale that could potentially be disturbed due to the UXO clearance, based on the precautionary 5 km disturbance range¹, is less than 2 animals (0.24% of estimated Moray Firth population), but there is **no potential AEoSI of the Southern Trench NCMMPA in relation to the conservation objectives for minke whale**. The recent findings of confirmed UXOs (Figure 1) to date have identified one UXO item, an air-dropped 500lb mine, which overlaps with the Southern Trench MPA. The removal of this UXO item would be one of the first ones to be disposed of in April, to avoid disturbance of minke whale present in the Moray Firth, primarily in the summer months (June – September) (Reid *et al.*, 2003; Hammond *et al.*, 2021).

¹<https://www.nature.scot/sites/default/files/2019-06/Southern%20Trench%20possible%20MPA%20-%20Conservation%20and%20Management%20Advice.pdf>

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5 References

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