# Appendix 10-7:
# NAS Technical Report - Marine Mammals, Megafauna and Fish

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

rps A TETRA TECH COMPANY

JERA NEX BP

ESB Energy for generations

C1 – Public

# ORIEL WIND FARM PROJECT

## Environmental Impact Assessment Report - Addendum
## Appendix 10-7: Noise Abatement System (NAS) Technical Report - Marine Mammals, Megafauna and Fish

MDR1520C
EIAR
Appendix 10-7
A1 C01
December 2025

rpsgroup.com

# Contents



## Figures



## Tables

# Acronyms

| Term | Meaning |
|---|---|
| ADD | Acoustic Deterrent Device |
| CGNS | Celtic and Greater North Seas |
| CIS | Celtic and Irish Sea |
| DBBC | Double Big Bubble Curtain |
| HF | High Frequency |
| LF | Low Frequency |
| MU | Management Unit |
| NAS | Noise Abatement System |
| N/E | Not Exceeded |
| NMFS | National Marine Fisheries Service |
| PCW | Phocid Carnivore in Water |
| PTS | Permanent Threshold Shift |
| RFI | Request for Further Information |
| RMS (rms throughout) | Root Mean Square |
| SCANS | Small Cetacean in European Atlantic Waters and the North Sea |
| SEL | Sound Exposure Level |
| SPL | Sound Pressure Level |
| TTS | Temporary Threshold Shift |
| VHF | Very High Frequency |

# Units

| Unit | Description |
|---|---|
| m | Metre (distance) |
| km | Kilometre (distance) |
| $km^2$ | Kilometres squared (area) |
| dB | Decibel |
| μPa | Micropascal |
| $μPa^2s$ | Micropascals squared per second |
| s | Second |
| % | Percentage |

# 1 INTRODUCTION

This Technical Report has been prepared in response to a Request for Further Information (RFI) from An Coimisiún Pleanála (formerly An Bord Pleanála) regarding the planning application (case reference ABP-319799-24) for the Oriel Wind Farm Project (hereafter referred to as "the Project"). The report sets out an overview of the Noise Abatement Systems (NAS) scenarios modelled (section 2) (also see appendix 10-6: NAS Modelling Report); the NAS modelling results for marine mammals (section 3.1) and for fish and shellfish (section 3.2); and overall conclusions (section 4).

This technical report provides a response to RFI 9.A.iii Marine Mammals & Megafauna – Underwater Noise – Mitigation & Noise Abatement, which requested "*Revised noise modelling and mapping which provides detailed consideration of the noise abatement strategy selected in response to (ii) above and include:*

- *a. The modelled peak sound pressure level ($SPL_{pk}$) and Sound Exposure Level ($SEL_{cum}$) Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) contours for each functional hearing group potentially present, emanating from the existing locations proposed in the application at the periphery of the proposed development to demonstrate the full potential spatial extent of underwater noise propagation. Modelling must also show the noise level ($SPL_{pk}$, $SEL_{ss}$) at 750 m from the locations of each of the piling activities selected.*

- *b. The modelled $SEL_{ss}$ contours for 120-180 dB re 1µPa$^2$s at 5 dB increments at the locations in (a) above. Mapping provided must show the relevant noise contours in the context of implementing the abatement technologies/ measures identified at (i) above and should be displayed alongside the noise contours in the absence of any such noise abatement measures being implemented.*

- *c. Revised details showing the change in total impacted individuals of each species before and after consideration of noise abatement technologies.*

- *d. Modelling must be performed for monopiles and pin piles, as both are under consideration within the project design envelope.*

- *e. Any additional abatement and/or mitigation measures should also be considered where practicable in terms of their potential for reduction of cumulative effects with other projects in terms of underwater noise."*

The modelled $SPL_{pk}$ and $SEL_{cum}$ PTS and TTS contours/ranges (request 'a') are presented for marine mammals in section 3.1.1, and mortality, recoverable injury, and TTS ranges for fish and shellfish are presented in section 3.2.1.

The noise levels ($SPL_{pk}$, $SEL_{ss}$) at 750 m from the locations of each of the piling activities selected (also request for further information 'a' above) are presented in appendix 10-6: NAS Modelling Report, for scenarios with and without mitigation, and are not repeated in this report.

The modelled $SEL_{ss}$ contours for 120-180 dB re 1µPa$^2$s at 5 dB increments (request or further information 'b' above) are presented for marine mammals in section 3.1.2, alongside modelled $SPL_{pk}$ contours for 150-200 dB re 1 µPa at 5 dB increments which are presented for fish in section 3.2.2.

Revised details showing the change in total impacted individuals of each species before and after consideration of noise abatement technologies (request 'c') are presented in respective sections for marine mammals (sections 3.1).

Modelling has been performed for monopiles only (request 'd') for a range of NAS scenarios (request 'e') - it should be noted that pin piles are not proposed for the Project and therefore have not been considered.

It is also noted that any reduction in underwater noise impacts by the application of NAS will have inherent reductions on potential cumulative effects with other projects, but this has not been considered quantitatively in this report (beyond the consideration of a range of NAS scenarios).

RFI 9.A.ii referred to in 9.A.iii requested:

- "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 $SEL_{ss}$ and 190 dB re 1 µPa $SPL_{pk}$ thresholds that must not be exceeded at a distance of 750m from a piling site; or the or the frequency weighted $SEL_{cum}$ 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."

RFI 10.F.vi for fish and shellfish receptors is also addressed in this report, which requested:

- "Given the extensive distance of TTS on fish with a swim bladder used in hearing, the location of sensitive Atlantic spawning herring grounds within the boundary of the site, and the sensitivities of the species in terms of their spawning habitat in the region, the applicant is requested to assess the possibility for the use of NAS to reduce the spatial impact of underwater noise associated with impact piling beyond the soft start procedures."

# 2 SCENARIOS MODELLED

The impact piling scenarios are modelled as a single impact pile unmitigated and with noise abatement at the east piling location. Two mitigation methods were considered against the unmitigated base scenario; the PULSE[1] in-line hammer noise reduction unit and a double big bubble curtain (DBBC[2]). These scenarios are outlined in Table 2-1.

The swim speeds used in the estimation of cumulative sound exposure ($SEL_{cum}$) for the species likely to be present in the vicinity of the Project are the same as those used in chapter 10: Marine Mammals and Megafauna (EIAR volume 2B).

**Table 2-1: Summary of modelling scenarios.**

| Scenario | Description |
|---|---|
| Unmitigated | Unmitigated scenario of piling of monopile at the east of the offshore wind farm area. |
| PULSE | Mitigated piling with use of in-line hammer noise reduction unit (PULSE) at the east of the offshore wind farm area. |
| DBBC | Mitigated piling with use of DBBC at the east of the offshore wind farm area. |

## 2.1 Marine mammals

Auditory injury (PTS) and TTS from impact piling of monopiles was modelled using a dual metric approach (SEL and $SPL_{pk}$) at the east location for scenarios with and without NAS, with results in terms of both injury/TTS ranges and the numbers of animals potentially impacted presented in section 3.1.1. The unmitigated scenario is based upon the revised updated underwater noise modelling (see appendix 10-4: Updated Subsea Noise Modelling Report).

For disturbance, $SEL_{ss}$ contours in 120-180 dB re 1µ$Pa^2$s at 5 dB increments were also modelled both with and without NAS. Results are presented in section 3.1.2, demonstrating the changes in total impacted numbers of animals per species with the inclusion of NAS.

## 2.2 Fish and shellfish

Impact piling of monopiles was modelled at the east location for scenarios with and without NAS, with results for mortality, recoverable injury, TTS presented in section 3.2.1 and behavioural disturbance presented in section 3.2.2. Modelling was conducted for all fish groups (defined in Popper *et al.* (2014) as four groups of fish with increasing sensitivity to underwater sound based on physiological adaptations) for all scenarios. Modelling was conducted for the unmitigated, PULSE mitigated, and DBBC mitigated scenarios using the dB re 1 µ$Pa^2$s $SEL_{cum}$ metric for impact thresholds for mortality, injury, and TTS. For an assessment of behavioural disturbance an $SPL_{pk}$ metric (dB re 1 µPa) was applied as contours in 5 dB increments for all fish groups. The conservative 160 dB re 1 µPa $SPL_{pk}$ behavioural disturbance threshold was applied to assess areas of overlap with herring nursery grounds, as the highest sensitivity fish species (group 4 herring *Clupea harengus*). This species was identified as an important ecological feature within chapter 9: Fish and shellfish ecology (EIAR volume 2B).

For ease of presentation of approach to noise modelling, note that basking shark and sea turtle have been included in the fish and shellfish sections as opposed to the marine mammal section (as presented in chapter 10: Marine Mammals and Megafauna (EIAR volume 2B).

[1] PULSE mitigation comprises an add-on to existing hammer technologies that consists of two plungers with a fluid layer in-between, the use of which can reduce the SEL of conventional hammers by 6-9 dB and the SPL by up to 9-12 dB (https://iqip.com/pulse/

[2] Two layers of air bubble production hoses deployed surrounding the installation activity to absorb the sound from piling produced and reduce the noise entering the wider environment.

## 2.3 Project bespoke system

As outlined in chapter 5 Addendum: Project Description (EIAR volume 2A Addendum) and appendix 10-6: NAS Modelling report (EIAR volume 2B Addendum), the Applicant proposes to use a system (known as the MODIGA), which will be fitted with an internal air bubble ring to provide underwater noise reduction during piling (see chapter 9 Addendum: Fish and Shellfish Ecology and chapter 10 Addendum: Marine Mammals and Megafauna).

While the assessment of injury and/or disturbance to marine megafauna from underwater noise and fish during pile driving in the EIAR concluded no significant impact, in an abundance of caution, the Project is committed to the use of noise abatement measures for the purpose of reducing sound levels from construction piling and will use a MODIGA with internal air bubble ring as its noise abatement system to provide reduction in underwater noise during impact piling.

It was not possible to model the precise level of reduction of noise levels at this stage as this system will be bespoke to the Project, however, a noise modelling study was undertaken for a range of NAS options to demonstrate the efficacy of applying commercially available NAS technology during piling at the Project, and it is anticipated the MODIGA will result in a noise abatement (compared to an unmitigated piling scenario) similar to other casing systems.

# 3 RESULTS

## 3.1 Marine mammals

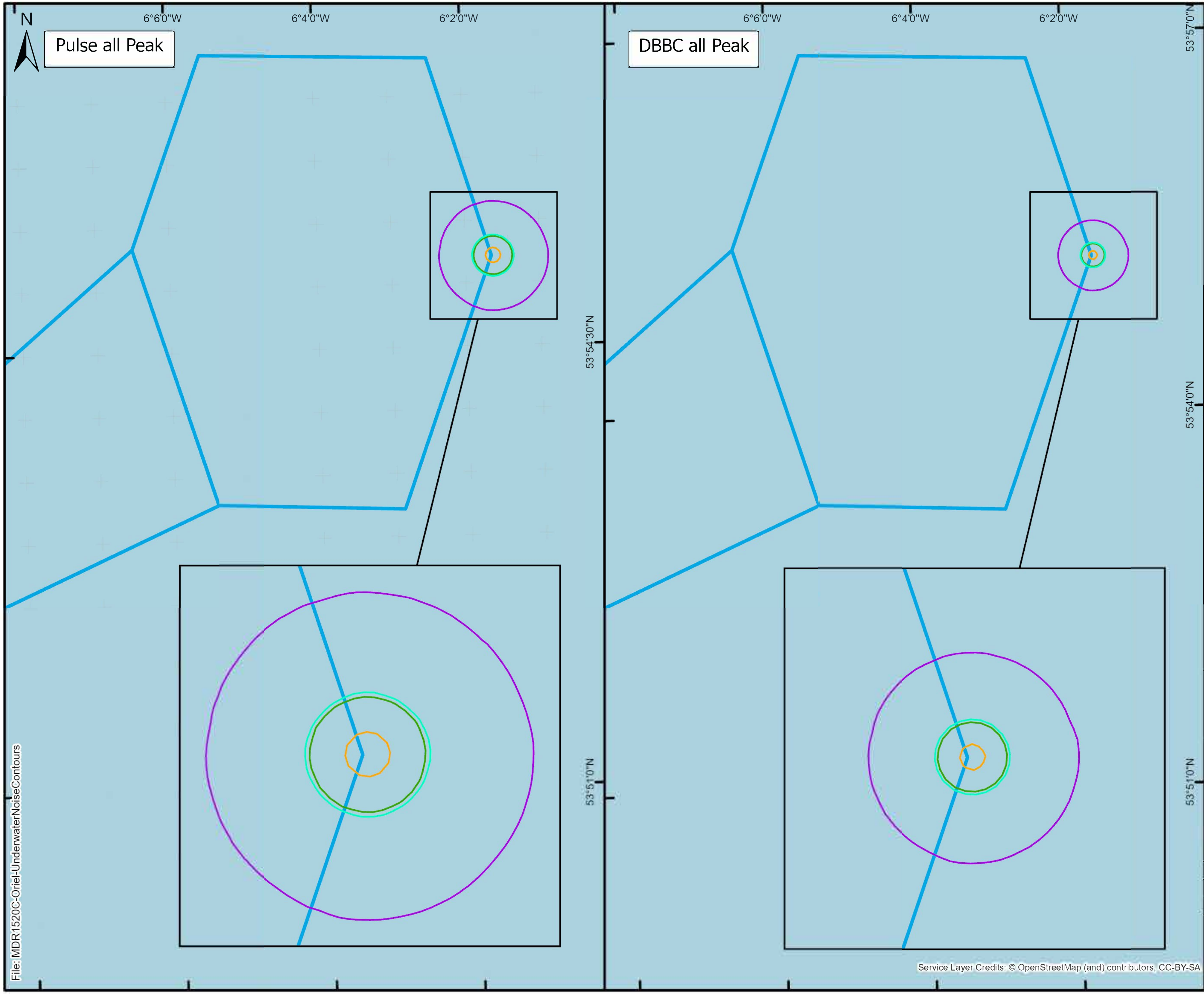
### 3.1.1 Auditory Injury (PTS) and TTS

All impact piling ranges for auditory injury (PTS) and TTS are based on a comparison to the relevant impulsive sound thresholds from Southall *et al.* (2019). The injury ranges for $SEL_{cum}$ and $SPL_{pk}$ are both modelled for PTS and TTS (Figure 3-1 to Figure 3-4). Impact ranges for mammals for $SEL_{cum}$ without an Acoustic Deterrent Device (ADD) and with 15 minutes of ADD are presented in Table 3-1 and Table 3-2 respectively. Impact ranges for mammals for $SPL_{pk}$ for the first hammer strike and maximum hammer energy are presented in Table 3-3.

**Table 3-1: Potential auditory injury (PTS) and TTS ranges for marine mammals from installation of a single pile based on the $SEL_{cum}$ metric, without ADD.**

| Species / Group | Threshold, $SEL_{cum}$ (dB re 1 µPa²s) | Range (m) | | |
|---|---|---|---|---|
| | | Unmitigated | PULSE | DBBC |
| Low Frequency (LF) | PTS – 183 dB re 1 µPa²s | 1,135 | 635 | 98 |
| | TTS – 168 dB re 1 µPa²s | 21,500 | 16,500 | 1,145 |
| High Frequency (HF) | PTS – 185 dB re 1 µPa²s | N/E | N/E | N/E |
| | TTS – 170 dB re 1 µPa²s | 21 | 19 | <curtain |
| Very High Frequency (VHF) | PTS – 155 dB re 1 µPa²s | 815 | 454 | 280 |
| | TTS – 140 dB re 1 µPa²s | 14,500 | 7,720 | 2,050 |
| Phocid Carnivore in Water (PCW) | PTS – 185 dB re 1 µPa²s | 11 | N/E | <curtain |
| | TTS – 170 dB re 1 µPa²s | 5,520 | 2,470 | <curtain |

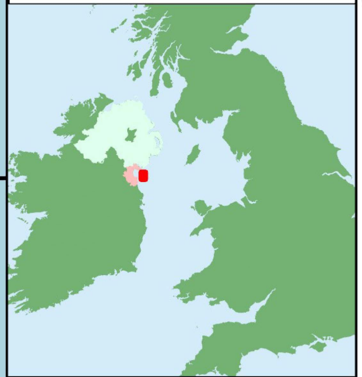
N/E = threshold not exceeded, < curtain = injury range contained within DBBC.




## Legend

- Application Boundary
- VHF cetaceans (202 dB re 1 μPa (pk))
- HF cetaceans (230 dB re 1 μPa (pk))
- LF cetaceans (219 dB re 1 μPa (pk))
- Pinnipeds (218 dB re 1 μPa (pk))

**Data Sources:** Client, Marine Scotland



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

**Oriel Wind Farm Project**

Title Figure 3-1

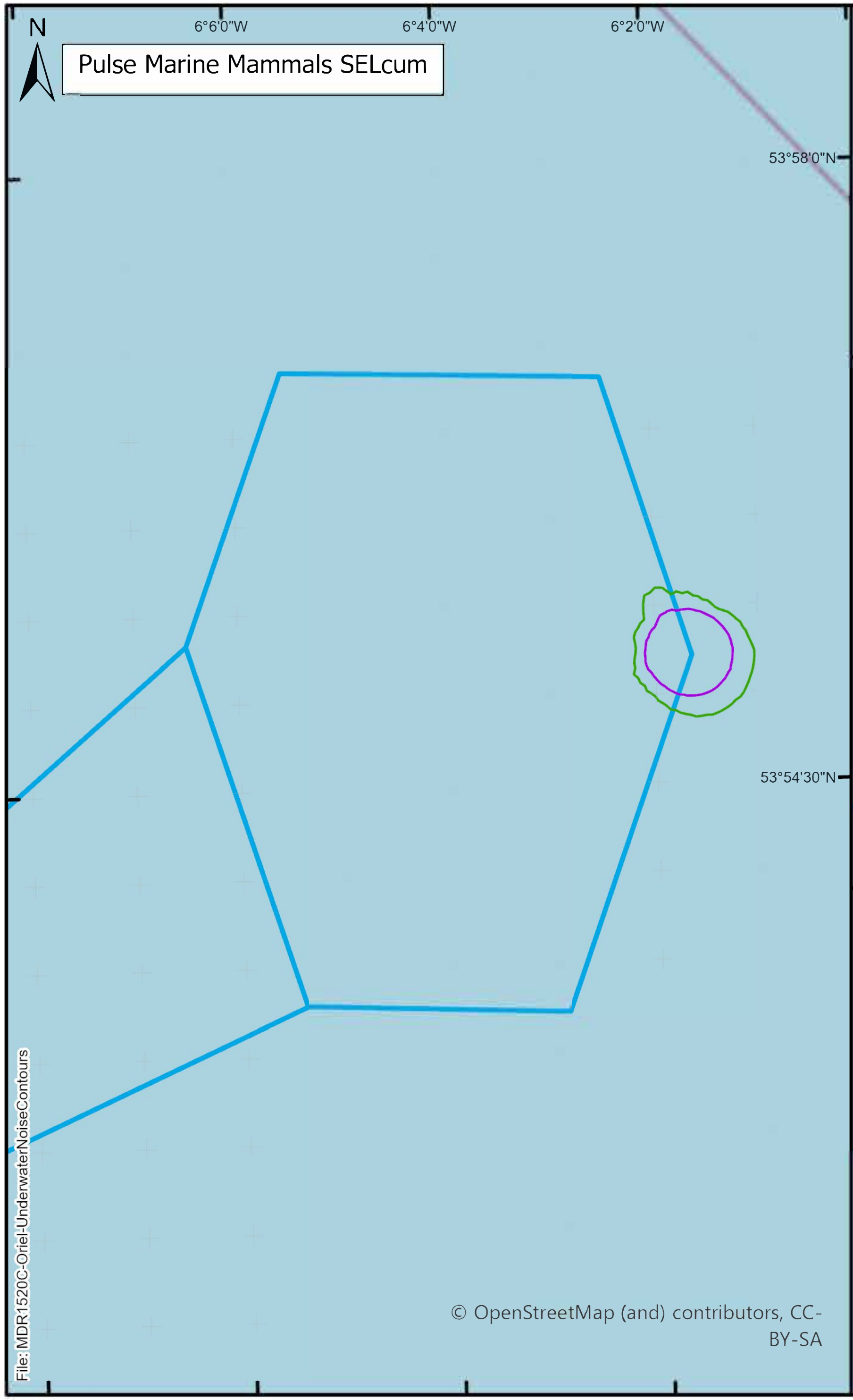
**PTS contours for single piling with PULSE and single piling with DBBC, for the SPLpk metric.**

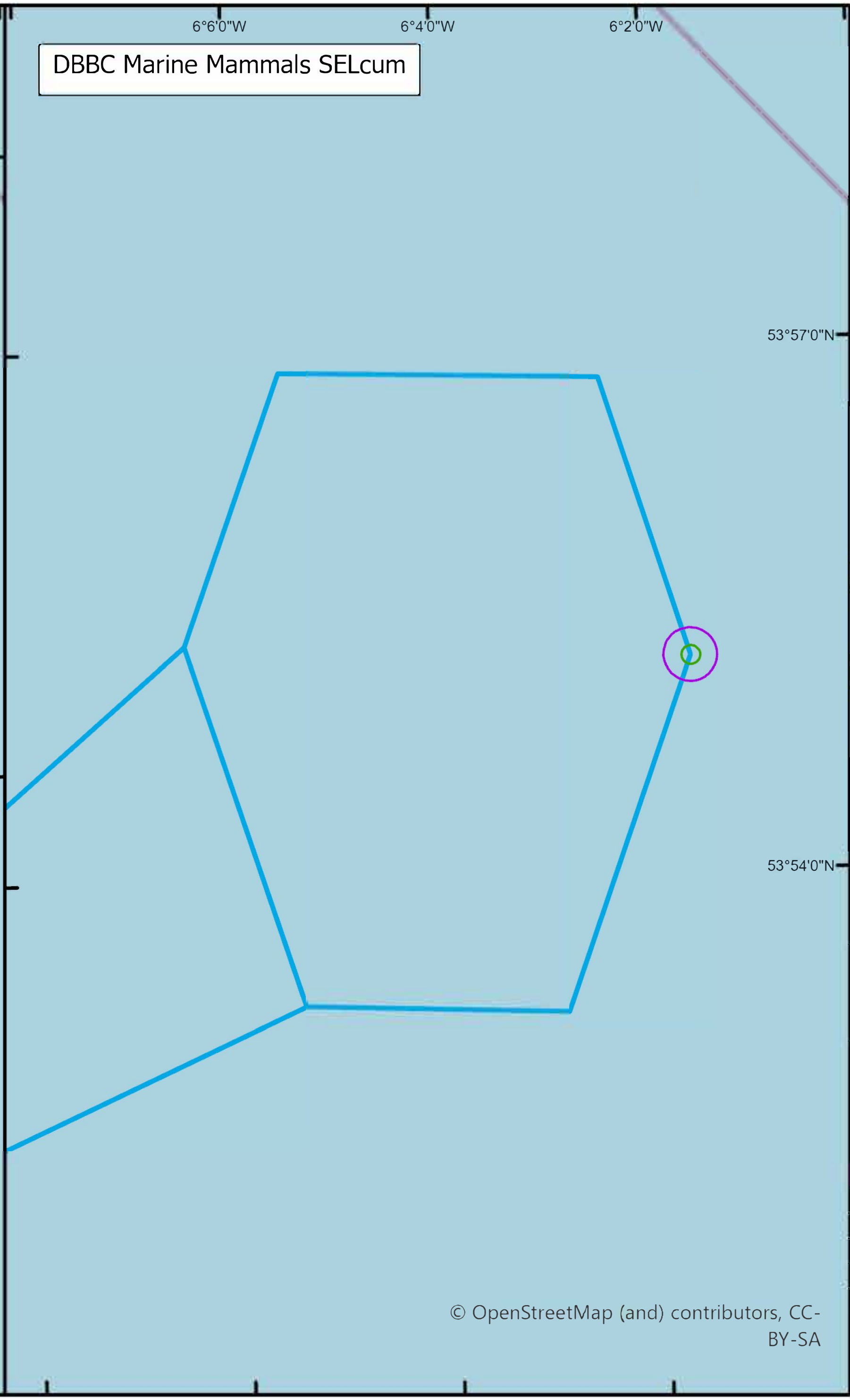
West Pier Business Campus,
Dun Laoghaire,
Co Dublin,
Ireland.

Tel: +353 (0) 1 4882900
Email: ireland@rpsgroup.com
Web Page: rpsgroup.com/ireland

***Issue Details***

| | |
|---|---|
| **Drawn By:** MJ/LM | **Project No.** MDR1520C |
| **Checked By:** BP/LB | **File Ref:** MDR1520C-UWN-004-01 |
| **Approved By:** BP/LB | |
| **Scale:** 1:75,000 @A4 | **Projection:** ITM (IRENET95) Geographic Co-ordinates: ETRS89 |
| **Date:** 29/08/2025 | |

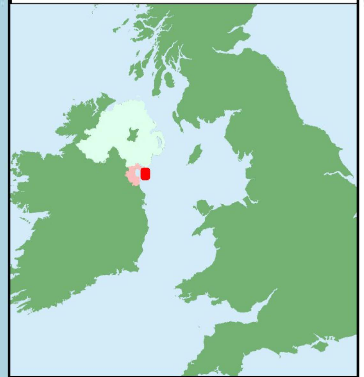



## Legend

- Application Boundary
- VHF cetaceans (155 dB re 1 μPa2s)
- LF cetaceans (183 dB re 1 μPa2s)

**Data Sources:** Client. Marine Scotland



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

# Oriel Wind Farm Project

Title Figure 3-2

**PTS contours for single piling with PULSE and single piling with DBBC, for the SELcum metric.**


A TETRA TECH COMPANY

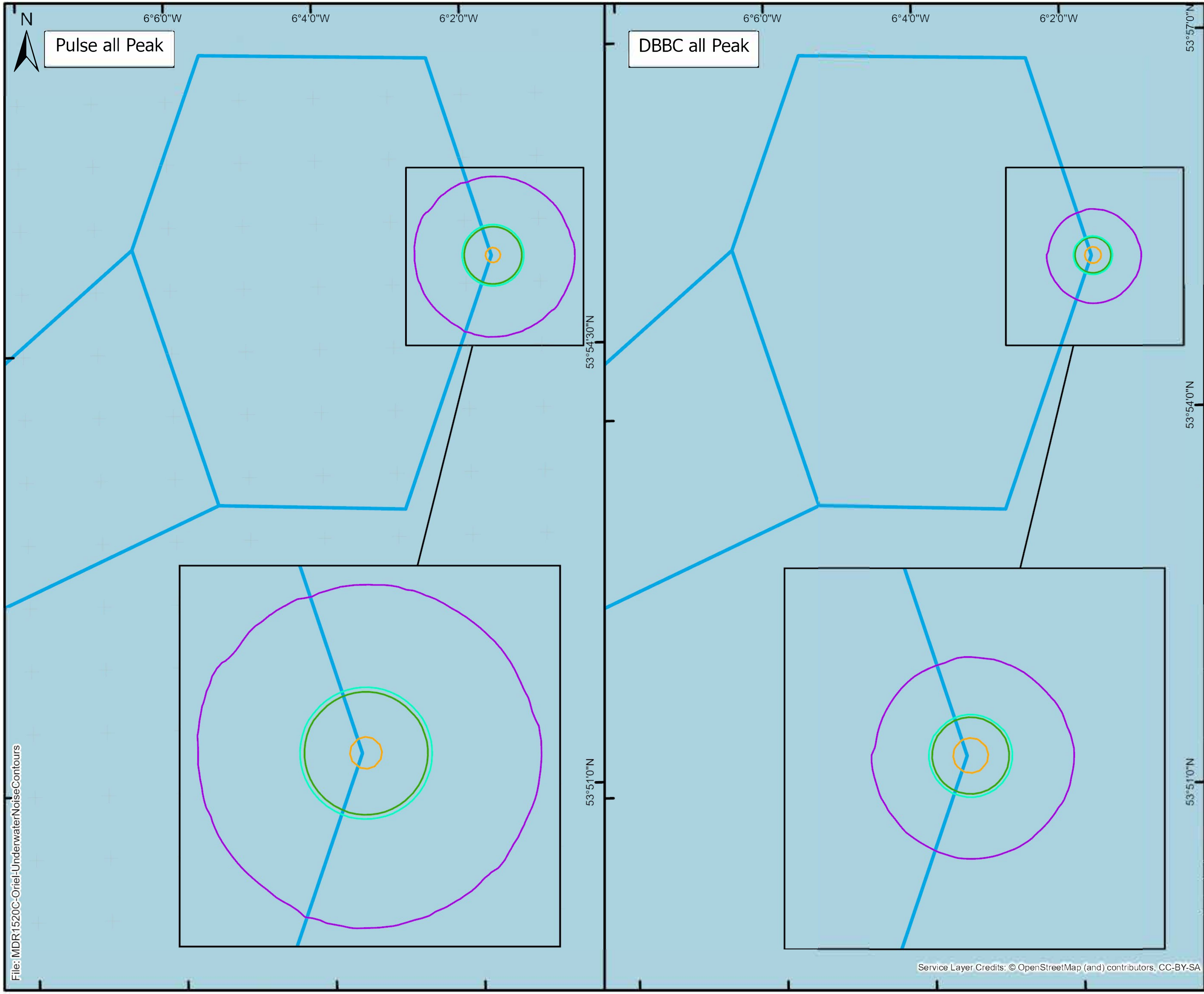
West Pier Business Campus,
Dun Laoghaire,
Co Dublin,
Ireland.

Tel: +353 (0) 1 4882900
Email: ireland@rpsgroup.com
Web Page: rpsgroup.com/ireland


*Issue Details*

| | |
|---|---|
| **Drawn By:** MJ | **Project No.** MDR1520C |
| **Checked By:** MJ | **File Ref:** MDR1520C-UWN-005-00 |
| **Approved By:** BP | |
| **Scale:** 1 75,000 @ A4 | **Projection:** ITM (IRENET95) Geographic Co-ordinates ETRS89 |
| **Date:** 19/08/2025 | |

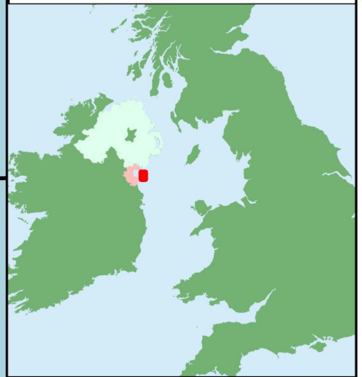
**NOTE:** 1. This drawing is the property of RPS Group Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent.
2. All levels are referred to Ordnance Datum, Malin Head.




## Legend

- Application Boundary
- VHF cetaceans (196 dB re 1 μPa (pk))
- HF cetaceans (224 dB re 1 μPa (pk))
- LF cetaceans (213 dB re 1 μPa (pk))
- Pinnipeds (212 dB re 1 μPa (pk))

**Data Sources:** Client, Marine Scotland



**Client**

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

**Project**

## Oriel Wind Farm Project

**Title** Figure 3-3

**TTS contours for single piling with PULSE and single piling with DBBC, for the SPLpk metric**

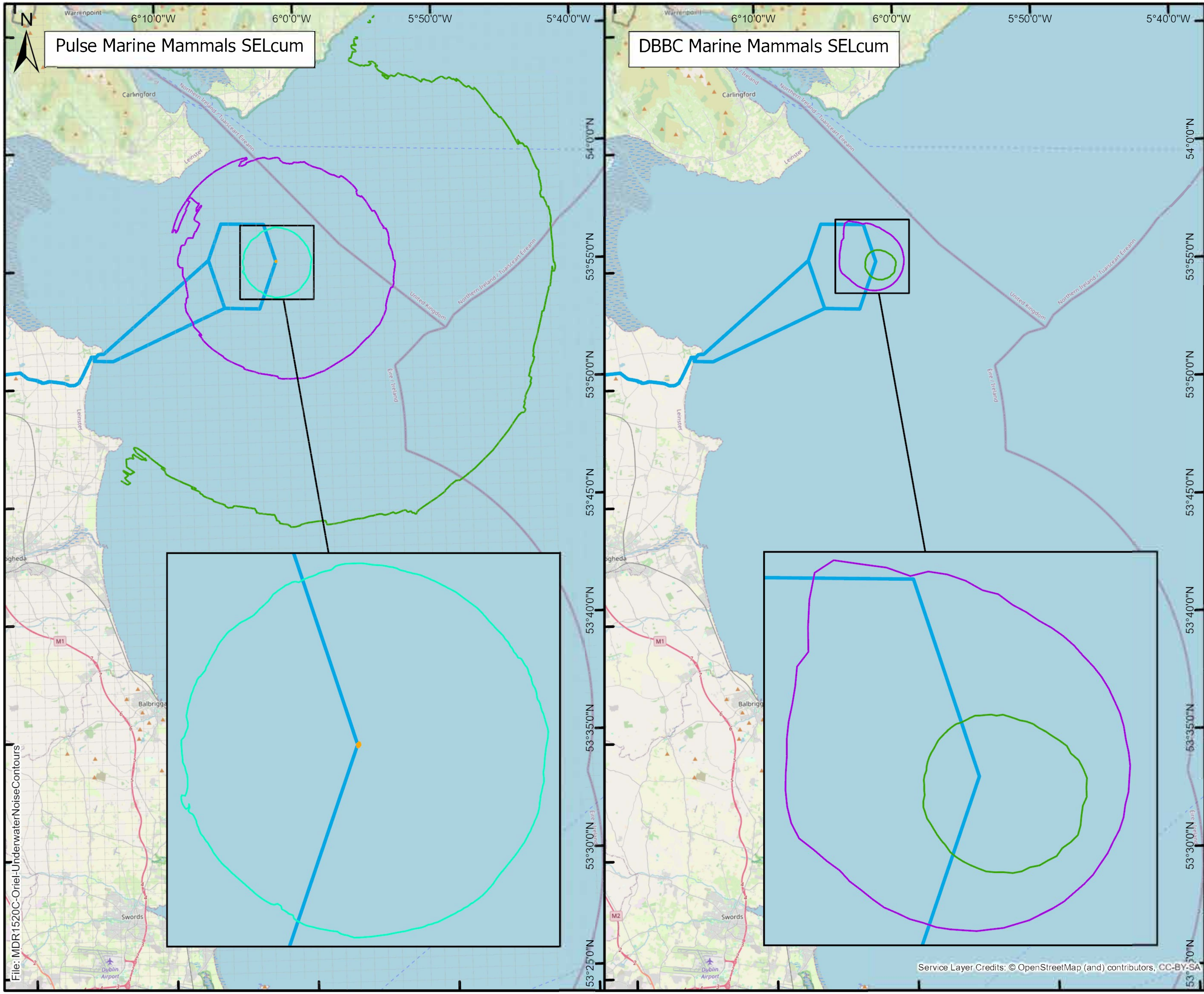

West Pier Business Campus,
Dun Laoghaire,
Co Dublin,
Ireland.

Tel: +353 (0) 1 4882900
Email: ireland@rpsgroup.com
Web Page: rpsgroup.com/ireland


***Issue Details***

| | |
|---|---|
| **Drawn By:** MJ/LM | **Project No.** MDR1520C |
| **Checked By:** BP/LB | **File Ref:** MDR1520C-UWN-006-01 |
| **Approved By:** BP/LB | |
| **Scale:** 1:75,000 @ A4 | **Projection:** ITM (IRENET95) Geographic Co-ordinates: ETRS89 |
| **Date:** 29/08/2025 | |

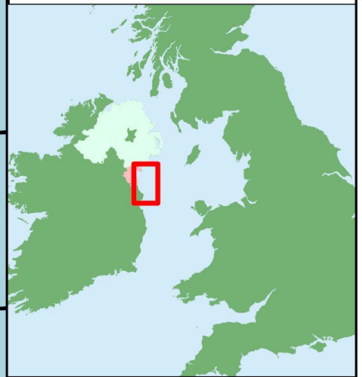
**NOTE:**
1. This drawing is the property of RPS Group Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent
2. All levels are referred to Ordnance Datum, Malin Head
3. Ordnance Survey Ireland Licence EN 0005019 ©Copyright Government of Ireland




## Legend

- Application Boundary
- VHF cetaceans (140 dB re 1 µPa2s)
- HF cetaceans (170 dB re 1 µPa2s)
- LF cetaceans (168 dB re 1 µPa2s)
- Pinnipeds (170 dB re 1 µPa2s)

**Data Sources:** Client, Marine Scotland



**Client**

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

**Project**

## Oriel Wind Farm Project

**Title** Figure 3-4

**TTS contours for single piling with PULSE and single piling with DBBC, for the SELcum metric**

West Pier Business Campus,
Dun Laoghaire,
Co Dublin,
Ireland.

Tel: +353 (0) 1 4882900
Email: ireland@rpsgroup.com
Web Page: rpsgroup.com/ireland

**Issue Details**

| | | | |
|---|---|---|---|
| Drawn By: | MJ/LM | Project No. | MDR1520C |
| Checked By: | BP/LB | File Ref: | |
| Approved By: | BP/LB | | MDR1520C-UWN-007-01 |
| Scale: | 1:400,000 @ A4 | Projection: | ITM (IRENET95) |
| Date: | 29/08/2025 | | Geographic Co-ordinates: ETRS89 |

**Table 3-2: Potential auditory injury (PTS) and TTS ranges for marine mammals from installation of a single pile based on the $SEL_{cum}$ metric, with 15 minutes ADD.**

| Species / Group | Threshold, SEL (dB re 1 µPa²s) | Range (m) | | |
|---|---|---|---|---|
| | | Unmitigated | PULSE | DBBC |
| LF | PTS – 183 dB re 1 µPa²s | N/E | N/E | N/E |
| | TTS – 168 dB re 1 µPa²s | 19,500 | 15,000 | <curtain |
| HF | PTS – 185 dB re 1 µPa²s | N/E | N/E | N/E |
| | TTS – 170 dB re 1 µPa²s | N/E | N/E | N/E |
| VHF | PTS – 155 dB re 1 µPa²s | N/E | N/E | N/E |
| | TTS – 140 dB re 1 µPa²s | 13,000 | 6,280 | 725 |
| PCW | PTS – 185 dB re 1 µPa²s | N/E | N/E | N/E |
| | TTS – 170 dB re 1 µPa²s | 3,890 | 910 | <curtain |

N/E = threshold not exceeded, < curtain = injury range contained within DBBC.

**Table 3-3: Potential auditory injury (PTS) and TTS ranges for marine mammals from installation of a single pile based on the $SPL_{pk}$ metric, for the first hammer strike and highest energy hammer strike.**

| Species / Group | Threshold, Lp,0-pk, dB re 1 µPa | Range (m) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Unmitigated | | PULSE | | DBBC | |
| | | First Strike | Max Energy | First Strike | Max Energy | First Strike | Max Energy |
| LF | PTS – 219 dB re 1 µPa (pk) | 169 | 425 | 144 | 285 | < curtain | 147 |
| | TTS – 213 dB re 1 µPa (pk) | 273 | 684 | 241 | 424 | 106 | 208 |
| HF | PTS – 230 dB re 1 µPa (pk) | 71 | 177 | 56 | 120 | < curtain | 77 |
| | TTS – 224 dB re 1 µPa (pk) | 114 | 286 | 93 | 180 | < curtain | 110 |
| VHF | PTS – 202 dB re 1 µPa (pk) | 653 | 1,638 | 624 | 804 | 201 | 395 |
| | TTS – 196 dB re 1 µPa (pk) | 1,051 | 2,638 | 1,048 | 1,178 | 285 | 559 |
| PCW | PTS – 218 dB re 1 µPa (pk) | 183 | 460 | 157 | 307 | < curtain | 156 |
| | TTS – 212 dB re 1 µPa (pk) | 295 | 741 | 263 | 454 | 112 | 221 |

< curtain = injury range contained within DBBC.

The numbers of animals potentially impacted and the proportion of the relevant species-specific reference populations was calculated for both auditory injury (PTS) and TTS. Only the maximum density estimate per species, and corresponding Management Unit (MU) (Table 3-4) were applied in this report in order to take a precautionary approach.

**Table 3-4: Density estimates and MUs applied.**

| Species | Maximum density estimate (animals/km$^2$) | Source | MU population | Source |
|---|---|---|---|---|
| Harbour porpoise *Phocoena phocoena* | 1.33 | Maximum density estimate, derived from monthly peak, Oriel site-specific surveys | 62,517 | Celtic and Irish Sea (CIS) MU (IAMMWG, 2022) |
| Bottlenose dolphin *Tursiops truncatus* | 0.235 | Maximum density estimate, derived from the Small Cetacean in European Atlantic Waters and the North Sea (SCANS)-IV Block CS-D (Gilles et al., 2023) | 8,326 | SCANS-IV Irish Sea Abundance Estimate from Block CS-D and Block CS-E (Gilles et al., 2023) |
| Common dolphin *Delphinus delphis* | 0.027* | Density estimate derived from SCANS-IV Block CS-D (Gilles et al., 2023) | 102,656 | Celtic and Greater North Seas (CGNS) MU (IAMMWG, 2022) |
| Minke whale *Balaenoptera acutorostrata* | 0.26 | Maximum density estimate, derived from monthly peak, Oriel site-specific surveys | 20,118 | CGNS MU (IAMMWG, 2022) |
| Grey seal *Halichoerus grypus* | 0.372* | Density estimate derived from Carter *et al.* (2022) | 5,882 | Grey Seal Reference Population (Oriel Windfarm Ltd, 2024) |
| Harbour seal *Phoca vitulina* | 0.28* | Density estimate derived from Carter *et al.* (2022) | 1,635 | Harbour Seal Reference Population (Oriel Windfarm Ltd, 2024) |

* A single density estimate was identified for the EIAR volume 2B, chapter 10: Marine Mammals and Megafauna (rather than a minimum and maximum density estimate)

## PTS

The numbers of animals predicted to experience PTS and equivalent proportion of the reference population based on the $SEL_{cum}$ metric is presented in Table 3-5 without ADD and with 15 minutes ADD. N/E indicates where thresholds were not exceeded, whilst '< curtain' indicates that the threshold was not exceeded beyond the limits of the DBBC.

For auditory injury (PTS), for both the scenarios without ADD and with 15 minutes of ADD, the modelled impacted ranges (based on $SEL_{cum}$) reduce with the use of PULSE compared to the unmitigated range and further reduce with the use of DBBC. For example, without ADD use, for harbour porpoise, the unmitigated range is 815 m, which reduces to 454 m for the PULSE scenario and 280 m for the DBBC scenario. This leads to a reduction in the number of animals predicted to experience PTS also. For harbour porpoise, without ADD use, this leads to up to three harbour porpoise (0.004% of the CIS MU) were predicted to experience PTS in the unmitigated scenario, which reduces to less than one in both the PULSE and DBBC scenarios (both 0.001% of the CIS MU).

For minke whale, the unmitigated range is 1,135 m, which reduces to 635 m for the PULSE scenario and 98 m for the DBBC scenario. This leads to a reduction in the number of animals predicted to experience PTS also; up to two minke whale (0.005% of the CIS MU) were predicted to experience PTS in the unmitigated scenario, which reduces to less than one animal in the PULSE and DBBC scenarios (0.002% and 0.00004% of the CIS MU respectively).

With the use of 15 minute ADD ranges are further reduced, and for all species for all three scenarios (based on $SEL_{cum}$) PTS thresholds were not exceeded (and therefore no table of ranges is presented) and therefore no animals were predicted to experience PTS.

The numbers of animals predicted to experience PTS and equivalent proportion of the reference population based on the $SPL_{pk}$ metric is presented in Table 3-6. The modelled impacted ranges (based on $SPL_{pk}$) reduce with the use of PULSE compared to the unmitigated range and further reduce with the use of DBBC. For example, for harbour porpoise, the unmitigated range is 1,638 m at maximum strike hammer energy, which reduces to 804 m for the PULSE scenario and 395 m for the DBBC scenario. This leads to reduction in the number of animals predicted to experience PTS also; up to 12 harbour porpoise (0.018% of the CIS MU) were predicted to experience PTS in the unmitigated scenario which reduces to, up to three (0.004% of the CIS MU) for the PULSE scenario, and less than one for the DBBC scenario (0.001% of the CIS MU). For soft start ranges a similar pattern of reduction can be seen in Table 3-6, with the greatest reduction presented for the DBBC scenario; for all species other than harbour porpoise, thresholds were not exceeded beyond the DBBC, and for harbour porpoise the range reduces from 653 m (unmitigated) to 624 m (PULSE) to 201 m (DBBC). The equivalent number of animals predicted to be affected reduces from, up to 2 harbour porpoise (up to 0.0003% of the CIS MU) (unmitigated and PULSE) to less than one harbour porpoise (up to 0.003% of the CIS MU) (DBBC).

**Table 3-5: Number of animals potentially affected by auditory injury (PTS) from impact piling at a single monopile location at the east of the offshore wind farm area based on $SEL_{cum}$ injury ranges without ADD (N/E = threshold not exceeded), for unmitigated, PULSE and DBBC scenarios.**

| Species | Threshold (Unweighted Peak) | Range (m) | | | Number animals within impact zone | | | Percentage of MU population (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC |
| Harbour porpoise | PTS - 155 dB re 1 μPa²s | 815 | 454 | 280 | 3 | <1 | <1 | 0.004 | 0.001 | 0.0001 |
| Bottlenose dolphin | PTS - 185 dB re 1 μPa²s | N/E | N/E | N/E | N/A | N/A | N/A | N/A | N/A | N/A |
| Common dolphin | PTS - 185 dB re 1 μPa²s | N/E | N/E | N/E | N/A | N/A | N/A | N/A | N/A | N/A |
| Minke whale | PTS - 183 dB re 1 μPa²s | 1,135 | 635 | 98 | 2 | <1 | <1 | 0.0005 | 0.002 | 0.00004 |
| Grey seal | PTS - 185 dB re 1 μPa²s | 11 | N/E | <curtain | <1 | N/A | N/A | N/A | N/A | N/A |
| Harbour seal | PTS - 185 dB re 1 μPa²s | 11 | N/E | <curtain | <1 | N/A | N/A | N/A | N/A | N/A |

**Table 3-6: Number of animals potentially affected by auditory injury (PTS) from impact piling at a single monopile location at the east of the offshore wind farm area based on $SPL_{pk}$ injury ranges for the first strike and maximum hammer energy (N/E = threshold not exceeded, < curtain = contained within DBBC), for unmitigated, PULSE and DBBC scenarios.**

| Species | Threshold, Lp,0-pk, dB re 1 µPa | Strike | Range (m) | | | Number of animals within impact zone | | | Percentage of MU population (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC |
| Harbour porpoise | PTS – 202 dB re 1 µPa (pk) | *First strike* | 653 | 624 | 201 | 2 | 2 | <1 | 0.003% | 0.003% | 0.0003% |
| | | *Max energy* | 1,638 | 804 | 395 | 12 | 3 | <1 | 0.018% | 0.00% | 0.001% |
| Bottlenose dolphin | PTS – 230 dB re 1 µPa (pk) | *First strike* | 71 | 56 | < curtain | <1 | <1 | N/A | 0.00004% | 0.00003% | N/A |
| | | *Max energy* | 177 | 120 | 77 | <1 | <1 | <1 | 0.0003% | 0.0001% | 0.00005% |
| Common dolphin | PTS – 230 dB re 1 µPa (pk) | *First strike* | 71 | 56 | < curtain | <1 | <1 | N/A | 0.0000004% | 0.0000003% | N/A |
| | | *Max energy* | 177 | 120 | 77 | <1 | <1 | <1 | 0.000003% | 0.000001% | 0.0000005% |
| Minke whale | PTS – 219 dB re 1 µPa (pk) | *First strike* | 169 | 144 | < curtain | <1 | <1 | N/A | 0.0001% | 0.0001% | N/A |
| | | *Max energy* | 425 | 285 | 147 | <1 | <1 | <1 | 0.0007% | 0.0003% | 0.0001% |
| Grey seal | PTS – 218 dB re 1 µPa (pk) | *First strike* | 183 | 157 | < curtain | <1 | <1 | N/A | 0.0007% | 0.0005% | N/A |
| | | *Max energy* | 460 | 307 | 156 | <1 | <1 | <1 | 0.004% | 0.002% | 0.0005% |
| Harbour seal | PTS – 218 dB re 1 µPa (pk) | *First strike* | 183 | 157 | < curtain | <1 | <1 | N/A | 0.002% | 0.001% | N/A |
| | | *Max energy* | 460 | 307 | 156 | <1 | <1 | <1 | 0.011% | 0.005% | 0.001% |

### TTS

The numbers of animals with the potential to experience TTS and proportion of the reference population (based on the $SEL_{cum}$ metric) is presented in Table 3-7 without ADD and Table 3-8 with 15 minutes ADD. For TTS, for both the scenarios without ADD and with 15 minutes of ADD, the modelled impacted ranges reduce with the use of PULSE compared to the unmitigated range and further reduce with the use of DBBC. Without ADD, but with the use of DBBC harbour porpoise and minke whale were the only species for which the threshold was exceeded beyond the DBBC.

For example, without ADD use, for harbour porpoise, the unmitigated range is 14,500 m, which reduces to 7,720 m with the use of PULSE and 2,050 m with the use of DBBC. This leads to a reduction in the number of animals potentially impacted; up to 879 harbour porpoise (1.41% of the CIS MU) have the potential to experience TTS in the unmitigated scenario, which reduces to up to 250 harbour porpoise in the PULSE scenario (0.40% of the CIS MU) and up to 18 in the DBBC scenario (0.03% of the CIS MU).

With use of 15 minute ADD TTS ranges are further reduced. For harbour porpoise the unmitigated range is 13,000 m, which reduces to 6,280 m with the use of PULSE and 725 m with the use of DBBC. This leads to reduction in the number of animals with the potential to experience TTS; up to 707 harbour porpoise (1.13% of the CIS MU) in the unmitigated scenario, which reduces to up to 165 harbour porpoise in the PULSE scenario (0.26% of the MU) and up to three harbour porpoise in the DBBC scenario (0.004% of the CIS MU).

For minke whale, without ADD use the unmitigated range is 21,500 m, which reduces to 16,500 m with the use of PULSE and 1,145 m with the use of DBBC. This leads to a reduction in the number of animals potentially impacted; up to 378 minke whale (1.88% of the CGNS MU) have the potential to experience TTS in the unmitigated scenario, which reduces to up to 223 minke whale in the PULSE scenario (1.11% of the CGNS MU) and up two in the DBBC scenario (0.01% of the CGNS MU).

With use of 15 minute ADD TTS ranges are further reduced. For minke whale the unmitigated range is 19,500 m, which reduces to 15,000 m with the use of PULSE and to within the curtain with the use of DBBC. This leads to reduction in the number of animals with the potential to experience TTS; up to 311 minke whale (1.54% of the CGNS MU) in the unmitigated scenario, which reduces to up to 184 minke whale in the PULSE scenario (0.91% of the CGNS MU) and no minke whale in the DBBC scenario.

The numbers of animals with the potential to experience TTS and equivalent proportion of the reference population (based on the $SPL_{pk}$ metric) is presented in Table 3-9. The modelled impacted ranges reduce with the use of PULSE compared to the unmitigated range and further reduce with the use of DBBC. For example, for harbour porpoise, the unmitigated range is 2,638 m at maximum strike hammer energy, which reduces to 1,178 m with the use of PULSE and 559 m with the use of DBBC. This leads to reduction in the number of animals with the potential to experience TTS; up to 30 harbour porpoise (0.047% of the CIS MU) in the unmitigated scenario, which reduces to up to six (0.009% of the CIS MU) in the PULSE scenario, and up to two in the DBBC scenario (0.002% of the CIS MU).

For soft start ranges a similar pattern of reduction can be seen in Table 3-9, with the greatest reduction presented for the DBBC scenario. For bottlenose dolphin and common dolphin thresholds were not exceeded beyond the DBBC. For harbour porpoise the range reduces from 1,051 m (unmitigated) to 1,048 m (PULSE) to 285 m (DBBC). The equivalent number of animals predicted to be affected reduces from up to five harbour porpoise (up to 0.007 % of the CIS MU) (unmitigated and PULSE) to less than one harbour porpoise (up to 0.0005% of the CIS MU) (DBBC). For minke whale the range reduces from 273 m (unmitigated) to 241 m (PULSE) to 106 m (DBBC). The equivalent number of animals predicted to be affected reduces was less than one minke whale for unmitigated, PULSE and DBBC scenarios.

**Table 3-7: Number of animals potentially affected by TTS from impact piling at a single monopile location at the east of the offshore wind farm area based on SEL injury ranges without ADD (N/E = threshold not exceeded, < curtain = contained within DBBC), for unmitigated, PULSE and DBBC scenarios.**

| Species | Threshold (Unweighted Peak) | Range (m) | | | Number animals within impact zone | | | Percentage of MU population (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC |
| Harbour porpoise | TTS - 140 dB re 1 $\mu Pa^2 s$ | 14,500 | 7,720 | 2,050 | 879 | 250 | 18 | 1.41% | 0.40% | 0.03 |
| Bottlenose dolphin | TTS - 170 dB re 1 $\mu Pa^2 s$ | 21 | 19 | <curtain | <1 | <1 | N/A | $4.0 \times 10^{-6}$ % | $3.0 \times 10^{-6}$ % | N/A |
| Common dolphin | TTS - 170 dB re 1 $\mu Pa^2 s$ | 21 | 19 | <curtain | <1 | <1 | N/A | $4.0 \times 10^{-8}$ % | $3.0 \times 10^{-8}$ % | N/A |
| Minke whale | TTS - 168 dB re 1 $\mu Pa^2 s$ | 21,500 | 16,500 | 1,145 | 378 | 223 | 2 | 1.88% | 1.11% | 0.01 |
| Grey seal | TTS - 170 dB re 1 $\mu Pa^2 s$ | 5,520 | 2,470 | <curtain | 36 | 8 | N/A | 0.61% | 0.12% | N/A |
| Harbour seal | TTS - 170 dB re 1 $\mu Pa^2 s$ | 5,520 | 2,470 | <curtain | 27 | 6 | N/A | 1.64% | 0.33% | N/A |

**Table 3-8: Number of animals potentially affected by TTS from impact piling at a single monopile location at the east of the offshore wind farm area based on SEL injury ranges with ADD (N/E = threshold not exceeded, < curtain = contained within DBBC), for unmitigated, PULSE and DBBC scenarios.**

| Species | Threshold (Unweighted Peak) | Range (m) | | | Number animals within impact zone | | | Percentage of MU population (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC |
| Harbour porpoise | TTS - 140 dB re 1 $\mu Pa^2 s$ | 13,000 | 6,280 | 725 | 707 | 165 | 3 | 1.13% | 0.26% | 0.004% |
| Bottlenose dolphin | TTS - 170 dB re 1 $\mu Pa^2 s$ | N/E | N/E | N/E | N/A | N/A | N/A | N/A | N/A | N/A |
| Common dolphin | TTS - 170 dB re 1 $\mu Pa^2 s$ | N/E | N/E | N/E | N/A | N/A | N/A | N/A | N/A | N/A |
| Minke whale | TTS - 168 dB re 1 $\mu Pa^2 s$ | 19,500 | 15,000 | <curtain | 311 | 184 | N/A | 1.54% | 0.91% | N/A |
| Grey seal | TTS - 170 dB re 1 $\mu Pa^2 s$ | 3,890 | 910 | <curtain | 18 | < 1 | N/A | 0.30% | 0.02% | N/A |
| Harbour seal | TTS - 170 dB re 1 $\mu Pa^2 s$ | 3,890 | 910 | <curtain | 14 | < 1 | N/A | 0.81% | 0.05% | N/A |

**Table 3-9: Number of animals potentially affected by TTS from impact piling at a single monopile location at the east of the offshore wind farm area based on $SPL_{pk}$ injury ranges for both first strike and maximum hammer energy (N/E = threshold not exceeded, < curtain = contained within DBBC), for unmitigated, PULSE and DBBC scenarios**

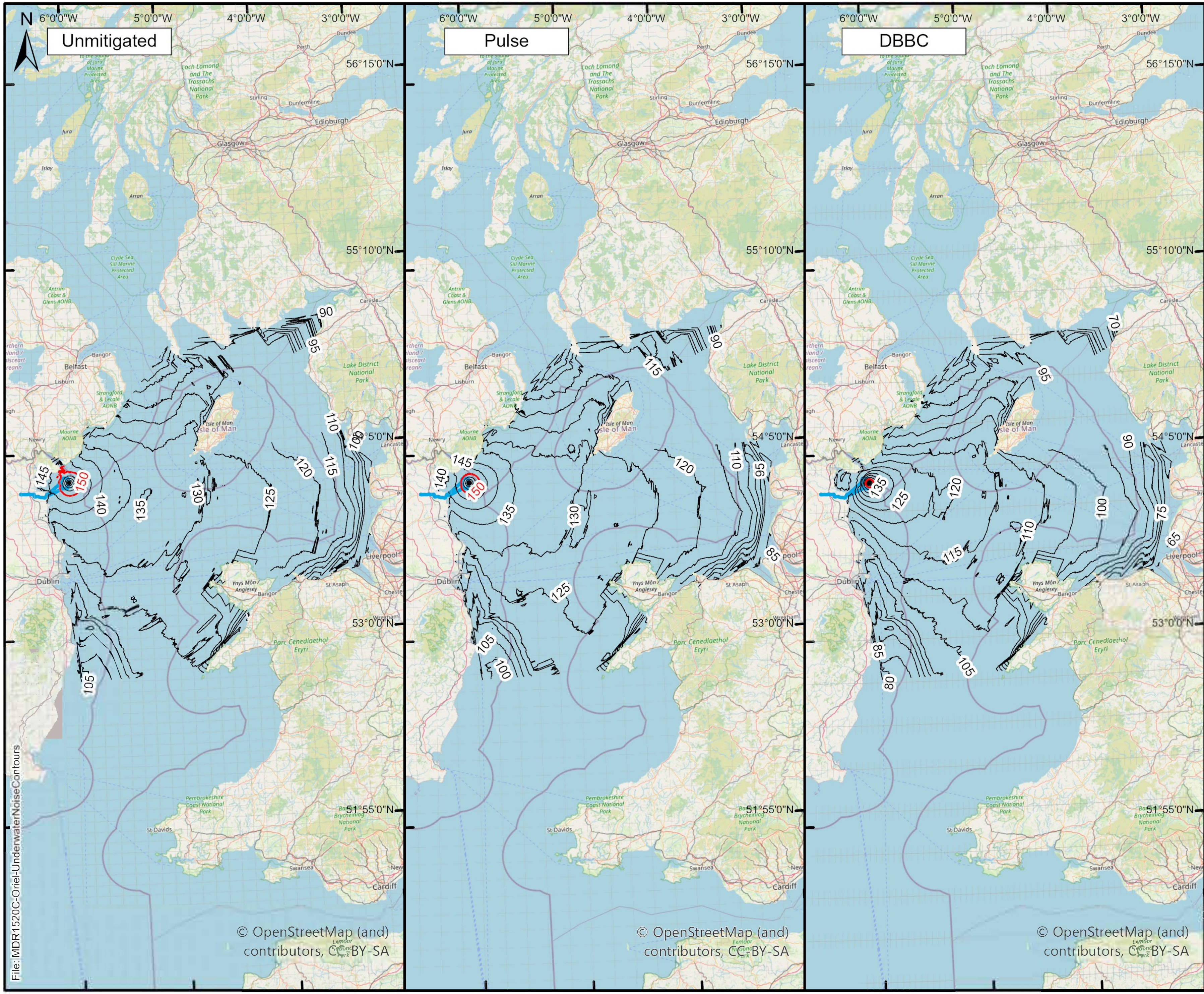
| Species / Group | Threshold, Lp,0-pk, dB re 1 µPa | Strike | Range (m) | | | Number of animals within impact zone | | | Percentage of MU population (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC | Unmitigated | PULSE | DBBC |
| Harbour porpoise | TTS – 196 dB re 1 µPa (pk) | *First strike* | 1,051 | 1,048 | 285 | 5 | 5 | < 1 | 0.007% | 0.007% | 0.0005% |
| | | *Max energy* | 2,638 | 1,178 | 559 | 30 | 6 | 2 | 0.047% | 0.009% | 0.002% |
| Bottlenose dolphin | TTS – 224 dB re 1 µPa (pk) | *First strike* | 114 | 93 | < curtain | < 1 | < 1 | N/A | 0.0001% | 0.00008% | N/A% |
| | | *Max energy* | 286 | 180 | 110 | < 1 | < 1 | < 1 | 0.0001% | 0.0003% | 0.0001% |
| Common dolphin | TTS – 224 dB re 1 µPa (pk) | *First strike* | 114 | 93 | < curtain | < 1 | < 1 | N/A | 0.000001% | 0.0000007% | N/A% |
| | | *Max energy* | 286 | 180 | 110 | < 1 | < 1 | < 1 | 0.000007% | 0.000003% | 0.000001% |
| Minke whale | TTS – 213 dB re 1 µPa (pk) | *First strike* | 273 | 241 | 106 | < 1 | < 1 | < 1 | 0.0003% | 0.0002% | 0.00005% |
| | | *Max energy* | 684 | 424 | 208 | < 1 | < 1 | < 1 | 0.002% | 0.0007% | 0.0002% |
| Grey seal | PTS – 218 dB re 1 µPa (pk) | *First strike* | 295 | 263 | 112 | < 1 | < 1 | < 1 | 0.002% | 0.001% | 0.0002% |
| | | *Max energy* | 741 | 454 | 221 | < 1 | < 1 | < 1 | 0.011% | 0.004% | 0.001% |
| Harbour seal | PTS – 218 dB re 1 µPa (pk) | *First strike* | 295 | 263 | 112 | < 1 | < 1 | < 1 | 0.005% | 0.004% | 0.0002% |
| | | *Max energy* | 741 | 454 | 221 | < 1 | < 1 | < 1 | 0.030% | 0.011% | 0.003% |

### 3.1.2 Behavioural Disturbance

The potential number of animals predicted to be disturbed within unweighted $SEL_{ss}$ contours (applying a dose response approach) alongside the numbers of animals predicted to experience strong and mild disturbance (using the strong and mild disturbance thresholds under National Marine Fisheries Service (NMFS) (2005)) are presented in Table 3-10. Figure 3-5 presents the unweighted disturbance contours ($SEL_{ss}$) for unmitigated piling, piling with PULSE and piling with DBBC all at the east piling location, with Figure 3-6 and Figure 3-7 showing contours overlaid onto the Carter *et al.* (2022) at-sea usage maps for grey seal and harbour seal respectively. The NMFS (2005) threshold for strong disturbance (160 dB re 1 µPa SPL root mean square (rms)) given in red contour. The predicted number of animals disturbed (Table 3-10) is based on the maximum density estimates (Table 3-4), representing the maximum numbers that could be affected in each scenario.

The numbers of animals potentially disturbed reduce for the PULSE scenario, and further reduce for the DBBC scenario for all species. Overall the greatest reduction in the number of animals predicted to be disturbed can be seen when comparing the unmitigated scenario with the DBBC scenario. This leads to a reduction in proportion of the MU population predicted to be disturbed, with the greatest proportion disturbed for the unmitigated scenario, and the least disturbed for the DBBC scenario (resulting in less than 1% of the MU disturbed for all species with the use of the DBBC). For strong disturbance (NMFS, 2005), the proportion of the MU population predicted to be disturbed is less than 1% for the PULSE and DBBC scenario. For mild disturbance (NMFS, 2005), the proportion of the MU population predicted to be disturbed is less than 1% for the DBBC scenario only.

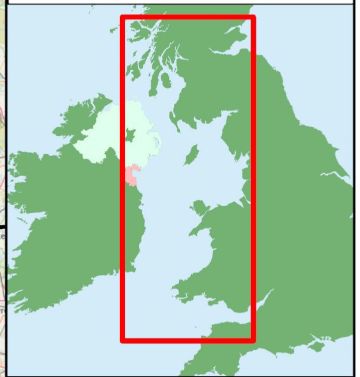
For example, for harbour porpoise, the number of animals predicted to be disturbed using a dose response approach for the unmitigated scenario is 2,360 animals (3.77% of the CIS MU). This reduces to 1,855 (2.97% of the CIS MU) for the PULSE scenario, and further reduces to 165 for the DBBC scenario (0.26% of the CIS MU). The number of animals that fall within the strong disturbance threshold (≥ 160 dB re 1µ Pa) reduces from 256 (0.41% of the CIS MU) in the unmitigated scenario, to 165 (0.26% of the CIS MU) for the PULSE scenario, to 29 (0.05% of the CIS MU) for the DBBC scenario.




## Legend

- Application Boundary
- Noise contour (dB re 1 µPa$^2$s $SEL_{ss}$)
- Strong Disturbance (160 dBrms)

Data Sources: Client, Marine Scotland



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

**Oriel Wind Farm Project**

Title **Figure 3-5**

**Unweighted disturbance contours (SELss) for piling with PULSE and piling with DBBC. Threshold for strong disturbance (160 dB re 1 µPa SPLrms) given in red contour**


rps
A TETRA TECH COMPANY

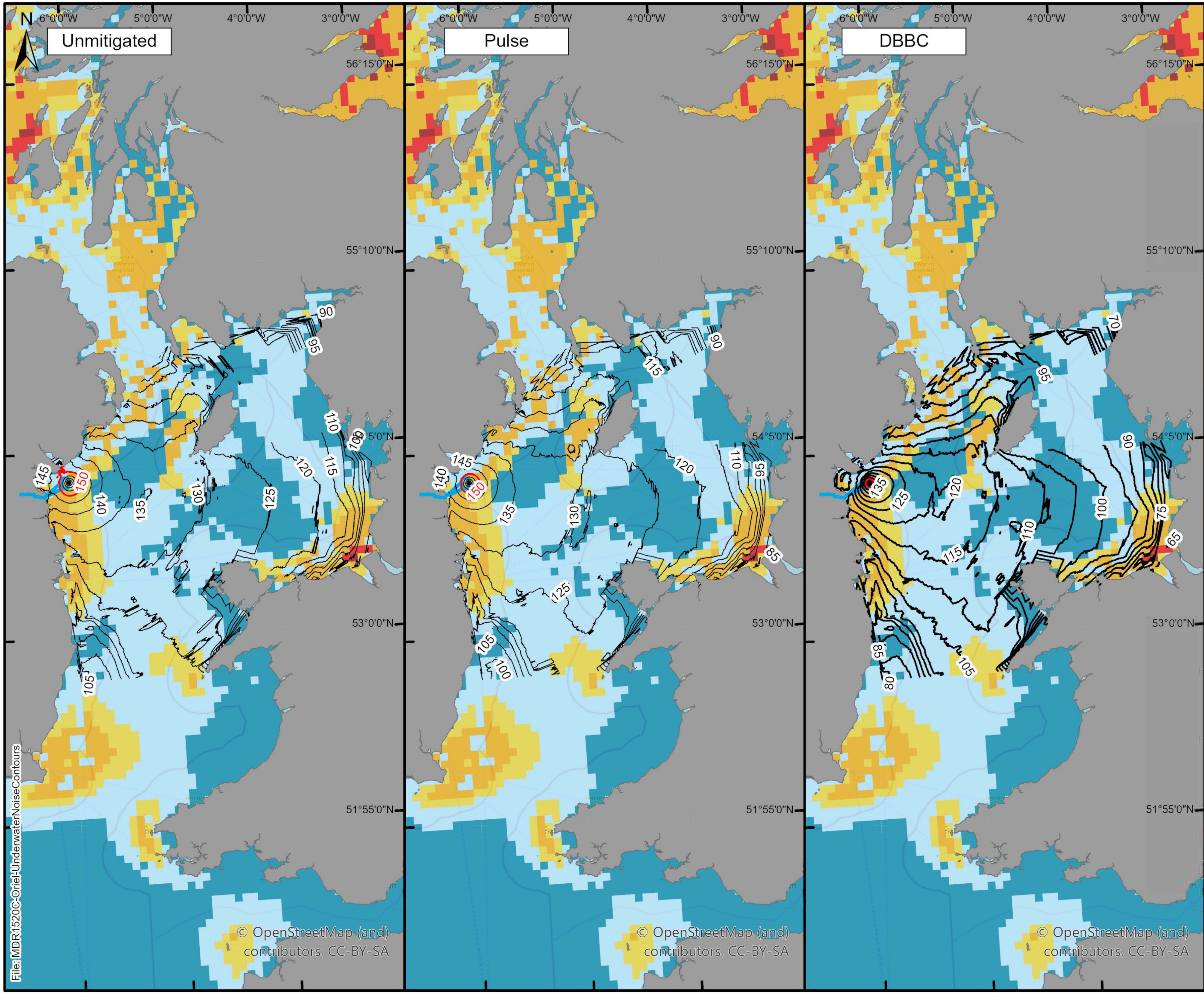
West Pier Business Campus,
Dun Laoghaire,
Co Dublin,
Ireland.

Tel: +353 (0) 1 4882900
Email: ireland@rpsgroup.com
Web Page: rpsgroup.com/ireland


*Issue Details*

| | |
|---|---|
| **Drawn By:** MJ | **Project No.** MDR1520C |
| **Checked By:** MJ | **File Ref:** MDR1520C-UWN-008-01 |
| **Approved By:** HM | |
| **Scale:** 1:3,300,000 @ A4 | **Projection:** ITM (IRENET95) Geographic Co-ordinates ETRS89 |
| **Date:** 10/08/2025 | |

**NOTE:**
1. This drawing is the property of RPS Group Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent
2. All levels are referred to Ordnance Datum, Malin Head
3. Ordnance Survey Ireland Licence EN 0005019 ©Copyright Government of Ireland



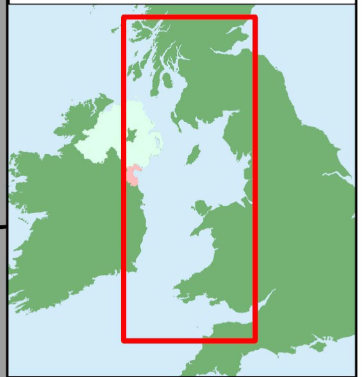

**Legend**

- Application Boundary
- Noise contour (dB re 1 μPa$^2$s $SEL_{ss}$)
- Strong Disturbance (160 dBrms)

Grey seal at sea usage (animals per 5x5 km grid cell) Mean values (Based on Carter *et. al.* 2022)

- 0
- >0 to 1
- >1 to 5
- >5 to 10
- >10 to 50
- >50 to 100
- >100

**Data Sources:** Client. Marine Scotland



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

**Oriel Wind Farm Project**

Title **Figure 3-6**

**Unweighted disturbance contours (SELss) for piling with PULSE and piling with DBBC, overlaid with grey seal at-sea usage (Carter et al., 2022). Threshold for strong disturbance (160 dB re 1 μPa SPLrms) given in red contour**

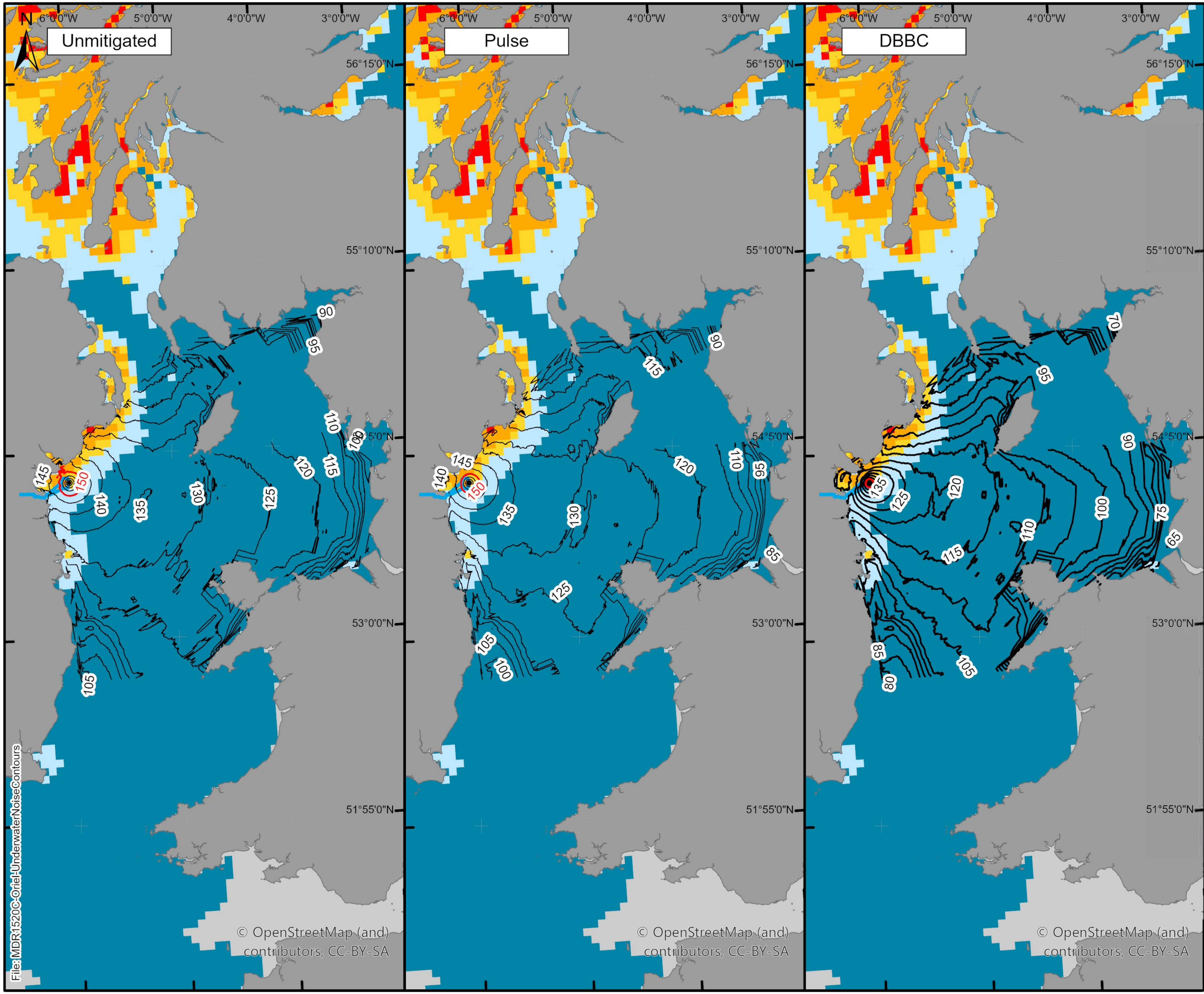
rps
A TETRA TECH COMPANY

West Pier Business Campus,
Dun Laoghaire,
Co Dublin,
Ireland.

Tel: +353 (0) 1 4882900
Email: ireland@rpsgroup.com
Web Page: rpsgroup.com/ireland

*Issue Details*

| | |
|---|---|
| Drawn By: MJ | Project No. MDR1520C |
| Checked By: MJ | File Ref: |
| Approved By: HM | MDR1520C-UWN-009-01 |
| Scale: 1:3,300,000 @ A4 | Projection: ITM (IRENET95) Geographic Co-ordinates ETRS89 |
| Date: 19/08/2025 | |



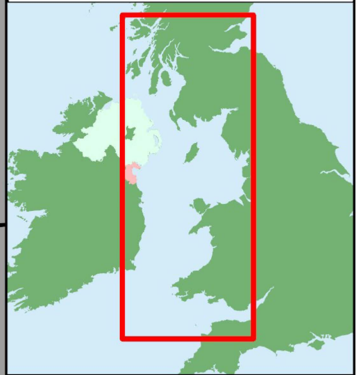

## Legend

- Application Boundary
- Noise contour (dB re 1 μPa$^2$s $SEL_{ss}$)
- Strong Disturbance (160 dBrms)

Harbour seal at sea usage (animals per 5x5 km grid cell) Mean values (Based on Carter *et. al.* 2022)

- 0
- >0 to 1
- >1 to 5
- >5 to 10
- >10 to 50
- >50 to 100
- >100

**Data Sources:** Client. Marine Scotland



**Client**

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

**Project**

## Oriel Wind Farm Project

**Title** Figure 3-7

**Unweighted disturbance contours (SELss) for piling with PULSE and piling with DBBC, overlaid with harbour seal at-sea usage (Carter et al., 2022). Threshold for strong disturbance (160 dB re 1 μPa SPLrms) given in red contour**

RPS
A TETRA TECH COMPANY

West Pier Business Campus,
Dun Laoghaire,
Co Dublin,
Ireland.

Tel: +353 (0) 1 4882900
Email: ireland@rpsgroup.com
Web Page: rpsgroup.com/ireland

**Issue Details**

| | |
|---|---|
| **Drawn By:** MJ | **Project No.** MDR1520C |
| **Checked By:** MJ | **File Ref:** MDR1520C-UWN-010-01 |
| **Approved By:** HM | |
| **Scale:** 1:3,300,000 @ A4 | **Projection:** ITM (IRENET95) Geographic Co-ordinates ETRS89 |
| **Date:** 19/08/2025 | |

**Table 3-10: Number of animals predicted to be disturbed within unweighted $SEL_{ss}$ noise contours as a result of impact piling of monopiles at the east of the offshore wind farm area using a dose response approach. Also shows number of animals predicted to be disturbed, calculated within unweighted $SEL_{ss}$ noise contours, that equate to strong and mild disturbance thresholds under NMFS (2005).**

| Scenario | Species | Dose response ($SEL_{ss}$) | | Strong disturbance (equivalent to ≥ 160 dB re 1µ Pa (rms); NMFS, 2005) | | Mild disturbance (equivalent to 140 – 160 dB re 1µ Pa (rms); NMFS, 2005) | |
|---|---|---|---|---|---|---|---|
| | | Number of animals | Proportion of MU population (%) | Number of animals | Proportion of MU population (%) | Number of animals | Proportion of MU population (%) |
| Unmitigated | Harbour porpoise | 2,360 | 3.77% | 256 | 0.41% | 9,648 | 15.43% |
| | Bottlenose dolphin | 417 | 5.01% | 46 | 0.54% | 1,705 | 20.47% |
| | Common dolphin | 48 | 0.05% | 6 | 0.01% | 196 | 0.19% |
| | Minke whale | 462 | 2.29% | 51 | 0.25% | 1,886 | 9.37% |
| | Grey seal | 83 | 1.40% | 31 | 0.52% | 45 | 0.76% |
| | Harbour seal | 71 | 4.30% | 17 | 1.03% | 33 | 1.96% |
| PULSE | Harbour porpoise | 1,855 | 2.97% | 165 | 0.26% | 7,050 | 11.28% |
| | Bottlenose dolphin | 328 | 3.94% | 29 | 0.35% | 1,246 | 14.97% |
| | Common dolphin | 38 | 0.04% | 3 | 0.003% | 144 | 0.14% |
| | Minke whale | 363 | 1.80% | 32 | 0.16% | 1,379 | 6.85% |
| | Grey seal | 55 | 0.92% | 20 | 0.34% | 30 | 0.51% |
| | Harbour seal | 44 | 2.64% | 10 | 0.62% | 21 | 1.28% |
| DBBC | Harbour porpoise | 165 | 0.26% | 29 | 0.05% | 458 | 0.73% |
| | Bottlenose dolphin | 30 | 0.35% | 5 | 0.06% | 81 | 0.97% |
| | Common dolphin | 4 | 0.003% | 1 | 0.001% | 10 | 0.01% |
| | Minke whale | 33 | 0.16% | 6 | 0.03% | 90 | 0.45% |
| | Grey seal | 6 | 0.10% | 2 | 0.03% | 4 | 0.07% |
| | Harbour seal | 6 | 0.37% | 4 | 0.25% | 3 | 0.18% |

## 3.2 Fish and shellfish

### 3.2.1 Mortality, Recoverable Injury, and TTS

Table 3-11 presents indicative mortality, recoverable injury, and TTS ranges for fish modelled as moving receptors, and Table 3-12 presents these ranges for fish modelled as static receptors. The fish groups presented are based on Popper *et al.* (2014), with the three scenarios identified in section 1 presented for each fish group.

#### 3.2.1.1 Mortality

When comparing mortality ranges for moving fish receptors between the unmitigated, PULSE mitigated, and DBBC mitigated scenarios, impact ranges were reduced from 21 m (group 2 fish and sea turtles) and 51 m (group 3 and 4 fish) in the unmitigated scenario to 18 m and 39 m respectively in the PULSE mitigation scenario, and to below the curtain range of the DBBC for all groups in the DBBC mitigation scenario. For group 1 fish and basking shark, no thresholds were exceeded for mortality in any scenario. The mortality range for fish eggs and larvae reduced from 935 m in the unmitigated scenario to 810 m in the PULSE mitigation scenario and further reduced to 506 m in the DBBC mitigation scenario.

For static fish receptors, the mortality ranges reduced from 385 m for group 1 fish in the unmitigated scenario, to 340 m in the PULSE scenario, to 265 m in the DBBC scenario. A similar reduction was seen for group 3 and 4 fish, with mortality reducing from 1,250 m in the unmitigated scenario, to 1,075 m in the PULSE scenario, to 630 m in the DBBC scenario. The mortality range for basking shark reduced from 385 m in the unmitigated scenario to 340 m in the PULSE mitigation scenario and further reduced to 265 m in the DBBC mitigation scenario. Similarly, for sea turtles, the mortality range reduced from 935 m in the unmitigated scenario to 810 m in the PULSE mitigation scenario and further reduced to 506 m in the DBBC mitigation scenario.

#### 3.2.1.2 Recoverable Injury

Similar to mortality, the recoverable injury ranges for moving fish reduced when mitigation was applied for all fish groups except group 1 fish and basking shark, for which no thresholds were exceeded in any scenario. For group 2, and group 3 and 4 fish, recoverable injury ranges reduced from 147 m in the unmitigated scenario to 107 m in the PULSE mitigated scenario, to below the curtain range of the DBBC.

For static fish receptors, the recoverable injury ranges were significantly larger for all fish groups, due to increased exposure to underwater sound compared to moving receptors, but a trend of recoverable injury range reduction was noted with the use of mitigation in all scenarios. For group 1 fish, the unmitigated scenario caused recoverable injury to a range of 516 m, reducing to 457 m for the PULSE mitigation scenario, and to 329 m in the DBBC mitigated scenario. For group 2, 3, and 4 fish, recoverable injury reduced from 1,860 m in the unmitigated scenario to 1,580 m in the PULSE mitigated scenario, and further to 835 m in the DBBC mitigated scenario.

#### 3.2.1.3 TTS

When comparing TTS ranges between the three scenarios for moving fish receptors, these ranged from 5,520 m (all fish groups) and 3,200 m (basking shark) in the unmitigated scenario and reduced to 4,020 m and 2,1000 m, respectively, in the PULSE mitigation scenario. This reduced further to 700 m and 382 m, respectively, in the DBBC mitigated scenario.

For static fish receptors, the TTS ranges were greater than that modelled for moving receptors, with unmitigated ranges of 9,620 m (all fish groups and basking shark), with only a slight reduction to 7,920 m noted in the PULSE mitigated scenario. This further reduced to 2,820 m in the DBBC mitigated scenario.

**Table 3-11: Potential injury ranges for moving fish from installation of a single pile based on the $SEL_{cum}$ metric**

| Hearing Group | Response | Threshold, SEL (dB re 1 μPa²s) | Unmitigated range (m) | PULSE range (m) | DBBC range (m) |
|---|---|---|---|---|---|
| Group 1 Fish: No swim bladder | Mortality | 219 dB re 1 μPa²s | N/E | N/E | N/E |
| | Recoverable Injury | 216 dB re 1 μPa²s | N/E | N/E | N/E |
| | TTS | 186 dB re 1 μPa²s | 5,520 | 4,020 | 700 |
| Group 2 Fish: Swim bladder no involved in hearing | Mortality | 210 dB re 1 μPa²s | 21 | 18 | <curtain |
| | Recoverable Injury | 203 dB re 1 μPa²s | 147 | 107 | <curtain |
| | TTS | 186 dB re 1 μPa²s | 5,520 | 4,020 | 700 |
| Group 3 and 4 Fish: Swim bladder involved in hearing | Mortality | 207 dB re 1 μPa²s | 51 | 39 | <curtain |
| | Recoverable Injury | 203 dB re 1 μPa²s | 147 | 107 | <curtain |
| | TTS | 186 dB re 1 μPa²s | 5,520 | 4,020 | 700 |
| Fish eggs and larvae | Mortality | 210 dB re 1 μPa²s | 935 | 810 | 506 |
| Basking shark | Mortality | 219 dB re 1 μPa²s | N/E | N/E | N/E |
| | Recoverable Injury | 216 dB re 1 μPa²s | N/E | N/E | N/E |
| | TTS | 186 dB re 1 μPa²s | 3,200 | 2,110 | 382 |
| Sea turtles | Mortality | 210 dB re 1 μPa²s | 21 | 18 | <curtain |

N/E = threshold not exceeded, < curtain = injury range contained within DBBC.

**Table 3-12: Potential injury ranges for static fish from installation of a single pile based on the $SEL_{cum}$ metric**

| Hearing Group | Response | Threshold, SEL (dB re 1 µPa²s) | Unmitigated range (m) | PULSE range (m) | DBBC range (m) |
|---|---|---|---|---|---|
| Group 1 Fish: No swim bladder | Mortality | 219 dB re 1 µPa²s | 385 | 340 | 265 |
| | Recoverable Injury | 216 dB re 1 µPa²s | 516 | 457 | 329 |
| | TTS | 186 dB re 1 µPa²s | 9,620 | 7,920 | 2,820 |
| Group 2 Fish: Swim bladder no involved in hearing | Mortality | 210 dB re 1 µPa²s | 935 | 810 | 506 |
| | Recoverable Injury | 203 dB re 1 µPa²s | 1,860 | 1,580 | 835 |
| | TTS | 186 dB re 1 µPa²s | 9,620 | 7,920 | 2,820 |
| Group 3 and 4 Fish: Swim bladder involved in hearing | Mortality | 207 dB re 1 µPa²s | 1,250 | 1,075 | 630 |
| | Recoverable Injury | 203 dB re 1 µPa²s | 1,860 | 1,580 | 835 |
| | TTS | 186 dB re 1 µPa²s | 9,620 | 7,920 | 2,820 |
| Fish eggs and larvae | Mortality | 210 dB re 1 µPa²s | 935 | 810 | 506 |
| Basking shark | Mortality | 219 dB re 1 µPa²s | 385 | 340 | 265 |
| | Recoverable Injury | 216 dB re 1 µPa²s | 516 | 457 | 329 |
| | TTS | 186 dB re 1 µPa²s | 9,620 | 7,920 | 2,820 |
| Sea turtles | Mortality | 210 dB re 1 µPa²s | 935 | 810 | 506 |

### 3.2.2 Behavioural Disturbance

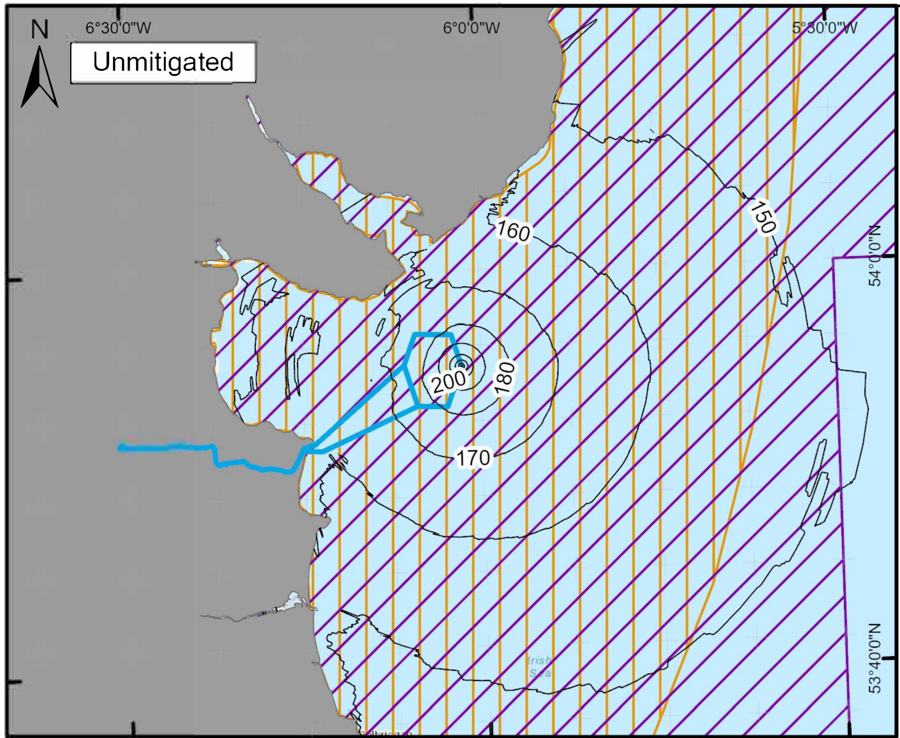
Figure 3-8 presents underwater sound contours using the $SPL_{pk}$ metric for a monopile for the unmitigated, PULSE mitigated, and DBBC mitigated scenarios alongside mapped herring nursery grounds derived from Coull *et al.* (1998) and Ellis *et al.* (2012). Noise levels in excess of 160 dB re 1 µPa $SPL_{pk}$ (defined in section 1) are expected to lead to behavioural effects on fish. Whilst the underwater noise report (appendix 10-6: NAS Modelling Report) presents 150 dB re 1 µPa $SPL_{rms}$ as an alternative behavioural threshold, this contour is expected to be a conservative threshold for behavioural effects, with a 160 dB re 1 µPa $SPL_{pk}$ threshold providing a more realistic behavioural disturbance threshold. Herring nursery grounds have been presented, given that this species is within the highest sensitivity hearing Group 4 (Popper *et al.*, 2014), and therefore underwater noise is likely to have the greatest impact on this group, with all other groups experiencing a lesser impact.

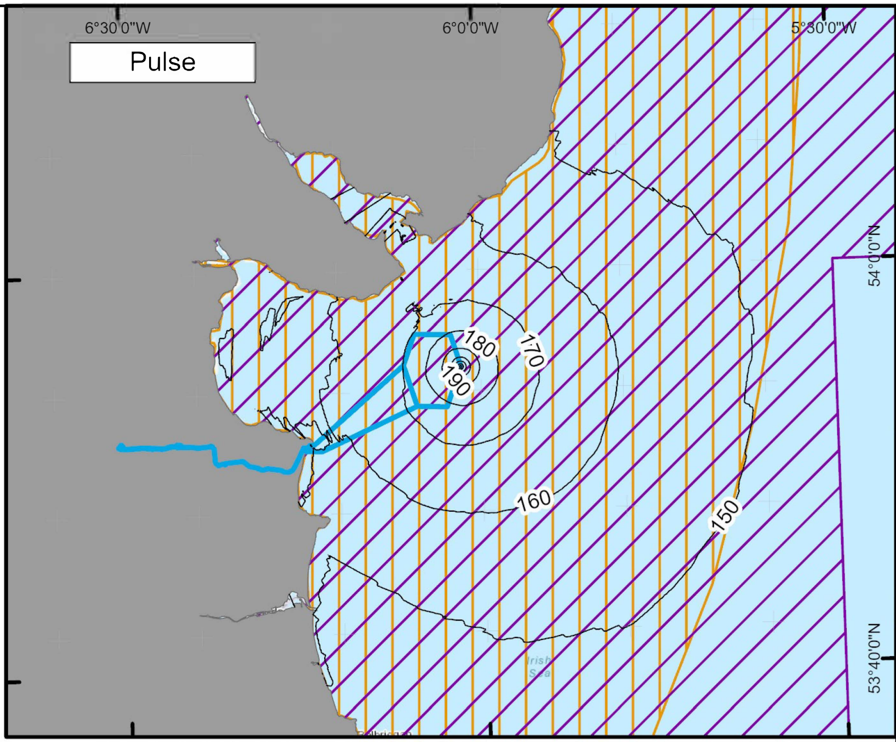
When comparing modelled contours using the $SPL_{pk}$ metric against mapped herring nursery grounds, all piling scenarios fully overlapped with both high intensity nursery ground (Ellis *et al.*, 2012) and unspecified intensity nursery ground (Coull *et al.*, 1998), but the areas impacted showed a significant decrease with increased mitigation measures modelled (Figure 3-8).

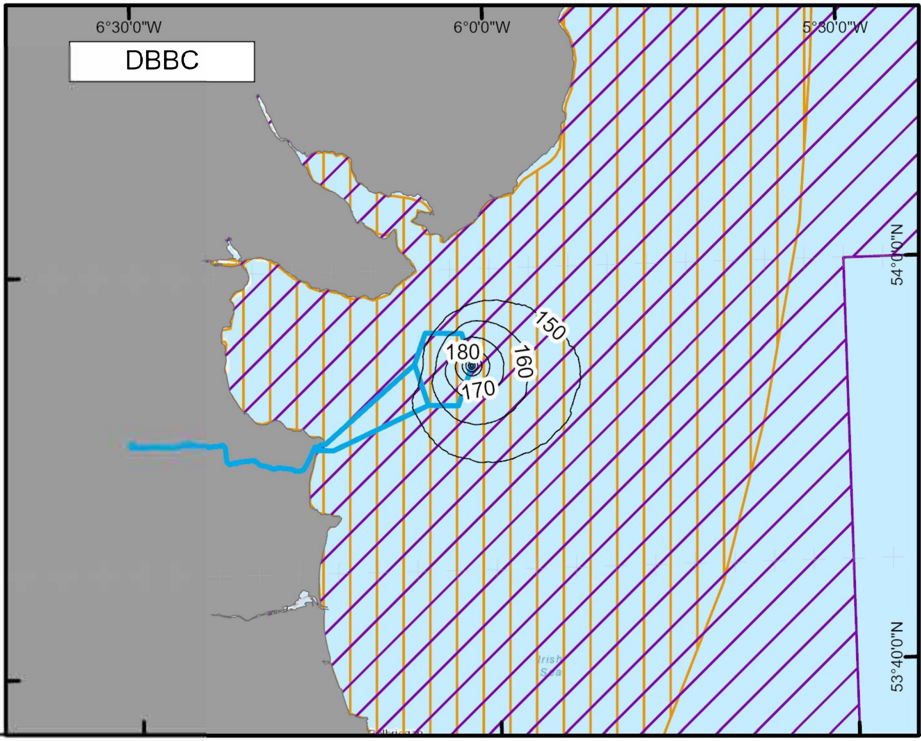
Specifically, the unmitigated piling scenario 160 dB re 1 µPa $SPL_{pk}$ behavioural disturbance contour for group 4 fish overlapped with 812.4 $km^2$ of both high intensity and unspecified intensity herring nursery grounds. In the PULSE mitigated scenario, this area of overlap reduced by 30.90% to 561.35 $km^2$, and in the DBBC mitigated scenario the area of overlap reduced by 91.82% compared to the unmitigated scenario to 66.45 $km^2$. This indicates significant reductions with increasing levels of mitigation, even when only applying the PULSE mitigation method.

In relation to the Western Irish Sea Fish and Shellfish Ecology Study Area (defined in chapter 9: Fish and Shellfish Ecology (EIAR volume 2B)), the unmitigated scenario 160 dB re 1 µPa $SPL_{pk}$ behavioural disturbance contour ensonified 5.91% of the Study Area, the PULSE mitigated scenario ensonified 4.08% of the Study Area, and the DBBC ensonified 0.48% of the Study Area, indicating a low level of impact overall even without mitigation.

In the context of the herring nursery grounds within the Western Irish Sea Fish and Shellfish Ecology Study Area, the unmitigated scenario 160 dB re 1 µPa $SPL_{pk}$ behavioural disturbance contour impacted 18.13% of high intensity nursery grounds (Ellis *et al.*, 2012) and 22.92% of unspecified intensity nursery grounds (Coull *et al.*, 1998). This reduced to 12.53% of high intensity nursery grounds and 15.83% of unspecified intensity nursery grounds in the PULSE mitigated scenario, and to 1.48% of high intensity nursery grounds and 1.87% of unspecified intensity nursery grounds in the DBBC mitigated scenario.



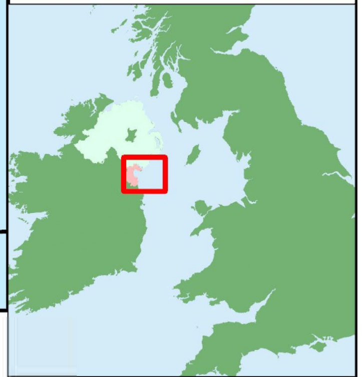




Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA. DoBH, OS, Esri, HERE, Garmin, USGS, NGA

## Legend

- Application Boundary
- Noise contours: dB re 1 μPa (SPLpk)
- Nursery Ground - High Intensity (Ellis et al., 2012)
- Nursery Ground - Intensity Not Specified (Coull et el., 1998)

**Data Sources:** Client. CEFAS



Client

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

Project

**Oriel Wind Farm Project**

Title Figure 3 - 8
Herring nursery grounds with subsea contours for moving fish from installation of a single pile based on the SPLpk metric


RPS
A TETRA TECH COMPANY

West Pier Business Campus,
Dun Laoghaire,
Co Dublin,
Ireland.

Tel: +353 (0) 1 4882900
Email: ireland@rpsgroup.com
Web Page: rpsgroup.com/ireland


***Issue Details***

| | |
|---|---|
| **Drawn By:** MJ/LM | **Project No.** MDR1520C |
| **Checked By:** HM | **File Ref:** MDR1520C-UWN-001-01 |
| **Approved By:** HM | |
| **Scale:** 1:700,000 @ A4 | **Projection:** ITM (IRENET95) Geographic Co-ordinates: ETRS89 |
| **Date:** 29/08/2025 | |

# 4 CONCLUSIONS

The NAS modelling clearly demonstrates the potential for measurable reductions in auditory injury, TTS and disturbance impact ranges/areas for both the scenarios modelled (PULSE and DBBC systems).

The Applicant highlights that the modelling presented in this report is just an example of suitable types of NAS, and other options are available (as detailed in the review of NAS technology, in appendix 10.8: Comprehensive Review of Relevant Mitigation (Noise Abatement)). Given the range of reductions demonstrated it is expected that application of NAS available at the time of construction will produce similar results. Furthermore, given that the impact assessment has already concluded no significant impact on marine mammals, it is considered that any application of NAS would simply further reduce the magnitude of effect on marine mammals for PTS, TTS and disturbance.

Finally, given the potential for measurable reductions in impact zones, it is considered that this will also lead to a reduction in the Project's contribution to potential underwater noise cumulative effects with other projects in the vicinity of the Project, should construction programme and piling schedules overlap.

## 4.1 Marine mammals

Overall modelling for impact piling of monopiles on the Project with different NAS scenarios results in reduced impact ranges and areas, for both the PULSE and DBBC scenarios when compared to unmitigated piling. The DBBC scenario modelling results in the greatest reduction in ranges and areas compared to the unmitigated scenario.

For PTS ($SEL_{cum}$), without ADD, thresholds for harbour porpoise and minke whale were exceeded for the unmitigated, PULSE and DBBC scenarios (though PTS ranges reduced for the PULSE scenario, and further reduced for the DBBC scenario). With the application of PULSE or DBBC, PTS ranges were below the NPWS (2014) recommended mitigation zone of 1,000 m for all species. With the inclusion of ADD, no PTS threshold was exceeded for any species, for any scenario.

For PTS ($SPL_{pk}$), ranges reduced with PULSE and further with DBBC, leading to a maximum of up to one animal predicted to experience PTS with DBBC for all species at max energy and less than 0.01% of the respective MUs. For all species other than harbour porpoise, the range of the PTS threshold remained within the DBBC. For harbour porpoise, the threshold was exceeded by 395 m leading to less than one animal predicted to experience PTS (0.001% of the CIS MU).

For TTS, ranges reduced with PULSE and further with DBBC, both with and without ADD. Without ADD, the threshold was exceeded with PULSE but at smaller ranges than the unmitigated scenario. For bottlenose dolphin and short-beaked common dolphin less than one animal was predicted to experience TTS under the PULSE scenario. The TTS threshold was within the DBBC curtain for bottlenose dolphin, common dolphin, grey seal and harbour seal, leading to no animals predicted to experience TTS for the DBBC scenario. With the inclusion of ADD, the TTS threshold was within the DBBC curtain for all species except for harbour porpoise. The TTS range for harbour porpoise was 725 m, within the 1,000 m mitigation zone (leading to up to three harbour porpoise predicted to experience TTS, 0.004% of the CIS MU).

For disturbance, using the dose response approach, the numbers of animals potentially disturbed reduced for the PULSE scenario and further reduced for the DBBC scenario for all species (with less than 0.5% of the respective MU's disturbed for all species for the DBBC scenario). The number of animals predicted to experience strong disturbance and mild disturbance (NMFS, 2005) also decreased for the PULSE scenario, and further reduced for the DBBC scenario. For mild and strong disturbance thresholds, the DBBC scenario was less than 1% of the MU for all species.

## 4.2 Fish and shellfish

For mortality, recoverable injury, TTS, and behavioural disturbance, the evidence presented in section 3 indicated that the use of NAS technology can reduce impact ranges for highly sensitive group 4 herring when modelled both as moving and static receptors. Furthermore, underwater noise modelling indicated that the use of NAS has the potential to reduce the overlap of ensonification with juvenile herring populations in high and unspecified intensity spawning grounds. The underwater noise modelling assumptions and the behavioural impact threshold applied for herring (160 dB re 1 μPa $SPL_{pk}$) are considered to be conservative (appendix 10-4: Updated Subsea Noise Modelling Report, section 3.1), and therefore these indicative scenarios likely represent an overestimate of the potential impact on herring nursery grounds. This NAS modelling work demonstrates the effectiveness of both PULSE and DBBC as potential NAS mitigation measures, in significantly reducing noise levels associated with piling activity, even in a highly conservative scenario.

# References

Carter, M. I. D., Boehme, L., Cronin, M. A., Duck, C. D., Grecian, W. J., Hastie, G. D., Jessopp, M., Matthiopoulos, J., McConnell, B. J., Miller, D. L., Morris, C. D., Moss, S. E. W., Thompson, D., Thompson, P. M. and Russell, D. J. F. (2022). *Sympatric Seals, Satellite Tracking and Protected Areas: Habitat-Based Distribution Estimates for Conservation and Management*. Frontiers in Marine Science, 9, pp.18. DOI:10.3389/fmars.2022.875869.

Coull, K., Johnstone, R. and Rogers, S. (1998). *Fisheries sensitivity maps in British waters.* Published and distributed by UKOOA Ltd pp.63.

Ellis, J., Milligan, S., Readdy, L., Taylor, N. and Brown, M. (2012). *Spawning and nursery grounds of selected fish species in UK waters, Centre for Environment Fisheries and Aquaculture Science (CEFAS).* CEFAS Science Series Technical Report pp.56.

Gilles, A., Authier, M., Ramirez-Martinez, N. C., Araújo, H., Blanchard, A., Carlström, J., Eira, C., Dorémus, G., Fernández-Maldonado, C., Geelhoed, S. C. V., Kyhn, L., Laran, S., Nachtsheim, D., Panigada, S., Pigeault, R., Sequeira, M., Sveegaard, S., Taylor, N. L., Owen, K., Saavedra, C., Vázquez-Bonales, J. A., Unger, B. and Hammond, P. S. (2023). *Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys.* Final report published 29 September 2023 pp.64.

IAMMWG. (2022). *Updated abundance estimates for cetacean Management Units in UK waters.* JNCC Report No. 680 (Revised March 2022). Joint Nature Conservation Committee. Peterborough. Document Number 0963-8091. pp.22.

NMFS. (2005). *Scoping Report for NMFS EIS for the National Acoustic Guidelines on Marine Mammals*. Federal Register, 70 (7), pp.1871-1875.

NPWS. (2014). *Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters.* pp.59.

Oriel Windfarm Ltd (2024). *Chapter 10 Marine Mammals and Megafauna.* Environmental Impact Assessment Report - Volume 2B

Popper, A., Hawkins, A., Fay, R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W., Gentry, R., Halvorsen, M., Løkkeborg, S., Rogers, P., Southall, B., Zeddies, D. and Tavolga, W. (2014). *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.* New York, Springer.

Southall, B. L., Finneran, J. J., Reichmuth, C., Nachtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W. T., Nowacek, D. P. and Tyack, P. L. (2019). *Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects*. Aquatic Mammals, 45 (2), pp.125-232. DOI:10.1578/am.45.2.2019.125.