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Updated Effective Deterrent Ranges (EDRs) for assessing the significance of noise disturbance in harbour porpoise Special Areas of Conservation (SACs)

(England, Wales & Northern Ireland)

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For further information please contact:
JNCC, Quay House, 2 East Station Road, Fletton Quays, Peterborough PE2 8YY.
https://jncc.gov.uk/

Communications@jncc.gov.uk

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Summary

In 2020, the Joint Nature Conservation Committee (JNCC), Natural England (NE) and the Department of Agriculture, Environment and Rural Affairs in Northern Ireland (DAERA) published advice to competent authorities on what could constitute significant disturbance within harbour porpoise Special Areas of Conservation (SACs) in England, Wales and Northern Ireland marine areas. In addition, guidance was provided on a noise management approach, based on area-time thresholds of disturbance, to keep underwater noise within levels that do not affect a site's integrity. A key element of that approach is the estimation of the disturbance footprints resulting from impulsive noise-generating activities within and around the SACs. The recommendation was that for each activity of concern, a fixed Effective Deterrence Range (EDR) would be used to estimate the area where harbour porpoise could be disturbed or deterred. Default EDRs were recommended for seven broad categories of activities, informed by published empirical ranges where the bulk of the effect (reduction in porpoise vocal activity or sightings) had been detected.

There was also a commitment in the guidance to regularly review the suitability of the EDRs, considering emerging evidence such as that gathered through monitoring and research. The first such review was conducted in 2025 through two commissioned reports: Brown *et al.* (2025) and Majewska *et al.* (2025). The aim of these was to recommend default EDRs, through a review of the evidence underpinning the current EDRs and subsequently published studies (empirical and modelled) and, where possible, through revisiting existing data with the aim of defining EDRs in a more standardised way.

JNCC, NE and DAERA have considered the outcomes of the two reports, the robustness of the evidence reviewed and the remaining uncertainty. The updated EDRs (Table 1) provided in this advice note remain precautionary but they are more robustly underpinned by the existing evidence than those in 2020. In addition to updating the seven EDRs provided in 2020, this advice introduces twelve new EDRs. Some of these sub-divide previous noise sources while others relate to noise sources not previously considered.

Table 1. Updated Effective Deterrent Ranges (EDRs) for 2025. Please refer to the advice note for details and caveats.

Activity	JNCC (2020) EDRs km	Updated 2025 EDRs km
Monopiles without noise abatement	26	20
Monopile with noise abatement (≥ 10 dB noise reduction)	15	11
Pin piles without noise abatement	15	20
Pin piles with noise abatement (≥ 10 dB noise reduction)	15	11
Sheet piling	NA	5
Conductor piling	15	5
High-order UXO clearance without bubble curtain (≤ 263 kg)	26	20
High-order UXO clearance with bubble curtain (≤ 525 kg)	NA	10

Activity	JNCC (2020) EDRs km	Updated 2025 EDRs km
Low-order UXO clearance	NA	5
Explosives use in decommissioning - open water and within < 10 m below the mudline)	NA	15
Explosives use in decommissioning – within 10 to 100m of the mudline	NA	5
Seismic surveys of airgun arrays of sizes > 12 and < 3,570 in^3	12	10
Mini-airguns of ≤ 12 in^3	NA	5
Sub Bottom Profilers (all types)	5	3
Ultrasonic Baseline USBL	NA	3
Lofitech seal scarer ADD (< 15 min)	NA	8
Lofitech seal scarer ADD (> 15 min)	NA	11
FaunaGuard ADD (any duration)	NA	2.5
Multiple-transducer SBES or MBES with an operating frequency of ≤ 12kHz operating in waters > 200 m depth.	NA	5
Multiple-transducer SBES or MBES with an operating frequency of ≤ 12 kHz operating in waters ≤ 200 m depth.	NA	3
Military Sonar	NA	20

Note to users

This document provides an update to the advice by JNCC, Natural England and DAERA on Effective Deterrent Ranges (EDRs) to be used in assessing significant disturbance in UK Special Areas of Conservation (SACs) for harbour porpoise within English, Welsh and Northern Irish waters. Nature Scot will provide separate advice for the Scottish harbour porpoise SAC and Natural Resources Wales will provide separate advice for sites which are their joint responsibility with Natural England and/or JNCC.

Natural Resources Wales advice is accessed here: Natural Resources Wales / Harbour porpoise: assessing the effect from underwater noise on their behaviour

Nature Scot's advice is accessed here: Conservation and Management Advice: INNER HEBRIDES AND THE MINCHES SAC

Contents

1. Introduction

In 2020, JNCC, Natural England and DAERA, published guidance on noise management in harbour porpoise Special Areas of Conservation (SACs). This guidance recommended area-time thresholds within harbour porpoise SACs. A plan or project, individually or in combination, is considered to result in significant disturbance if it excludes harbour porpoises from more than:

1. 20% of the relevant area of the site in any given day, or
2. an average of 10% of the relevant area of the site over a season.

This management approach ensures that noise disturbance in important habitats (i.e. SACs) is kept low so that animals can utilise and access those habitats. This helps ensure the SACs continue to contribute to the species' Favourable Conservation Status.

To assess the area of a site that may be affected by noise disturbance, the guidance recommended the use of Effective Deterrence Ranges (EDRs), equivalent to the mean loss of habitat per animal (Tougaard *et al.* 2013). These fixed radii are used to estimate the area around an impulsive noise event from which harbour porpoises are disturbed/deterred. The EDRs do not equate with 100% disturbance/deterrence in the associated area (i.e. some animals show greater reaction than others), but nor do they represent the full extent at which effects have been detected. Instead, they represent the area over which the bulk of the effect occurs.

The 2020 EDRs were developed following a review of empirical evidence. However, evidence projects available at the time reported porpoise responses to noise differently, meaning there was no straightforward way to standardise deriving an EDR. In addition, the full spectrum of animals' response to noise were not, and cannot yet be, recorded (e.g. physiological changes). This means it is possible that empirical studies observed only the most visible of effects. As there was only a handful of field studies of porpoise responses to noise to base the EDRs on, it was not possible to match the evidence to the specific characteristics of individual activities. Therefore, most EDRs were informed by matching a suite of generic activity categories (e.g. monopiles, pin-piles, seismic surveys) to the available empirical evidence covering an activity with the most similar characteristics and sound levels, with values chosen at the precautionary end of the spectrum.

In JNCC (2020) there was a commitment to regularly review the suitability of the EDRs, considering emerging evidence such as that gathered through monitoring and research. The first dedicated review was conducted in 2025 through two commissioned reports, one on impact piling (Brown *et al.* 2025) and the other covering all other relevant noise sources (Majewska *et al.* 2025). The main aim of the reports was to recommend revised default EDRs, through a review of the evidence underpinning the current EDRs and subsequently published studies (empirical and modelled) and, where possible, through revisiting existing data with the aim of deriving EDRs in a more standardised way. Where data were sufficient, an EDR was proposed for each study, resulting in a response range for each noise source.

The reports found large variability in the types of evidence available between noise sources, which were grouped as:

(i) Empirical studies of responses of animals to noise sources ('empirical response studies').

(ii) Studies reporting on measured sound levels during use of relevant sources ('noise measurement studies').

(iii) Studies undertaking modelling to estimate sound levels from relevant sources ('noise modelling studies').

For pile-driving (mono and pin piles), seismic surveys and Acoustic Deterrent Devices (ADDs), EDRs were able to be derived from the data presented in some published empirical studies through the examination of deterrence functions (magnitude/ probability of response vs distance to noise source), similar to that performed by Tougaard *et al.* (2013) on data presented in Dähne *et al.* (2013). For all other sources, recommended EDRs were informed by limited empirical response studies in some cases, but mostly by a combination of measured or modelled sound levels around the noise source and fixed disturbance thresholds. This assumes that animals will respond if sounds levels exceed those thresholds. It carries additional uncertainty over empirical response studies but was needed given the limited availability of empirical data for other sources.

To assess the robustness of the evidence in informing the EDRs, as well as relevance to harbour porpoise in UK waters, each piece of evidence was assigned a score based on whether the study looked at empirical responses, noise measurements or modelling; whether an EDR could be estimated from the data; and additional criteria relating to the relevance of the study to current UK practices as well as limitations of the study design or analysis (Brown *et al.* 2025, see Appendix 1). Empirical studies of animal responses, such as those reporting visual or acoustic detections, received the highest confidence scores. Penalties applied for limitations such as small datasets or lack of statistical analysis.

JNCC, NE and DAERA have considered the outcomes of these two reports, the robustness of the evidence reviewed and the remaining uncertainty and used this to update the EDRs. The revised EDRs continue to be considered precautionary (the more uncertainty there is, the more conservative the EDR) but they are more robustly underpinned by the existing evidence than those in 2020. As in JNCC (2020), different EDRs to those recommended here may be used in assessments with SNCB and regulator agreement, if there is evidence to justify it. For example, empirical evidence of porpoise responses to an activity with comparable parameters to the activity being assessed, such as sound characteristics and propagation, environmental conditions, location, noise abatement. The revised EDRs will be implemented as the default ones in the UK Marine Noise Registry for running scenarios with the 'disturbance tool'.

In addition to updating the EDRs provided in 2020, this guidance introduces a series of new EDRs. Some of these arise from added granularity to previous noise sources (e.g. EDR value dependent on airgun array size for seismic surveys) while others relate to noise sources not previously considered. The advice contained here can be used as a stand-alone reference but more detail on the supporting evidence can be found in Brown *et al.* (2025) and Majewska *et al.* (2025), such as:

- Field and statistical methods of the studies reviewed.
- Reported disturbance ranges.
- Measured and modelled sound levels.
- Approaches to estimating EDRs.
- Discussion on the limitations.
- Evidence scoring methodology.
- Recommended priorities for filling in evidence gaps.

2. Piling

Pile-driving (of mono and pin piles) was the activity for which there was the most empirical data on harbour porpoise responses to noise. It was also possible to derive EDRs from the data of multiple studies using a common definition, that being a distance representing the average habitat loss per individual (Tougaard *et al.* 2013). This resulted in a total of 13 estimated EDRs for monopiles and/or pin piles. For this activity only empirical studies were looked at. For conductor and sheet piling, response ranges were estimated from predictive noise modelling or field measurements of underwater noise due to the lack of empirical response studies.

Brown *et al.* 2025 confirmed that there is considerable variation in the approach to data collection, analysis and reporting of results among studies. This complicates comparison of results and adds considerable uncertainty to the estimation of effects ranges. It also limits the extent to which EDRs can be recommended for anything other than broad categories of piling activity (e.g. with vs without noise abatement); the extent to which extrapolations can be made from existing studies to current piling practices in the UK (e.g. ADD durations, hammer energies); and the extent to which conservatism can be confidently reduced.

2.1. Recommended default EDRs

For **monopiles or pin piles without noise abatement**, the recommended EDR is **20 km**.

- Estimated EDRs ranged from 12.1 to 24.0 km for monopiles without noise abatement (n=3), and 9.5-26.0 km for pin piles also without noise abatement (n=7).
- Eight of the estimated EDRs for unabated piling are ≤ 17.8 km and two are larger than 20 km: a) the Alpha Ventus offshore wind farm at 26km (Tougaard *et al.* 2013), which included long periods of piling and ADD deployment, and b) the Gemini offshore wind farm at 24.0km (de Jong *et al.* 2022), which reported conservative effects ranges when compared to other studies for this wind farm (see Section 3.3.2 of Brown *et al.* 2025).
- Evidence scores averaged 7 out of 10.
- Using evidence scores as weights, Brown et al (2025) also provided a weighted average response distance for unabated monopiles or pin piles of 17.4 km, as averaged across the eight estimated EDRs and a further six studies reporting only an effects range.
- Brown *et al.* (2025) recommended that the EDR for monopiles or pin piles without noise abatement should be the same and in the range of 15-20 km. Given the remaining uncertainty, the SNCBs' advice is to use the upper end of that range (i.e. 20 km.
- Brown *et al.* (2025) noted that EDRs of less than 15 km have been reported for unabated piling, including from recent analyses of UK projects (East Anglia ONE, Moray West and Moray East), and that comparable data collection is planned for several projects in UK waters in 2025. These may be relevant for assessments of comparable installations (e.g. same pile size, ADD duration, environmental conditions) and will be most relevant to future EDR reviews.

For **monopiles or pin piles with noise abatement (≥10 dB reduction)**, the recommended EDR is **11 km.**

- Estimated EDRs ranged from 6.2-10.5 km for monopiles and/or pin piles with noise abatement (n = 4). Noise abatement was either one Bubble curtain (BBC), one Double bubble curtain (DBBC), one isolation casing (IHC-NMS) or a combination of systems, (i.e. DBBC/Hydrosound damper, DBBC/AdBm resonator).

- While noise modelling and dose-response assumptions may support a graduated approach of smaller EDRs within this range for increasing dB reductions achieved through noise abatement, the empirical evidence does not currently provide strong support for such an approach.
- Evidence scores averaged 7 out of 10.
- Using evidence scores as weights, Brown *et al.* (2025) also provided a weighted average response distance for monopiles or pin piles with noise abatement of 10.8 km, as averaged across the four estimated EDRs and a further three studies reporting only an effects range.
- Brown *et al.* (2025) recommended that the EDR for monopiles or pin piles with noise abatement should be in the range of 10-15 km. Given the largest EDR estimated was 10.5 km the SNCBs' advice is to use 11 km.
- An EDR of 10 – 15 km would assume a reduction in broadband SEL_{SS} @750 m (from that corresponding to an EDR of 20) of approximately 10 dB or more, resulting from noise abatement (Brown et al 2025). Developers must therefore provide evidence of their proposed noise abatement and/or mitigation system achieving a minimum of 10 dB reduction in sound levels to justify the use of the 11 km EDR, subject to agreement by the regulator. Reductions of less than 10 dB will require the higher associated EDR of 15 km.

For **sheet piling**, the recommended EDR is **5 km.**

- The single empirical response study (Carstensen *et al.* 2006) related to sheet piling was at an offshore wind farm and involved concurrent and lengthy ADD use. The maximum reported effect range was 15.7 km. However, this is not considered to be representative of the nature of sheet piling likely to occur in UK waters, which does not routinely use ADDs as mitigation.
- Evidence score was 5 out of 10.
- Sheet piles are usually small, used in coastal construction and installed using low hammer energies. Limited available noise modelling in EIAs presented estimates of auditory injury impact ranges for very high frequency cetaceans such as harbour porpoise of less than 100m (Subacoustech 2021), less than 1000 m (ABPmer 2023) and Level B harassment take for all species of 2.52 km (NMFS, 2023).
- Brown *et al.* (2025) recommended that the EDR for sheet piling with ADDs should be ≤ 10 km.
- Given the limited evidence, and remaining uncertainty, the SNCBs' advice is to use 5 km for sheet piling.
- Should sheet piling occur with the use of an ADD, the EDR required will reflect the ADD device type and duration as outlined in Section 7 if this EDR is higher than 5 km.
- Should sheet piling occur with the use of noise abatement, the EDR would need to be agreed with regulators.

For **conductor piling**, the recommended EDR is **5 km**.

- Two sound measurement studies reported distances of up to approximately 1 km to the disturbance threshold level of SPL_{rms} 160 dB re 1µPa. While this evidence base is very limited and likely underestimates the disturbance effect, it does indicate the lower noise emissions associated with this activity compared to other forms of piling and the lower potential for disturbance.

- Evidence scores averaged 4.5 out of 10.
- Brown *et al.* (2025) recommended that the EDR for conductor piling with ADDs should be ≤ 10 km.

Given the limited evidence, and remaining uncertainty, the SNCBs' advice is to use 5 km for conductor piling.

- Should conductor piling occur with the use of an ADD, the EDR required will reflect the ADD device type and duration as outlined in Section 7 if this EDR is higher than 5 km.
- Should conductor piling occur with the use of noise abatement, the EDR would need to be agreed with regulators.

3. UXO Clearance

Unlike for pile-driving, for UXO clearance it was not possible to derive EDRs directly from empirical animal response data using the definition of Tougaard *et al.* (2013). While a considerable amount of sound measurement data now exists for high- and low-order UXO clearance, there is only one empirical study of harbour porpoise responses to high order UXO clearance (van Geel *et al*. 2024). Therefore, Majewska *et al.* (2025) reviewed mostly studies that:

(i) reported on sound levels measured during UXO clearance (n=11), and

(ii) modelled sound levels for UXO clearance (n=3).

For each study, where possible, the key parameter informing the disturbance ranges and therefore the recommended EDRs were the distances from the noise source to the temporary threshold shift (TTS) onset threshold for impulsive sounds for very-high frequency (VHF) cetaceans (Southall *et al.* 2019), as follows:

- SPL_{pk} 196 dB re 1 µPa (unweighted)
- SEL 140 dB re 1 µPa^{2}s (frequency-weighted)

TTS-onset criteria are not empirically-derived behavioural response thresholds. However, they are widely used and accepted in the UK by regulators and their advisors as a proxy for behavioural response thresholds to single pulsed sounds (i.e. explosions), with the assumption that they correspond to the noise level at which a fleeing response may be expected to occur in marine mammals (Majewska *et al.* 2025).

Where data allowed, an additional threshold, SPL_{pk} 168 dB re 1 µPa, was considered in Majewska *et al.* (2025). This was the sound level at which aversive behavioural reactions were observed in a captive harbour porpoise when exposed to single airgun pulses (adjusted to impulsive sounds from Lucke *et al.* 2009). Various field studies have shown support for this threshold when applied to exposure to multiple pulses (Brandt *et al.* 2016; Thompson *et al.* 2013) but for single pulses at distance such as those from UXO clearance this threshold is potentially overly conservative and therefore it is not considered in the current EDR advice for UXO clearance.

To inform the EDRs, Majewska *et al.* (2025) used reported response ranges and distances to behavioural response thresholds within the reviewed studies, as well as estimated distances to thresholds via additional examination of results within the reviewed studies.

3.1. Recommended Default EDRs

For low-order (deflagration only) UXO clearance, the recommended EDR is **5 km.**

- The current EDR for low-order deflagration clearance of 5 km is well-supported by evidence from sound measurement studies (6 studies, 166 clearance events). This encompasses the reported range to TTS-onset thresholds (0.1 to 5 km) from a considerable number of clearance events (with weight of donor charge sizes ranging between 0.03 – 0.45 kg NEQ) in relevant environments. These studies averaged an evidence score of 5 out of 10, given the lack of evidence from empirical response studies.
- The noise modelling studies (n=3), used a range of donor charges (0.25 to 0.5kg NEQ) and the estimated range to TTS-onset thresholds was between 0.8 and 2.3 km. The evidence score assigned to modelling studies was 4 out of 10.

- For low-order deflagration, sound levels correlate to the donor charge weight and not the UXO itself, as the explosive material within the UXO is not expected to undergo detonation. Therefore, this EDR can be applied to all deflagration clearances regardless of the explosive weight of the UXO.
- Should low-order deflagration occur with the use of an ADD, the EDR required will reflect the ADD device type and duration as outlined in Section 7 if this EDR is higher than 5 km.

For high-order UXO clearance (≤ 263 kg) without bubble curtain, the recommended EDR is **20 km.**

- While it is noted that modelling can be used to predict TTS-onset ranges for specific UXO sizes, measurement data suggest wide variability in sound levels with a poor correlation to UXO size (Majewska *et al.* 2025). As such, this EDR is largely based on the findings of van Geel *et al.* (2024) which recorded reduced harbour porpoise presence/acoustic activity up to a distance of 20 km for UXOs weighing 101 and 250 kg NEQ. Although the responses to UXO detonation could not be disentangled from the pre-detonation use of ADDs, it is expected the duration for which an ADD is active will be proportional to the explosive content of the UXO for any high-order UXO clearance without noise abatement (Majewska *et al.* 2025).
- This study had an evidence score of 6 out of 10. Although it provides empirical evidence of responses, there were limitations. For example, the data did not enable EDR quantification to the definition of Tougaard *et al.* (2013), it was a small sample size, and there was no information on sound levels.
- Seven sound measurement studies (97 clearance events) had distances to TTS-onset thresholds between 1.5-21 km. The largest measured distances to TTS-onset were for UXO sizes between 121-263 kg based on inferred distances from data in von Benda-Beckmann *et al.* (2015) and Salomons *et al.* (2021).
- These sound measurement studies had an average score of 5 out of 10.
- Majewska *et al.* (2025) recommended that the EDR for high order UXO clearance should be in the range of 15-20 km.
- Given the limited empirical and modelled evidence, and remaining uncertainty, SNCB's advice is to use the upper end of that range (i.e. 20 km). This is applicable to UXOs weighing 263 kg (the largest UXO the evidence is based on) or less.
- For UXOs larger than 263 kg, noise modelling should be undertaken to derive the distance to the TTS-onset thresholds (SPL_{pk} and frequency-weighted SEL as above). If noise modelling results in a distance greater than 20 km, the modelled distance should be used as the EDR, subject to agreement by the regulator. If lower, then the default 20 km should be used.

For high-order UXO clearance (≤ 525 kg) with bubble curtain, the recommended EDR is **10 km.**

- From two measurement studies (5 clearances), the inferred distances to the TTS-onset thresholds for clearance events with successful applications of bubble curtains ranged between 0.4-5.6 km. However, these are drawn from a very limited evidence base: only 5 clearance events (240-525 kg NEQ), with inconclusive evidence of the effectiveness of the bubble curtain, since no detonations were carried out without the bubble curtain for direct comparison.

- Data from quarry trials of small charges (Cheong *et al.* 2023b) and open-ocean high-order clearance studies (Schmidtke 2010; Grimsbo & Kvadsheim 2018), indicate that effective abatement can be achieved with a bubble curtain, yielding reductions in SPL_{pk} of 12-17 dB. However, the evidence from the open ocean UXO clearance studies reviewed in Majewska *et al.* (2025) is inconclusive with regard to both the magnitude and consistency of effectiveness of bubble curtains in reducing sound levels from high-order UXO clearance (Majewska *et al.* 2025). As such, Majewska *et al.* 2025 recommended a precautionary approach until the evidence base improves and the suggested EDR reflects this.
- Given the limited evidence (two measurement studies), and remaining uncertainty, SNCB advice is to use 10 km. This is applicable to UXOs weighing 525 kg (the largest UXO the evidence is based on) or less, when using bubble curtains.
- For UXOs larger than 525 kg, noise modelling should be undertaken to derive the distance to the TTS-onset thresholds (SPL_{pk} and frequency-weighted SEL as above). If noise modelling results in a distance greater than 10 km, the modelled distance should be used as the EDR, subject to agreement by the regulator. If lower, then the 10 km default should be used.
- Should high-order UXO clearance (≤ 525 kg) with bubble curtain occur with the use of an ADD, the EDR required will reflect the ADD device type and duration as outlined in Section 7 if this EDR is higher than 10 km.

4. Explosive Use in Decommissioning

There is very limited evidence on sound levels from sound measurement studies for explosive use in decommissioning, and none on harbour porpoise responses. Like the approach used for UXO clearance, Majewska *et al.* (2025) provided, where results allowed, the reported ranges to the TTS-onset thresholds for impulsive sounds for VHF cetaceans. In cases where response ranges were not explicitly reported but sufficient data were presented, these were further examined to estimate the distances at which TTS-onset thresholds would be reached. Additionally, Majewska *et al.* (2025) discussed comparing the sound levels measured during explosive detonations at various depths below the seabed with those recorded for charges of similar sizes detonated in open water, since noise measurements of detonations close to the mudline were comparable to those of unconfined detonations (Nedwell *et al.* 2001).

Sound measurements carried out during two well perforation campaigns in the southern North Sea (Confidential 2018a,b) at depths between 193 to 2,734 m below the mudline using 0.4 kg of high-explosives, showed that sound levels within the water column remained consistent with ambient levels. In addition, Confidential (2020) illustrated that sound levels from explosive use approximately 70-160 m below the mudline resulted in sound levels in the water column below SPL_{pk} TTS-onset thresholds and just above the VHF-weighted SEL threshold (Southall *et al.* 2019), in the immediate vicinity of the well (within a few tens of meters). This is considered unlikely to result in any measurable behavioural response (Majewska *et al.* 2025). This study used only small quantities of explosives (less than 3 kg per event), typical of explosive use deeper below the mudline. Current advice will therefore remain (i.e. that the use of explosives > 100 m below the mudline is considered to not result in disturbance to harbour porpoise so there is no associated EDR).

It's worth noting that ADDs are widely used for mitigation during explosive use. In a review of Marine Mammal Observer data, 63% of decommissioning projects were found to have used ADDs for mitigation when using explosives (Stone 2023a). This could have implications for the disturbance ranges if the EDR for the associated ADD is larger than the one advised for the decommissioning operation (see advice on ADDs).

4.1. Recommended default EDRs

For open water detonations and detonations up to 10 m below the mudline, the recommended EDR is **15 km.**

- Alternatively, assessments can use an EDR picked from the range of distances predicted from modelling (using TTS-onset thresholds) in proportion to the charge size being used as for open water detonation modelling, as recommended by Majewska et al (2025).
    - One study of well head severance in the North Sea (16 blasts, charge weights of 36-81 kg within 2-3 m of the mudline; Nedwell *et al.* 2001) resulted in sound levels from which unweighted SPLpk TTS-onset ranges were estimated to extend up to approximately 10 km (Majewska *et al.* 2025). This distance is comparable to model-predictions of open water detonations of similar charge sizes (i.e. up to c. 50 kg) (Majewska *et al.* 2025).
    - Another study (< 3 kg total perforation charges per event detonated at depths 5.2-8.5 m below seabed) resulted in TTS-onset thresholds being exceeded in close proximity to the source (Confidential 2020). No range to TTS-onset threshold could be estimated due to measurements being confined to close (i.e. a few metres) to the source. However, measured noise levels from shallow

perforations were such that with typical transmission loss, ranges to SPL_{pk} TTS-onset thresholds would not extend beyond a few tens of metres from the source (Majewska *et al.* 2025).

- The sound measurement studies had an average evidence score of 4.5. The score for relevant modelling studies (open water detonations, Subacoustech 2024a, b, c) was 4. Measurement studies were penalised for their limited spatial extent of measurement locations, in addition to being conducted in water depths greater than those within UK harbour porpoise SACs.
- The very limited available evidence from sound measurements of explosives used in decommissioning at depths of less than 10 m below mudline justifies a recommended precautionary EDR of 15 km.
- The recommended default EDR applies only to charges weighing less than 81 kg, given this is the maximum charge weight in the available evidence. For larger charges (rarely used), noise modelling should be undertaken to derive the distance to the TTS-onset thresholds (SPL_{pk} and frequency-weighted SEL as above). If noise modelling results in a distance greater than 15 km, the modelled distance should be used as the EDR, subject to agreement by the regulator. If lower, and given the uncertainties and limited evidence, then the 15 km default should be used.

- In the UK to date, noise abatement systems have not been employed for explosive use in decommissioning activities. Consequently, no data were available to inform the assessment of sound levels associated with such mitigated explosive use. However, modelling of open water detonation as proxy could also be applicable to the use of explosives with noise abatement, with assumptions made about the anticipated noise level reductions with noise abatement applied.

For open water detonations and detonations between 10 and 100 m below the mudline, the recommended EDR is **5 km.**

- One of the two decommissioning noise measurement studies reviewed in Majewska *et al.* (2025) with charges used approximately 70 - 160 m below the mudline (Confidential, 2020a) resulted in elevated noise levels in the water column, albeit not at levels anticipated to cause disturbance using unweighted SPL_{pk} TTS-onset thresholds as a proxy. Using the VHF-weighted SEL metric, the TTS-onset thresholds could be exceeded in the immediate vicinity of the well (within a few tens of meters) and therefore is unlikely to result in any measurable behavioural response. This study used only small quantities of explosives (less than 3 kg per event) and therefore the uncertainty is high for explosives used at these depths below mudline, hence a precautionary 5 km EDR is recommended.

5. Seismic Surveys

Two empirical studies looking at harbour porpoise responses to medium to large airgun surveys (Thompson *et al.* 2013, Sarnocińska *et al.* 2020) were reviewed by Majewska *et al.* (2025), but only the Sarnocińska *et al.* (2020) study allowed an EDR to be estimated in line with the definition of Tougaard *et al.* (2013). In addition, van Beest *et al.* (2018) investigated the responses of harbour porpoises in inner Danish waters to experimental exposures to a mini-airgun (< 12 in^3) but this was not suitable for estimating a maximum spatial extent of effects or an EDR.

Also included in the Majewska *et al.* (2025) review were sound measurement studies. For these, the review extracted the reported ranges to behavioural response thresholds. Where these were not available, and where the data allowed, Majewska *et al.* (2025) estimated ranges based on the measured sound levels. The following behavioural response thresholds were used in Majewska *et al.* (2025):

- SEL 145 dB re 1 $\mu Pa^2 s$ / $SPL_{pk\text{-}pk}$ 174 dB re 1 μPa (unweighted) aversive behavioural reactions (Lucke *et al.* 2009) - adjusted to 168 dB $SPL_{pk.}$
- SPL_{rms} 160 dB re 1 μPa National Marine Fisheries Service (NMFS) Level B harassment threshold (NOAA 2005).
- Alternative thresholds as reported in individual studies (e.g. Hermannsen *et al.* (2015) used thresholds between SPL_{rms} 141 and 149 dB re 1 μPa from Tougaard *et al.* (2015)).

The modelling studies reviewed presented significant inconsistencies in the disturbance ranges estimated due to the variety of methods used and data limitations, so no further assessment using these was possible.

5.1. Recommended Default EDRs

For seismic surveys using **mini-airguns of ≤ 12 in^3**, the recommended EDR is **5 km**

- The maximum estimated disturbance distance from sound measurements presented in Jiménez-Arranz *et al.* (2020) was 0.6 km for a mini-airgun (≤ 12 in^3). However, at such distances the potential effects of disturbance arising from the vessel itself begin to become a factor and with only a single study to inform the EDR, the uncertainty remains high.
- The Jiménez-Arranz *et al.* (2020) sound measurement study received average score of 6 out of 10.
- Given the lack of empirical evidence and very limited sound measurement data for mini-airguns, the recommended EDR in Majewska *et al.* (2025) approximately aligns with those of other high-resolution seismic sources (e.g. sparkers, boomers, see Section 6).

For seismic surveys of **airgun arrays of sizes between 12 and 3,570 in^3,** the recommended EDR is **10 km.**

- Sarnocińska *et al.* (2020) studied the effects of a large 3D seismic survey (3,570 in^3) in the Danish sector of the North Sea on harbour porpoise acoustic activity and found effects up to 12 km. The EDRs derived from the different parameters measured in this study using the Tougaard *et al.* (2013) definition were between 3.9 and 4.3 km. with an additional estimate of 7.8 km should a particularly conservative approach be taken (see Section 5.4.5 of Majewska *et al.* (2025)).

- It was not possible to extract an EDR from Thompson *et al.* (2013), which showed a reduction in porpoise density during a 470 in^3 survey within 10 km of the survey vessel. The distances from the airgun array at which the $SPL_{pk\text{-}pk}$ 174 dB re 1 μPa (Lucke *et al.* 2009) and SPL_{rms} 160 dB re 1μPa (NOAA 2005) behavioural response thresholds were exceeded were estimated as 4.2 km and 3.2 km, respectively (Majewska *et al.* 2025).
- Response ranges were inferred by Majewska *et al.* (2025) from sound measurements of airgun arrays of different sizes in Jiménez-Arranz *et al.* (2020). Estimated median / maximum distances to SPL_{rms} 160 dB re 1 μPa, were 1.3 / 4.6 km for arrays ≤ 1,200 in^3 (including single airguns) and 9.5 / 18.6 km for arrays > 1,200 in^3.
- Estimated distances to the behavioural thresholds for two other sound measurement studies (Hermannsen *et al.* 2015 and Confidential, 2020b) ranged from 1.6 km for a single airgun (40 in^3) to 14.7 km for arrays with volumes 3,500 – 7,000 in^3
- Reported distances to behavioural thresholds from modelling studies reviewed in Majewska *et al.* (2025) were up to 12.4 km, for arrays larger than 3,390 in^3 (OPRED 2019, 2020, 2021a, 2021b). However, there was not sufficient confidence in these results due to inconsistencies and lack of clarity in methods used.
- For airgun arrays of ≤ 1,200 in^3 (excluding mini-airguns), the single relevant empirical study (Thompson *et al.* 2013) received a score of 7 out of 10. There were two relevant sound measurement studies with an average score of 5.5 out of 10.
- For airgun arrays of > 1,200 in^3, the relevant empirical response study (Sarnocińska *et al.* 2020) had an evidence score of 8. There were two relevant sound measurement studies (Jiménez-Arranz *et al.* 2020, Confidential, 2020b) which averaged 5.5 out of 10.
- Sound measurement studies generally supported a gradient approach to assigning an EDR according to airgun array volume. However, the evidence from empirical response studies is currently too limited to support such an approach.
- Majewska *et al.* (2025) recommended the EDR for seismic surveys (except when using mini airguns) should be in the range of 5-10 km.
- Given the limited empirical and modelled evidence, and remaining uncertainty, SNCB advice is to use the upper end of that range (i.e. 10 km), but only for seismic surveys of airgun arrays of sizes between 12 and 3,500 in^3 for which empirical evidence exists.
- For arrays larger than 3570 in^3 there is no empirical evidence, and the very limited sound measurement and modelling studies pointed to larger effects ranges (although with large variability). Therefore, SNCB advise that for airgun arrays larger than 3570 in^3 noise modelling should be undertaken to derive the distance to the behavioural thresholds above. If noise modelling results in a distance greater than 10 km the modelled distance should then be used as the EDR, subject to agreement by the regulator. If the modelled distance is lower than 10 km, then the default 10 km should be used.

6. Sub Bottom Profilers (SBP) and Ultra Sonic Baseline (USBL)

There is very limited empirical evidence of harbour porpoise responses to SBP and USBL noise sources. What is available comes mainly from observations from Marine Mammal Observers during mitigation watches and limited to within 1-2 km of the sources (Stone, 2024b). These show that cetaceans show aversive reactions to some SBPs but are not suitable for estimating a maximum distance of effect of EDR.

There is one further study (Veneruso, 2024) that looked at the effect of a boomer on the distribution of harbour porpoise. Although it demonstrated a significant reduction in porpoise acoustic activity concurrent with the survey located between 0-9 km from the monitored area, the results were not considered suitable for estimation of an EDR or response distance.

Subsequently, Majewska *et al.* (2025) reviewed studies that measured sound levels (n=4) and noise modelling studies (n=8). For these, the review extracted the reported ranges to behavioural response thresholds. Where these were not available, and where the data allowed, it estimated ranges based on the measured sound levels. The following behavioural response thresholds were used in Majewska *et al.* (2025):

- SEL 145 dB re 1 μPa^{2}s / $SPL_{pk\text{-}pk}$ 174 dB re 1 μPa (unweighted) aversive behavioural reactions (Lucke *et al.* 2009) - adjusted to SPL_{pk} 168 dB.
- SPL_{rms} 160 dB re 1 μPa ('Level B harassement', NOAA 2005).
- Alternative thresholds as reported in individual studies reported the distance to a VHF-weighted SPL_{rms} 100 dB re 1 μPa threshold (Pace *et al.* 2021) or to a VHF-weighted SPL_{rms} 103 dB re 1 μPa threshold proposed by Tougaard (2021) (Confidential 2023).

6.1. Recommended Default EDRs

For all types of SBPs and USBL, the recommended EDR is **3 km.**

- Reported and estimated distances to the behavioural response thresholds from both sound measurements and noise modelling ranged between less than 0.1 km for parametric SBPs, chirper, pinger and sparker to 2.2 km for a sparker.
- For USBLs, reported and estimated distances to the behavioural response thresholds from both sound measurements and noise modelling ranged between less than 0.1 to 4.1 km.
- For all SBPs, sound measurement studies scored an average of 5 out of 10. The score assigned to all modelling studies was 3.
- For USBL, the two relevant sound measurement studies averaged a score of 5 and the modelled study a score of 3.
- The empirical response data are very limited but do provide some evidence of displacement of animals to SBP sources within the range suggested by the measured and modelled studies.
- Majewska *et al.* (2025) recommended that the EDR for SBPs and USBLs should be in the range of 2-3 km. Given the limited empirical and modelled evidence, and remaining uncertainty, the SNCBs advice is to use the upper end of that range (i.e. 3 km).

7. Acoustic Deterrent Devices (ADDs)

In the JNCC (2020) guidance EDRs were not recommended for ADDs. However, empirical studies have shown the potential for ADDs, widely used as mitigation for the risk of injury in operations like pile driving and UXO clearance, to result in large areas of porpoise deterrence. It is often not possible to disentangle the relative effect of the ADD and piling/UXO clearance operations and in some cases the disturbance effect distance resulting from the ADD has the potential to be greater than that from the operation itself. In these cases, the EDRs recommended below for the ADDs should be used in assessments instead of the EDR recommended for the operation.

Majewska *et al.* (2025) did not consider studies which estimated response ranges from modelled predictions and used solely empirical studies which are favoured over modelled/measurement studies. These studies reported harbour porpoise responses to two types of ADDs, the Lofitech seal scarer and the Van Oord/SEAMARCO and Ace Aquatec: Fauna Guard Porpoise Module (FaunaGuard for short). Where data allowed, Majewska *et al.* (2025) estimated EDRs from existing data through the examination/ interpretation of deterrence functions (magnitude/ probability of response vs distance to noise source) within published studies.

7.1. Recommended default EDRs

For use of the **Lofitech seal scarer ADD for short durations (15 min or less),** the recommended EDR is **8 km.**

- A single empirical study and single exposure event of a 15 minute duration (Thompson *et al.* 2020) allowed for an estimation of an EDR according to the definition of Tougaard *et al.* (2013). While the distance at which a > 50% probability of response in a 12-h period after exposure is 3.9 km, the corresponding EDR (for data truncated at 40 km) is 8 km. This relates to methodological characteristics explained in Majewska *et al.* (2025).
- This study had an evidence score of 7 out of 10.
- Additionally, Elmegaard *et al.* (2023), a study with the same score of 7, reported pronounced responses to exposures of 15 minutes ADD duration at 7 km distance.
- Majewska *et al.* (2025) recommended that the EDR for Lofitech seal scarer should be up to 8 km for short durations, and the SNCB advice reflects that.

For use of the **Lofitech seal scarer ADD for long durations (more than 15 min),** the recommended EDR is **11 km.**

- A single study (score 7 out of 10) across multiple exposures of average 66 minutes duration (range 37-235 minutes) in advance of impact pile driving with noise abatement (Dähne *et al.* 2017) allowed for an estimation of an EDR according to the definition of Tougaard *et al.* (2013). While the distance at which a > 50% probability of response during exposure is 6.6 km, the corresponding EDR is 11.1 km. However, results from other studies of longer exposures of > 60 minutes (Brandt *et al.* 2013, and likely Voß *et al.* 2023) report near-complete deterrence to 5-10 km, such that responses can be expected to extend beyond this distance (these studies scored 6-7 out of 10).
- Majewska *et al.* (2025) recommended that the EDR for Lofitech seal scarer should be 11 km for longer durations (> 15min), and the SNCB advice reflects that.

For the use of the **FaunaGuard for any duration** the recommended EDR is **2.5 km.**

- A single study (score 7 out of 10) across multiple exposures of up to 43 minutes in advance of impact pile driving with noise abatement (Voß *et al.* 2023) reported a distance of 2.5. km to which porpoise detection rates were reduced relative to baseline. The data in the study were not considered suitable for estimation of an EDR.
- Majewska *et al.* (2025) recommended that the EDR for FaunaGuard should be 2.5 km and the SNCB advice reflects that.

8. Single and Multibeam Echo Sounders (SBES / MBES)

Only MBES systems with frequencies equal to or less than 12 kHz require reporting to the UK Marine Noise Registry (JNCC, 2016). Above those frequencies there is limited sound propagation and therefore the potential for disturbance of marine mammals is much reduced. MBESs equal to or less than 12 kHz are only rarely used in UK waters, and usually in deeper waters, where harbour porpoises do not commonly occur.

There is an absence of empirical data on the responses of free-ranging harbour porpoises to low-frequency MBES and limited evidence of reported responses among beaked whales to an array of SBES (18 - 200 kHz) (one study with evidence score of 4 out of 10; Majewska *et al.* 2025). Further, sound measurement studies are lacking for equipment operating at ≤ 12 kHz, and so low-scoring modelling studies (2-4 points out of 10) dominate the evidence base. Where results allowed, ranges to the Level B harassment threshold for impulsive noise (SPL_{rms} 160 dB re 1 µPa) were reported in Majewska *et al.* (2025).

Given these limitations, there is a high degree of uncertainty in any recommendations for a default EDR.

8.1. Recommended default EDRs

For **multiple-transducer SBES or MBES with an operating frequency of ≤ 12 kHz operating in waters > 200 m depth** the recommended EDR is **5 km**.

For **multiple-transducer SBES or MBES with an operating frequency of ≤ 12 kHz operating in waters ≤ 200 m depth** the recommended EDR is **3 km**.

- Reported and estimated effects ranges are all ≤ 4 km. Values closer to 4 km relate to a complex multiple SBES array or MBES use in deep water (> 1,000 m) and for the lowest frequencies of 12 kHz (Majewska *et al.* 2025).
- For shallower depths (≤ 200m), using the NMFS (2020) tool for an example high power 12 kHz MBES resulted in estimated effects range of less than 500 m.
- Majewska *et al.* (2025) recommended that the EDR for these two categories should be a precautionary 3 and 5 km and SNCB advice reflects that due to the lack of empirical evidence for harbour porpoise.

9. Military Sonar

There is an absence of empirical data on the responses of free-ranging harbour porpoises to sonar. Also, there is wide variability in reported responses among other species, and limitations in terms of estimating effects ranges (Majewska *et al.* 2025). As such, the evidence base is limited and scored low (between 3 – 5 out of 10) in the context of estimating harbour porpoise EDRs. Given these limitations, there is a high degree of uncertainty in any recommendations for a default EDR.

9.1. Recommended default EDRs

For **military sonar** the recommended EDR is **20 km.**

- Based on distances reported for other species (many reported beyond 10 km) and limited noise modelling results, as well as known sensitivity of harbour porpoise to a variety of anthropogenic noise sources, it can be expected that harbour porpoise may respond behaviourally to military sonar to **at least 10 km** from the sonar sound source.
- Majewska *et al.* (2025) recommended that a precautionary approach to assigning an EDR for military sonar is adopted. For example, that the EDR be consistent with the largest EDR recommended for other impulsive noise sources (i.e. high-order UXO clearance and/or unabated impact piling).

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Appendix 1. Scoring decision tree

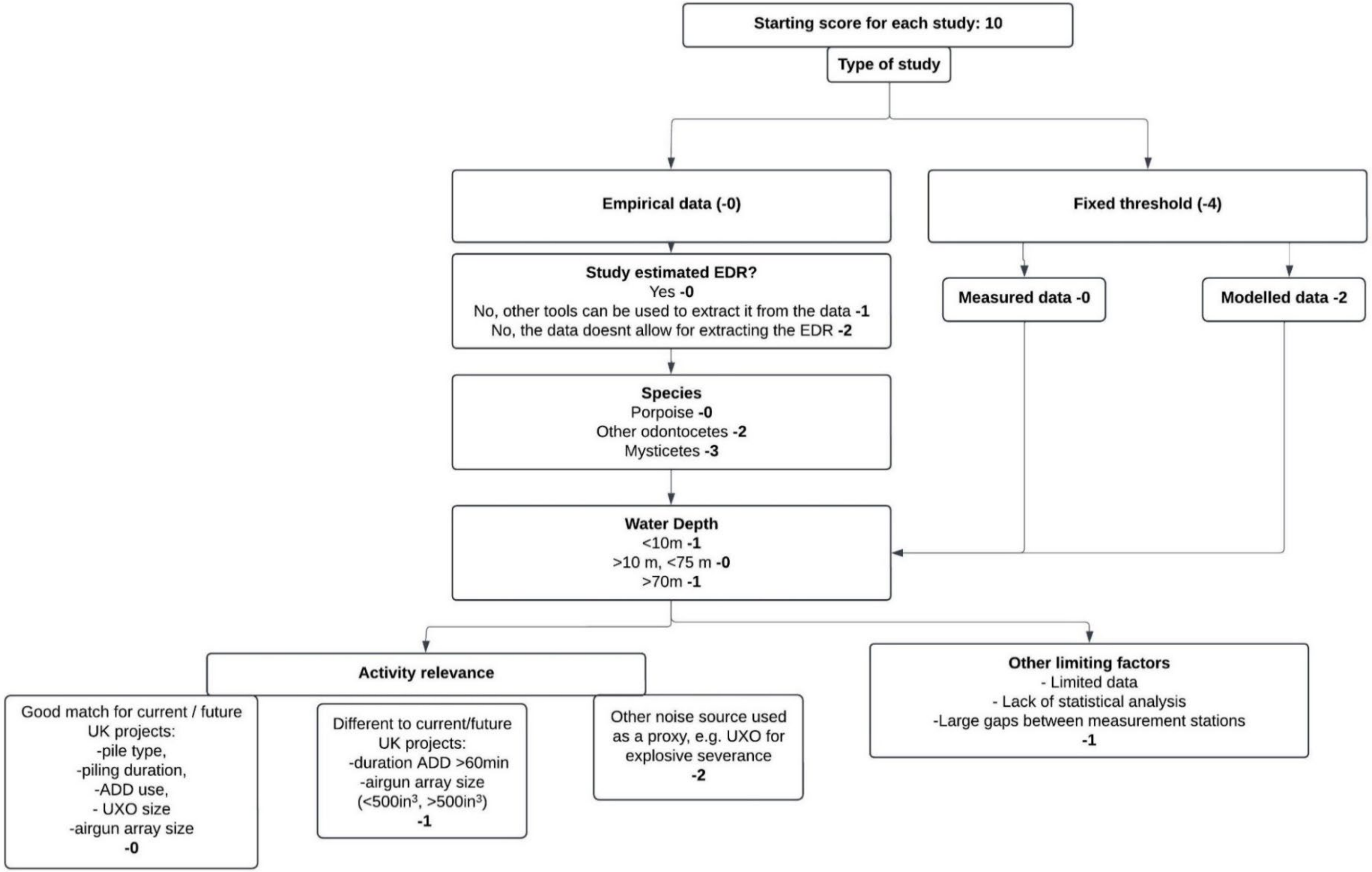

Figure 1. Scoring Decision Tree (in Brown *et al.* 2025).