Alexandra Basin Redevelopment 2

Bringing Dublin Port To 2040

Environmental Impact Assessment Report

Chapter 13 Underwater Noise & Vibration

Volume 2



CALAFORT ÁTHA CLIATH
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13 Underwater Noise and Vibration

Chapter Contents

13 Underwater Noise and Vibration 13-1
13.1 Introduction 13-2
13.2 Assessment Methodology 13-3
13.3 Baseline Environment 13-19
13.4 Results 13-19
13.5 Inter-relationships 13-22
13.6 Mitigation and Monitoring 13-22
13.7 Potential Cumulative Effects 13-22
13.8 Residual Impacts 13-23
13.9 Summary of Results 13-23
13.10 Limitations of Assessment 13-23

13.1 Introduction

This Chapter of the Environmental Impact Assessment Report (EIAR) comprises an appraisal of the existing Underwater Noise conditions within the Project study area and addresses the potential effects of the Project on Underwater Noise. The assessment is based on the description of works as noted in **Chapter 5 Project Description**. Where potential adverse impacts are identified, the assessment identifies impact ranges and mitigation measures that will be implemented to prevent, reduce or offset potential adverse effects.

Appendices have been prepared to support this assessment, contained within **Appendix 13-1** and **13-2** of the EIAR.

13.1.1 Scope of the Assessment

The primary purpose of this technical report is to provide an assessment of the likely ranges of exceedance of thresholds for adverse auditory effects of Underwater Noise on marine mammals and fish from the ABR2 Project.

The construction activities of the ABR2 Project will emit noise with the potential to cause adverse effects on marine life. At close ranges from a noise source with high noise levels, permanent hearing injury or brief hearing impairment may occur to marine species, while at a very close range, gross physical trauma is possible. At long ranges (several kilometres), the introduction of any additional noise could, for the duration of the activity, potentially cause behavioural changes, e.g. changes to the ability of species to communicate and to determine the presence of predators, food, underwater features and obstructions.

This chapter provides an overview of the potential effects due to Underwater Noise from the ABR2 Project on the surrounding marine environment based on the NMFS/NOAA 2024 and Popper et al. (2014) frameworks for assessing impact from noise on marine mammals and fishes. In addition, an assessment of likely ranges for behavioural effects based on a review of UK and Danish guidance documents on behavioural impacts has been undertaken.

Consequently, the primary purpose of the underwater noise assessment is to predict the likely range of onset of injury as given in the relevant guidance (Auditory Injury, AUD INJ) and ranges to potential behavioural effects due to anthropogenic noise because of the ABR2 Project.

13.1.2 Specific Activities Assessed

During the scoping phase, one main activity was identified as having a potential significant adverse effect on Underwater Noise; Noise from the demolition of the jetty structures and dolphins within Berths 52 and 53.

Note that the current ABR2 Project plan assumes that a full closure of the basin at Berths 52/53 is complete prior to the demolition works in the basin. For this assessment, incomplete closure has been assumed, meaning noise can still propagate out of the basin, into the remaining port waters. If the basin is completely closed, with no waterborne path, the noise will, for the purpose of ecological impact, be contained within the basin.

A dredging campaign of Alexandra Basin West is also included in the ABR2 Project, but due to low noise levels compared to the ambient noise levels of a working port, this activity has been scoped out with respect to adverse impacts from noise and will not be assessed in this report.

13.2 Assessment Methodology

This section describes the methodology which has been used in the assessment of Underwater Noise, which may impact or be impacted by the ABR2 Project. The methodology and associated impact assessment had regard to the general guidance for the undertaking of an Environmental Impact Assessment (EIA), as presented in **Chapter 1 Introduction**, as well as best international and national practice (NMFS, 2024, NPWS, 2014, Popper et al., 2014).

13.2.1 Sound Classification

Underwater noise is generally split into two categories, depending on its characteristics:

- Impulsive sounds

Sounds which are typically transient, momentary (less than one second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay (ANSI, 2005; ANSI, 1986; NIOSH, 1998). This category includes sound sources such as seismic surveys, impact piling and underwater explosions. Additionally included here are sounds under 1 second in duration with a weighted kurtosis over 40 (see note below*).

- Non-impulsive (and continuous) sounds

Sounds which can be broadband, narrowband or tonal, momentary, brief or prolonged, continuous or intermittent and typically do not have a high peak sound pressure with a rapid rise/decay time that impulsive sounds do (ANSI, 1995; NIOSH, 1998). This category includes sound sources such as continuous vibro-piling, running machinery, some sonar equipment and vessels. Additionally included here are sounds over 1 second in duration with a weighted kurtosis under 40 (see note below*).

** Note that the European Guidance: "Monitoring Guidance for Underwater Noise in European Seas, Part II: Monitoring Guidance Specifications" (MSFD Technical Subgroup on Underwater Noise, 2014) includes sonar as an impulsive source (see Section 2.2 in the reference). However, the guidance suggests that "all loud sounds of duration less than 10 seconds should be included" as impulsive. This contradicts research on the impact of impulsive sounds, suggesting that a limit for "impulsiveness" can be set at a kurtosis of 40 (Martin & Klaus Lucke, 2020). See examples in Appendix A, Impulsiveness.*

Therefore, a criterion of kurtosis over 40 is used here to identify impulsive sounds. The justification for departing from the MSFD criterion is that the NMFS (2024) and the Popper et al. (2014) frameworks' thresholds are based on the narrower definition of impulsive as given in "Impulsive sounds" above.

Given impulsive sound's tendency to become less impulsive with increased range, a minimal range can be established where the noise is no longer impulsive (kurtosis <40) (Appendix A, Impulsiveness). This range is established using ray tracing with receivers and sources placed at multiple depths to account for variation in the final source setup.

13.2.2 Sound Impacts & Effects

Underwater noise has the potential to affect marine life in different ways depending on its noise level and characteristics. There are five zones of noise impact:

The zone of audibility: This is defined as the area within which the animal can detect the sound. Audibility itself does not imply that the sound will affect the animal. There are no agreed thresholds for this level of effect.

The zone of masking: This is defined as the area within which sound can interfere with the detection of other sounds, such as communication or echolocation clicks. This zone is very hard to estimate due to a paucity of data relating to how animals detect sound in relation to masking levels (for example, humans can hear tones well below the numeric value of the overall sound level). Continuous sounds will generally have a greater masking potential than intermittent sounds due to the latter providing some relative quiet between sounds. Masking only occurs if there is a near-overlap in sound and signal frequency content, such that a loud sound at e.g., 1000Hz will not be able to mask a signal at 10,000Hz[1]. There are no agreed thresholds for this level of effect.

The zone of responsiveness: This is defined as the area within which the animal responds either behaviourally or physiologically. The zone of responsiveness is usually smaller than the zone of audibility because, as stated previously, audibility does not necessarily evoke a reaction. For most species, there is very little data on response, but for species like harbour porpoise there exist several studies showing a relationship between received level and probability of response (Graham, 2019, Sarnocinska, 2020, Booth, 2017, Benhemma-Le Gall, 202).

The zone of temporary hearing loss: The area where the sound level is sufficient to cause the auditory system to lose sensitivity temporarily, causing loss of “acoustic habitat” (the volume of water that can be sensed acoustically by the animal). This hearing loss is typically classified as Temporary Threshold Shift (“TTS”, see **Section 13.2.5**).

The zone of injury / permanent hearing loss: This is the area where the sound level is sufficient to cause permanent hearing loss in an animal. This hearing loss is typically classified as Auditory Injury (“AUD INJ”, see **Section 13.2.5**). At even closer ranges, and for very high intensity sound sources (e.g., underwater explosions), physical trauma or acute mortal injuries are possible. In relation to fish, we included the impact “Recoverable Injury” as AUD INJ, as while it is not permanent, it is a serious effect and is assumed to have associated significant costs to population fecundity.

For this study, it is the zones of injury (range to exceedance of AUD INJ thresholds) that are of primary interest.

13.2.3 Marine Mammal Thresholds

The zone of injury in this study is classified as the distance over which a fleeing marine mammal can suffer AUD INJ, leading to non-reversible auditory injury. Injury thresholds are based on a dual criteria approach using both

[1] The exact limit of how near a noise can get to the signal frequency before causing masking will depend on the receivers’ auditory frequency resolution ability, but for most practical applications noise and signal frequencies will need to be within 1/3rd octave to start to have a masking effect.

un-weighted peak level (L_{pk} – maximal instantaneous SPL) and marine mammal hearing weighted sound exposure level (SEL). The hearing weighting functions are designed to represent the sensitivity for each group within which acoustic exposures can have auditory effects. The categories include:

- **Low Frequency (LF) cetaceans**: Marine mammal species such as baleen whales (e.g. minke whale *Balaenoptera acutorostrata*).
- **High Frequency (HF) cetaceans (NMFS) / Mid-frequency (Southall et al. 2007)**: Marine mammal species such as dolphins, toothed whales, beaked whales and bottlenose whales (e.g., bottlenose dolphin *Tursiops truncatus* and white-beaked dolphin *Lagenorhynchus albirostris*).
- **Very High Frequency (VHF) cetaceans (NMFS) / High-frequency (Southall et al. 2007)**: Marine mammal species such as true porpoises, river dolphins and pygmy/dwarf sperm whales and some oceanic dolphins, generally with auditory centre frequencies above 100kHz (e.g., harbour porpoise *Phocoena phocoena*).
- **Phocid Carnivores in Water (PCW/PC)**: True seals (e.g., harbour seal *Phoca vitulina* and grey seal *Halichoerus grypus*); hearing in air is considered separately in the group PCA.
- **Other Marine Carnivores in Water (OCW/OC)**: Including otariid pinnipeds (e.g., sea lions and fur seals), otters and polar bears; in-air hearing is considered separately in the group Other Marine Carnivores in Air (OCA).

These categories are used in this study and are shown in **Figure 13-1** (NMFS 2024 weightings). It should be noted that not all of the above hearing groups of marine mammals will be present in the ABR2 Project area, but all hearing groups are presented in this report for completeness. The primary groups of relevance for this report are the hearing groups containing porpoises (VHF), seals (PCW) and otters (OCW). Groups containing, e.g. minke whale (LF) and dolphins (HF) are also included for completeness.

13.2.3.1 NMFS 2004 Weights & Thresholds

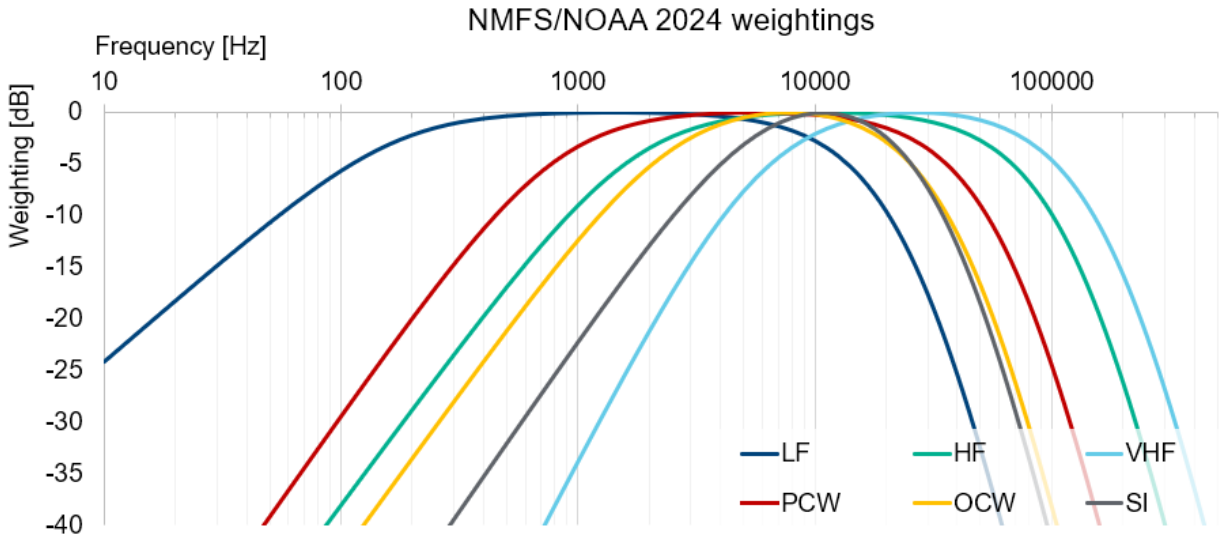


Figure 13-1: Auditory weighting functions for seals, whales and sirenians (NMFS, 2024).

The criteria for impulsive and non-impulsive sound are relevant for this study, given the nature of the sound sources used during the ABR2 Project. The relevant AUD INJ criteria proposed by NMFS 2024 are summarised in **Table 13-1**.

Table 13-1: AUD INJ thresholds (NMFS, 2024)

Hearing Group	Parameter	Impulsive [dB]		Non-impulsive [dB]	
		AUD INJ	TTS	AUD INJ	TTS
Low frequency (LF) cetaceans	L_{pk}, (unweighted)	222	216	-	-
	SEL, (weighted)	183	168	197	177
High frequency (HF) cetaceans	L_{pk}, (unweighted)	230	224	-	-
	SEL, (weighted)	193	178	201	181
Very high frequency (VHF) cetaceans	L_{pk}, (unweighted)	202	196	-	-
	SEL, (weighted)	159	144	181	161
Phocid carnivores in water (PCW)	L_{pk}, (unweighted)	223	217	-	-
	SEL, (weighted)	183	168	195	175
Other marine carnivores in water (OCW)	L_{pk}, (unweighted)	230	224	-	-
	SEL, (weighted)	185	170	199	179

Irish Guidance Interpretation of Marine Mammal Thresholds

We note that the NPWS/DAHG “Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters” 2014 (Department of Arts, Heritage and the Gaeltacht, 2014) prescribes the use of thresholds from a 2007 publication (Southall, 2007), these have since been superseded (Southall et al., 2019, NMFS, 2024) and no longer represent best available science or best practice internationally. Thus, the following excerpt from the guidance is relevant:

"The document will be subject to periodic review to allow its efficacy to be reassessed, to consider new scientific findings and incorporate further developments in best practice."

As there has been no such update to date and the guidance clearly states its intention to consider new scientific findings, we have applied the latest guidance for marine mammals (NMFS, 2024), reflecting the current best available method for assessing impact from noise on marine mammals. This means that following current scientific best practice, AUD INJ" (previously "PTS") is the criteria for injury, not "TTS".

It is worth noting that the NPWS (2014 guidance's reliance on Southall et al. 2007 TTS thresholds mean that for most scenarios, the impact ranges are comparable to the AUD INJ threshold from the NMFS 2024 guidance. Where NPWS 2014 is more conservative, it is often the result of including noise at frequencies where the relevant species group is not very sensitive (the weightings from Southall et al. 2007 were very broad and based on very little evidence compared to the NMFS 2024 weightings).

The TTS thresholds in Southall et al. 2007, Southall et al. 2019 and NMFS 2024 are not direct measurements of an exact exposure level where TTS occurs. Rather, the TTS thresholds are based on the level where 6dB of TTS is expected in the test animal. The 6dB level itself is found by plotting the exposure level against the amount of TTS caused by that exposure level and then fitting a regression line to estimate the amount of TTS caused per dB increase in exposure level. This line can then be used to estimate the level where 6dB of TTS is expected.

The PTS/AUD INJ threshold is the received level at which 40dB of TTS is expected (40dB TTS is believed to lead to PTS/AUD INJ). This has two important consequences:

1. At received levels equal to the TTS onset threshold, the expected TTS is 6dB, not 0dB, meaning that if *any* TTS is considered injury, no guidance currently contains sufficient information to assess impacts according to the NPWS 2014 guidance (where the language implies that any TTS should be considered injury).
2. Received levels below the PTS/AUD INJ thresholds are all seen as recoverable by Southall et al. 2007 & 2019 and NMFS 2024, they give rise to only "TTS". Given the lack of a stated *acceptable level* of TTS in the NPWS guidance, the guidance is open to interpretation as to whether the "*potential to induce TTS"* is at levels likely to cause 0dB to 40dB of TTS.

13.2.3.2 Disturbance to Marine Mammals

The noise thresholds for disturbance of marine mammals are not as mature as the AUD INJ and TTS thresholds and several different approaches exist. A conservative but realistic approach based on a review of Danish and UK guidance documents, as well as scientific reviews, has been applied.

This reflects the approach of the Danish guidance (Danish Centre for Environment and Energy, 2021) and a review submitted to the JNCC (Joint Nature Conservation Committee) of the UK (Nedwell et al., 2007). A review for Natural Resources Wales (Sinclair et al., 2023) also acknowledges this approach as suitable. These all recommend or acknowledge the use of a weighted received level along with a hearing group-specific threshold.

Using 21 suitable studies from these reports, hearing group-specific thresholds are derived (**Table 13-2** & **Figure 13-2**) to determine behavioural disturbance levels for non-impulsive noise (here understood to be noise

with a kurtosis below 40). These thresholds are compared to the range where the hearing group weighted received level exceeds the relevant threshold.

Table 13-2: Disturbance criteria for marine mammals used in this assessment, based on Danish, UK and USA guidance.

Effect	Non-impulsive Threshold [SPL] Weighted levels	Impulsive threshold [SPL 1 sec] Weighted levels
Low frequency (LF) cetaceans	120	120
High frequency (HF) cetaceans	113	106
Very high frequency (VHF) cetaceans	103	98
Phocid carnivores in water (PCW)	120	120
Other marine carnivores in water (OCW)	120	120

Contrary to the NOAA level B harassment levels, where the threshold for impulsive noise (160dB SPL[2]) is higher than for non-impulsive noise (120dB SPL), thresholds presented here are lower for noises that are impulsive at the source as this matches the observed tendency for impulsive noise to generate a greater behavioural response than non-impulsive noise (Danish Centre for Environment and Energy, 2021, Sinclair et al., 2023, Nedwell et al., 2007).

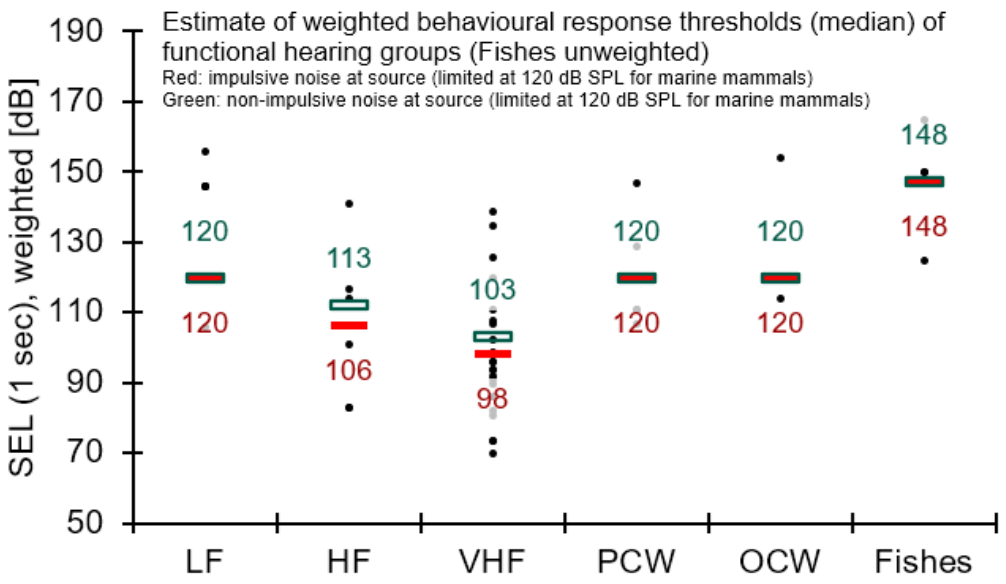


Figure 13-2: Data and behavioural disturbance thresholds. Lines/values given are median values or 120dB SPL, whichever is lower. Red is impulsive. Green is non-impulsive

13.2.3.3 Habituation

The estimates for behavioural disturbance thresholds use data from animals both naïve and accustomed to anthropogenic noise, so the large variation is likely to be, at least partly, due to real differences in sensitivity to noise types according to animal tolerance, rather than conventional measurement uncertainty. Thus, noises which are familiar to the animal are expected to elicit responses only at higher received levels that noises which

[2] SPL duration of 90-95% energy of a single pulse.

are novel, and noise which might be associated with discomfort are expected to elicit a response at lower levels (e.g. impact pile driving or explosions).

13.2.4 Fishes Thresholds

The injury criteria used in this noise assessment are based on Popper at al. 2014 and are given in **Table 13-3** and **Table 13-4** for impulsive noises (L_{pk}) and continuous noise (SEL), respectively. L_{pk} and SEL criteria presented in the tables are unweighted.

It is important to clarify that this lack of weighting for fishes reflects a lack of scientific consensus about the best method for applying frequency dependence to received levels for fishes, rather than a statement that fishes can hear all frequencies equally. A large review (Nedwell et al., 2004) reported that fishes generally cannot hear above 10kHz, and if they can, the sensitivity is generally very poor (**Figure 13-3**).

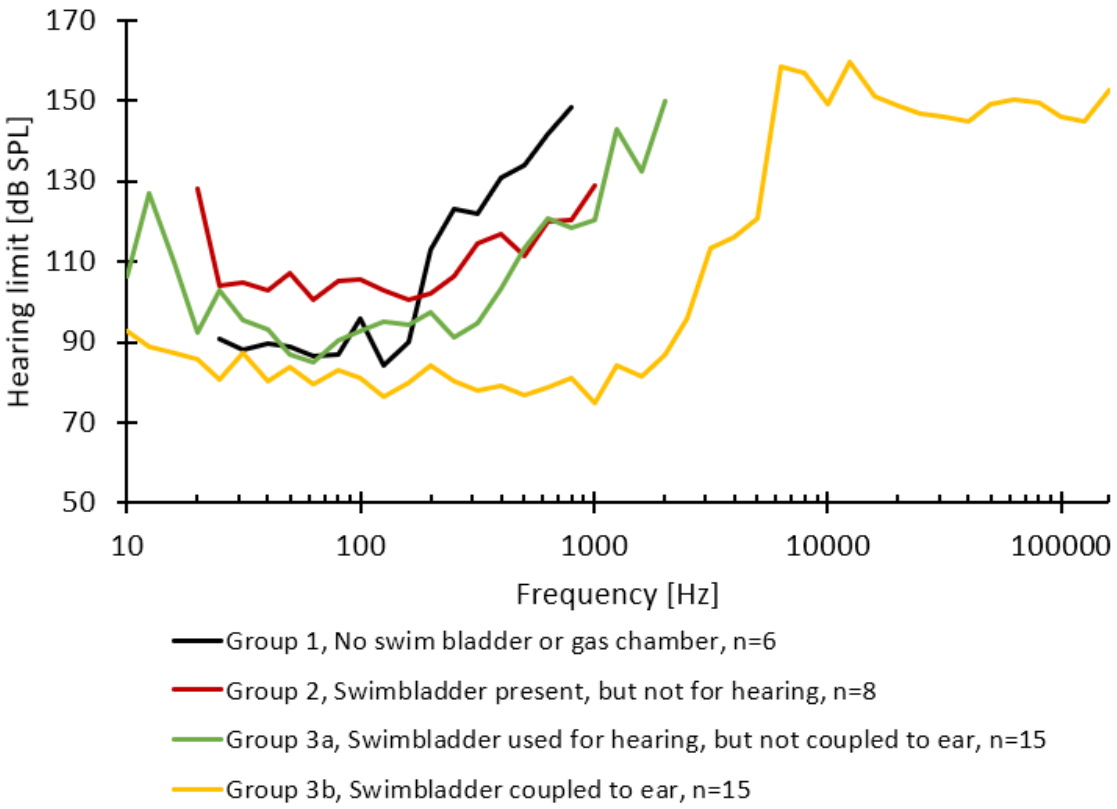


Figure 13-3:**Generalised hearing thresholds for fishes grouped by the presence of a swim bladder and its role in hearing.**

Additional limits for fishes:

Popper et al. 2014 does not set out specific TTS limits for L_{pk} and or disturbance limits for impulsive noise for fishes. Therefore, publications “Washington State Department of Transport Biological Assessment Preparation for Transport Projects Advanced Training Manual” (WSDOT, 2020) and “Canadian Department of Fisheries and

Ocean Effects of Seismic energy on Fish: A Literature review" (Worchester, 2006) on effects of seismic noise on fish are used to determine limits for these:

Threshold for behavioural disturbance and TTS from impulsive noise as SPL:

The criteria presented in the Washington State Department of Transport Biological Assessment Preparation for Transport Projects Advanced Training Manual (WSDOT, 2020) suggests an unweighted sound pressure level of 150dB SPL (assumed to be duration of 95 % of the energy) as the criterion for onset of behavioural effects, based on work by (Hastings, 2002). Sound pressure levels in excess of 150 dB SPL are expected to cause temporary behavioural changes, such as elicitation of a startle response, disruption of feeding, or avoidance of an area (2dB higher than from the data for fish presented in Figure 13-2). The document notes that levels exceeding this threshold are not expected to cause direct permanent injury but may indirectly affect the individual fish (such as by impairing predator detection). It is important to note that this threshold is for the onset of potential effects, and not necessarily an 'adverse effect' threshold. The threshold is implemented here as either a single impulse SEL or a 1-second SEL, whichever is greater.

TTS threshold from impulsive noise as L_{pk}:

The report from the Canadian Department of Fisheries and Ocean "Effects of Seismic energy on Fish: A Literature review on fish" (Worcester, 2006) found large differences in response between experiments. Onset of behavioural response varied from 107-246dB L_{pk}, the 10th percentile level for behavioural response was 160dB L_{pk} (rounded to nearest 5dB to reflect large variation in data).

Thus, the behavioural threshold for fishes for impulsive noise is 160dB L_{pk} and 148dB SPL.

Note that while there are multiple groups of fish presented, we have used the thresholds of the more sensitive group for all fish, thus covering all fishes (203/186 AUD INJ/TTS for impulsive sound & 222/204 AUD INJ/TTS for non-impulsive sound). These lower thresholds also cover "Eggs and Larvae".

Table 13-3: Criteria for onset of injury to fish and sea turtles due to impulsive noise. For this assessment the lowest threshold for any group is used for all groups (shown in bold).

Type of Animal	Unit	Mortality and Potential Mortal Injury [dB]	Recoverable Injury (AUD INJ) [dB]	TTS [dB]	Behavioural [dB]
Fish: no swim bladder (particle motion detection) Example: Sharks.	SEL	219[1]	216[1]	186[1]	150[3]
	L_{pk}	213[1]	213[1]	193[2]	160[2]
Fish: where swim bladder is not involved in hearing (particle motion detection). Example: Salmonoids.	SEL	210[1]	203[1]	186[1]	150[3]
	L_{pk}	207[1]	207[1]	193[2]	160[2]
Fish: where swim bladder is involved in hearing (primarily pressure detection). Example: Gadoids (cod-like).	SEL	207[1]	**203[1]**	**186**	**148[4] [SPL]**
	L_{pk}	207[1]	**207[1]**	**193[2]**	**160[2]**
Sea turtles	SEL	210[1]	(*Near*) High*	-	-

Type of Animal	Unit	Mortality and Potential Mortal Injury [dB]	Recoverable Injury (AUD INJ) [dB]	TTS [dB]	Behavioural [dB]
	L_{pk}	207[1]	(*Mid*) Low (*Far*) Low	-	-
Eggs and larvae	SEL	210[1]	(*Near*) Moderate (*Mid*) Low (*Far*) Low	-	-
	L_{pk}	207[1]		-	-

[1] (Popper et al. 2014) Table 7.4, [2] (Worcester, 2006), [3] (WSDOT, 2020), [4] (Danish Centre for Environment and Energy, 2021; Sinclair, et al., 2023; Nedwell, et al., 2007).

* Indicate (range) and risk of effect, e.g., "(Near) High", meaning high risk of that effect when near the source.

Where Popper et al. 2014 present limits as ">" 207 or ">>" 186, we have ignored the "greater than" and used the threshold level as given.

Relevant thresholds for non-impulsive noise for fishes relating to AUD INJ, TTS, and behaviour are given in **Table 13-4**.

Table 13-4: **Criteria for fish (incl. sharks) due to non-impulsive noise from Popper et al. 2014 (Table 7.7 & 7.5) and UK & Danish guidance.**

Type of Animal	Unit	Mortality and Potential Mortal Injury [dB]	Recoverable Injury (AUD INJ) [dB]	TTS [dB]	Behavioural [dB]
All fishes	SEL	(Near) Low (Mid) Low (Far) Low	222[b]	204[b]	-
All Fishes	SPL	>193[c]	193[d]	193[d]	126[a]

[a] Based on review in **Section 13.2.5.2**, also **Figure 13-2**.

[b] Based on 48 hours of 170dB SPL (AUD INJ) and 12 hours of 158dB SPL (TTS).

[c] "greater than" 193dB SPL as no effect was seen at this level, so the threshold must lie above this.

[d] Given as ">193dB SPL" in Popper et al 2014 but applied in this assessment as 193dB SPL. An SPL level of 193dB for 2 hours (the exposure time for this report) equals 222dB SEL.

13.2.5 Guidance and Legislation

13.2.5.1 Legislation

The main legislation in Ireland granting protection to marine mammals (and otters) is the 1976 Wildlife act and amendments[3], specifically section 23 (linked in footnote below).

EU Habitats Directive (92/43/EEC), which provides strict protection for cetaceans and seals through designated Special Areas of Conservation (SAC)s

Marine Strategy Framework Directive, which establishes a framework for achieving Good Environmental Status of marine waters, including Descriptor 11 relating to underwater noise and energy inputs

[3] https://revisedacts.lawreform.ie/eli/1976/act/39/revised/en/html#SEC23
(available as annotated pdf from:
https://revisedacts.lawreform.ie/eli/1976/act/39/revised/en/pdf?annotations=true)

13.2.5.2 Guidance

As set out in **Section 3.2 Assessment Methodology**, the main guidance documents are:

- Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI (Popper et al. 2014).
- 2024 Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0) Underwater and In-Air Criteria for Onset of Auditory Injury and Temporary Threshold Shifts (NMFS, 2024).
- Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters, Department of Arts, Heritage and the Gaeltacht, 2014 (NPWS, 2014).

13.2.6 Study Area

The central area of relevance for this Underwater Noise impact assessment is presented in **Figure 13-4** and primarily includes the waters of Dublin Port and the Tolka Estuary.

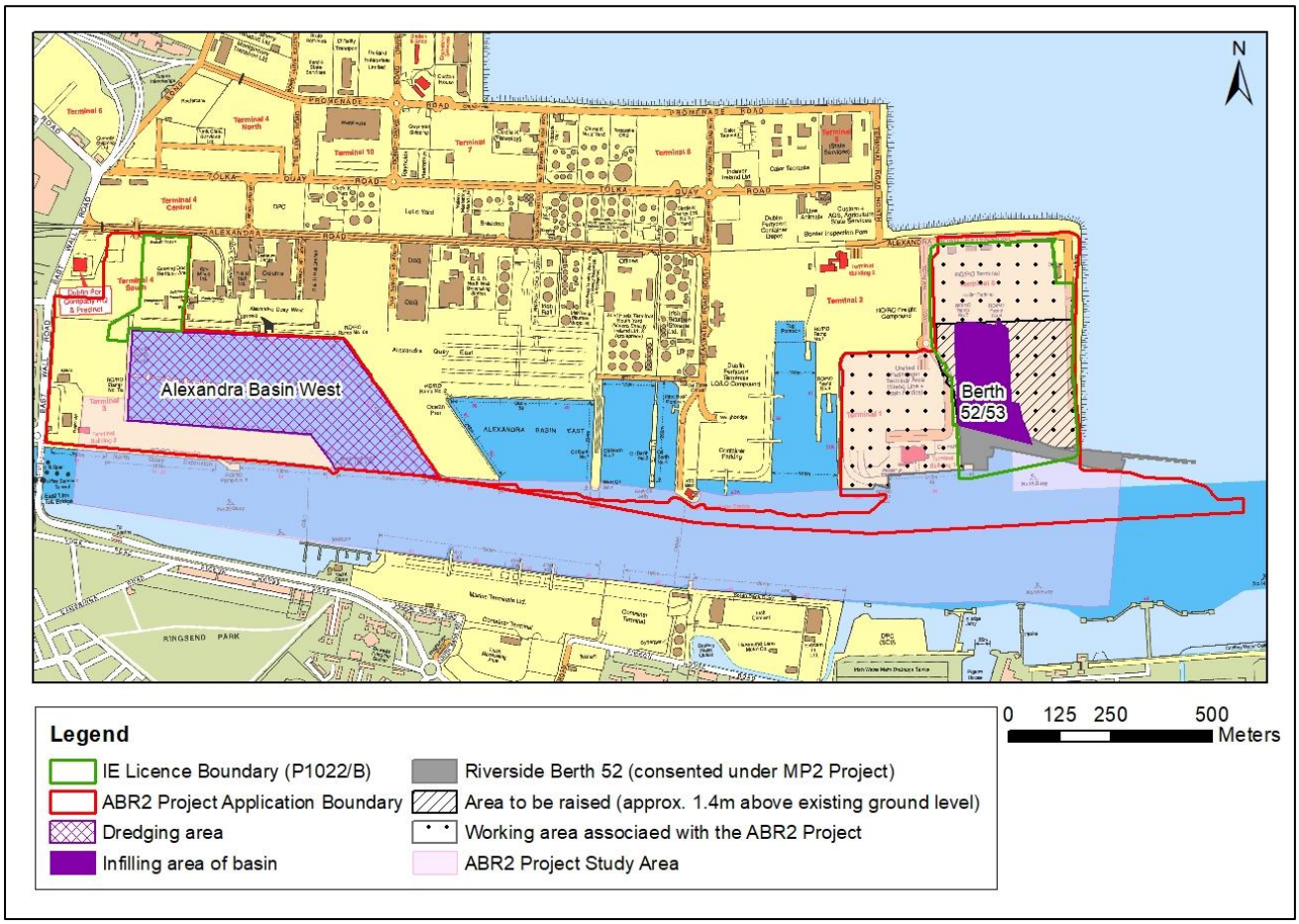


Figure 13-4: Underwater Noise Study Area

13.2.6.1 Water Properties

Water properties were determined from historical data for the area. Where values differ between e.g. seasons and tidal states, the values resulting in the lowest transmission loss were chosen for a more conservative assessment (more noise at range). Thus, this also covers seasonal variation.

- **Temperature:** 5-18 degrees Celsius – measurements from 2017-2023[6]. A higher temperature for modelling is more conservative for species sensitive to higher frequencies, and a lower temperature for species sensitive to mid and low frequencies, but effects are generally small compared to effects from salinity or sediment composition.
- **Salinity:** 20psu – lowest salinities measured in Dublin Port 2017-2023[4]. A lower value is more conservative.
- **Soundspeed profile:** Assumed uniform given high mixing as a result of tidal flows and generally shallow water. A uniform soundspeed profile is conservative compared to the likely downward refracting soundspeed profiles seen during summer months (higher temperature in the surface leads to higher soundspeeds).

13.2.6.2 Sediment Properties

Sediment properties are based on sediments given in **Table 13-5**.

Sediments in the port are generally fine and silty, sometimes clayey, leading to high absorption of noise below a depth-dependent frequency limit of approximately 300Hz. The soft sediment layer is underlain by bedrock. A sediment model (Ainslie, 2010) was used to derive the acoustic properties of the sediment from the grain size of 0.011mm.

Table 13-5: **Sediment properties**

Layer	ISO (14688-1:2017)	Density [kg/m³]	Soundspeed [m/s]	Grain size [mm] (nominal)
Unconsolidated sediment	Medium Silt	1554	1545	0.011
Bedrock (10m below sediment)	-	2700	5250	-

13.2.7 Baseline Environment

The baseline environment relevant to this EIAR Chapter was informed by previous surveys associated with the MP2 Project.

13.2.8 Sound Levels

Underwater noise sources are usually quantified in dB scale with values generally referenced to 1µPa as if measured at a hypothetical distance of 1m from the source (called the Source Level). In practice, it is not usually

[4] https://leap.epa.ie/docs/090151b2808fb6c9.pdf

possible to measure at 1m from a source, but the metric allows comparison and reporting of different source levels on a like-for-like basis.

For a large sound source, this imagined point at 1m from this acoustic centre does not exist, the energy is distributed across the source (like a ship's hull) and does not all emanate from this imagined acoustic centre point, rather it is the position in space that would lead to the equivalent received level at range (usually from ranges greater than the largest dimension of the source). Therefore, the stated sound pressure level at 1m does not exist for large sources. For such large sources, in the acoustic near field (i.e. close to the source), the sound pressure level will be significantly lower than the value predicted by the back-calculated source level as presented in **Figure 13-5**, which presents the received level trend from a line source versus the modelled level assuming an equivalent monopoint source.

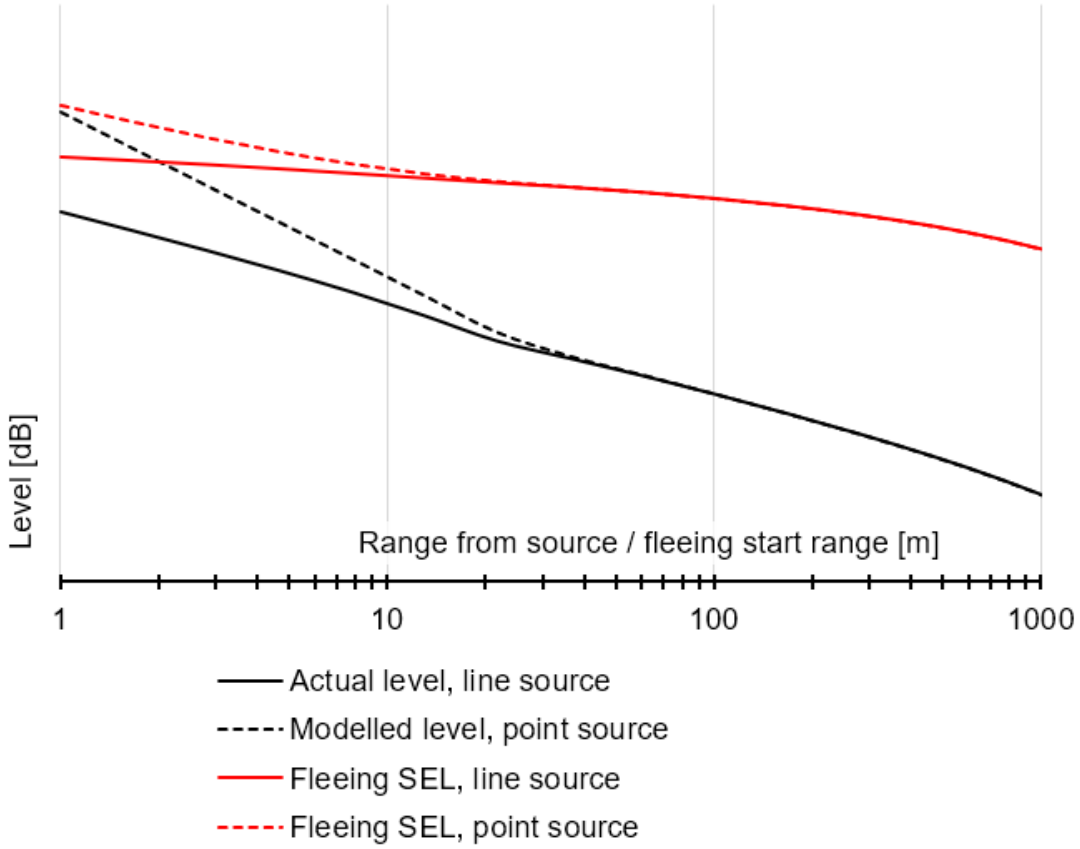


Figure 13-5: Schematic of the actual received level trend from a line source versus the modelled level assuming an equivalent monopoint source. Lines shown for both instantaneous received level and for cumulative level while fleeing.

13.2.8.1 Source Models

The noise sources and activities investigated during the underwater noise assessment study are summarised in **Table 13-6**. Source levels for the various activities were band-wise, logarithmically summed to produce a "combined" source that represents the total noise emissions from any given activity or combination of activities.

Note that as source levels have all been converted to 1-second SPL equivalents, the levels vary depending on the location to reflect changes in depth and sediment properties.

Table 13-6: **Summary of Noise Sources and Activities Included in the Underwater Noise Assessment**

Equipment/Activity	Source level [SPL]	Primary decidecade bands (-20dB width)	Impulsive/non-impulsive*	Assumptions
Demolition, excavation and rock breaking. Vessel <80m length	194	10-10,000Hz	Non-impulsive (due to high repetition rate of impacts)	Dynamic positioning active. Percussive rock breaking used.

* Using criteria for impulsiveness as laid out in **Section 13.2.3**.

13.2.8.2 Activities Source Levels – Demolition of Dolphins and Jetties

Demolition activities are assumed to not include the use of explosives. The activities will likely need to break the existing structures using rock breaking tools or percussive impact tools (pecking, hammering). Other demolition methods such as cutting/sawing or simple lifting will be less noisy and therefore are covered under this assessment.

The source model is based on recorded levels of pecking, rock breaking and a medium sized vessel (up to 80m length) with dynamic positioning active.

Rock breaking levels are based on a combination of measured levels from similar activities such as hydraulic rock breaking, pecking and percussive drilling (Connell, 2023, Barham, 2018, Erbe & McPherson, 2017).

The vessel model is based on an ensemble model that accounts for vessel type, speed, cavitation noise and noise from DP thrusters (Heitmeyer, 2001, Simard et al., 2016, Wittekind, 2014, Audoly & Rizzuto, 2015, MacGillivray & de Jong, 2021, Liefvendahl et al., 2015).

For this activity it's assumed that no acoustic positioning system (USBL/HiPaP) is used.

This modelled activity has a broadband level of 192dB SPL, with band levels presented in **Figure 13-6**.

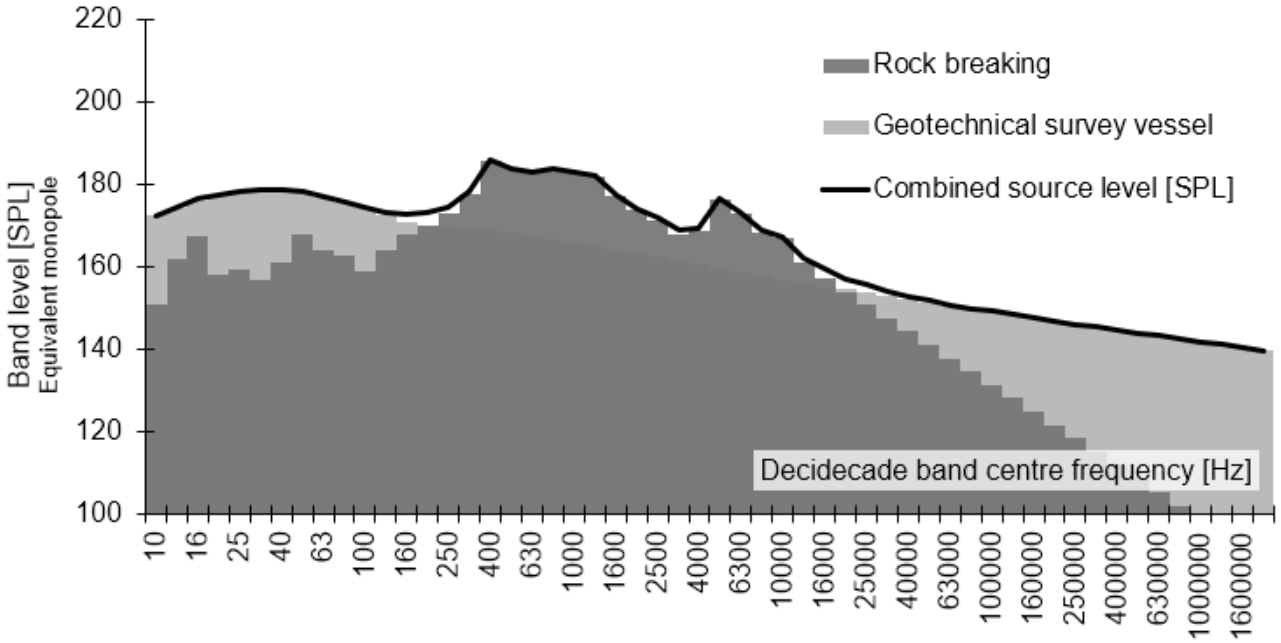


Figure 13-6: Rock breaking as proxy for non-explosive demolition, Geotechnical Survey vessel (DP enabled) as proxy for demolition vessel.

13.2.9 Sound Propagation Modelling

There are several methods available for modelling the propagation of sound between a source and receiver ranging from very simple models which simply assume spreading according to a $10\times\log_{10}$(range) or $20\times\log_{10}$(range) relationship, to full acoustic models (e.g., ray tracing, normal mode, parabolic equation, wavenumber integration and energy flux models). In addition, semi-empirical models are available which lie somewhere in between these two extremes in terms of complexity (e.g., Rogers (1981) and Weston (1971).

For simpler scenarios, such as this one, where the sediment is relatively uniform and mostly flat or where great detail in the sound field is not needed, the computational speed of these simpler models is preferred over the higher accuracy of numerical models and are routinely used for these types of assessments. For this assessment, we have used the Weston model (Weston, 1971) for all SPL and SEL modelling, which is suitable to depths of c. 200m and generally softer sediments (i.e. non-consolidated sediments) and the dBSea software's raytracing model, dBSeaRay3D for L_{pk} calculations.

These models will tend to underestimate the transmission losses (primarily due to the omission of surface roughness, wind effects and shear waves in the sediment) leading to range estimates greater than actual impact.

Validation examples of the Weston model can be found in **Appendix 13-2**, while validation examples of the dBSea software is available from https://docs.dbsea.co.uk/BenchmarkTesting.html

13.2.9.1 Modelling Assumptions

The main assumptions made for the modelling are:

1. Animals fleeing the area will not return within a 24-hour period.

2. Animals flee for up to 2 hours, after which they will be up to 10.8km and 3.6km away for marine mammals and fish, respectively, meaning the will be outside the Port area (1.5m/s and 0.5m/s, respectively).
3. Sources are modelled as point sources. While most sources are not strictly point sources, the source model is calibrated to be used with the assumption of a point source, and for larger ranges[5] the differences in source geometry are insignificant.
4. Modelling is done for high tide, being the tidal state with the least transmission loss.
5. Sea state <2, meaning the water surface is a perfect reflector and there are no significant bubbles in the surface. This is a conservative assumption, with increases in wind speed having a strong attenuating effect on the sound propagation.

13.2.9.2 Exposure Calculations (dB SEL)

To compare modelled levels with the two impact assessment frameworks (NMFS 2024 & Popper et al. 2014) it is necessary to calculate received levels as exposure levels (SEL), weighted for marine mammals and unweighted for fishes. For ease of implementation, sources have been presented as an SPL source level, meaning it was necessary to convert from SPL to SEL for a single, or multiple events.

To convert from SPL to SEL using elapsed time, the following relation can be used:

$$SEL = \mathrm{SPL} + 10 \cdot Log_{10}(t_2 - t_1) \quad (1)$$

Or, where it is inappropriate to convert SEL from one event to SEL cumulative by relating to the number of events as:

$$SEL_{,n\ events} = SEL_{\ single\ event} + 10 \cdot Log_{10}(n) \quad (2)$$

And SPL from SEL:

$$SPL = SEL_{\ cumulative} - 10 \cdot Log_{10}(t_2 - t_1) \quad (3)$$

As an animal swims away from the sound source, the noise it experiences will become progressively more attenuated; the cumulative, fleeing SEL is derived by logarithmically adding the SEL to which the mammal is exposed as it travels away from the source. This calculation is used to estimate the approximate minimum start distance for an animal in order for it to be exposed to sufficient sound energy to result in the exceedance of a threshold, or to check if a set exclusion zone is sufficient for an activity (e.g. will an exclusion zone of 500m be sufficient to prevent exceeding an AUD INJ threshold). It should be noted that the sound exposure calculations are based on the simplistic assumption that the animal will continue to swim away at a constant speed. The

[5] Range is greater than 2-5 times the water depth or the source length.

real-world situation is more complex, and the animal is likely to move in a more varied manner. Reported swim speeds are summarised in **Table 13-7** along with the sources.

For this assessment, a swim speed of 1.5m/s for marine mammals and 0.5m/s for fishes (including sharks) is assumed.

For very long fleeing durations, the ambient sound itself can exceed the thresholds, e.g., an ambient sound level of 122.4dB, weighted for the VHF group, will exceed the non-impulsive TTS threshold of 161dB SEL after 2 hours' exposure[6]. For this assessment, we consider fleeing durations of 2 hours, meaning that weighted received levels of 122.4dB SPL will exceed the VHF group's non-impulsive TTS threshold in the fleeing model.

Table 13-7: Swim speed examples from literature

Species	Hearing Group	Swim Speed (m/s)	Source Reference
Harbour porpoise	VHF	1.5	Otani *et al.,* 2000
Harbour seal	PCW	1.8	Thompson, 2015
Grey seal	PCW	1.8	Thompson, 2015
Minke whale	LF	2.3	Boisseau *et al.,* 2021
Bottlenose dolphin	HF	1.52	Bailey and Thompson, 2010
White-beaked dolphin	HF	1.52	Bailey and Thompson, 2010
Basking shark	Fish (unweighted)	1.0	Sims, 2000
All other fish groups	Fish (unweighted)	0.5	Popper *et al.,* 2014
Sea turtles	Fish (unweighted)	0.56-0.84 & 0.78-2.8	(F, et al., 1997; SA, 2002)

13.2.10 Consultation

Following completion of the EIA Scoping Report, consultation was undertaken to obtain opinions regarding the ABR2 Project and its potential and scope for significant effects. No specific comments in relation to Underwater Noise were received, however general comments received regarding the ABR2 Project are set out in **Table 13-8**, including where additional information in relation to issues can be found in the EIAR.

Table 13-8: ABR2 EIA Scoping Report Comments relating to Underwater Noise and Vibration

Organisation	Comment Response/Issue Raised	Response
Dublin City Council (2025-12-19)	Scoping report is comprehensive; further comments on the proposed EIAR methodology or assessments are suggested. Dublin City Council Strongly advises that the EIAR take account of: Dublin City Development Plan 2022-2028, Guidelines on the information to be contained in Environmental Impact Assessment Reports (May 2022) & Guidance on EIA Scoping, European Commission, 2017	This report will adhere to methodologies set out in the scoping report and have regard for the mentioned plans and guidance.

[6] 122.4dB SPL + 10*$\log_{10}$(3600 seconds) = 161dB SEL, TTS non-impulsive threshold for the VHF group is 161dB SEL.

13.2.11 Assessment Criteria and Assessment of Significance

The impact of modelled noise levels on various receptors is assessed in **Chapter 7 Biodiversity, Flora and Fauna**.

13.3 Baseline Environment

The baseline environment relevant to this EIAR Chapter was informed by previous surveys associated with the MP2 Project.

- Ambient noise mean levels: 80-100dB SPL (1-minute, unweighted, 10th to 90th percentile).
- Ambient noise peak pressure levels: Max levels of 130dB L_{pk} were observed during otherwise calm periods.
- Vessel noise mean levels: 120-150dB SPL (1-minute, unweighted, 10th to 90th percentile), suggesting vessel equivalent point source[7] levels of 150-180 dB SPL.
- Vessel noise peak pressure levels: Levels at or above 170 dB L_{pk} were recorded, suggesting vessel equivalent point source levels of 210-216dB L_{pk}.

13.4 Results

Results are presented here as the geographical “risk range” to an auditory threshold (AUD INJ/ TTS/ Behavioural), as given in **Table 13-1**, **Table 13-2**, **Table 13-3**, and **Table 13-4**.

A given risk range specifies the expected range, within which a fleeing receiver would exceed the relevant threshold. Risk ranges for SEL are given for the 90th percentile value and the maximal value of all modelled radials (**Figure 13-7**).

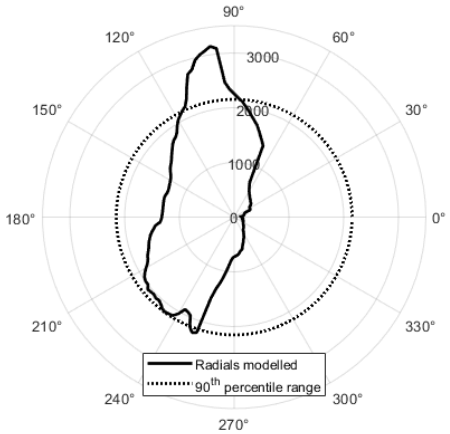


Figure 13-7: Example of ranges to a threshold modelled along radials (solid line) and 90th percentile range (dotted line) from a sound source in the centre

[7] Vessels are not point sources, but from a large range, the emitted soundfield will be indistinguishable from a point source.

Several result types are presented for each activity in **Table 13-9** to inform this assessment and to provide flexibility in mitigation.

Table 13-9: Result types summary

Effect	Description
Behavioural disturbance	The range at which the behavioural limit for the marine mammals or the fishes (including sharks) is exceeded. Where animals are accustomed to similar noises it can be expected that realised disturbance ranges are much shorter.
TTS,1 seconds' exposure	This is the range of acute risk of impact from the activity (a one second exposure) and is presented to indicate near-instantaneous risk and for comparison with other studies. This assumes a stationary animal (during the 1-second exposure) with all equipment operating at full power.
AUD INJ,1 seconds' exposure	
TTS, sound exposure, fleeing receiver	The minimal range a fleeing animal needs to start fleeing from to avoid being exposed to noise exceeding its TTS/ AUD INJ threshold. Animals are moving in a straight line away from the source at a constant speed of 1.5m/s (0.5m/s for fish, including sharks).
AUD INJ, sound exposure, fleeing receiver	

13.4.1 Assumptions and Notes on Results

The results should be read while keeping the following in mind:

- Results are rounded up to nearest 10m (ranges <1000m) and nearest 100m (ranges >1000m). This can lead to apparent overlaps in risk ranges.
- The modelling resolution of 10m means that, were results are lower than this, "<10" is stated to mean "below 10 metres".
- Animals are modelled as fleeing continuously.
- Modelling assumes a maximal fleeing time of 2 hours.
- Modelling is limited to a range of 3km from the site boundary.
- Where behavioural disturbance ranges are over 3km, ">3,000m" is reported. At those ranges it's likely that other noise sources (incl. biological ones) will be present and be the dominating noise source for the receiver. Where animals are accustomed to noise similar to noises from the Project, they are expected to have a much shorter disturbance range.
- Results assume no closure, or only partial closure of the basin containing the previous Berths 52/53. We retain this assumption despite the updated assumption of full closure, both as a conservative measure and in an effort to forestall the need for additional assessments given future changes to the ABR2 Project plan.

13.4.2 Construction (Demolition) Noise Risk Ranges, assuming no/partial closure of the Berth 52/53 basin

In the following sections the results from the modelling are presented as ranges to risk of onset of the relevant effect (Behavioural disturbance, TTS, AUD INJ) for both near-instantaneous (1 second's exposure) and for fleeing receivers.

The results presented in **Table 13-10** represent risk ranges for demolition of the jetty structure and the dolphins within the basin of Berths 52/53. Behavioural disturbance ranges are up to 1,200m for marine mammals and 600m for fish. TTS and AUD INJ ranges for immediate exposure (1 sec) are all <10m for all groups. TTS risk ranges for fleeing receivers are up to 150m for the LF group, 110m for the VHF group, 100m for the PCW group, and <10m for the remaining groups. AUD INJ ranges for fleeing receivers are <10m for all hearing groups.

Table 13-10: Risk ranges for Demolition

Effect	Range metric	LF	HF	VHF	PCW	OCW	Fishes
Behavioural disturbance	90th	700	700	700	700	700	500
	max	1,200	1,200	1,200	1,200	1,200	600
TTS,1 seconds' exposure	90th	<10	<10	<10	<10	<10	<10
AUD INJ,1 seconds' exposure	90th	<10	<10	<10	<10	<10	<10
TTS, sound exposure, fleeing receiver	90th	130	<10	80	60	<10	<10
	max	150	<10	110	100	<10	<10
AUD INJ, sound exposure, fleeing receiver	90th	<10	<10	<10	<10	<10	<10
	max	<10	<10	<10	<10	<10	<10

13.4.3 Construction (Demolition) Noise Risk Ranges, assuming full closure of the Berths 52/53 basin

Where the basin containing the historical Berths 52/53 is fully closed, the noise from the ABR2 Project will be efficiently attenuated by the constructed barrier, and while vibration measurement equipment might be able to register the activities, in-water noise will be well below the ambient noise and not relevant from an environmental assessment point of view, i.e. negligible.

13.4.4 Operational Noise Risk Ranges

No significant change to noise levels because of the ABR2 Project are likely. Although deeper draughted vessels will access Alexandra Basin West, the speed limit in the port means that the introduction of these vessels to this

part of the port will not result in a significant increase in noise. It should also be noted that deeper draughted vessels are already using the port.

Berths 52/53 will cease to exist in their current form (they will be infilled), meaning underwater noise is no longer a concern.

13.5 Inter-relationships

Effects on Underwater Noise also have the potential to have secondary effects on other receptors, which are considered in relevant topic-specific chapters. These receptors and effects are:

Marine Biodiversity (considered in **Chapter 7 Biodiversity, Flora and Fauna**):

- Temporary habitat loss/disturbance.

Population and Human Health (considered in **Chapter 19 Population and Human Health**):

- Underwater noise at levels that could cause discomfort to nearby (<100m) human divers.

13.6 Mitigation and Monitoring

13.6.1 Mitigation

No specific mitigation measures are suggested. The primary justifications for this are the generally negligible impact ranges for AUD INJ (<10m), and the fact that noise similar to noise from the ABR2 Project is common in the port and vessels with demolition equipment are not sudden onset sound sources, giving animals time to react and evade.

13.6.2 Monitoring

No monitoring is suggested, given the lack of risk of auditory impacts.

13.7 Potential Cumulative Effects

Chapter 21 Cumulative Effects and Environmental Interactions outlines the methodology used to complete the assessment of cumulative effects, which may arise from adjacent or nearby development, together with those predicted for the ABR2 Project. The projects which have been considered within the assessment of cumulative effects are outlined in **Chapter 21 Cumulative Effects and Environmental Interactions**.

The ABR2 Project has potential to overlap in time with multiple projects in Dublin Port, these may include the 3FM Project, MP2 Project and Powering Dublin Project.

At this stage, it is considered that while there can be temporal overlap and therefore potential cumulative effects arising from adjacent or nearby development, the fact that the risk ranges from the ABR2 Project are very modest, the impact from the ABR2 Project will be negligible compared to any project that involves vibratory or impact piling (e.g. 3FM and MP2 projects). The underwater noise effects from the ABR2 Project are comparable to the effects from large vessel traffic in the port.

13.8 Residual Impacts

No residual impacts related to underwater noise arising from the ABR2 Project.

13.9 Summary of Results

Two areas of activity are considered with the potential to emit significant levels of noise:

1. Dredging of the Alexandra West basin.
   This was scoped out due to comparatively low noise levels and the confinement of noise given the activity mainly takes place inside the basin.
2. Demolition of jetty and berth structures in the basin of the north of the new Berths 52 and 53. As there was initial uncertainty over whether the basin would be closed prior to the demolition the activities were assessed assuming an open basin, with the following risk ranges:
   a. Behavioural disturbance ranges are up to 1,200m for marine mammals and 600m for fish. This effectively means that marine mammals are likely to react within line-of-sight of the activities.
   b. TTS and AUD INJ ranges for immediate exposure (1 sec) are all <10m for all groups (all fishes and marine mammals).
   c. TTS risk ranges for fleeing receivers are up to 150m for the LF group (baleen whales), 110m for the VHF group (porpoises), 100m for the PCW group (seals), and <10m for the remaining groups (dolphins, otters and fishes).
   d. AUD INJ ranges for fleeing receivers are <10m for all hearing groups (all fishes and marine mammals).

   Where the basin is fully closed (completion of quay/jetty structure under the MP2 project), underwater noise emissions into the surrounding waters will be negligible.

Conclusion

Given the assumption that the basin will be closed prior to the demolition activities, there will only be negligible underwater noise emissions into the surrounding waters compared to the assessment framework thresholds for adverse auditory and behavioural effects from underwater noise.

13.10 Limitations of Assessment

No limitations were encountered, and the assessment presents conservative but realistic impact ranges for the species groups included.