Technical Memorandum

Marine Science Associates Pty Ltd

U3/24 Crocker Drive Malaga, WA, 6090

msa@mscienceresearch.com.au

To: Annaliese Eastough, Preston Consulting

Cc: Gavin Edwards

From: Iain Posnett

Date: 07 July 2025

Subject: Mardie Project – Offshore Dredge Spoil Disposal. Response to RFI. Underwater Noise Risk Assessment

Mardie Minerals Pty Ltd (Mardie Minerals; a wholly owned subsidiary of BCI Minerals Limited) has approval under Condition 36(c) of EPBC 2018/8236 and EPBC 2022/9169 to dredge up to 800,000 cubic metres (m^3) within the Mardie Project dredge channel. Onshore disposal of dredged material has been permitted under existing approvals. Mardie Minerals is now seeking to transport dredge spoil from capital and future maintenance dredging activities for the Mardie Project and dispose of it within a defined offshore spoil ground 'DMPA4' (the Proposed Action). The Proposed Action was referred to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in December 2024. A decision on the assessment approach was published by DCCEEW in May 2025 (EPBC 2024/10054) and a request for further information (RFI) has been issued.

Preston Consulting Pty Ltd (Preston Consulting), on behalf of Mardie Minerals, have requested MScience marine research (MScience) to provide advice on the response to the RFI. The RFI relates to underwater noise impacts from the Proposed Action, specifically an assessment of the risk of underwater noise impacts to marine fauna of significance from the disposal of dredge spoil at DMPA4. A previous risk assessment for the underwater noise impacts associated with the Mardie Project included only the proposed loading of dredge material and pile driving activities (Talis 2019).

This technical memorandum provides advice to Preston Consulting on the RFI, based on a desktop review of relevant existing data and published information about underwater noise associated with the transport and disposal of dredge spoil at DMPA4. The document is structured to provide:

Table 1: a summary of responses to the DCCEEW RFI.

Section 1: a qualitative review of available information to support an assessment of underwater noise impacts from the Proposed Action.

Section 2: a risk assessment of the potential impacts identified during the qualitative review.

Table 1. Summary response to RFI

DCCEEW Request for Further Information Related to Underwater Noise	Suggested Response
2. Baseline information *2.1 Underwater Noise and plume impacts* *The department notes that observation and exclusion zones are presented as a mitigation measure for the impacts of underwater noise, additionally to the information provided at referral, please provide:* *a) Modelling that indicates that the level of underwater noise produced by the action (split hull hopper barge dumping 1,200 m3 of dredge spoil) is sufficiently mitigated by the observation and exclusion zones presented.*	A qualitative review of available underwater noise data relevant to the Proposed Action has been completed (refer to Section 1 of this memo). On the basis of this review, the observation and exclusion zones prescribed by the Mardie Project dredge and spoil disposal management plan (O2 Marine 2024) require some small modification to mitigate the potential impact to marine fauna. At present there is a 500 m observation zone for whales and dolphins recommended during disposal operations. MScience recommends increasing the disposal observation zone to align with the 3,000 m observation zone to be implemented during dredging operations. This recommendation is based on the predicted distance for a marine mammal behavioural response to estimated sound source levels for the Proposed Action (refer to Section 1.5.2 of this memo).
2. Baseline information *2.1 Underwater Noise and plume impacts* *The department notes that sea snakes, sharks and sawfish are not considered in observation and exclusion zones. There is a concern that these species may be impacted by the plume created by the dredge spoil dump and/or underwater noise. In addition to the information provided at referral:*	a) MScience recommend updating the Mardie Project dredge and spoil disposal management plan (O2 Marine 2024) to include all listed species in the proposed observation and exclusion zones. The exclusion and observation zones proposed for turtles should also be applied to sea snakes, sharks and sawfish.

DCCEEW Request for Further Information Related to Underwater Noise	Suggested Response
a) Ensure that all species listed in 1.1 are included in observation and exclusion zones presented. *b) Ensure that observation and exclusion zones presented are sufficient to mitigate impacts.*	b) Observation and exclusion zones presented are sufficient to mitigate impacts (refer to response above).
3. Likely impacts *3.1 All species in 1.1* *The impacts of the proposed action on these MNES should be considered in the broadest scope, with all components considered, including any associated supporting infrastructure, with the following information to be outlined:* *b) A risk assessment of all identified direct and indirect impacts (within the proposed action area and surrounding areas) from the proposed action to the listed threatened species, including whether the nature and/or scale of the potential impacts are unknown, unpredictable, or irreversible, and an outline of the residual risk levels including at least the following issues:* *i. Elevated underwater noise increases the risk of displacement, adverse behavioural and physiological changes to marine fauna.*	A risk assessment of the potential impacts to listed marine fauna from the underwater noise generating activities associated with the Proposed Action has been provided in Section 2 of this memo and is summarised below. The inherent risk to the marine fauna of interest from the Proposed Action, with the exception of the low frequency (LF) cetacean group (cetaceans impacted by low frequency sounds), was considered low. The inherent risk to LF cetaceans (that includes humpback whales) was considered moderate. The low probability of marine megafauna being within the vicinity of the Proposed Action for sufficient time periods to accumulate the requisite length of exposure to noise at damaging levels and the mitigating potential of the recommended management measures, further reduce risk profiles.

Section 1. Dredge Spoil Disposal Underwater Noise Impact Assessment

1.1 Assessment Framework and Approach

The assessment presented in the following sections examine the potential impacts to marine fauna from the Proposed Action, specifically underwater noise impacts.

The approach adopted here followed the phased risk assessment approach proposed by McQueen et al. (2020) to assess risks to aquatic biota associated with underwater sounds from dredging. The first phase, a screening assessment, was used to estimate the potential (or lack thereof) that risks exist, identify the need (if any) for site specific data collection and provide a focus for phase two (if required), being a detailed risk assessment including noise modelling.

The screening assessment was based on a qualitative review of available information to support a risk assessment of underwater noise impacts from the Proposed Action. This assessment included:

- Reviewing publicly available information on the Mardie Project;
- Reviewing available literature to compile sound source levels for the Proposed Action;
- Reviewing noise effect criteria for the marine fauna of significance relevant to the Proposed Action;
- Defining the expected zones of impact to marine fauna of significance based on similar relevant existing studies; and
- An assessment of the risks of underwater noise from the Proposed Action to the marine fauna of significance.

1.1.1 Guidance Documents

- EPBC Regulations 2000 - Part 8 Division 8.1;
- Ecological Risk Assessment of Underwater Sounds from Dredging Operations (McQueen *et al.* 2020);
- Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2024);
- Marine Mammal Behavioural Response Acoustic Thresholds (NOAA Fisheries 2024);
- Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III) (Finneran et al. 2017);
- Sound Exposure Guidelines for Fishes and Sea Turtles (Popper et al. 2014); and
- Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid (McCauley et al. 2000).

1.2 Types of Sound and their Impacts on Marine Fauna

Several sound level metrics are commonly used to evaluate noise and its effects on marine life. Key terms include:

- peak pressure level (PK) is the maximum change in water pressure associated with underwater noise. It is the level (L_{pk}) of the squared maximum magnitude of the sound pressure (P^2_{pk}) in a stated frequency band and time window. Defined as $L_{pk} = 10\log10(P^2_{pk}/P^2_o) = 20\log10(p_{pk}/p_0)$. Unit: decibel (dB). Reference value (P^2_o) for sound in water: 1 μPa^2.
- sound pressure level (SPL) is the average change in water pressure associated with underwater noise. It is the level (Lp) of the time-mean-square sound pressure (P^2_{rms}) in a stated frequency band and time window: $Lp = 10\log10(P^2_{rms}/P^2_0) = 20\log10(p_{rms}/p_0)$, where rms is the abbreviation for root-mean-square. Unit: decibel (dB). Reference value (p^2_0) for sound in water: 1 µPa2. SPL can also be expressed in terms of the root-mean-square (rms) with a reference value of p_0 = 1 µPa. The two definitions are equivalent.
- sound exposure level (S_{EL}) is the cumulative level of energy contained within underwater noise, usually defined over a 24hr period. It is the level (LE) of the sound exposure (E) in a stated frequency band and time window: LE = 10log10(E/E0). Unit: decibel (dB). Reference value (E0) for sound in water: μPa^2s.

When assessing potential impacts of anthropogenic sound on marine life, sound sources and their resulting sounds are commonly divided into two main categories: impulsive and non-impulsive (NMFS 2024). Impulsive sounds are typically brief and intermittent; they rapidly rise and decay. Non-impulsive sounds can be brief or prolonged, continuous or intermittent, and do not generally have the high peak pressure and rapid rise time of impulsive sounds. Relevant to this assessment, the placement of dredge spoil (noises associated with splash, tumble and grinding sounds) may be considered impulsive or non-impulsive depending on the material to be placed (dropping of large rock/boulders = impulsive, dumping of fine unconsolidated material = non-impulsive). Noise generated by vessel propulsion may be considered non-impulsive.

Sound is important for most marine animals. Sound production and detection serve key biological functions including communication, foraging, reproduction, navigation and predator avoidance (OSPAR 2009). The potential impacts to marine fauna from underwater noise have been reviewed in detail (Erbe et al. 2019; ERM 2018; Finneran 2016; Hawkins and Popper 2017; OSPAR 2009; Popper and Hawkins 2019; Southall et al. 2019). The potential effects of noise can be broadly categorised into:

- Behavioural Impacts.
    - Behavioural response (displacement, attraction or avoidance); and
    - Masking or interfering with biologically important sounds (communication and echolocation).
- Physiological Impacts.
    - Stress, concussive effect and physical damage to tissues; and

- Hearing damage and/or impairment.
    - Temporary – termed temporary threshold shift (TTS); or
    - Permanent – termed permanent threshold shift (PTS).

1.3 Dredge Spoil Disposal, Noise Generating Activities and Acoustic Source Parameters

The Mardie Project dredge and spoil disposal management plan (DSDMP) (O2 Marine 2024) outlines the proposed dredging methodology. It is assumed there would be three (3) disposal runs between the dredging area and proposed spoil ground per day via a split hopper barge. The disposal run has been estimated to be a 27 nautical mile (nm) return journey. It has been assumed the split hopper barge would have a capacity of 1,200 m^3 and be able to travel at a speed of 7.5 kts once fully loaded. On the basis of the proposed dredging methodology, the duration of disposal events per day has been estimated (Table 2). Water depth at the proposed spoil ground is around 20 m. It is assumed the same methodology would be implemented for both the initial capital dredging and any future maintenance dredging.

Table 2. Estimated duration of disposal events per day

Activity	Events per day	Duration per event (mins)
Split hopper barge in transit between dredge and disposal area (27 nm return journey, travelling at 7.5 kts)	3	216
	Total duration per day	**648**
Dumping 1,200 m^3 of dredge spoil	3	15
	Total duration per day	**45**

This assessment considered impacts to the relevant marine fauna of significance from the following sound-producing activities expected to be generated by disposal of dredge spoil from a split hopper barge:

- Activity 1 – Radiated vessel noise from the spilt hopper barge during transit between the dredge area and disposal area.
- Activity 2 – Placement of dredged material at the disposal area (i.e. emptying of the split hopper barge).

1.3.1 Split Hopper Barge Radiated Noise Source

All vessels generate noise as a consequence of their operation. Modern powered vessels typically produce low frequency (<1,000 Hz) sound from hydrodynamic flow noise, onboard machinery, and, primarily, from propeller and thruster cavitation (when vacuum bubbles created by the motion of propellers collapse) (Southall et al. 2017). Sound levels tend to be the highest when thrusters are used to position the vessel and when the vessel is transiting at high

speeds. There is considerable variability in the radiated sound fields (in terms of source level and frequency bandwidth) from individual vessels of various sizes and types (OSPAR 2009).

It is anticipated that a single split-hopper barge will be used to transport and dispose of dredged material per event at the proposed spoil ground. The split-hopper barge is proposed to have a capacity of 1,200 m^3 with indicative dimensions of 73 m length, 13 m width and 4.5 m depth, and a maximum installed thruster power of 2944 kW.

The acoustic source level for the proposed split-hopper barge has not been measured, but the acoustic source level for a vessel in transit can be estimated from the measured levels of a proxy source. The proxy source used here was the *Skandi Feistein*, a platform supply vessel with length 87.9 m, a width of 19.0 m, and a draft of 6.6 m and a maximum installed thruster power of 12820 kW. The sound level of the *Skandi Feistein* has been measured to be 172.6 dB re 1 μPa^2m^2 while transiting (Esso Australia 2021). The values for the *Skandi Feistein* were scaled for the proposed split hopper barge based on the difference in max installed thruster power using the following equation:

$$SL = SLref + 10\log_{10}\left(\frac{P}{Pref}\right)$$

where SL is the source level of the split hopper barge, SL_{ref} is the corresponding source level of the *Skandi Feistein*, P is the split hopper barge installed thruster power and P_{ref} is the *Skandi Feistein* installed thruster power of 12820 kW.

Based on the above, the maximum broadband (10 Hz to 25 kHz) source level of the split hopper barge transiting was estimated to be 166.2 dB re 1 μPa^2m^2. This is similar to levels reported in the existing literature for other non-impulsive sound sources generated by commercial activities (Figure 1).

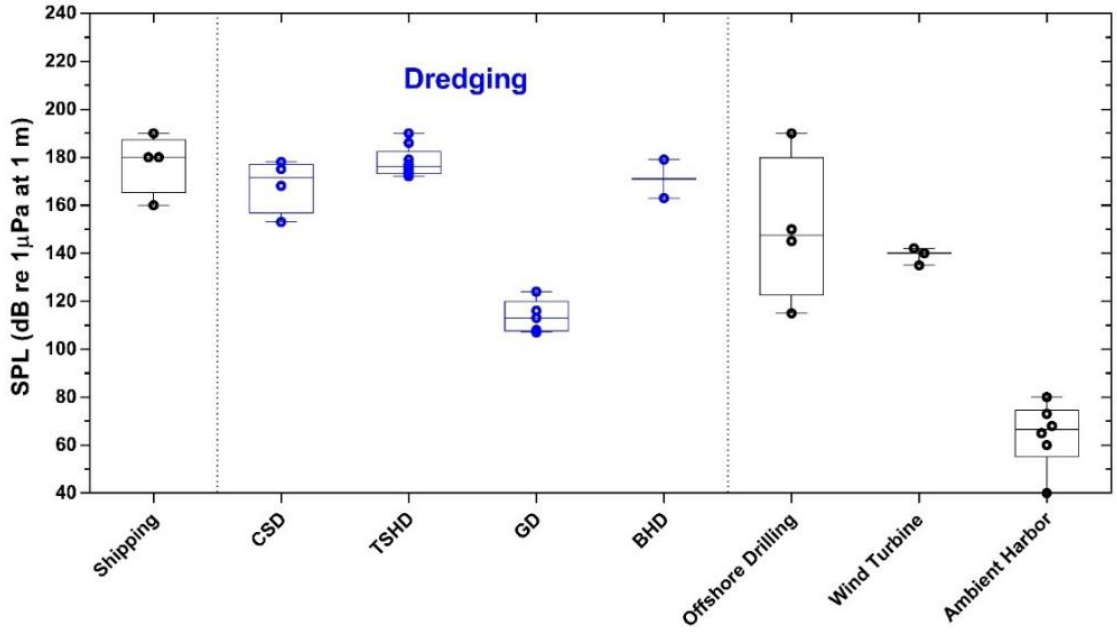

Figure 1. Summary of non-impulsive underwater SPLs by sound source (McQueen et al. 2019): CSD – cutter suction dredge, TSHD – trailing suction hopper dredge, GD – grab dredge, BHD – backhoe dredge

1.3.2 Dredge Disposal Noise Source

The offshore disposal of dredge spoil is a common activity in both capital and maintenance dredging projects. Due to the common occurrence and scale of the activity, there is rarely a requirement for data collection to understand the noise emitted during offshore spoil disposal or validate any proposed exclusion zones. Many environmental impact assessments provide general descriptions of the dredge spoil disposal, but the assessments are primarily generic and qualitative.

Four publications are known to the author to report measured acoustic sound levels of offshore dredge spoil disposal or a similar activity, such as the placement of rock material into water.

Dickerson et al. (2001) measured underwater sound levels during the release of unconsolidated dredge spoil material from a split-hopper barge. The acoustic receiver was located 316 m from the sound source. The disposal event lasted approximately 60 seconds. The peak SPL (dB rms) was measured at 108.7 dB re 1 µPa-m at 45.8 Hz. Between 20 to 1,000 Hz, the lowest SPL was measured at 96 dB re 1 µPa-m.

De Jong et al. (2010) measured the source level of a trailer suction hopper dredge (TSHD) during the release of unconsolidated dredge spoil material (sand) in 13 m of water. The vessel was not moving during the dumping operation. The acoustic receiver was located 70 m from the sound source. The peak SPL (dB rms) was measured at 155 dB re 1 μPa^2m^2s at ~1,200 Hz.

GHD (2012) and McPherson et al. (2019) estimated source levels of 179 dB re 1 μPa^2m^2s and 188.0 dB re 1 μPa^2m^2s, respectively, for truck tipping of large rocks from land into water during rock wall construction as part of studies implemented for the Port of Townsville Expansion Project. Sound level estimates from GHD were based on sample measurements collected during construction of the Townsville Marine Precinct. The estimates from McPherson et al. (2019) were based on measurements collected as part of the Underwater Noise Monitoring Program for rock placement construction activities during the Port of Townsville Expansion Project. Tipping rock from trucks above the waterline is likely to be an overestimate of the noise levels from underwater opening of hopper doors on barges and/or unconsolidated spoil material settling on the seabed and thus these noise source levels have not been considered further in this assessment.

1.4 Noise Effect Criteria

To assess the potential effects of a sound–producing activity, it is necessary to first establish exposure criteria (thresholds) for which sound levels may be expected to have a negative effect on animals. The thresholds presented in the following sections represent current best available science and have been accepted by regulatory agencies.

1.4.1 Marine Fauna of Significance

O2 Marine (2020) completed a desktop assessment and likelihood of occurrence assessment for the marine fauna of significance (excluding marine birds and marine turtles) with the potential to occur within and/or adjacent to the Proposed Action. Pendoley Environmental (2023) assessed the marine turtle activity in the Mardie Region, based on field surveys implemented for the Mardie Project, and identified the marine turtle species with the potential to occur within and/or adjacent to the Proposed Action.

Table 3 lists the marine fauna species of environmental significance identified within the DCCEEW RFI, as well as those assessed by O2 Marine and Pendoley Environmental as having the potential to occur within or adjacent to the Proposed Action. The assessment provided in the following sections have been limited to marine fauna of Table 3 with a high and moderate potential to occur within or adjacent to the Proposed Action.

Table 3. Marine fauna of significance likely to occur in the Proposal area

Species	**Likelihood of Occurrence**
Marine Mammals	
Blue whale (*Balaenoptera musculus)*	Moderate
Dugong (*Dugong dugon)*	High
Humpback whale (*Megaptera novaeangliae)*	High
Southern right whale (*Eubalaena australis*)	Low
Australian humpback dolphin (*Sousa sahulensis)*	High
Australian snubfin dolphin (*Orcaella heinsohni*)	Low
Indo-Pacific bottlenose dolphin (*Tursiops aduncus)*	Moderate
Spinner dolphin (*Stenella longirostris*)	Low
Marine Reptiles	
Short-nosed sea snake (*Aipysurus apraefrontalis)*	High
Leaf-scaled Sea Snake (Aipysurus foliosquama)	Low
Green turtle (*Chelonia mydas)*	High
Loggerhead Turtle (*Caretta caretta*)	Low
Leatherback Turtle (*Dermochelys coriacea*)	Low
Hawksbill turtle (*Eretmochelys imbricata)*	High

Species	Likelihood of Occurrence
Flatback turtle (*Natator depressus)*	High
Elasmobranchs and other fish	
Dwarf sawfish (*Pristis clavate*)	Moderate
Narrow sawfish (*Anoxypristis cuspidate*)	Moderate
Green sawfish (*Pristis zijsron)*	High
Great white shark (*Carcharodon carcharias*)	Low
Grey nurse shark (*Carcharias taurus)*	Moderate
Whale shark (*Rhincodon typus)*	Low
Scalloped hammerhead shark (*Sphyrna lewini)*	Low
Giant manta ray (*Mobula birostris*)	Moderate
Reef manta ray (*Mobula alfredi*)	Moderate
Bluespotted emperor (*Lethrinus punctulatus*)	High

1.4.2 Noise Effect Criteria - Marine Mammals

The marine mammal thresholds (Table 4) chosen for this assessment have been based on the 2024 update to the National Marine Fisheries Service Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2024), including:

- The frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) for the onset of PTS and TTS in marine mammals for non-impulsive sound sources
- Peak pressure levels (PK; L_{pk}) and frequency–weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) for the onset of PTS and TTS in marine mammals for impulsive sources.
- Marine mammal behaviour thresholds of 120 dB re 1 µPa (SPL; L_p) for non-impulsive sound sources and 160 dB re 1 µPa (SPL; L_p) for impulsive sound sources.

Table 4. Criteria for effect of impulsive and non-impulsive noise exposure for marine mammals

Marine Mammal Group	Behaviour	PTS onset thresholds		TTS onset thresholds	
	SPL	Weighted SEL_{24h}	PK	Weighted SEL_{24h}	PK
Impulsive Sound					
Cetacean - Low Frequency (LF)	160	183	222	168	216
Cetacean – High Frequency (HF)		193	230	178	224
Sirenian (SI)		186	225	171	219
Non-impulsive Sound					
Cetacean - Low Frequency (LF)	120	197	n/a	177	n/a
Cetacean – High Frequency (HF)		201		181	
Sirenian (SI)		200		180	

Peak Sound Pressure (PK) and Sound Pressure Level (SPL) thresholds are in dB re 1 µPa

Sound Exposure Level (SEL) thresholds are in dB re 1 μPa^2s. SEL_{24h} denotes cumulative sound exposure over a 24 h period.

1.4.3 Noise Effect Criteria - Marine Reptiles and Fish

Popper et al. (2014) suggested thresholds for onset of mortal injury (including PTS), recoverable injury and TTS for fish and sea turtles for both impulsive and non-impulsive noise exposure (Table 5 and Table 6). Finneran et al. (2017) in turn presented revised thresholds for sea turtle injury and hearing impairment (TTS and PTS) (Table 7). The rationale being that sea turtles have best sensitivity at low frequencies and are known to have poor auditory sensitivity. Accordingly, TTS and PTS thresholds for turtles are likely more similar to those of fishes than to marine mammals (Popper et al. 2014).

McCauley et al. (2000) observed the behavioural response of caged sea turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the sea turtles increased their swimming activity, and above 175 dB re 1 µPa they began to behave erratically, which was interpreted as an agitated state. The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017) acknowledges the 166 dB re 1 µPa SPL reported by McCauley et al. (2000) as the level that may result in a behavioural response to marine turtles. The 175 dB re 1 µPa level from McCauley et al. (2000) is recommended as a criterion for behavioural disturbance (Table 7).

There is little information about the effects of underwater noise on sea snakes, however, they are likely to be similar to other reptiles i.e. turtles. Sea snakes are not sedentary, and like turtles, can swim away from a sound source. Sound

exposure criteria for fishes without a swim bladder are proposed to be the most appropriate for elasmobranchs (i.e. the sawfish, sharks and rays of interest to this assessment).

Table 5. Criteria for impulsive noise exposure for fish, adapted from Popper et al. (2014)

Marine Fauna Type	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	> 219 dB SEL_{24h} or > 213 dB PK	> 216 dB SEL_{24h} or > 213 dB PK	>> 186 dB SEL_{24h}	Pile driving: (N) Moderate (I, F) Low Seismic: (N, I, F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	>> 186 dB SEL_{24h}	Pile driving: (N) Moderate (I, F) Low Seismic: (N, I, F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	186 dB SEL_{24h}	Pile driving: (N, I) High (F) Moderate Seismic: (N, I) Low (F) Moderate	(N, I) High (F) Moderate
Fish eggs and fish larvae	> 210 dB SEL_{24h} or > 207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	Pile driving: (N) Moderate (I, F) Low Seismic: (N, I, F) Low	(N) Moderate (I, F) Low

Peak Sound Pressure (PK) thresholds are in dB re 1 µPa

Weighted SEL_{24h} denotes cumulative sound exposure over a 24 h period in dB re 1 μPa^2s

Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N) – tens of metres, intermediate (I) – hundreds of metres, and far (F) – thousands of metres.

Table 6. Criteria for non-impulsive noise exposure for fish and sea turtles, adapted from Popper et al. (2014)

Marine Fauna Type	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable Injury	TTS	Masking	
Sea Turtle	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Fish (Particle motion detection) No swim bladder; and Swim bladder not involved in hearing	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish (primarily pressure detection) Swim bladder involved in hearing	(N) Low (I) Low (F) Low	170 dB SPL for 48 h	158 dB SPL for 12 h	(N) High (I) High (F) High	(N) Moderate (I) Moderate (F) Low
Fish eggs and fish larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Sound pressure level dB re 1 µPa.

Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N) – tens of metres, intermediate (I) – hundreds of metres, and far (F) – thousands of metres.

Table 7. Suggested sound level thresholds related to various acoustic effects of impulsive and non-impulsive sound on sea turtles

Effect type	SPL	Weighted SEL_{24h}	PK
Impulsive Sound			
Behavioural response	175	n/a	
Behavioural disturbance	166		
PTS onset	n/a	204	232
TTS onset		189	226
Non-impulsive Sound			
PTS onset	n/a	220	n/a
TTS onset		200	n/a

Peak Sound Pressure (PK) and Sound Pressure Level (SPL) thresholds are in dB re 1 µPa

Weighted SEL_{24h} denotes cumulative sound exposure over a 24 h period in dB re 1 μPa^2s

1.5 Estimated Zones of Impact

1.5.1 Considered Source Levels

The sound level for radiated vessel noise from the proposed split hopper barge was calculated from the available measurements of a proxy vessel (refer to Section 1.3.1). This yielded a maximum broadband (10 Hz to 25 kHz) source level of 166.2 dB re 1 μPa^2m^2.

As stated in Section 1.3.2, only two publications are known to the author to report acoustic sound levels of offshore dredge spoil disposal. The maximum source level measured from the release of unconsolidated dredged material from a split-hopper barge and TSHD was 108.7 dB re 1 µPa-m (Dickerson et al. 2001) and 155 dB re 1 μPa^2m^2s (De Jong et al. 2010), respectively. The average of these two source levels (131.9 dB re 1 μPa^2m^2s) was used as the basis to infer zones of impact for the placement of dredge spoil.

1.5.2 Review of existing studies

Talis (2019) completed the only previous risk assessment for the underwater noise impacts associated with the Mardie Project, which included the proposed loading of dredge material via a backhoe dredge. The study showed noise generated by the proposed dredging did not reach any of the noise effect criteria for marine reptiles or fish (including elasmobranchs). The modelling indicated received noise levels attenuated below the marine mammal behavioural response threshold for HF and LF cetaceans at 200 m and 1,500 m, respectively, from the dredging noise source.

In contrast, JASCO (2025) provided the following predictions for underwater noise associated with dredging activities completed as part of the environmental impact assessment (currently ongoing) for the Eramurra Solar Salt Project at Cape Preston, ~40 km northwest of the Mardie Project. Importantly, that assessment defined dredging activities as the combined noise generated by a cutter suction dredge at the uplift site (not a backhoe as is likely to be utilised at Mardie) and two split hopper barges for spoil disposal:

- A marine mammal behavioural response was estimated to extend for 6.3 km from the dredging noise source.
- Onset of TTS and PTS for the LF cetacean group, using the worst case SEL_{24h} criteria did not extend beyond 2.21 km and 330 m, respectively, from the dredging noise source.
- Onset of TTS and PTS for the HF cetacean group was estimated to extend for 240 m and 10 m, respectively, of the dredging noise source.
- Onset of TTS in dugongs, using the worst case SEL_{24h} criteria, extends for 50 m from the dredging noise source. Onset of PTS in dugongs was not predicted to occur during dredging activities.
- Onset of TTS and PTS in marine turtles did not extend beyond 260 m and 10 m, respectively, from the dredging noise source.

- Dredging noise criteria thresholds for fish without a swim bladder (relevant to this assessment) were not reached.

No publicly available existing studies could be sourced to provide distance estimates to auditory injury in marine fauna due to the disposal of dredge spoil as the sole noise generating activity i.e. the dredging source level at the uplift site was always considered in the modelling. This is likely because there is rarely a requirement for data collection to understand the noise emitted during offshore spoil disposal or validate any proposed exclusion zones. Jimenez- Arranz et al. (2020) suggest that the dominant underwater noise generated during commercial activities associated with the disposal or placement of material from a vessel at sea is from the surface activities (vessel engines and thrusters) rather than the noise from the actual placement of material on the seabed. As such, existing modelling studies based on the sound levels generated by more dominant vessel radiated noise were sourced.

Koessler et al. (2020) modelled underwater sound levels from vessel radiated noise associated with surface towing operations through the Exmouth Gulf and between North West Cape and the Muiron Islands to beyond the 3 nm coastal waters limit. Acoustic source parameters for the model included three tow vessels with estimated source levels of 192.1 dB re 1 µPa-m (lead tug), 185.6 dB re 1 µPa-m (command vessel) and 166.7 dB re 1 µPa-m (trailing tug). As such, the acoustic source levels modelled were greater than those estimated for the current assessment. The study predicated:

- vessel radiated noise from towing operations did not reach any of the noise effect criteria for the HF - cetacean group or dugongs.
- the onset of PTS and TTS in the LF cetacean group did not extend beyond 80 m and 1.63 km, respectively from the towing operations.
- The onset of TTS in marine reptiles did not extend beyond 90 m from towing operations. Onset of PTS in marine reptiles was not predicted to occur.

The study with most relevance to the current assessment was completed as part of the nearby Eramurra Solar Salt Project. JASCO (2025) performed a modelling study of underwater sound levels associated with proposed vessel activities in shallow water (up to ~15 m depth). That study predicted the propagation of vessel radiated noise (during vessel transit and berthing), based on a maximum broadband (10 Hz to 25 kHz) source level of 172.9 dB re 1 μPa^2m^2 (which is slightly more than the estimated source level for the proposed Mardie split hopper barge of 166.2 dB re 1 μPa^2m^2). The study showed vessel radiated noise did not reach any of the noise effect criteria for the high frequency (HF) cetacean group, sirenian (dugong) group, marine reptiles or fish within the model resolution (10 m). The modelling indicated the onset of TTS in the low frequency (LF) cetacean group did not extend beyond 170 m from a vessel in transit. A marine mammal behavioural response zone was estimated to extend for 3.17 km from the vessel noise source. This information has been summarised in Table 8

Table 8. Maximum horizontal distance to behavioural response and auditory injury from vessel movements associated with the Eramurra Project (JASCO 2025).

Marine Fauna	Marine Mammal Behavioural Response – SPL R_{max} (km)	TTS – SEL_{24h}	PTS - SEL_{24h}
		R_{max} (km)	R_{max} (km)
LF-cetacean	3.17	0.17	-
HF-cetacean		-	-
Sirenians (dugongs)		-	-
Marine Reptiles	N/A	-	-
Fish (incl Elasmobranchs)	N/A	-	-

R_{max} is the maximum horizontal distance to the response and threshold criteria.

A dash indicates the level was not reached within the limits of the modelled resolution (10 m).

1.5.3 Recommended Management Zones

Vessel radiated noise is likely to be the dominant noise source during the Proposed Action, as it is likely the split hooper barge will still be under propulsion during release (dumping) of the spoil material.

The model inputs for the JASCO (2025) study for the Eramurra Project are most relevant to the Mardi Project in terms of the vessel radiated noise source levels and bathymetry of the area. As such, the distances to behavioural response and auditory injury (TTS or PTS) due to vessel radiated noise predicted by JASCO (2025) were used to inform the zones recommended in Table 9.

Noise effect criteria were not predicted to be reached for the HF cetacean group, dugongs, marine reptiles or fish by JASCO (2025). As such, the estimated distance to auditory injury (the exclusion zone) for those marine fauna groups has been set at double the resolution of the JASCO (2025) model (10 m). The observation zone for marine reptiles and elasmobranchs has been set at a minimum distance of 50 m.

The estimated distance to auditory injury (the exclusion zone) for the LF cetacean group as been set at slightly less than double the distance for the onset of TTS (170 m). The observation zone for both LF and HF cetaceans reflects the estimated distance to a marine mammal behavioural response predicted by the JASCO (2025) model (3.17 km).

A precautionary approach has been applied to the distance estimates due to large uncertainties in the aspects of estimation from a review of existing information in lieu of a numerical modelling study.

Table 9. Estimated distance to behavioural response and recommended management zones for the Proposed Action

Marine Fauna	Behavioural Response Zone (m)	Recommended Exclusion Zone (m)	Recommended Observation Zone (m)
LF Cetaceans (e.g. humpback whales)	3,000	300	3,000
HF Cetaceans (e.g. dolphins)		20	
Marine reptiles (e.g. sea turtles and others)	N/A	20	50
Fish (e.g. elasmobranchs and others)	N/A	20	50

Section 2. Risk Assessment of Potential Underwater Noise Impacts

2.1 Risk Assessment

An assessment of the risks of the Proposed Action (specifically underwater noise impacts) to marine fauna of significance known to occur within and /or adjacent to the Mardie Project has been undertaken. The risk assessment was undertaken using a systematic approach, based on international best practice standards (AS/NZS ISO 31000:2018: Risk Management – Guidelines), of assigning a consequence and probability to potential negative outcomes.

Risk ratings were assigned to each impacting activity using the risk matrix in Appendix A.

The assessment of inherent risks for underwater noise impacts has assumed the worst-case scenario i.e. the furthest distance identified in the literature review associated with a marine mammal injury (the maximum horizontal distances for a behavioural response and exceedance of frequency-weighted TTS and PTS thresholds for marine turtles and fish were much less than for marine mammals).

Table 10 presents the outcomes of the risk assessment, including the inherent and residual risks after implementation of the mitigation measures proposed in the Mardie Project DSDMP (O2 Marine 2024).

Table 10. Risk assessment of underwater noise impacts to marine fauna and management controls

Scenario	Potential Impact	Cause	Consequence	Likelihood	Inherent Risk	Mitigation Measures	Consequence	Likelihood	Residual Risk
Noise emissions from: • Placement of dredge spoil at the disposal site.	Behavioural and physiological impacts to marine megafauna (detail provided in Section 1).	Proposed dredge disposal action related noise (detail provided in Section 1).	1	C	Low	N/A – Inherent risk assessed as Low	1	D	Low
Noise emissions from: • Propulsion of the split hopper barge during transit (between the dredge area and spoil ground), and whilst disposing of spoil.		Vessel radiated noise associated with propulsion of the vessel (detail provided in Section 1).	2	C	Mod	As per the existing Mardi Project DSDMP (O2 Marine 2024): • Implement marine fauna monitoring and management plan. Including, observation and exclusion zones during dredge spoil disposal, and dedicated marine fauna observer (MFO) vessels at the DMPA4 spoil ground. • Dedicated MFO on all dredges/barges during humpback whale season (June to November) including transit to Spoil Ground DMPA4. Trained MFO on all dredges/barges outside of humpback whale season. • Ensure all vessel equipment and machinery is in good condition and subject to regular maintenance. When in	2	D	Low

Scenario	Potential Impact	Cause	Consequence	Likelihood	Inherent Risk	Mitigation Measures	Consequence	Likelihood	Residual Risk
						transit, all Project vessels will be operated in accordance with EPBC Regulations 2000-Part 8 Division 8.1. Minimise the duration of run-time for vessel engines, thrusters and dredging plant by avoiding stand-by or running mode to the degree practical and consistent with safe operations.			

2.2 Risk Assessment Summary

On the basis of the qualitative review of available information relevant to this assessment, the following conclusions can be drawn regarding the risk of underwater noise impacts to significant marine fauna from the Proposed Action. Noting the distance estimates for SEL_{24h} criteria (continuous, non-impulsive, noise over a 24 hour period) reported by the existing studies does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with either PTS or TTS if it remained in that location for 24 hours.

- The inherent risk to the marine fauna of interest from the Proposed Action, with the exception of the LF cetacean group, was considered low.
    - Noise criteria thresholds from estimated sound source levels for the Proposed Action were considered unlikely to be reached.
- The inherent risk to LF cetaceans, including humpback whales, was considered moderate.
    - A previous modelling study has shown the onset of TTS in LF cetaceans may extend for 170 m from a vessel noise source with a similar level (172.9 dB re 1 μPa^2m^2) to that estimated for the Proposed Action 166.2 dB re 1 μPa^2m^2).

Disposal activity will be frequent but brief. It will generally be three periods of 15 mins for spoil disposal and three periods of ~3.5 hours for vessel transit per day.

The probability of marine megafauna being within the vicinity of the Proposed Action for sufficient time periods to accumulate the requisite length of exposure to noise at damaging levels and the mitigating potential of the recommended management measures, further reduce risk profiles.

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Appendix A – Risk Assessment Matrix

	Consequence	1-Insignificant Localised disturbance to marine fauna that is confined to the operating footprint and can be rectified or reversed within a day	2-Minor Localised harm to marine fauna that is confined to the operating footprint and can be rectified or reversed within weeks of work effort or natural recovery	3-Moderate Harm to regionally significant marine fauna that can be rectified or reversed within weeks to months of work effort or natural recovery	4-Major Harm to nationally significant marine fauna that can be rectified or reversed within months to years of work effort or natural recovery	5-Catastrophic Widespread harm to globally significant marine fauna that can be rectified or reversed within years to decades of work effort or natural recovery
Likelihood	**A-Almost certain** Recurring event during the lifetime of an operation / project. Occurs more than twice per year	Moderate	High	High	Critical	Critical
	B-Likely Event that may occur frequently during the lifetime of an operation / project. Typically occurs once or twice per year	Moderate	Moderate	High	High	Critical
	C-Possible Event that may occur during the lifetime of an operation / project. Typically occurs in 1-10 years	Low	Moderate	Moderate	High	Critical
	D-Unlikely Event that is unlikely to occur during the lifetime of an operation / project. Typically occurs in 10-100 years	Low	Low	Moderate	Moderate	High
	E-Rare Event that is very unlikely to occur during the lifetime of an operation / project. Greater than 100-year event	Low	Low	Low	Moderate	High