Att6: Impact of high-resolution surveying equipment on marine fauna.

Anthropogenic noise pollution is a potential concern for cetaceans, Australian sea lions, green turtles, leatherback turtles, loggerhead turtles and southern bluefin tuna (Department of Sustainability, Environment, Water, Population and Communities, 2012). This document provides an overview of underwater sound, its potential impacts on marine wildlife, the sound signature of the equipment likely to be used in the survey and associated mitigation measures.

What is sound

Sound is produced by a vibrating object emitting waves of alternating higher and lower pressure into a medium such as air or water. It can be categorised based on its frequency, duration (pulse length), sound pressure (Sound Pressure Level: SPL) or integration over time of the square of the sound pressure (Sound Exposure Level: SEL). Sound measurements are expressed in decibel (dB), a relative unit of measurement based on a logarithmic scale. Sound dB values are expressed with reference to 20 µPa in air and 1 µPa in water (Erbe et al, 2022), meaning that they are not directly comparable.

The nature of sound changes with distance from the source as it can be combined, absorbed, reflected, transmitted, refracted, or distorted depending on the properties of the source and the propagation medium. In general, the sound level decreases with distance, and, for a far field source, the sound received can be expressed as:

$$RS = SL - A - PL \qquad \text{Eq (1)}$$

Where RS is the received sound pressure level (SPL), SL the source level, A the absorption of sound in seawater and PL the propagation loss (Erbe et al, 2022), also known as the transmission loss, TL.

Sound and the marine fauna

Natural light is scarce in the marine environment and many marine species rely on sound as their primary modality for navigation, detection, foraging and communication. Marine species are particularly sensitive to anthropogenic noise and may experience temporary (TTS) or permanent (PTS) threshold shifts, which can lead to behavioural changes, injury, or death (Southall et al, 2019). The likelihood of causing either TTS or PTS can be directly related to the SEL of the source. Each species has different sensitivity thresholds depending on its auditory system. It is therefore critical to ensure that anthropogenic activities do not expose marine species to SELs above their estimated threshold. The TTS and PTS onset values defined by Southall et al (2019) for different mammal hearing groups are often used as a reference. It is important to note that the hearing sensibilities for many cetacean species is unknown. Similar hearing group estimates have also been produced by the Fisheries Hydroacoustic Working Group for fishes and by the Department of the Navy for sea turtles (Table 1).

Table 1: Marine mammal TTS and PTS threshold for impulsive sources. Values from Southall et al (2019), Fisheries Hydroacoustic Working Group (2008) and the Department of the Navy (2017).

Marine fauna hearing group	TTS onset: SEL re 1 µPa2s·m	TTS onset: Peak SPL dB re 1 µPa·m	PTS onset: SEL re 1 µPa2s·m	PTS onset: Peak SPL dB re 1 µPa·m
Low frequency	168	213	183	219
Mid frequency	170	224	185	230
High frequency	140	196	155	202
Sirenians	175	220	190	226
phocid carnivores	170	212	185	218
Other carnivores	188	226	203	232
Fishes < 2g	187	206	na	229
Fishes > 2g	183	206	na	229
Sea Turtles	189	226	204	232

Legal framework

Typical seismic exploration surveys use airguns to generate short and loud impulsions of sound to image the subsurface several kilometres below the seafloor. Achieving this level of penetration requires the use of high energy and low frequency sound impulses which could have the potential to exceed TTS and PTS thresholds at short range (Gedamke et al, 2011;Gray et al, 2011; Tougaard et al, 2015).

The EPBC Policy Statement 2.1 was developed to establish management procedures to follow during seismic surveys to minimise the risk of adverse effects on cetaceans and more broadly marine wildlife. The management procedures are based on a SEL of less than 160 dB re 1µPa2·s at 1 km range.

It should be noted that although the EPBC policy statement 2.1 sets the threshold to 160 dB re 1µPa2·s at 1 km range to account for potential cumulative effects, significant uncertainties remain regarding the duration of exposure needed to reach TTS and PTS threshold values.

Impact of the proposed high-resolution surveying equipment

The university plans to acquire high-resolution seismic data (using either a sparker or boomer source), sub bottom profiling data (SBP), multibeam bathymetry data and side scan sonar data. The make and parameters of the equipment used during the survey will be determined by the contractor. It is important to note that the sound signature of this high resolution geophysical survey equipment is very different from the sound signature of the exploration geophysical survey equipment for which the legal framework was developed. In fact, high resolution geophysical equipment use much higher frequencies which are rapidly absorbed by water and may be beyond the hearing capabilities of marine fauna. In any case, in order to assess the impact of this high-resolution geophysical equipment on the marine environment, it is necessary to investigate the maximum SEL of the sources at different ranges.

First, the SPLs received at any given range are calculated with Eq (1) with the source parameters, the equations of sound absorption in seawater from Ainslie and McColm (1998) using http://resource.npl.co.uk/acoustics/techguides/seaabsorption/, and the equations of propagation loss from Erbe (2022). More specifically, the propagation loss was calculated using spherical spreading where range < water depth (Eq. 2) combined with cylindrical spreading where range > water depth (Eq. 3). SELs were then calculated as follows (Eq. 4):

PL = 20Log(range) Eq (2)

PL = 10Log(water depth) + 10Log(range) Eq (3)

SEL = SPL + 10Log(pulse length) Eq (4)

Although not true sound modelling, this approach provides very conservative results as it excludes sound losses at the water – air and water – seabed interfaces and considers the maximum theoretically possible source levels (which are rarely used in practice). The results (Table 2) confirm that high-resolution survey equipment generates significantly less noise than typical airguns for which the EPBC policy statement 2.1 was designed for, and is systematically below the SEL threshold of 160 dB re 1 µPa2s·m at a range of 1000 m. In fact, in most cases, the value is reached within a few tens of metres from the vessel, significantly limiting the risk of TTS and PTS for marine fauna.

Another aspect to consider, is how marine animals may be impacted beyond the potential for PTS or TTS. Noise disturbances may have the potential to impact behaviour and displace animals from areas of importance. In this regard, the shelf and more largely the whale migration corridor cover an area in excess of 10,000 km^2 offshore Bunbury. The survey, on the other hand, will only have the potential to impact an area of about 3 km^2 at any given time, considering a conservative range of impact of 1 km around the vessel. Any local displacements resulting from the survey are therefore not expected to keep animals away from areas of importance.

Table 2: Summary of the sound signature of a typical airgun for which the EPBC policy statement 2.1 was designed for, and of the equipment that will likely be used for the survey.

Survey Equipment	Source parameters				Absorption dB / km	Range: 1000 m		min range (m) SEL < 160 dB re 1 µPa2s·m2
	Operating Frequency kHz	SPL 1 m dB re 1 µPa·m	Pulse Length (ms)	Pulse per second		SPL dB re 1 µPa·m	SEL dB re 1 µPa2s·m2	
Typical airgun (NOT USED HERE)	0 – 0.25	230	20	0.07	0.01	183.0	166.0	4000
Sparker	0 - 5	226	1	2	0.16	178.9	148.9	80
Boomer	1.5 - 3	222	0.4	3	0.14	174.9	140.9	30
SBP	70	246	1	20 – 40	24	175.0	145.0	500
MBES Bathymetry	100	220	1	20 – 40	38	135.0	105.0	30
Side Scan Sonar	100 - 400	220	0.1	20 – 40	90	83.0	43.0	10

Noise mitigation measures

The survey will adhere to the guidelines of the EPBC Policy Statement 2.1 Interaction between offshore seismic exploration and whales: Industry guidelines. The guidelines are developed around precaution zones and management procedures.

Precaution zones

For proposed surveys with SEL of less than 160 dB re 1 µPa2s·m at a range of 1000 m, the following precaution zones should be enforced:

- Observation zone – 3 km radius
- Low power zone – 1 km radius
- Shut-down zone – 500 m radius

A Marine Fauna Observer (MFO) will be responsible for monitoring the marine life and enforcing the precaution zones. The MFO will have completed a recognised training course that will need to be approved by UWA. The MFO will also be responsible for preparing compliance and sighting reports in accordance with the EPBC Policy Statement 2.1. All crew will be briefed by the MFO on key sighting criteria and will be required to report all sightings to the MFO.

Management Procedures

During survey, the following procedure will be followed at any time as outlined in the EPBC Policy Statement 2.1:

- Pre start-up visual observations. During daylight hours and prior to commencement, the MFO shall monitor the precaution zones for at least 30 minutes to ensure that no whales are present.
- Soft start. After completion of the pre-start visual observation, the acoustic sources are gradually brought up to operating conditions over a period of 30 minutes.

- Start-up delay. If a whale is sighted within the observation zone during the soft start, the MFO is responsible for monitoring it until it exits the observation zone or until 30 minutes have lapsed since the last sighting. Should the whale enter the low power zone or the shutdown zone, the powering of the acoustic sources is either stopped or cancelled depending on the intersected zone.
- Operations. Trained crew and the MFO should maintain continuous visual observations of the precaution zones during operation. The MFO is responsible for monitoring any whale sighted within the precaution zones. Procedures for powering down and stopping work should be followed if a whale is identified within either the low power or shut down precaution zones.
- Power down and stop work. If a whale enters the low power zone or the shut down zone, the acoustic sources are either reduced to their lowest operable levels or shut down depending on the intersected zone. Operation can resume following the soft start procedure when the whale has moved out of the relevant precaution zone or after 30 minutes has elapsed since the last sighting.

When visibility is not sufficient within the observation zone, the team will follow the night time and low visibility procedures as defined in the EPBC Policy Statement 2.1. In addition, the survey team will liaise with other vessels present in the area and relevant stakeholders to identify and monitor any likely whale concentration areas. The survey layout and timing of acquisition of the survey lines will be continuously updated during the survey to ensure that any identified whale concentration areas are avoided.

References

Ainslie, M.A. and McColm, J.G., 1998. A simplified formula for viscous and chemical absorption in sea water. The Journal of the Acoustical Society of America, 103(3): 1671-1672, 10.1121/1.421258.

Erbe, C., Duncan, A. and Vigness-Raposa, K.J., 2022. Introduction to Sound Propagation Under Water. In: C. Erbe and J.A. Thomas (Editors), Exploring Animal Behavior Through Sound: Volume 1: Methods. Springer International Publishing, Cham, pp. 185-216, 10.1007/978-3-030-97540-1_6.

Department of the Navy, 2017. Technical Report: Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III). San Diego, California: SSC Pacific.

Department of Sustainability, Environment, Water, Population and Communities, 2012. Marine bioregional plan for the South-west Marine Region. Commonwealth of Australia

Fisheries Hydroacoustic Working Group, 2008. Agreement in principle for interim criteria for injury to fish from pile driving activities.

Gedamke, J., Gales, N. and Frydman, S., 2011. Assessing risk of baleen whale hearing loss from seismic surveys: The effect of uncertainty and individual variation. The Journal of the Acoustical Society of America, 129(1): 496-506, 10.1121/1.3493445.

Gray, H. and Van Waerebeek, K., 2011. Postural instability and akinesia in a pantropical spotted dolphin, Stenella attenuata, in proximity to operating airguns of a geophysical seismic vessel. Journal for Nature Conservation, 19(6): 363-367, https://doi.org/10.1016/j.jnc.2011.06.005.

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

Tougaard, J., Wright, A.J. and Madsen, P.T., 2015. Cetacean noise criteria revisited in the light of proposed exposure limits for harbour porpoises. Marine Pollution Bulletin, 90(1): 196-208, https://doi.org/10.1016/j.marpolbul.2014.10.051.