SONGKHLA BRIDGE CONSTRUCTION UNDERWATER NOISE ASSESSMENT

DEPARTMENT OF RURAL ROADS THAILAND

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EXECUTIVE SUMMARY

The Songkhla Lake Bridge will be constructed in Songkhla Lake, which is known to be inhabited by Irrawaddy dolphins. The core area of dolphin activity (8 km from the proposed bridge location) was mapped based on relatively brief (24 hour) snapshots of acoustic monitoring. However, it is understood that dolphins may forage outside of the core zone and they are not prevented from approaching the construction area. The potential impact of underwater noise generated during construction or operation of the Songkhla Lake Bridge Project on the critically endangered Irrawaddy dolphin was qualitatively assessed.

Exposure of marine animals to underwater noise can adversely impact marine animals, by hearing damage, barotrauma, stress-related injuries, and behavioral disruptions. The specific injuries and impacts can vary depending on the species, their sensitivity to noise, and the intensity and duration of exposure.

During construction, installation of piles to support a temporary construction platform and temporary jetties, and to support bridge foundations, will result in elevated noise levels in the Songkhla Lake.

The piles for the temporary construction platform (and it is assumed for the temporary jetties) will be H-section piles 300 mm x 300 mm wide installed to 7 m depth. Up to 32 piles will be installed per day vibratory driving. Vibratory driving involves using a vibrating hammer in continuous contact with the pile head to drive the pile into the ground. The noise level radiated into the water column from these activities is expected to be L_E 170 dB re 1μPa^2·S at 1 m for vibratory piling[1]. The piles for the temporary platform will be removed later in the construction process. Removal of the piles using a vibratory extractor would also generate noise levels of around L_E 170 dB re 1μPa^2·S at 1 m.

The piles for the bridge foundations will be installed in the lakebed by the boring method, where an auger drill is used to form a cylindrical excavation that is backfilled with steel reinforcement and concrete. Each pile installation will require approximately two days of drilling and 760 piles will be installed over approximately 36 months. Vibration generated in the auger bit by the driving mechanism and by interaction of the auger with the lakebed material will be radiated into the water as noise, generating levels of around L_E 162 dB re 1μPa^2·S at 1 m [2].

During operation, lower-level noise will be radiated from the submerged elements of the bridge structure. Vehicles moving on the bridge deck will generate vibration in the supporting structure,

[1] CalTrans 2009 *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish*

[2] NPL 2013 *Scoping study: Review of current knowledge of underwater noise emissions from wave and tidal stream energy devices*, National Physical Laboratory, Middlesex TW11 0LW UK

which will be radiated into the water column. Publicly available data[3] indicates that underwater noise levels at 100m from a heavily trafficked road bridge would be L_p 110 to 115 dB re 1 µPa.

The noise levels that may be generated during construction and operation will reduce further away from the Project site and fall below the assessment criteria within hundreds of meters. Noise emissions generated during construction may be higher than the assessment criteria within a limited zone (300 m). As a result, Irrawaddy dolphins within 300 m of the construction activities could be exposed to noise levels higher than the assessment thresholds during piling operations. The noise levels that may be generated during operation should fall below the assessment criteria within 100 m.

Implementation of the mitigation measures set out below would minimize the residual risk of Project-generated noise impacting the Irrawaddy dolphin population.

Before commencement of piling:

- Demonstrate that Best Available Technology (BAT) is being used. The bored piling method that the Project will use is an example of a BAT for low-noise pile installation.
- Provide appropriately equipped Marine Mammal Observers (MMOs) who have completed a JNCC certified MMO Course to detect dolphins either acoustically or visually and alert the construction crew about their presence so a work stoppage or delay in the commencement of piling activity can be triggered without delay according to a pre-determined protocol. MMOs should be equipped with Passive Acoustic Monitoring (PAM) and visual survey equipment.
- Establish mitigation zones. These are areas in which the MMO / PAM operative will monitor either visually and/or acoustically for marine mammals before piling commences (1,000 m observation zone with a 500 m shutdown zone has been recommended for vibro pile driving).

During piling:

- Pre-piling search: The mitigation zone should be monitored visually and acoustically by MMOs for an agreed period prior to the commencement of piling. It is recommended that the pre-piling search duration should be a minimum of 30 minutes.
- Delay if marine mammals are detected: Piling should not be commenced if marine mammals are detected within the mitigation zone or until 20 minutes after the last visual or acoustic detection.
- Pause in piling: If there is a pause in the piling operations for a period of greater than 10 minutes, then the pre-piling search should be repeated before piling recommences.

[3] Shima et al *Studying Underwater Sound Level Caused by Bridge Traffic in Lake Washington* 176th Meeting of the Acoustical Society of America, Nov. 2018

- Acoustic Deterrent Devices: The use of devices that have the potential to exclude animals from the piling area is recommended be considered. Acoustic Deterrent Devices (ADDs) should only be used in conjunction with visual monitoring. ADDs are a mitigation measure recommended in the '*Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise*'[4].

[4] JNCC *Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise*, August 2010

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1 INTRODUCTION

1.1 Scope

This report presents the findings of a qualitative underwater noise assessment conducted for the Songkhla Lake Bridge Project. The assessment determines the potential impacts of the construction and operational noise on the critically endangered Irrawaddy dolphin population in the lake.

1.2 Project Overview

The Songkhla Lake Bridge will span across Songkhla Lake, starting at Moo 1 Laem Jong Thanon, Jong Thanon Sub-District, Khao Chai Son District, Phatthalung Province, and ending in Ban Laem Yang, Ko Yai Sub-district, Krasae Sin District, Songkhla Province. The bridge will be 7 km long and 14.5 meters wide and supported by 29 pier structures that will be anchored in the lakebed by 2 to 6 piles per pier. Installation of the concrete piles will require 6 days of boring over a 21-day period.

Temporary construction platforms will be installed for the construction of each bridge span, approximately 300m long and 50m wide to cover 4 pier structures. Construction of each temporary platform will require up to 10 days and installation of the piles would require up to 4 days (40 of the H-section piles can be driven within a 10-hour window). Construction is expected to take approximately 36 months, with the main span construction requiring around 30 months.

Two temporary jetties will also be installed, and the supporting piles and installation method would be the same as for the temporary construction platform, with installation requiring 3 days and removal requiring 2 days.

An area known to be inhabited by Irrawaddy dolphins is approximately 8 km north of the proposed bridge location (refer Figure 1-1 overleaf). The core area of dolphin activity shown in Figure 1-1 was mapped based on pre-existing records from DMCR. However, it is understood that dolphins may forage outside of the core zone and they are not prevented from approaching the construction area.

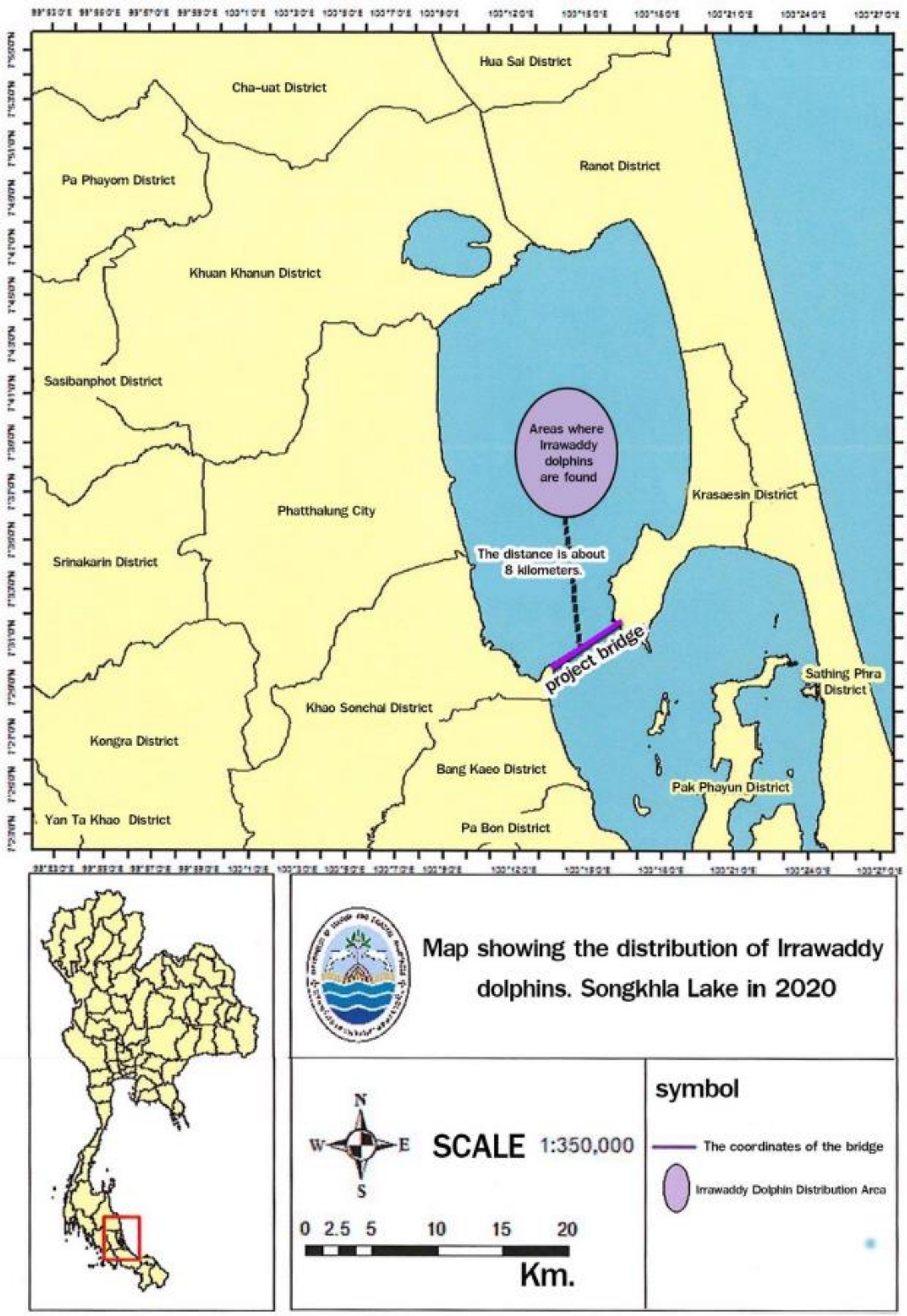

Figure 1-1 Map of Irrawaddy dolphins distribution in Sonkhla Lake, year 2020 (source: Adapted from the The Marine and Coastal Resources Research Center Lower Gulf of Thailand)

1.3 Sensitive Marine Fauna

Southhall et al (2019)[5] divides marine mammals into various sensitivity groups (Table 1-1), with the same impact thresholds used for all species within a group. Irrawaddy dolphins, which are classified as high-frequency cetaceans, are known to be present in the study area.

Table 1-1 Sensitivity classification of identified marine mammal species

Marine Mammal Hearing Group	Auditory Weighting Function	Species
Low-frequency cetaceans	LF	None identified in study area
High-frequency cetaceans	HF	Irawaddy Dolphin
Very high-frequency cetaceans	VHF	None identified in study area
Sirenians	SI	None identified in study area
Phocid carnivores in water Phocid carnivores in air	PCW PCA	None identified in study area
Other marine carnivores in water Other marine carnivores in air	OCW OCA	None identified in study area

1.4 Effects of Underwater Noise

The potential impacts of underwater noise on Irrawaddy Dolphins can be divided into three broad issues:

- Sounds causing permanent harm including hearing damage and stress related injuries.
- Sounds causing temporary hearing damage.
- Sounds that mask sounds used for echolocation (including navigation and foraging) and/or social interactions (including communication that affects group cohension such as signature whistles which allows calves to find their mother). These disruptions can have indirect physical consequences, such as increased energy expenditure, reduced foraging efficiency, or decreased reproductive success.

The specific injuries and impacts can vary depending on the intensity and duration of exposure.

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

2 METHODOLOGY

2.1 Underwater Noise Criteria

Assessment criteria were drawn from Southall et al (2019). Southall provides weighted sound exposure level ($L_{E,p}$ dB re 1μPa^{2}·S (weighted)) and unweighted peak sound pressure level (L_{pk} dB re 1μPa (unweighted)) criteria at which Permanent Threshold Shift (PTS), Temporary Threshold Shift (TTS) may occur. Additionally, NMFS (2013)[6] recommends interim root-mean-square sound pressure level criteria (L_p) for impulsive noise and non-impulsive noise at which behavioural disturbance may occur. PTS, TTS, L_{pk} and L_p are further defined in APPENDIX A. The criteria relevant to this assessment are summarised in Table 2-1.

Table 2-1 Marine Mammal Sound Exposure Criteria

Sensitivity Classification	PTS - Permanent Injury		TTS - Impairment		Behaviour	
	Impulsive	Non-Impulsive	Impulsive	Non-Impulsive	Impulsive	Non-Impulsive
High-frequency cetaceans	230 L_{pk} 185 dB $L_{E,p}$	198 dB $L_{E,p}$	224 L_{pk} 170 dB $L_{E,p}$	178 dB $L_{E,p}$	160 dB L_p	120 dB L_p

Irrawaddy dolphins can produce broadband clicks (commonly referred to as 'click trains'), pulsed sounds ('creak' or 'buzz' sounds), and whistles (narrow band, frequency modulated sounds)[7]. Broadband clicks and pulsed sounds are produced above 22 kHz and whistles are produced from 1 kHz to 8 kHz, whereas dominant noise from construction activities would be emitted at frequencies below 1 kHz[8]. Therefore, additional criteria to address masking of sounds produced by the Irrawaddy dolphin were not adopted.

2.2 Project Related Noise Sources

The assessment considered noise sources generating sounds of L_p 120 dB or higher, which can cause PTS, TTS or behavioral changes in high-frequency hearing cetaceans. The noise sources considered were:

[6] *NMFS (2013): National Marine Fisheries Services (NMFS), 2013, Marine mammals: Interim Sound Threshold Guidance (webpage), National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.*

[7] *Sounds produced by Australian Irrawaddy dolphins, Orcaella brevirostris* Sofie M. Van Parijs,a) Guido J. Parra, and Peter J. Corkeron School of Tropical Environment Sciences and Geography, James Cook University, Townsville QLD 4811, Australia

[8] Figure I.4-4 pp I-43 CalTrans 2009 *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish*

- Pile installation during construction using the boring method; and
- Traffic induced noise radiated from the bridge piers during operation.

The piles will be installed in the lakebed by the boring method, where an auger drill is used to form a cylindrical excavation that is backfilled with steel reinforcement and concrete. The noise levels generated by the boring method of pile installation are several orders of magnitude lower than noise levels generated by the impact piling method, where piles are driven into the ground by repeated strikes from a powered hammer.

During construction, installation of piles to support temporary construction platforms and the temporary jetties, and to support bridge foundations, will result in elevated noise levels in the Songkhla Lake.

The piles for the temporary construction platform (and it is assumed the temporary jetties) will be H-section piles 300 mm x 300 mm wide installed to 7 m depth. Up to 40 piles will be installed per day by vibratory driving over up to 10 hours. Installation by vibratory driving involves using a vibrating hammer in continuous contact with the pile head to drive the pile into the ground. The noise level radiated into the water column from these activities is expected to be L_E 170 dB re 1µPa^2·S at 1 m for vibratory piling[9]. The piles for the temporary platform will be removed later in the construction process. Removal of the piles using a vibratory extractor would also generate noise levels of around L_E 170 dB re 1µPa^2·S at 1 m, with up to 40 piles removed over 7 hours.

Each permanent pile installation will require approximately two days of drilling and 760 piles will be installed over approximately 36 months. Vibration generated in the auger bit by the driving mechanism and by interaction of the auger with the lakebed material will be radiated into the water as noise, generating levels of around L_p 162 dB re 1 µPa at 1 m[10].

During operation, lower-level noise will be radiated from the submerged elements of the bridge structure. Vehicles moving on the bridge deck will generate vibration in the supporting structure, which will be radiated into the water column. Publicly available data indicates that underwater noise levels at 100m from a heavily trafficked road bridge could be L_p 110 to 115 dB re 1 µPa[11].

[9] CalTrans 2009 *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish*

[10] NPL 2013 *Scoping study: Review of current knowledge of underwater noise emissions from wave and tidal stream energy devices*, National Physical Laboratory, Middlesex TW11 0LW UK

[11] Shima et al *Studying Underwater Sound Level Caused by Bridge Traffic in Lake Washington* 176th Meeting of the Acoustical Society of America, Nov. 2018

2.3 Propagation of Project Related Noise

The level of noise emissions from the significant project activities at range was estimated using a precautionary method from Caltrans (2009)[12], reproduced in Figure 2-1 below. Inputting the combination of noise source level and criterion that results in the highest transmission loss (criterion of 120 dB re 1 µPa and noise level for vibratory piling of 170 dB re 1 µPa^2.S and F = 20) yields an impact zone of 316 m.

The following input variables, which are precautionary, were used:

Source Level	170
Criterion	120
TL	50
D2	1
F	20

Equation 4-1

$$\text{Transmission loss (dB)} = F*\log(D_1/D_2)$$

Where:

D_1 = The distance at which the targeted transmission loss occurs;

D_2 = The distance from which transmission loss is calculated (usually 10 meters);

F = A site-specific attenuation factor based on several conditions, including water depth, pile type, pile length, substrate type, and other factors; and

Transmission loss (TL) = The initial sound pressure level (dB) produced by a sound source (i.e., pile driving) *minus* the ambient sound pressure level or a target sound pressure level (e.g., the injury threshold for salmon). TL also can be thought of as the change in sound pressure level between D_1 and D_2.

Figure 2-1 Precautionary method for prediction of piling noise level with range in shallow water environments

[12] CalTrans 2009 *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish*

3 QUALITATIVE IMPACT ASSESSMENT

The underwater noise assessment identified underwater noise sources that could cause temporary or permanent threshold shifts, or temporary behavioral changes (that may have permanent impacts), in high-frequency cetaceans. Pile installation during construction by boring or vibratory methods, and structure-radiated noise during operation, were evaluated based on the worst-case levels that could be generated at the Irrawaddy dolphin habitat relative to the noise criteria established for the assessment.

Noise emissions generated during construction may be higher than the assessment criteria within a limited zone (300 m). As a result, Irrawaddy dolphins within 300 m of the construction activities could be exposed to noise levels higher than the assessment thresholds during piling operations.

The noise levels that may be generated during operation should fall below the assessment criteria within 100 m.

4 RECOMMENDED MITIGATION MEASURES

Recommended mitigation measures are outlined below.

Before commencement of pile installation:

- Use Best Available Technology (BAT) to reduce noise emissions. Examples of BAT for the activities include:
  - Bored piling.
  - Selecting the lowest power vibratory pile driver that would be practical for the project, considering equipment availability, ground conditions and schedule.

- Provide appropriately equipped Marine Mammal Observers (MMOs) who have completed a JNCC certified MMO Course to detect dolphins either acoustically or visually and alert the construction crew about their presence so a work stoppage or delay in the commencement of piling activity can be triggered without delay according to a pre-determined protocol. MMOs should be equipped with Passive Acoustic Monitoring (PAM) and visual survey equipment.
- Establish communication procedures between the MMO and piling crew, including a formal chain of communication between the observers and the person who can stop the piling operation.
- Establish a mitigation zone. This is an area in which the MMO / PAM operative will monitor visually and acoustically for marine mammals before piling commences. A 1,000 m observation zone with a shutdown zone of 500 m is recommended for vibro pile driving)

During pile installation:

- Pre-piling search: The mitigation zone should be monitored visually and acoustically by MMOs for an agreed period prior to the commencement of piling. It is recommended that the pre-piling search duration should be a minimum of 30 minutes.
- Delay if marine mammals are detected: Piling should not be commenced if marine mammals are detected within the mitigation zone or until 20 minutes after the last visual or acoustic detection.
- Pause in piling: If there is a pause in the piling operations for a period of greater than 10 minutes, then the pre-piling search should be repeated before piling recommences.
- Acoustic Deterrent Devices: The use of devices that have the potential to exclude animals from the piling area is recommended to be considered. Acoustic Deterrent Devices (ADDs) should only be used in conjunction with visual monitoring. ADDs are a mitigation measure

recommended in the '*Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise*'[13].

It is recommended that the requirements described above are reflected in the Project Environmental and Social Management Plan (ESMP).

[13] JNCC *Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise*, August 2010

5 CONCLUSIONS

The assessment indicates that underwater noise from Project activities during construction could exceed the assessment thresholds within a limited zone (300 m) during piling activities.

Implementation of the precautionary mitigation measures outlined above, which include pausing piling operations if a dolphin is detected within a 500 m shutdown zone or 1,000m observation zone, would minimize the risk of Project-generated noise impacting the Irrawaddy dolphin population in Lake Songkhla.

APPENDIX A PRINCIPLES OF UNDERWATER NOISE

Sound Pressure Level

Sound Pressure Level – The RMS level of sound at the instant (or in practice within one second) of the noise occurring. Since sound travels as a pressure wave, with high and low pressure amplitudes, the sound pressure level is always varying in time. Sound pressure level is expressed in dB, with relation to a reference sound pressure p_{ref}. The mathematical definition of sound pressure level (L_p) is:

$$L_P = 10 \log_{10}\left(\frac{\overline{p^2}}{p_{ref}^2}\right) \quad \text{(A.1)}$$

(SPL is the commonly used descriptor for sound pressure level in historical published documents, however the official standard descriptor is L_p. For clarity and consistency with ISO 18405:2007 L_p is used in this report.)

Because sound pressure is a continuously varying value, it is useful to average the sound pressure over a certain time period, to provide a reliable and meaningful comparison of the amplitude of sound. This averaging is conducted on an energy basis, and because sound pressure is varying about a zero mean pressure, the root mean square (rms) is used. In airborne acoustics, this averaging yields a value commonly referred to as the *Equivalent Level*, or L_{eq}. While L_{eq} is the commonly accepted and used notation, the official standard term and notation for this value is *Time Averaged Level*, L_T.

In a number of publications regarding the impact of underwater noise, "SPL" has been used as the descriptor for continuous received noise upon which the proposed assessment criteria are based. In these documents the term sound pressure level has been defined as an *averaged* sound pressure. This definition, mathematically, is the same as that for the Time Averaged Level, discussed above.

Additional opportunity for confusion has arisen in the field since the NOAA guidelines (2018) have reverted to the original definition of "SPL".

Since this document refers to criteria that use the "SPL descriptor", and this descriptor was intended to mean an averaged level by the author of the publication, L_p is intended to mean a time averaged level of rms sound pressure. Therefore, the following definition of Sound Pressure Level is adopted:

Sound Pressure Level (L_p) is defined as the sound pressure, relative to some reference pressure, averaged over the time period T. For underwater acoustics, the reference pressure is generally taken to be p_{ref} = 1 µPa. Mathematically this is expressed as:

$$L_p = 10\ \log_{10}\left(\frac{1}{T}\int_0^T \frac{p(t)^2}{p_{ref}^2}dt\right) \tag{B.2}$$

Sound Exposure Level

The Sound Exposure Level ($L_{E,p}$), also known as the energy flux density, the constant sound pressure level that if maintained for one second, would deliver the same total sound energy as the original source. It is usually used to describe discrete noise events. SEL is the commonly used (ANSI defined) descriptor for sound exposure level such as it is used in the NOAA guidelines, however the official standard descriptor is $L_{E,p}$. For conformity to ISO 18405:2007 the $L_{E,p}$ notation is used in this study.

The Sound Exposure Level is especially useful as it can be used in an accumulative context by summing all energy over an extended time period T, or over N discrete events, to find the total received sound energy level. The disturbance and injury criteria for marine life is commonly given in $L_{E,p}$ for impulsive noise sources such as blasting or pile-driving, and $L_{E,p}$ (i.e. SEL) is also used by NOAA for newer criteria even for non-impulsive sources.

$$L_{E,p} = 10\ \log_{10}\left(\int_0^T \frac{p(t)^2}{p_{ref}^2}dt\right) \tag{B.3}$$

In deriving the $L_{E,p}$ for a continuous source, the time T should be taken as 1 second.

The Cumulative $L_{E,p}$ (denoted SEL_{cum} in ANSI standards and ANSI compliant publications such as the NOAA guidelines) is the total sound energy for a set number of discrete events, or in the instance of a continuous source, for the total period under consideration.

For *n* pulses, the cumulative $L_{E,p}$ can be derived from the single pulse $L_{E,p}$ by equation B.4:

$$L_{E,p} = L_{E,p\,(single\ event)} + 10\log(n) \tag{B.4}$$

For *a continuous source*, the cumulative $L_{E,p}$ for a defined exposure time T can be can be derived from the $L_{E,p}$ by equation B.5:

$$L_{E,p} = L_{E,p} + 10\log(T) \tag{B.5}$$

Other Descriptors of Sound

Hz	Hertz, the SI unit of frequency, meaning cycles per second.
Impulsive	Sound sources that produce sounds that are typically transient, brief (less than 1 second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay (ANSI 1986; NIOSH 1998; ANSI 2005). They can occur in

repetition or as a single event. Examples of impulsive sound sources include: explosives, seismic airguns, and impact pile drivers.

L_{pk} The absolute maximum peak pressure level (not RMS or mean level) reached at any time within the measurement period. L_{pk} gives a true representation of the actual maximum physical pressure of an acoustic wave.

Crest Factor The peak amplitude of the waveform divided by the RMS value of the waveform. The Crest Factor describes the how the peak of a wave form relates the average (rms) level. The Crest Factor is also sometimes called the Peak to Average Ratio (PAR) when expressed in engineering units (i.e. for sound when expressed as pressure (Pa). Because sound is typically expressed in dB, (a logarithmic unit) and log(ab) = Log(a) + Log(b), when the crest factor is expressed in dB it is the difference between the peak value and the mean value, i.e. CF = L_{pk} - L_p

Octave Band A 'constant percentage bandwidth' where each successive band centre frequency is double the previous one. International standards define nominal centre frequencies of 16 Hz, 31.5Hz, 63Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz, 4kHz, 8kHz, and 16kHz. Each octave band has a bandwidth which is proportional to the frequency so that there are no gaps or overlaps between bands. A separate noise level can be measured for each band, allowing definition of the frequency content of the noise.

Non-Impulsive Sound sources that produce sounds that can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent) and typically do not have a high peak sound pressure with rapid rise time that impulsive sounds do. Examples of non-impulsive sound sources include: marine vessels, machinery operations/construction (e.g., drilling), and vibratory pile drivers.

Pa Pascal, the SI unit for pressure.

RMS Root Mean Square – the mathematical means by which a regularly oscillating signal is 'averaged' such that the result is not zero.

SSP Sound Speed Profile – A table or graph showing how the speed of sound varies in a fluid (usually a body of water). The speed of sound in water is dependent upon temperature, pressure, and salinity. Differing speeds of sound through the water column causes refraction and in some cases reflection of the sound waves, and is therefore an important consideration in underwater noise propagation modelling.

Tonality A qualitative term used to identify when a noticeable tone or series of tones are detectable. In environmental noise this can be used to can be used describe noise that may be more annoying (due to its frequency content), than other noise of a similar overall level – when it is so used, the appropriate authority will usually define a quantitative means for determining when a noise demonstrates 'tonality'.

Effects of Noise

PTS	Permanent Threshold Shift - A permanent, irreversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level. Noise-induced PTS represents tissue injury.
TTS	A temporary, reversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level. Although TTS involves reduced hearing sensitivity following exposure, it results primarily from the fatigue (as opposed to loss) of cochlear hair cells and supporting structures and is, by definition, reversible. Since TTS represents a temporary change in sensitivity without permanent damage to sensory cells or support structures, it is not considered to represent tissue injury.
Behavioural Disturbance	Encompasses a broad range of potential responses to noise, including but not limited to: orienting to hear it; investigating it; changes or interruptions to normal behaviour (feeding, breeding, communicating etc), and panic or fleeing.