

2018 Revision to:

Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0)

Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts

Office of Protected Resources
National Marine Fisheries Service
Silver Spring, MD 20910



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

NOAA Technical Memorandum NMFS-OPR-59
April 2018



Table 6: TTS onset thresholds for non-impulsive sounds.

Hearing Group	<i>K</i> (dB)	<i>C</i> (dB)	Weighted TTS onset acoustic threshold (SEL _{cum})
Low-frequency (LF) cetaceans	179	0.13	179 dB
Mid-frequency (MF) cetaceans	177	1.20	178 dB
High-frequency (HF) cetaceans	152	1.36	153 dB
Phocid pinnipeds (underwater)	180	0.75	181 dB
Otariid pinnipeds (underwater)	198	0.64	199 dB

Determination of TTS onset threshold by individual based on methodology from Finneran 2016 for impulsive and non-impulsive sounds:

- Only TTS data from behavioral studies were used.
- TTS onset derived on a per individual basis by combining available data to create single TTS growth curve by frequency as a function of SEL_{cum}.
- TTS onset was defined as the SEL_{cum} value from the growth curve interpolated at a value of TTS = 6 dB.
- Interpolation was used to estimate SEL_{cum} necessary to induce 6 dB of TTS by hearing group.
- Weighted thresholds for TTS onset were determined by the minimum value of the auditory exposure function, which is mathematically equivalent to $K + C$ (Table 6).

2.3.1 Impulsive and Non-Impulsive Source Thresholds

This Technical Guidance divides sources into impulsive and non-impulsive based on physical characteristics at the source, with impulsive sound having physical characteristics making them more injurious than non-impulsive sound sources.

The characteristics of the sound at a receiver, rather than at the source, are the relevant consideration for determining potential impacts. Understanding these physical characteristics in a dynamic system with receivers moving over space and time is difficult. As sound propagates from the source the characteristics of impulsive sounds that make them more injurious start to dissipate due to effects of propagation.

For the purposes of this Technical Guidance sources are divided and defined as the following:

- **Impulsive:** 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.
- **Non-impulsive:** 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/decay time that impulsive sounds do.

Note: The term “impulsive” in this document relates specifically to NIHL and specifies the physical characteristics of an impulsive sound source, which likely gives them a higher potential to cause auditory TTS/PTS. This definition captures how these sound types may be more likely to affect auditory physiology and is not meant to reflect categorizations associated with behavioral disturbance.

Table 4: Summary of PTS onset thresholds.

Hearing Group	PTS Onset Thresholds* (Received Level)	
	Impulsive	Non-impulsive
Low-Frequency (LF) Cetaceans	<i>Cell 1</i> $L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	<i>Cell 2</i> $L_{E,LF,24h}$: 199 dB
Mid-Frequency (MF) Cetaceans	<i>Cell 3</i> $L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	<i>Cell 4</i> $L_{E,MF,24h}$: 198 dB
High-Frequency (HF) Cetaceans	<i>Cell 5</i> $L_{pk,flat}$: 202 dB $L_{E,HF,24h}$: 155 dB	<i>Cell 6</i> $L_{E,HF,24h}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	<i>Cell 7</i> $L_{pk,flat}$: 218 dB $L_{E,PW,24h}$: 185 dB	<i>Cell 8</i> $L_{E,PW,24h}$: 201 dB
Otariid Pinnipeds (OW) (Underwater)	<i>Cell 9</i> $L_{pk,flat}$: 232 dB $L_{E,OW,24h}$: 203 dB	<i>Cell 10</i> $L_{E,OW,24h}$: 219 dB

* Dual metric thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds are recommended for consideration.

Note: Peak sound pressure level ($L_{p,0-pk}$) has a reference value of 1 μ Pa, and weighted cumulative sound exposure level ($L_{E,p}$) has a reference value of 1 μ Pa²s. In this Table, thresholds are abbreviated to be more reflective of International Organization for Standardization standards (ISO 2017). The subscript “flat” is being included to indicate peak sound pressure are flat weighted or unweighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz). The subscript associated with weighted cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these thresholds will be exceeded.