National Marine Fisheries Service: Summary of Endangered Species Act Acoustic Thresholds (Marine Mammals, Fishes, and Sea Turtles)

This document summarizes NMFS acoustic thresholds for marine mammals, protected fishes, and sea turtles. These acoustic thresholds use the best available science at the time which they were developed (see references following each section or threshold table).

SOUND SOURCE CHARACTERIZATION (NMFS 2024)

To determine which threshold is appropriate, NMFS characterizes sound sources as impulsive/non-impulsive (AUD INJ/TTS) and intermittent/continuous (behavioral harassment):

- <u>Continuous sound sources</u>: emit sound with a sound pressure level that remains above ambient sound during the entire observation period. Examples of continuous sound sources include drilling and vibratory pile driving.

- <u>Intermittent sound sources:</u> have interrupted levels of low or no sound or bursts of sound separated by silent periods. Typically, intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle). Examples of intermittent sound sources include scientific sonar, high-resolution geophysical survey equipment (*i.e.*, sub-bottom profilers), and impact pile driving.

- <u>Impulsive sound sources</u>: produce sounds that are typically transient, brief (less than one second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay. Impulsive sounds can occur in repetition (e.g., seismic airguns, impact pile driving) or as a single event (e.g., explosives).

- <u>Non-impulsive sound sources:</u> can be continuous or intermittent, and produce sounds that can be broadband, narrowband or tonal, and brief or prolonged. Non-impulsive sources do not have the high peak sound pressure with rapid rise time typical of impulsive sounds. Examples of non-impulsive sources include drilling, vibratory pile driving, and certain active sonars.

MARINE MAMMALS

Marine Mammal Hearing Groups

The application of marine mammal hearing groups occurs in two ways. First, thresholds are designated by hearing group to acknowledge that not all marine mammal species have identical hearing or susceptibility to noise-induced hearing loss. Second, marine mammal hearing groups are used to establish marine mammal auditory weighting functions.

Marine Mammal Hearing Groups (NMFS 2024)

Hearing Group^	Generalized Hearing Range*
UNDERWATER	
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 36† kHz
High-frequency (HF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
Very High-frequency (VHF) cetaceans (true porpoises, *Kogia*, river dolphins, Cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*)	200 Hz to 165 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	40 Hz to 90 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 68 kHz
IN-AIR	
Phocid pinnipeds (PA) (true seals)	42 Hz to 52 kHz
Otariid pinnipeds (OA) (sea lions and fur seals)	90 Hz to 40 kHz

^ Southall et al. 2019 indicates that as more data become available there may be separate hearing group designations for Very Low-Frequency cetaceans (blue, fin, right, and bowhead whales) and Mid-Frequency cetaceans (sperm, killer, and beaked whales). However, at this point, all baleen whales are part of the LF cetacean hearing group, and sperm, killer, and beaked whales are part of the HF cetaceans hearing group. Additionally, recent data indicates that as more data become available for Monachinae seals, separate hearing group designations may be appropriate for the two phocid subfamilies (Ruscher et al. 2021; Sills et al. 2021).

***** Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall et al. 2007) and PW pinniped (approximation).

† NMFS is aware that the National Marine Mammal Foundation successfully collected preliminary hearing data on two minke whales during their third field season (2023) in Norway. These data have implications for not only the generalized hearing range for low-frequency cetaceans but also on their weighting function. However, at this time, no official results have been published. Furthermore, a fourth field season (2024) is proposed, where more data will likely be collected. Thus, it is premature for us to propose any changes to our current Updated Technical Guidance. However, mysticete hearing data is identified as a special circumstance that could merit re-evaluating the acoustic criteria in this document. Therefore, we anticipate that once the data from both field seasons are published, it will likely necessitate updating this document (i.e., likely after the data gathered in the summer 2024 field season and associated analysis are published).

Onset of Auditory Injury and Temporary Threshold Shifts (NMFS 2024)

Onset of Auditory Injury (AUD INJ) Criteria (NMFS 2024)

	AUD INJ Onset Criteria* **(Received Level)**	
Hearing Group	**Impulsive**	**Non-impulsive**
UNDERWATER		
Low-Frequency (LF) Cetaceans	*Cell 1* $L_{p,\text{0-pk,flat}}$: 222 dB $L_{E,p,\text{ LF,24h}}$: 183 dB	*Cell 2* $L_{E,p,\text{ LF,24h}}$: 197 dB
High-Frequency (HF) Cetaceans	*Cell 3* $L_{p,\text{0-pk,flat}}$: 230 dB $L_{E,p,\text{ HF,24h}}$: 193 dB	*Cell 4* $L_{E,p,\text{ HF,24h}}$: 201 dB
Very High-Frequency (VHF) Cetaceans	*Cell 5* $L_{p,\text{0-pk,flat}}$: 202 dB $L_{E,p,\text{VHF,24h}}$: 159 dB	*Cell 6* $L_{E,p,\text{ VHF,24h}}$: 181 dB
Phocid Pinnipeds (PW)	*Cell 7* $L_{p,\text{0-pk.flat}}$: 223 dB $L_{E,p,\text{PW,24h}}$: 183 dB	*Cell 8* $L_{E,p,\text{PW,24h}}$: 195 dB
Otariid Pinnipeds (OW)	*Cell 9* $L_{p,\text{0-pk,flat}}$: 230 dB $L_{E,p,\text{OW,24h}}$: 185 dB	*Cell 10* $L_{E,p,\text{OW,24h}}$: 199 dB
IN-AIR		
Phocid Pinnipeds (PA)	*Cell 11* $L_{p,\text{0-pk.flat}}$: 162 dB $L_{E,p,\text{PA,24h}}$: 140 dB	*Cell 12* $L_{E,p,\text{PA,24h}}$: 154 dB
Otariid Pinnipeds (OA)	*Cell 13* $L_{p,\text{0-pk,flat}}$: 177 dB $L_{E,p,\text{OA,24h}}$: 163 dB	*Cell 14* $L_{E,p,\text{OA,24h}}$: 177 dB

TTS Onset Criteria for Impulsive and Non-impulsive Sources (NMFS 2024)

	TTS Onset Criteria* **(Received Level)**	
Hearing Group	**Impulsive**	**Non-impulsive**
UNDERWATER		
Low-Frequency (LF) Cetaceans	*Cell 1* $L_{p,\text{0-pk,flat}}$: 216 dB $L_{\text{E},p,\text{ LF,24h}}$: 168 dB	*Cell 2* $L_{\text{E},p,\text{ LF,24h}}$: 177 dB
High-Frequency (HF) Cetaceans	*Cell 3* $L_{p,\text{0-pk,flat}}$: 224 dB $L_{\text{E},p,\text{ HF,24h}}$: 178 dB	*Cell 4* $L_{\text{E},p,\text{ HF,24h}}$: 181 dB
Very High-Frequency (VHF) Cetaceans	*Cell 5* $L_{p,\text{0-pk,flat}}$: 196 dB $L_{\text{E},p,\text{VHF,24h}}$: 144 dB	*Cell 6* $L_{\text{E},p,\text{ VHF,24h}}$: 161 dB
Phocid Pinnipeds (PW)	*Cell 7* $L_{p,\text{0-pk.flat}}$: 217 dB $L_{\text{E},p,\text{PW,24h}}$: 168 dB	*Cell 8* $L_{\text{E},p,\text{PW,24h}}$: 175 dB
Otariid Pinnipeds (OW)	*Cell 9* $L_{p,\text{0-pk,flat}}$: 224 dB $L_{\text{E},p,\text{OW,24h}}$: 170 dB	*Cell 10* $L_{\text{E},p,\text{OW,24h}}$: 179 dB
IN-AIR		
Phocid Pinnipeds (PA)	*Cell 11* $L_{p,\text{0-pk.flat}}$: 156 dB $L_{\text{E},p,\text{PA,24h}}$: 125 dB	*Cell 12* $L_{\text{E},p,\text{PA,24h}}$: 134 dB
Otariid Pinnipeds (OA)	*Cell 13* $L_{p,\text{0-pk,flat}}$: 171 dB $L_{\text{E},p,\text{OA,24h}}$: 148 dB	*Cell 14* $L_{\text{E},p,\text{OA,24h}}$: 157 dB

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculateing AUD INJ onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level criteria associated with impulsive sounds, the PK SPL criteria are recommended for consideration for non-impulsive sources.

<u>Note</u>: Peak sound pressure ($L_{\text{p,0-pk}}$) has a reference value of 1 µPa (underwater) and 20 µPa (in air), and weighted cumulative sound exposure level ($L_{\text{E},p}$) has a reference value of 1 µPa^{2}s (underwater) and 20 µPa^{2}s (in air). In this Table, criteria are abbreviated to be more reflective of International Organization for Standardization standards (ISO 2017; ISO 2020). The subscript "flat" is being included to indicate peak sound pressure are flat weighted or

unweighted within the generalized hearing range of marine mammals underwater (i.e., 7 Hz to 165 kHz) or in air (i.e., 42 Hz to 52 kHz). The subscript associated with cumulative sound exposure level criteria indicates the designated marine mammal auditory weighting function (LF, HF, and VHF cetaceans, and PW, OW, PA, and OA pinnipeds) and that the recommended accumulation period is 24 hours. The weighted cumulative sound exposure level criteria 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 criteria will be exceeded.

Onset of Behavioral Disturbance

NMFS acoustic thresholds for the onset of behavioral disturbance (underwater and in-air) are determined by the root-mean-square (RMS) received levels.

*Note: NMFS is currently updating the Marine Mammal Behavioral Disturbance Guidance

Underwater Onset of Behavioral Disturbance Acoustic Thresholds (NMFS 2005)

Source type	Threshold
Continuous	$L_{p,\mathrm{RMS,flat}}$: 120 dB re 1 μPa
Non-explosive impulsive or intermittent	$L_{p,\mathrm{RMS,flat}}$: 160 dB re 1 μPa

In-Air Onset of Behavioral Disturbance Acoustic Thresholds (Southall et al. 2007; NOAA 2009)

Species/Group	Threshold*
Harbor seal	$L_{p,\mathrm{RMS,flat}}$: 90 dB re 20 μPa
All other pinnipeds	$L_{p,\mathrm{RMS,flat}}$: 100 dB re 20 μPa

* A cumulative sound exposure level threshold of 100 dB re 20 μPa (DoN 2017) has been used for Navy military readiness activities. NMFS is currently in the process of re-evaluating the Navy's threshold.

Note: Sound levels underwater (re 1 μPa) have a different reference pressure compared to in-air sounds (re 20 μPa). Thus, it is not appropriate to compare sound levels in-air to those underwater.

Underwater Explosives

NMFS uses the acoustic and pressure thresholds below to predict the onset of AUD INJ, TTS, behavioral disturbance, tissue damage (i.e., lung and g.i. tract), and mortality from the use of underwater explosives.

Note: For a single detonation (within a 24-h period), NMFS relies on the TTS onset threshold. For multiple detonations (within a 24-h period), NMFS relies on a behavioral thresholds that is -5 dB from TTS onset (see Table below).

AUD INJ Onset, TTS Onset, and Behavioral Disturbance Onset (Multiple Detonations) for Underwater Explosives (NMFS 2024)

Hearing Group	AUD INJ Impulsive Thresholds	TTS Impulsive Thresholds	Behavioral Threshold (multiple detonations)
Low-Frequency (LF) Cetaceans	*Cell 1* $L_{p,\text{0-pk,flat}}$: 222 dB $L_{\text{E,LF,24h}}$: 183 dB	*Cell 2* $L_{p,\text{0-pk,flat}}$: 216 dB $L_{\text{E,LF,24h}}$: 168 dB	*Cell 3* $L_{\text{E,LF,24h}}$: 163 dB
High-Frequency (HF) Cetaceans	*Cell 4* $L_{p,\text{0-pk,flat}}$: 230 dB $L_{\text{E,HF,24h}}$: 193 dB	*Cell 5* $L_{p,\text{0-pk,flat}}$: 224 dB $L_{\text{E,HF,24h}}$: 178 dB	*Cell 6* $L_{\text{E,HF,24h}}$: 173 dB
Very High-Frequency (VHF) Cetaceans	*Cell 7* $L_{p,\text{0-pk,flat}}$: 202 dB $L_{\text{E,VHF,24h}}$: 159 dB	*Cell 8* $L_{p,\text{0-pk,flat}}$: 196 dB $L_{\text{E,VHF,24h}}$: 144 dB	*Cell 9* $L_{\text{E,VHF,24h}}$: 139 dB
Phocid Pinnipeds (PW) (Underwater)	*Cell 10* $L_{p,\text{0-pk,flat}}$: 223 dB $L_{\text{E,PW,24h}}$: 183 dB	*Cell 11* $L_{p,\text{0-pk,flat}}$: 217 dB $L_{\text{E,PW,24h}}$: 168 dB	*Cell 12* $L_{\text{E,PW,24h}}$: 163 dB
Otariid Pinnipeds (OW) (Underwater)	*Cell 13* $L_{p,\text{0-pk,flat}}$: 230 dB $L_{\text{E,OW,24h}}$: 185 dB	*Cell 14* $L_{p,\text{0-pk,flat}}$: 224 dB $L_{\text{E,OW,24h}}$: 170 dB	*Cell 15* $L_{\text{E,OW,24h}}$: 165 dB

* Dual metric criteria for impulsive sounds: Use whichever criteria results in the larger isopleth for calculating AUD INJ onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level criteria associated with impulsive sounds, the PK SPL criteria are recommended for consideration for non-impulsive sources.

Note: Peak sound pressure level ($L_{p,\text{0-pk}}$) has a reference value of 1 µPa , and weighted cumulative sound exposure level ($L_{\text{E},p}$) has a reference value of 1 µPa^{2}s . In this Table, criteria are abbreviated to be more reflective of International Organization for Standardization standards (ISO 2017; ISO 2020). The subscript "flat" is being included to indicate peak sound pressure are flat weighted or unweighted within the generalized hearing range of marine mammals underwater (i.e., 7 Hz to 165 kHz). The subscript associated with cumulative sound exposure level criteria indicates the designated marine mammal auditory weighting function (LF, HF, and VHF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The weighted cumulative sound exposure level criteria 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 criteria will be exceeded.

Lung and G.I. Tract Injury Thresholds (DoN 2017)

Hearing Group	Mortality (Severe lung injury)*	Slight Lung Injury*	G.I. Tract Injury
All Marine Mammals	*Cell 1* Modified Goertner model; Equation 1	*Cell 2* Modified Goertner model; Equation 2	*Cell 3* $L_{\text{pk,0-pk,flat}}$: 237 dB

* Lung injury (severe and slight) thresholds are dependent on animal mass (Recommendation: Table C.9 from DON 2017 based on adult and/or calf/pup mass by species).

Note: Peak sound pressure (L_{pk}) has a reference value of 1 µPa. In this Table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, ANSI defines peak sound pressure as incorporating frequency weighting, which is not the intent for this Technical Guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the overall marine mammal generalized hearing range.

Modified Goertner Equations for severe and slight lung injury (pascal-second)

Equation 1: $103M^{1/3}(1 + D/10.1)^{1/6}$ Pa-s

Equation 2: $47.5M^{1/3}(1 + D/10.1)^{1/6}$ Pa-s

M = animal (adult and/or juvenile) mass (kg) (Table C.9 in DoN 2017)

D = animal depth (meters)

FISHES

Below are the protected fish acoustic thresholds. Note that NMFS's acoustic thresholds for fishes are for all species of fish and do not distinguish between fishes of different groups (e.g., elasmobranchs or teleosts).

Onset of Physical Injury

Because of limited data, the FHWG relied on data from a variety of surrogate impulsive sources (i.e., explosives: Govoni et al. 2003; Govoni et al. 2007; Hastings et al. 2007; Yelverton et al. 1975; seismic airguns: Popper et al. 2005; Song et al. 2008; See Stadler and Woodbury 2009 for more information) to derive dual interim thresholds for impact pile driving that account for vulnerability depending on fish size. These thresholds are appropriate for other non-explosive impulsive sources.

Onset of Physical Injury[1] for Impulsive Sources for Fishes (FHWG 2008)

	Onset of Physical Injury (Received Level)
Fish Size	**Impulsive**
Fishes ≥ 2 g	*Cell 1* $L_{p,\text{0-pk,flat}}$: 206 dB $L_{\text{E},p,,\text{12h}}$: 187 dB
Fishes < 2 g	*Cell 2* $L_{p,\text{0-pk,flat}}$: 206 dB $L_{\text{E},p,\text{12h}}$: 183 dB

[1] For fishes, generally, the accumulation period can be reset to zero after a 12-h period of no pile driving, especially in a river or tidally-influenced waterway when the fish should be moving. Note: The accumulation period for marine mammals and sea turtles is 24-h. Furthermore, NMFS does not have physical injury thresholds for non-impulsive sources, except tactical sonar.

For fishes, the SELcum metric also incorporated effective quiet, which means if the received SEL from an individual pile strike is below a certain level (150 dB SELss), then the accumulated energy from multiple strikes would not contribute to injury, regardless of how many pile strikes occur. Effective quiet establishes a limit on the maximum distance from the pile where injury is expected. Beyond this distance no physical injury is expected, regardless of the number of pile strikes. There is currently not enough data to support an effective quiet level for other taxa.

Onset of Mortality and Physical Injury for Underwater Explosives for Fishes (FHWG 2008; Popper et al. 2014)

Onset of Mortality (Received Level)	Onset of Physical Injury (Received Level)
Cell 1 $L_{p,\text{0-pk,flat}}$: 229 dB	*Cell 2* $L_{p,\text{0-pk,flat}}$: 206 dB $L_{E,p,,12h}$: 187 dB ($\geq$ 2 g) $L_{E,p,,12h}$: 183 dB (< 2 g)

Onset of Behavioral Disturbance

While this is not a “formal” threshold, it allows us to have a level where one can begin to look at potential responses.

Behavioral Disturbance Acoustic Thresholds for Fishes[2]

Source Type	Threshold
All Sources	L_{RMS} 150 dB

[2] Note: The derivation and origin of the informal 150 dB threshold is not as well-defined as other thresholds. However, various recent publications do not refute that behavioral disturbance can occur around this level. As one example study, Hawkins et al. 2014 present their data in peak-to-peak sound pressure level and single strike SEL. However, in general, RMS levels for impact pile driving are approximately 10 dB higher than single strike SEL levels. Based on this conversion, the 50% RMS response level, from this study, for sprat and mackerel, range from 145 to 152 dB.

Note: Popper et al. 2019 advocate that the peak-to-peak metric is more appropriate for impulsive sounds compared to the RMS metric. However, pile driving data are not typically reported in this metric.

SEA TURTLES

Onset of Permanent Threshold Shift (PTS)

Onset of Permanent Threshold Shift (PTS) for Sea Turtles (DoN 2017)

Hearing Group	PTS Onset Thresholds (Received Level) for Impulsive Sources*	PTS Onset Thresholds (Received Level) for Non-impulsive Sources*
Sea Turtles	*Cell 1* $L_{p,\text{0-pk,flat}}$: 232 dB $L_{E,p,\text{ TU,24h}}$: 204 dB	*Cell 2* $L_{E,p,\text{ TU,24h}}$: 220 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 ($L_{p,\text{0-pk}}$) has a reference value of 1 µPa, and weighted cumulative sound exposure level ($L_{E,p}$) has a reference value of 1µPa^{2}s. 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 sea turtles (i.e., below 2 kHz). The subscript associated with cumulative sound exposure level thresholds indicates the designated sea turtle weighting function and that the recommended accumulation period is 24 hours. The weighted 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.

Onset of Temporary Threshold Shift (TTS)

Onset of Temporary Threshold Shift (TTS) for Sea Turtles (DoN 2017)

Hearing Group	TTS Onset Thresholds (Received Level) for Impulsive Sources*	TTS Onset Thresholds (Received Level) for Non-impulsive Sources*
Sea Turtles	*Cell 1* $L_{p,\text{0-pk,flat}}$: 226 dB $L_{E,p,\text{ TU,24h}}$: 189 dB	*Cell 2* $L_{E,p,\text{ TU,24h}}$: 200 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 ($L_{p,\text{0-pk}}$) has a reference value of 1 µPa, and weighted cumulative sound exposure level ($L_{E,p}$) has a reference value of 1µPa^{2}s. 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 sea turtles (i.e., below 2 kHz). The subscript associated with cumulative sound exposure level thresholds indicates the designated sea turtle weighting function and that the recommended accumulation period is 24 hours. The weighted 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.

Onset of Behavioral Disturbance

Data on behavioral reactions of sea turtles to sound sources is limited. However, in general, behavioral disturbance occurs around RMS 175 dB (O'Hara and Wilcox 1990; Moein et al. 1994; Lenhardt 2002; McCauley et al. 2002).

Onset of Behavioral Disturbance Acoustic Thresholds for Sea Turtles (DoN 2017)

Source Type	Threshold
All Sources*	L_{RMS} 175 dB

***** Currently, there are not enough data to derive separate thresholds for different source types.

Note: This threshold is also used for multiple detonations.

Underwater Explosives

For a single detonation (within a 24-h period), NMFS relies on the TTS onset threshold. For multiple detonations (within a 24-h period), NMFS relies on a behavioral thresholds that is -5 dB from TTS onset (see Table below).

Lung and G.I. Tract Injury Thresholds for Sea Turtles (DoN 2017)

Hearing Group	Mortality (Severe lung injury)*	Slight Lung Injury*	G.I. Tract Injury
All Sea Turtles	*Cell 1* Modified Goertner model; Equation 1	*Cell 2* Modified Goertner model; Equation 2	*Cell 3* $L_{pk,flat}$: 237 dB

Modified Goertner Equations for severe and slight lung injury (pascal-second)

Equation 1: $103M^{1/3}(1 + D/10.1)^{1/6}$ Pa-s

Equation 2: $47.5M^{1/3}(1 + D/10.1)^{1/6}$ Pa-s

M = animal (adult and/or juvenile) mass (kg) (Table C.9 in DoN 2017)

D = animal depth (meters)

* Lung injury (severe and slight) thresholds are dependent on animal mass (Recommendation: Table C.9 from DON 2017 based on adult and/or calf/pup mass by species).

Note: Peak sound pressure (L_{pk}) has a reference value of 1 µPa. In this Table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, ANSI defines peak sound pressure as incorporating frequency weighting, which is not the intent for this Technical Guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the overall marine mammal generalized hearing range.

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