Manual for Optional USER SPREADSHEET Tool (Version 2.2, December) for:

2018 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

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Dall's porpoise (*Phocoenoides dalli*), High-frequency cetacean Photo: Kate Stafford (NOAA)
California sea lion (*Zalophus californianus*), Otariid pinniped Photo: Sharon Melin (NOAA)

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

a	Low-frequency exponent
ANSI	American National Standards Institute
b	High-frequency exponent
BOEM	Bureau of Ocean Energy Management
C	Weighting function gain (dB)
dB	Decibel
-dB	Weighting function amplitude
DTH	Down-the-hole pile driving/installation
f_1	Low-frequency cutoff (kHz)
f_2	High-frequency cutoff (kHz)
FM	Frequency modulated
FR	Federal Register
$E_{\text{aud}}(f)$	Exposure function
ESA	Endangered Species Act
h	hour
H	water depth
HF	High-frequency
Hz	Hertz
IAGC	International Association of Geophysical Contractors
in	Inch
in^3	Cubic inches
ISO	International Organization for Standardization
K	Exposure function gain (dB)
kHz	Kilohertz
km	kilometers
LF	Low-frequency
$L_{0\text{-pk}}$	Peak sound pressure level
$L_{0\text{-pk,flat}}$	Peak sound pressure level (unweighted)
$L_{E,\,24}$	Sound exposure level, cumulative 24h
log	logarithm
L_{rms}	Root Mean Square sound pressure level
MF	Mid-frequency
m	meter
MMPA	Marine Mammal Protection Act
msec	milliseconds
NA	Non-applicable
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OCW	Other Marine Carnivores in Water
OTO	One-third octave levels
OW	Otariids in water
Pa	Pascals
PCW	Phocid Carnivores in Water
PK	Peak sound pressure level
PL	Propagation loss
PSD	Power spectral density levels
PTS	Permanent Threshold Shift
PW	Phocids in water
R	Range from source
RMS	Root Mean Square sound pressure level
SEL	Sound exposure level
SEL_{cum}	Cumulative sound exposure level
SEL_{ss}	Single ping/pulse/strike/shot sound exposure level
SL	Source Level
SPL	Sound Pressure Level
TL	Transmission loss
TTS	Temporary Threshold Shift
VHF	Very high-frequency
VLF	Very low-frequency
$W_{\text{aud}}(f)$	Auditory weighting function
WFA	Weighting factor adjustments

MANUAL FOR OPTIONAL USER SPREADSHEET TOOL (VERSION 2.0)

I. INTRODUCTION

NOAA's National Marine Fisheries Service (NMFS) recognizes that the permanent threshold shift (PTS) onset thresholds and marine mammal auditory weighting functions provided in the Technical Guidance (NMFS 2018; summarized in Appendix A of this Manual) are more complex than NMFS' previous thresholds and that different action proponents may have different levels of modeling capabilities. Thus, NMFS has provided a companion optional User Spreadsheet tool[1] for those action proponents unable to implement the Technical Guidance's thresholds in the weighted cumulative sound exposure level (SEL_{cum}) and peak sound pressure (PK) level metrics via other means.

There is no obligation to use the optional User Spreadsheet tool, and the use of more sophisticated exposure modeling or consideration of additional activity-, source-, or location-specific factors, if possible, is encouraged. Appendix D of the Technical Guidance (NMFS 2018) provides more information on the methodologies, associated with the optional User Spreadsheet tool.

> **NOTE**: The optional User Spreadsheet tool provides a means to estimate distances (isopleths) associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

1.1 COMPARISON TO SOUTHALL ET AL. 2019

The PTS onset thresholds and marine mammal auditory weighting functions provided in the Technical Guidance (NMFS 2018) directly adopts the methodology the Navy, via Dr. James Finneran, proposed for their Phase III Environmental Impact Analysis for testing and training activities (Finneran 2016).

Furthermore, Southall et al. 2019 adopted the Dr. Finneran's methodology, via a parallel process. Thus, the thresholds and weighting functions between NMFS 2018, Finneran 2016, and Southall et al. 2019 are nearly identical. However, Southall et al. (2019) adopts an updated and slightly modified approach for segregating marine mammals into hearing groups, as well as naming these hearing groups (i.e., essentially species formerly classified as MF cetaceans in Southall et al. 2007 are now classified as HF cetaceans in Southall et al. 2019, and species formerly classified as HF cetaceans in Southall et al. 2007 are now classified as Very High-Frequency (VHF) cetaceans in Southall et al. 2019; Table 1).

NMFS will continue to rely upon the marine mammal hearing group categorizations provided in the 2018 Revised Technical Guidance (NMFS 2018), until a subsequent revision to this document is necessary. At this time, NOAA recommends when action proponents refer to a marine mammal hearing group that they specify what publication that hearing group is based upon (i.e., Southall et al. 2019 or NMFS 2018).

[1] There is also an optional Web Calculator tool that is a web-based version of NMFS' optional User Spreadsheet tool. Action proponents are free to use either of these optional tools. The web-based version was designed to be more intuitive and user-friendly.

Table 1: Comparison of marine mammal hearing group categorization between Southall et al. 2019 and NMFS 2018.

Family/Genera/Species Included	Southall et al. 2019 Hearing Group	NOAA 2018 Hearing Group	NOAA 2018 Weighting Function
Balaena mysticetus; *Balaenoptera musculus; Balaenoptera physalus; Eubalaenidae* spp.	LF+ cetaceans	**LF Cetacean**	**LF Cetacean**
All other baleen whales	LF Cetaceans	**LF Cetacean**	**LF Cetacean**
Physeter macrocephalis; *Orcinus orca*; Ziphiidae	HF^ Cetaceans	**MF Cetaceans**	**MF Cetaceans**
Other members of Delphinidae; Monodontidae; Plantanistidae*	HF Cetaceans	**MF Cetaceans**	**MF Cetaceans**
Phocoenidae; Iniidae; Kogiidae, Lipotidae; Pontoporiidae; *Cephalorhynchus* spp.; *Lagenorhynchus cruciger*; *Lagenorhynchus australis*	Very High-Frequency (VHF) Cetaceans	**HF Cetaceans**	**HF Cetaceans**
Phocidae	Phocid Carnivores in Water (PCW)	**PW Pinnipeds**	**PW Pinniped**
Otariidae‡	Other Marine Carnivores in Water (OCW)	**OW Pinnipeds**	**OW Pinnipeds**

+ Southall et al. (2019) indicate as more data become available, these species may necessitate their own hearing group (i.e., Very Low-Frequency cetaceans).

^ Southall et al. (2019) indicate as more data become available, these species may necessitate their own hearing group (i.e., Mid-Frequency cetaceans).

* Formerly, NMFS classified all river dolphins were classified as HF cetaceans (based on NMFS 2018 hearing groups) but will now recognize members of the Plantanistidae family as MF cetacean (based on NMFS 2018 hearing groups).

‡ Southall et al. (2019) includes Odobenidae, Ursidae, and Mustelidae within the OCW hearing group. However, these additional families do not include any species under NMFS' jurisdiction. Southall et al. (2019) also includes an additional hearing group, Sirenians, which is not included by NMFS, since none of the species contained within this group fall under NMFS's jurisdiction.

II. ACCOUNTING FOR CUMULATIVE SOUND EXPOSURE

Thresholds expressed in the weighted SEL_{cum} metric account for the level and duration of exposure, both of which are factors that contribute to the potential for a sound source to induce hearing loss. However, despite the advantages associated with the use of this metric, it is recognized that accounting for duration of exposure is complicated when there are moving animals (receivers), as well as potentially moving sources (i.e., difficult to account for dynamic exposure scenarios that change over space and time). Thus, optional User Spreadsheet tool relies on two simple methods, one for mobile sources and the other for stationary sources, to account for this weighted cumulative metric. For mobile sources, the optional User Spreadsheet tool relies upon the concept of "safe distance" from Sivle et al. 2014, while for stationary sources, it relies on deriving a simple maximum 24-h accumulation isopleth.

2.1 MOBILE SOURCES

"Safe distance" is defined as "the distance from the source beyond which a threshold for that metric (SPL_0 or SEL_0) is not exceeded" (Sivle et al. 2014[2]). This method allows one to model a simple moving source and accounts for four main factors:

[2] The threshold considered by Sivle et al. 2014 was associated with behavioral responses.

1) Unweighted source level (action proponent provided)
2) "Pulse"[3] duration and repetition rate (action proponent provided)
3) Transit speed or velocity (action proponent provided)
4) Exposure threshold (NMFS provided from Technical Guidance)

There are several assumptions with this method, including simple source movement (constant velocity, constant direction); a stationary receiver (no avoidance or attraction to the source) with no vertical or horizontal movement; distance between "pulses" for intermittent sources is consistent, and propagation loss is simple (spherical spreading).

2.2 STATIONARY SOURCES

The derivation of isopleths for stationary sources in the optional User Spreadsheet tool is by simply accumulating the total duration sound exposure within a 24-hour (h) accumulation period (or less than 24-h, if the period over which the activity occurs is less than 24 hours). This method assumes the receiver (animal) remains stationary during the duration of the activity and is neither attracted nor avoids the source. Recovery between intermittent sounds, regardless of time between sounds, (i.e., all sound within the accumulation period are counted), is not considered. It is possible to specify propagation loss using this methodology.

2.2.1 Assumptions

NMFS understands the optional User Spreadsheet tool's assumptions for stationary sources are simple. Several important factors determine the likelihood and duration a receiver is expected to be in close proximity to a sound source (i.e., overlap in space and time between the source and receiver). For stationary sources, accumulation time is driven primarily by the characteristics of the receiver (i.e., swim speed and whether transient or resident to the area where the activity is occurring). NMFS recommends a maximum baseline accumulation period of 24-h[4], but acknowledges that there may be specific exposure situations where this accumulation period requires adjustment (e.g., if activity lasts less than 24 h or for situations where receivers are predicted to experience shorter or unusually long exposure durations).

> **NOTE**: The optional User Spreadsheet tool is flexible and allows the action proponent to specify the duration of sound production within a 24-h period, if appropriate. Thus, if there is enough information to determine that within the duration of sound production in a 24-h period that a receiver (animal) will only be exposed for a portion of that 24-h period, then the actual exposure duration may be used instead. If exposure duration is substituted for sound production duration, then NMFS recommends the action proponent provide information and assumptions used to support this substitution. If the substituted exposure duration varies by species and/or hearing group, it is important to remember to keep track and note which isopleths are appropriate for which hearing groups/species, since the optional User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, optional User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

2.3 RECEIVER CONSIDERATIONS

Ultimately, these methods to account for cumulative sound exposure are attempting to predict what an exposure an individual animal is likely to receive within a 24-h period. However, capturing the true exposure history of individuals is challenging. For example, the likely cumulative exposure for a resident individual (e.g., pinniped near a haul-out sight) from a passing mobile source is very different from a

[3] The term "pulse" in the context of the "safe distance" methodology, including the optional User Spreadsheet tool, is a generic term used to determine isopleths for intermittent sources, and does not imply that these sources are necessarily impulsive.

[4] During review of the Technical Guidance under Presidential Executive Order 13795, Implementing an America-First Offshore Energy Strategy (82 FR 20815; April 28, 2017), public commenters and Federal agencies recommended NMFS convene a working group to investigate means for deriving more realistic accumulation periods, especially for stationary sources. NMFS has convened a working group and is hoping to provide more guidance on this issue in the near future.

transient individual (e.g., migrating cetacean) exposed to that same mobile source. Similarly, a transient individual swimming past a stationary source would receive a different cumulative exposure compared to a resident individual inhabiting an area near that same stationary source. Thus, the optional User Spreadsheet tool's simple methods attempt to capture cumulative sound exposure by focusing on the more predictable characteristics of the sound sources. More sophisticated methods (e.g., Effects of Sound in the Marine Environment workbench (Mountain et al. 2011); Acoustic Integration Model (Frankel et al. 2002), where individual animals are modeled as simulated "animats" capable of accounting for changing sound exposure over space and time via incorporation species-specific swim speeds and dive profiles, are capable of predicting more realistic[5] exposure levels.

Understanding recovery after sound exposure is also an important consideration. Currently, there is a lack of recovery data for marine mammals, especially for exposure to durations and levels expected under real-world scenarios. Thus, additional marine mammal noise-induced recovery data would be useful. A better understanding of likely exposure scenarios, including the potential for recovery, including how long after noise exposure recovery is likely to occur, could also improve the recommended baseline accumulation period.

2.3.1 How the Cumulative Metric Differs from "Traditional" RMS Sound Pressure Level Metric

With NMFS' "traditional" thresholds in the RMS sound pressure level (L_{rms}) metric (e.g., 120/160 dB behavioral harassment thresholds), once a receiver enters the predicted isopleth associate with a particular threshold, it exceeds the threshold and has the potential for PTS onset, in the case of NMFS' former 180 dB and 190 dB L_{rms} thresholds. Thus, duration of exposure was not a consideration (i.e., once a receiver entered the predicted isopleth, it exceeded the threshold no matter whether it stayed there for one second or for 24 hours).

However, with the SEL_{cum} metric, since time (duration of exposure) is inherently included, it makes the situation more complicated. The potential a receiver has for acquiring PTS onset also depends on how long it is exposed and at what level.

III. ACCOUNTING FOR MARINE MAMMAL AUDITORY WEIGHTING FUNCTIONS

Within the optional User Spreadsheet tool, action proponents have two options to incorporate the Technical Guidance's marine mammal auditory weighting functions: 1) Weighting Factor Adjustments or 2) Spectrum to override the Weighting Factor Adjustment outputs.

The Weighting Factor Adjustment (WFA) only accounts for marine mammal auditory weighting functions via a single frequency, while relying upon source's spectrum to override the WFA, means that multiple frequencies are considered in the application of marine mammal auditory weighting functions. The choice as to whether a single frequency or multiple frequencies are most appropriate for a sound source, depends primarily on the source's bandwidth[6]:

- Narrowband: a source that produces sounds over a more narrow frequency range, typically with a spectrum having a localized a peak in amplitude.
    - Typical sources include: sonar and sonar-like sources
    - Accounting for weighting in terms of a single frequency is most appropriate

- Broadband: a source that produces sound over a broad range of frequencies
    - Typical sources include: seismic airguns, drilling platforms/drill ships, impact, DTH and vibratory pile driving hammers.

[5] However, species-specific swim speeds and dive profiles typically incorporated in "animat" models rely on data from animals under "normal" or non-noise exposed conditions. Thus, how representative these characteristics are of individuals under noise-exposed conditions needs to be considered.

[6] Bandwidth (Hz or kHz) is the range of frequencies over which a sound occurs or upper and lower limits of frequency band (ANSI 2005).

- Accounting for weighing in terms of the source spectrum or surrogate spectrum is most appropriate. However, if this is not possible, then a single frequency can be used (See Section 3.1.1.)

NOTE: If the broadband source is a frequency modulated (FM), for example a chirper, and sweeps through a series of frequencies, one at a time, rather than all the frequencies occurring at the same time, which is typical of most other broadband sources (e.g., seismic airguns, impact pile driving hammers, DTH pile driving/installation, and vibratory pile driving hammers), these FM sources should be treated differently in terms of weighting (See Section 3.2.2).

If the action proponent has no information on how to incorporate weighting for their source (either as a single frequency or multiple frequencies), it is suggested they consider it unweighted (See Section 3.2).

3.1 WEIGHTING FACTOR ADJUSTMENTS (SINGLE FREQUENCY)

Weighting factor adjustments (WFAs) are another simple tool within the optional User Spreadsheet tool to help action proponents unable to incorporate the Technical Guidance's full (i.e., over the entire frequency band associated with the sound source) marine mammal auditory weighting functions. WFAs allow action proponents to rely on the same PTS onset thresholds but accounts for auditory weighting functions by the incorporation of a single frequency.

Within the optional User Spreadsheet tool, WFAs automatically make appropriate adjustments for each marine mammal hearing group based on the frequency chosen. For narrowband sounds, the choice of an appropriate WFA frequency is simple and based on the specified frequency. For broadband sounds, the choice of an appropriate WFA frequency is based on the 95% frequency contour of the particular sound source, which is defined as upper frequency below which 95% of total cumulative energy is contained.

NOTE: If the broadband source is a frequency modulated (FM), for example a chirper, and sweeps through a series of frequencies, one at a time, rather than all the frequencies are occurring at the same time, which is typical of most other broadband sources (e.g., seismic airguns, impact pile driving hammers, and vibratory pile driving hammers), these FM sources should be treated differently in terms of weighting (See Section 3.2.2).

The results from the optional User Spreadsheet tool will be nearly identical for narrowband sources and more conservative for broadband sources compared to action proponents who can fully implement the Technical Guidance's auditory weighting functions.

Figure 1 illustrates the concept of WFAs, with using a 1 kHz example (which could be from a 1 kHz narrowband source or a broadband source with a 95% frequency contour at 1 kHz) for all five marine mammal hearing groups. In this Figure the weighting function amplitude (-dB) by hearing group is:

- LF cetaceans: -0.06 dB
- MF cetaceans: -29.11 dB
- HF cetaceans: -37.55 dB
- PW pinnipeds: -5.90 dB
- OW pinnipeds: -4.87 dB

NOTE: The action proponent enters 1 kHz as the WFA in the optional User Spreadsheet tool (Step 2 in optional User Spreadsheet tool). The weighting function amplitude (-dB) by marine mammal hearing group are then automatically produced by the tool (i.e., the action proponent does not enter the weighting function amplitude (-dB) directly).

As this example illustrates, WFAs always result in zero or a negative dB amplitude. Additionally, the more a sound's frequency is outside a hearing group's most susceptible range (most susceptible range is where the auditory weighting function amplitude equal zero), the more negative WFA that results (i.e., in example above 1 kHz is outside the most susceptible range for MF and HF cetaceans but in the most

susceptible range for LF cetaceans; Figure 1, top). Further, the more negative WFA that results will lead to a smaller effect distance (isopleth) compared to a less negative or zero WFA. In other words, considering an identical SEL_{cum} acoustic threshold, a more negative WFA (i.e., source outside most susceptible frequency range) will result in a smaller effect distance (isopleth) compared to one that is less negative or closer to zero (i.e., source inside most susceptible frequency range; Figure 2). In more simplistic terms, the more negative the weighting function amplitude, the louder a sound has to be for an animal to experience noise-induced hearing loss.

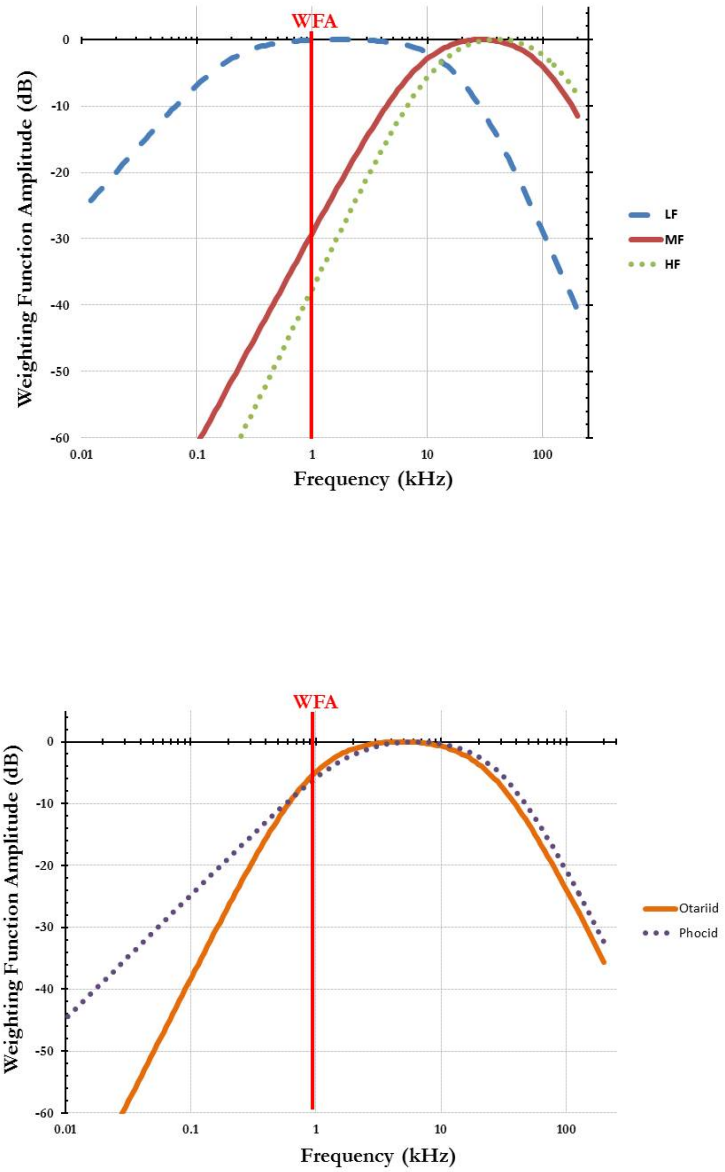


Figure 1: Example illustrating concept of weighting factor adjustment at 1 kHz (red line) with cetacean (top) and pinniped (bottom) auditory weighting functions.

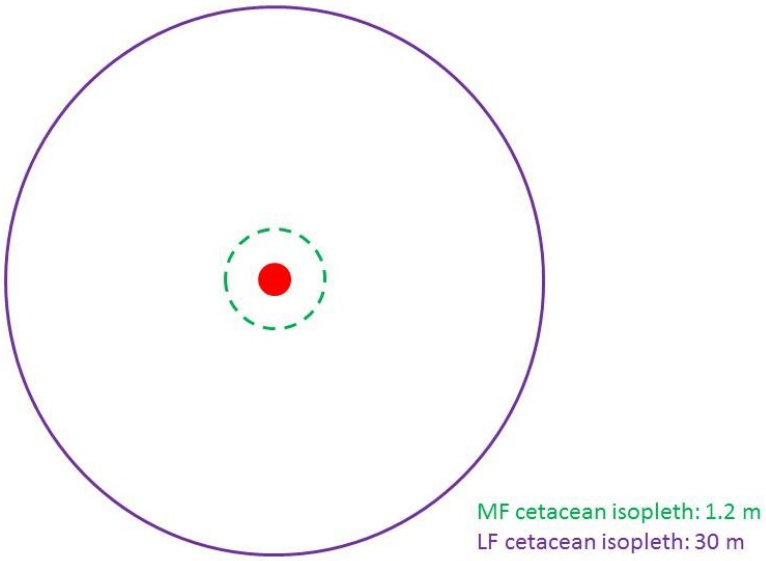


Figure 2: **Simple example illustrating concept of weighting factor adjustment on isopleths for LF and MF cetaceans using hypothetical 1 kHz narrowband, intermittent source represented by the red dot (unweighted source level of 200 dB L_{rms}; 1-second ping every 2 minutes for 24 h). For a non-impulsive source, the PTS onset SEL_{cum} threshold for LF cetaceans is 199 dB, while for MF cetaceans is 198 dB. Despite LF cetaceans having a higher PTS onset threshold than MF cetaceans, the isopleth associated with LF cetaceans (30 m solid purple circle) is larger than that for MF cetaceans (1.2 m dashed green circle) based on 1 kHz being within LF cetacean's most susceptible frequency range vs. outside the most susceptible frequency range for MF cetaceans (isopleths not to scale).**

In this specific 1 kHz WFA example, there is a larger adjustment for MF and HF cetaceans compared to LF cetaceans. This because for LF cetaceans, 1 kHz is in this hearing group's most susceptible frequency range, while it is outside the most susceptible frequency range for the other two cetacean hearing groups (i.e., MF and HF cetaceans).

The optional User Spreadsheet tool's sage cell in Step 2, on each sound source tab, is where an action proponent, based on the specific sound source, can provide a WFA or a default can be used.

Corresponding rose cells at the bottom of each tab labeled "Weighting Function Calculations" provide the adjustment (-dB) associated with the particular WFA provided by marine mammal hearing group (Figure 3). These outputs are calculated automatically within the optional User Spreadsheet tool, unless an action proponent chooses to override these outputs (See Section 3.2).

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (-dB)†	-0.06	-29.11	-37.55	-5.90	-4.87

Figure 3: Screenshot of weighting function amplitude (-dB) associated with 1 kHz WFA by hearing group in white cells (last row of in each tab of optional User Spreadsheet tool under "Weighting Function Calculations").

3.1.1 Choice of Weighting Factor Adjustments for Broadband Sources

There are a couple of options for an action proponents determining the appropriate WFA for their broadband sound source: 1) NMFS default WFA or 2) Source-specific WFA. If neither a default nor source-specific WFA can be provided, it is recommended that the source be considered unweighted (See Section 3.2).

NMFS Default WFAs

Action proponents may rely upon a NMFS suggested default for their broadband source, which NMFS acknowledges are likely conservative (Table 2).

Table 2: NMFS suggested default weighting factor adjustments (WFAs) for broadband sources.

Source	WFA	Example Supporting Sources
Seismic airguns	1 kHz	Breitzke et al. 2008; Tashmukhambetov et al. 2008; Tolstoy et al. 2009
Impact pile driving hammers	2 kHz	Blackwell 2005; Reinhall and Dahl 2011
Vibratory pile driving hammers	2.5 kHz	Blackwell 2005; Dahl et al. 2015a
DTH pile driving/installation	2 kHz	Denes et al. 2016; Denes et al. 2019; Reyff and Heyvaert 2019
Drilling vessels/platforms	2 kHz	Greene 1987; Blackwell et al. 2004a; Blackwell and Greene 2006

Source-Specific WFAs

Action proponents may rely upon a WFA based off the 95% frequency contour from measurements of their particular source. However, if the action proponent has data on the spectrum associated with their source, they are encouraged to incorporate the full auditory weighting functions, rather than relying upon a simple WFA that only accounts for weighting at one frequency (See Section 3.2).

If an action proponent decides to rely upon a source-specific WFA for their broadband source and if the WFA is above 5 kHz for LF cetaceans, above 9 kHz for otariid pinnipeds, or above 11 kHz for phocid pinnipeds, then source should be treated as unweighted (0 dB adjustment; See Section 3.2) (Table 3).

> **NOTE**: An action proponent does not need to be concerned about the applicability of a frequency chosen for a narrowband source (i.e., Table 3 does not apply to narrowband sources; All frequencies are applicable).

Table 3: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

FICTITIOUS EXAMPLES: A) If a broadband source had a source-specific WFA of 12 kHz, then the action proponent would enter 12 kHz for the WFA to use for MF and HF cetaceans but then override the WFA outputs for LF cetaceans, Phocid pinnipeds, and Otariid pinnipeds (e.g., (Adjustment (-dB)) for LF cetaceans, Otariid pinnipeds, and Phocid pinnipeds) by changing the WFA output (Adjustment (-dB)) to 0 dB to make the source unweighted.

B) If the source-specific WFA was 7 kHz, only LF cetaceans would have to be considered unweighted (i.e., otariid and phocid pinnipeds would not have to be considered unweighted).

3.2 SPECTRUM (MULTIPLE FREQUENCIES) TO OVERRIDE WEIGHTING FACTOR ADJUSTMENT

An action proponent need not rely upon WFAs and may override[7] the WFAs adjustment (Figure 4) if: 1) The action proponent has no information on an appropriate WFA value for their source and no default value is available (i.e., Adjustment (-dB) is set to zero, so source is unweighted), 2) The action proponent has specific information on the spectrum associated with their source, or 3) The action proponent chooses to rely on a default spectrum provided by NMFS (see Section 5.2.1.2 for more information on option 3).

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (-dB)†	-0.06	-29.11	-37.55	-5.90	-4.87

Figure 4: Example illustrating weighting factor adjustment override. Adjustment (-dB), white cells, may be directly modified (overridden) if an action proponent has data/measurements that provide a more realistic application of the auditory weighting function. An override can occur when a sound source spectrum is available or if the action proponent needs to make the value unweighted (i.e., adjustment would be set to 0).

NOTE: If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

[7] Note: The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet tool. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

By including a source's entire spectrum, this will allow an action proponent to incorporate the Technical Guidance's marine mammal auditory weighting functions over the entire broadband frequency range of the source, rather than just for one frequency via the WFA. As a result, overriding the optional User Spreadsheet tool's WFA with a sound sources' spectrum will result in more realistic (i.e., likely smaller) isopleths (i.e., NMFS' preference is that spectrum data be use for broadband sources, when possible, compared to the simple WFA). However, the action proponent must provide clear evidence to NMFS of how the spectrum data were derived and used. NMFS is currently evaluating whether surrogate spectrum are available and applicable for particular sound sources, if an action proponent does not have data of their own to use.

Spectral levels, depending on the sound source, are typically depicted as power spectral density (PSD) (1 Hz bands) or one-third octaves (OTO) (base 10) (Figure 5[8]). NMFS recommends that action proponents provide spectra as a power spectral density, which provides the most detail about the source in terms of frequency (e.g., by 1 Hz bands). However, we recognize that this may not be appropriate or feasible for all sound sources. In those situations, NMFS recommends that action proponents relying upon OTO data apply the auditory weighting functions via the center frequency of each applicable OTO for each hearing group (Table 4; ANSI 2009).

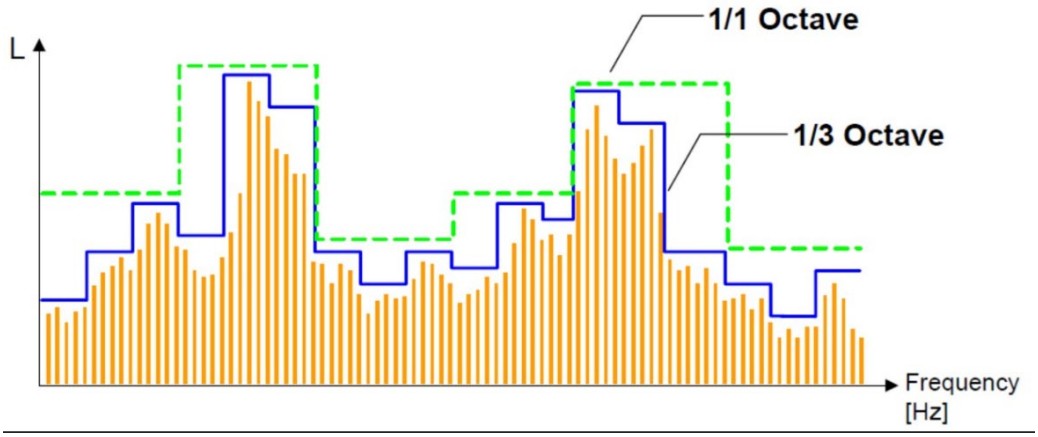


Figure 5: **Illustration comparing spectral levels presented as octaves (dashed line), one-third octave (solid line), and power spectral density (vertical bars) for a generic sound source.**

Table 4: **Auditory weighting functions based on one-third octave (OTO) bands (ANSI 2009).***

Center (Hz)	LF Cetaceans	MF Cetaceans	HF Cetaceans	Phocids Underwater	Otariids Underwater
8	**-27.84**	-96.12	-112.98	-46.76	-82.16
10	**-25.90**	-93.02	-109.49	-44.83	-78.29
12.5	**-23.97**	-89.92	-106.00	-42.89	-74.41
16	**-21.84**	-86.49	-102.14	-40.74	-70.12
20	**-19.91**	-83.39	-98.65	-38.80	-66.25
25	**-18.00**	-80.29	-95.16	-36.87	-62.37
31.5	**-16.03**	-77.08	-91.55	-34.86	-58.36
40	**-14.02**	-73.76	-87.82	-32.79	-54.22

[8] For general information on spectral analysis and relationship between PSD and OTO levels, see Richardson et al. 1995.

Center (Hz)	LF Cetaceans	MF Cetaceans	HF Cetaceans	Phocids Underwater	Otariids Underwater
50	**-12.17**	-70.66	-84.33	**-30.85**	-50.35
63	**-10.31**	-67.44	-80.71	**-28.84**	**-46.35**
80	**-8.47**	-64.13	-76.98	**-26.77**	**-42.22**
100	**-6.86**	-61.02	-73.49	**-24.84**	**-38.38**
125	**-5.38**	-57.92	-70.00	**-22.91**	**-34.56**
160	**-3.96**	**-54.49**	-66.14	**-20.77**	**-30.37**
200	**-2.88**	**-51.39**	-62.66	**-18.85**	**-26.63**
250	**-2.02**	**-48.30**	**-59.17**	**-16.94**	**-22.96**
315	**-1.34**	**-45.09**	**-55.56**	**-14.98**	**-19.28**
400	**-0.84**	**-41.77**	**-51.83**	**-12.97**	**-15.65**
500	**-0.52**	**-38.68**	**-48.34**	**-11.14**	**-12.49**
630	**-0.30**	**-35.48**	**-44.74**	**-9.30**	**-9.54**
800	**-0.15**	**-32.18**	**-41.01**	**-7.48**	**-6.90**
1000	**-0.06**	**-29.11**	**-37.55**	**-5.90**	**-4.87**
1250	**-0.02**	**-26.06**	**-34.09**	**-4.46**	**-3.27**
1600	**0.00**	**-22.72**	**-30.28**	**-3.10**	**-1.97**
2000	**-0.01**	**-19.74**	**-26.87**	**-2.08**	**-1.15**
2500	**-0.05**	**-16.83**	**-23.50**	**-1.29**	**-0.60**
3150	**-0.12**	**-13.92**	**-20.08**	**-0.69**	**-0.24**
4000	**-0.26**	**-11.07**	**-16.65**	**-0.29**	**-0.05**
5000	**-0.46**	**-8.62**	**-13.59**	**-0.07**	**0.00**
6300	**-0.78**	**-6.35**	**-10.63**	**0.00**	**-0.09**
8000	**-1.29**	**-4.36**	**-7.88**	**-0.09**	**-0.33**
10000	**-2.00**	**-2.86**	**-5.66**	**-0.32**	**-0.73**
12500	**-2.99**	**-1.71**	**-3.81**	**-0.74**	**-1.35**
16000	**-4.53**	**-0.82**	**-2.24**	**-1.49**	**-2.37**
20000	**-6.35**	**-0.31**	**-1.22**	**-2.48**	**-3.68**

* Bold text indicates OTO bands within generalized hearing range of each marine mammal group.

3.2.1 Example Default Spectra for Seismic Surveys

As an example illustrating the use of a source spectrum (OTO), Figure 118 in Appendix D of the Final Environmental Impact Statement for Gulf of Mexico OCS Proposed Geological and Geophysical Activities (BOEM 2017) provides a generic spectrum for an 8000 in^3 airgun array from 10 Hz to 5 kHz (Figure 6).

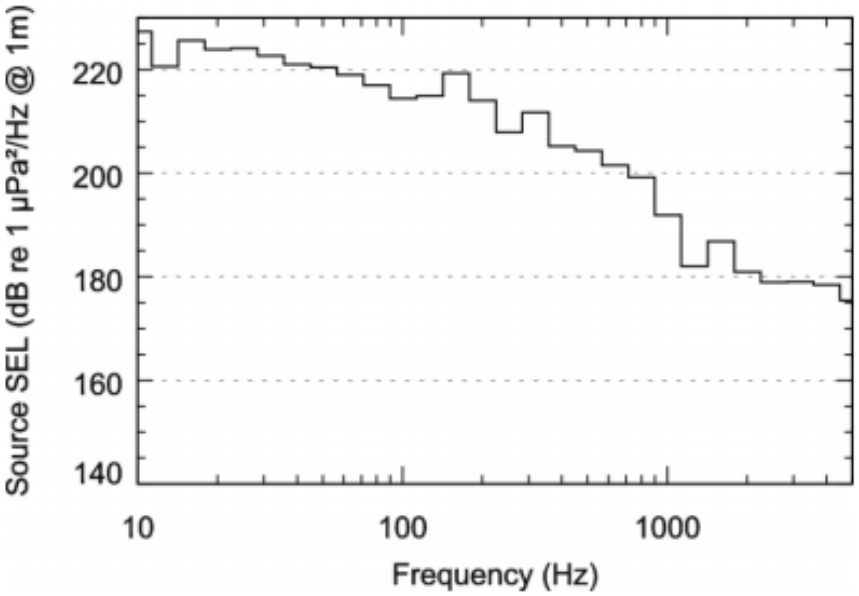


Figure 6: Maximum one-third octave band unweighted source level in the horizontal plane for a generic 8000 in^3 seismic array (BOEM 2017).

With the BOEM source spectrum, the action proponent can compare the unweighted source level to the weighted source level by hearing group. The weighting adjustment (-dB) is the difference between the weighted and unweighted source level (e.g., if LF cetacean weighted source level was 227.3 dB and the unweighted source level was 240 dB, then the weighting adjustment would be -12.7 dB). This adjustment can directly be used to override the WFA in the optional User Spreadsheet tool (i.e., white cells labeled Adjustment (-dB)). If an action proponent needs further guidance on how to do this, NMFS has an additional spreadsheet to help with this computation.

Recently[9], the International Association of Geophysical Contractors (IAGC) compiled data from multiple geophysical surveys to produce a default spectrum (1.25 Hz to 20 kHz) for seismic surveys to estimate isopleths for sources pressurized to levels between 1800-2200 psi (nominal 138 bar[10]) (Gisiner et al. 2020).

Table 5 provides a comparison of the -dB adjustment between using the BOEM 2017 spectrum (10 Hz to 5 kHz), the IAGC and the default WFA. As NMFS has stated previously, the more factors an action proponent can incorporate in their modeling, the more realistic results expected.

[9] IAGC submitted recommendations for a default spectrum as a Revised User Spreadsheet and Supplemental User Guide in association with NMFS's 2018 public comment period on our optional User Spreadsheet tool (Version 2.0). IAGC submitted their final recommendations in late 2020. NMFS has provided IAGC's recommendations, in which NMFS agrees, via modifications to our optional User Spreadsheet tool (Version 2.2)) and User Manual.

[10] IAGC indicated that it is very rare to encounter system pressure levels outside this range within the operational geophysical exploration industry and that 138 bar corresponds to a source level of about 263 dB re 1 µPa.

Table 5: Seismic weighting using a broadband spectrum vs. default, single frequency WFA.

Weighting Adjustment (-dB)	LF cetacean	MF cetacean	HF cetacean	PW pinniped	OW pinniped
Default WFA for seismic array (1 kHz)	-0.06 dB	-29.11 dB	-37.55 dB	-5.90 dB	-4.87 dB
Seismic array spectrum (BOEM 2017)*	-12.7 dB	-57.4 dB	-65.7 dB	-28.7 dB	-33.6 dB
Seismic array spectrum (Gisiner et al. 2020)	-14.0 dB	-47.9 dB	-51.1 dB	-30.9 dB	-36.5 dB

* BOEM 2017 spectrum was digitized using WebPlotDigitizer. In this example, the adjustments from the seismic arrays spectrum could be used to override the optional User Spreadsheet tool's default WFA for seismic.

3.2.2 Spectral Considerations for Broadband Sources

NMFS understands and acknowledges that the frequency spectra of a source changes dramatically over propagation conditions. NMFS recommends one consider the spectrum in terms of what is most representative for the impacts expected, which is expected to be at shorter ranges associated with the Technical Guidance's PTS onset thresholds.

3.2.3 Special Consideration: Frequency Modulated Broadband Sources (e.g. chirpers)

Frequency modulated (FM) sources that sweep through a range of frequencies, one or few at a time, have the same spectral content of a broadband sound where all the frequencies are occurring simultaneously. However, for the purposes of the optional User Spreadsheet tool, evaluating FM sources the same as other broadband sources is not appropriate (e.g., not appropriate to choose a WFA or directly use the spectrum for purposes of incorporating the Technical Guidance's auditory weighting functions).

Instead, NMFS recommends action proponents treat FM sources as narrowband for the purposes of incorporating the Technical Guidance's auditory weighting functions. This means an action proponent will need to evaluate multiple frequencies to determine the most appropriate isopleth by marine mammal hearing group (i.e., NMFS recommends the action proponent evaluate the isopleths produced using the lowest and highest frequencies produced and relying upon which frequency produces the largest isopleth for each hearing group).

Additionally, if the FM source produces sound in or around a hearing group's most susceptible frequency range (Table 6), then the action proponent should treat the source as unweighted for that hearing group and use the unweighted isopleth produced by the optional User Spreadsheet tool (See Section 3.2).

Table 6: Marine mammal hearing group's most susceptible frequency range*.

Marine Mammal Hearing Group	Most Susceptible Frequency Range
Low-frequency (LF) cetaceans	0.5 to 5 kHz
Mid-frequency (MF) cetaceans	18 to 47 kHz
High-frequency (HF) cetaceans	25 to 62 kHz
Phocid (PW) pinnipeds	3.5 to 11 kHz
Otariid (OW) pinnipeds	2.5 to 9 kHz

*Most susceptible hearing range based on range where auditory weighting function amplitude was ~0.5 dB or less.

IV. PEAK SOUND PRESSURE LEVEL THRESHOLDS

The PK metric (for impulsive sources) is included in the optional User Spreadsheet tool. When evaluating impulsive sources that have dual metric thresholds (i.e., SEL_{cum} and PK), an action proponent relies upon whichever metric yields the largest isopleth for a particular marine mammal hearing group. The PK

thresholds are unweighted/flat-weighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz).

> **NOTE**: If an action proponent get output "NA" instead of a numerical isopleth associated with the PTS PK isopleth, this means the PK source level is less than or equal to the threshold for the particular marine mammal hearing group.
>
> For impact pile driving and DTH pile driving/installation, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead, for these sources, sound levels (L_{rms}, Single Strike SEL, or PK) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

V. USER SPREADSHEET TOOL TABS

The optional User Spreadsheet tool consists of nine color-coded worksheets or tabs (i.e., one informational tabs and eight sound source tabs). Sound source tabs categorize each source as either: 1) Impulsive or Non-impulsive[11], 2) Mobile or Stationary, and 3) Intermittent or Continuous[12].

> **NOTE**: NMFS created tabs to cover all current and future sound sources. However, this does not mean **all** sources have equal potential to cause noise-induced hearing loss or exceed the Technical Guidance's PTS onset thresholds. For example, some tabs are likely used more often compared to others (e.g., Tab A.1, Tab E.1, and Tab F), while other tabs are available if needed for future use.

NMFS recommends an action proponent start with the Introduction tab, which provides general instructions, guidance on which tab is applicable to a particular source, and assumptions in using this optional tool.

The ten tabs are as follows:

1. Introduction (White): This tab provides instructions and an introduction to the optional User Spreadsheet tool, including information to help an action proponent determine what source tab to use. It also contains assumptions and information on updates.

2. Tab A, Non-impulsive, Stationary, Continuous Sources (Red): Tab A is appropriate for sources such as drilling vessels/platforms or dynamic thrusters.

3. Tab A.1 Vibratory Pile Driving (Brick Red): This sub-tab is a custom tab specifically for vibratory pile driving and is performing essentially the same calculations as tab A, except that the inputs are described in a manner that is more user-friendly and specific for vibratory pile driving activities.

4. Tab B, Non-impulsive, Stationary, Intermittent (Yellow): Tab B is appropriate for sources such as stationary sonar sources.

   NOTE: The optional User Spreadsheet tool treats all sound sources as omnidirectional (i.e., this may not be appropriate for sources that are highly directional and/or have narrow beam patterns).

[11] The term "impulsive" in this document relates specifically to noise-induced hearing loss and specifies the physical characteristics of an impulsive sound source, which likely gives them a higher potential to cause noise-induced hearing loss. 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.

[12] Within the optional User Spreadsheet tool, a key distinction between continuous and intermittent sound sources is that intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle), which continuous sounds do not.

5. Tab C, Non-impulsive, Mobile, Continuous (Blue): Tab C is appropriate for sources such as vessels.

6. Tab D, Non-impulsive, Mobile, Intermittent (Orange): Tab D is appropriate is for mobile sonar or sonar-like sources.

   NOTE: The optional User Spreadsheet tool treats all sound sources as omnidirectional (i.e., this may not be appropriate for sources that are highly directional and/or have narrow beam patterns).

7. Tab E, Impulsive, Stationary (Green): Tab E is appropriate for sources such as vertical seismic profiling (VSP).

   NOTE: A previous version of the optional User Spreadsheet tool (i.e., Version 2.0) contained two additional tables for single and multiple detonations. After further evaluation, NMFS considers the use of the optional User Spreadsheet tool as overly simplistic for the consideration of underwater detonations and has removed those tabs. Please consult NMFS as to how most appropriately evaluate underwater detonations in the context of the Technical Guidance.

8. Tab E.1, Impact Pile Driving (Evergreen): This sub-tab is a custom tab specifically for impact pile driving and is performing essentially the same calculations as tab E, except that inputs are described in a manner that is more user-friendly and specific for impact pile driving activities.

9. Tab E.2, DTH Pile Driving/Installation (Teal): This sub-tab is a custom tab specifically for DTH pile driving/installation and is performing essentially the same calculation as Tab E, except the inputs are described in a manner that is more user-friendly and specific for DTH pile driving/installation activities.

10. Tab F, Impulsive, Mobile (Purple): Tab F is appropriate for sources such as mobile seismic airgun arrays.

5.1 CELLS WITHIN INDIVIDUAL TABS

Within the appropriate worksheet, the action proponent will notice numerous cells with the following corresponding colors:

- Sage cells: Represents information provided by the action proponent. There is basic information an action proponent provides such as unweighted source level (either in L_{rms}, SEL, or PK metric), duty cycle or repetition rate (if an intermittent source), transit speed (if mobile source), and appropriate WFA (which can be specific to sound source, if known or a default). For stationary sources, the action proponent is also required to specify propagation loss.

  NOTE: When given the choice in providing unweighted source levels in terms of L_{rms} or single strike/pulse/shot/ping SEL, NMFS recommends action proponents provide single strike/pulse/shot/ping SEL source levels. Single strike/pulse/shot/ping SEL already accounts for strike/pulse/shot/ping duration (i.e., action proponent is not required to provide/estimate this information).

  NOTE: If an action proponent can provide more sophisticated weighting than provided by the WFA for broadband sources, there is a means to modify the adjustment (-dB) and override the output created by auditory weighting function parameters (See Section 3.2). However, NMFS recommends the action proponent provide additional justification supporting this modification.

- Rose cells: Represents information provided by NMFS (i.e., action proponent cannot modify), such as PTS onset thresholds and auditory weighting function parameters.

- Sky Blue cells: Represents the optional User Spreadsheet tool output in terms of estimated isopleths (meters) by hearing group. These outputs are automatically calculated based on the

action proponents inputs provided within the sage cells and cannot be directly modified by the action proponent.

- White cells: Represent calculations and factors done automatically within the optional User Spreadsheet tool (i.e., action proponent cannot modify) or are informational. Even though the action proponent cannot modify these cells, it may be helpful to pay attention to their outputs as a crosscheck to ensure action proponent information is entered correctly.

Within the optional User Spreadsheet tool, all cells are locked (i.e., cannot be modified) except sage cells and the -dB adjustment associated with the auditory weighting functions that can be overridden. However, if an action proponent requires access to unlocked cells, they may contact NMFS and request an unlocked version[13] of the tab of interest.

When an action proponent relies on the optional User Spreadsheet tool for modeling, NMFS requests they include a copy (e.g., screenshot) of their completed tab illustrating their inputs and resulting output (isopleth)

5.1.1 Activity-, Source-, or Location-Specific Data

As mentioned, earlier, the consideration of additional activity-, source-, or location-specific data by action proponents, if possible, is encouraged and will result in the optional User Spreadsheet tool providing results that are more reflective of expected conditions compared to relying on surrogate or default data (Figure 7).

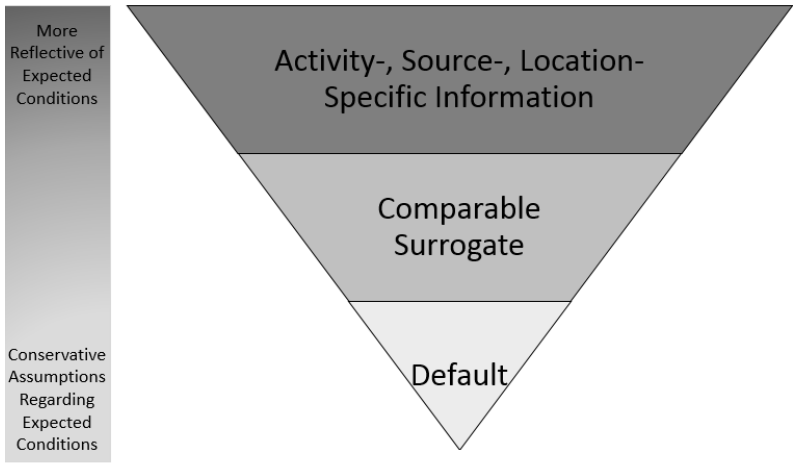


Figure 7: Illustration of data hierarchy and impacts on portraying expected conditions.

5.2.1 Default Values for Sage Cells

NMFS understands that the optional User Spreadsheet tool requires additional source parameter information that has not been previously required. For those action proponents unable to provide key pieces of information, NMFS has created appropriate defaults. NMFS acknowledges that suggested default values are likely conservative, which is the intent when activity-specific information is unavailable, in order to cover potential variability.

> **NOTE:** Defaults are meant to be conservative in order to encompass the broad potential range of values associated with an activity or sound source (e.g., for pile driving variation could result from water depth associated with the activity, sediment characteristics, pile diameter, pile material, etc.). Thus, an action proponent is always encouraged to use activity-specific information, if available, as a substitute for using NMFS' recommended default values, as this activity-specific

[13] NMFS locks certain cells within the optional User Spreadsheet tool to prevent users from accidentally modifying or deleting formulas or content within these cells.

information will provide a more realistic representation of the isopleths associated with that activity.

5.2.1.1 Weighting Factor Adjustment Suggested Defaults

For example, NMFS provides suggested default WFAs for common broadband sources (Table 7).

Table 7: NMFS suggested default WFA for common* broadband sources.

Source	Default WFA	References supporting default WFA
Seismic airguns	1 kHz	Breitzke et al. 2008; Tashmukhambetov et al. 2008; Tolstoy et al. 2009
Impact pile driving hammers	2 kHz	Blackwell 2005; Reinhall and Dahl 2011
Vibratory pile driving hammers	2.5 kHz	Blackwell 2005; Dahl et al. 2015a
DTH pile driving/installation	2 kHz	Denes et al. 2016; Denes et al. 2019; Reyff and Heyvaert 2019
Drilling vessels/platforms	2 kHz	Greene 1987; Blackwell et al. 2004a; Blackwell and Greene 2006

5.2.1.2 Source Level and Pulse Duration

If source level information is unavailable, NMFS recommends the action proponent find an appropriately similar surrogate source. If a surrogate source is used, NMFS requests the action proponent provide information on why it is an appropriate substitute.

If an action proponent only has unweighted source level information based upon the L_{rms} metric, then it may be necessary to determine the pulse duration or rely upon an appropriate default value. NMFS' recently completed an analysis to provide a default value (100 milliseconds) for both the impact pile driving hammers and seismic airgun sources provided in Appendix B (impact pile driving) and Appendix C (seismic airguns).

> **NOTE**: If the action proponent has unweighted source level information expressed in the single strike/shot SEL metric, then determining the pulse duration is not necessary. Many of the sound source tabs provide a choice between two methods (i.e., one relying on L_{rms} source levels or one relying upon single strike/shot SEL source levels). NMFS advises action proponents to rely on the method using the single strike/shot SEL source level, so needing to determine the pulse duration (or appropriate default) is unnecessary.
>
> For sources, such as vibratory pile driving hammers, DTH pile drivers, and impact pile driving hammers, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead, for these sources, sound levels (L_{rms}, Single Strike SEL, or PK) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

Cumulative sound exposure can be computed using a simple equation, assuming a constant received sound pressure level (SPL) that does not change over space and time (Equation E1.; e.g., Urick 1983; ANSI 1986; Madsen 2005):

$$SEL_{cum} = L_{rms} + 10 \log_{10} (\text{duration of exposure, expressed in seconds}) \text{ dB} \qquad \textbf{Equation 1}$$

> **USER TIP**: Sources producing pulses/pings/strikes less than a second in duration have a larger L_{rms} value compared to SEL value, while sources producing pulses/pings/strikes greater than a second have a larger SEL value compared L_{rms} value. If the pulse/ping/strike is exactly 1 second, then the L_{rms} and SEL values are equal.

For example, a source producing a 100 msec pulse has a SEL value that is 10 dB less than its L_{rms} value.

5.2.1.3 Propagation/Transmission Loss[14] Coefficient Defaults

NMFS also acknowledges that the optional User Spreadsheet tool takes a simple approach to propagation/transmission loss. Sound propagation/transmission loss through the environment can be complicated and depend on a multitude of factors, which can vary temporally and spatially (see reviews in Urick 1979, 1983; Forest 1994; Richardson et al. 1995). Many of these factors that affect sound propagation/transmission loss can be site-specific. This is particularly the case for shallow water (Richardson et al. 1995). Sound propagation/transmission loss can be measured directly or modeled. The more site-specific data available, the greater chance of accurately predicting sound propagation/transmission loss through the environment via modeling and ultimately the level at the receiver. Thus, NMFS recommends that when site-specific information on propagation/transmission loss is available, it be used. For coastal activities, such as pile driving, if area-specific information on propagation/transmission loss is not available, NMFS typically recommends practical spreading[15] (TL=15 log R2/R1) (e.g., Stadler and Woodbury 2009; Caltrans 2015).

NOTE: The distinction between "shallow" and "deep" water is typically based the ratio of acoustic wavelength to water depth. "Deep" water considered > 100 times the acoustic wavelength and where there is little to no interaction between the sound with the bottom and spherical spreading (20 Log R) is appropriate. "Shallow" water propagation loss is dominated by multiple surface and bottom reflections (Urick 1983; Richardson et al. 1995).

The optional User Spreadsheet tool's "safe distance" methodology for mobile sources assumes propagation loss (default) is spherical spreading (20 Log R).

VI. HOW TO NAVIGATE THE OPTIONAL USER SPREADSHEET TOOL'S INDIVIDUAL TABS

Each tab separates sound sources based on three main characteristics:

1. Whether a sound source is non-impulsive or impulsive
    - Non-impulsive sound: 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), certain sonars (e.g. tactical, navigational, and scientific), and vibratory pile driving hammers.

NOTE: The optional User Spreadsheet tool treats all sound sources as omnidirectional (i.e., This may not be appropriate for sources that are highly directional and/or have narrow beam patterns).

    - Impulsive sound: 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 seismic airguns, DTH pile driving hammers, and impact pile driving hammers.

[14] Note: Transmission loss is conceptually different from propagation loss (i.e., propagation loss is associated with the source level, while transmission loss is associated with a measurement at a specified distance) (ISO 2017).

[15] R1 is the range for a close range measurement, typically 10 m from the pile source, and R2 is a longer range at which an underwater sound metric such a peak pressure, or sound exposure level is estimated (Dahl et al. 2012). Additionally NMFS is aware that other TL models may be more appropriate for pile driving (e.g., Reinhall and Dahl 2011; Zampolli et al. 2013; Schecklman et al. 2015; Lippert et al. 2018) but until various factors (e.g., decay factor associated with Lippert et al. 2018) can be derived/estimated for all pile types and locations, a simplified model is recommended.

NOTE: The term "impulsive" in this document relates specifically to noise-induced hearing loss 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 sounds may be more likely to affect auditory physiology and is not meant to reflect categorizations associated with behavioral disturbance.

2. Whether a sound source is stationary or mobile

3. Whether a sound source is continuous or intermittent
    - Continuous sound: A sound whose sound pressure level remains above ambient sound during the observation period (ANSI 2005).

    - Intermittent sound: Interrupted levels of low or no sound (NIOSH 1998) or bursts of sounds separated by silent periods (Richardson and Malme 1993). Typically, intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle).

    NOTE: Within the optional User Spreadsheet tool, a key distinction between continuous and intermittent sound sources is that intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle), which continuous sounds do not.

    NMFS created tabs to cover all current and future sound sources. However, this does not mean **all** sources have equal potential to cause noise-induced hearing loss or exceed the Technical Guidance's PTS onset thresholds. For example, some tabs (e.g., Tab A.1, Tab E.1, and Tab F) are more likely used more often compared to others, which there may not be current need for use.

6.1 INTRODUCTION TAB (WHITE)

The Introduction tab provides general instructions and basic information associated with the optional User Spreadsheet tool. NMFS recommends that all action proponents start with this tab.

> **DISCLAIMER**: NMFS has provided this spreadsheet as an optional tool to provide estimated effect distances (i.e., isopleths) where PTS onset thresholds may be exceeded. Results provided by this spreadsheet tool do not represent the entirety of the comprehensive effects analysis, but rather serve as one tool to help evaluate the effects of a proposed action on marine mammal hearing and make findings required by NOAA's various statutes. Input values are the responsibility of the individual action proponent.

6.1.1 Instructions

Step 1: How to determine what tab to use:

1. Is the sound source NON-IMPULSIVE or IMPULSIVE? (If it is unclear which category describes your source, consult NMFS)?
    a) NON-IMPULSIVE (e.g., drilling equipment, vibratory pile driving hammers, tactical sonar): Go to Question 2.
    b) IMPULSIVE (e.g., impact pile driving hammers, DTH pile driving hammers, seismic airguns): Go to Question 5.

2. Is the NON-IMPULSIVE sound source STATIONARY or MOBILE?
    a) STATIONARY: Go to Question 3.
    b) MOBILE: Go to Question 4.

3. Is the NON-IMPULSIVE, STATIONARY source CONTINUOUS or INTERMITTENT?
    a) CONTINUOUS: Use Tab A*.
        *If source is vibratory pile driving: Use Tab A.1.
    b) INTERMITTENT: Use Tab B.

4. Is the NON-IMPULSIVE, MOBILE source CONTINUOUS or INTERMITTENT?
    a) CONTINUOUS: Use Tab C (methodology from Sivle et al. 2014).
    b) INTERMITTENT: Use Tab D (methodology from Sivle et al. 2014).

5. Is the IMPULSIVE sound source STATIONARY or MOBILE?
    a) STATIONARY: Use Tab E*
        *If source is impact pile driving: Use Spreadsheet E.1.
        *If source is DTH pile driving/installation: Use Spreadsheet E.2.
    b) MOBILE: Use Tab F (methodology from Sivle et al. 2014).

Step 2: Action proponent provides appropriate project-specific information in the selected tab's sage cells. NMFS requests action proponents provide information used to support values in provided in sage boxes (e.g., surrogate data, direct measurements, etc.).

Step 3: Predicted isopleths (meter) will be provided in sky blue cells by marine mammal hearing group.

Step 4: NMFS recommends that an action proponent provide a copy of the tab they used in their analysis (e.g., screenshot).

6.1.2 Assumptions and Additional Information

This section provides a list of general assumptions, which includes:

1. Marine mammals remain stationary during activity.

2. Currently, recovery between intermittent sounds is not considered regardless of time between sounds (i.e., all sounds within the accumulation period are counted).

It also provides default weighting factor adjustments (WFA) and citations to support these default values (Table 8).

Table 8: NMFS suggested default weighting factor adjustments (WFAs) for broadband sources.

Source	WFA	Example Supporting Sources
Seismic airguns+	1 kHz	Breitzke et al. 2008; Tashmukhambetov et al. 2008; Tolstoy et al. 2009
Impact pile driving hammers+	2 kHz	Blackwell 2005; Reinhall and Dahl 2011
Vibratory pile driving hammers	2.5 kHz	Blackwell 2005; Dahl et al. 2015a
DTH pile driving/installation	2 kHz	Denes et al. 2016; Denes et al. 2019; Reyff and Heyvaert 2019
Drilling vessels/platforms	2 kHz	Greene 1987; Blackwell et al. 2004a; Blackwell and Greene 2006

6.1.3 Updates

Finally, one of the most important sections, the update section, is at the bottom of this tab. It is important the action proponents ensure they are relying upon the most recent version of the optional User Spreadsheet tool to perform their isopleth calculations[16]. This section also provides information on what has changed from one version to the other and the date of posting for the most recent version.

> **NOTE**: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

The next sections walk through how to use each source tab. Most of the information is identical between tabs but is included for completeness.

[16] The most recent version of the optional User Spreadsheet tool is posted at: Link to Technical Guidance web page.

6.2 NON-IMPULSIVE, STATIONARY, CONTINUOUS (TAB A: RED)

Tab A is for use with non-impulsive, stationary sources that are continuous[17] temporally. The use of Tab A is most appropriate for drilling vessels/platforms and may be used for sources such as dynamic positioning (stationary) associated with various types of ships. If the activity of interest is vibratory pile driving, see Section 5.2A1 (Tab A.1).

6.2.1 Step 1: General Project Information

These sage cells provide information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.

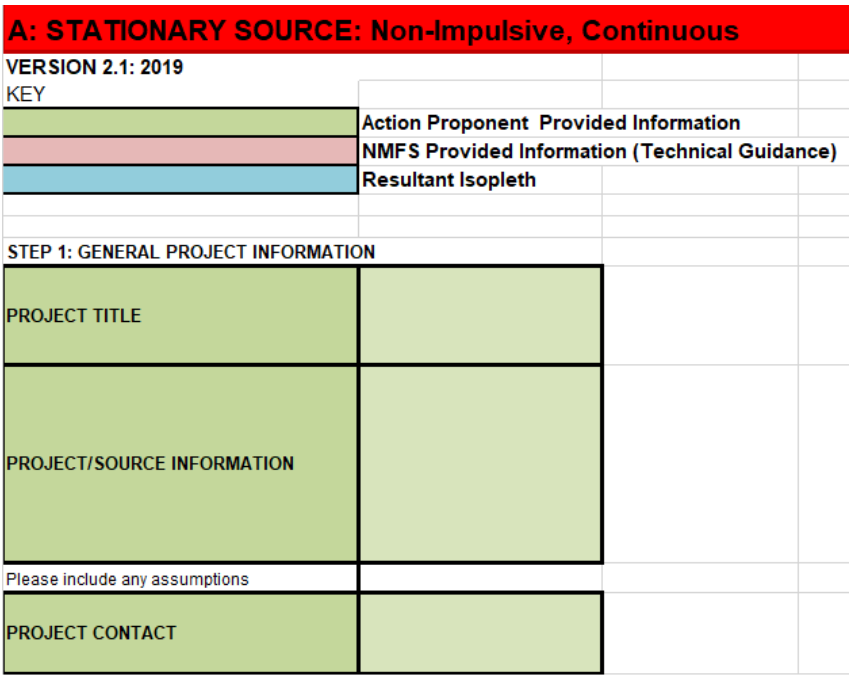


Figure 8: Screenshot of Step 1 for Tab A.

NOTE: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

6.2.2 Step 2: Weighting Factor Adjustment (WFA)

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting functions based on whether the source is:

- Broadband source: Provide the 95% frequency contour percentile (kHz)

  NOTE: Most non-impulsive, stationary, continuous sources are broadband.

- Narrowband source: Provide frequency (kHz)

[17] NMFS recognizes there are very few sound sources that are truly continuous temporally. However, a key distinction between continuous and intermittent sound sources is that intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle), which continuous sounds do not.

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default WFA or spectrum value
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within optional User Spreadsheet tool).

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (-dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, action proponents must ensure the chosen WFA is within a hearing group's applicable frequency range (Table 9).

Table 9: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

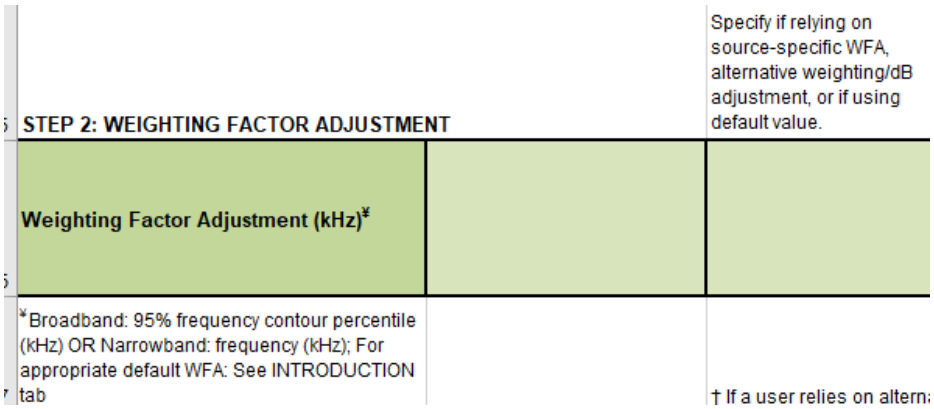


Figure 9: Screenshot of Step 2 for Tab A.

6.2.3 Step 3: Source-Specific Information

These sage cells provide information regarding:

- Source Level (L_{rms}): Source level in the root mean square sound pressure level metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Duration of Sound Production (hours) within a 24-h period: Representative (typical) amount of time (hours) a sound source is producing sound within a 24-h period.

  FICTITIOUS EXAMPLE: If an action proponent was drilling two holes and each hole took ~5 hours to drill (i.e., sound produced entire 5 hours), then the activity duration would be 10 h.

  NOTE: The optional User Spreadsheet tool is flexible and allows the action proponent to specify the duration of sound production within a 24-h period. Thus, if there is enough information to determine that within the duration of sound production in a 24-h period that a receiver (animal) will only be exposed for a portion of that 24-h period, then the actual exposure duration may be used instead. If exposure duration is substituted for sound production duration, then NMFS recommends the action proponent provide information and assumptions used to support this substitution. If the substituted exposure duration varies by species and/or hearing group, it is important to remember to keep track and note which isopleths are appropriate for which hearing groups/species, since the optional User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, optional User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- Propagation loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell and specify this in the sage Project/Source Information in Step 1. If not, NMFS recommends that an action proponent contact us to determine an appropriate surrogate value.

  USER TIP: NMFS typically recommends practical spreading (15 Log R) for projects occurring in shallow, coastal areas.

Within Step 3 are two white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Duration of Sound Production (seconds): The duration, in seconds, within a 24-h period that the source is producing sound based directly on the action proponent input in Step 3.

- 10 Log duration of sound production: This cell is 10 log the duration of the duration of sound production in seconds and represents the necessary duration of exposure needed to calculate PTS onset isopleths in the SEL_{cum} metric. The larger the number, the longer the duration of exposure.

STEP 3: SOURCE-SPECIFIC INFORMATION	
Source Level (L_{rms})	
Duration of Sound Production (hours) within 24-h period	
Duration of Sound Production (seconds)	0
10 Log (duration of sound production)	#NUM!
Propagation loss	

Figure 10: Screenshot of Step 3 for Tab A.

NOTE: Since the Technical Guidance recommends a maximum accumulation period of 24-h, the maximum Duration of Sound Production (seconds) is 86400 (i.e., number of seconds within a 24-h period), and the maximum value in the 10 Log duration of sound production cell is 49.37. If an action proponent notices values in these cells are larger than this, there is an error.

6.2.4 Resultant Isopleths

Rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleth (SEL_{cum} metric), in meters, for each marine mammal hearing group.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Figure 11: Screenshot of Resultant Isopleths for Tab A.

NOTE: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.2A1 VIBRATORY PILE DRIVING (TAB A.1: BRICK RED)

Tab A.1 is for use specifically with vibratory pile driving activities.

6.2.A1.1 Step 1: General Project Information

These sage cells are for providing information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.

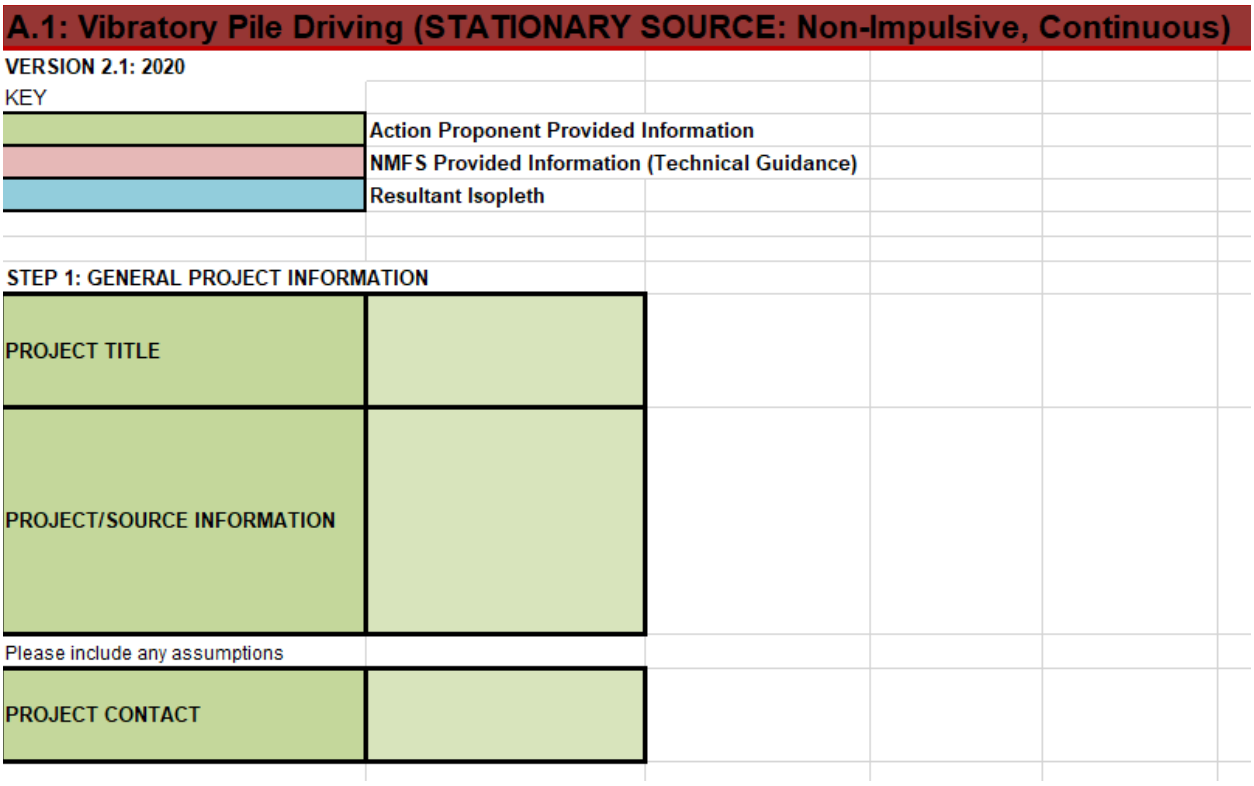


Figure 12: Screenshot of Step 1 for Tab A.1.

NOTE: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

6.2.A1.2 Step 2: Weighting Factor Adjustment

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting functions:

- Broadband source: Provide the 95% frequency contour percentile (kHz)

NOTE: Vibratory pile driving is a broadband source.

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement.
- Relying upon NMFS suggested default value, which 2.5 kHz for vibratory pile driving.
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within optional User Spreadsheet tool).

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

NOTE: For broadband sources, action proponents must ensure chosen WFA is within a hearing group's applicable frequency range (Table 10).

Table 10: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

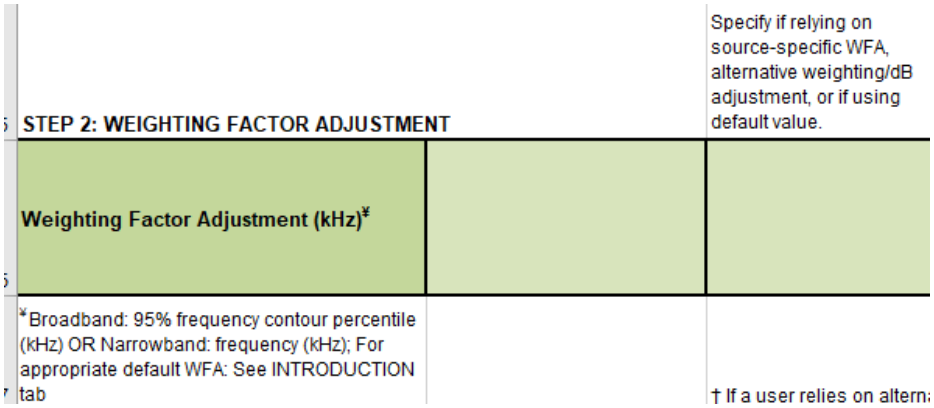


Figure 13: Screenshot of Step 2 for Tab A.1.

6.2.A1.3 Step 3: Source-Specific Information

These sage provide information regarding:

- Sound Pressure Level (L_{rms}), specified at "x" meters: Source pressure level in the root mean square sound pressure level metric specified a certain distance from the source. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

  For sources, such as vibratory pile driving hammers, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead, for these sources, sound pressure levels (L_{rms}) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

- Number of piles within 24-h period: The total number of piles expected to be driven within a 24-h period.

- Duration to drive a single pile (minutes): The representative (typical) amount of time needed to drive a single pile in minutes. This duration assume sound is produced during the entire time.

- Transmission loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell and specify this in the sage Project/Source Information in Step 1. If not, NMFS recommends that an action proponent contact them to determine an appropriate surrogate value.

  USER TIP: For pile driving projects occurring in shallow, coastal areas, NMFS typically recommends practical spreading (TL=15 log R2/R1, where R1 is the range for a close range measurement, typically 10 m from the pile source, and R2 is a longer range at which an underwater sound metric such a peak pressure, or sound exposure level is estimated (Dahl et al. 2012)).

- Distance of sound pressure level measurement (meters): The typical source levels reference is 1 meter from the source. However, for activities such as vibratory pile driving, the typical distance is 10 meters or more. The action proponent enters whatever value is appropriate for their specific source.

Within Step 3 are two white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Duration of Sound Production (seconds): The duration, in seconds, within a 24-h period that the source is producing sound based directly on the action proponent input in Step 3.

  FICTITIOUS EXAMPLE: If an action proponent was driving 5 piles within a 24-h period, via vibratory pile driving, and each pile took 120 minutes to drive, then the activity duration would be 600 minutes, which when converted to seconds is 36,000.

  NOTE: The optional User Spreadsheet tool is flexible and allows the action proponent to specify the duration of sound production within a 24-h period. Thus, if there is enough information to determine that within the duration of sound production in a 24-h period that a receiver (animal) will only be exposed for a portion of that 24-h period, then the actual exposure duration may be used instead. If exposure duration is substituted for sound production duration, then NMFS recommends the action proponent provide information and assumptions used to support this substitution. If the substituted exposure duration varies by species and/or hearing group, it is important to remember to keep track and note which isopleths are appropriate for which hearing

groups/species, since the optional User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, optional User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- 10 Log duration of sound production: This cell is 10 log the duration of the duration of sound production in seconds and represents the necessary duration of exposure needed to calculate PTS onset isopleths in the SEL_{cum} metric. The larger the number, the longer the duration of exposure.

STEP 3: SOURCE-SPECIFIC INFORMATION	
Sound Pressure Level (L_{rms}), specified at "x" meters (Cell B30)	
Number of piles within 24-h period	
Duration to drive a single pile (minutes)	
Duration of Sound Production within 24-h period (seconds)	0
10 Log (duration of sound production	#NUM!
Transmission loss coefficient	
Distance of sound pressure level (L_{rms}) measurement (meters)	

Figure 14: Screenshot of Step 3 for Tab A.1.

NOTE: Since the Technical Guidance recommends a maximum accumulation period of 24-h, the maximum Duration of Sound Production (seconds) is 86400 (i.e., number of seconds within a 24-h period), and the maximum value in the 10 Log duration of sound production cell is 49.37. If an action proponent notices values in these cells are larger than this, there is an error.

6.2.A1.4 Resultant Isopleths

Rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleth (SEL_{cum} metric), in meters, for each marine mammal hearing group.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Figure 15: Screenshot of Resultant Isopleths for Tab A.1.

NOTE: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.3 NON-IMPULSIVE, STATIONARY, INTERMITTENT (TAB B: YELLOW)

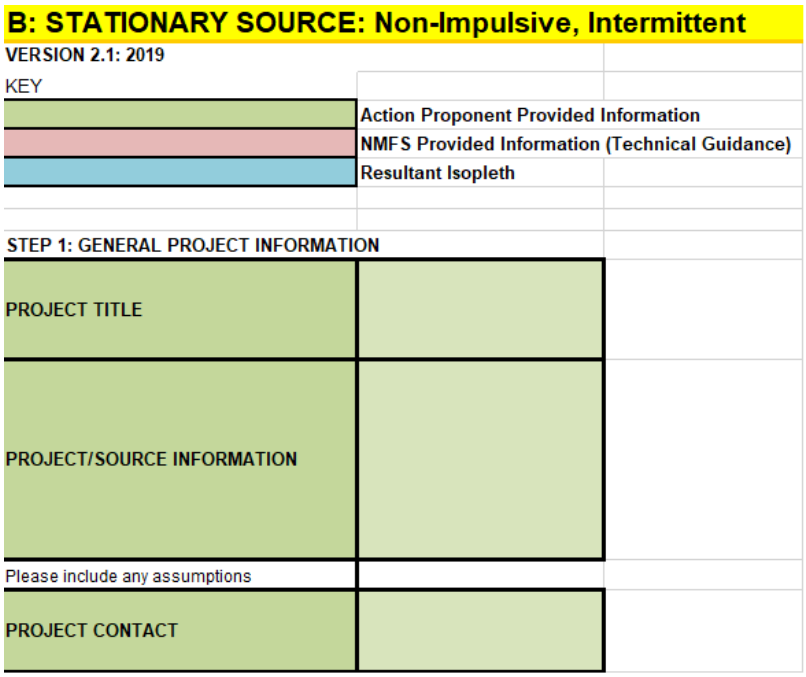
Tab B is for use with non-impulsive, stationary sources that are intermittent[18] temporally. The use of this tab is most appropriate for sources such as certain stationary sonars.

> **NOTE**: The optional User Spreadsheet tool treats all sound sources as omnidirectional (i.e., may not be appropriate for sources that are highly directional and/or have narrow beam patterns).

6.3.1 Step 1: General Project Information

These sage cells are for providing information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.



B: STATIONARY SOURCE: Non-Impulsive, Intermittent		
VERSION 2.1: 2019		
KEY		
	Action Proponent Provided Information	
	NMFS Provided Information (Technical Guidance)	
	Resultant Isopleth	
STEP 1: GENERAL PROJECT INFORMATION		
PROJECT TITLE		
PROJECT/SOURCE INFORMATION		
Please include any assumptions		
PROJECT CONTACT		

Figure 16: Screenshot of Step 1 for Tab B.

> **NOTE**: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

6.3.2 Step 2: Weighting Factor Adjustment

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting functions based on whether the source is:

- Broadband source: Provide the 95% frequency contour percentile (kHz)
- Narrowband source: Provide frequency (kHz)

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement.

[18] A key distinction between continuous and intermittent sound sources is that intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle), which continuous sounds do not.

- Relying upon NMFS suggested default WFA or spectrum value.
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within optional User Spreadsheet tool).

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (-dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, action proponents must ensure chosen WFA is within a hearing group's applicable frequency range (Table 11).

Table 11: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override)

The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

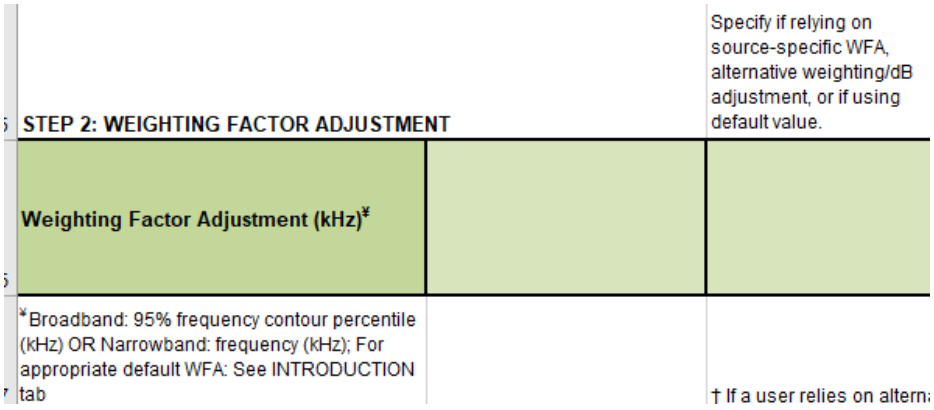


Figure 17: Screenshot of Step 2 for Tab B.

6.3.3 Step 3: Source-Specific Information

There are two methods an action proponent can choose (i.e., B1 OR B2) to calculate isopleths. Method B1 is preferred when SEL-based source levels are available (because pulse duration is not required). Only use method B2 if SEL-based source levels are not available.

NOTE: The action proponent is not required to fill in sage boxes for both methods (i.e., the action proponent is to pick one method OR the other).

If the action proponent has unweighted source level information expressed in the SEL metric, then determining the pulse duration is not necessary. Many of the sound source tabs provide a choice between two methods (i.e., one relying on L_{rms} source levels or one relying upon SEL source levels). NMFS advises action proponents to rely on the method using the SEL source level, so needing to determine the pulse duration (or appropriate default) is not necessary. For this tab, it would be method B1.

B1: Preferred Method (Single ping/pulse equivalent)

These sage cells provide information regarding:

- Source Level (Single Ping/Single Pulse SEL): Source level in single ping/pulse SEL metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method). **NOTE**: This single ping/single pulse SEL metric represents the sound exposure of a single ping/pulse and is not cumulative.

  When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Activity Duration (hours) within a 24-h period: Represents the amount of time (hours) an activity that is producing sound is expected to occur within a 24-h period.

  NOTE: Since the B1 Method also asks for values to derive the duty cycle (i.e., time sound is "on" vs. time sound is "off") of the sound via the pulse duration (seconds) and 1/repetition rate (seconds), this cell is asking for the amount of hours over which the activity is expected to occur within a 24-period. It is NOT asking for the total time (in hours) over which the source is producing sound (see Fictitious Example below).

- **FICTITIOUS EXAMPLE**: If an action proponent had an activity that occurred during daylight (i.e. 12 h) regardless of the pulse duration and 1/repetition rate (inter-pulse interval), then the input for activity duration would be 12 h.

- Number of pulses in a 1-h period: Representative number of pulses occurring within an hour. For example if one knows 1/repetition rate (inter-pulse interval) for their source (even though this is not directly asked using this method), they can use this to figure out the number of pulses in an hour by taking 3600 (number of seconds in an hour) divided by 1/repetition rate.

  FICTITIOUS EXAMPLE: If a source has a 1/repetition rate of 15 seconds, then the number of pulses in an hour would be 240 (3600 seconds/15 seconds).

  NOTE: The B1 Method does not require the action proponent to consider pulse duration, which already accounted for in the single ping/pulse SEL source level.

- Propagation loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell. If site-specific information is available, the action proponent specifies this in the sage Project/Source Information in Step 1. If not, NMFS recommends that an action proponent contact them to determine an appropriate surrogate value.

USER TIP: NMFS typically recommends practical spreading (15 Log R) for projects occurring in shallow, coastal areas.

Within Step 3 are two white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Number of pulses in 24-h: This value is the number of pulses in a 1-h period multiplied by the activity duration within a 24-h period.

- 10 Log (number of pulses): This cell is 10 log the total number of pulses expected within a 24-h period. The larger the number, the longer the duration of exposure.

B1: METHOD (SINGLE PING/PULSE EQUIVALENT)	PREFERRED METHOD
Source Level ($L_{E,p,\ \text{single ping/pulse}}$)	
Activity Duration (hours) within 24-h period	
Number pulses in 1-h period	
Number of pulses in 24-h	0
10 Log (number of pulses)	#NUM!
Propagation loss coefficient	

Figure 18: Screenshot of Step 3, Method B1 for Tab B.

B2: Method using L_{rms} Source Level

These sage cells are for providing information regarding:

- Source Level (L_{rms}): Source level in the root mean square sound pressure level metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Activity Duration (hours) within a 24-h period: Represents the amount of time (hours) an activity is expected to occur within a 24-h period.

  NOTE: Since the B2 Method also asks for values to derive the duty cycle (i.e., time sound is "on" vs. time sound is "off") of the sound via the pulse duration (seconds) and 1/repetition rate (seconds), this cell is asking for the amount of hours over which the *activity* is expected to occur within a 24-period. It is NOT asking for the total time (in hours) over which the source is producing sound (see Fictitious Example below).

  This input is different from those for continuous sources (e.g., Tab A: Non-impulsive, Stationary, Continuous), which asks the action proponent to input the *actual* amount of time the source is producing sound (i.e., Duration of Sound Production)

  FICTITIOUS EXAMPLE: If an action proponent had an activity that occurred during daylight (i.e. 12 h), regardless of the pulse duration and 1/repetition rate (inter-pulse interval), then the input for activity duration would be 12 h.

  NOTE: The optional User Spreadsheet tool is flexible and allows the action proponent to specify the duration of sound production within a 24-h period. Thus, if there is enough information to

determine that within the duration of sound production in a 24-h period that a receiver (animal) will only be exposed for a portion of that 24-h period, then the actual exposure duration may be used instead. If exposure duration is substituted for sound production duration, then NMFS recommends the action proponent provide information and assumptions used to support this substitution. If the substituted exposure duration varies by species and/or hearing group, it is important to remember to keep track and note which isopleths are appropriate for which hearing groups/species, since the optional User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, optional User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- Pulse Duration (seconds): Duration of pulse/ping (i.e., Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005).

- 1/Repetition Rate (seconds): 1/Number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second OR the time between onset of successive pulses (Inverse of repetition rate or inter-pulse interval).

- **FICTITIOUS EXAMPLE**: If a device produces a 9-second ping every 6 seconds, then 1/repetition rate would be 15 seconds (i.e., onset between successive pulses is 15 seconds).
  Sometimes sonar sources may indicate pings in terms of Hz (i.e., pings per second). For example, if a sonar has a 4 Hz ping rate, this translates to a ping every 0.25 seconds (1 second/4 pings per second). Thus, 1/repetition rate would be 0.25 seconds. In this example, 4 Hz only provides 1/ repetition rate. It does provide the pulse duration.

- Propagation loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell and specify this in the sage Project/Source Information in Step 1. If not, NMFS recommends that an action proponent contact them to determine an appropriate surrogate value.
  USER TIP: NMFS typically recommends practical spreading (15 Log R) for projects occurring in shallow, coastal areas.

Within Step 3 are three white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Duty cycle: Pulse duration divided by 1/repetition rate (inter-pulse interval) or the percent of time source produces sound (i.e., time on vs. time off).

  FICTITIOUS EXAMPLE: If a device has a 0.10 (or 10%) duty cycle, this indicates sound is produced or is “on” 10% time and is silent or “off” 90% of the time.

- Duration of Sound Production (seconds): The duration, in seconds, within a 24-h period that the source is *actually* producing sound. This value is derived by multiplying the sage input of Activity Duration (hours) within a 24-h period by 3600 to convert the value to seconds. Once converted to seconds, the value is multiplied by the duty cycle in order to get the number of seconds within a 24-h period the source is producing sound.

  It is recommended that an action proponent crosscheck this value to ensure it is accurately reflecting the total duration (in seconds) the source is actually expected to produce sound within a 24-h period.

  NOTE: The Duration of Sound Production output in this cell is different from the activity duration specified by the action proponent previously in Step 3. The Duration of Sound Production output of this cell reflects the total duration a source is actually producing sound in a 24-h period vs. the previous input provided by the action proponent (i.e., Activity Duration), which accounts for the

amount of time within a 24-h period that a sound producing activity occurs (see Fictitious Example below).

FICTITIOUS EXAMPLE: If a device produces a 9-second ping every 6 seconds, then it would have a 0.60 (or 60%) duty cycle (i.e., pulse duration divided by 1/repetition rate; 9 seconds/15 seconds). If this source produced sound only during daylight hours (i.e., 12 h), then the activity duration in seconds would be 25920 (0.60 x 3600 x 12 hours).

In this example, 12 h is the activity duration specified by the action proponent in Step 3, while 25920 seconds is the duration of sound production produced by this cell.

NOTE: The optional User Spreadsheet tool is flexible and allows the action proponent to specify the duration of sound production within a 24-h period. Thus, if there is enough information to determine that within the duration of sound production in a 24-h period that a receiver (animal) will only be exposed for a portion of that 24-h period, then the actual exposure duration may be used instead. If exposure duration is substituted for sound production duration, then NMFS recommends the action proponent provide information and assumptions used to support this substitution. If the substituted exposure duration varies by species and/or hearing group, it is important to remember to keep track and note which isopleths are appropriate for which hearing groups/species, since the optional User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, optional User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- 10 Log duration of sound production: This cell is 10 log the duration of sound production in seconds and represents the necessary duration of exposure needed to calculate PTS onset isopleths in the SEL_{cum} metric. The larger the number, the longer the duration of exposure.

B2: METHOD USING RMS SPL SOURCE LEVEL	
Source Level (L_{rms})	
Activity Duration (hours) within 24-h period	
Pulse duration (seconds)	
1/Repetition rate^ (seconds)	
Duty cycle	#DIV/0!
Duration of Sound Production (seconds)	#DIV/0!
10 Log (duration of sound production)	#DIV/0!
Propagation loss coefficient	
^Time between onset of successive pulses.	

Figure 19: Screenshot of Step 3, Method B2 for Tab B.

NOTE: Since the Technical Guidance recommends a maximum accumulation period of 24-h, the maximum Duration of Sound Production (seconds) is 86400 (i.e., number of seconds within a 24-h period), and the maximum value in the 10 Log duration of sound production cell is 49.37. If values in these cells are larger than this, there is an error. Since this tab is for intermittent sounds, which are not continuous and offer sound breaks of silence, this value is never 49.37 (i.e., always less).

6.3.4 Resultant Isopleths

Under either methods B1 or B2 (depending on action proponent's preference), rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleth (SEL_{cum} metric), in meters, for each marine mammal hearing group.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Figure 20: Screenshot of Resultant Isopleths for Tab B.

NOTE: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

The optional User Spreadsheet tool currently does not account for the source directionality or beam pattern (i.e., assumes all sources are omnidirectional. Thus, the optional User Spreadsheet tool will likely over-estimate resultant PTS onset isopleths for these source types.

6.4 NON-IMPULSIVE, MOBILE, CONTINUOUS (TAB C: BLUE)

Tab C is for use for non-impulsive, mobile sources that are continuous[19] temporally. This tab's calculations rely upon the "safe distance" methodology from Sivle et al. (2014). The use of this tab is appropriate for sources such as moving vessels.

> **NOTE**: The assumptions associated with the "safe distance" methodology may not be appropriate, if the source has the potential to move in a manner where the same group of receivers could be exposed to multiple passes from the source.

6.4.1 Step 1: General Project Information

These sage cells provide information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.

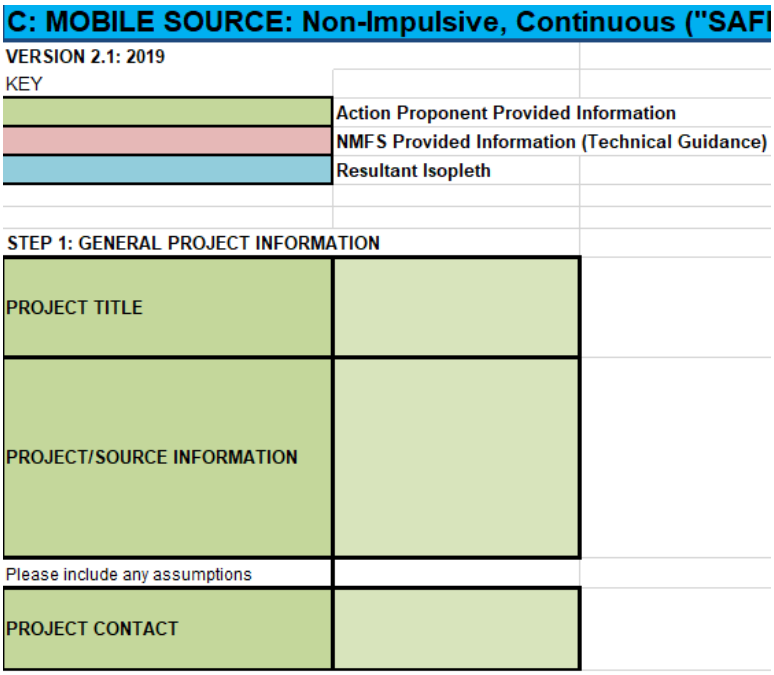


Figure 21: Screenshot of Step 1 for Tab C.

> **NOTE**: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

6.4.2 Step 2: Weighting Factor Adjustment

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting functions based on whether the source is:

- Broadband source: Provide the 95% frequency contour percentile (kHz)

[19] NMFS recognizes there are very few sound sources that are truly continuous temporally. However, a key distinction between continuous and intermittent sound sources is that intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle), which continuous sounds do not.

NOTE: Most non-impulsive, mobile, continuous sources are broadband.

- Narrowband source: Provide frequency (kHz)

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default WFA or spectrum value
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within optional User Spreadsheet tool)

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (-dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, action proponents must ensure chosen WFA is within a hearing group's applicable frequency range (Table 12).

Table 12: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

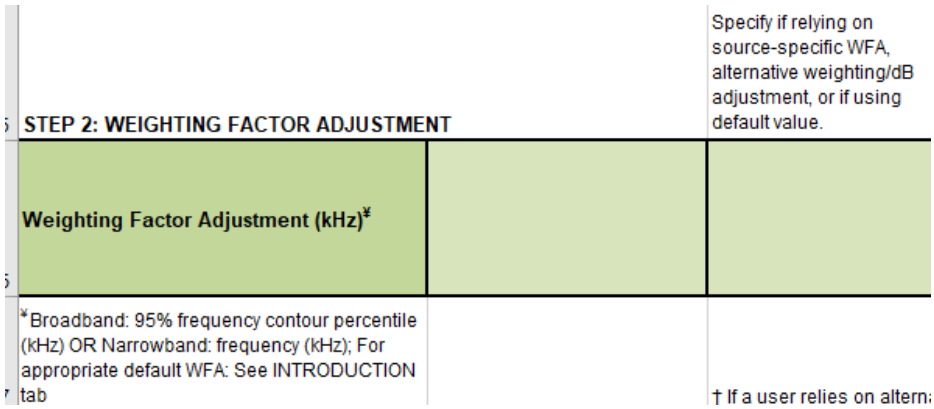


Figure 22: Screenshot of Step 2 for Tab C.

6.4.3 Step 3: Source-Specific Information

These sage cells are for providing information regarding:

- Source Level (L_{rms} SPL): Source level in the root mean square sound pressure level metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Source velocity (meters/second): Represents the source velocity (i.e., if source attached to vessel, it is the vessel speed).

  NOTE: This tab does not require the action proponent to specify the propagation loss coefficient. The "safe distance" methodology assumes propagation loss of 20 log R. Additionally, this tab does not ask the action proponent to specify the duration of the activity within a 24-h period. This is because this methodology is activity duration (time) independent.

Within Step 3 are two white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Duty cycle: Represents the percent of time source produces sound (i.e., time on vs. time off). Since this tab is for a continuous source, it assumes a duty cycle of 1 (or 100%).

- Source factor: This cell converts the unweighted source level to micropascals (i.e., source factor) and then multiplies that value times the duty cycle to complete the calculation associated with "safe distance" methodology.

STEP 3: SOURCE-SPECIFIC INFORMATION‡	
Source Level (L_{rms})	
Source Velocity (meters/second)	
Duty cycle	1
Source Factor	1

Figure 23: Screenshot of Step 3 for Tab C.

6.4.4 Resultant Isopleths

Rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleth (SEL_{cum} metric), in meters, for each marine mammal hearing group.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Figure 24: Screenshot of Resultant Isopleths for Tab C.

NOTE: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.5 NON-IMPULSIVE, MOBILE, INTERMITTENT (TAB D: ORANGE)

Tab D is for use with non-impulsive, mobile sources that are intermittent[20] temporally. This tab's calculations rely upon the "safe distance" methodology from Sivle et al. (2014). The use of this tab is appropriate for certain mobile sonars.

> **NOTE**: The assumptions associated with the "safe distance" methodology may not be appropriate, if the source has the potential to move in a manner where the same group of receivers could be exposed to multiple passes from the source.
>
> The optional User Spreadsheet tool treats all sound sources as omnidirectional (i.e., may not be appropriate for sources that are highly directional and/or have narrow beam patterns).

6.5.1 Step 1: General Project Information

These sage cells provide information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.

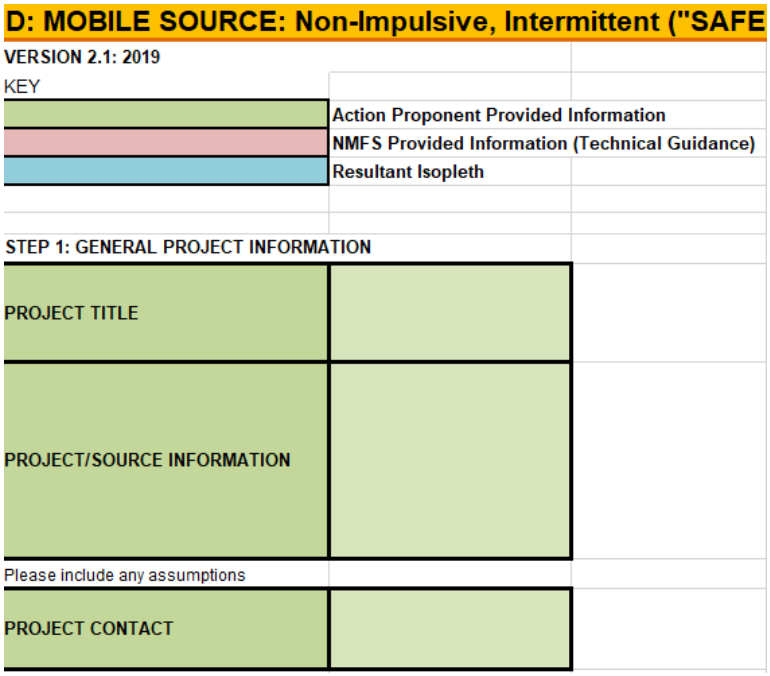


Figure 25: Screenshot of Step 1 for Tab D.

> **NOTE**: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure the optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

6.5.2 Step 2: Weighting Factor Adjustment

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting functions based on whether the source is:

- Broadband source: Provide the 95% frequency contour percentile (kHz)

[20] A key distinction between continuous and intermittent sound sources is that intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle), which continuous sounds do not.

- Narrowband source: Provide frequency (kHz)

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default WFA or spectrum value
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within optional User Spreadsheet tool).

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (-dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, action proponents must ensure chosen WFA is within a hearing group's applicable frequency range (Table 13).

Table 13: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override)

The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

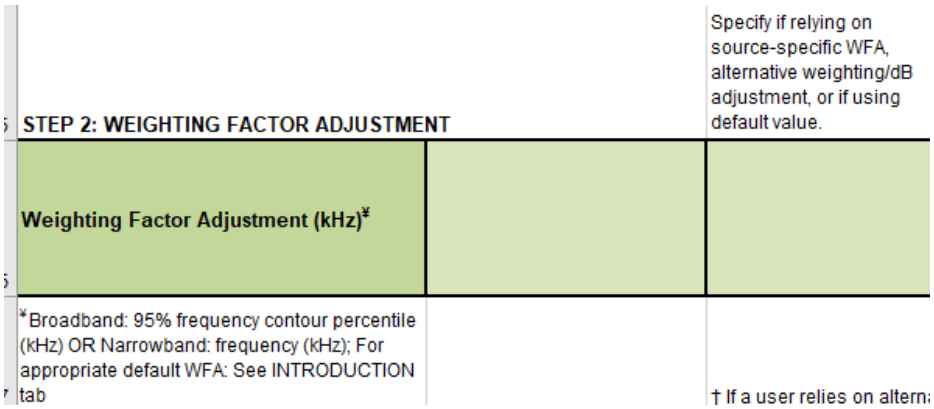


Figure 26: Screenshot of Step 2 for Tab D.

6.5.3 Step 3: Source-Specific Information

There are two methods an action proponent can choose (i.e., D1 OR D2) to calculate isopleths. Method D1 is preferred when SEL-based source levels are available (because pulse duration is not required). Only use method D2 if SEL-based source levels are not available.

> **NOTE**: The action proponent is not required to fill in sage boxes for both methods (i.e., the action proponent is to pick one method OR the other).
>
> If the action proponent has unweighted source level information expressed in the SEL metric, then determining the pulse duration is not necessary. Many of the sound source tabs provide a choice between two methods (i.e., one relying on L_{rms} source levels or one relying upon SEL source levels). NMFS advises action proponents to rely on the method using the SEL source level, so needing to determine the pulse duration (or appropriate default) is not necessary. For this tab, this would be method D1.

D1: Preferred Method (Single ping/pulse equivalent)

These sage cells are for providing information regarding:

- Source Level (Single Ping/Single Pulse SEL): Source level in single ping/pulse SEL metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: This single ping/single pulse SEL metric represents the sound exposure of a single ping/pulse and is not cumulative.

  When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Source Velocity: Represents the source velocity (i.e., if source attached to vessel, it is the vessel speed).

- 1/Repetition Rate (seconds): 1/Number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second OR the time between onset of successive pulses (inverse or repetition rate or inter-pulse interval)

  FICTITIOUS EXAMPLE: If a device produces a 9-second ping every 6 seconds, then 1/repetition rate would be 15 seconds (i.e., onset between successive pulses is 15 seconds).

- **NOTE**: The D1 Method does not require the action proponent to consider pulse duration, which already accounted for in the single ping/pulse SEL source level.

This tab does not require the action proponent to specify the propagation loss coefficient. The "safe distance" methodology assumes propagation loss of 20 log R. Additionally, this tab does not ask the action proponent to specify the duration of the activity within a 24-h period. This is because this methodology is activity duration (time) independent.

Within Step 3 is one white cell, that the action proponent cannot modify, which represents calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Source factor: This cell converts the unweighted source level to micropascals (i.e., source factor) and then multiplies that value times the duty cycle to complete the calculation associated with "safe distance" methodology.

D1: METHOD† (SINGLE PING/PULSE EQUIVALENT)		PREFERRED METHOD (p
Source Level ($L_{E,p,\text{ single ping/pulse}}$)		
Source Velocity (meters/second)		
1/Repetition rate^ (seconds)		
Source Factor	#DIV/0!	
†Methodology assumes propagation loss of 20 log R; Activity duration (time) independent		
^Time between onset of successive pulses.		

Figure 27: Screenshot of Step 3, Method D1 for Tab D.

D2: Method using L_{rms} Source Level

These sage cells are for providing information regarding:

- Source Level (L_{rms}): Source level in the root mean square pressure level metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Source Velocity: Represents the source velocity (i.e., if source attached to vessel, it is the vessel speed).

- Pulse Duration (seconds): Duration of pulse/ping (i.e., Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005).

- 1/Repetition Rate (seconds): 1/Number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second OR the time between onset of successive pulses (inverse of repetition rate or inter-pulse interval).

- **FICTITIOUS EXAMPLE**: If a device produces a 9-second ping every 6 seconds, then 1/repetition rate would be 15 seconds (i.e., time between onset of successive pulses).

  Sometimes sonar sources may indicate pings in terms of Hz (i.e., pings per second). For example, if a sonar has a 4 Hz ping rate, this translates to a ping every 0.25 seconds (1 second/4 pings per second). Thus, 1/repetition rate would be 0.25 seconds (i.e., time between onset of successive pulses). In this example, 4 Hz only provides 1/repetition rate. It does provide the pulse duration.

- **NOTE**: This tab does not require the action proponent to specify the propagation loss coefficient. The "safe distance" methodology assumes propagation loss of 20 log R. Additionally, this tab does not ask the action proponent to specify the duration of the activity within a 24-h period. This is because this methodology is activity duration (time) independent.

Within Step 3 are three white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Duty cycle: Pulse duration divided by 1/repetition rate (nter-pules interval) or the percent of time source produces sound (i.e., time on vs. time off).

  FICTITIOUS EXAMPLE: If a device has a 0.10 (or 10%) duty cycle, this indicates sound is produced or is "on" 10% time and is silent or "off" 90% of the time.

- Source factor: This cell converts the unweighted source level to micropascals (i.e., source factor) and then multiplies that value times the duty cycle to complete the calculation associated with "safe distance" methodology.

D2: METHOD‡ USING RMS SPL SOURCE LEVEL	
Source Level (L_{rms})	
Source Velocity (meters/second)	
Pulse Duration (seconds)	
1/Repetition rate^ (seconds)	
Duty Cycle	#DIV/0!
Source Factor	#DIV/0!
‡Methodology assumes propagation loss of 20 log R; Activity duration (time) independent	
^Time between onset of successive pulses.	

Figure 28: Screenshot of Step 3, Method D2 for Tab D.

6.5.4 Resultant Isopleths

Under either methods D1 or D2 (depending on action proponent's preference), rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleth (SEL_{cum} metric), in meters, for each marine mammal hearing group.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Figure 29: Screenshot of Resultant Isopleths for Tab D.

NOTE: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

The optional User Spreadsheet tool currently does not account for the source directionality or beam pattern (i.e., assumes all sources are omnidirectional. Thus, the optional User Spreadsheet tool will likely over-estimate resultant PTS onset isopleths for these source types.

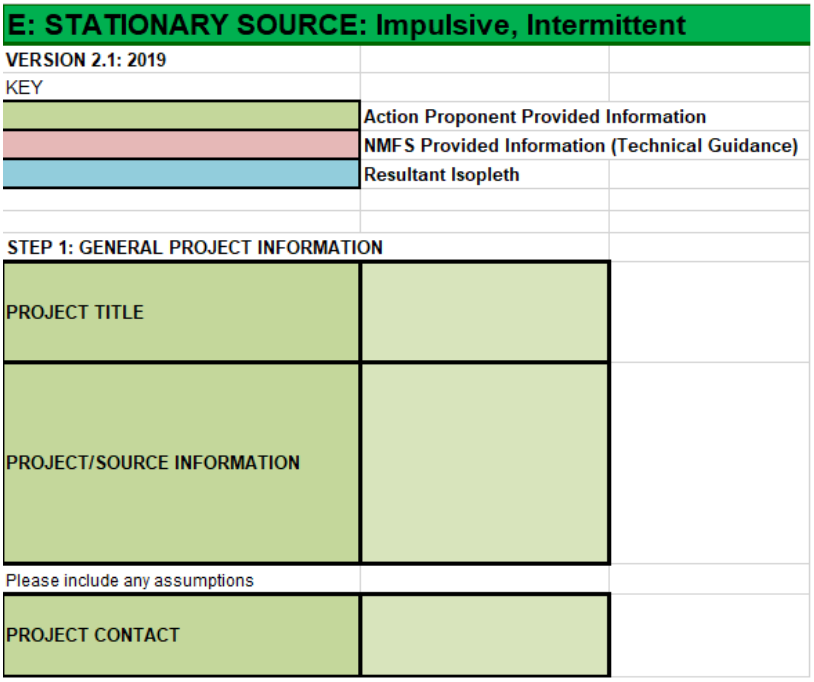
6.6 IMPULSIVE, STATIONARY (TAB E: GREEN)

Tab E is for use with impulsive stationary sources, which are inherently intermittent temporally. The use of this tab is appropriate for vertical seismic profiling (VSPs). If the activity of interest is impact pile driving, see Section 5.6E1 (Tab E.1).

6.6.1 Step 1: General Project Information

These sage cells provide information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.



E: STATIONARY SOURCE: Impulsive, Intermittent		
VERSION 2.1: 2019		
KEY		
	Action Proponent Provided Information	
	NMFS Provided Information (Technical Guidance)	
	Resultant Isopleth	
STEP 1: GENERAL PROJECT INFORMATION		
PROJECT TITLE		
PROJECT/SOURCE INFORMATION		
Please include any assumptions		
PROJECT CONTACT		

Figure 30: Screenshot of Step 1 for Tab E.

NOTE: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

6.6.2 Step 2: Weighting Factor Adjustment

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting functions:

- Broadband source: Provide the 95% frequency contour percentile (kHz)

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default WFA or spectrum value
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within optional User Spreadsheet tool).

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, action proponents must ensure chosen WFA is within a hearing group's applicable frequency range (Table 14).

Table 14: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

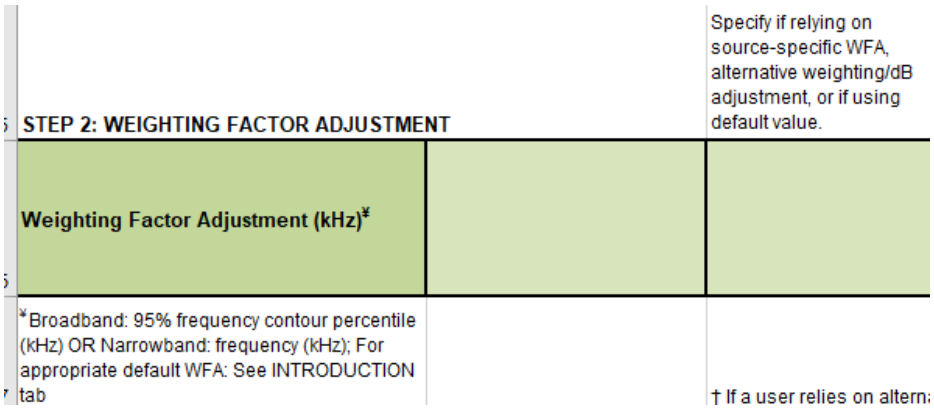


Figure 31: Screenshot of Step 2 for Tab E

6.6.3 Step 3: Source-Specific Information

There are two methods an action proponent can choose (i.e., E1 OR E2) to calculate isopleths. Method E1 is preferred when SEL-based source levels are available (because pulse duration is not required). Only use method E2 if SEL-based source levels are not available.

> **NOTE**: The action proponent is not required to fill in sage boxes for both methods (i.e., the action proponent is to pick one method OR the other).
>
> If the action proponent has unweighted source level information expressed in the SEL metric, then determining the pulse duration is not necessary. Many of the sound source tabs provide a choice between two methods (i.e., one relying on L_{rms} source levels or one relying upon SEL source levels). NMFS advises action proponents to rely on the method using the SEL source level, so needing to determine the pulse duration (or appropriate default) is not necessary. For this tab, this would be method E1.

E1: Preferred Method (Single ping/pulse equivalent)

These sage cells are for providing information regarding:

- Source Level (Single shot SEL): Source level in single shot SEL metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: This single shot pulse SEL metric represents the sound exposure of a single shot and is not cumulative.

  When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Activity Duration (hours) within a 24-h period: Represents the amount of time (hours) an activity that is producing sound is expected to occur within a 24-h period.

  NOTE: Since the E1 Method later accounts for the total number of pulses within a 24-h period, this cell is asking for the amount of hours over which the activity is expected to occur within a 24-period. It is NOT asking for the total time (in hours) over which the source is producing sound (see Fictitious Example below) but instead the amount of time over which the *activity* is expected to occur within a 24-h period.

  This input is different from those for continuous sources (e.g., Tab A: Non-impulsive, Stationary, Continuous), which asks the action proponent to input the *actual* amount of time the source is producing sound (i.e., duration of sound production).

FICTITIOUS EXAMPLE: If an action proponent had an activity that occurred during daylight (i.e. 12 h) regardless of the pulse duration and 1/repetition rate (inter-pulse interval), then the input for activity duration would be 12 h.

NOTE: The optional User Spreadsheet tool is flexible and allows the action proponent to specify the duration of sound production within a 24-h period. Thus, if there is enough information to determine that within the duration of sound production in a 24-h period that a receiver (animal) will only be exposed for a portion of that 24-h period, then the actual exposure duration may be used instead. If exposure duration is substituted for sound production duration, then NMFS recommends the action proponent provide information and assumptions used to support this substitution. If the substituted exposure duration varies by species and/or hearing group, it is important to remember to keep track and note which isopleths are appropriate for which hearing groups/species, since the optional User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, the optional User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- Number of pulses in a 1-h period: Representative number of shots occurring within an hour. For example if one knows 1/repetition rate (inter-pulse interval) for their source (even though this is not directly asked using this method), they can use this to figure out the number of pulses in an hour by taking 3600 (number of seconds in an hour) divided by 1/repetition rate (inter-pulse interval).

  FICTITIOUS EXAMPLE: If a source has a 1/repetition rate of 15 seconds, then the number of pulses in an hour would be 240 (3600 seconds/15 seconds).

  NOTE: The E1 Method does not require the action proponent to consider pulse duration, which already accounted for in the single shot/strike SEL source level.

- Propagation loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell. If site-specific information is available, the action proponent specifies this in the sage Project/Source Information in Step 1. If not, NMFS recommends that an action proponent contact them to determine an appropriate surrogate value.

- **USER TIP**: For activities occurring in shallow, coastal areas, NMFS typically recommends practical spreading (TL=15 log R2/R1, where R1 is the range for a close range measurement, typically 10 m from the pile source, and R2 is a longer range at which an underwater sound metric such a peak pressure, or sound exposure level is estimated (Dahl et al. 2012)).

Within Step 3 is two white cell, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Number of pulses in 24-h: This value is the number of pulses in a 1-h period multiplied by the activity duration within a 24-h period.

- 10 Log (number of pulses): This cell is 10 log the total number of pulses expected within a 24-h period. The larger the number, the longer the duration of exposure.

E1: METHOD TO CALCULATE PK AND SEL_{cum} (SHOT/PULSE EQUIVALENT)	
SEL_{cum}	
Source Level ($L_{E,p,\ single\ ping/pulse/shot}$)	
Activity Duration (hours) within 24-h period	
Number of pulses in 1-h period	
Propagation loss coefficient	
Number of pulses in 24-h period	0
10 log (number of pulses)	#NUM!

Figure 32: Screenshot of Step 3, Method E1 for Tab E.

Step 3 also asks for source level in the peak sound pressure level (PK) metric, since impulsive sources have dual thresholds.

- Source Level (PK SPL): The updated version of the optional User Spreadsheet tool (Version 2.0) now allows action proponents to evaluate the Technical Guidance's peak sound pressure level (PK) thresholds. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

PK	
Source Level ($L_{p,0\text{-}pk}$)	

Figure 33: Screenshot of peak sound pressure level source level input.

NOTE: Technical Guidance recommends that the PK thresholds are unweighted/flat-weighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz).

If an action proponent get output "NA" instead of a numerical isopleth associated with the PTS PK isopleth, this means the PK source level is less than or equal to the threshold for the particular marine mammal hearing group.

E2: Method using L_{rms} Source Level

These sage cells are for providing information regarding:

- Source Level (L_{rms}): Source level in the root mean square sound pressure level metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Activity Duration (hours) within a 24-h period: Represents the amount of time (hours) an activity that is producing sound is expected to occur within a 24-h period.

  NOTE: Since the E2 Method also asks for values to derive the duty cycle (i.e., time sound is "on" vs. time sound is "off") of the sound via the pulse duration (seconds) and 1/repetition rate (seconds), this cell is asking for the amount of hours over which the activity is expected to occur within a 24-period. It is NOT asking for the total time (in hours) over which the source is producing sound (see Fictitious Example below) but instead the amount of time over which the activity is expected to occur within a 24-h period.

This input is different from those for continuous sources (e.g., Tab A: Non-impulsive, Stationary, Continuous), which asks the action proponent to input the *actual* amount of time the source is producing sound (i.e., Duration of Sound Production).

FICTITIOUS EXAMPLE: If an action proponent had an activity that occurred during daylight (i.e. 12 h) regardless of the pulse duration and 1/repetition rate (inter-pulse interval), then the input for activity duration would be 12 h.

NOTE: The optional User Spreadsheet tool is flexible and allows the action proponent to specify the duration of sound production within a 24-h period. Thus, if there is enough information to determine that within the duration of sound production in a 24-h period that a receiver (animal) will only be exposed for a portion of that 24-h period, then the actual exposure duration may be used instead. If exposure duration is substituted for sound production duration, then NMFS recommends the action proponent provide information and assumptions used to support this substitution. If the substituted exposure duration varies by species and/or hearing group, it is important to remember to keep track and note which isopleths are appropriate for which hearing groups/species, since the optional User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, optional User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- Pulse Duration (seconds): Duration of pulse/ping (i.e., Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005).

- 1/Repetition Rate (seconds): 1/Number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second OR the time between onset of successive pulses (inverse of repetition rate or inter-pulse interval).

- **FICTITIOUS EXAMPLE**: If a device produces a 9-second ping every 6 seconds, then 1/repetition
- rate would be 15 seconds (i.e., onset between successive pulses is 15 seconds).

- Propagation loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell and specify this in the sage Project/Source Information in Step 1. If not, NMFS recommends that an action proponent contact them to determine an appropriate
- surrogate value.

USER TIP: NMFS typically recommends practical spreading (15 Log R) for projects occurring in shallow, coastal areas.

Within Step 3 are three white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Duty cycle: Pulse duration divided by 1/repetition rate (inter-pulse interval) or the percent of time source produces sound (i.e., time on vs. time off).

  FICTITIOUS EXAMPLE: If a device has a 10% duty cycle, this indicates sound is produced or is "on" 10% time and is silent or "off" 90% of the time.

- Duration of Sound Production (seconds): The duration, in seconds, within a 24-h period that the source is producing sound. This value is derived by multiplying the sage input of Activity Duration (hours) within a 24-h period by 3600 to convert the value to seconds. Once converted to seconds, the value is multiplied by the duty cycle in order to get the number of seconds within a 24-h period the source is producing sound. It is recommended that an action proponent crosscheck this value to ensure it is accurately reflecting the total duration (in seconds) the source is expected to produce wound within a 24-h period.
  NOTE: The Duration of Sound Production output in this cell is different from the activity duration specified by the action proponent previously in Step 3. The Duration of Sound Production output

of this cell reflects the total duration a source is actually producing sound in a 24-h period vs. the previous input provided by the action proponent (Activity Duration), which accounts for the amount of time within a 24-h period that a sound producing activity occurs (see Fictitious Example below).

FICTITIOUS EXAMPLE: If a device produces a 9-second ping every 6 seconds, then it would have a 0.60 (or 60%) duty cycle (i.e., pulse duration divided by 1/repetition rate; 9 seconds/15 seconds). If this source produced sound only during daylight hours (i.e., 12 h), then the activity duration in seconds would be 25920 (0.60 x 3600 x 12 hours).
In this example, 12 h is the activity duration specified by the action proponent in Step 3, while 25920 seconds is the duration of sound production produced by this cell.

NOTE: The optional User Spreadsheet tool is flexible and allows the action proponent to specify the duration of sound production within a 24-h period. Thus, if there is enough information to determine that within the duration of sound production in a 24-h period that a receiver (animal) will only be exposed for a portion of that 24-h period, then the actual exposure duration may be used instead. If exposure duration is substituted for sound production duration, then NMFS recommends the action proponent provide information and assumptions used to support this substitution. If the substituted exposure duration varies by species and/or hearing group, it is important to remember to keep track and note which isopleths are appropriate for which hearing groups/species, since the optional User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, the optional User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- 10 Log duration of sound production: This cell is 10 log the duration sound production in seconds and represents the necessary duration of exposure needed to calculate PTS onset isopleths in the SEL_{cum} metric. The larger the number, the longer the duration of exposure.

E2: METHOD TO CALCULATE PK AND SEL_{cum} (USING RMS SPL SOURCE LEVEL)	
SEL_{cum}	
Source Level (L_{rms})	
Activity Duration (hours) within 24-h period	
Pulse Duration$^{\Delta}$ (seconds)	
1/Repetition rate^ (seconds)	
Duty cycle	#DIV/0!
Duration of Sound Production (seconds)	#DIV/0!
10 Log (duration of sound production)	#DIV/0!
Propagation loss coefficient	
$^{\Delta}$Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005	
^Time between onset of successive pulses.	

Figure 34: Screenshot of Step 3, Method E2 for Tab E.

NOTE: Since the Technical Guidance recommends a maximum accumulation period of 24-h, the maximum Duration of Sound Production (seconds) is 86400 (i.e., number of seconds within a 24-h period), and the maximum value in the 10 Log duration of sound production cell is 49.37. If an action proponent notices values in these cells are larger than this, there is an error.
Since this tab is for intermittent sounds, which are not continuous and offer sound breaks of silence, this value is never 49.37 (i.e., always less).

Step 3 also asks for source level in the peak sound pressure level (PK) metric, since impulsive sources have dual thresholds.

- Source Level (PK SPL): The updated version of the optional User Spreadsheet tool (Version 2.0) now allows action proponents to evaluate the Technical Guidance's peak sound pressure level (PK) thresholds. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

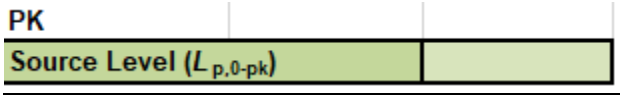


Figure 35: Screenshot of peak sound pressure level source level input.

NOTE: Technical Guidance recommends that the PK thresholds are unweighted/flat-weighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz).

If an action proponent get output "NA" instead of a numerical isopleth associated with the PTS PK isopleth, this means the PK source level is less than or equal to the threshold for the particular marine mammal hearing group.

6.6.4 Resultant Isopleths

Under either methods E1 or E2 (depending on action proponent's preference), rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} metric and PK metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleth (SEL_{cum} metric and PK), in meters, for each marine mammal hearing group. Since both SEL_{cum} and PK resultant isopleths are provided, the action proponent relies on whichever metric produces the largest isopleth.

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
PK Threshold	219	230	202	218	232
PTS PK Isopleth to threshold (meters)	NA	NA	NA	NA	NA

Figure 36: Screenshot of Resultant Isopleths for Tab E.

NOTE: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.6.E1 IMPACT PILE DRIVING (TAB E.1: EVERGREEN)

Tab E.1 is for use specifically with impact pile driving activities.

6.6.E1.1 Step 1: General Project Information

These sage cells provide information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.

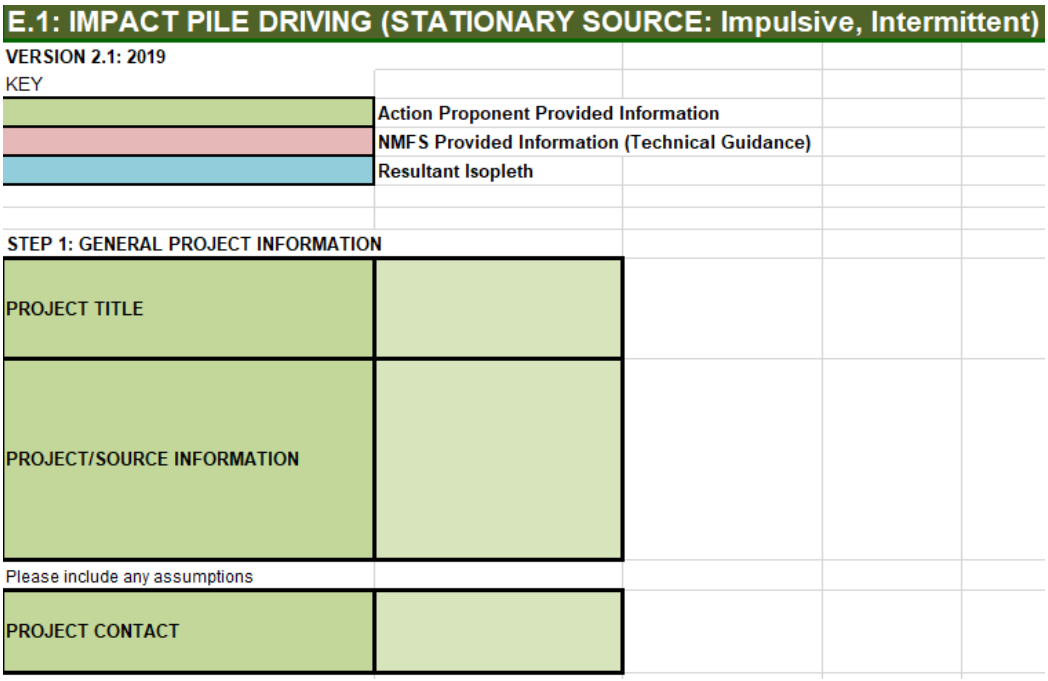


Figure 37: Screenshot of Step 1 for Tab E.1.

NOTE: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure the optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

6.6.E1.2 Step 2: Weighting Factor Adjustment

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting functions:

- Broadband source: Provide the 95% frequency contour percentile (kHz)

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default WFA or spectrum value.
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within the optional User Spreadsheet tool).

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, action proponents must ensure chosen WFA is within a hearing group's applicable frequency range (Table 15).

Table 15: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

In the case of the NMFS suggested default of 2 kHz, this value is within each hearing group's applicable frequency range.

The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

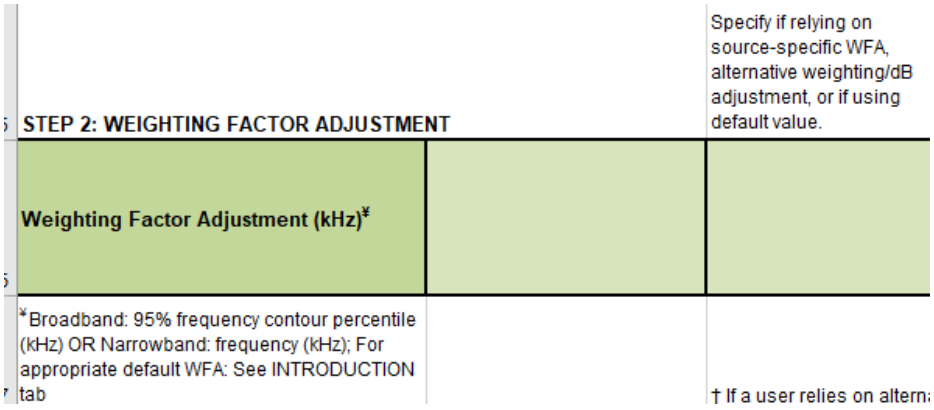


Figure 38: Screenshot of Step 2 for Tab E.1.

6.6.E1.3 Step 3: Source-Specific Information

There are two methods an action proponent can choose (i.e., E.1-1 OR E.1-2) to calculate isopleths. Method E.1-1 is preferred when SEL-based source levels are available (because pulse duration is not required). Only use method E.1-2 if SEL-based source levels are not available.

NOTE: The action proponent is not required to fill in sage boxes for both methods (i.e., the action proponent is to pick one method OR the other).

If the action proponent has unweighted source level information expressed in the SEL metric, then determining the pulse duration is not necessary. Many of the sound source tabs provide a choice between two methods (i.e., one relying on L_{rms} source levels or one relying upon SEL source levels). NMFS advises action proponents to rely on the method using the SEL source level, so needing to determine the pulse duration (or appropriate default) is not necessary. For this tab, this would be Method E.1-1.

E.1-2: Preferred Method (Single strike equivalent)
These sage cells are for providing information regarding:

- Single Strike SEL specified at "x" meters: Single strike SEL metric measured a certain distance from the source. If the single strike SEL provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: This single strike SEL metric represents the sound exposure of a single strike and is not cumulative.

  When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

  For impact pile driving hammers, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead, for these sources, sound levels (L_{rms}, Single Strike SEL, or PK) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

- Number of piles per day: Number of piles expected to be driven within a 24-h period.

- Number of strikes per pile: Representative (typical) number of strikes per pile.

  NOTE: The E.1-1 Method does not require the action proponent to consider pulse duration, which already accounted for in the single shot/strike SEL source level.

- Transmission loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell and specify this in the sage Project/Source Information in Step 1. If not, NMFS recommends that an action proponent contact them to determine an appropriate surrogate value.

  USER TIP: For pile driving projects occurring in shallow, coastal areas, NMFS typically recommends practical spreading (TL=15 log R2/R1, where R1 is the range for a close range measurement, typically 10 m from the pile source, and R2 is a longer range at which an underwater sound metric such a peak pressure, or sound exposure level is estimated (Dahl et al. 2012)).

- Distance of sound pressure level measurement (meters): The typical source levels reference is 1 meter from the source. However, for activities such as impact pile driving, the typical distance is 10 meters or more. The action proponent enters whatever value is appropriate for their specific source.

Within Step 3 is one white cell, that the action proponent cannot modify, which represents calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Unweighted SEL_{cum} (at measured distance) = SELss + 10 Log (# strikes): This cell calculates the unweighted SEL_{cum} from the prior values entered in this tab. This equation is often used to derive cumulative exposure from pile driving activities (e.g. Caltrans 2015).

E.1-1: METHOD TO CALCULATE PK AND SEL_{cum} (SINGLE STRIKE EQUIVAL	
Unweighted SEL_{cum} (at measured distance) = SEL_{ss} + 10 Log (# strikes)	#NUM!
SEL_{cum}	
Single Strike SEL_{ss} ($L_{E,p,\ single\ strike}$) specified at "x" meters (Cell B32)	
Number of strikes per pile	
Number of piles per day	
Transmission loss coefficient	
Distance of single strike SEL_{ss} ($L_{E,p,\ single\ strike}$) measurement (meters)	

Figure 39: Screenshot of Step 3, Method E.1-1 for Tab E.1.

Step 3 also asks for source level in the peak sound pressure level (PK) metric, since impulsive sources have dual thresholds.

- PK SPL specified at "x" meters: The updated version of the optional User Spreadsheet tool (Version 2.0) now allows action proponents to evaluate the Technical Guidance's peak sound pressure level (PK) thresholds. If the PK SPL provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

  For impact pile driving hammers, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead, for these sources, sound levels (L_{rms}, Single Strike SEL, or PK) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

- Distance of sound pressure level measurement (meters): The typical source levels reference is 1 meter from the source. However, for activities such as impact pile driving, the typical distance is 10 meters or more. The action proponent enters whatever value is appropriate for their specific source.

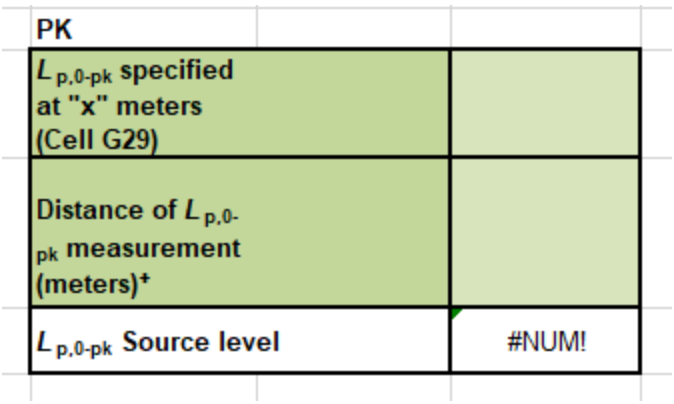


Figure 40: Screenshot of inputs associated with peak sound pressure level.

NOTE: Technical Guidance recommends that the PK thresholds are unweighted/flat-weighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz).

If an action proponent get output "NA" instead of a numerical isopleth associated with the PTS PK isopleth, this means the PK source level is less than or equal to the threshold for the particular marine mammal hearing group.

Lippert et al. (2015) provide methodology to predict PK SPL from SELss, if values are unknown.

E.1-2: Method using L_{rms} Source Level

These sage cells are for providing information regarding:

- Sound Pressure Level (L_{rms}), specified at "x" meters: Sound pressure level in the root mean square sound pressure level metric specified a certain distance from the source. If the sound pressure level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.
  For impact pile driving hammers, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead for these sources, sound levels (L_{rms}, Single Strike SEL, or PK) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

- Number of piles per day: Number of piles expected to be driven within a 24-h period.

- Strike (pulse) duration (seconds): Duration of strike (pulse) (i.e., Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005). If this value is unknown, NMFS recommends using a default value of 100 msec (See Appendix B).

- Number of strikes per pile: Representative (typical) number of strikes per pile.

- Transmission loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell and specify this in the sage Project/Source Information in Step 1. If not, NMFS recommends that an action proponent contact them to determine an appropriate surrogate value.

  USER TIP: For pile driving projects occurring in shallow, coastal areas, NMFS typically recommends practical spreading (TL=15 log R2/R1, where R1 is the range for a close range measurement, typically 10 m from the pile source, and R2 is a longer range at which an

underwater sound metric such a peak pressure, or sound exposure level is estimated (Dahl et al. 2012)).

- Distance of sound pressure level measurement (meters): The typical source levels reference is 1 meter from the source. However, for activities such as impact pile driving, the typical distance is 10 meters or more. The action proponent enters whatever value is appropriate for their specific source.

Within Step 3 are two white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Duration of Sound Production (seconds): The duration, in seconds, within a 24-h period that the source is producing sound. This value is derived by multiplying the sage input of number of piles per day by the strike duration by the number of strikes per pile. It is recommended that an action proponent crosscheck this value to ensure it is accurately reflecting the total duration (in seconds) the source is expected to produce wound within a 24-h period.

  FICTITIOUS EXAMPLE: If there are 10 piles expected to be driven in one day, with 1000 strikes per pile, and a strike duration of 0.100 sec (100 msec), then the activity duration would be 1000 seconds.

- 10 Log duration of sound production: This cell is 10 log the duration of the activity duration in seconds and represents the necessary duration of exposure needed to calculate PTS onset isopleths in the SEL_{cum} metric. The larger the number, the longer the duration of exposure.

  NOTE: Since the Technical Guidance recommends a maximum accumulation period of 24-h, the maximum Activity duration (seconds) is 86400 (i.e., number of seconds within a 24-h period), and the maximum value in the 10 Log duration of sound production cell is 49.37. If an action proponent notices values in these cells are larger than this, there is an error.
  Since this tab is for impact pile driving, which is intermittent, this value is never be 49.37 (i.e., always less).

E.1.2: METHOD TO CALCULATE PK AND SEL_{cum} (USING RMS SPL SOURCE LEV	
SEL_{cum}	
Sound Pressure Level (L_{rms}), specified at "x" meters (Cell B53)	
Number of piles per day	
Strike (pulse) Duration$^{\Delta}$ (seconds)	
Number of strikes per pile	
Duration of Sound Production (seconds)	0
10 Log (duration of sound production)	#NUM!
Transmission loss coefficient	
Distance of sound pressure level (L_{rms}) measurement (meters)	
$^{\Delta}$Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005	

Figure 41: Screenshot of Step 3, Method E.1-2 for Tab E.1.

Step 3 also asks for source level in the peak sound pressure level (PK) metric, since impulsive sources have dual thresholds.

- PK SPL specified at "x" meters: The updated version of the optional User Spreadsheet tool (Version 2.0) now allows action proponents to evaluate the Technical Guidance's peak sound pressure level (PK) thresholds. If the PK SPL provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.
  For impact pile driving hammers, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead, for these sources, sound levels (L_{rms}, Single Strike SEL, or PK) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

- Distance of sound pressure level measurement (meters): The typical source levels reference is 1 meter from the source. However, for activities such as impact pile driving, the typical distance is 10 meters or more. The action proponent enters whatever value is appropriate for their specific source.

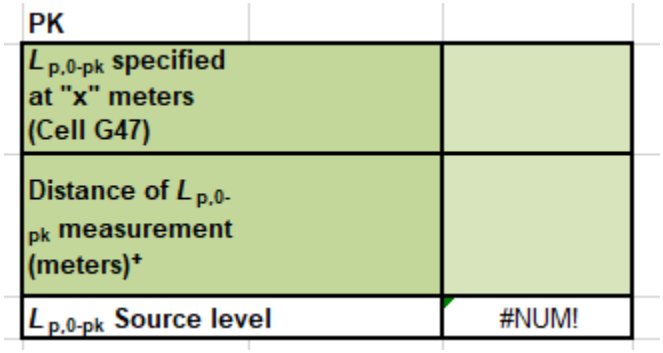


Figure 42: Screenshot of inputs associated with peak sound pressure level.

NOTE: Technical Guidance recommends that the PK thresholds are unweighted/flat-weighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz).
If an action proponent get output "NA" instead of a numerical isopleth associated with the PTS PK isopleth, this means the PK source level is less than or equal to the threshold for the particular marine mammal hearing group.

6.6.E1.4 Resultant Isopleths

Under either methods E.1-1 or E.1-2 (depending on action proponent's preference), rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} metric and PK metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleths (SEL_{cum} metric and PK), in meters, for each marine mammal hearing group. Since both SEL_{cum} and PK resultant isopleths are provided, the action proponent relies on whichever metric produces the largest isopleth.

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
PK Threshold	219	230	202	218	232
PTS PK Isopleth to threshold (meters)	NA	NA	NA	NA	NA

Figure 43: Screenshot of Resultant Isopleths for Tab E.1.

NOTE: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.6.E2 DTH PILE DRIVING/INSTALLATION (TAB E.2: TEAL)[21]

Tab E.2 is for use specifically with DTH pile driving/installation activities.

> **NOTE**: DTH pile driving/installation often involved both drilling (non-impulsive sound) and hammering (impulsive sound) to penetrate rocky substrates (Denes et al. 2016; Denes et al. 2019; Reyff and Heyvaert 2019). In terms of evaluating PTS onset, DTH pile driving/installation activities are evaluated using the impulsive criteria. If DTH installation strictly involves only drilling (non-impulsive sound), then it may be more appropriate to rely upon the Vibratory pile driving tab (Tab A.1).
>
> This DTH pile driving/installation tab is designed to more user-friendly for this type of activity. However, action proponents may find the Impact pile driving tab (Tab E.1) to be more appropriate for their evaluation. If so, NMFS recommends action proponents only use Method E.1-2 from Tab E.1 (i.e., Method E.1-1 requires the action proponent to specify strike (pulse) duration, which may be highly variable for DTH pile driving/installation).

6.6.E2.1 Step 1: General Project Information

These sage cells provide information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.

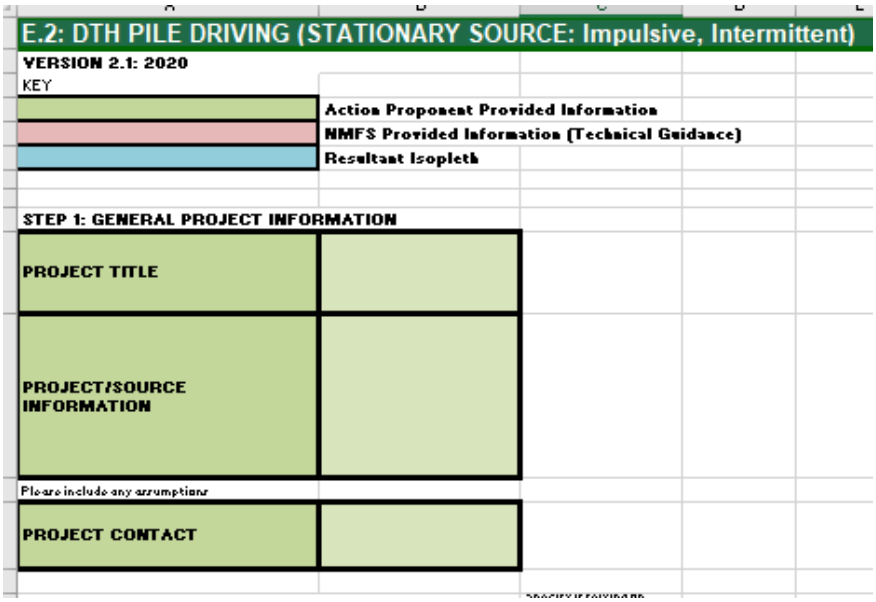


Figure 44: Screenshot of Step 1 for Tab E.2.

> **NOTE**: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure the optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

[21] Note: The DTH pile driving/installation option is only available via this optional User Spreadsheet tool. It is currently not available for the optional Web Calculator tool.

6.6.E2.2 Step 2: Weighting Factor Adjustment

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting functions:

- Broadband source: Provide the 95% frequency contour percentile (kHz)

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default WFA or spectrum value.
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within the optional User Spreadsheet tool).

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, action proponents must ensure chosen WFA is within a hearing group's applicable frequency range (Table 16).

Table 16: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

In the case of the NMFS suggested default of 2 kHz, this value is within each hearing group's applicable frequency range.

The term "override" refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these "blank" cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

If an action proponent decides to override the optional User Spreadsheet tool's WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet's default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

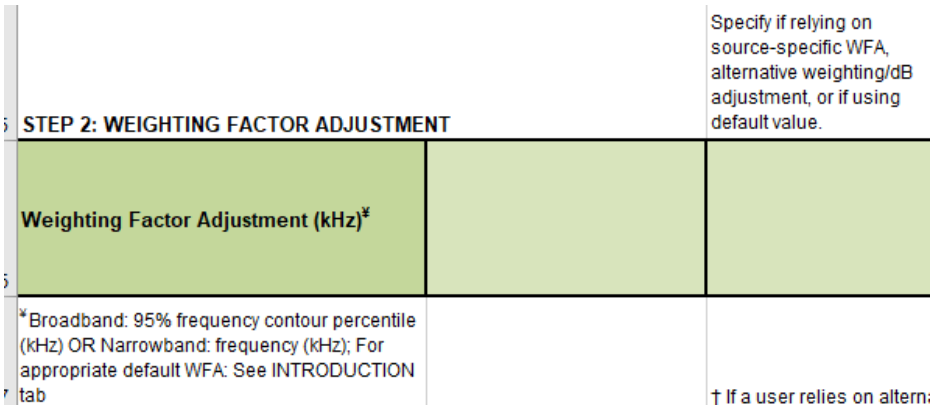


Figure 45: Screenshot of Step 2 for Tab E.2.

6.6.E1.3 Step 3: Source-Specific Information

These sage cells are for providing information regarding:

- Single Strike SEL specified at "x" meters: Single strike SEL metric measured a certain distance from the source. If the single strike SEL provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: This single strike SEL metric represents the sound exposure of a single strike and is not cumulative.

  When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

  For DTH pile driving hammers, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead, for these sources, sound levels (L_{rms}, Single Strike SEL, or PK) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

- Strike rate (strikes per second): Average strikes per second. If the action proponent does not know strike rate, this information may be available from the hammer manufacturer.

  USER TIP: Sometimes strike rate may be presented as x Hz. If this is the case, then x can be entered into this cell (e.g., if strike rate was 10 Hz, then the action proponent can simply enter 10 into this cell).

  Additionally, if strike rate is presented as strikes per minute, then the action proponent will need to convert to strikes per second by dividing strikes per minute by 60, and enter this value into the cell (e.g., 600 strikes per minute divided by 60 equals 10 strikes per second).

  NOTE: Action proponent does not need to consider pulse duration, which is already accounted for in the single shot/strike SEL source level.

- Duration to drive a pile (minutes): This is the amount of time needed to drive a pile in minutes. This duration assume sound is produced during the entire time.

- Number of piles per day: Number of piles expected to be driven within a 24-h period.

- Transmission loss coefficient: If an action proponent has site-specific propagation loss information, they may enter it in this cell and specify this in the sage Project/Source Information in

Step 1. If not, NMFS recommends that an action proponent contact them to determine an appropriate surrogate value.

USER TIP: For pile driving projects occurring in shallow, coastal areas, NMFS typically recommends practical spreading (TL=15 log R2/R1, where R1 is the range for a close range measurement, typically 10 m from the pile source, and R2 is a longer range at which an underwater sound metric such a peak pressure, or sound exposure level is estimated (Dahl et al. 2012)).

- Distance of sound pressure level measurement (meters): The typical source levels reference is 1 meter from the source. However, for activities such as down-the-hole pile driving, the typical distance is 10 meters or more. The action proponent enters whatever value is appropriate for their specific source.

Within Step 3 is two white cells, that the action proponent cannot modify, which represents calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Unweighted SEL_{cum} (at measured distance) = SELss + 10 Log (# strikes): This cell calculates the unweighted SEL_{cum} from the prior values entered in this tab. This equation is often used to derive cumulative exposure from pile driving activities (e.g. Caltrans 2015).

- Total number of strikes in a 24-h period: This cell calculates the total number of strikes occurring in a 24-h period by multiplying strike rate times amount of time to drive a pile (minutes converted to seconds). Action proponents are encouraged to check this number to see if it is representative of their activity within a 24-h period.

STEP 3: SOURCE-SPECIFIC INFORMATION	
Unweighted $SEL_{cum\ (at\ measured\ distance)}$ = SEL_{ss} + 10 Log (# strikes)	#NUM!
SEL_{cum}	
Single Strike SEL_{ss} ($L_{E,p,\ single\ strike}$) specified at "x" meters (Cell B30)	
Strike rate (average strikes per second)	
Duration to drive pile (minutes)	
Number of piles per day	
Transmission loss coefficient	
Distance of single strike SEL_{ss} ($L_{E,p,\ single\ strike}$) measurement (meters)	
Total number of strikes in a 24-h period	0

Figure 46: Screenshot of Step 3 for Tab E.2

Step 3 also asks for source level in the peak sound pressure level (PK) metric, since impulsive sources have dual thresholds.

- PK SPL specified at "x" meters: The updated version of the optional User Spreadsheet tool (Version 2.0) now allows action proponents to evaluate the Technical Guidance's peak sound pressure level (PK) thresholds. If the PK SPL provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

  For DTH pile driving hammers, true source levels (i.e., levels reference to 1 m from the source) are typically not provided. Instead, for these sources, sound levels (L_{rms}, Single Strike SEL, or PK) are typically referenced 10 m from the source. Thus, for these sources, the action proponent is also asked to specify the distance of the sound level measurement.

- Distance of sound pressure level measurement (meters): The typical source levels reference is 1 meter from the source. However, for activities such as impact pile driving, the typical distance is 10 meters or more. The action proponent enters whatever value is appropriate for their specific source.

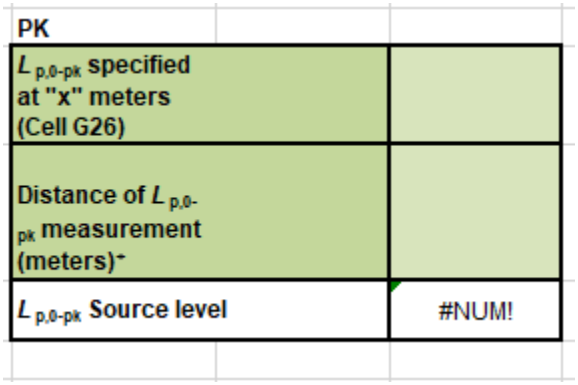


Figure 47: Screenshot of inputs associated with peak sound pressure level.

NOTE: Technical Guidance recommends that the PK thresholds are unweighted/flat-weighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz).

If an action proponent get output "NA" instead of a numerical isopleth associated with the PTS PK isopleth, this means the PK source level is less than or equal to the threshold for the particular marine mammal hearing group.

6.6.E1.4 Resultant Isopleths

Rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} metric and PK metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleths (SEL_{cum} metric and PK), in meters, for each marine mammal hearing group. Since both SEL_{cum} and PK resultant isopleths are provided, the action proponent relies on whichever metric produces the largest isopleth.

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
PK Threshold	219	230	202	218	232
PTS PK Isopleth to threshold (meters)	NA	NA	NA	NA	NA

Figure 48: Screenshot of Resultant Isopleths for Tab E.2.

NOTE: The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.7 IMPULSIVE, MOBILE (TAB F: PURPLE)

Tab F is for use with impulsive, mobile sources that are inherently intermittent temporally. This tab's calculations rely upon the "safe distance" methodology from Sivle et al. (2014). The use of this tab is appropriate for seismic surveys.

> **NOTE**: The assumptions associated with the "safe distance" methodology may not be appropriate, if the source has the potential to move in a manner where the same group of receivers could be exposed to multiple passes from the source.

6.7.1 Step 1: General Project Information

These sage cells provide information regarding:

- Project Title: Project type and location.
- Project/Source Information: Basic information about the activity as well as any assumptions included in when completing the optional User Spreadsheet tool.
- Project Contact: Person responsible for completing the optional User Spreadsheet tool.

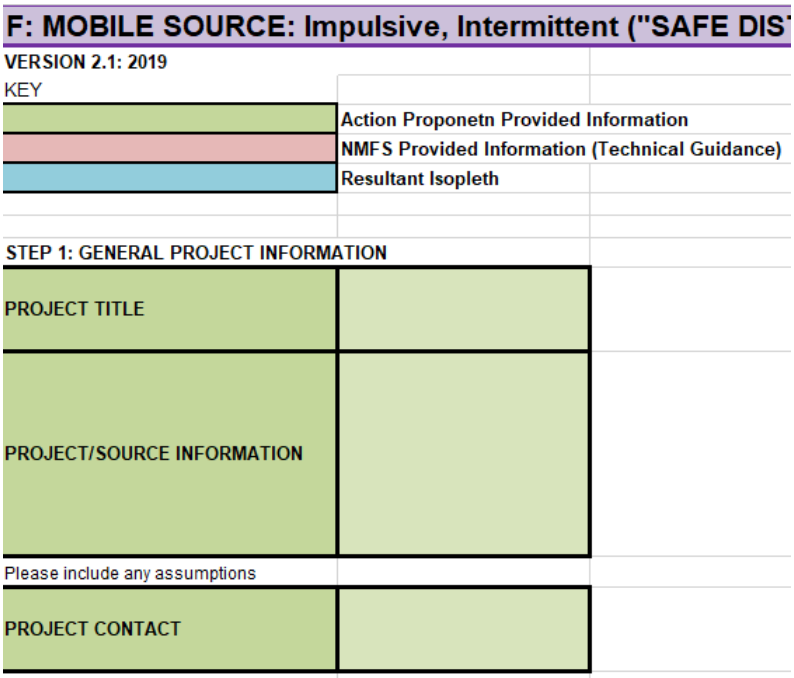
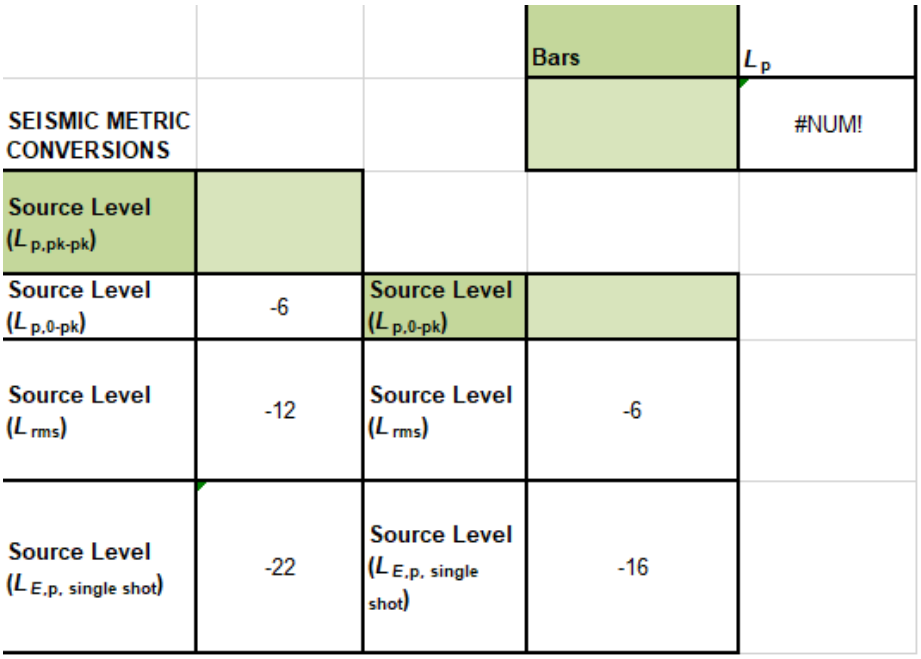


Figure 49: Screenshot of Step 1 for Tab F.

> **NOTE**: This set of sage cells does not need to be complete in order for the tab to calculate resultant PTS onset isopleths. However, this information is useful to ensure the optional User Spreadsheet tool inputs are entered correctly for a particular project/source.

Tab F also provides some generic, unweighted source level metric conversions for seismic airgun sources to offer additional flexibility to action proponents, if they only have source levels in a single metric (e.g., bar, PK sound pressure level, or peak-to-peak sound pressure level) (Gisiner et al. 2020).



			Bars	L_p
SEISMIC METRIC CONVERSIONS				#NUM!
Source Level ($L_{p,pk-pk}$)				
Source Level ($L_{p,0-pk}$)	-6	Source Level ($L_{p,0-pk}$)		
Source Level (L_{rms})	-12	Source Level (L_{rms})	-6	
Source Level ($L_{E,p,\ single\ shot}$)	-22	Source Level ($L_{E,p,\ single\ shot}$)	-16	

Figure 50: Screenshot of seismic (airgun) metric source level conversions.

6.7.2 Step 2: Weighting Factor Adjustment

This sage cell provides information for incorporating the Technical Guidance's marine mammal auditory weighting function:

- Broadband source: Provide the 95% frequency contour percentile (kHz)

An action proponent specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default WFA or spectrum value.
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within the optional User Spreadsheet tool).

NOTE: This cell **does** need an input for the tab to calculate resultant PTS onset isopleths (i.e., if a WFA value is not entered, this tab cannot calculate an isopleth). The only exception to this rule is if an action proponent plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, action proponents must ensure chosen WFA is within a hearing group's applicable frequency range (Table 17).

Table 17: Applicability of weighting factor adjustments for broadband sources.

Source-Specific WFA	Hearing Group to be Treated as Unweighted
Above 5 kHz	LF Cetaceans
Above 9 kHz	LF Cetaceans & Otariid Pinnipeds
Above 11 kHz	LF Cetaceans, Otariid Pinnipeds, & Phocid Pinnipeds

If WFA is not within an applicable frequency range for a group, then action proponents are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

The term “override” refers to an action proponent incorporating a more appropriate Adjustment (-dB). It does not refer to the action proponent overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Action proponents may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the optional User Spreadsheet. This is not an error. There are additional formulas in these “blank” cells related to the weighting function calculation that are not visible (hidden) to the action proponent.

NOTE: For seismic airguns there are some considerations for a default spectrum in Section 3.2.1 (e.g., Gisiner et al. 2020).

If an action proponent decides to override the optional User Spreadsheet tool’s WFA output (i.e., Adjustment (-dB)) to make the source either unweighted (i.e., set Adjustment to zero) or to input specific information on the spectrum associated with their source, it is important to understand that by doing so, one is also overriding the built-in calculations associated with these cells. Thus, if an action proponent later desires to rely upon the optional User Spreadsheet’s default WFA calculations, they will need to download another copy of the optional User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

Adjustments (-dB) are always either zero or a negative value (i.e., they are never positive).

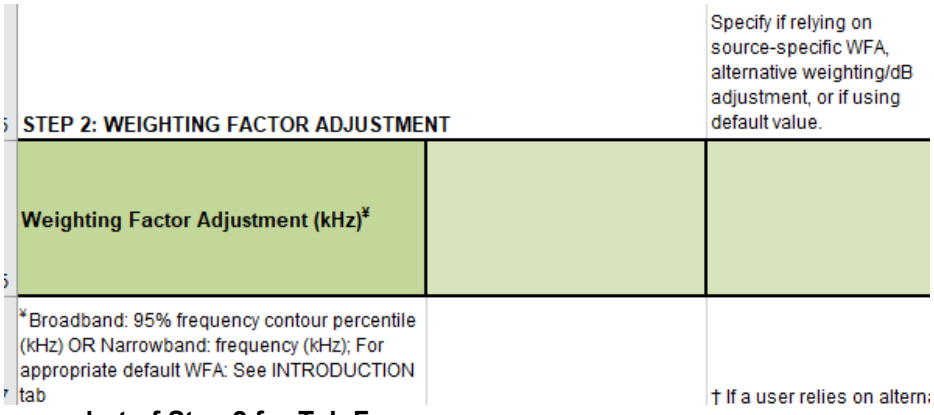


Figure 51: Screenshot of Step 2 for Tab F.

6.7.3 Step 3: Source-Specific Information

There are two methods an action proponent can choose (i.e., F1 OR F2) to calculate isopleths. Method F1 is preferred when SEL-based source levels are available (because pulse duration is not required). Only use method F2 if SEL-based source levels are not available.

NOTE: The action proponent is not required to fill in sage boxes for both methods (i.e., the action proponent is to pick one method OR the other).

If the action proponent has unweighted source level information expressed in the SEL metric, then determining the pulse duration is not necessary. Many of the sound source tabs provide a choice between two methods (i.e., one relying on L_{rms} source levels or one relying upon SEL source levels). NMFS advises action proponents to rely on the method using the SEL source level, so needing to determine the pulse duration (or appropriate default) is not necessary. For this tab, this would be method F1.

F1: Preferred Method (Single strike/shot/pulse equivalent)

These sage cells are for providing information regarding:

- Source Level (Single shot/pulse SEL): Source level in single shot/pulse SEL metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

NOTE: This single shot/pulse SEL metric represents the sound exposure of a single ping/pulse and is not cumulative.

When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Source Velocity: Represents the source velocity (i.e., if source attached to vessel, it is the vessel speed).

  NOTE: For seismic airgun surveys, a default source velocity of 2.5 m/sec may be an appropriate default for source velocity (Gisiner et al. 2020).

- 1/Repetition Rate (seconds): 1/Number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second OR the time between onset of successive pulses (inverse of repetition rate or inter-pulse interval).
- **FICTITIOUS EXAMPLE**: If a device produces a 9-second ping every 6 seconds, then 1/repetition
- rate would be 15 seconds (i.e., onset between successive pulses is 15 seconds).

  NOTE: For seismic airgun surveys, a default 1/repetition rate of 10 seconds may be an appropriate
- default value (Gisiner et al. 2020).
-
  The F1 Method does not require the action proponent to consider pulse duration, which already
- accounted for in the single ping/pulse SEL source level.
  This tab does not require the action proponent to specify the propagation loss coefficient. The "safe distance" methodology assumes propagation loss of 20 log R. Additionally, this tab does not ask the action proponent to specify the duration of the activity within a 24-h period. This is because this methodology is activity duration (time) independent.

Within Step 3 is one white cell, that the action proponent cannot modify, which represents calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Source factor: This cell converts the source level to micropascals (i.e., source factor) and then multiplies that value times the duty cycle to complete the calculation associated with "safe distance" methodology.

F1: METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE SHOT/PULSE EQUIVALENT)	
SEL_{cum}	
Source Level ($L_{E,p,\ single\ ping/pulse/shot}$)	
Source Velocity (meters/second)	
1/Repetition rate^ (seconds)	
Source Factor	#DIV/0!
†Methodology assumes propagation loss of 20 log R; Activity duration (time) independent	
^Time between onset of successive pulses.	

Figure 52: Screenshot of Step 3, Method F1 for Tab F.

Step 3 also asks for source level in the peak sound pressure level (PK) metric, since impulsive sources have dual thresholds.

- Source Level (PK SPL): The updated version of the optional User Spreadsheet tool (Version 2.0) now allows action proponents to evaluate the Technical Guidance's peak sound pressure level (PK) thresholds. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

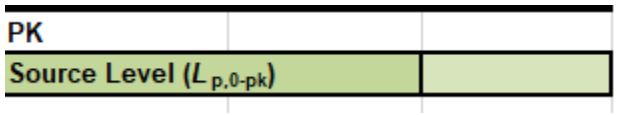


Figure 53: Screenshot of inputs associated with peak sound pressure level.

NOTE: Technical Guidance recommends that the PK thresholds are unweighted/flat-weighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz).

If an action proponent get output "NA" instead of a numerical isopleth associated with the PTS PK isopleth, this means the PK source level is less than or equal to the threshold for the particular marine mammal hearing group.

Galindo-Romero et al. (2015) provide methodology to predict PK SPL from SELss for seismic arrays, if values are unknown.

F2: Method using L_{rms} Source Level

These sage cells are for providing information regarding:

- Source Level (L_{rms}): Source level in the root mean square sound pressure level metric. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).

  NOTE: When relying upon the optional User Spreadsheet tool, action proponents are to provide unweighted source levels. The Technical Guidance's auditory weighting functions are incorporated via the Adjustment (-dB) in the last row of each sound source tab.

- Source Velocity: Represents the source velocity (i.e., if source attached to vessel, it is the vessel speed).

  NOTE: For seismic airgun surveys, a default source velocity of 2.5 m/sec may be an appropriate default for source velocity (Gisiner et al. 2020).

- Pulse Duration (seconds): Duration of pulse/shot (i.e., Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005). If this value is unknown, NMFS recommends using a default value of 100 msec for seismic airguns (See Appendix C).

- 1/Repetition Rate (seconds): 1/Number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second OR the time between onset of successive pulses (inverse of repetition rate or inter-pulse interval).

- **NOTE**: For seismic airgun surveys, a default 1/repetition rate of 10 seconds may be an appropriate default value (Gisiner et al. 2020).

- **FICTITIOUS EXAMPLE**: If a device produces a 9-second ping every 6 seconds, then 1/repetition rate would be 15 seconds (i.e., onset between successive pulses is 15 seconds).

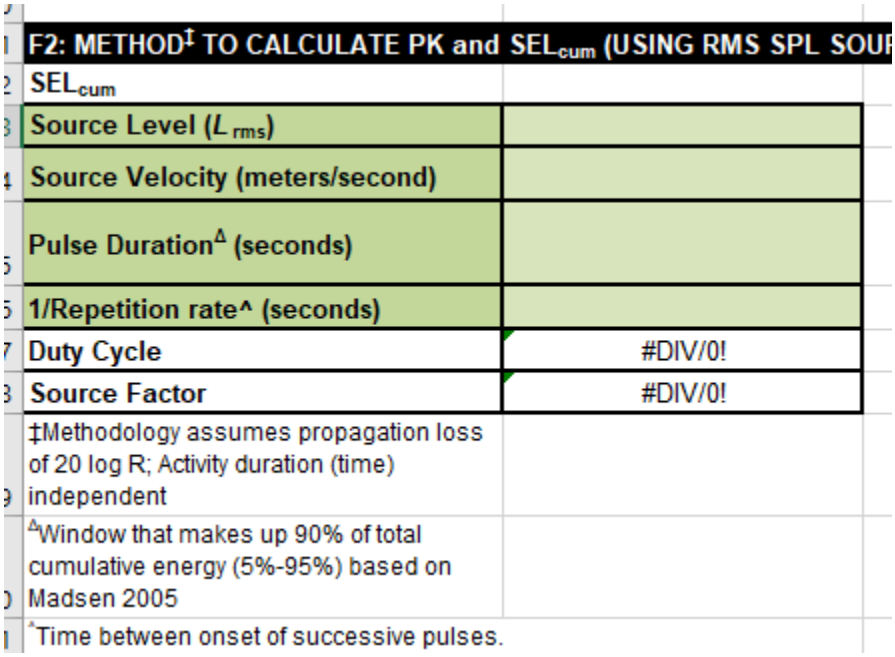
  NOTE: This tab does not require the action proponent to specify the propagation loss coefficient. The "safe distance" methodology assumes propagation loss of 20 log R. Additionally, this tab does not ask the action proponent to specify the duration of the activity within a 24-h period. This is because this methodology is activity duration (time) independent.

Within Step 3 are two white cells, that the action proponent cannot modify, which represent calculations and/or factors done automatically within the optional User Spreadsheet tool to produce resultant PTS onset isopleths:

- Duty cycle: Pulse duration divided by 1/repetition rate (inter-pulse interval) or the percent of time source produces sound (i.e., time on vs. time off).

  FICTITIOUS EXAMPLE: If a device has a 0.10 (or 10%) duty cycle, this indicates sound is produced or is "on" 10% time and is silent or "off" 90% of the time.

- Source factor: This cell converts the unweighted source level to micropascals (i.e., source factor) and then multiplies that value times the duty cycle to complete the calculation associated with "safe distance" methodology.

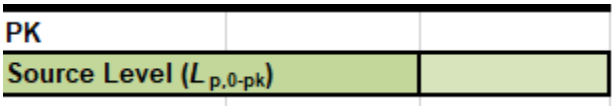


F2: METHOD‡ TO CALCULATE PK and SEL_{cum} (USING RMS SPL SOUF	
SEL_{cum}	
Source Level (L_{rms})	
Source Velocity (meters/second)	
Pulse Duration$^{\Delta}$ (seconds)	
1/Repetition rate^ (seconds)	
Duty Cycle	#DIV/0!
Source Factor	#DIV/0!
‡Methodology assumes propagation loss of 20 log R; Activity duration (time) independent	
$^{\Delta}$Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005	
^Time between onset of successive pulses.	

Figure 54: Screenshot of Step 3, Method F2 for Tab F.

Step 3 also asks for source level in the peak sound pressure level (PK) metric, since impulsive sources have dual thresholds.

- Source Level (PK SPL): The updated version of the optional User Spreadsheet tool (Version 2.0) now allows action proponents to evaluate the Technical Guidance's peak sound pressure level (PK) thresholds. If the source level provided includes an attenuation methods (e.g., bubble curtain), please note that in the Project/Source Information cell in Step 1 (i.e., attenuated source level via *xx* method).



PK	
Source Level ($L_{p,0\text{-}pk}$)	

Figure 55: Screenshot of inputs associated with peak sound pressure level.

NOTE: Technical Guidance recommends that the PK thresholds are unweighted/flat-weighted within the generalized hearing range of marine mammals (i.e., 7 Hz to 160 kHz).

If an action proponent get output "NA" instead of a numerical isopleth associated with the PTS PK isopleth, this means the PK source level is less than or equal to the threshold for the particular marine mammal hearing group.

For seismic arrays, RMS levels are typically 10 dB lower than PK (Harris et al. 2001; Breitzke et al. 2008).

6.7.4 Resultant Isopleths

Under either methods F1 or F2 (depending on action proponent's preference), rose cells display the Technical Guidance's PTS onset non-impulsive thresholds, in the SEL_{cum} and PK metric, by marine mammal hearing group. The sky blue cells provide the resultant PTS onset isopleths (SEL_{cum} and PK metrics), in meters, for each marine mammal hearing group. Since both SEL_{cum} and PK resultant isopleths are provided, the action proponent relies on whichever metric produces the largest isopleth.

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
PK Threshold	219	230	202	218	232
PTS PK Isopleth to threshold (meters)	NA	NA	NA	NA	NA

Figure 56: Screenshot of Resultant Isopleths for Tab F.

NOTE: Since airgun arrays are distributed sources and do not act as a point source close to the array, consideration should be given to whether resultant isopleths reside in the near or far field (Caldwell and Dragoset 2000; Tolstoy et al. 2009; Gisiner et al. 2020).

The optional User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the optional User Spreadsheet tool.

If there is an error in the sky blue cells (i.e., #NUM!), please make sure all sage cells from Steps 2 and 3 are completed/have inputs. One of the most common reasons for this error is from action proponents forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

APPENDIX A: SUMMARY OF TECHNICAL GUIDANCE THRESHOLDS AND AUDITORY WEIGHTING FUNCTIONS

Table A1: Marine mammal hearing groups.

Hearing Group	Generalized Hearing Range*
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-frequency (HF) cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz

***** 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).

Table A2: Summary of auditory weighting and exposure function parameters.*

Hearing Group	*a*	*b*	f_1 (kHz)	f_2 (kHz)	*C* (dB)	*K* (dB)
Low-frequency (LF) cetaceans	1.0	2	0.2	19	0.13	179
Mid-frequency (MF) cetaceans	1.6	2	8.8	110	1.20	177
High-frequency (HF) cetaceans	1.8	2	12	140	1.36	152
Phocid pinnipeds (PW) (underwater)	1.0	2	1.9	30	0.75	180
Otariid pinnipeds (OW) (underwater)	2.0	2	0.94	25	0.64	198

* Equations associated with Technical Guidance's auditory weighting ($W_{aud}(f)$) (dB) and exposure functions ($E_{aud}(f)$) (dB):

$$W_{aud}(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a\,[1+(f/f_2)^2]^b}\right\}$$

$$E_{aud}(f) = K - 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{\left[1+(f/f_1)^2\right]^a\left[1+(f/f_2)^2\right]^b}\right\}$$

Table A3: Summary of PTS onset acoustic thresholds.

	PTS Onset Thresholds* (Received Level)	
Hearing Group	**Impulsive**	**Non-impulsive**
Low-Frequency (LF) Cetaceans	*Cell 1* $L_{p,0\text{-pk,flat}}$: 219 dB $L_{E,p,\text{ LF,24h}}$: 183 dB	*Cell 2* $L_{E,p,\text{ LF,24h}}$: 199 dB
Mid-Frequency (MF) Cetaceans	*Cell 3* $L_{p,0\text{-pk,flat}}$: 230 dB $L_{E,p,\text{ MF,24h}}$: 185 dB	*Cell 4* $L_{E,p,\text{ MF,24h}}$: 198 dB
High-Frequency (HF) Cetaceans	*Cell 5* $L_{p,0\text{-pk,flat}}$: 202 dB $L_{E,p,\text{HF,24h}}$: 155 dB	*Cell 6* $L_{E,p,\text{ HF,24h}}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	*Cell 7* $L_{p,0\text{-pk.flat}}$: 218 dB $L_{E,p,\text{PW,24h}}$: 185 dB	*Cell 8* $L_{E,p,\text{PW,24h}}$: 201 dB
Otariid Pinnipeds (OW) (Underwater)	*Cell 9* $L_{p,0\text{-pk,flat}}$: 232 dB $L_{E,p,\text{OW,24h}}$: 203 dB	*Cell 10* $L_{E,p,\text{OW,24h}}$: 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 ($L_{p,0\text{-pk}}$) 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 marine mammals (i.e., 7 Hz to 160 kHz). The subscript associated with 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 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.

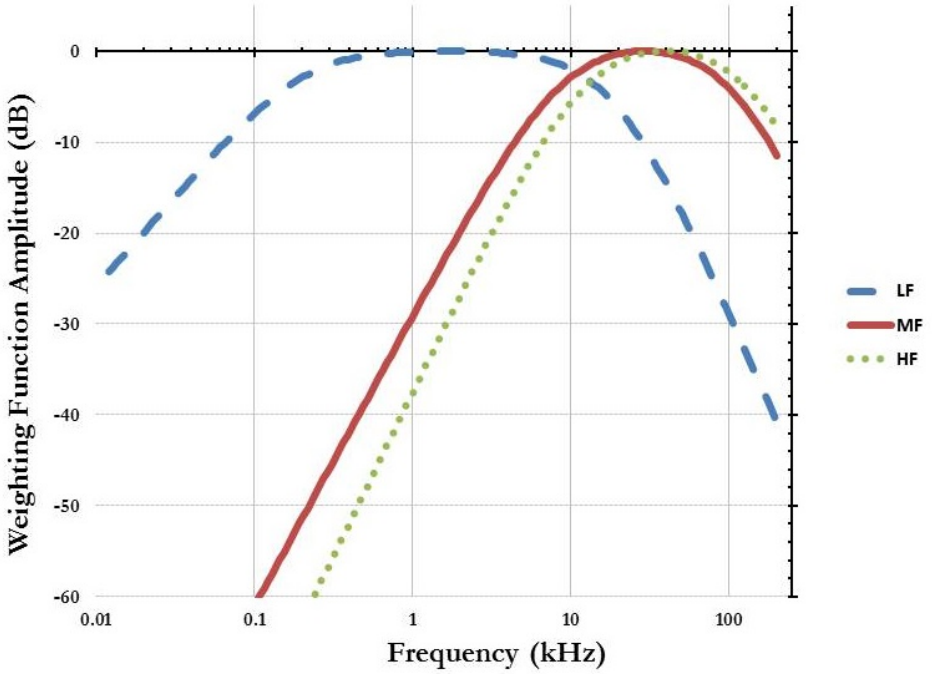


Figure A1: **Auditory weighting functions for low-frequency (LF), mid-frequency (MF), and high-frequency (HF) cetaceans.**

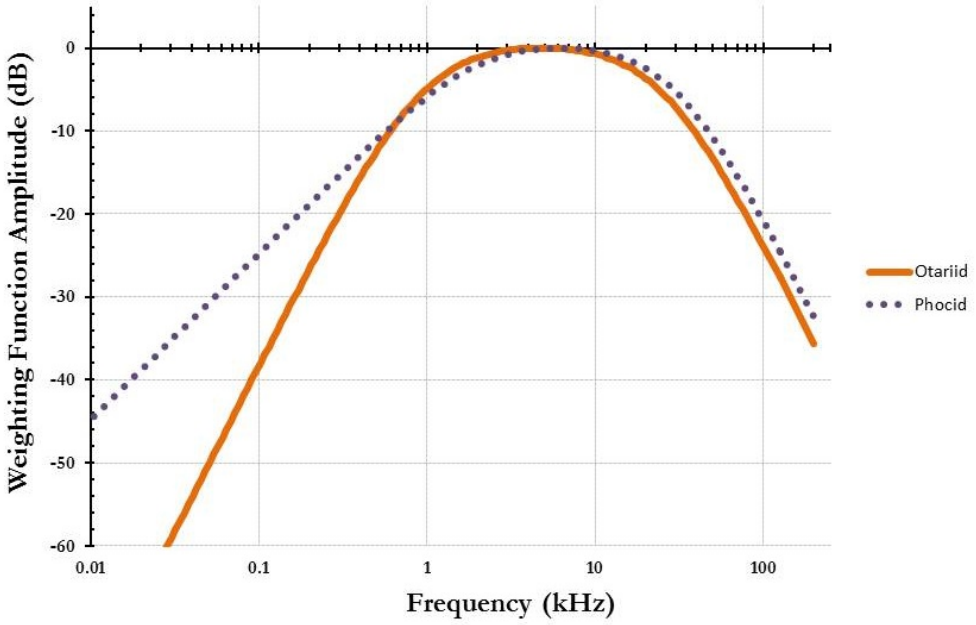


Figure A2: **Underwater auditory weighting functions for otariid (OW) and phocid (PW) pinnipeds.**

APPENDIX B: RECOMMENDED 100 MSEC (DEFAULT) PULSE DURATION FOR IMPACT PILE DRIVING ACTIVITIES[22]

NOTE: If the action proponent has unweighted source level information expressed in the SEL metric, then determining the pulse duration is not necessary. Many of the sound source tabs provide a choice between two methods (i.e., one relying on L_{rms} source levels or one relying upon SEL source levels). NMFS advises action proponents to rely on the method using the SEL source level, so needing to determine the pulse duration (or appropriate default) is not necessary.

Additionally, if the action proponent has direct pulse duration information, then they are encouraged to use this direct information, rather than the default value provided in this Appendix.

1.0 INTRODUCTION

The optional User Spreadsheet tool provides an optional tool for approximating isopleths associated with the Guidance's updated PTS onset thresholds. When information is unavailable for an action proponent to accurately fill-out the optional User Spreadsheet tool's "Action Proponent Provided Information" (Sage cells), then default values are needed for substitution. NMFS has worked to provide appropriate default values for several of these cells within the optional User Spreadsheet tool (e.g., default weighting factor adjustments (WFAs) for various sound sources). However, it has become necessary to provide further appropriate default values, including pulse duration for impulsive sources (i.e., impact pile driving hammer strikes and seismic airgun shots (Appendix C)).

Defaults are meant to be conservative in order to encompass the broad potential range of values associated with an activity or sound source (e.g., for pile driving variation could result from water depth associated with activity, sediment characteristics, pile diameter, pile material, etc.). Thus, an action proponent is always encouraged to use activity-specific information, if available, as a substitute for using NMFS' recommended default values, as this activity-specific information will provide a more realistic representation of the isopleths associated with that activity.

> **NOTE**: When a single strike SEL source level is available, action proponents are encouraged to use this value. By doing so, there is no need to specify a pulse duration (default or otherwise).

2.0 DERIVATION OF DEFAULT PULSE DURATION FOR IMPACT PILE DRIVING ACTIVITIES

As impulsive sounds propagate through the environment, their physical characteristics begin to change. For example, pulse duration increases because of multipath propagation loss[23] and reverberation (e.g., Richardson 2000; Blackwell et al. 2004b; Madsen et al. 2006). Range (R) from the source, as well as water depth (H), are important factors contributing to pulse duration (i.e., more multipath arrivals in shallower water and with higher R/H ratio; Harrison and Nielsen 2007; Harrison 2011; Ainslie et al. 2014). For example, Tolstoy et al. (2009) demonstrated this with seismic airgun shots stating, "reverberations in the shallow arrivals mean that the 90% RMS integration window is longer, whereas deep arrivals are more impulsive and therefore have a shorter integration window." This same phenomenon also occurs for impact pile driving hammer strikes (e.g., Robinson et al. 2007). Thus, NMFS evaluated the available data to determine what would be an appropriate default pulse duration for impact pile driving activities considering these various factors.

2.1 Analysis of Caltrans (2015) Compendium

The Compendium (Appendix I) within Caltrans (2015) provides one of the most comprehensive resources for previously measured coastal pile driving activities. Using the summary data provided at the beginning

[22] Note: This Appendix is only valid for impact pile driving and not for DTH pile driving/installation.

[23] Multipath propagation loss occurs whenever there is more than one propagation path between the source and receiver (i.e., direct path and paths from reflections off the surface and bottom or reflections within a surface or deep-ocean duct; Urick 1983).

of this compendium, 10 m levels expressed as single strike SEL, PK, and L_{rms} levels were analyzed for all pile types (e.g., steel, concrete) (Table B1).

Table B1: Caltrans (2015) Compendium analysis.*

PEAK-RMS			PEAK-SEL			RMS-SEL	
Mean	**17.9393939**		**Mean**	**28.48438**		**Mean**	**11.24**
Standard Er	0.82328547		Standard Error	0.597196		Standard Error	0.354055
Median	15.5		Median	28		Median	10.5
Mode	**15**		**Mode**	**25**		**Mode**	**10**
Standard De	6.68840279		Standard Deviatio	4.777567		Standard Deviat	2.503549
Sample Var	44.7347319		Sample Variance	22.82515		Sample Variance	6.267755
Kurtosis	4.64041808		Kurtosis	0.147072		Kurtosis	1.006221
Skewness	1.88360263		Skewness	0.407213		Skewness	-0.21923
Range	33		Range	24		Range	12
Minimum	10		Minimum	19		Minimum	4
Maximum	43		Maximum	43		Maximum	16
Sum	1184		Sum	1823		Sum	562
Count	66		Count	64		Count	50
Confidence	1.64421463		Confidence Level(	1.193401		Confidence Leve	0.711501

* Difference (dB) between 10 m levels provided in various metrics. These data used to were determine appropriate surrogate pulse duration (i.e., difference between L_{rms} and single strike SEL).

From this analysis, the mean difference between RMS and single strike SEL mean is 11.24 dB, while the mode is 10 dB. A 10-dB difference translates to a pulse duration of 100 msec via Equation B1:

$$SEL_{ss} = L_{rms\ ss} + 10\ Log\ (duration\ in\ seconds) \qquad \textbf{Equation B1}$$

Solve equation assuming a 10 dB difference (mode from Table B1) between SEL_{ss} and $L_{rms\ ss}$:
-10 dB = 10 Log (duration)
-1 = Log (duration)
= 0.1 seconds (100 msec)

An 11.24-dB difference (mean from Table B1) translates to a pulse duration of ~75 msec via Equation B1.

Thus, the data in the Compendium support the general statement from its Appendix IV, Section 4 Underwater Noise Monitoring Plan that states, “that 90 percent of the acoustic energy for most pile driving impulses occurred over a 50 to 100 millisecond period with most of the energy concentrated in the first 30 to 50 milliseconds.”

2.2 Other Available Measurements

In addition to the Caltrans (2015) Compendium, there are various other reports and publications available that provide information on pulse duration associated with impact pile driving activities. For example, other reported measurements of impact pile driving, associated with both windfarm and other construction activities, pulse durations of 50 and 100 msec have been reported at distances of 1 km or closer to the source (e.g., Blackwell et al. 2005; Bailey et al. 2010; de Jong and Ainslie 2012; Illingworth & Rodkin 2014).
Finally, Dr. Peter Dahl (2016) recommended “50 ms[ec] (0.05 sec) as notional pulse length for range 100 m; assume it is less than this for closer ranges (approaching 10 ms) and more than this for longer ranges (approaching 100 ms)” based on analysis of pile driving activities in Puget Sound (Dahl et al. 2015b).

2.3 WCR Pile Driving Calculator[24] for Fish Injury Thresholds

The NMFS West Coast Region (WCR) Pile Driving Calculator for fishes recommends estimating single strike SEL source levels, when no direct measurement is available based on reducing the peak sound pressure source level by 25 dB for coastal pile driving activities.[25] Additionally, this same calculator recommends estimating L_{rms} source levels sound pressure when no direct measurement is available based on reducing the peak sound pressure source level by 15 dB. Note that these recommended values are supported by data from Caltrans (2015) (See Table B1 in this document).

Thus, based on these recommendations, this results in a 10-dB difference between single strike SEL and L_{rms} values (i.e., single strike SEL is 10 dB lower than L_{rms}), which translates to a pulse duration of 100 msec via Equation D1.

3.0 RECOMMENDED DEFAULT PULSE DURATION FOR COASTAL IMPACT PILE DRIVING ACTIVITIES

Based on the information summarized above, NMFS is recommending a default value of 100 msec be used in the optional User Spreadsheet tool for impact pile driving activities when a single strike SEL source level is unavailable. Again, if an action proponent as activity-specific information suggesting an alternative value than the suggested default, it is recommended that the most appropriate value be used.

[24] Posted on Caltrans web site.

[25] The relationship between peak sound pressure level and single strike SEL may be different for pile driving associated with offshore windfarms (Lippert et al. 2015).

APPENDIX C: RECOMMENDED 100 MSEC (DEFAULT) PULSE DURATION FOR SEISMIC ACTIVITIES (AIRGUNS)

NOTE: If the action proponent has unweighted source level information expressed in the SEL metric, then determining the pulse duration is not necessary. Many of the sound source tabs provide a choice between two methods (i.e., one relying on L_{rms} source levels or one relying upon SEL source levels). NMFS advises action proponents to rely on the method using the SEL source level, so needing to determine the pulse duration (or appropriate default) is not necessary.

1.0 INTRODUCTION

The optional User Spreadsheet tool provides a means for approximating isopleths associated with the Technical Guidance's updated PTS onset thresholds. However, there is a need for default values, when information is unavailable for an action proponent to fill-out the optional User Spreadsheet tool's "Action Proponent Provided Information" (Sage cells). NMFS has worked to provide appropriate default values for several of these cells within the optional User Spreadsheet tool (e.g., default weighting factor adjustments (WFAs) for various sound sources). However, with the NMFS (2016) updated thresholds, it has become necessary to provide further appropriate default values, including pulse duration for impulsive sources (i.e., impact pile driving hammer strikes (Appendix B) and seismic airgun shots).

Defaults are conservative in order to encompass the broad potential range of values associated with an activity or sound source (e.g., for seismic airgun shots variation could result from water depth or other environmental parameters associated with activity). Thus, an action proponent is always encouraged to use activity-specific information, if available, as a substitute for using NMFS' recommended default values, as this activity-specific information will provide a more realistic representation of the isopleths associated with that activity.

> **NOTE**: When a single shot SEL source level is available, action proponents are encouraged to use this value. By doing so, there is no need to specify a pulse duration (e.g., default or otherwise).

2.0 DERIVATION OF DEFAULT PULSE DURATION FOR SEISMIC ACTIVITIES (AIRGUNS)

As impulsive sounds propagate through the environment, their physical characteristics begin to change. For example, pulse duration increases with multipath propagation loss[26] and reverberation (e.g., Richardson 2000; Blackwell et al. 2004b; Madsen et al. 2006). Range (R) from the source, as well as water depth (H), are important factors contributing to pulse duration (i.e., more multipath arrivals in shallower water and with higher R/H ratio; Harrison and Nielsen 2007; Harrison 2011; Ainslie et al. 2014). For example, Tolstoy et al. (2009) demonstrated this with seismic airgun shots stating, "reverberations in the shallow arrivals mean that the 90% RMS integration window is longer, whereas deep arrivals are more impulsive and therefore have a shorter integration window." Additionally, frequency content also factors into pulse duration, with those shots with more high-frequency content being shorter (HESS 1999). Moreover, airgun arrays with larger volumes typically have more low-frequency energy compared to those with smaller volumes (Watson et al. 2016). Thus, NMFS evaluated the available data to determine what would be an appropriate default pulse duration for seismic activities involving airguns considering these various factors.

2.1 Available Measurements

Table C1 provides a summary of available airgun shots measurements provided in the metrics of single shot sound exposure level (SEL) and root mean square (L_{rms}) sound pressure level such that pulse duration can be derived.

[26] Multipath propagation loss occurs whenever there is more than one propagation path between the source and receiver (i.e., direct path and paths from reflections off the surface and bottom or reflections within a surface or deep-ocean duct; Urick 1983).

Table C1: Summary of Available Measurements

Study	Water Depth	Measurement Distances	Array Size	Difference between L_{rms} - SEL†	Pulse Duration
Richardson 1997; Harris et al. 2001	3-17 m	up to 2 km	1,320 in^3	~10 dB	100 msec
Richardson 1999	2-5 m	up to 3 km		~10 dB	100 msec
McCauley et al. 2000	30-120 m	up to 22.1 km	2,678 in^3	11.4 to 14.6 dB*	35 to 72 msec
Patterson et al. 2007	40 m	up to 0.3 km	3,147 in^3	~10 dB+	~100 msec
Tolstoy et al. 2009	~50 m	up to 15 km	6,600 in^3	~8 dB	158 msec
Tolstoy et al. 2009	~1600 m	up to 4 km	6,600 in^3	~14 dB	40 msec
Diebold et al. 2010	~50 m	up to 15 km	3,300 in^3	~8-10 dB	10 to 158 msec
Diebold et al. 2010	~1600 m	up to 2 km	3,300 in^3	10-20 dB^	10 to 100 msec

* This study reports equivalent energy (proportional to energy). Differences displayed are mean values.
+ 8.5 dB (141 msec) difference with increasing range (out to 3 km)
^5-10 dB difference with increasing range (2 to 6 km)
†A 10-dB difference translates to a pulse duration of 100 msec via Equation C1:

SEL = L_{rms} + 10 Log (duration in seconds) **Equation C1**
Solve equation assuming a 10 dB difference between SEL and L_{rms}:
-10 dB = 10 Log (duration)
-1 = Log (duration)
= 0.1 seconds (100 msec)

Other monitoring efforts have reported pulse durations of ~100 msec or less at distances 1 km or less from the source (e.g., Reiser et al. 2010; Hartin et al. 2011; Beland 2013), while others have reported a pulse duration of 200 msec at distances ~1 km from the source (e.g., Greene and Richardson 1988)

Often for modeling purposed, 100 msec is chosen as representative pulse duration value for airgun shots expected within a few kilometers from the source (e.g., MacGillivray and Chapman 2005; NSF and USGS 2011; BOEM 2016). For their evaluation of marine mammal audibility of shallow-water (40 m) survey sources, MacGillivray et al. (2014) assumed an airgun array to have pulse duration of 100 msec.

BOEM (2014) estimated range-dependent SPL-SEL offsets (Figure C1) by combining full waveform estimations using idealized flat bottom models with water depths ranging from 40 to 1000 with data obtained during field measurements with bottom types of sand (40 and 150 m models) and clay (1000 m model).

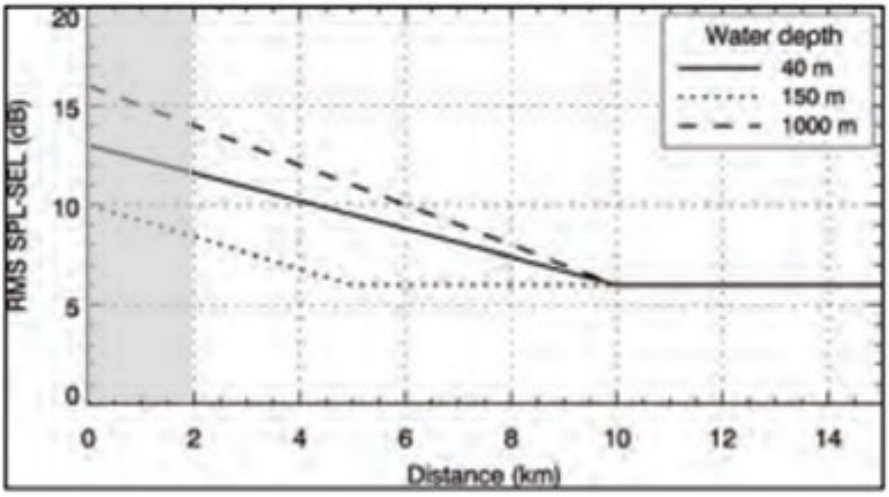


Figure C1: SPL-SEL conversion functions for different water depths (BOEM 2014). The gray shading indicates closer distances where the likelihood of PTS is higher.

Figure C1 shows that the SPL-SEL offset tends to be larger at closer distances (km), where the pulse duration is short, and diminishes at longer distances, where the pulse duration increases as a result of reverberation/multipath propagation loss. Within 2 km of the source, the SPL-SEL offset is $\geq$ 8 dB, which results in a pulse duration of 158 msec or shorter for the majority of depths. Thus, choosing a 100 msec default pulse duration is conservative in most situations, unless there is site-specific information (i.e., shallow water, etc.) indicating that there is a more appropriate pulse duration (i.e., a default pulse duration longer than 100 msec is more appropriate).

3.0 RECOMMENDED DEFAULT PULSE DURATION FOR SEISMIC ACTIVITIES (AIRGUNS)

Based on the information summarized above, NMFS is recommending a default value of 100 msec for use in the optional User Spreadsheet tool for seismic activities involving airguns when a single shot SEL source level is unavailable. Again, an action proponent can use activity-specific information, if available, instead of relying on the default value.

APPENDIX D: GLOSSARY

95% Frequency contour percentile: Upper frequency below which 95% of total cumulative energy is contained (Charif et al. 2010).

Accumulation period: The amount of time a sound accumulates for the SEL_{cum} metric.

Acoustic center: Point from which outgoing wavefronts appear to diverge in the acoustic far field under free-field conditions (ISO 2017).

Acoustic far field: Spatial region in a uniform medium where the direct-path field amplitude, compensated by absorption loss, varies inversely with range (ISO 2017).

Auditory weighting function: Auditory weighting functions take into account what is known about marine mammal hearing sensitivity and susceptibility to noise-induced hearing loss and can be applied to a sound-level measurement to account for frequency-dependent hearing (i.e.,. an expression of relative loudness as perceived by the ear)(Southall et al. 2007; Finneran 2016). Specifically, this function represents a specified frequency-dependent characteristic of hearing sensitivity in a particular animal, by which an acoustic quantity is adjusted to reflect the importance of that frequency dependence to that animal (ISO 2017). Similar to OSHA (2013), marine mammal auditory weighting functions in this document are used to reflect the risk of noise exposure on hearing and not necessarily capture the most sensitive hearing range of every member of the hearing group.

Bandwidth: Bandwidth (Hz or kHz) is the range of frequencies over which a sound occurs or upper and lower limits of frequency band (ANSI 2005). Broadband refers to a source that produces sound over a broad range of frequencies (for example, seismic airguns), while narrowband or tonal sources produce sounds over a more narrow frequency range, typically with a spectrum having a localized a peak in amplitude (for example, sonar) (ANSI 1986; ANSI 2005).

Broadband: See “bandwidth.”

Continuous sound: A sound whose sound pressure level remains above ambient sound during the observation period (ANSI 2005).

Decibel (dB): One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI 2013).

Frequency: The number of periods occurring over a unit of time (unless otherwise stated, cycles per second or hertz) (Yost 2007).

Hertz (Hz): Unit of frequency corresponding to the number of cycles per second. One hertz corresponds to one cycle per second.

Impulsive sound: 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 driving hammers.

Intermittent sound: Interrupted levels of low or no sound (NIOSH 1998) or bursts of sounds separated by silent periods (Richardson and Malme 1993). Typically, intermittent sounds have a more regular (predictable) pattern of bursts of sounds and silent periods (i.e., duty cycle).

Isopleth: A line drawn through all points having the same numerical value. In the case of sound, the line has equal sound pressure or exposure levels.

Mean-square sound pressure: Integral over a specified time interval of squared sound pressure divided by the duration of the time interval, for a specified frequency range (ISO 2017).

Narrowband: See "bandwidth."

Non-impulsive sound: 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), certain sonar (e.g. tactical, navigational, and scientific), and vibratory pile driving hammers.

Octave: The interval between two sounds having a basic frequency ratio of two (Yost 2007). For example, one octave above 400 Hz is 800 Hz. One octave below 400 Hz is 200 Hz.

Omnidirectional: Receiving or transmitting signals in all directions (i.e., variation with direction is designed to be as small as possible).

One-third octave (base 10): The frequency ratio corresponding to a decidecade or one tenth of a decade (ISO 2017).

Peak sound pressure (p_{pk}): Greatest magnitude of the sound pressure during a specified time interval, for a specified frequency range. Can arise from a positive or negative sound pressure (ISO 2017).

Peak sound pressure level (PK; re: 1 µPa): Twenty times the logarithm of the base 10 of the ratio of peak sound pressure, p_{pk}, to the specified reference value, p_0, in decibels (ISO 2017).

Permanent threshold shift (PTS): 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. The amount of permanent threshold shift is customarily expressed in decibels (ANSI 1995; Yost 2007). Available data from humans and other terrestrial mammals indicate that a 40 dB threshold shift approximates PTS onset (see Ward et al. 1958, 1959; Ward 1960; Kryter et al. 1966; Miller 1974; Ahroon et al. 1996; Henderson et al. 2008).

Power spectral density: the distribution of acoustic power into frequency components composing that signal.

Pulse duration: For impulsive sources, window that makes up 90% of total cumulative energy (5%-95%) (Madsen 2005).

Propagation loss (PL): Difference between source level in a specified direction and root mean square sound pressure level at a specified position (ISO 2017). Note: Propagation loss is conceptually different from transmission loss (i.e., propagation loss is associated with the source level, while transmission loss is associated with a measurement at a specified distance).

Received level: The level of sound at a specified distance of interest, r, (i.e., at the animal or receiver). Note: Received level is conceptually different from source level (i.e., different quantities with different reference values).

Repetition rate: Number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second. The inter-pulse interval is the inverse of this quantity.

Root-mean-square sound pressure level (L_{rms}; re: 1 µPa): Ten times the logarithm to the base 10 of the ratio of the mean-square sound pressure to the specified reference value in decibels (ISO 2017).

Single Strike/Pulse/Ping/Strike Sound Exposure Level (SEL_{ss}; re: 1µPa^2 s): A measure of sound level that takes into account the duration of the signal, which in this case would be the duration of a single

strike, ping, pulse, or strike. Ten times the logarithm to the base 10 of the ratio of time-integrated squared sound pressure to the specified reference value in decibels

Sound Exposure Level (SEL_{cum}; re: 1µPa^2 s): A measure of sound level that takes into account the duration of the signal. Ten times the logarithm to the base 10 of the ratio of time-integrated squared sound pressure to the specified reference value in decibels (ISO 2017).

Sound Pressure Level (SPL): A measure of sound level that represents only the pressure component of sound. Ten times the logarithm to the base 10 of the ratio of time-mean square pressure of a sound in a stated frequency band to the square of the reference pressure (1 µPa in water) (ANSI 2013).

Source Factor: Product of the square of distance from the acoustic center of a source, in a specified direction, and mean-square sound pressure in the acoustic far field that distance.

Source Level (SL): Sound pressure level measured in a given radian direction, corrected for absorption, and scaled to a reference distance (Morfey 2001). Ten times the logarithm to the base 10 of the ratio of the source factor to the specified reference value in decibels (ISO 2017). Note: Source level is conceptually different from received level (i.e., different quantities with different reference values).

Spectral/spectrum: Of or relating to frequency component(s) of sound. The spectrum of a function of time is a description of its resolution into components (frequency, amplitude, etc.). The spectrum level of a signal at a particular frequency is the level of that part of the signal contained within a band of unit width and centered at a particular frequency (Yost 2007).

Time-integrated squared sound pressure: Integral of the square of sound pressure over a specified time interval or event, for a specified frequency range (ISO 2017).

Transmission Loss (TL): Reduction in a specified level between two specified points that are within an underwater acoustic field (ISO 2017). Note: Transmission loss is conceptually different from propagation loss (i.e., propagation loss is associated with the source level, while transmission loss is associated with a measurement at a specified distance).

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