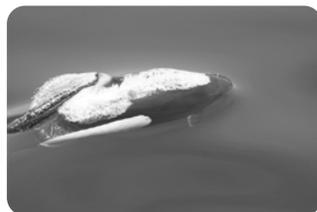


Manual for Optional User Spreadsheet Tool (Version 2.0) for:

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

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



Recommended citation:

National Marine Fisheries Service. 2018. Manual for Optional User Spreadsheet Tool (Version 2.0) 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. Silver Spring, Maryland: Office of Protected Resources, National Marine Fisheries Service.

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TABLE OF CONTENTS

I.	Introduction.....	1
II.	ACCOUNTING FOR CUMULATIVE SOUND EXPOSURE	1
2.1	MOBILE SOURCES	1
2.2	STATIONARY SOURCES.....	2
2.2.1	Assumptions.....	2
2.3	RECEIVER CONSIDERATIONS.....	3
2.3.1	How the Cumulative Metric Differs from “Traditional” RMS SPL Metric	3
III.	ACCOUNTING FOR MARINE MAMMAL AUDITORY WEIGHTING FUNCTIONS.....	4
3.1	WEIGHTING FACTOR ADJUSTMENTS	4
3.1.1	Choice of Weighting Factor Adjustments for Broadband Sources.....	7
3.2	WEIGHTING FACTOR ADJUSTMENT OVERRIDE.....	9
3.3	Spectral Considerations for Broadband Sources.....	13
IV.	Peak Sound Pressure Level Thresholds.....	14
V.	USER SPREADSHEET TOOL TABS	14
5.1	CELLS WITHIN INDIVIDUAL TABS.....	15
5.1.1	Activity-, Source-, or Location-Specific Data.....	16
5.2.1	Default Values for Sage Cells	16
VI.	How to Navigate THE USER Spreadsheet tool’s Individual Tabs	19
6.1	INTRODUCTION TAB (WHITE).....	21
6.1.1	Instructions	21
6.1.2	Assumptions and Additional Information.....	21
6.1.3	Updates	22
6.2	NON-IMPULSIVE, STATIONARY, CONTINUOUS (TAB A: RED)	23
6.2.1	Step 1: General Project Information.....	23
6.2.2	Step 2: Weighting Factor Adjustment (WFA)	23
6.2.3	Step 3: Source-Specific Information.....	24
6.2.4	Resultant Isopleths.....	26
6.2A1	Vibratory Pile Driving (Tab A.1: Brick Red).....	27
6.2.A1.1	Step 1: General Project Information.....	27
6.2.A1.2	Step 2: Weighting Factor Adjustment.....	27
6.2.A1.3	Step 3: Source-Specific Information.....	28
6.2.A1.4	Resultant Isopleths.....	30
6.3.1	Step 1: General Project Information.....	31
6.3.2	Step 2: Weighting Factor Adjustment.....	31

6.3.3	Step 3: Source-Specific Information.....	33
6.3.4	Resultant Isopleths.....	37
6.4	NON-IMPULSIVE, MOBILE, CONTINUOUS (TAB C: BLUE).....	38
6.4.1	Step 1: General Project Information.....	38
6.4.2	Step 2: Weighting Factor Adjustment.....	38
6.4.3	Step 3: Source-Specific Information.....	39
6.4.4	Resultant Isopleths.....	40
6.5.1	Step 1: General Project Information.....	41
6.5.2	Step 2: Weighting Factor Adjustment.....	41
6.5.3	Step 3: Source-Specific Information.....	42
6.5.4	Resultant Isopleths.....	45
6.6.1	Step 1: General Project Information.....	46
6.6.2	Step 2: Weighting Factor Adjustment.....	46
6.6.3	Step 3: Source-Specific Information.....	47
5.6.4	Resultant Isopleths.....	52
6.6.E1	Impact Pile Driving (Tab E.1: Evergreen)	54
6.6.E1.1	Step 1: General Project Information.....	54
6.6.E1.2	Step 2: Weighting Factor Adjustment.....	54
6.6.E1.3	Step 3: Source-Specific Information.....	55
6.6.E1.4	Resultant Isopleths.....	59
6.6.E2	Explosive-Multiple Detonations (Tab E.2: Seafoam)	61
6.6.E2.1	Step 1: General Project Information.....	61
6.6.E2.2	Step 2: Weighting Factor Adjustment.....	61
6.6E2.3	Step 3: Source-Specific Information.....	62
6.6.4	Resultant Isopleths.....	66
6.6.E3	Explosives-Single Detonation (Tab E.3: Lime)	69
6.6.E3.1	Step 1: General Project Information.....	69
6.6.E3.2	Step 2: Weighting Factor Adjustment.....	69
6.6E3.3	Step 3: Source-Specific Information.....	70
6.6.4	Resultant Isopleths.....	73
6.7	IMPULSIVE, MOBILE (TAB F: PURPLE)	75
6.7.1	Step 1: General Project Information.....	75
6.7.2	Step 2: Weighting Factor Adjustment.....	75
6.7.3	Step 3: Source-Specific Information.....	76
6.7.4	Resultant Isopleths.....	80
6.8.1	Narrowband Sources	82
6.8.2	Broadband Sources	82

APPENDIX A: SUMMARY OF TECHNICAL GUIDANCE THRESHOLDS AND AUDITORY WEIGHTING FUNCTIONS 84

APPENDIX B: Recommended 100 ms (default) Pulse Duration for Impact Pile Driving Activities 87

 1.0 INTRODUCTION..... 87

 2.0 DERIVATION OF DEFAULT PULSE DURATION FOR IMPACT PILE DRIVING ACTIVITIES . 87

 2.1 Analysis of Caltrans (2015) Compendium 87

 2.2 Other Available Measurements..... 88

 2.3 Default Suggested by WCR Pile Driving Calculator for Fish Injury Thresholds..... 89

 3.0 RECOMMENDED DEFAULT PULSE DURATION FOR IMPACT PILE DRIVING ACTIVITIES 89

APPENDIX C: Recommended 100 ms (default) Pulse Duration for Seismic Activities (Airguns) 90

 1.0 INTRODUCTION..... 90

 2.0 DERIVATION OF DEFAULT PULSE DURATION FOR SEISMIC ACTIVITIES (AIRGUNS)..... 90

 2.1 Available Measurements..... 90

 3.0 RECOMMENDED DEFAULT PULSE DURATION FOR SEISMIC ACTIVITIES (AIRGUNS).... 92

APPENDIX D: GLOSSARY..... 93

LITERATURE CITED 96

FIGURES

Figure 1: Example illustrating concept of weighting factor adjustment at 1 kHz with cetacean and pinniped auditory weighting functions. 5

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 RMS source level of 200 dB; 1-second ping every 2 minutes for 24 h). 6

Figure 3: Screenshot of weighting function amplitude associated with 1 kHz WFA by hearing group. .. 6

Figure 4: Example auditory weighting function illustrating where the use of weighting factor adjustments are and are not appropriate for broadband sources..... 8

Figure 5: Example illustrating weighting factor adjustment override..... 10

Figure 6: Illustration comparing spectrum levels presented as octaves, one-third octave, and power spectral density for a generic sound source 11

Figure 7: Maximum one-third octave band unweighted source level in the horizontal plane for a generic 8000 in³ seismic array 13

Figure 8: Illustration of data hierarchy and impacts on portraying expected conditions. 17

Figure 9: Screenshot of Step 1 for Tab A..... 23

Figure 10: Screenshot of Step 2 for Tab A..... 24

Figure 11: Screenshot of Step 3 for Tab A..... 25

Figure 12: Screenshot of Resultant Isopleths for Tab A. 26

Figure 13: Screenshot of Step 1 for Tab A.1..... 27

Figure 14: Screenshot of Step 2 for Tab A.1..... 28

Figure 15: Screenshot of Step 3 for Tab A.1..... 29

Figure 16: Screenshot of Resultant Isoleths for Tab A.1. 30

Figure 17: Screenshot of Step 1 for Tab B..... 31

Figure 18: Screenshot of Step 2 for Tab B..... 32

Figure 19: Screenshot of Step 3, Method B1 for Tab B. 35

Figure 20: Screenshot of Step 3, Method B2 for Tab B. 36

Figure 21: Screenshot of Resultant Isoleths for Tab B. 37

Figure 22: Screenshot of Step 1 for Tab C..... 38

Figure 23: Screenshot of Step 2 for Tab C..... 39

Figure 24: Screenshot of Step 3 for Tab C..... 40

Figure 25: Screenshot of Resultant Isoleths for Tab C. 40

Figure 26: Screenshot of Step 1 for Tab D..... 41

Figure 27: Screenshot of Step 2 for Tab D..... 42

Figure 28: Screenshot of Step 3, Method D1 for Tab D..... 44

Figure 29: Screenshot of Step 3, Method D2 for Tab D. 45

Figure 30: Screenshot of Resultant Isoleths for Tab D. 45

Figure 31: Screenshot of Step 1 for Tab E..... 46

Figure 32: Screenshot of Step 2 for Tab E..... 47

Figure 33: Screenshot of Step 3, Method E1 for Tab E. 50

Figure 34: Screenshot of peak sound pressure level source level input..... 50

Figure 35: Screenshot of Step 3, Method E2 for Tab E. 52

Figure 36: Screenshot of peak sound pressure level source level input..... 52

Figure 37: Screenshot of Resultant Isoleths for Tab E. 53

Figure 38: Screenshot of Step 1 for Tab E.1..... 54

Figure 39: Screenshot of Step 2 for Tab E.1..... 55

Figure 40: Screenshot of Step 3, Method E.1-1 for Tab E.1. 57

Figure 41: Screenshot of inputs associated with peak sound pressure level. 57

Figure 42: Screenshot of Step 3, Method E.1-2 for Tab E.1..... 59

Figure 43: Screenshot of inputs associated with peak sound pressure level. 59

Figure 44: Screenshot of Resultant Isoleths for Tab E.1. 60

Figure 45: Screenshot of Step 1 for Tab E.2..... 61

Figure 46: Screenshot of Step 2 for Tab E.2..... 62

Figure 47: Screenshot of Step 3, Method E.2-1 for Tab E.2..... 64

Figure 48: Screenshot of inputs associated with peak sound pressure level. 65

Figure 49: Screenshot of Step 3, Method E.2-2 for Tab E.2..... 66

Figure 50: Screenshot of inputs associated with peak sound pressure level. 66

Figure 51: Screenshot of Resultant Isoleths for Tab E.2. 67

Figure 52: Screenshot of Step 1 for Tab E.3..... 69

Figure 53: Screenshot of Step 2 for Tab E.3..... 70

Figure 54: Screenshot of Step 3, Method E.3-1 for Tab E.3..... 71

Figure 55: Screenshot of inputs associated with peak sound pressure level. 72

Figure 56: Screenshot of Step 3, Method E.3-2 for Tab E.3. 72

Figure 57: Screenshot of inputs associated with peak sound pressure level. 72

Figure 58: Screenshot of Resultant Isopleths for Tab E.3. 74

Figure 59: Screenshot of Step 1 for Tab F. 75

Figure 60: Screenshot of Step 2 for Tab F. 76

Figure 61: Screenshot of Step 3, Method F1 for Tab F..... 78

Figure 62: Screenshot of inputs associated with peak sound pressure level. 78

Figure 63: Screenshot of Step 3, Method F1 for Tab F..... 79

Figure 64: Screenshot of inputs associated with peak sound pressure level. 80

Figure 65: Screenshot of Resultant Isopleths for Tab F..... 80

Figure 66: Example auditory weighting function illustrating where the use of weighting factor adjustments are (and are not appropriate for broadband sources..... 83

Figure A1: Auditory weighting functions for low-frequency, mid-frequency, and high-frequency cetaceans. 86

Figure A2: Underwater auditory weighting functions for otariid and phocid pinnipeds..... 86

TABLES

Table 1: NMFS suggested default weighting factor adjustments for broadband sources. 7

Table 2: Applicability of weighting factor adjustments for frequencies broadband sounds 9

Table 3: Auditory weighting functions in center frequency of one-third octave bands from 8 to 20,000 Hz 11

Table 4: Comparison of adjustment associated with incorporating entire broadband spectrum vs. default, single frequency WFA for a seismic array. 13

Table 5: NMFS suggested default WFA for common broadband sources. 17

Table 6: NMFS suggested default weighting factor adjustments for broadband sources. 22

Table 7: Applicability of weighting factor adjustments for broadband sound. 83

Table A1: Marine mammal hearing groups. 84

Table A2: Summary of auditory weighting and exposure function parameters..... 84

Table A3: Summary of PTS onset acoustic thresholds. 85

Table B1: Caltrans (2015) Compendium analysis illustrating difference (dB) between 10 m levels provided in various metrics. 88

Table C1: Summary of Available Measurements 91

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ANSI	American National Standards Institute	m	meter
b	High-frequency exponent	msec	milliseconds
BOEM	Bureau of Ocean Energy Management	NMFS	National Marine Fisheries Service
C	Weighting function gain (dB)	NOAA	National Oceanic and Atmospheric Administration
dB	Decibel	OTO	One-third octave levels
f_1	Low-frequency cutoff (kHz)	OW	Otariids in water
f_2	High-frequency cutoff (kHz)	Pa	Pascals
ESA	Endangered Species Act	PK	Peak sound pressure level
G&G	Geological and Geophysical	PSD	Power spectral density levels
h	hour	PTS	Permanent Threshold Shift
H	water depth	PW	Phocids in water
HF	High-frequency	R	Range from source
Hz	Hertz	RMS	Root Mean Square
in ³	Cubic inches	SEL	Sound exposure level
ISO	International Organization for Standardization	SEL _{cum}	Cumulative sound exposure level
K	Exposure function gain (dB)	SL	Source Level
kHz	Kilohertz	SPL	Sound Pressure Level
LF	Low-frequency	TTS	Temporary Threshold Shift
MF	Mid-frequency	$W_{aud}(f)$	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 users may have different levels of modeling capabilities. Thus, NMFS has provided a companion optional User Spreadsheet tool for those users unable to implement the Technical Guidance's thresholds in the weighted cumulative sound exposure level (SEL_{cum}) and peak sound pressure (PK) level metrics and the associated marine mammal auditory weighting functions.

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 User Spreadsheet tool provides a means to estimate 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 User Spreadsheet tool.

II. ACCOUNTING FOR CUMULATIVE SOUND EXPOSURE¹

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, 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 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. 2014²). This method allows one to model a simple moving source and accounts for four main factors:

- 1) Unweighted source level (user provided)

¹ The PK metric (for impulsive sources) is also included in the updated User Spreadsheet tool (Version 2.0). When evaluating impulsive sources that have dual metric thresholds (i.e., SEL_{cum} and PK), users rely upon whichever metric yields the largest isopleth for a particular marine mammal hearing group.

² The threshold considered by Sivle et al. 2014 was associated with behavioral reactions.

- 2) "Pulse"³ duration and repetition rate (user provided)
- 3) Transit speed or velocity (user provided)
- 4) Exposure threshold (NMFS provided from Technical Guidance)

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

2.2 STATIONARY SOURCES

The derivation of isopleths for stationary sources in the User Spreadsheet tool are 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 and is neither attracted or avoids the source. Additionally, it is possible to specify propagation using this methodology.

2.2.1 Assumptions

NMFS understand the 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-h⁴, 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 unusually long exposure durations).

NOTE: The User Spreadsheet tool is flexible and allows the user 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 user 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 User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

³ The term "pulse" in the context of the "safe distance" methodology, including the User Spreadsheet, is a generic term used to represent 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 (working group anticipated in 2018). NMFS is hoping to provide more guidance on this issue in the near future.

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 over 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 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 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 individuals 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 realistic⁵ 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 SPL Metric

With NMFS' "traditional" thresholds in the RMS SPL metric, once a receiver entered the predicted isopleth associate with a particular threshold, it exceeded the threshold and had the potential for PTS onset, in the case of NMFS' former RMS SPL 180 dB and 190 dB thresholds. Thus, duration of exposure was not a consideration (i.e., once receiver entered the predicted isopleth is exceeded the threshold no matter whether it stayed there for one second or for 24 hours).

However, with the SEL_{cum} metric, since there is a time (duration of exposure) component aspect 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.

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.

III. ACCOUNTING FOR MARINE MAMMAL AUDITORY WEIGHTING FUNCTIONS

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

3.1 WEIGHTING FACTOR ADJUSTMENTS

Weighting factor adjustments (WFAs) are another simple tool within the User Spreadsheet tool to help users 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 allows users to rely on the same PTS onset thresholds but accounts for auditory weighting functions by the incorporation of a single frequency.

Within the 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. For broadband sounds, the choice of an appropriate WFA frequency is based on the 95% frequency contour of the particular sound source (95% frequency contour is defined as upper frequency below which 95% of total cumulative energy is contained). The results from the User Spreadsheet tool will be nearly identical for narrowband sources and more conservative for broadband sources compared to users 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 adjustment (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

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 adjustment, the louder a sound has to be for an animal to experience noise-induced hearing loss.

In this specific 1 kHz WFA example, one can see, there is a larger adjustment for MF and HF cetaceans compared to LF cetaceans. This because for LF cetaceans, 1 kHz is in this functional 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).

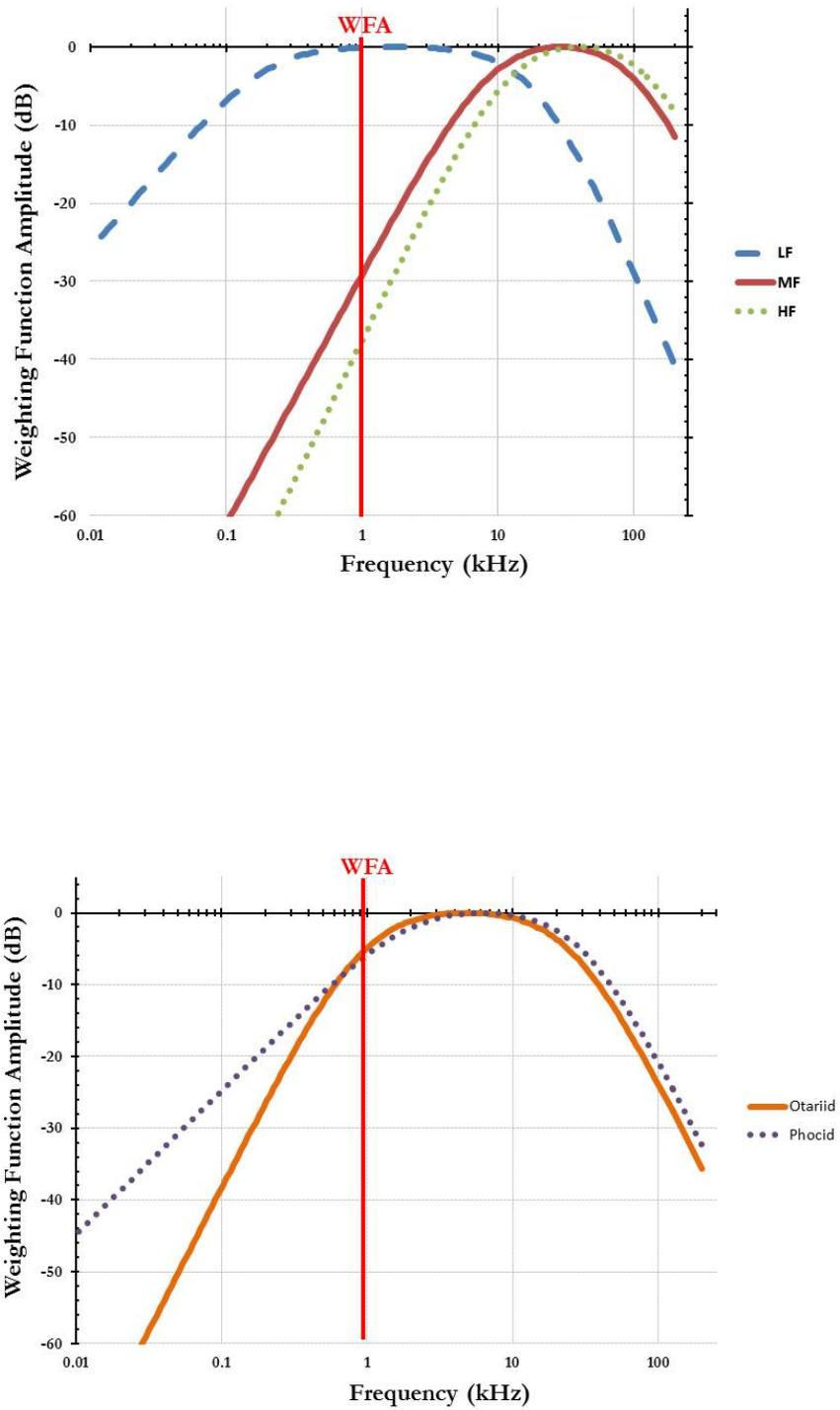


Figure 1: Example illustrating concept of weighting factor adjustment at 1 kHz (red line) with cetacean (top) and pinniped (bottom) auditory weighting functions.

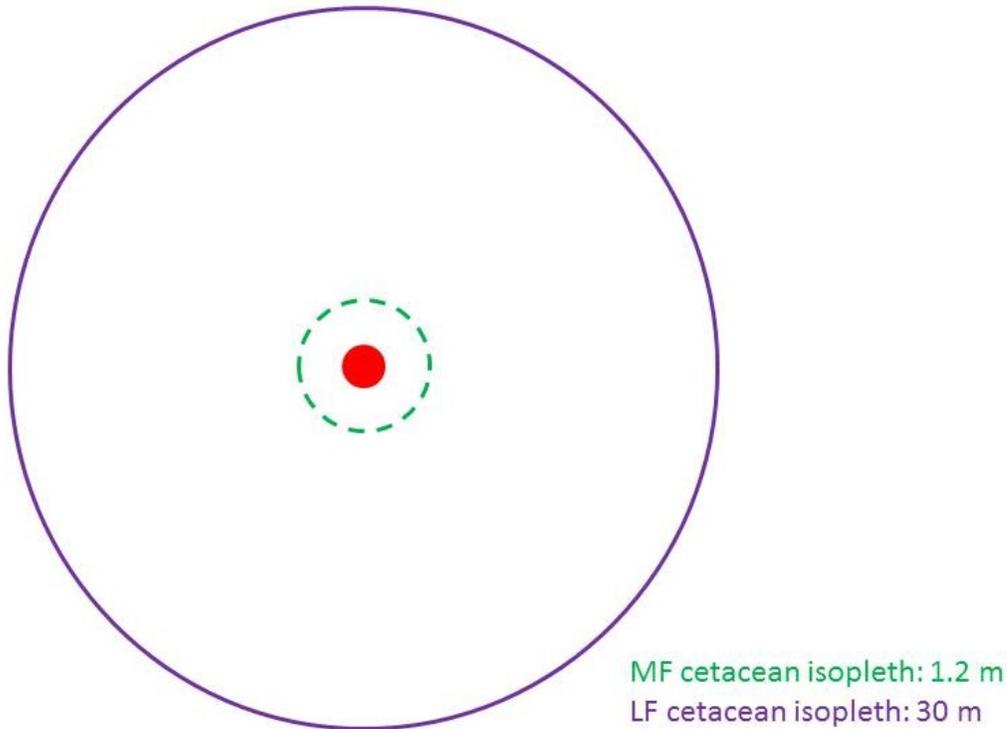


Figure 2: Simple example illustrating concept of weighting factor adjustment on isopleths for LF and MF cetaceans using hypothetical 1 kHz narrowband, intermittent source represented by the red dot (unweighted RMS source level of 200 dB; 1-second ping every 2 minutes for 24 h). For a non-impulsive source, 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).

The User Spreadsheet tool's sage cell in Step 2, on each sound source tab, is where a WFA can be provided by a user based on the specific sound source 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 User Spreadsheet tool, unless a user 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 associated with 1 kHz WFA by hearing group (last row of in each tab of 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 users for determining the appropriate WFA for their broadband sound source. First, users may rely upon a WFA based off the 95% frequency contour from measurements of their particular source. Second, users may rely upon a NMFS suggested default for their broadband source, which acknowledges are likely conservative (Table 1).

Table 1: 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	2 kHz	Blackwell 2005; Reinhall and Dahl 2011
Vibratory pile driving	2.5 kHz	Blackwell 2005; Dahl et al. 2015a
Drilling	2 kHz	Greene 1987; Blackwell et al. 2004a; Blackwell and Greene 2006

NOTE: Since spectra associated with underwater explosives vary by detonation size and depth (Urick 1983), the User Spreadsheet tool does not provide a default. However, if the user has the spectrum associated with their detonation, they may override the WFA outputs and directly use this information.

Since the intent of WFAs is to account for auditory weighting functions below the 95% frequency contour percentile, it is important to note that for each marine mammal hearing group, there are frequencies where using WFAs are appropriate and then there are frequencies where using WFAs are not appropriate. As illustrated in Figure 4, it is important that only frequencies on the “left side” of the auditory weighting function be used to make adjustments (i.e., frequencies below those where the auditory

weighting function amplitude is zero⁶ or below where the function is essentially flat; resulting in every frequency below the WFA always having a more negative amplitude than the chosen WFA).

It is inappropriate to use WFAs for frequencies on the “right side” of the auditory weighting function (i.e., frequencies above those where the auditory weighting function amplitude is zero; Figure 4).

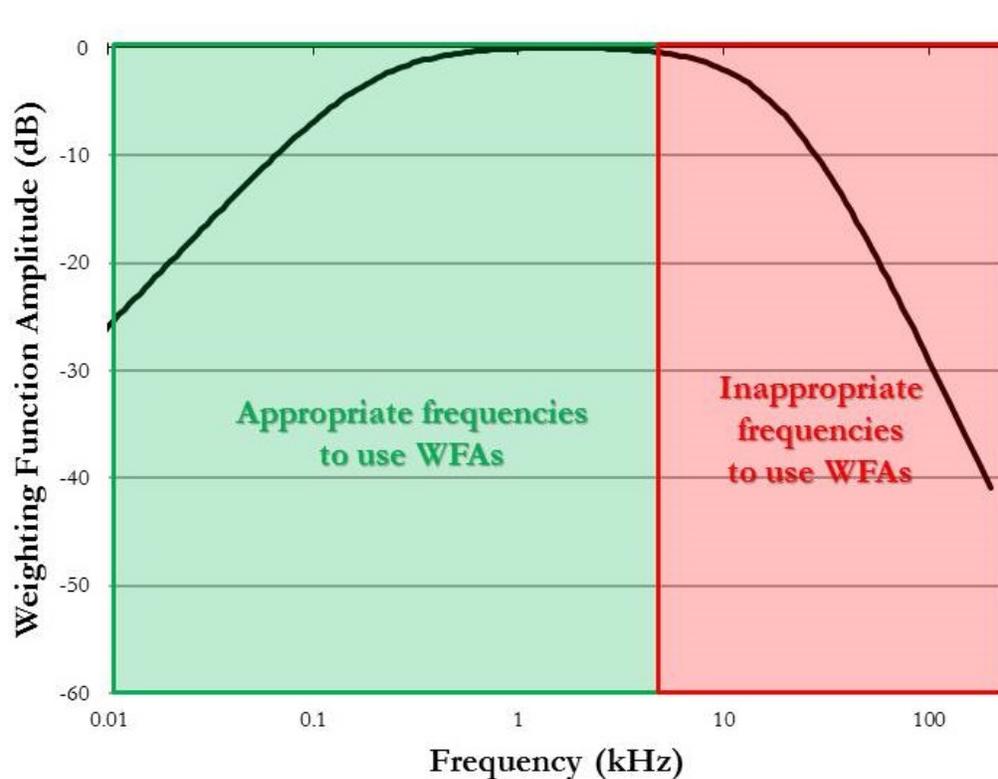


Figure 4: Example auditory weighting function illustrating where the use of weighting factor adjustments are (Green: “left side”) and are not (Red: “right side”) appropriate for broadband sources.

For a frequency on the “right side” of the auditory weighting function (Table 2), any adjustment is inappropriate and WFAs cannot be used. If a sound source occurs within a hearing groups’ non-applicable frequency range, then a user is directed to input a frequency that produces an unweighted isopleth or override the WFA adjustment (dB) to 0.00 (See Section 3.2).

⁶ A criteria of a -0.4 dB weighting function amplitude from the Technical Guidance’s auditory weighting function was used to determine the demarcation between appropriate and inappropriate frequencies to use the WFAs.

Table 2: Applicability of weighting factor adjustments for frequencies broadband sounds

Hearing Group	Applicable Frequencies	Non-Applicable Frequencies*
Low-Frequency Cetaceans (LF)	4.8 kHz and lower	Above 4.8 kHz (Use: 1.7 kHz)
Mid-Frequency Cetaceans (MF)	43 kHz and lower	Above 43 kHz (Use: 28 kHz)
High-Frequency Cetaceans (HF)	59 kHz and lower	Above 59 kHz (Use: 42 kHz)
Phocid Pinnipeds (PW)	11 kHz and lower	Above 11 kHz (Use: 6.2 kHz)
Otariid Pinnipeds (OW)	8.5 kHz and lower	Above 8.5 kHz (Use: 4.9 kHz)

* With non-applicable frequencies, a user inputs the “use” frequency in the User Spreadsheet tool, which will result in a weighting function amplitude of 0 dB (i.e., unweighted) or user can directly override the WFA Adjustment (dB) at the bottom of the tab to 0.00 dB for the particular hearing group that requires an unweighted adjustment.

Please note, the applicable and non-applicable frequencies vary by hearing group. If it is necessary to rely upon a frequency resulting in an unweighted isopleth, this applies to isopleths calculated only for the hearing group (i.e., resulting isopleths for this non-applicable frequency adjustment, for other hearing groups, should not be used). For example, if a broadband source WFA equals 5 kHz, this would not be appropriate for LF cetaceans BUT would be appropriate for all other marine mammal hearing groups. Thus, the user should input 5 kHz and use the resulting isopleths for all marine mammal groups, and then redo their inputs for LF cetaceans using a WFA of 1.7 kHz to get the isopleth for this hearing group.

3.2 WEIGHTING FACTOR ADJUSTMENT OVERRIDE

A user is not obligated to use WFAs and may override⁷ the WFAs adjustment if: 1) The user 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) or 2) The user has specific information on the spectrum associated with their source.

If a user has data or measurements depicting the spectrum of their sound source, they may use these data to override the User Spreadsheet tool WFA output (Figure 5).

NOTE: If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet's default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

⁷ Note: The term “override” refers to a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

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)†	-0.01	-19.74	-26.87	-2.08	-1.15

Figure 5: Example illustrating weighting factor adjustment override. Adjustment (dB) may be directly modified (overridden), white cells, if a user 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 user needs to make the value unweighted (i.e., adjustment would be set to 0).

By including a source's entire spectrum, this will allow a user 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 user 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 applicant 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 6⁸). NMFS recommends that users 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 users relying upon OTO data apply the auditory weighting functions via the center frequency of each applicable OTO for each hearing group (Table 3; ANSI 2009).

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

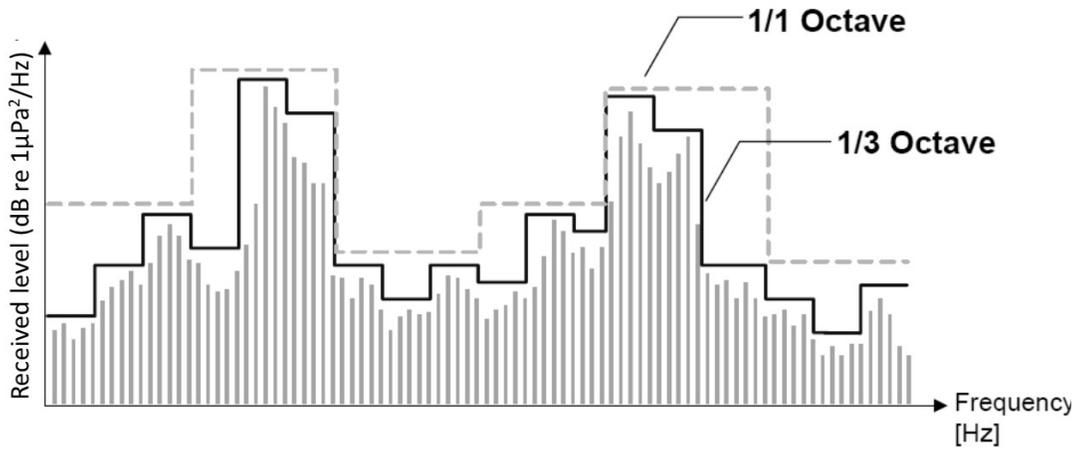


Figure 6: Illustration comparing spectrum levels presented as octaves (dashed grey line), one-third octave (solid black line), and power spectral density (vertical grey bars) for a generic sound source (Note: X-axis label applies to spectral density levels; octave band and one-third octave band levels have the units of dB re 1 μPa).

Table 3: 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
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

Center (Hz)	LF Cetaceans	MF Cetaceans	HF Cetaceans	Phocids Underwater	Otariids Underwater
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.

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 in³ airgun array (Figure 6).

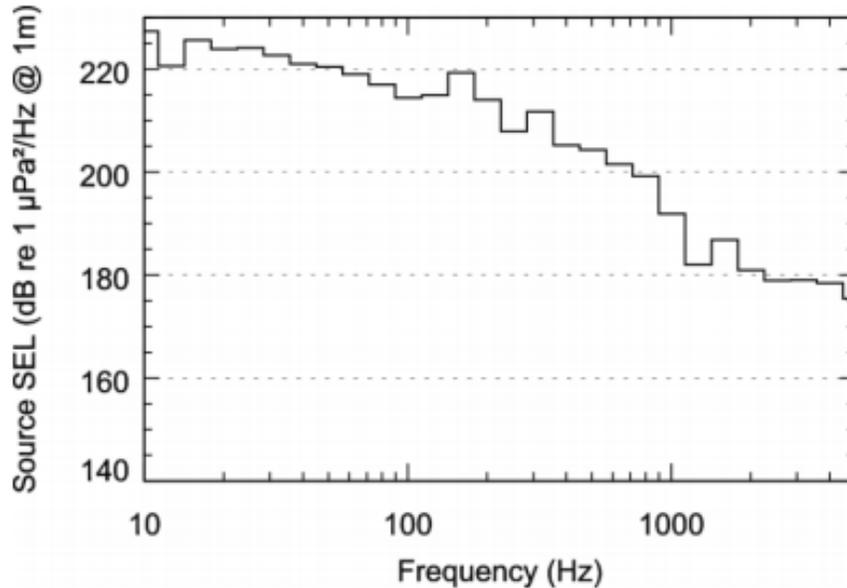


Figure 7: Maximum one-third octave band unweighted source level in the horizontal plane for a generic 8000 in³ seismic array (BOEM 2017).

Table 4 provides a comparison of the dB adjustment between using the BOEM 2017 spectrum to override the optional User Spreadsheet tool's default WFA 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.

Table 4: Seismic weighting using broadband spectrum vs. default, single frequency WFA.

Weighting (dB Adjustment)	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

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

3.3 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.

IV. PEAK SOUND PRESSURE LEVEL THRESHOLDS

The PK metric (for impulsive sources) is also included in the updated User Spreadsheet tool (Version 2.0). When evaluating impulsive sources that have dual metric thresholds (i.e., SEL_{cum} and PK), a user relies upon whichever metric yields the largest isopleth for a particular marine mammal hearing group. 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).

V. USER SPREADSHEET TOOL TABS

The User Spreadsheet tool consists of twelve color-coded worksheets or tabs (i.e., two informational tabs and ten sound source tabs). Sound source tabs categorize each source as either: 1) Impulsive or Non-impulsive⁹, 2) Mobile or Stationary, and 3) Intermittent or Continuous¹⁰.

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 a user 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 twelve tabs are as follows:

1. Introduction (White): This tab provides instructions and introduction to the User Spreadsheet tool, including instructions to help a user 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 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 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).

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

⁹ 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 sound types may be more likely to affect auditory physiology and is not meant to reflect categorizations associated with behavioral disturbance.

¹⁰ Within the User Spreadsheet, 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.

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

NOTE: The 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).

7. Tab E, Impulsive, Stationary (Green): Tab E is appropriate for sources such as vertical seismic profiling (VSP).
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, Multiple Explosive Detonations (Seafoam): This sub-tab is a custom tab specifically for multiple detonations.

NOTE: This tab allows users to determine the PTS onset, TTS onset, and explosive behavioral harassment onset isopleths for multiple detonations. This tab **does not** provide isopleths for other explosive non-auditory injury thresholds such as lung and gastrointestinal tract injury. In evaluating explosives, users are reminded not forget to evaluate these other non-auditory injury thresholds in their assessment.

10. Tab E.3, Single Explosive (Lime): This sub-tab is a custom tab specifically for single detonations.

NOTE: This tab allows users to determine the PTS onset and TTS onset isopleths for a single detonation. This tab **does not** provide isopleths for other explosive non-auditory injury thresholds such as lung and gastrointestinal tract injury. In evaluating explosives, users are reminded not forget to evaluate these other non-auditory injury thresholds in their assessment.

11. Tab F, Impulsive, Mobile (Purple): Tab F is appropriate for sources such as mobile seismic arrays.
12. Weighting Function Adjustment (Gray): This tab provides additional considerations when relying upon the use of WFAs.

5.1 CELLS WITHIN INDIVIDUAL TABS

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

- Sage cells: Represents information provided by user. There is basic information a user provides such as unweighted source level (either in 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; See separate Tab on WFA and appropriate frequencies for broadband sounds). For stationary sources, the user is also required to specify propagation.

NOTE: If a user 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 user provide additional justification supporting this modification.

- **Rose cells:** Represents information provided by NMFS (i.e., user cannot modify), such as PTS onset thresholds and auditory weighting function parameters.
- **Sky Blue cells:** Represents the User Spreadsheet tool output in terms of estimated isopleths (meters) by hearing group. These outputs are automatically calculated based on the user inputs provided within the sage cells and cannot be directly modified by the user.
- **White cells:** Represent calculations and factors done automatically within the User Spreadsheet tool (i.e., user cannot modify) or are informational. Even though the user cannot modify these cells, it may be helpful to pay attention to their outputs as a crosscheck to ensure user information is entered correctly.

Within the 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 a user requires access to unlocked cells, they may contact NMFS and request an unlocked version¹¹ of the tab of interest.

When an applicant relies on the User Spreadsheet tool for modeling, NMFS requests they include a copy 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 users, if possible, is encouraged and will result in the User Spreadsheet tool providing results that are more reflective of expected conditions compared to relying on surrogate or default data (Figure 7).

5.2.1 Default Values for Sage Cells

NMFS understands that the User Spreadsheet tool requires additional source parameter information that has not been previously required. For those users 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 activity, pile diameter, pile material, etc.). Thus, a user 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.

¹¹ NMFS locks certain cells within the User Spreadsheet to prevent users from accidentally modifying or deleting formulas or content within these cells.

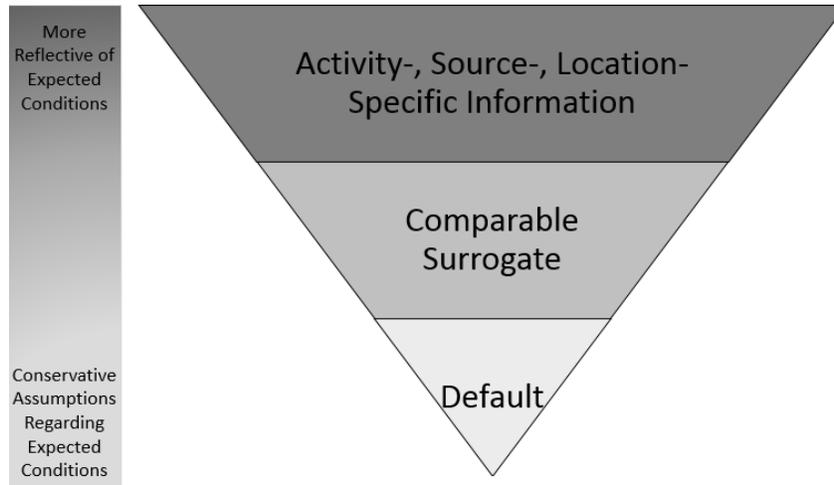


Figure 8: Illustration of data hierarchy and impacts on portraying expected conditions.

5.2.1.1 Weighting Factor Adjustment Suggested Defaults

For example, NMFS provides suggested default WFAs for common broadband sources (Table 5).

Table 5: 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 drivers	2 kHz	Blackwell 2005; Reinhall and Dahl 2011
Vibratory pile drivers	2.5 kHz	Blackwell 2005; Dahl et al. 2015a
Drilling	2 kHz	Greene 1987; Blackwell et al. 2004a; Blackwell and Greene 2006

NOTE: Since spectra associated with underwater explosives vary by detonation size and depth (Urick 1983), the User Spreadsheet tool does not provide a default. However, if the user has the spectrum associated with their detonation, they may override the WFA outputs and directly use this information.

5.2.1.2 Spectrum Defaults

NMFS is working to investigate whether default spectrum can be provided for common sound sources (e.g., seismic airguns), but acknowledge for sources like pile driving, this is difficult due to inherent variability from multiple factors (pile material, pile diameter, sediment, etc.) (Guan et al. 2017).

NOTE: If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to

download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

5.2.1.3 Source Level and Pulse Duration

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

If a user only has unweighted source level information in the RMS SPL 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 driver and seismic airgun sources provided in Appendix B (impact pile driving) and Appendix C (seismic airguns).

NOTE: If the user 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 RMS SPL source levels or one relying upon SEL source levels). NMFS advises users to rely on the method using the SEL source level, so needing to determine the pulse duration (or appropriate default) is not necessary.

Additionally, since NMFS behavioral harassment thresholds are still expressed in the RMS SPL metric, then it may also be necessary to understand the relationship between RMS SPL and SEL source levels.

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):

$$SEL_{cum} = \text{RMS SPL} + 10 \log_{10} (\text{duration of exposure, expressed in seconds}) \text{ dB} \quad \text{Equation 1}$$

USER TIP: Sources producing pulses/pings/strikes less than a second in duration have a larger RMS SPL value compared to SEL value, while sources producing pulses/pings/strikes greater than a second have a larger SEL value compared RMS SPL value. If the pulse/ping/strike is exactly 1 second, then the RMS SPL 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 RMS SPL value.

5.2.1.4 Propagation Defaults

NMFS also acknowledges that the User Spreadsheet tool takes a simple approach to propagation. Sound propagation 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 1995). Many of these factors that affect sound propagation can be extremely site-specific. This is particularly the case for shallow water (Richardson et al. 1995). Sound propagation can be measured directly or modeled. The more site-specific data available, the greater chance of accurately predicting sound propagation through the environment via modeling and ultimately the sound at the receiver. Thus, NMFS recommends that when site-specific information on propagation is available, it be used. For coastal activities, such as pile driving, if area-specific information on propagation is not available, NMFS typically recommends a default propagation value is practical spreading (15 log R) (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 is dominated by multiple surface and bottom reflections (Urlick 1983; Richardson et al. 1995).

NOTE: The User Spreadsheet tool’s “safe distance” methodology for mobile sources assumes propagation (default) is spherical spreading (20 Log R).

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

Each tab separates sound sources based on three main characteristics:

1. Whether 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 active sonar (e.g. tactical), and vibratory pile drivers.

NOTE: The 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).

- **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 drivers.

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 sound types may be more likely to affect auditory physiology and is not meant to reflect categorizations associated with behavioral disturbance.

2. Whether sound source is stationary or mobile
3. Whether 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 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 User Spreadsheet tool. NMFS recommends that all users 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 user.

6.1.1 Instructions

Step 1: How to determine what sheet 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, vibratory pile driving, tactical sonar): Go to Question 2.
 - b) IMPULSIVE (e.g., explosives, impact pile driving, seismic): 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 Spreadsheet A*.
 - *If source is vibratory pile driving: Use Spreadsheet A.1.
 - b) INTERMITTENT: Use Spreadsheet B.
4. Is the NON-IMPULSIVE, MOBILE source CONTINUOUS or INTERMITTENT?
 - a) CONTINUOUS: Use Spreadsheet C (methodology from Sivle et al. 2014).
 - b) INTERMITTENT: Use Spreadsheet D (methodology from Sivle et al. 2014).
5. Is the IMPULSIVE sound source STATIONARY or MOBILE?
 - a) STATIONARY: Use Spreadsheet E*
 - *If source is impact pile driving: Use Spreadsheet E.1.
 - *If source is multiple explosives: Use Spreadsheet E.2.
 - *If source is single explosive: Use Spreadsheet E.3.
 - b) MOBILE: Use Spreadsheet F (methodology from Sivle et al. 2014).

Step 2: User provides appropriate user provided information in the selected spreadsheet's sage cells. NMFS requests users 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 a user provide a copy of the spreadsheet they used in their analysis.

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 7).

Table 6: 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	2 kHz	Blackwell 2005; Reinhall and Dahl 2011
Vibratory pile driving	2.5 kHz	Blackwell 2005; Dahl et al. 2015a
Drilling	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 users ensure they are relying upon the most recent version of the User Spreadsheet tool to perform their isopleth calculations¹². 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 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 User Spreadsheet tool.

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

¹² The most recent version of the User Spreadsheet 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 continuous¹³ temporally. The use of Tab A is most appropriate for drilling activities and may also 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:

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

A: STATIONARY SOURCE: Non-Impulsive, Continuous	
VERSION 2.0: 2018	
KEY	
	User 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 9: 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 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:

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

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

- o Narrowband source: Provide frequency (kHz)

¹³ 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.

A user specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default value (e.g., 2 kHz for drilling)
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within 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 a user plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, users must ensure the chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users 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 a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value	
Weighting Factor Adjustment (kHz) [‡]			
<small>‡ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab</small>			
		<small>† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 43), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.</small>	

Figure 10: Screenshot of Step 2 for Tab A.

6.2.3 Step 3: Source-Specific Information

These sage cells provide information regarding:

- Source Level (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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.

FICTICIOUS EXAMPLE: If a user 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 User Spreadsheet tool is flexible and allows the user 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 user 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 User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- Propagation (x Log R): If a user has site-specific propagation 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 a user 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 user cannot modify, which represent calculations and/or factors done automatically within the 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 user 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 this number the longer the duration of exposure.

STEP 3: SOURCE-SPECIFIC INFORMATION	
Source Level (RMS SPL)	
Duration of Sound Production (hours) within 24-h period	
Duration of Sound Production (seconds)	0
10 Log (duration of sound production)	#NUM!
Propagation (xLogR)	

Figure 11: 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 a user notices values in these cells are larger than this, there is an error.

6.2.4 Resultant Isoleths

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.

RESULTANT ISOPLETHS						
Marine Mammal Hearing Group	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Low-frequency (LF) cetaceans: baleen whales						
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales						
High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalorhynchid, <i>Lagenorhynchus crasirostris</i> & <i>L. australis</i>						
Phocid pinnipeds (PW): true seals						
Otariid pinnipeds (OW): sea lions and fur seals						
	SEL _{cum} Threshold	199	198	173	201	219
	PTS Isoleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Figure 12: Screenshot of Resultant Isoleths for Tab A.

NOTE: The 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 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 users 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:

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

A.1: Vibratory Pile Driving (STATIONARY SOURCE: Non-Impulsive, Continuous)	
VERSION 2.0: 2018	
KEY	
	User 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 13: 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 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:

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

NOTE: Vibratory pile driving is a broadband source.

A user specifies if either:

- o Relying on source-specific WFA and if so, the origin of this information/measurement.
- o Relying upon NMFS suggested default value, which 2.5 kHz for vibratory pile driving.
- o Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within 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 a user plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

NOTE: For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies).

If WFA is not within an applicable frequency range for a group, then users 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 a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value	
Weighting Factor Adjustment (kHz) [‡]			
[‡] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab			
		[†] If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 46), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.	

Figure 14: Screenshot of Step 2 for Tab A.1.

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

These sage provide information regarding:

- Source Level (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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.

- 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.
- Propagation (x Log R): If a user has site-specific propagation 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 a user 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 (e.g., pile driving).

- Distance of 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 user enters whatever value is appropriate for their specific source.

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

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

FICTICIOUS EXAMPLE: If a user 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 User Spreadsheet tool is flexible and allows the user 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 user 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 User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- o 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 this number the longer the duration of exposure.

STEP 3: SOURCE-SPECIFIC INFORMATION	
Source Level (RMS SPL)	
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!
Propagation (xLogR)	
Distance from source level measurement (meters)?	

?Unless otherwise specified, source levels are referenced 1 m from the source.

Figure 15: 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 a user notices values in these cells are larger than this, there is an error.

6.2.A1.4 Resultant Isoleths

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.

RESULTANT ISOPLETHS						
Marine Mammal Hearing Group	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Low-frequency (LF) cetaceans: baleen whales						
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales						
High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalothynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>	SEL_{cum} Threshold	199	198	173	201	219
Phocid pinnipeds (PW): true seals						
Otariid pinnipeds (OW): sea lions and fur seals	PTS Isoleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Figure 16: Screenshot of Resultant Isoleths for Tab A.1.

NOTE: The 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 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 users 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 intermittent¹⁴ temporally. The use of this tab is most appropriate for sources such as certain stationary sonars.

NOTE: The 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 User Spreadsheet tool.
- Project Contact: Person responsible for completing the User Spreadsheet tool.

B: STATIONARY SOURCE: Non-Impulsive, Intermittent			
VERSION 2.0: 2018			
KEY			
	User 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 17: 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 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)

A user specifies if either:

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

¹⁴ 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: 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 a user plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users 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 a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz) ^x		
^y Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab		
		[†] If a user relies on alternative weighting/ dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

Figure 18: Screenshot of Step 2 for Tab B.

6.3.3 Step 3: Source-Specific Information

There are two methods a user can choose (i.e., B1 OR B2) to calculate isopleths.

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

If the user 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 RMS SPL source levels or one relying upon SEL source levels). NMFS advises users 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 B2.

B1: Method using RMS SPL Source Level

These sage cells are for providing information regarding:

- Source Level (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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 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).

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

FICTICIOUS EXAMPLE: If a user had an activity that occurred during daylight (i.e. 12 h), regardless of the pulse duration and 1/repetition rate, then the input for activity duration would be 12 h.

NOTE: The User Spreadsheet tool is flexible and allows the user 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 user 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 User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, 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): 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.

FICTICIOUS 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.

- Propagation (x Log R): If a user has site-specific propagation 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 a user 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 (e.g., pile driving).

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

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

FICTICIOUS 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 a user crosscheck this value to ensure it is accurately reflecting the total duration (in seconds) the source is expected to *actually* 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 user 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 user (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).

FICTICIOUS 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 user in Step 3, while 25920 seconds is the duration of sound production produced by this cell.

NOTE: The User Spreadsheet tool is flexible and allows the user 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 user 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 User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, User Spreadsheet tool may need to be run multiple times to account for this variability among species/hearing groups.

- o 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 this number the longer the duration of exposure.

STEP 3: SOURCE-SPECIFIC INFORMATION				
NOTE: Choose either B1 OR B2 method to calculate isopleths (not required to fill in sage boxes for both)				
B1: METHOD USING RMS SPL SOURCE LEVEL				
Source Level (RMS SPL)				
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 (xLogR)				
[^] Time between onset of successive pulses.				

Figure 19: Screenshot of Step 3, Method B1 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).

B2: Alternative Method (Single ping/pulse equivalent)

These sage cells provide information regarding:

- o 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 User Spreadsheet tool, users 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 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).

FICTICIOUS EXAMPLE: If a user had an activity that occurred during daylight (i.e. 12 h) regardless of the pulse duration and 1/repetition rate, 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 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.

FICTICIOUS 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 B2 Method does not require the user to consider pulse duration, which already accounted for in the single ping/pulse SEL source level.

- Propagation (x Log R): If a user has site-specific propagation information, they may enter it in this cell. If site-specific information is available, the user specifies this in the sage Project/Source Information in Step 1. If not, NMFS recommends that a user 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 (e.g., pile driving).

Within Step 3 are two white cells, that the user cannot modify, which represent calculations and/or factors done automatically within the 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 this number the longer the duration of exposure.

B2: ALTERNATIVE METHOD (SINGLE PING/PULSE EQUIVALENT)		
Source Level (Single Ping/Pulse SEL)		
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 (xLogR)		

Figure 20: Screenshot of Step 3, Method B2 for Tab B.

6.3.4 Resultant Isoleths

Under either methods B1 or B2 (depending on user’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.

RESULTANT ISOPLETHS						
Marine Mammal Hearing Group	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Low-frequency (LF) cetaceans: baleen whales						
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales						
High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalorhynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>	SEL _{cum} Threshold	199	198	173	201	219
Phocid pinnipeds (PW): true seals	PTS Isoleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
Otariid pinnipeds (OW): sea lions and fur seals						

Figure 21: Screenshot of Resultant Isoleths for Tab B.

NOTE: The 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 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 users forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

The User Spreadsheet tool currently does not account for the source directionality or beam pattern (i.e., assumes all sources are omnidirectional). Thus, the 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 continuous¹⁵ temporally. This tab’s calculations relies 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:

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

C: MOBILE SOURCE: Non-Impulsive, Continuous ("SAFE DISTANCE" METHODOLOGY)	
VERSION 2.0: 2018	
KEY	
	User Provided Information
	NMFS Provided Information (Technical Guidance)
	Resultant Isoleth
STEP 1: GENERAL PROJECT INFORMATION	
PROJECT TITLE	
PROJECT/SOURCE INFORMATION	
Please include any assumptions	
PROJECT CONTACT	

Figure 22: 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 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:

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

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

- o Narrowband source: Provide frequency (kHz)

A user specifies if either:

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

¹⁵ 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.

- Relying upon NMFS suggested default value
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within 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 a user plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users 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 a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz) ^Y		
^Y Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab		
		[†] If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 43), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

Figure 23: 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 (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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 user to specify the propagation. The “safe distance” methodology assumes propagation of 20 log R. Additionally, this tab does not ask the user 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 user cannot modify, which represent calculations and/or factors done automatically within the User Spreadsheet tool to produce resultant PTS onset isopleths:

- o **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%).
- o **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 (RMS SPL)	
Source Velocity (meters/second)	
Duty cycle	1
Source Factor	1

‡Methodology assumes propagation of 20 log R; Activity duration (time) independent

Figure 24: 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.

RESULTANT ISOPLETHS						
Marine Mammal Hearing Group	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Low-frequency (LF) cetaceans: baleen whales						
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales						
High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalorhynchid, <i>Lagenorhynchus cruxiger</i> & <i>L. australis</i>						
Phocid pinnipeds (PW): true seals						
Otariid pinnipeds (OW): sea lions and fur seals						
	SEL_{cum} Threshold	199	198	173	201	219
	PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Figure 25: Screenshot of Resultant Isopleths for Tab C.

NOTE: The 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 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 users 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 intermittent¹⁶ temporally. This tab’s calculations relies 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 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:

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

D: MOBILE SOURCE: Non-Impulsive, Intermittent ("SAFE DISTANCE" METHODOLOGY)	
VERSION 2.0: 2018	
KEY	
	User 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 26: 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 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:

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

A user specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default value

¹⁶ 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 alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within 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 a user plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users 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 a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value	
Weighting Factor Adjustment (kHz) [‡]			
[‡] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab			
		[†] If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 61), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.	

Figure 27: Screenshot of Step 2 for Tab D.

6.5.3 Step 3: Source-Specific Information

There are two methods a user can choose (i.e., D1 OR D2) to calculate isopleths.

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

If the user 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 RMS SPL source levels or one relying upon SEL source levels). NMFS advises users 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 D2.

D1: Method using RMS SPL Source Level

These sage cells are for providing information regarding:

- Source Level (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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): 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.

FICTICIOUS EXAMPLE: If a device produces a 9-second ping every 6 seconds, then 1/repetition rate would be 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.

NOTE: This tab does not require the user to specify the propagation. The "safe distance" methodology assumes propagation of $20 \log R$. Additionally, this tab does not ask the user 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 user cannot modify, which represent calculations and/or factors done automatically within the User Spreadsheet tool to produce resultant PTS onset isopleths:

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

FICTICIOUS 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.

STEP 3: SOURCE-SPECIFIC INFORMATION				
NOTE: Choose either D1 <u>OR</u> D2 method to calculate isopleths (not required to fill in sage boxes for both)				
D1: METHOD[‡] USING RMS SPL SOURCE LEVEL				
Source Level (RMS SPL)				
Source Velocity (meters/second)				
Pulse Duration (seconds)				
1/Repetition rate [^] (seconds)				
Duty Cycle	#DIV/0!			
Source Factor	#DIV/0!			
[‡] Methodology assumes propagation of 20 log R; Activity duration (time) independent				
[^] Time between onset of successive pulses.				

Figure 28: Screenshot of Step 3, Method D1 for Tab D.

D2: Alternative 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 User Spreadsheet tool, users 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): 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.

FICTICIOUS 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 D2 Method does not require the user to consider pulse duration, which already accounted for in the single ping/pulse SEL source level.

This tab does not require the user to specify the propagation. The “safe distance” methodology assumes propagation of 20 log R. Additionally, this tab does not ask the user 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 user cannot modify, which represent calculations and/or factors done automatically within the 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.

D2: ALTERNATIVE METHOD[†] (SINGLE PING/PULSE EQUIVALENT)			
Source Level (Single Ping/Pulse SEL)			
Source Velocity (meters/second)			
1/Repetition rate [^] (seconds)			
Source Factor	#DIV/0!		
†Methodology assumes propagation of 20 log R; Activity duration (time) independent			
^Time between onset of successive pulses.			

Figure 29: Screenshot of Step 3, Method D2 for Tab D.

6.5.4 Resultant Isoleths

Under either methods D1 or D2 (depending on user’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.

RESULTANT ISOPLETHS						
Marine Mammal Hearing Group	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Low-frequency (LF) cetaceans: baleen whales						
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales						
High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalothynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>						
Phocid pinnipeds (PW): true seals						
Otariid pinnipeds (OW): sea lions and fur seals						
SEL_{cum} Threshold		199	198	173	201	219
PTS Isoleth to threshold (meters)		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Figure 30: Screenshot of Resultant Isoleths for Tab D.

NOTE: The 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 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 users forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

The User Spreadsheet tool currently does not account for the source directionality or beam pattern (i.e., assumes all sources are omnidirectional). Thus, the 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), if it involves multiple explosives/detonations, see Section 5.6E2 (Tab E.2), and if it involves a single explosive/detonation, see Section 5.6E3 (Tab E.3).

6.6.1 Step 1: General Project Information

These sage cells provide information regarding:

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

E: STATIONARY SOURCE: Impulsive, Intermittent	
VERSION 2.0: 2018	
KEY	
	User 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 31: 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 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:

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

A user specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default value
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within 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 a user plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users 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 a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value	
Weighting Factor Adjustment (kHz) [‡]			
[‡] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab			
		[†] If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 69), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.	

Figure 32: Screenshot of Step 2 for Tab E.

6.6.3 Step 3: Source-Specific Information

There are two methods a user can choose (i.e., E1 OR E2) to calculate isopleths.

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

If the user 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 RMS SPL source levels or one relying upon SEL source levels). NMFS advises users 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 E2.

E1: Method using RMS SPL Source Level

These sage cells are for providing information regarding:

- Source Level (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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 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 user to input the *actual* amount of time the source is producing sound (i.e., Duration of Sound Production).

FICTICIOUS EXAMPLE: If a user had an activity that occurred during daylight (i.e. 12 h) regardless of the pulse duration and 1/repetition rate, then the input for activity duration would be 12 h.

NOTE: The User Spreadsheet tool is flexible and allows the user 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 user 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 User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, 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): 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.

FICTICIOUS 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 (x Log R): If a user has site-specific propagation 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 a user 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 (e.g., pile driving).

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

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

FICTICIOUS 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 a user crosscheck this value to ensure it is accurately reflecting the total duration (in seconds) the source is 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 user 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 user (Activity Duration), which accounts for the amount of time within a 24-h period that a sound producing activity occurs (see Fictitious Example below).

FICTICIOUS 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 user in Step 3, while 25920 seconds is the duration of sound production produced by this cell.

NOTE: The User Spreadsheet tool is flexible and allows the user 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 user 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 User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, 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 this number the longer the duration of exposure.

E1: METHOD TO CALCULATE PK AND SEL _{cum} (USING RMS SPL SOURCE LEVEL)			
SEL _{cum}			
Source Level (RMS SPL)			
Activity Duration (hours) within 24-h period			
Pulse Duration ^Δ (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 (xLogR)			
^Δ Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005			
[^] Time between onset of successive pulses.			

Figure 33: Screenshot of Step 3, Method E1 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 a user 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 User Spreadsheet tool (Version 2.0) now allows users 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 (PK SPL)		

Figure 34: 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).

When relying upon the User Spreadsheet tool, users 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.

E2: Alternative 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 User Spreadsheet tool, users 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 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 user to input the *actual* amount of time the source is producing sound (i.e., duration of sound production)

FICTICIOUS EXAMPLE: If a user had an activity that occurred during daylight (i.e. 12 h) regardless of the pulse duration and 1/repetition rate, then the input for activity duration would be 12 h.

NOTE: The User Spreadsheet tool is flexible and allows the user 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 user 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 User Spreadsheet tool will calculate isopleths based on the entered duration for all groups. Thus, 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 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.

FICTICIOUS 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 E2 Method does not require the user to consider pulse duration, which already accounted for in the single shot/strike SEL source level.

- Propagation (x Log R): If a user has site-specific propagation information, they may enter it in this cell. If site-specific information is available, the user specifies this in the sage Project/Source Information in Step 1. If not, NMFS recommends that a user 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 (e.g., pile driving).

Within Step 3 is two white cell, that the user cannot modify, which represent calculations and/or factors done automatically within the 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 this number the longer the duration of exposure.

E2: ALTERNATIVE METHOD TO CALCULATE PK AND SEL_{cum} (SHO		
SEL _{cum}		
Source Level (Single shot SEL)		
Activity Duration (hours) within 24-h period		
Number of pulses in 1-h period		
Propagation (xLogR)		
Number of pulses in 24-h period	0	
10 log (number of pulses)	#NUM!	

Figure 35: Screenshot of Step 3, Method E2 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 User Spreadsheet tool (Version 2.0) now allows users 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 (PK SPL)		

Figure 36: 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).

When relying upon the User Spreadsheet tool, users 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.

5.6.4 Resultant Isopleths

Under either methods E1 or E2 (depending on user’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 user relies on whichever metric produces the largest isopleth.

RESULTANT ISOPLETHS*		*Impulsive sounds have dual metric thresholds (SEL _{cum} & PK). Metric producing largest isopleth should be used.				
Marine Mammal Hearing Group	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Low-frequency (LF) cetaceans: baleen whales						
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales						
High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalothynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>	SEL _{cum} Threshold	183	185	155	185	203
Phocid pinnipeds (PW): true seals	PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
Otariid pinnipeds (OW): sea lions and fur seals	PK Threshold	219	230	202	218	232
	PTS PK Isopleth to threshold (meters)	NA	NA	NA	NA	NA

Figure 37: Screenshot of Resultant Isopleths for Tab E.

NOTE: The 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 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 users 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 User Spreadsheet tool.
- Project Contact: Person responsible for completing the User Spreadsheet tool.

E.1: IMPACT PILE DRIVING (STATIONARY SOURCE: Impulsive, Intermittent)	
VERSION 2.0: 2018	
KEY	
	User Provided Information
	NMFS Provided Information (Technical Guidance)
	Resultant Isoleth
STEP 1: GENERAL PROJECT INFORMATION	
PROJECT TITLE	
PROJECT/SOURCE INFORMATION	
Please include any assumptions	
PROJECT CONTACT	

Figure 38: 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 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)

A user specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default value (i.e., 2 kHz for impact pile driving).
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within 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 a user plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users 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 a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value	
Weighting Factor Adjustment (kHz) ^Y			
^Y Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab			
		† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 73), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.	

Figure 39: Screenshot of Step 2 for Tab E.1.

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

There are two methods a user can choose (i.e., E.1-1 OR E.1-2) to calculate isopleths.

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

If the user 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 RMS SPL source levels or one relying upon SEL source levels). NMFS advises users 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.1-2.

E.1-1: Method using RMS SPL Source Level

These sage cells are for providing information regarding:

- o Source Level (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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.

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

- Strike 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.
- Propagation (x Log R): If a user has site-specific propagation 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 a user 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 (e.g., pile driving).

- Distance of 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 user enters whatever value is appropriate for their specific source.

Within Step 3 are two white cells, that the user cannot modify, which represent calculations and/or factors done automatically within the 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 a user crosscheck this value to ensure it is accurately reflecting the total duration (in seconds) the source is expected to produce sound within a 24-h period.

FICTICIOUS 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 this 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 a user 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 1: METHOD TO CALCULATE PK AND SEL _{cum} (USING RMS SPL SOURCE LEVEL)			
SEL _{cum}			
Source Level (RMS SPL)			
Number of piles per day			
Strike Duration ^Δ (seconds)			
Number of strikes per pile			
Duration of Sound Production (seconds)	0		
10 Log (duration of sound production)	#NUM!		
Propagation (xLogR)			
Distance of source level measurement (meters)?			
^Δ Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005 Unless otherwise specified, source levels are referenced 1 m from the source.			

Figure 40: 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.

- **Source Level (PK SPL):** The updated version of the User Spreadsheet tool (Version 2.0) now allows users 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).

NOTE: When relying upon the User Spreadsheet tool, users 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.

- **Distance of 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 user enters whatever value is appropriate for their specific source.

PK			
Source Level (PK SPL)			
Distance of source level measurement (meters)?			
Source level at 1 meter	#NUM!		
Unless otherwise specified, source levels are referenced 1 m from the source.			

Figure 41: 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).

E.1-2: Alternative Method (Single strike equivalent)

These sage cells are for providing information regarding:

- Source Level (Single strike SEL): Source level in single strike 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 strike SEL metric represents the sound exposure of a single strike and is not cumulative.

When relying upon the User Spreadsheet tool, users 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.

- 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.1-2 Method does not require the user to consider pulse duration, which already accounted for in the single shot/strike SEL source level

- Propagation (x Log R): If a user has site-specific propagation 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 a user 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 (e.g., pile driving).

- Distance of 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 user enters whatever value is appropriate for their specific source.

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

- Unweighted SEL_{cum} (at measured distance) = $SEL_{ss} + 10 \text{ Log} (\# \text{ strikes})$: 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.1-2: ALTERNATIVE METHOD TO CALCULATE PK AND SEL _{cum} (SINGLE STRIKE P)			
Unweighted SEL _{cum} (at measured distance) = SEL _{ss} + 10 Log (# strikes)	#NUM!		
SEL _{cum}			
Source Level (Single Strike SEL)			
Number of strikes per pile			
Number of piles per day			
Propagation (xLogR)			
Distance of single strike SEL measurement (meters)?			
Unless otherwise specified, source levels are referenced 1 m from the source.			

Figure 42: 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.

- o Source Level (PK SPL): The updated version of the User Spreadsheet tool (Version 2.0) now allows users 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).

NOTE: When relying upon the User Spreadsheet tool, users 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.

- o Distance of 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 user enters whatever value is appropriate for their specific source.

PK			
Source Level (PK SPL)			
Distance of source level measurement (meters)?			
Source level at 1 meter	#NUM!		
Unless otherwise specified, source levels are referenced 1 m from the source.			

Figure 43: 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).

6.6.E1.4 Resultant Isopleths

Under either methods E.1-1 or E.1-2 (depending on user’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 user relies on whichever metric produces the largest isopleth.

RESULTANT ISOPLETHS*		*Impulsive sounds have dual metric thresholds (SEL _{cum} & PK). Metric producing largest isopleth should be used.				
Marine Mammal Hearing Group	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Low-frequency (LF) cetaceans: baleen whales	SEL _{cum} Threshold	183	185	155	185	203
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales	PTS Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalorhynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>	PK Threshold	219	230	202	218	232
Phocid pinnipeds (PW): true seals	PTS PK Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
Otariid pinnipeds (OW): sea lions and fur seals						

Figure 44: Screenshot of Resultant Isopleths for Tab E.1.

NOTE: The User Spreadsheet tool provides a means to estimate 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 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 users forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.6.E2 Explosive-Multiple Detonations (Tab E.2: Seafoam)

Tab E.2 is for use specifically with explosives with multiple detonations. Multiple detonations occur when more than one detonation occurs within a 24-h period. However, there may be some situations where detonations occur close enough in space and time (e.g., microdelay) to be considered a single detonation. Please consult NMFS if there are questions about a particular situation.

NOTE: This tab allows users to determine the PTS onset, TTS onset, and explosive behavioral harassment onset isopleths for multiple detonations. This tab **does not** provide isopleths for other explosive non-auditory injury thresholds such as lung and gastrointestinal tract injury. In evaluating explosives, users is reminded not forget to evaluate these other non-auditory injury thresholds in their assessment.

6.6.E2.1 Step 1: General Project Information

These sage cells provide information regarding:

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

E.2: Explosives: Impulsive, Intermittent (Multiple detonations)	
PTS, TTS, and BEHAVIOR	
VERSION 2.0: 2018	
KEY	
	User 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 45: 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 isopleths. However, this information is useful to ensure User Spreadsheet tool inputs are entered correctly for a particular project/source.

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:

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

A user specifies if either:

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

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

For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

Since spectra associated with underwater explosives vary by detonation size and depth (Urick 1983), the User Spreadsheet tool does not provide a default. However, if the user has the spectrum associated with their detonation, they may override the WFA outputs and directly use this information.

The term “override” refers to a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz) [‡]		
[‡] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab		
		[†] If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 96), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

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

6.6E2.3 Step 3: Source-Specific Information

There are two methods a user can choose (i.e., E.2-1 OR E.2-2) to calculate isopleths.

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

If the user 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 RMS SPL source levels or one relying upon SEL source levels). NMFS advises users 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.2-2.

E.2-1: Method using RMS SPL Source Level

These sage cells are for providing information regarding:

- Source Level (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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: This cell is asking for 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 user to input the *actual* amount of time the source is producing sound (i.e., Duration of Sound Production).

FICTICIOUS EXAMPLE: If a user had an activity that occurred during daylight (i.e. 12 h) regardless of the pulse duration and 1/repetition rate, then the input for activity duration would be 12 h.

- Shot Duration (seconds): Duration of detonation (i.e., Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005).
- Number of detonations in a 1-h period: Representative (typical) number of detonations expected to occur within a 1-h period.
- Propagation (x Log R): If a user has site-specific propagation 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 a user 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 (e.g., pile driving).

Within Step 3 are two white cells, that the user cannot modify, which represent calculations and/or factors done automatically within the 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 Activity Duration (hours) within a 24-h period by the number of detonations within an hour times the shot duration in order to get the number of seconds within a 24-h period the source is producing sound. It is recommended that a user 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.

E.2 1: METHOD TO CALCULATE PK AND SEL _{cum} (USING RMS SPL SOURCE LEVEL)			
SEL _{cum}			
Source Level (RMS SPL)			
Activity Duration (hours) within 24-h period			
Shot Duration ^Δ (seconds)			
Number of detonations in 1 h period			
Duration of Sound Production (seconds)		0	
10 log (duration of sound production)		#NUM!	
Propagation (xLogR)			

^ΔWindow that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005

Figure 47: Screenshot of Step 3, Method E.2-1 for Tab E.2.

NOTE: The Duration of Sound Production output in this cell is different from the activity duration specified by the user 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 user (Activity Duration), which accounts for the amount of time within a 24-h period that a sound producing activity occurs (see Fictitious Example below).

FICTICIOUS EXAMPLE: If the typical number of shot expected in 1-h is 10, the activity is expected to occur over 2 hours, and the shot duration is 0.01 seconds (10 msec), then the duration of sound production in seconds would be 0.2 (10 x 2 x 0.01).

In this example, 2 h is the activity duration specified by the user in Step 3, while 0.2 seconds is the duration of sound production produced by this cell.

- 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 this number the longer the duration of exposure.

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 a user 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). This probably especially the case for multiple detonations which because of their short duration and typical use are not expected have a duration of sound production (seconds) anywhere near 86400 s.

- Source Level (PK SPL): The updated version of the User Spreadsheet tool (version) now allows users 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).

NOTE: When relying upon the User Spreadsheet tool, users 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.

PK	
Source Level (PK SPL)	

Figure 48: 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).

E.2-2: Alternative Method (Shot 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 User Spreadsheet tool, users 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 later accounts for the total number of shots/detonations 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 user to input the *actual* amount of time the source is producing sound (i.e., duration of sound production).

FICTICIOUS EXAMPLE: If a user had an activity that occurred during daylight (i.e. 12 h) regardless of the pulse duration and 1/repetition rate, then the input for activity duration would be 12 h.

- Number of pulses in a 1-h period: Typical number of detonations expected to occur within a 1-h period.

NOTE: The E2-2 Method does not require the user to consider shot duration, which already accounted for in the single shot SEL source level.

- Propagation (x Log R): If a user has site-specific propagation information, they may enter it in this cell. If site-specific information is available, the user specifies this in sage Project/Source Information in Step 1. If not, NMFS recommends that a user 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 (e.g., pile driving).

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

- Number of shots in 24-h: This value is the number of shots in a 1-h period multiplied by the activity duration within a 24-h period.
- 10 Log (number of shots): This cell is 10 log the total number of shots expected within a 24-h period. The larger this number the longer the duration of exposure.

E.2-2: ALTERNATIVE METHOD TO CALCULATE PK AND SEL_{cum} (SHOT EQUIVALENT)			
SEL _{cum}			
Source Level (Single shot SEL)			
Activity Duration (hours) within 24-h period			
Number of detonations in 1-h period			
Number of shots in 24-h period		0	
10 log (number of shots)		#NUM!	
Propagation (xLogR)			

Figure 49: Screenshot of Step 3, Method E.2-2 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.

- Source Level (PK SPL): The updated version of the User Spreadsheet tool (Version 2.0) now allows users 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 (PK SPL)		

Figure 50: 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).

When relying upon the User Spreadsheet tool, users 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.

6.6.4 Resultant Isopleths

Under either methods E.2-1 or E.2-2 (depending on user’s preference), rose cells display the Technical Guidance’s PTS onset and TTS onset thresholds, in the SEL_{cum} metric and PK metric, and the explosive behavioral harassment threshold in the SEL_{cum} metric by marine mammal hearing group. The sky blue cells provide the resultant PTS and TTS onset isopleths (SEL_{cum} metric and PK), in meters, for each marine mammal hearing group, while the behavioral harassment threshold is only in the SEL_{cum} metric. Since both SEL_{cum} and PK resultant isopleths are provided, the user relies on whichever metric produces the largest isopleth when considering PTS and TTS. However, for consideration of mortality and non-auditory injury associated with explosives, users also need to consider NMFS’ thresholds for lung and gastrointestinal tract injury, which are not calculated within the User Spreadsheet tool.

NOTE: Since the behavioral harassment thresholds for explosives are directly derived from the TTS onset thresholds (i.e., 5 dB lower than TTS onset), the Technical Guidance in addition to updating PTS and TTS onset thresholds, also updates behavioral thresholds. This is the only sound source where this is the case. Additionally, as a result of being derived from TTS onset thresholds, the explosive behavioral harassment threshold are expressed using a cumulative metric and incorporate auditory weighting functions (i.e., no other of NMFS current behavioral thresholds do so).

RESULTANT ISOPLETHS*		*Impulsive sounds have dual metric thresholds (SEL _{cum} & PK). Metric producing largest isopleth should be used. Additionally, explosives have thresholds associate with lung and g.i. tract injury that need to be considered.										
PTS	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds						
	SEL _{cum} Threshold	183	185	155	185	203						
	PTS SEL _{cum} 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						
<table border="1"> <tr><td>Marine Mammal Hearing Group</td></tr> <tr><td>Low-frequency (LF) cetaceans: baleen whales</td></tr> <tr><td>Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales</td></tr> <tr><td>High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i>, river dolphins, cephalothynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i></td></tr> <tr><td>Phocid pinnipeds (PW): true seals</td></tr> <tr><td>Otariid pinnipeds (OW): sea lions and fur seals</td></tr> </table>		Marine Mammal Hearing Group	Low-frequency (LF) cetaceans: baleen whales	Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales	High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalothynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>	Phocid pinnipeds (PW): true seals	Otariid pinnipeds (OW): sea lions and fur seals	*Impulsive sounds have dual metric thresholds (SEL _{cum} & PK). Metric producing largest isopleth should be used.				
Marine Mammal Hearing Group												
Low-frequency (LF) cetaceans: baleen whales												
Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales												
High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalothynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>												
Phocid pinnipeds (PW): true seals												
Otariid pinnipeds (OW): sea lions and fur seals												
TTS	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds						
	SEL _{cum} Threshold	168	170	140	170	188						
	TTS SEL _{cum} Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!						
	PK Threshold	213	224	196	212	226						
	TTS PK Isopleth to threshold (meters)	NA	NA	NA	NA	NA						
Behavior	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds						
	SEL _{cum} Threshold	163	165	135	165	183						
	Behavior Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!						

Figure 51: Screenshot of Resultant Isopleths for Tab E.2.

NOTE: The 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 User Spreadsheet tool.

This tab allows users to determine the PTS onset, TTS onset, and explosive behavioral harassment onset isopleths for multiple detonations. This tab **does not** provide isopleths for other

explosive non-auditory injury thresholds such as lung and gastrointestinal tract injury. In evaluating explosives, users is reminded not forget to evaluate these other non-auditory injury thresholds in their assessment.

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 users forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.6.E3 Explosives-Single Detonation (Tab E.3: Lime)

Tab E.3 is for use specifically with single detonation explosives.

NOTE: This tab allows users to determine the PTS onset and TTS onset isopleths for a single detonation. This tab **does not** provide isopleths for other explosive non-auditory injury thresholds such as lung and gastrointestinal tract injury. In evaluating explosives, users is reminded not forget to evaluate these other non-auditory injury thresholds in their assessment.

6.6.E3.1 Step 1: General Project Information

These sage cells provide information regarding:

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

E.3: Explosives: Impulsive, Intermittent (Single detonation)	
PTS and TTS	
VERSION 2.0: 2018	
KEY	
	User 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 52: Screenshot of Step 1 for Tab E.3.

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

6.6.E3.2 Step 2: Weighting Factor Adjustment

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

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

A user specifies if either:

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

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

For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users are directed to override the WFA adjustment using a value of zero dB (See Section 3.2 on WFA Override).

Since spectra associated with underwater explosives vary by detonation size and depth (Urick 1983), the User Spreadsheet tool does not provide a default. However, if the user has the spectrum associated with their detonation, they may override the WFA outputs and directly use this information.

The term “override” refers to a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz) [‡]		
[‡] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab		
		[†] If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 78), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

Figure 53: Screenshot of Step 2 for Tab E.3.

6.6E3.3 Step 3: Source-Specific Information

There are two methods a user can choose (i.e., E.3-1 OR E.3-2) to calculate isopleths.

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

If the user 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 RMS SPL source levels or one relying upon SEL source levels). NMFS advises users 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.3-2.

E.3-1: Method using RMS SPL Source Level

These sage cells are for providing information regarding:

- **Source Level (RMS SPL):** Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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.

- **Shot Duration (seconds):** Duration of detonation (i.e., Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005).
- **Propagation (x Log R):** If a user has site-specific propagation 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 a user 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 (e.g., pile driving).

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

- **10 Log duration of sound production:** This cell is 10 log the duration sound production in seconds from the single shot duration.

E.3 1: METHOD TO CALCULATE PK AND SEL_{cum} (USING RMS SPL SOURCE LEVEL)			
SEL_{cum}			
Source Level (RMS SPL)			
Shot Duration^Δ (seconds)			
10 Log (duration of sound production)	#NUM!		
Propagation (xLogR)			

^ΔWindow that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005

Figure 54: Screenshot of Step 3, Method E.3-1 for Tab E.3.

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 User Spreadsheet tool (version) now allows users 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 (PK SPL)		

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).

When relying upon the User Spreadsheet tool, users 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.

E.3-2: Alternative Method (Shot 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: When relying upon the User Spreadsheet tool, users 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.

- **Propagation (x Log R):** If a user has site-specific propagation information, they may enter it in this cell. If site-specific information is available, the user specifies this in sage Project/Source Information in Step 1. If not, NMFS recommends that a user contact them to determine an appropriate surrogate value.

E.3-2: ALTERNATIVE METHOD TO CALCULATE PK AND SEL _{cum} (SI)		
SEL _{cum}		
Source Level (Single shot SEL)		
Propagation (xLogR)		

Figure 56: Screenshot of Step 3, Method E.3-2 for Tab E.3.

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

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 User Spreadsheet tool (Version 2.0) now allows users 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 (PK SPL)		

Figure 57: 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).

When relying upon the User Spreadsheet tool, users 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.

6.6.4 Resultant Isoleths

Under either methods E.2-1 or E.2-2 (depending on user's preference), rose cells display the Technical Guidance's PTS onset and TTS onset thresholds in the SEL_{cum} metric and PK metric by marine mammal hearing group. The sky blue cells provide the resultant PTS and TTS 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 user relies on whichever metric produces the largest isopleth when considering PTS and TTS. However, for consideration of mortality and non-auditory injury associated with explosives, users also need to consider NMFS' thresholds for lung and gastrointestinal tract injury, which are not calculated within the User Spreadsheet tool.

NOTE: The 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 User Spreadsheet tool.

This tab allows users to determine the PTS onset, TTS onset, and explosive behavioral harassment onset isopleths for multiple detonations. This tab **does not** provide isopleths for other explosive non-auditory injury thresholds such as lung and gastrointestinal tract injury. In evaluating explosives, users is reminded not forget to evaluate these other non-auditory injury thresholds in their assessment.

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 users forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

RESULTANT ISOPLETHS*		*Impulsive sounds have dual metric thresholds (SEL _{cum} & PK). Metric producing largest isopleth should be used. Additionally, explosives have thresholds associated with lung and g.i. tract injury that need to be considered.				
PTS	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
	SEL _{cum} Threshold	183	185	155	185	203
	PTS SEL _{cum} 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
Marine Mammal Hearing Group Low-frequency (LF) cetaceans: baleen whales Mid-frequency (MF) cetaceans: dolphins, toothed whales, beaked whales, bottlenose whales High-frequency (HF) cetaceans: true porpoises, <i>Kogia</i> , river dolphins, cephalothynchid, <i>Lagenorhynchus craciger</i> & <i>L. australis</i> Phocid pinnipeds (PW): true seals Otariid pinnipeds (OW): sea lions and fur seals		*Impulsive sounds have dual metric thresholds (SEL _{cum} & PK). Metric producing largest isopleth should be used.				
TTS	Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
	SEL _{cum} Threshold	168	170	140	170	188
	TTS SEL _{cum} Isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
	PK Threshold	213	224	196	212	226
	TTS PK Isopleth to threshold (meters)	NA	NA	NA	NA	NA

Figure 58: Screenshot of Resultant Isopleths for Tab E.3.

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 relies 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:

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

F: MOBILE SOURCE: Impulsive, Intermittent ("SAFE DISTANCE" METHODOLOGY)	
VERSION 2.0: 2018	
KEY	
	User 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 59: 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 User Spreadsheet tool inputs are entered correctly for a particular project/source.

6.7.2 Step 2: Weighting Factor Adjustment

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

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

A user specifies if either:

- Relying on source-specific WFA and if so, the origin of this information/measurement
- Relying upon NMFS suggested default value (e.g., 1 kHz for seismic surveys).
- Relying upon alternative weighting/dB adjustment (i.e., overriding output of WFA adjustment within 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 a user plans to override the WFA adjustments (dB) using a source specific spectrum (See Section 3.2 on WFA Override).

For broadband sources, users must ensure chosen WFA is within a hearing group’s applicable frequency range (see GRAY tab for more information on WFA applicable frequencies). If WFA is not within an applicable frequency range for a group, then users 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 a user incorporating a more appropriate Adjustment (dB). It does not refer to the user overriding the formulas associated with these cells to recalculate isopleths using an entered WFA. Users may notice that the formulas associated with the WFA calculations refer to cells that appear blank in the 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 user.

If a user decides to override the 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 a user later desires to rely upon the User Spreadsheet’s default WFA calculations, they will need to download another copy of the User Spreadsheet tool to ensure that the built-in calculations are functioning properly.

STEP 2: WEIGHTING FACTOR ADJUSTMENT		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz) [‡]		
[‡] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab		
		[†] If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 68), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

Figure 60: Screenshot of Step 2 for Tab F.

6.7.3 Step 3: Source-Specific Information

There are two methods a user can choose (i.e., F1 OR F2) to calculate isopleths.

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

If the user 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 RMS SPL source levels or one relying upon SEL

source levels). NMFS advises users 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 F2.

F1: Method using RMS SPL Source Level

These sage cells are for providing information regarding:

- Source Level (RMS SPL): Source level in the root mean square (RMS) 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 User Spreadsheet tool, users 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/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): 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.

FICTICIOUS 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 user to specify the propagation. The "safe distance" methodology assumes propagation of 20 log R. Additionally, this tab does not ask the user 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 user cannot modify, which represent calculations and/or factors done automatically within the User Spreadsheet tool to produce resultant PTS onset isopleths:

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

FICTICIOUS 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.

F1: METHOD [‡] TO CALCULATE PK and SEL _{cum} (USING RMS SPL SOURCE LEVEL)			
SEL _{cum}			
Source Level (RMS SPL)			
Source Velocity (meters/second)			
Pulse Duration [^] (seconds)			
1/Repetition rate [^] (seconds)			
Duty Cycle	#DIV/0!		
Source Factor	#DIV/0!		
‡Methodology assumes propagation of 20 log R; Activity duration (time) independent			
^Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005			
^Time between onset of successive pulses.			

Figure 61: 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 User Spreadsheet tool (Version 2.0) now allows users 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 (PK SPL)			
‡Methodology assumes propagation of 20 log R; Activity duration (time) independent			

Figure 62: 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).

When relying upon the User Spreadsheet tool, users 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.

F2: Alternative 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 User Spreadsheet tool, users 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):** 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.

FICTICIOUS 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 F2 Method does not require the user to consider pulse duration, which already accounted for in the single ping/pulse SEL source level.

This tab does not require the user to specify the propagation. The “safe distance” methodology assumes propagation of 20 log R. Additionally, this tab does not ask the user 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 user cannot modify, which represent calculations and/or factors done automatically within the 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.

F2: ALTERNATIVE METHOD[†] TO CALCULATE PK and SEL_{cum} (SINGLE SHOT/P			
SEL _{cum}			
Source Level (Single shot/pulse SEL)			
Source Velocity (meters/second)			
1/Repetition rate [^] (seconds)			
Source Factor	#DIV/0!		
†Methodology assumes propagation of 20 log R; Activity duration (time) independent			
[^] Time between onset of successive pulses.			

Figure 63: 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 User Spreadsheet tool (Version 2.0) now allows users 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 (PK SPL)				
‡Methodology assumes propagation of 20 log R; Activity duration (time) independent				

Figure 64: 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).

When relying upon the User Spreadsheet tool, users 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.

6.7.4 Resultant Isoleths

Under either methods F1 or F2 (depending on user’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 user relies on whichever metric produces the largest isopleth.

RESULTANT ISOPLETHS*		*Impulsive sounds have dual metric thresholds (SEL_{cum} & 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 SEL_{cum} Isoleth to threshold (meters)		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
PK Threshold		219	230	202	218	232
PTS PK Isoleth to threshold (meters)		NA	NA	NA	NA	NA

Figure 65: Screenshot of Resultant Isoleths 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).

The 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 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 users forgetting to enter a WFA value in Step 2 or overriding this value (See Section 3.2).

6.8 WEIGHTING FACTOR ADJUSTMENT TAB (GREY)

Numerical criteria presented in the Technical Guidance consist of both an acoustic threshold and auditory weighting function associated with the SEL_{cum} metric. NMFS recognizes that the implementation of marine mammal auditory weighting functions represents a new factor for consideration, which may extend beyond the capabilities of some users. Thus, NMFS has developed simple weighting factor adjustments (WFA) for those who cannot fully apply auditory weighting functions associated with the SEL_{cum} metric.

WFAs consider marine mammal auditory weighting functions by focusing on a single frequency. This will typically result in similar, if not identical, predicted exposures for narrowband sounds or higher predicted exposures for broadband sounds, since only one frequency is being considered, compared to exposures associated with the ability to fully incorporate the Technical Guidance's auditory weighting functions.

WFAs have the advantage of allowing everyone to use the same acoustic thresholds and allows adjustments to be made for each hearing group based on source-specific information.

6.8.1 Narrowband Sources

The selection of the appropriate frequency for consideration associated with WFAs is straightforward. WFAs for a narrowband sound would take the weighting function amplitude, for each hearing group, associated with the particular frequency of interest and use it to make an adjustment to reflect the hearing's group susceptibility to that narrowband sound.

6.8.2 Broadband Sources

The selection of the appropriate frequency for consideration associated with WFAs is more complicated. The selection of WFAs associated with broadband sources is similar to the concept used for to determine the 90% total cumulative energy window (5 to 95%) for consideration of duration associated with the RMS metric and impulsive sounds (Madsen 2005) but considered in the frequency domain, rather than the time domain. This is typically referred to as the 95% frequency contour percentile (Upper frequency below which 95% of total cumulative energy is contained; Charif et al. 2010).

6.8.2.1 Special Considerations for Broadband Sources

Since the intent of WFAs is to broadly account for auditory weighting functions below the 95% frequency contour percentile, it is important that only frequencies on the "left side" of the auditory weighting function be used to make adjustments (i.e., frequencies below those where the auditory weighting function amplitude is zero or below where the function is essentially flat; resulting in every frequency below the WFA always having a more negative amplitude than the chosen WFA) (Figure below). It is inappropriate to use WFAs for frequencies on the "right side" of the auditory weighting function (i.e., frequencies above those where the auditory weighting function amplitude is zero, Figure 65). For a frequency on the "right side" of the auditory weighting function (Table below), any adjustment is inappropriate and WFAs cannot be used (i.e., an action proponent would be advised to not use auditory weighting functions and evaluate its source as essentially unweighted; see "Use" frequencies in Table 8, which will result in a weighting function amplitude of 0 dB).

NOTE: NMFS' preference is that spectrum data be use for broadband sources, when possible, compared to the simple WFA. By including a source's entire spectrum, this will allow a user 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 (See Section 3.2 on WFA Override).

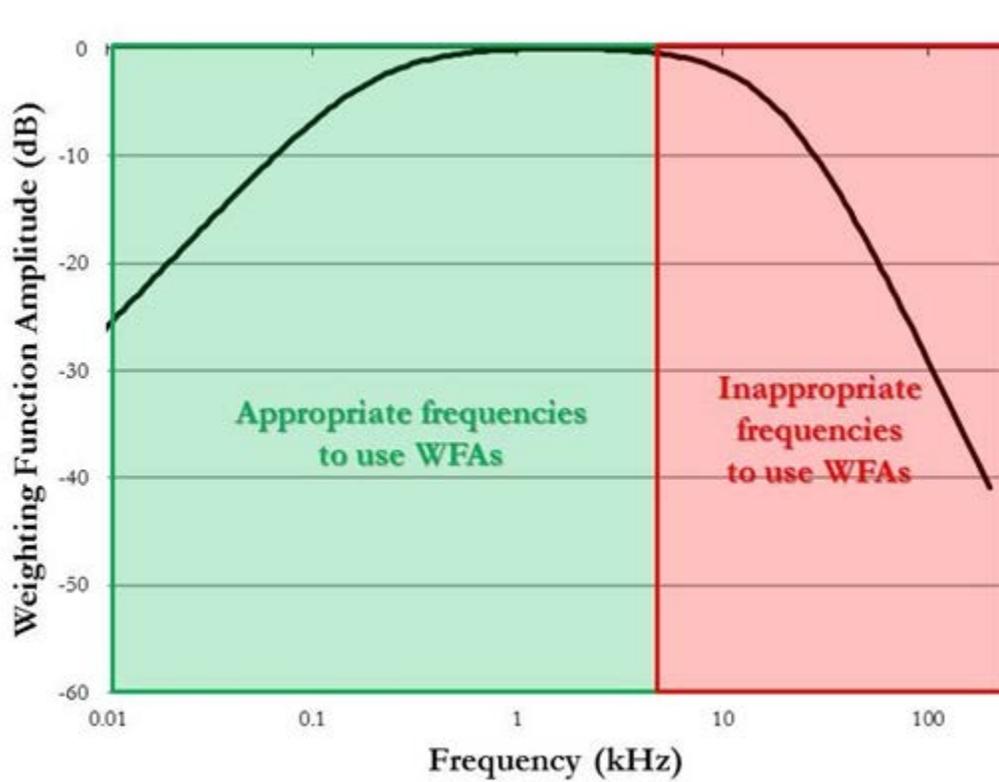


Figure 66: Example auditory weighting function illustrating where the use of weighting factor adjustments are (Green: “left side”) and are not (Red: “right side”) appropriate for broadband sources.

Table 7: Applicability of weighting factor adjustments for broadband sound.

Hearing Group	Applicable Frequencies	Non-Applicable Frequencies*
Low-Frequency Cetaceans (LF)	4.8 kHz and lower	Above 4.8 kHz (Use: 1.7 kHz)
Mid-Frequency Cetaceans (MF)	43 kHz and lower	Above 43 kHz (Use: 28 kHz)
High-Frequency Cetaceans (HF)	59 kHz and lower	Above 59 kHz (Use: 42 kHz)
Phocid Pinnipeds (PW)	11 kHz and lower	Above 11 kHz (Use: 6.2 kHz)
Otariid Pinnipeds (OW)	8.5 kHz and lower	Above 8.5 kHz (Use: 4.9 kHz)

* With non-applicable frequencies, a user inputs the “use” frequency in the User Spreadsheet tool, which will result in a weighting function amplitude of 0 dB (i.e., unweighted) or user can directly override the WFA Adjustment (dB) at the bottom of the tab to 0.00 dB for the particular hearing group that requires an unweighted adjustment.

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, <i>Kogia</i> , river dolphins, cephalorhynchid, <i>Lagenorhynchus cruciger</i> & <i>L. australis</i>)	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	<i>a</i>	<i>b</i>	<i>f</i> ₁ (kHz)	<i>f</i> ₂ (kHz)	<i>C</i> (dB)	<i>K</i> (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 ($W_{\text{aud}}(f)$) (dB) and exposure functions ($E_{\text{aud}}(f)$) (dB):

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

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

Table A3: Summary of PTS onset acoustic thresholds.

Hearing Group	PTS Onset Thresholds* (Received Level)	
	Impulsive	Non-impulsive
Low-Frequency (LF) Cetaceans	<i>Cell 1</i> $L_{p,0-pk,flat}$: 219 dB $L_{E,p,LF,24h}$: 183 dB	<i>Cell 2</i> $L_{E,p,LF,24h}$: 199 dB
Mid-Frequency (MF) Cetaceans	<i>Cell 3</i> $L_{p,0-pk,flat}$: 230 dB $L_{E,p,MF,24h}$: 185 dB	<i>Cell 4</i> $L_{E,p,MF,24h}$: 198 dB
High-Frequency (HF) Cetaceans	<i>Cell 5</i> $L_{p,0-pk,flat}$: 202 dB $L_{E,p,HF,24h}$: 155 dB	<i>Cell 6</i> $L_{E,p,HF,24h}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	<i>Cell 7</i> $L_{p,0-pk,flat}$: 218 dB $L_{E,p,PW,24h}$: 185 dB	<i>Cell 8</i> $L_{E,p,PW,24h}$: 201 dB
Otariid Pinnipeds (OW) (Underwater)	<i>Cell 9</i> $L_{p,0-pk,flat}$: 232 dB $L_{E,p,OW,24h}$: 203 dB	<i>Cell 10</i> $L_{E,p,OW,24h}$: 219 dB

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

Note: Peak sound pressure level ($L_{p,0-pk}$) has a reference value of 1 μPa , and weighted cumulative sound exposure level ($L_{E,p}$) has a reference value of 1 $\mu\text{Pa}^2\text{s}$. 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.

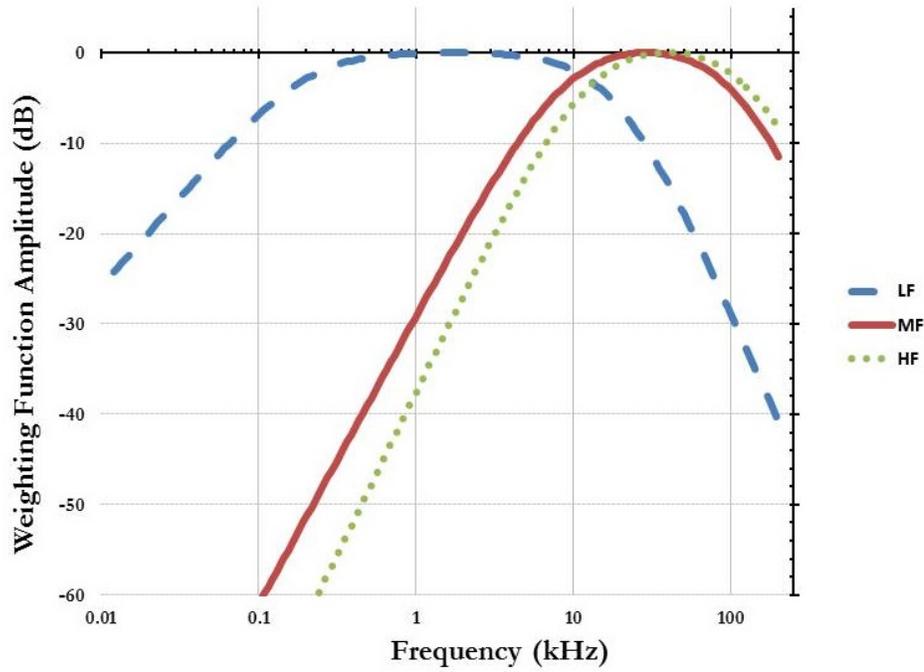


Figure A1: Auditory weighting functions for low-frequency (LF), mid-frequency (MF), and high-frequency (HF) cetaceans.

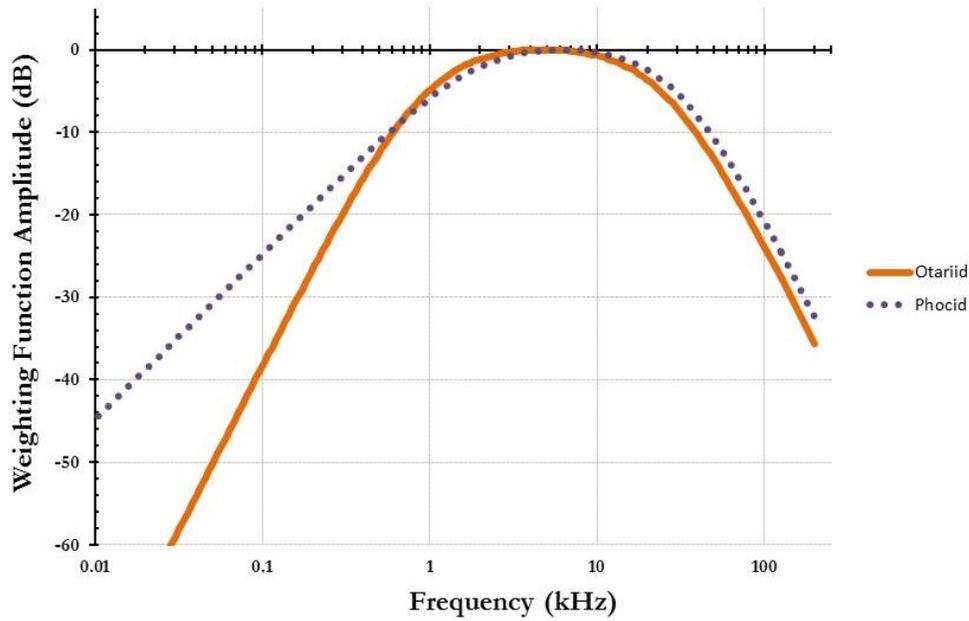


Figure A2: Underwater auditory weighting functions for otariid (OW) and phocid (PW) pinnipeds.

APPENDIX B: RECOMMENDED 100 MS (DEFAULT) PULSE DURATION FOR IMPACT PILE DRIVING ACTIVITIES

1.0 INTRODUCTION

The User Spreadsheet tool provides an optional tool for approximating isopleths associated with the Guidance's updated PTS onset thresholds. When information is unavailable for a user to accurately fill-out the User Spreadsheet tool's "User 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 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 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, pile diameter, pile material, etc.). Thus, a user 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.

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 as a result of multipath propagation¹⁷ 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 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 pile driving activities. Using the summary data provided at the beginning of this compendium, 10 m levels expressed as single strike SEL, PK, and RMS sound pressure level were analyzed for all pile types (e.g., steel, concrete) (Table B1).

¹⁷ Multipath propagation 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; Urlick 1983).

Table B1: Caltrans (2015) Compendium analysis.*

PEAK-RMS		PEAK-SEL		RMS-SEL	
Mean	17.9393939	Mean	28.48438	Mean	11.24
Standard Error	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 Deviation	6.68840279	Standard Deviation	4.777567	Standard Deviation	2.503549
Sample Variance	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 Level	1.64421463	Confidence Level	1.193401	Confidence Level	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 RMS and single strike SEL).

From this analysis, the mean difference between RMS and single strike SEL 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:

$$SEL_{ss} = RMS_{ss} + 10 \text{ Log (duration in seconds)} \quad \text{Equation B1}$$

Solve equation assuming a 10 dB difference (mode from Table B1) between SEL_{ss} and RMS_{ss} :

$$-10 \text{ dB} = 10 \text{ Log (duration)}$$

$$-1 = \text{Log (duration)}$$

$$= 0.1 \text{ seconds (100 msec)}$$

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, pulse duration demonstrate values between 50 and 100 msec at distances 1 km or closer to the source (e.g., Blackwell et al. 2005; Bailey et al. 2010; de Jong and Ainslie 2012; Illingsworth & Rodkin 2014).

Finally, Dr. Peter Dahl (2016) recommended “50 ms (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 Default Suggested by WCR Pile Driving Calculator¹⁸ for Fish Injury Thresholds

The NMFS West Coast Region Pile Driving Calculator for fishes recommends estimating single strike SEL, if no direct measurement is available that one assumes that this value is 25 dB lower than the peak sound pressure level measurement. Additionally, this same calculator recommends estimating single strike RMS sound pressure, if no direct measurement is available that one assumes that this value is 15 dB lower than the peak sound pressure level measurement. Note that these recommended values are supported by data within Caltrans (2015) (See Table 1 in this document).

Thus, based on these recommendations, this results in a 10 dB difference between single strike SEL and RMS values (Single strike SEL value is 10 dB lower than RMS), which translates to a pulse duration of 100 ms via Equation B1.

3.0 RECOMMENDED DEFAULT PULSE DURATION FOR IMPACT PILE DRIVING ACTIVITIES

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

¹⁸ Posted on [Caltrans web site](#).

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

1.0 INTRODUCTION

The 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 a user to fill-out the 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 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 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 applicant 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.

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 propagation¹⁹ 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, seismic airgun shot frequency content also factors into pulse duration, with those pulses with more high-frequency content being shorter (HESS 1999), and those airgun arrays with larger volumes having 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 (RMS) sound pressure level such that pulse duration can be derived.

¹⁹ Multipath propagation 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; Urlick 1983).

Table C1: Summary of Available Measurements

Study	Water Depth	Measurement Distances	Difference between RMS-SEL [†]	Pulse Duration
Richardson 1997; Harris et al. 2001	3-17 m	up to 2 km	~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	11.4 to 14.6 dB*	35 to 72 msec
Patterson et al. 2007	40 m	up to 0.3 km	~10 dB ⁺	~100 msec
Tolstoy et al. 2009	~50 m	up to 15 km	~8 dB	158 msec
Tolstoy et al. 2009	~1600 m	up to 4 km	~14 dB	40 msec
Diebold et al. 2010	~50 m	up to 15 km	~8-10 dB	10 to 158 msec
Diebold et al. 2010	~1600 m	up to 2 km	10-20 dB [^]	10 to 100 msec

* This study reports equivalent energy (proportional to energy²⁰). Differences displayed are mean values.

⁺ 8.5 dB (141 ms) 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:

$$\text{SEL} = \text{RMS} + 10 \text{ Log} (\text{duration in seconds}) \quad \text{Equation C1}$$

Solve equation assuming a 10 dB difference between SEL and RMS:

$$-10 \text{ dB} = 10 \text{ Log} (\text{duration})$$

$$-1 = \text{Log} (\text{duration})$$

$$= 0.1 \text{ seconds (100 msec)}$$

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 purposes, 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).

²⁰ McCauley et al. 2000 explains that energy per unit area is sometimes termed “energy flux,” and since almost all underwater acoustic measurements use pressure sensitive transducers that convert sound pressure to voltage then it is common practice to present measurements in terms of pressure only. Since for a given medium the acoustic impedance is relatively constant then one can derive a measure directly proportional to ‘energy per unit area’ by dropping the specific acoustic impedance term, to give ‘equivalent energy per unit area’.

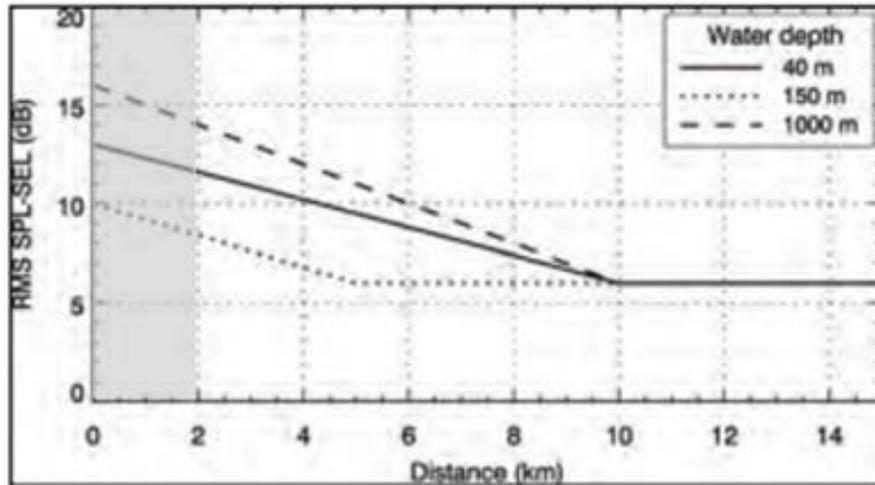


Figure C1: SPL-SEL conversion functions for different water depths (BOEM 2014). The gray shading indicates closer distances where the likelihood of PTS is higher.

Looking at Figure C1, one sees that the SPL-SEL offset tends to be larger at closer distances (km), where the pulse duration is short, and to diminish as longer distances, where the pulse duration increases as a result of propagation. Within 2 km of the source, the SPL-SEL offset is ≥ 8 dB, which results in a pulse duration of 158 ms 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 appropriate²¹).

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 User Spreadsheet tool for seismic activities involving airguns. Again, an applicant can use activity-specific information, if available, instead of relying on the default value.

²¹ Martin et al. 2017 recently recommended the use of a 125 ms pulse duration for seismic activities based on measured data, because it is a standard used in terrestrial sound level meters for fast-time weighting, and represents the integration time of the mammals ear.

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.

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).

Cumulative sound exposure level (SEL_{cum} ; re: $1\mu Pa^2 s$): Level of acoustic energy accumulated over a given period of time or event (EPA 1982) or specifically, ten times the logarithm to the base ten of the ratio of a given time integral of squared instantaneous frequency-weighted sound pressure over a stated time interval or event to the reference sound exposure (ANSI 1995; ANSI 2013).

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 drivers.

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.

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 active sonar (e.g. tactical), and vibratory pile drivers.

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 level (PK; re: 1 μ Pa): The greatest absolute instantaneous sound pressure within a specified time interval and frequency band (ANSI 1986; ANSI 2013).

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: Reduction in magnitude of some characteristic of a signal between two stated points in a transmission system (for example the reduction in the magnitude of a signal between a source and a receiver) (ANSI 2013). Received level: The level of sound measured at the receiver.

Repetition rate: Number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second.

Root-mean-square sound pressure level (RMS SPL; re: 1 μ Pa): The square root of the average of the square of the pressure of the sound signal over a given duration (ANSI 2005).

Sound Exposure Level (SEL_{cum}; re: 1 μ Pa² 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 ration of a given time integral of squared instantaneous frequency-weighted sound pressure over a stated time interval or event to the product of the squared reference sound pressure and reference duration of one second (ANSI 2013).

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 Level (SL): Sound pressure level measured in a given radian direction, corrected for absorption, and scaled to a reference distance (Morfey 2001). For underwater sources, the sound pressure level of is measured in the far-field and scaled to a standard reference distance (1 meter) away from the source (Richardson et al. 1995; ANSI 2013).

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).

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