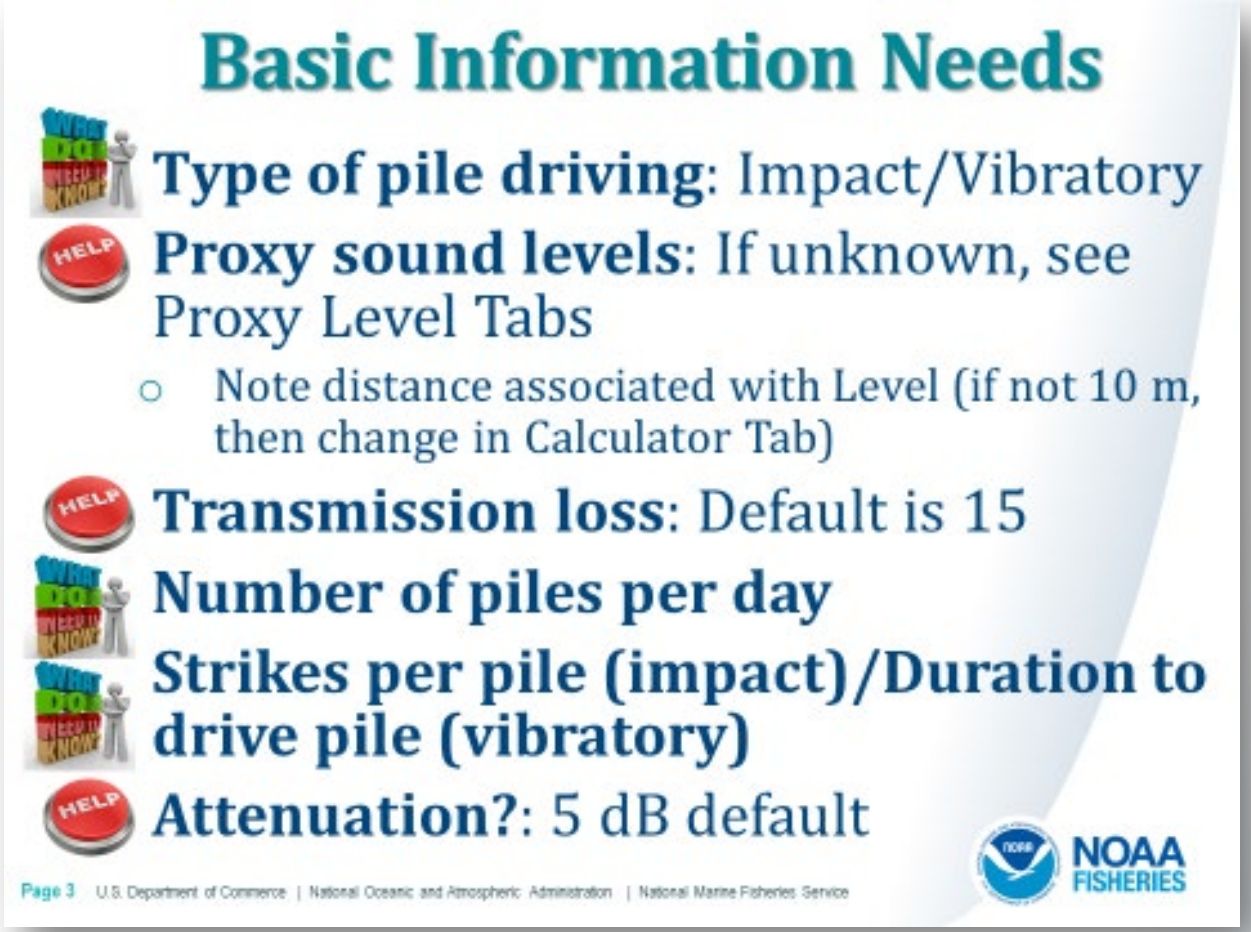
Introduction to:

NMFS's Multi-Species Pile Driving Calculator Tool

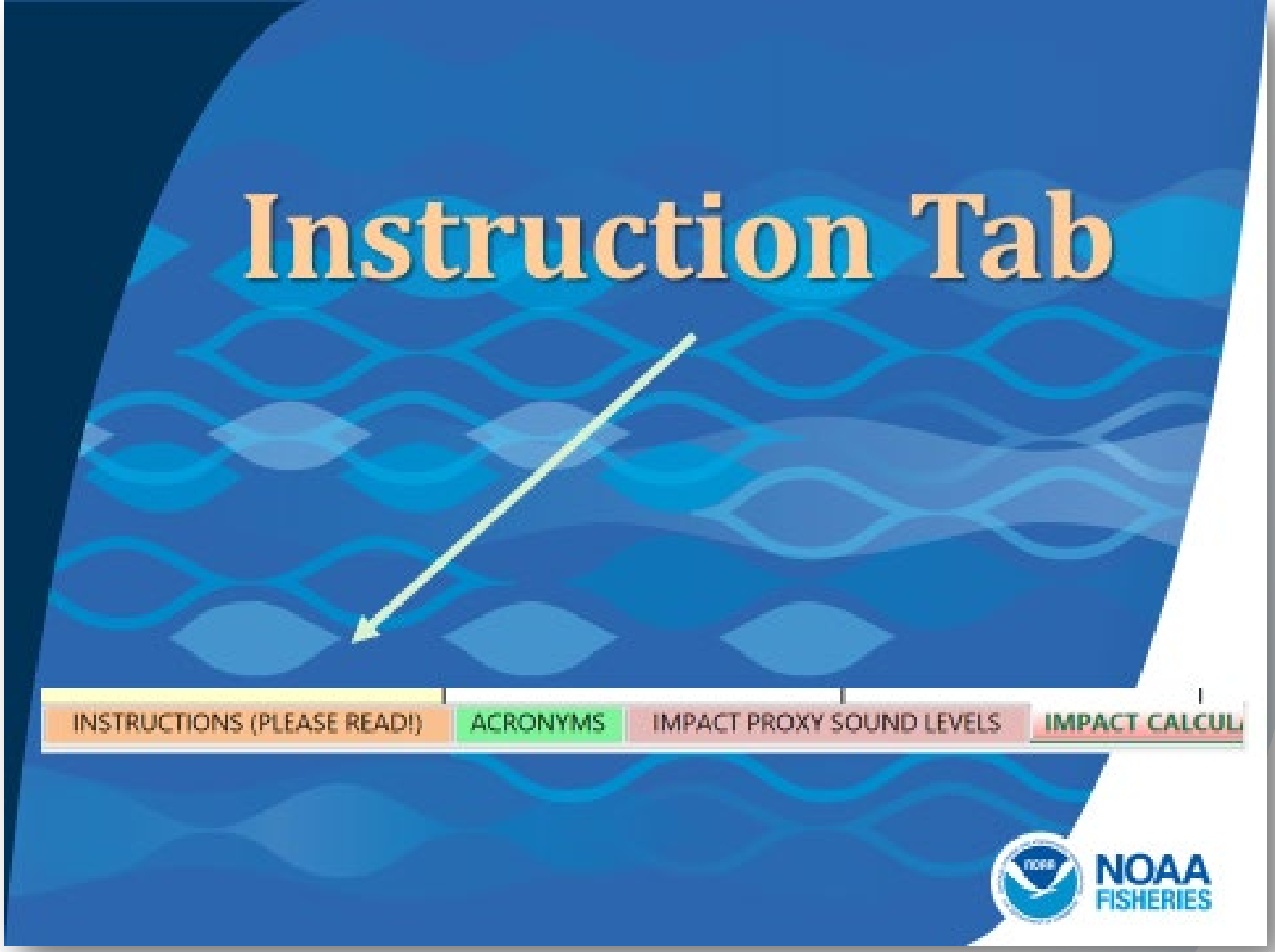
Version 1.0, 2021

Welcome to an Introduction to NMFS's Multispecies Pile Driving Calculator. This PowerPoint is designed to be a basic tutorial on how to use this optional Tool. You may advance through these slides at your own pace.

Before you start, there are a few items of note, including that different Regions may have different requirements, please check with the appropriate Regional/HQ staff before using this tool. 1) This Tool was primarily designed for coastal pile driving activities, 2) Reading the Instruction Tab is recommended, and 3) Use of this Tool is optional. If you have more accurate means of estimating isopleths, please do so. Finally, this Tool provides a means to estimate distances associated with various NMFS thresholds. Mitigation and monitoring requirements associated with a MMPA or an 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 this Tool.

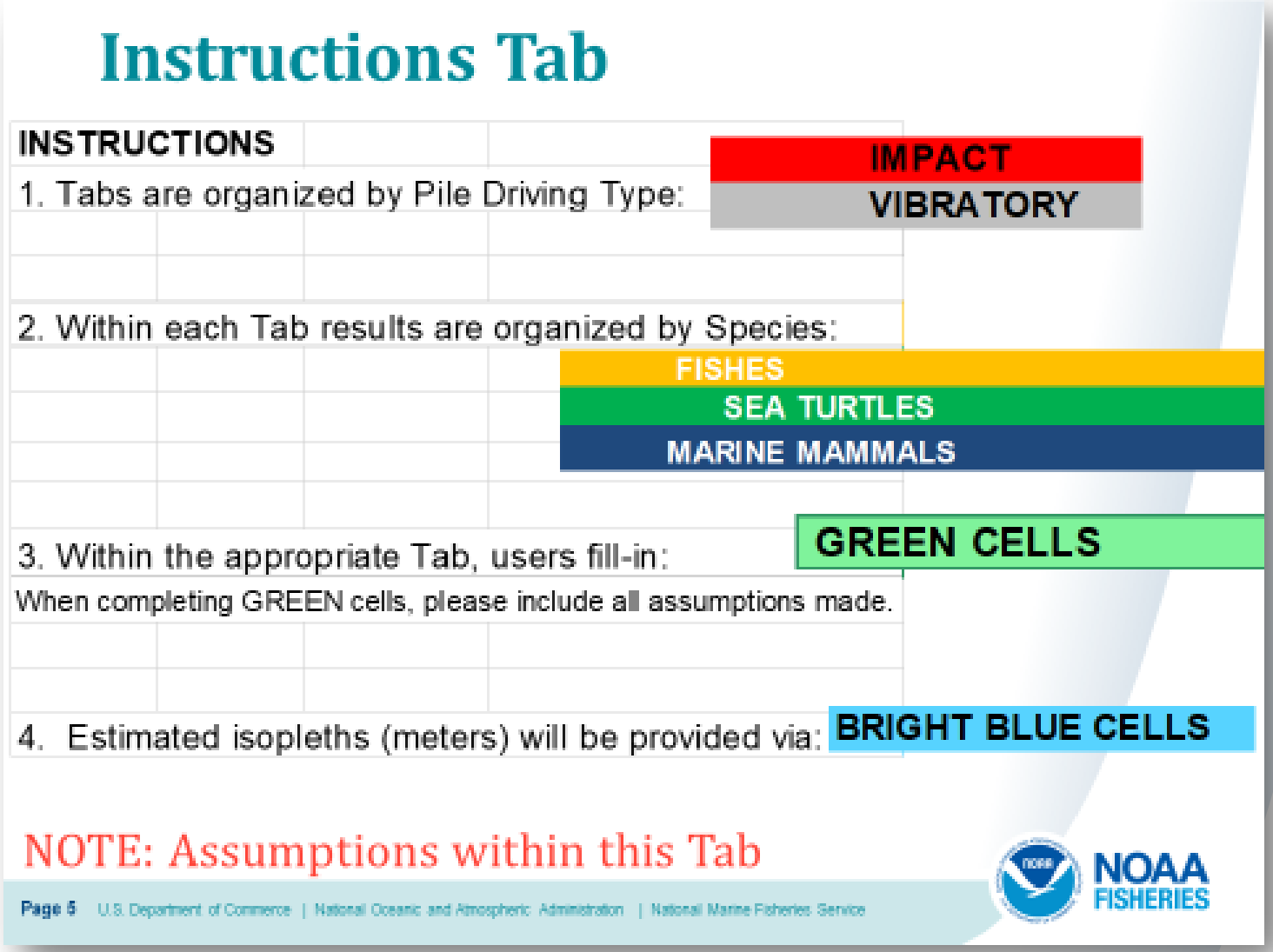


There are some basic pieces of information needed to use this Tool. First, one must know what type of pile driving activity they are doing, either impact or vibratory. Proxy sound levels are also needed, but if unknown, NMFS provides help by the Tool having a Tab with surrogate levels. Note: Most proxy levels are specified at 10 m from the pile. If this distance is different from 10 m, this needs to be changed in the Calculator Tab. Transmission loss is needed, but NMFS provides help via a default value of 15 (practical spreading), if unknown. This default may be changed if transmission loss data are available. One must know the number of piles per day and either strikes per pile for impact pile driving or duration (minutes) to drive a pile using vibratory pile driving. NMFS suggests using a best estimate based on previous experience. If a bubble curtain or other attenuation device is being used, NMFS provides help via recommending a -5 dB default, unless better information is available

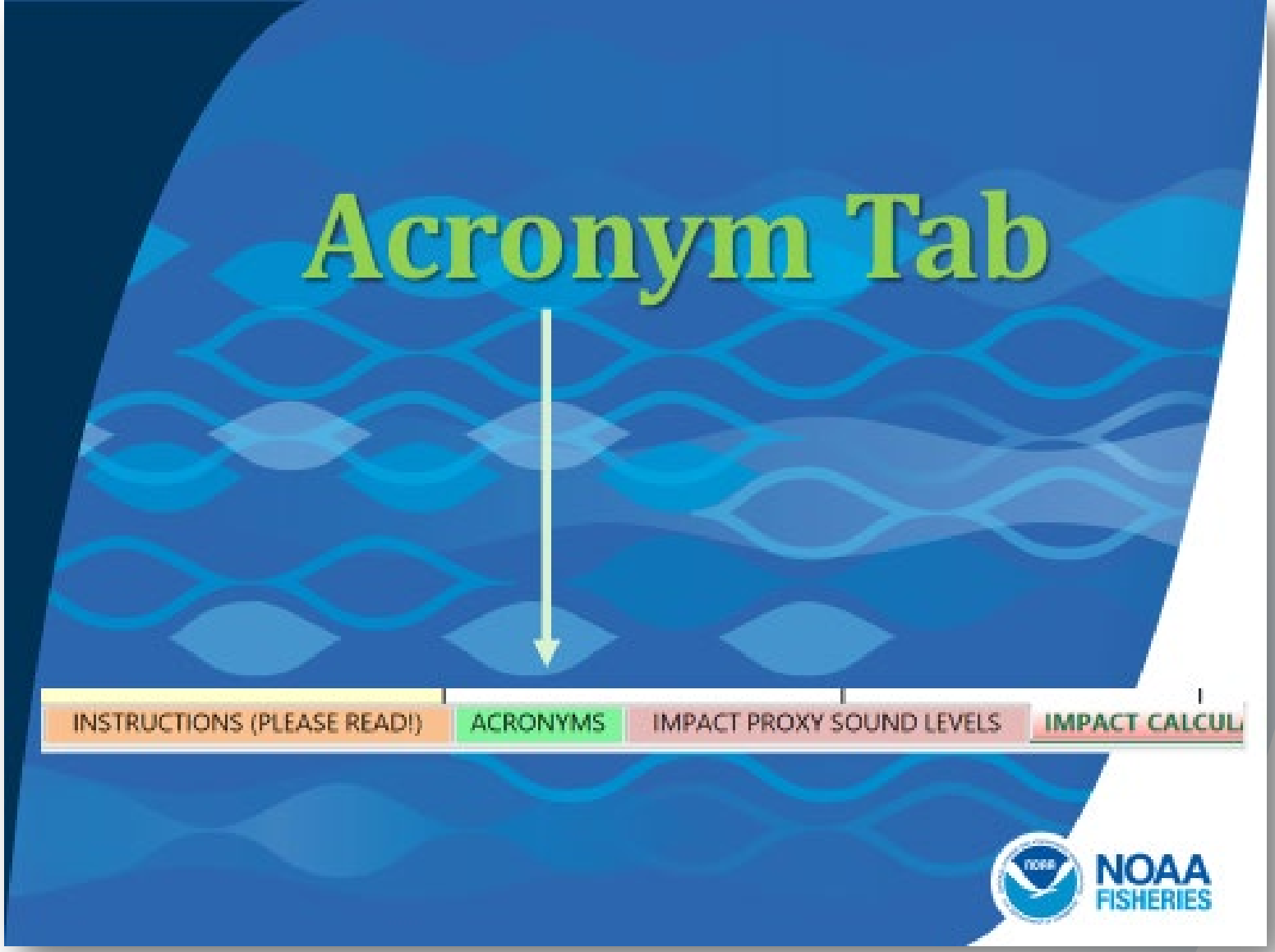


There are eight Tabs in this tool. Let's start with the Instruction Tab, which you can access using the toolbar found at the bottom of the Tool.

Instructions Tab

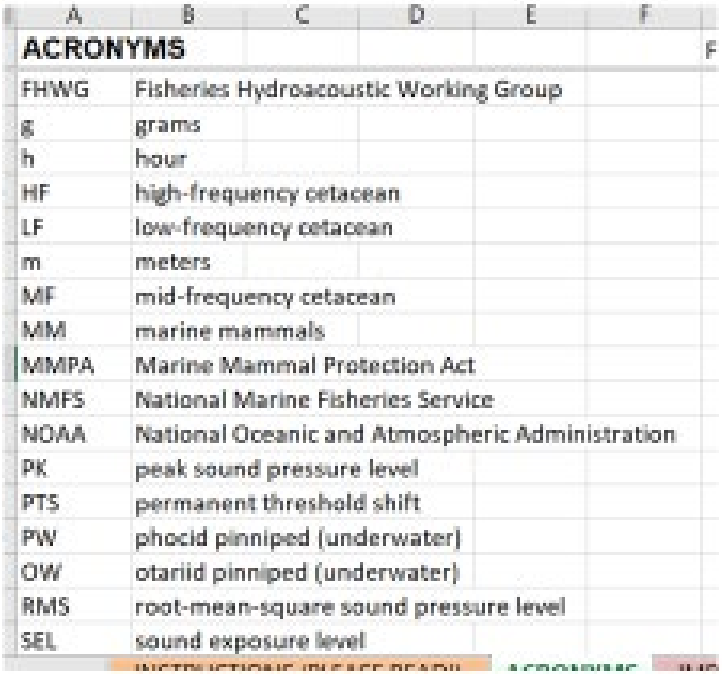


The Instruction Tab provides instructions and a general overview of other tabs within the Tool. Tabs are organized by pile driving type: either impact (red) or vibratory (gray). Within each Tab, results are organized by species (fishes, sea turtles, or marine mammals). Within each Tab, the user provides information via green cells with output (isopleths in meters) provided in bright blue cells. Additionally in this Tab, note the various Assumptions listed. This Tab also includes a Contact for technical questions or suggestions, proxy sound level references, and threshold references.



The Acronym Tab can be accessed using the toolbar found at the bottom of the Tool.

Acronym Tab



ACRONYMS	
FHWG	Fisheries Hydroacoustic Working Group
g	grams
h	hour
HF	high-frequency cetacean
LF	low-frequency cetacean
m	meters
MF	mid-frequency cetacean
MM	marine mammals
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PK	peak sound pressure level
PTS	permanent threshold shift
PW	phocid pinniped (underwater)
OW	otariid pinniped (underwater)
RMS	root-mean-square sound pressure level
SEL	sound exposure level

For definitions of common terms in this Tool see:
https://media.fisheries.noaa.gov/dam-migration/tech_memo_acoustic_guidance_(20)_(pdf)_508.pdf

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The Acronym Tab provides various acronyms used throughout the Tool. It also provides a link to definitions of common terms used in the Tool.

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Test Drive/Demo: Updated Tool

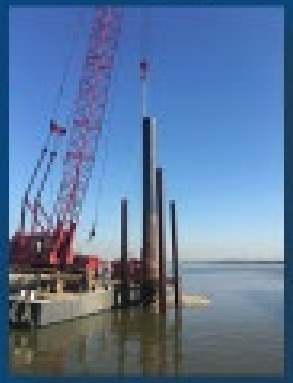
Examples:

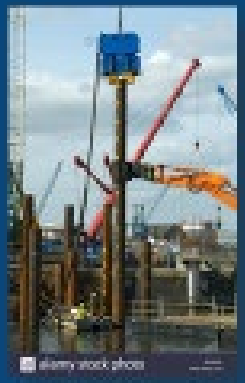
A. Impact pile driving

- 36" steel pipe, 3 piles, 1000 strikes/pile, with bubble curtain

B. Vibratory pile driving

- 36" steel pipe, 3 piles, 30 minutes





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Today, we will be walking through two examples, starting with an impact pile driving example (36" steel pipe piles, 3 piles per day, 1000 strikes/pile, with a bubble curtain).

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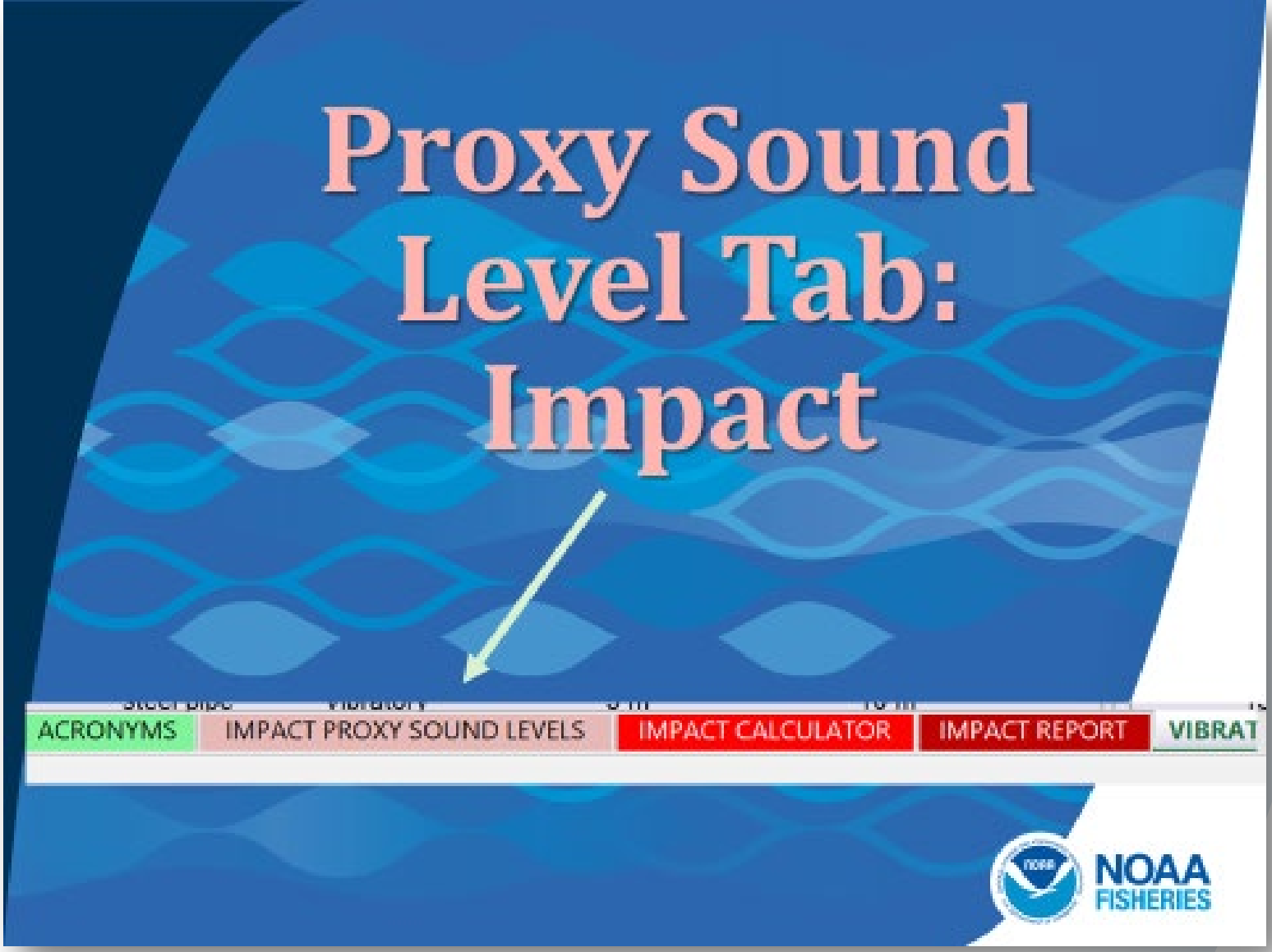

Let's demonstrate the Proxy Sound Level Tab for impact pile driving. Again, this Tab can be accessed using the toolbar found at the bottom of the Tool.

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Proxy Sound Level Tab: Impact

1. Tab is sortable
2. Note: Pile size, Material, Water depth, & Comments
3. If exact pile size/material is not listed: Consult NMFS or use next largest size
4. Copy from Tab & then paste directly in Calculator Tab (paste as Value 123)

NOTE: Measurement Distance from Pile if not 10 m, then value will need to be updated in Calculator Tab

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Note the various assumptions listed at the top of this Tab. This Tab is sortable by various pile features (size, material, etc.). Note the complete row of information provided for each pile, including water depth, location, reference, and comments. Please pick the proxy that is most applicable to your activity. If the exact pile size or material is not listed, consult NMFS or use next largest size. Copy the information from this Tab and then paste directly in the corresponding Calculator Tab (paste as a Value, 123). Note: If the measurement distance from the pile is not 10 m, then this value will need to be updated in Calculator Tab. If you have specific information on sound levels for your pile size/material, then it is not necessary to rely on a proxy.

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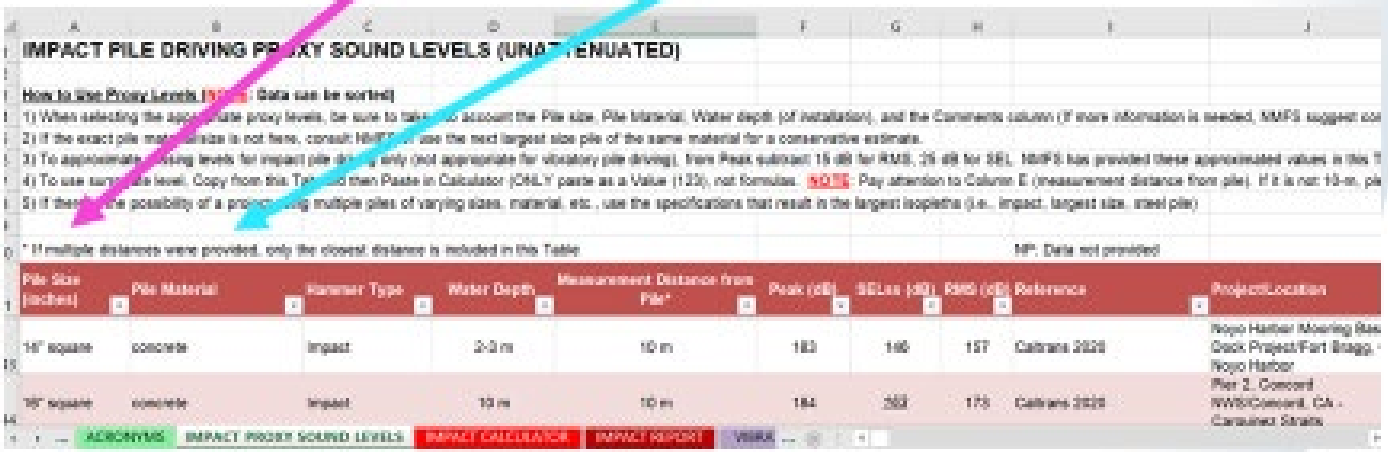
Proxy Sound Level Tab: Impact

To use this Tab, it makes sense to sort data by appropriate pile size and pile material.



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To use the Proxy Sound Level Tab, it makes sense to sort data by appropriate pile size (hot pink arrow) and pile material (turquoise arrow).

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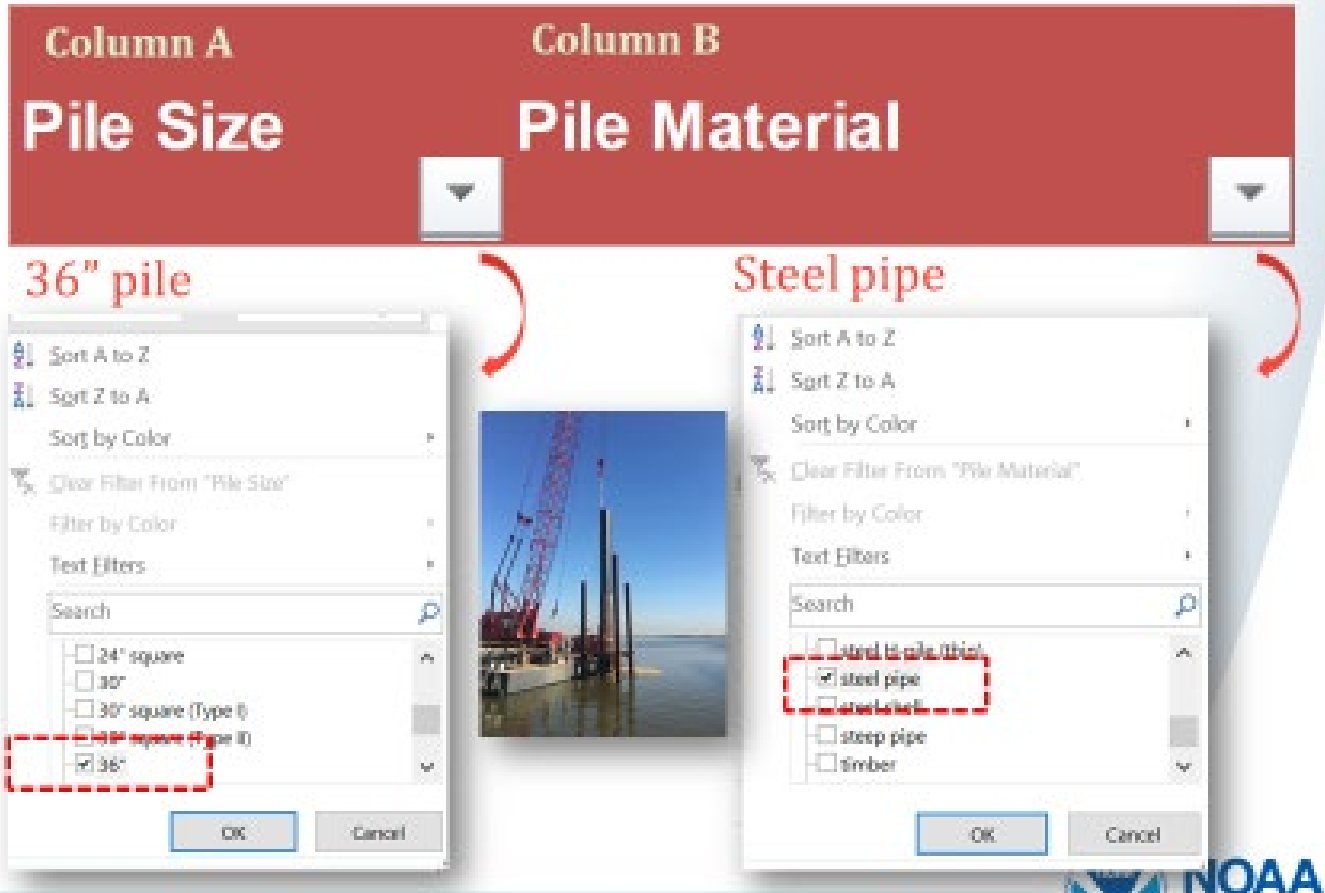
Proxy Sound Level Tab: Impact



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Here is a closer look at sorting columns, specifically Column A for pile size and Column B for pile material. In this example, we are interested in available data for 36" steel pipe piles.

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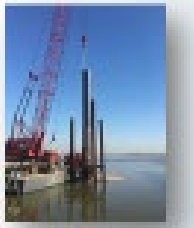
Proxy Sound Level Tab: Impact Results of Sort



Pile Size	Pile Material	Hammer Type	Water Depth	Measurement Distance from Pile*	Peak	SELss	RMS	Reference
36"	steel pipe	Impact	10 m	10 m	210	183	193	Caltrans 2015
36"	steel pipe	Impact	<5 m	10 m	208	180	190	Caltrans 2015
36"	steel pipe	Impact	NA	10 m	210	183	193	Caltrans 2020

1. Red box indicates proxy sound levels for 36" steel pipe pile
2. Check water depth & other factors (location, notes)
3. For this example: All three choices are generic examples (no specified location)
4. Will choose 3rd row choice, since depth unknown
   - Copy values of all 3 metrics (Peak, SEL_{ss}, & RMS) for this row

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Once data are sorted (by pile size and material), three potential choices for proxy levels are provided (see red box). To choose the most appropriate of the three, check water depth and other factors, such as location, notes, etc. to decide which most closely resembles your situation. For this example, all three choices are generic examples (no specified location). Since for this example, water depth is unknown, we will choose the 3rd row as the most appropriate proxy level. Once chosen, copy values in all three metrics (Peak, SEL_{ss}, and RMS) for this proxy. Note: Pay attention to the measurement distance from the pile if it is anything other than 10 m.

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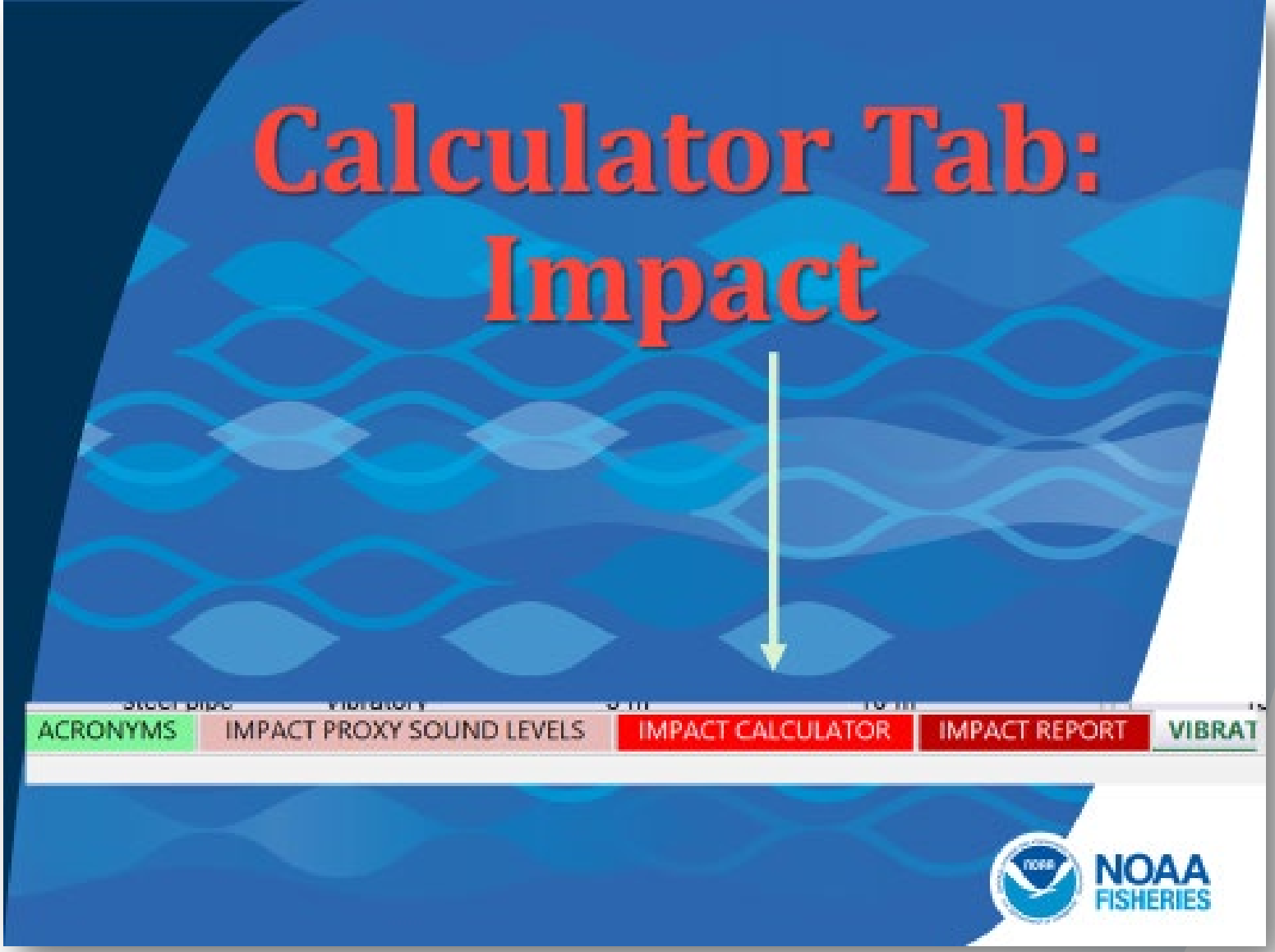

Let's take a look at the Calculator Tab for impact pile driving. This Tab can be accessed using the toolbar found at the bottom of the Tool.

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Calculator Tab: Impact

KEY

User Provided Information *Default values are in bold, italics turquoise (can be changed by user if project-specific information is available).*

Preset NMFS Provided Information (cannot be altered by user). NMFS thresholds/default weighting value are in bold red.

OUTPUT: Resultant Isopleth (cannot be altered by user)

Automatically Calculated Values Based on User Provided Information (only weighting adjustment (-dB) can be altered by user

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This slide illustrates the Key at the top of the Calculator Tab. Green cells are for user provided information. Note that default values are in bold italics turquoise font. These default values may be changed by the user if project-specific information is available. Yellow cells represent preset NMFS provided information and cannot be altered by the user. NMFS thresholds/default weighting values are in bold red. Bright blue cells represent outputs of the Tool or resultant isopleths based on user provided information and cannot be altered by the user. Finally, gray cells represent automatically calculated values based on user provided information (only weighting adjustment (-dB) values can be altered by the user and are found in the last row of the Tool). Please see Advanced Features later in this presentation for more information on adjusting these values.

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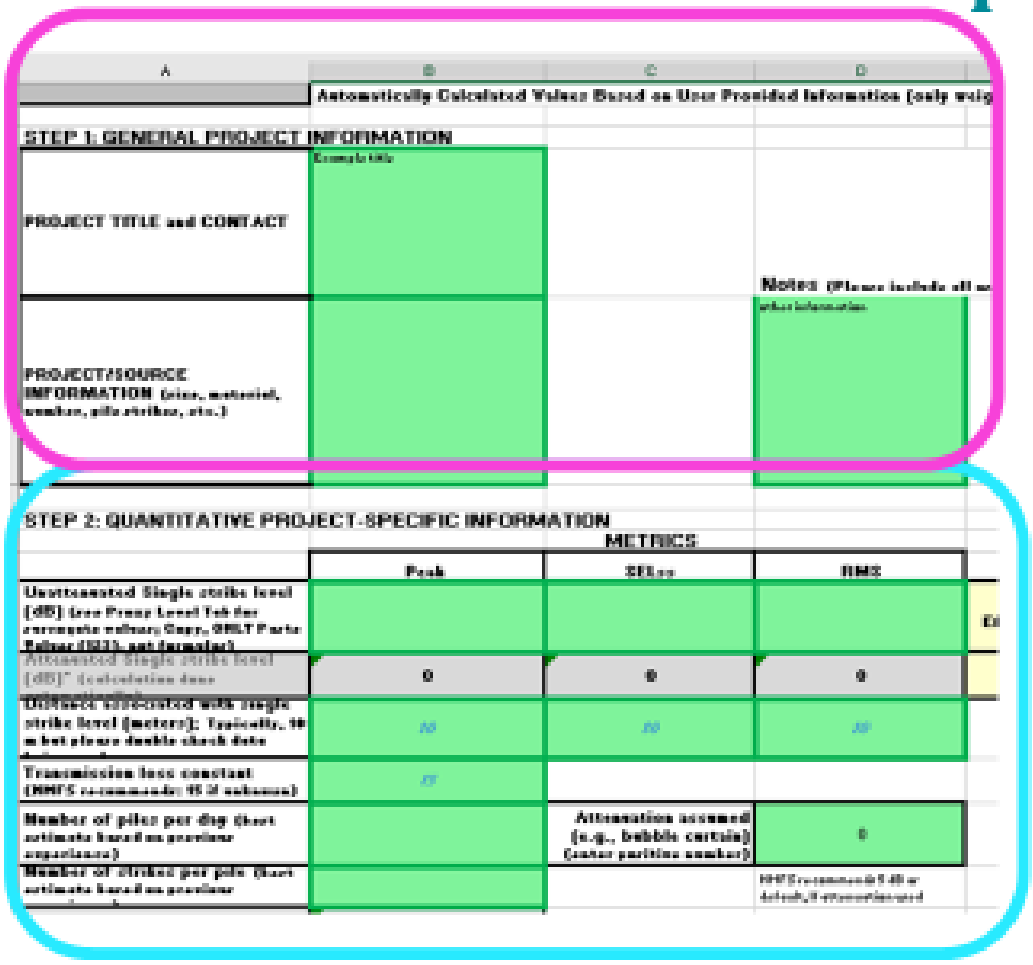
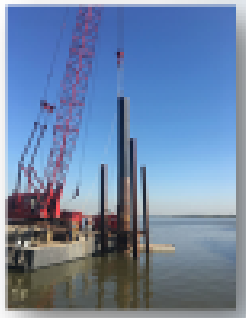
Calculator Tab: Impact



This slide illustrates the first two steps of the Impact Calculator Tab. Step 1 outlined in hot pink, where a user will enter qualitative project-specific information and Step 2 outlined in turquoise, where the user will enter quantitative project-specific information. We will go into more detail on both these steps in the next slides.

Calculator Tab: Impact

Step 1: General Project Information



STEP 1: GENERAL PROJECT INFORMATION			
PROJECT TITLE and CONTACT	Example title		Notes (Please include all assumptions) other information
PROJECT/SOURCE INFORMATION (size, type, number, pile strikes, etc.)			

NOTE: Please include any assumptions, including if relying upon proxy sound levels.

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Step 1 in the Calculator Tab is where the user provides general project information, such as project title and contact; source information such as pile size material, strikes per pile; and any other assumptions or notes, including if proxy levels were used or if any type of attenuation is assumed.

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Calculator Tab: Impact

Step 2: Quantitative Project-Specific Information

STEP 2: QUANTITATIVE PROJECT-SPECIFIC INFORMATION			
		METRICS	
	Peak	SELss	RMS
Unattenuated Single strike level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)			
Attenuated Single strike level (dB)* (calculation done automatically)	0	0	0
Distance associated with single strike level (meters); Typically, 10-m but please double check data being used	10	10	10
Transmission loss constant (NMFS recommends: 15 if unknown)	15		
Number of piles per day (best estimate based on previous experience)		Attenuation assumed (e.g., bubble curtain) (enter positive number)	0
Number of strikes per pile (best estimate based on previous experience)			NMFS recommends 5 dB as default, if attenuation used
Number of strikes per day	0		
Cumulative SEL at measured distance	#NUM!		

NOTE: Default values already included in *italic turquoise* (can be changed)

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Step 2 is where quantitative project-specific information is entered, such as levels, distance associated with level, transmission loss, number of piles per day, number of strikes per pile, and attenuation assumed. Default values (italics, turquoise) are provided for distance associated with level and transmission loss. Please confirm these defaults are applicable. If not, they may be modified. Gray cells represent automatically calculated values based on user provided information (and cannot be changed in Step 2). The next slides go into more detail on Step 2 inputs.

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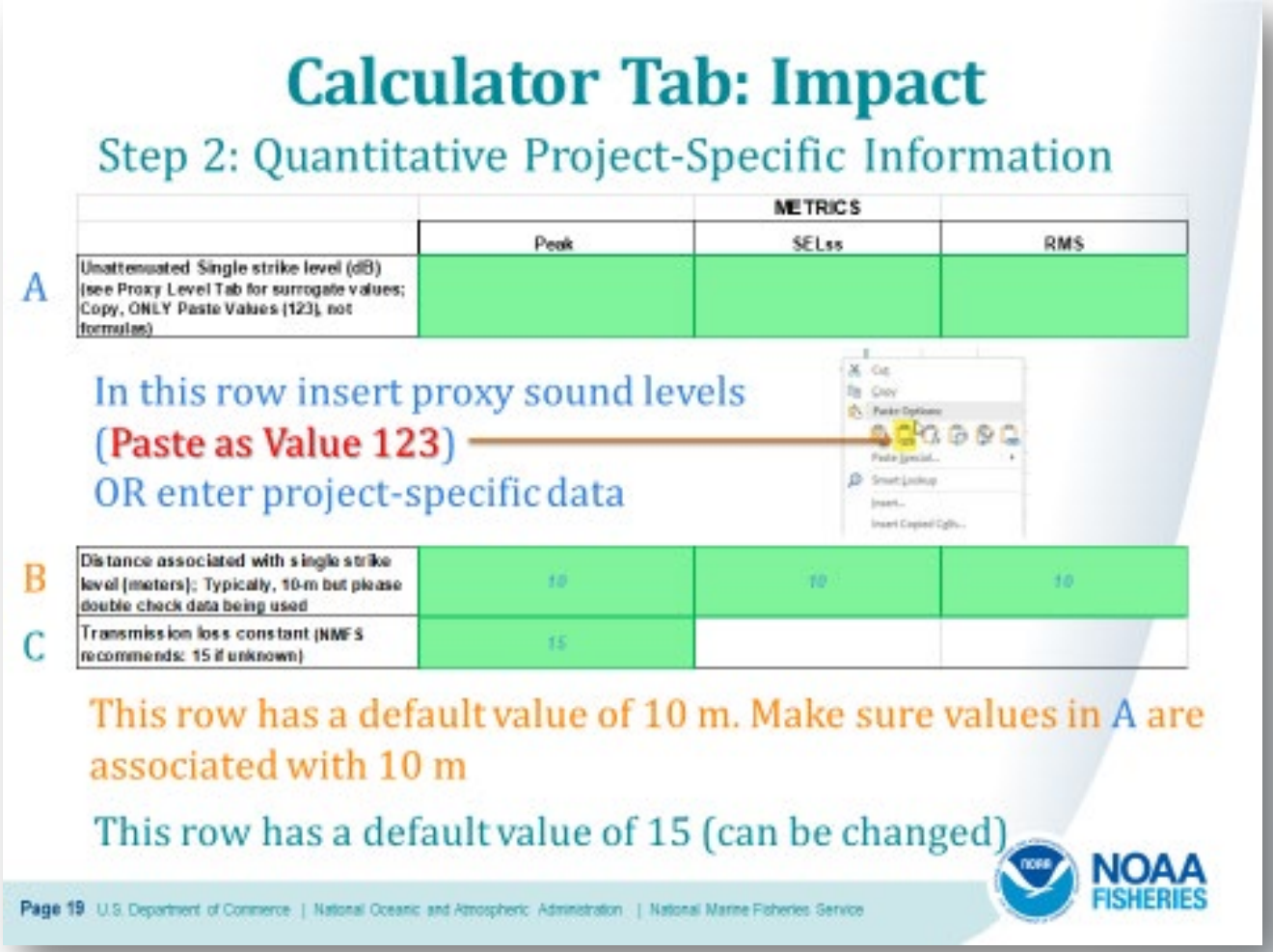

Let's take a closer look at some of the specific cells in Step 2 (labeled by row letter). Row A represents the unattenuated levels in three various metrics (Peak, SEL_{ss}, and RMS). Here a user may enter project-specific levels, if available or enter surrogate levels from the Proxy Level Tab. If values are copied from the Proxy Level Tab, paste them in Row A as a value (see red arrow). Row B represents the distance associated with the previously entered levels. The default value is 10-m, but one should ensure this is correct. This value may be changed if the default is not correct. Row C represents transmission loss. The default value is 15 and is recommended if this value is unknown. If site-specific transmission loss is available, it may be used here instead of the default.

Calculator Tab: Impact

Step 2: Quantitative Project-Specific Information

D	Number of piles per day (best estimate based on previous experience)		Attenuation assumed (e.g., bubble curtain) (enter positive number)	0	F
E	Number of strikes per pile (best estimate based on previous experience)			NMFS recommends 5 dB as default, if attenuation used	

This cell for the number of piles per day

This cell is for the number of strikes per pile

This cell is for attenuation (recommended default 5 but can be changed). If no attenuation leave as zero.

	Peak	SELss	RMS
Unattenuated Single strike level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)			
Attenuated Single strike level (dB)* (calculation done automatically)	0	0	0

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Two additional rows are in Step 2. Cell D represents the number of piles per day based on best estimate from previous experience. Cell F represents attenuation, if being used. If it is unclear the appropriate decibel reduction associated with the attenuation method used, NMFS recommends a default of 5 dB. Please only enter positive numbers in this cell. If nothing is being used, please leave value as zero. Whatever attenuation is used will be reflected automatically in the attenuated levels (subtracted off levels entered on previous slide), as shown in the gray cells being illustrated by the red arrow. This will be illustrated further in the next slide. Finally, Cell E represents the number of strikes per pile based on best estimate from previous experience.

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Calculator Tab: Impact

Step 2: Quantitative Project-Specific Information

	METRICS		
	Peak	SELss	RMS
Unattenuated Single strike level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)	210	183	193
Attenuated Single strike level (dB)* (calculation done automatically)	205	178	188
Distance associated with single strike level (meters): Typically, 10-m but please double check data being used	10	10	10
Transmission loss constant (NMFS recommends: 15 if unknown)	15		
Number of piles per day (best estimate based on previous experience)		Attenuation assumed (e.g., bubble curtain) (enter positive number)	5

This cell is automatically subtracts 5 dB off previously entered sound levels (gray row).

NOTE: Always enter positive number for attenuation

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This illustrates all the green cells in Step 2. In this example, a bubble curtain is being used but attenuation is unknown. Thus, the NMFS suggested default value of 5 dB is being used (red circle; always enter a positive number). This attenuation is automatically subtracted from the unattenuated values entered previously, as illustrated in the gray cells. These attenuated values are used for calculating resulting isopleths, which will be illustrated next.

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Calculator Tab: Impact

Step 2: Quantitative Project-Specific Information

Fully entered values

STEP 2: QUANTITATIVE PROJECT-SPECIFIC INFORMATION			
		METRICS	
	Peak	SELss	RMS
Unattenuated Single strike level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)	210	183	193
Attenuated Single strike level (dB)* (calculation done automatically)	205	178	188
Distance associated with single strike level (meters); Typically, 10-m but please double check data being used	10	10	10
Transmission loss constant (NMFS recommends: 15 if unknown)	15		
Number of piles per day (best estimate based on previous experience)	3	Attenuation assumed (e.g., bubble curtain) (enter positive number)	5
Number of strikes per pile (best estimate based on previous experience)	1000		NMFS recommends 5 dB as default, if attenuation used
Number of strikes per day	3000		
Cumulative SEL at measured distance	213		

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This slide illustrates all the values entered in Step 2 for our specific example.

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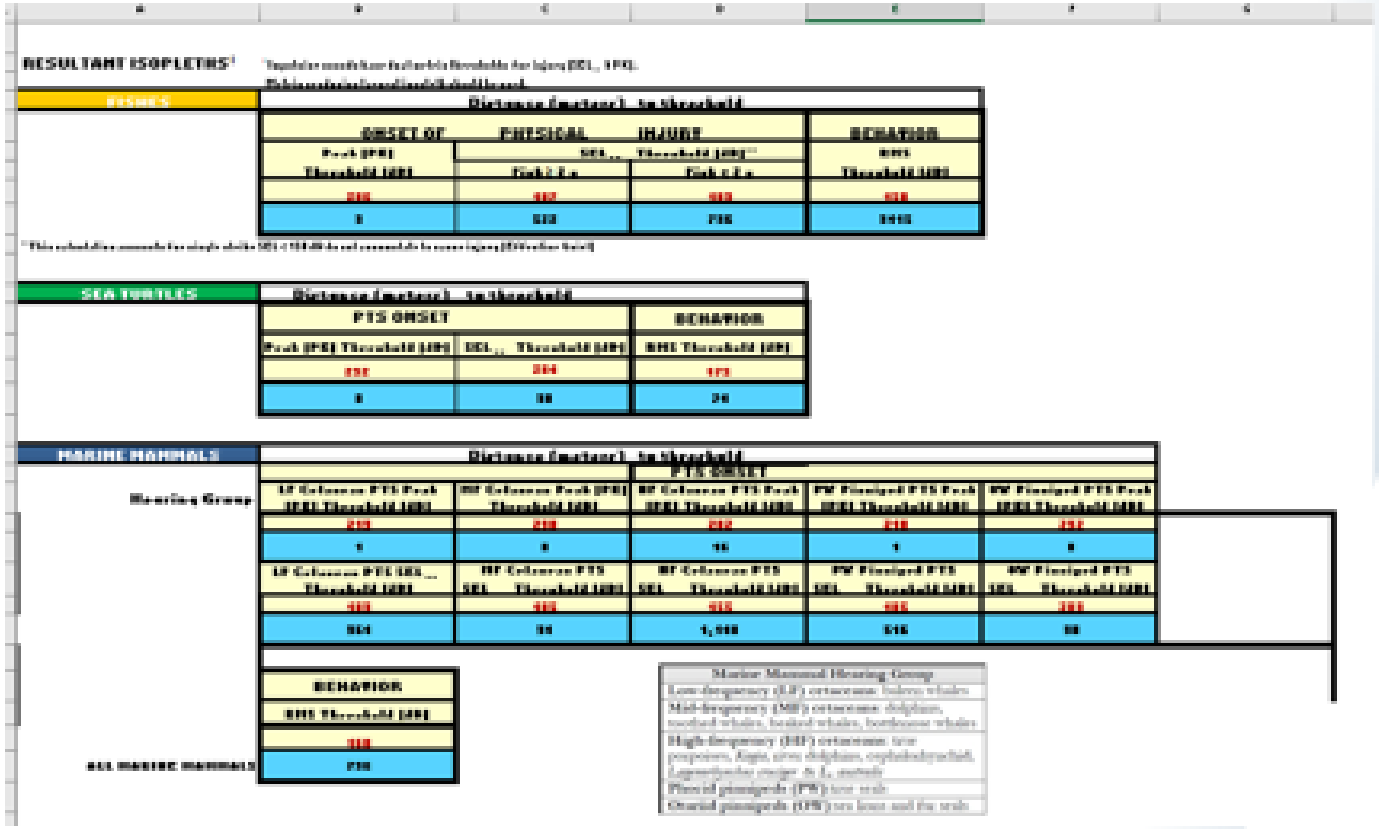
Calculator Tab: Impact

Resultant Isopleths (by taxa)



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After quantitative project-specific information is entered in Step 2 of the Calculator, resultant isopleths (bright blue cells) are produced by taxa.

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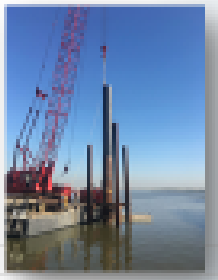
Calculator Tab: Impact

Resultant Isopleths (by taxa)

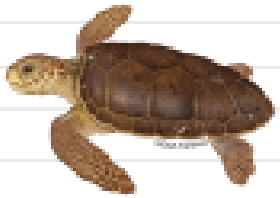


RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds for injury (SEL_{cum} & PK). Metric producing largest isopleth should be used.

FISHES	Distance (meters) to threshold			
	ONSET OF PHYSICAL INJURY			BEHAVIOR
	Peak (PK) Threshold (dB)	SEL_{cum} Threshold (dB)**		RMS Threshold (dB)
		Fish ≥ 2 g	Fish < 2 g	
	206	187	183	150
	9	522	736	3415

**This calculation accounts for single strike SEL < 158 dB do not accumulate to cause injury (Effective Quiet)

SEA TURTLES	Distance (meters) to threshold		
	PTS ONSET		BEHAVIOR
	Peak (PK) Threshold (dB)	SEL_{cum} Threshold (dB)	RMS Threshold (dB)
	232	204	175
	0	38	74

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This slide illustrates the Resultant Isopleths (bright blue cells) for fishes and sea turtles based on the various taxa-specific acoustic thresholds.

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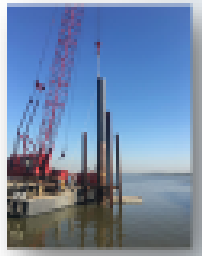
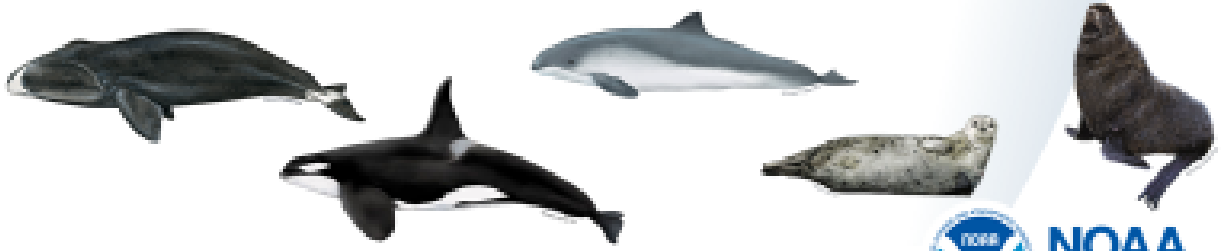
Calculator Tab: Impact

Resultant Isopleths (by taxa) cont'd



*Impulsive sounds have dual metric thresholds for injury (SEL_{cum} & PK). Metric producing largest isopleth should be used.

MARINE MAMMALS	Distance (meters) to threshold				
			PTS ONSET		
Hearing Group	LF Cetacean PTS Peak (PK) Threshold (dB)	MF Cetacean Peak (PK) Threshold (dB)	HF Cetacean PTS Peak (PK) Threshold (dB)	PW Pinniped PTS Peak (PK) Threshold (dB)	OW Pinniped PTS Peak (PK) Threshold (dB)
	219	230	202	218	202
	1	0	96	1	0
	LF Cetacean PTS SELcum Threshold (dB)	MF Cetacean PTS SELcum Threshold (dB)	HF Cetacean PTS SELcum Threshold (dB)	PW Pinniped PTS SELcum Threshold (dB)	OW Pinniped PTS SELcum Threshold (dB)
	183	185	155	185	203
	964	34	1,148	816	36
	BEHAVIOR				
	RMS Threshold (dB)				
	160				
ALL MARINE MAMMALS	736				



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This slide illustrates the Resultant Isopleths (bright blue cells) for marine mammals based on the various hearing group-specific acoustic thresholds.

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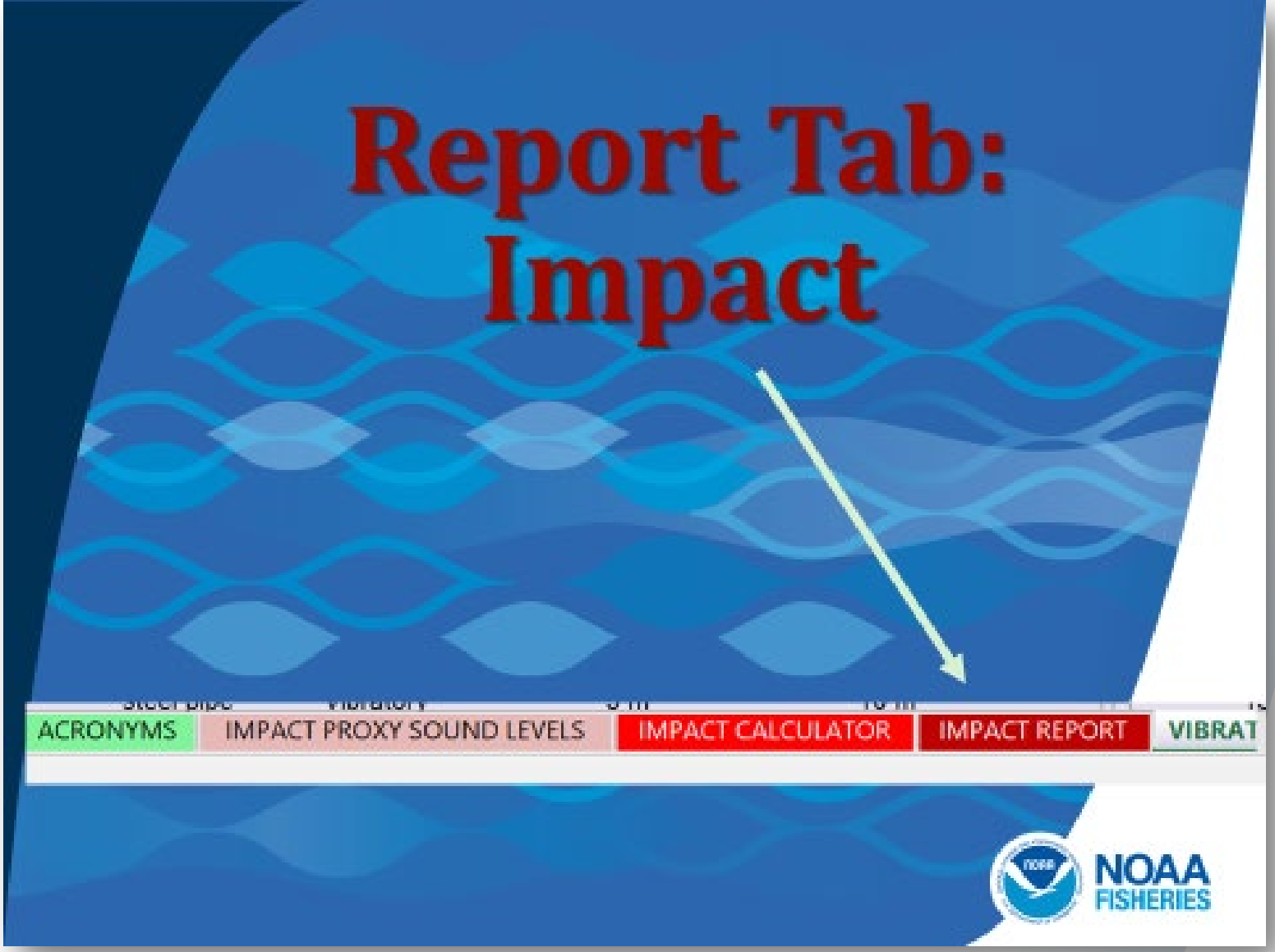
Report Tab: Impact



Let’s demonstrate the Impact pile driving Report Tab. This Tab can be accessed using the toolbar found at the bottom of the Tool.

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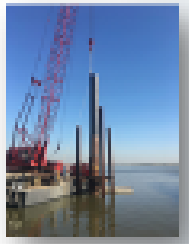
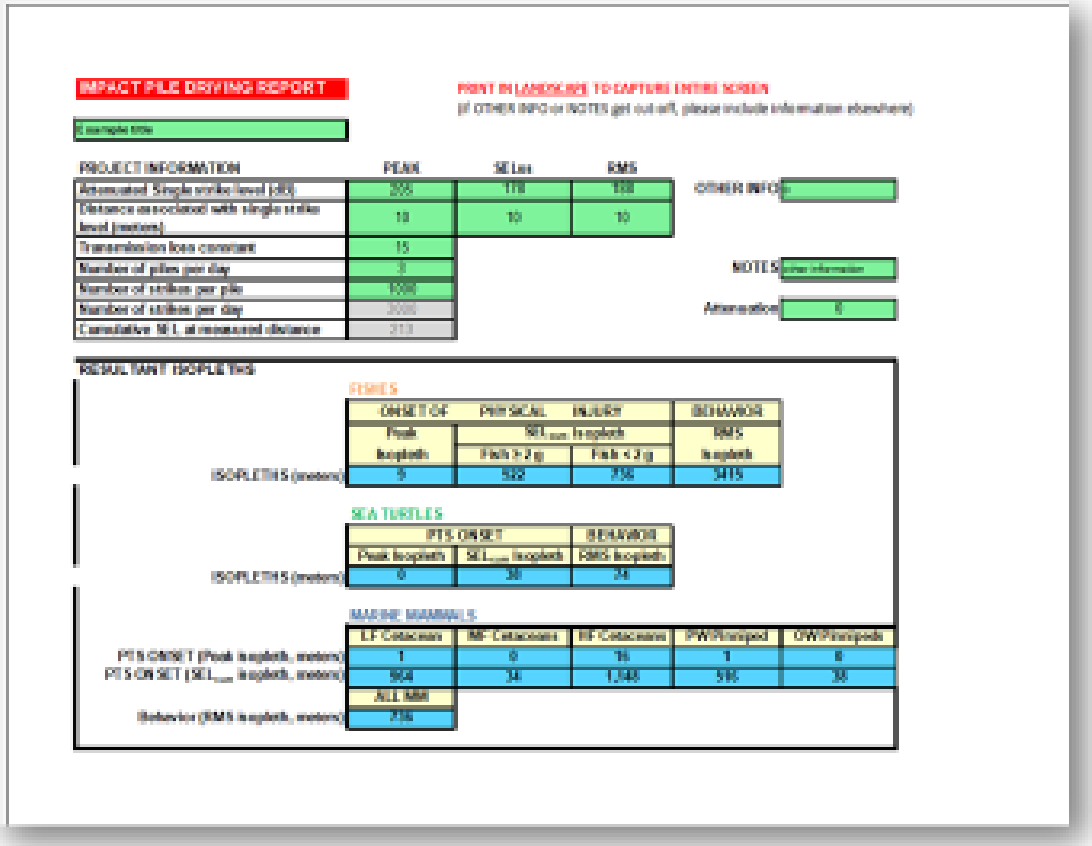
Report Tab: Impact

Summarizes user inputs and resulting isopleths





IMPACT PILE DRIVING REPORT

PROJECT INFORMATION

	PEAK	SEL$_{cum}$	RMS
Attenuated Single strike level (dB)	200	175	150
Distance associated with single strike level (meters)	10	10	10
Transmission loss constant	15		
Number of piles per day	3		
Number of strikes per pile	1000		
Number of strikes per day	3000		
Cumulative SEL at measured distance	213		

OTHER INFO:

NOTES:

Attenuation: 0

RESULTANT ISOPLETHS

FISHES

	ONSET OF PHYSICAL INJURY		BEHAVIOR
	Peak isopleth	SEL$_{cum}$ Isopleth	RMS isopleth
		Fish > 2 g	Fish < 2 g	
ISOPLETHS (meters)	9	502	716	3415

SEA TURTLES

	PTS ONSET		BEHAVIOR
	Peak Isopleth	SEL$_{cum}$ Isopleth	RMS Isopleth
ISOPLETHS (meters)	0	30	26

MARINE MAMMALS

	LF Cetaceans	MF Cetaceans	HF Cetaceans	PW Pinnipeds	OW Pinnipeds
PTS ONSET (Peak Isopleth, meters)	1	0	16	1	0
PTS ONSET (SEL$_{cum}$ isopleth, meters)	904	34	1,340	510	30
	ALL MM				
Behavior (RMS Isopleth, meters)	716				

- Fits on one sheet (landscape)
- If other info/notes get cut off, please include elsewhere

NOAA FISHERIES

The Report Tab summarizes the inputs and outputs provided in the Calculator Tab. The information in this Tab is designed to fit in a single sheet (landscape view). If other information or notes get cut-off from the what was provided in the Calculator Tab, please provide this information elsewhere.

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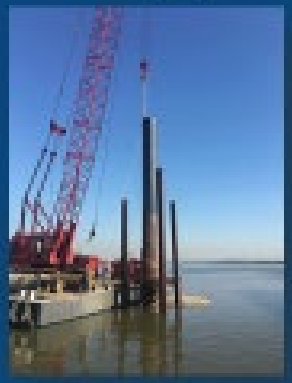
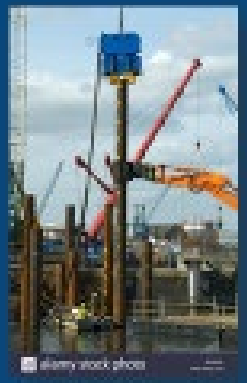
Test Drive/Demo: Updated Tool

Examples:

A. **Impact pile driving**
   - 36" steel pipe, 3 piles, 1000 strikes/pile, with bubble curtain

B. **Vibratory pile driving**
   - 36" steel pipe, 3 piles, 30 minutes





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Now, I will begin our second example: Vibratory pile driving (36" steel pipe pile, 3 piles per day, and time to drive a pile is 30 minutes)

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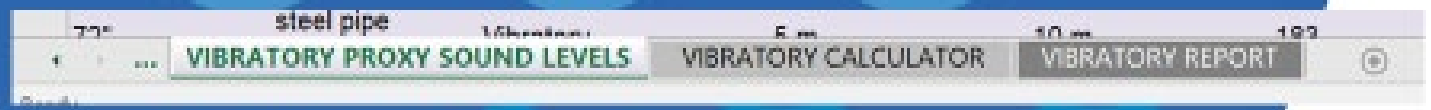
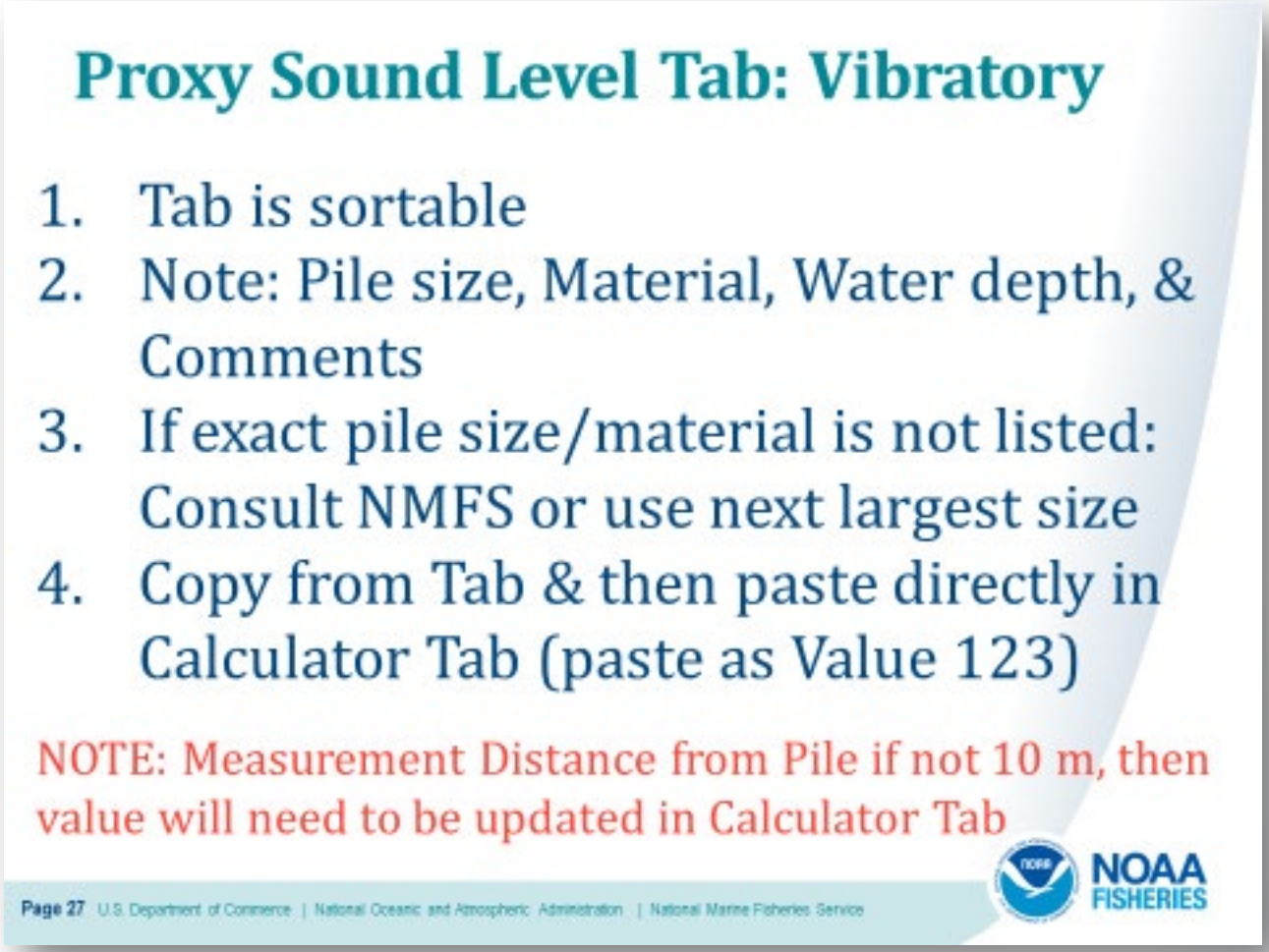
Proxy Sound Level Tab: Vibratory



NOAA FISHERIES

Let's demonstrate the Proxy Sound Level Tab for vibratory pile driving.
This Tab can be accessed using the toolbar found at the bottom of the Tool.

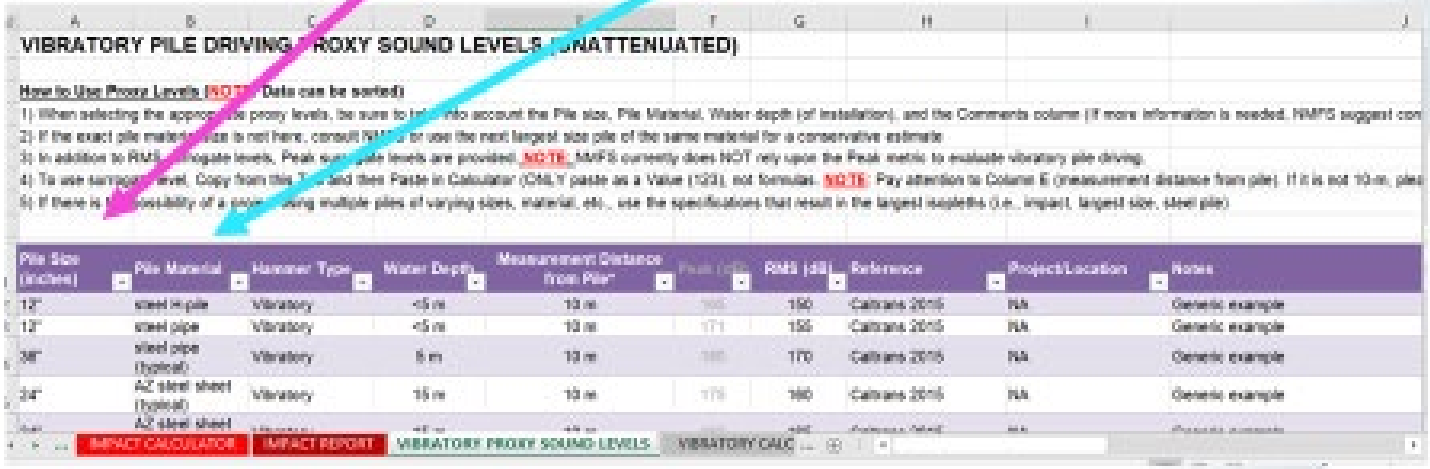
NOAA FISHERIES



Note the various assumptions listed at the top of this Tab. This Tab is sortable by various pile features (size, material, etc.). Note complete row of information provided for each pile, including water depth, location, reference, and comments. Please pick the proxy that is most applicable to your activity. If the exact pile size or material is not listed, consult NMFS or use next largest size. Copy the information from this Tab and then paste directly in the corresponding Calculator Tab (paste as a Value, 123). Note: If measurement distance from pile is not 10 m, then this value will need to be updated in Calculator Tab. If you have specific information on sound levels for your pile size/material, then it is not necessary to rely on a proxy.

Proxy Sound Level Tab: Vibratory

To use this Tab, it makes sense to sort data by appropriate pile size and pile material



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To use the Proxy Sound Level Tab, it makes sense to sort data by appropriate pile size (hot pink arrow) and pile material (turquoise arrow).

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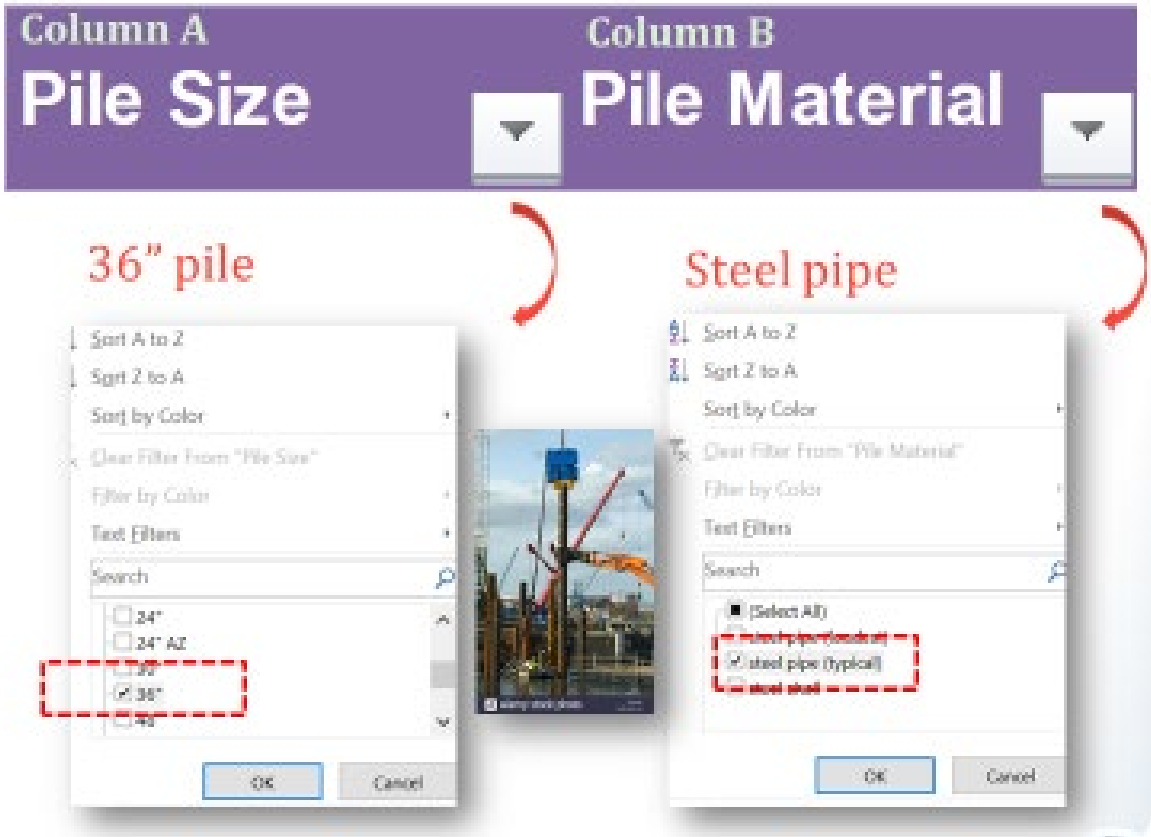
Proxy Sound Level Tab: Vibratory



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Here is a closer look at sorting columns, specifically Column A for pile size and Column B for pile material. In this example, we are interested in available data for 36" steel pipe piles. Since this is a more a generic assessment, we will choose steel pipe "typical" vs. "loudest."

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Proxy Sound Level Tab: Impact Results of Sort

Pile Size	Pile Material	Hammer Type	Water Depth	Measurement Distance from Pile*	Peak	RMS	Reference
36"	steel pipe (typical)	Vibratory	5 m	10 m	180	170	Caltrans 2015

1. Red box indicates proxy sound levels for 36" steel pipe pile
2. Check water depth & other factors (location, notes)
3. For this example: There is only one value provided
4. Copy only RMS value for this row (Don't need Peak!)

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Once data are sorted (by pile size and material), one potential choices for proxy levels is provided (see red box). Since this is the only choice, it used as the appropriate proxy level. Once chosen, copy values in only the RMS metric for this proxy (Peak is provided but not needed, which is why this column has gray text). Note: Pay attention to the measurement distance from the pile if it is anything other than 10 m.

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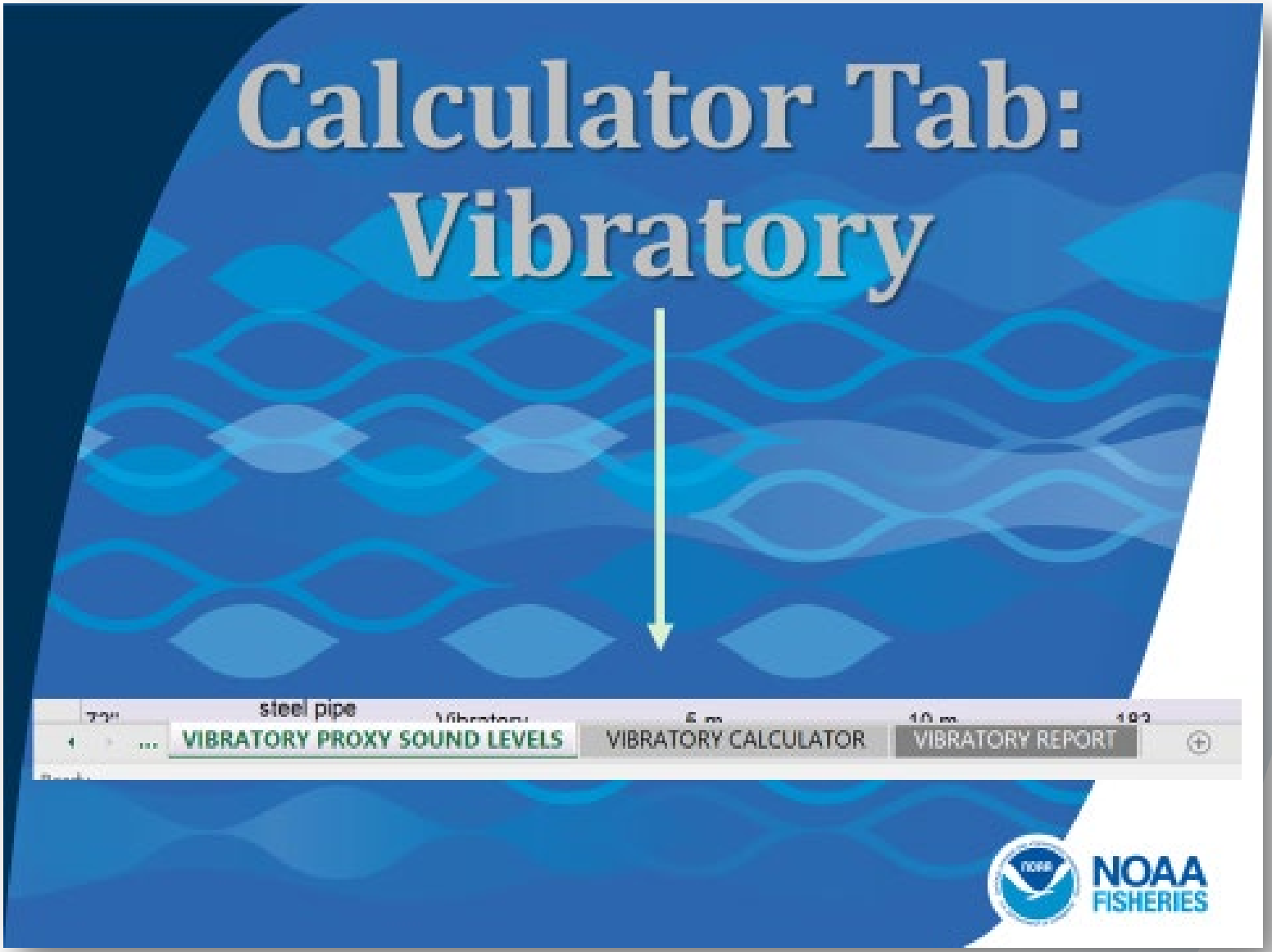

Let's take a look at the Calculator Tab for vibratory pile driving. This Tab can be accessed using the toolbar found at the bottom of the Tool.

NOAA FISHERIES

Calculator Tab: Vibratory

KEY

User Provided Information *Default values are in bold, italics turquoise (can be changed by user if project-specific information is available).*

Preset NMFS Provided Information (cannot be altered by user). NMFS thresholds/default weighting value are in bold red.

OUTPUT: Resultant Isopleth (cannot be altered by user)

Automatically Calculated Values Based on User Provided Information (only weighting adjustment (-dB) can be altered by user

NOAA FISHERIES

This slide illustrates the Key at the top of the Calculator Tab. Green cells are for user provided information. Note that default values are in bold italics turquoise font. These default values may be changed by the user if project-specific information is available. Yellow cells represent preset NMFS provided information and cannot be altered by the user. NMFS thresholds/default weighting values are in bold red. Bright blue cells represent outputs of the Tool or resultant isopleths based on user provided information and cannot be altered by the user. Finally, gray cells represent automatically calculated values based on user provided information (only weighting adjustment (-dB) values can be altered by the user and are found in the last row of the Tool). Please see Advanced Features later in this presentation for more information on adjusting these values.

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Calculator Tab: Vibratory

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This slide illustrates the first two steps of the Vibratory Calculator Tab. Step 1 outlined in hot pink, where a user will enter qualitative project-specific information and Step 2 outlined in turquoise, where the user will enter quantitative project-specific information. We will go into more detail on both these steps in the next slides.

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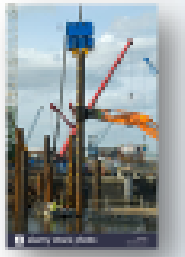
Calculator Tab: Vibratory

Step 1: General Project Information



STEP 1: GENERAL PROJECT INFORMATION			
PROJECT TITLE and CONTACT	Example title		Notes (Please include all assumptions)
PROJECT/ SOURCE INFORMATION (size, type, number, pile strikes, etc.)			other information

NOTE: Please include any assumptions, including if relying upon proxy sound levels.

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Step 1 in the Calculator Tab is where the user provides general project information, such as project title and contact; source information such as pile size material, duration to drive a pile; and any other assumptions or notes, including if proxy levels were used or if any type of attenuation is assumed.

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Calculator Tab: Vibratory

Step 2: Quantitative Project-Specific Information

STEP 2: QUANTITATIVE PROJECT-SPECIFIC INFORMATION			
	METRIC		
1 sec SEL = RMS	RMS	WEIGHTING (WFA in kHz)	
Unattenuated Sound Pressure Level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)		Sea Turtle Default WFA (kHz)	Marine Mammal Default WFA (kHz)
Attenuated Sound Pressure Level (dB)* (calculation done automatically)	0	0.16	2.5
Distance associated with sound pressure level measurement (meters); Typically, 10-m but please double check data being used	10		
Transmission loss constant (NMFS recommends: 15 if unknown)	15		
Number of piles per day (best estimate based on previous experience)		Attenuation (e.g., bubble curtain) (enter positive number)	0
Duration to drive a single pile (minutes) (best estimate based on previous experience)			
Duration of Sound Production within a day (seconds)	0	Cumulative SEL at measured distance (dB)	#NUM!
10 Log (duration of sound production)	#NUM!		

NOTE: Default values already included in *italic turquoise* (can be changed)

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Step 2 is where quantitative project-specific information is entered, such as levels, distance associated with level, transmission loss, number of piles per day, duration to drive a pile, and attenuation assumed. Default values (italics, turquoise) are provided for distance associated with level and transmission loss. Please confirm these defaults are applicable. If not, they may be modified. Gray cells represent automatically calculated values based on user provided information (and cannot be changed in Step 2). The next slides go into more detail on Step 2 inputs.

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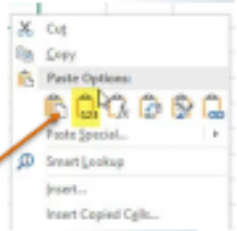
Calculator Tab: Vibratory

Step 2: Quantitative Project-Specific Information

		METRIC
	1 sec SEL = RMS	RMS
A	Unattenuated Sound Pressure Level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)	



In this cell insert proxy sound levels (Paste as Value 123) OR enter project-specific data

B	Distance associated with sound pressure level measurement (meters); Typically, 10-m but please double check data being used	10
C	Transmission loss constant (NMFS recommends: 15 if unknown)	15

This cell has a default value of 10 m. Make sure values in A are associated with 10 m

This cell has a default value of 15 (can be changed)

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Let's take a closer look at some of the specific cells in Step 2 (labeled by row letter). Row A represents the unattenuated levels in the RMS metric. Here a user may enter project-specific level, if available or enter surrogate level from the Proxy Level Tab. If a value is copied from the Proxy Level Tab, paste it in Row A as a value (see red arrow). Row B represents the distance associated with the previously entered level. The default value is 10-m, but one should ensure this is correct. This value may be changed if the default is not correct. Row C represents transmission loss. The default value is 15 and is recommended if this value is unknown. If site-specific transmission loss is available, it may be used here instead of the default.

NOAA FISHERIES

Calculator Tab: Vibratory

Step 2: Quantitative Project-Specific Information

D	Number of piles per day (best estimate based on previous experience)		Attenuation (e.g., bubble curtain) (enter positive number)	0
E	Duration to drive a single pile (minutes) (best estimate based on previous experience)			

F

This cell for the number of piles per day

This cell is for duration to drive a pile (minutes)

This cell is for attenuation (Note there is NO recommended default for vibratory pile driving. If no attenuation leave as zero.

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Two additional rows are in Step 2. Cell D represents the number of piles per day based on best estimate from previous experience. Cell F represents attenuation, if being used. Please only enter positive numbers in this cell. If nothing is being used, please leave value as zero. Whatever attenuation is used will be reflected automatically in the attenuated levels (subtracted off levels entered on previous slide). Finally, Cell E represents the duration to drive a pile (minutes) based on best estimate from previous experience.

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Calculator Tab: Impact

Step 2: Quantitative Project-Specific Information

Fully entered values

STEP 2: QUANTITATIVE PROJECT-SPECIFIC INFORMATION			
	METRIC		
1 sec SEL = RMS	RMS	WEIGHTING (WFA in kHz)	
Unattenuated Sound Pressure Level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)	170	Sea Turtle Default WFA (kHz)	Marine Mammal Default WFA (kHz)
Attenuated Sound Pressure Level (dB)* (calculation done automatically)	170	0.16	2.5
Distance associated with sound pressure level measurement (meters); Typically, 10-m but please double check data being used	10		
Transmission loss constant (NMFS recommends: 15 if unknown)	15		
Number of piles per day (best estimate based on previous experience)	3	Attenuation (e.g., bubble curtain) (enter positive number)	0
Duration to drive a single pile (minutes) (best estimate based on previous experience)	30		
Duration of Sound Production within a day (seconds)	5400	Cumulative SEL at measured distance (dB)	207.32
10 Log (duration of sound production)	37.32		

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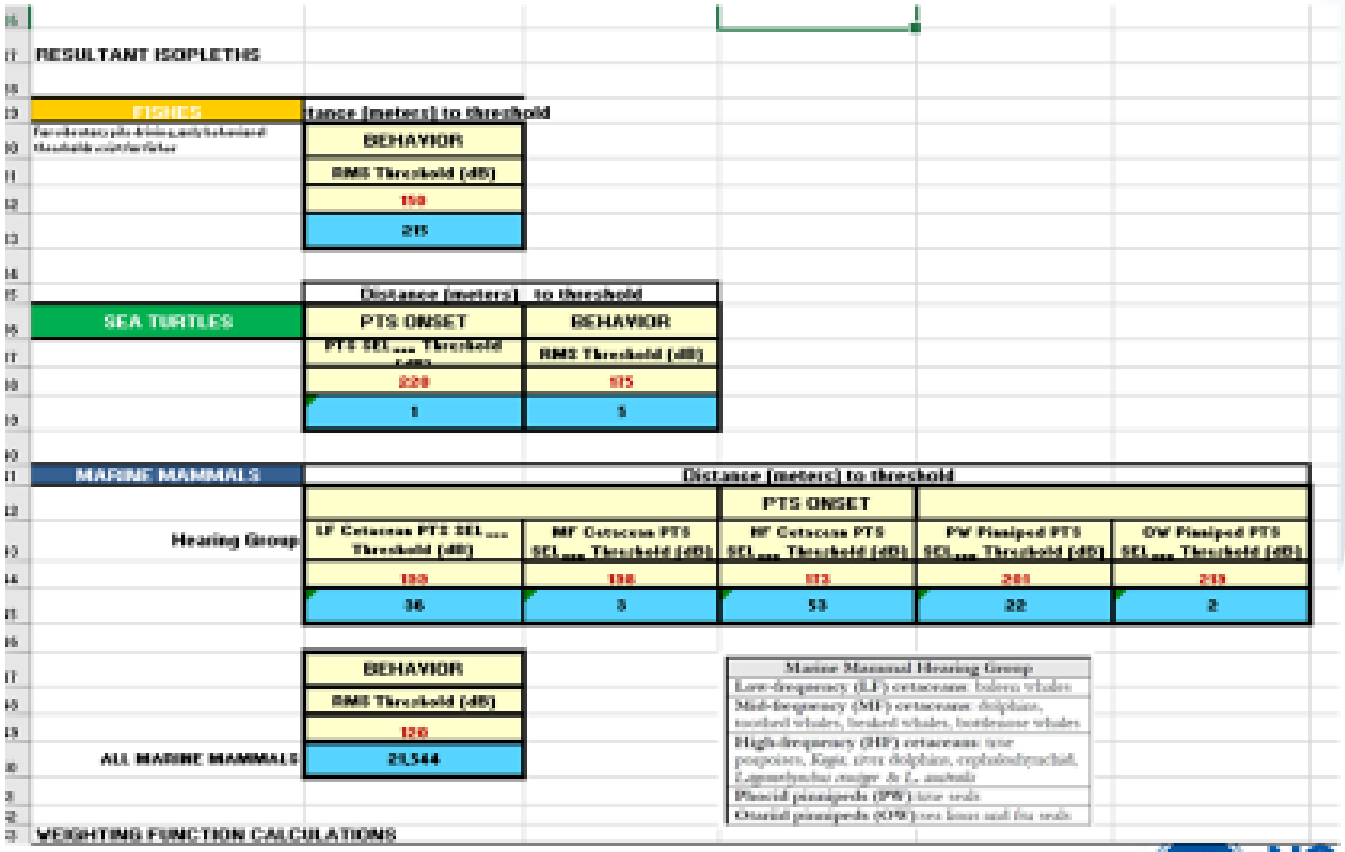
This slide illustrates all the values entered in Step 2 for our specific example. Note in this example, there is no attenuation (0), so the unattenuated and attenuated RMS level is identical (170 dB).

NOAA FISHERIES

Calculator Tab: Vibratory

Resultant Isopleths (by taxa)



RESULTANT ISOPLETHS

FISHES	tance (meters) to threshold
	BEHAVIOR
	RMS Threshold (dB)
	150
	215

	Distance (meters) to threshold	
SEA TURTLES	PTS ONSET	BEHAVIOR
	PTS SEL... Threshold	RMS Threshold (dB)
	220	175
	1	5

MARINE MAMMALS	Distance (meters) to threshold				
			PTS ONSET		
Hearing Group	LF Cetacean PTS SEL... Threshold (dB)	MF Cetacean PTS SEL... Threshold (dB)	HF Cetacean PTS SEL... Threshold (dB)	PW Pinniped PTS SEL... Threshold (dB)	OW Pinniped PTS SEL... Threshold (dB)
	199	198	173	201	219
	36	3	53	22	2

	BEHAVIOR
	RMS Threshold (dB)
	120
ALL MARINE MAMMALS	29,544

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, Kogia, river dolphins, cephalorhynchid, Lagenorhynchus cruciger & L. australis
Phocid pinnipeds (PW): true seals
Otariid pinnipeds (OW): sea lions and fur seals

WEIGHTING FUNCTION CALCULATIONS

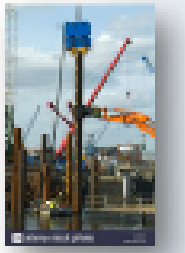
NOAA FISHERIES

After quantitative project-specific information is entered in Step 2 of the Calculator, resultant isopleths (bright blue cells) are produced by taxa.

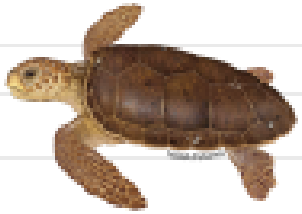
NOAA FISHERIES

Calculator Tab: Impact

Resultant Isopleths (by taxa)



FISHES	Distance (meters) to threshold	
For vibratory pile driving, only behavioral thresholds exist for fishes	BEHAVIOR	
	RMS Threshold (dB)	
	150	
	215	

SEA TURTLES	Distance (meters) to threshold	
	PTS ONSET	BEHAVIOR
	PTS SEL_{cum} Threshold (dB)	RMS Threshold (dB)
	220	175
	1	5

NOAA FISHERIES

This slide illustrates the Resultant Isopleths (bright blue cells) for fishes and sea turtles based on the various taxa-specific acoustic thresholds.

NOAA FISHERIES

Calculator Tab: Impact

Resultant Isopleths (by taxa) cont'd

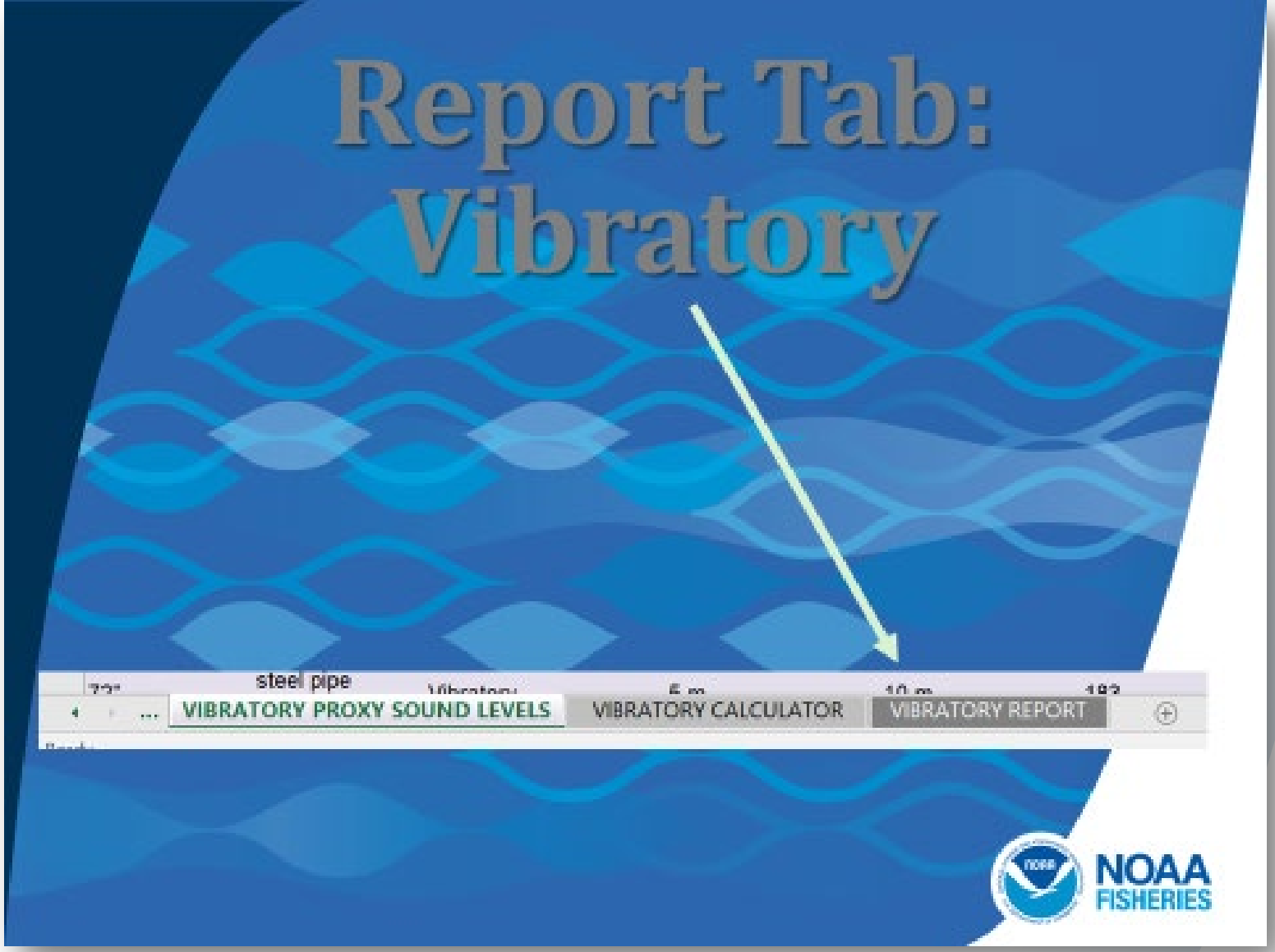
MARINE MAMMALS	Distance (meters) to threshold				
			PTS ONSET		
Hearing Group	LF Cetacean PTS SEL_{cum} Threshold (dB)	MF Cetacean PTS SEL_{cum} Threshold (dB)	HF Cetacean PTS SEL_{cum} Threshold (dB)	PW Pinniped PTS SEL_{cum} Threshold (dB)	OW Pinniped PTS SEL_{cum} Threshold (dB)
	183	198	173	201	219
	26	3	53	22	3

BEHAVIOR
RMS Threshold (dB)
120
ALL MARINE MAMMALS 21,554

NOAA FISHERIES

This slide illustrates the Resultant Isopleths (bright blue cells) for marine mammals based on the various hearing group-specific acoustic thresholds.

NOAA FISHERIES

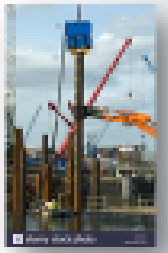


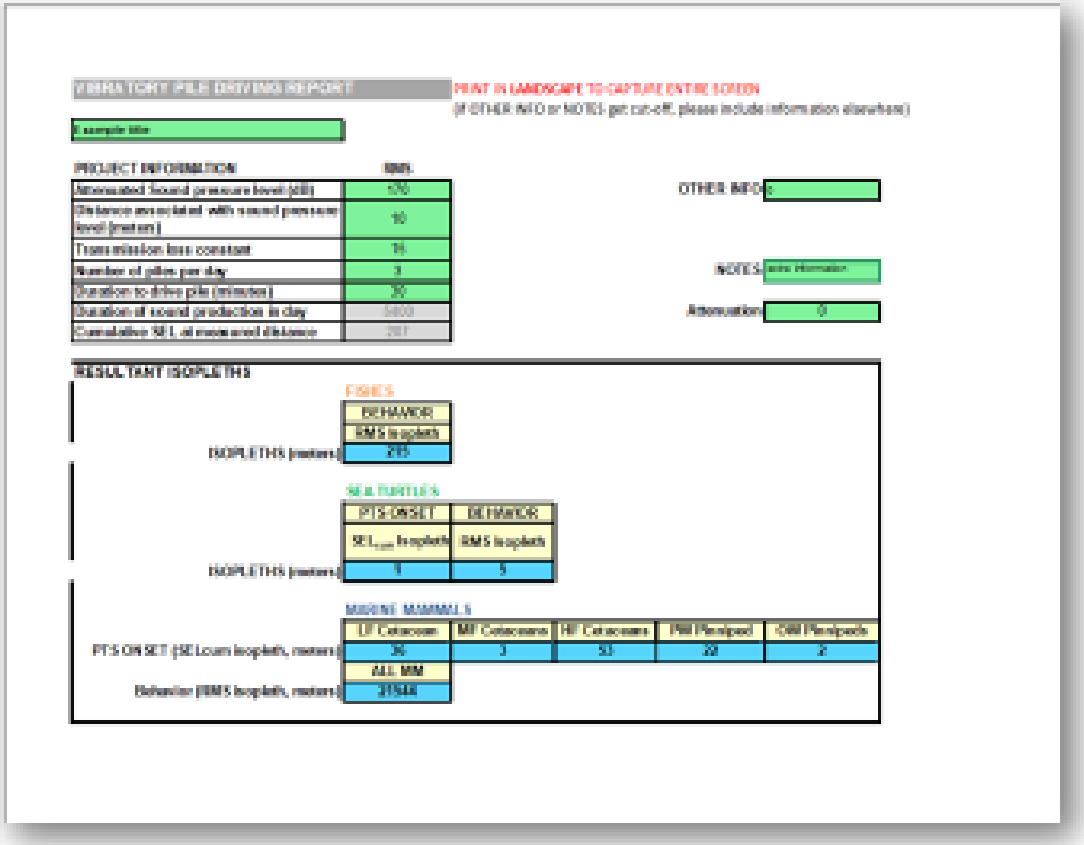
Let's demonstrate the Vibratory pile driving Report Tab. This Tab can be accessed using the toolbar found at the bottom of the Tool.

NOAA FISHERIES

Report Tab: Vibratory

Summarizes user inputs and resulting isopleths





VIBRATORY PILE DRIVING REPORT

PRINT IN LANDSCAPE TO CAPTURE ENTIRE SCREEN

(if OTHER INFO or NOTES get cut-off, please include information elsewhere)

Example title

PROJECT INFORMATION	INPUTS
Attenuated Sound pressure level (dB)	170
Distance associated with sound pressure level (meters)	10
Transmission loss constant	15
Number of piles per day	1
Duration to drive pile (minutes)	30
Duration of sound production in day	1800
Cumulative SEL at measured distance	201

OTHER INFO: 0

NOTES: some information

Attenuation: 0

RESULTANT ISOPLETHS

FISHES

BEHAVIOR
RMS Isopleth
215

ISOPLETHS (meters)

SEA TURTLES

PTS ONSET	BEHAVIOR
SEL_{cum} Isopleth	RMS Isopleth
1	5

ISOPLETHS (meters)

MARINE MAMMALS

	LF Cetaceans	MF Cetaceans	HF Cetaceans	PW Pinnipeds	OW Pinnipeds
PTS ONSET (SEL cum Isopleth, meters)	26	3	53	22	2
	ALL MM				
Behavior (RMS Isopleth, meters)	21544				

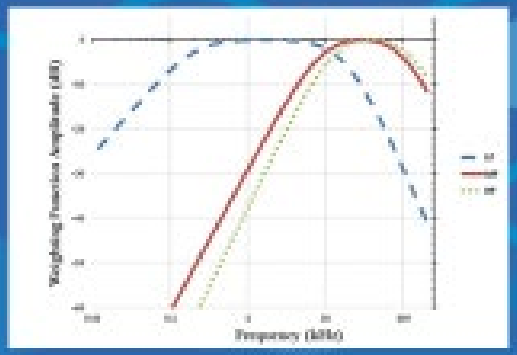
- Fits on one sheet (landscape)
- If other info/notes get cut off, please include elsewhere

NOAA FISHERIES

The Report Tab summarizes the inputs and outputs provided in the Calculator Tab. The information in this Tab is designed to fit in a single sheet (landscape view). If other information or notes get cut-off from the what was provided in the Calculator Tab, please provide this information elsewhere.

NOAA FISHERIES

Advanced Features: Weighting



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

NOAA FISHERIES

The final slides cover an advanced feature, specifically incorporating weighting based on the pile driving spectrum, if available. This feature is optional.

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Advanced Features: Weighting

Tool automatically provided default weighting for PTS threshold (SEL_{cum} metric) for **marine mammals** & **sea turtles** (none for **fishes**)

IMPACT

WEIGHTING (WFA in kHz)	
Sea Turtle Default WFA (kHz)	Marine Mammal Default WFA (kHz)
0.16	2

VIBRATORY

WEIGHTING (WFA in kHz)	
Sea Turtle Default WFA (kHz)	Marine Mammal Default WFA (kHz)
0.16	2.5

NOAA FISHERIES

This Tool automatically provides default weighting for PTS thresholds in the SEL_{cum} metric for both marine mammals and sea turtles. Note auditory weighting functions are not available for fishes. These defaults are illustrated in the yellow boxes and bold red text on this slide and within the Tool on the Calculator Tabs. Note that they are different for marine mammals depending on whether the activity is impact or vibratory pile driving.

NOAA FISHERIES

Advanced Features: Weighting

IMPACT

STEP 2: QUANTITATIVE PROJECT-SPECIFIC INFORMATION						
	METRICS					
	Peak	SEL,ss	RMS		WEIGHTING (WFA in kHz)	
Unattenuated Single strike level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)				Effective Quiet (Fish Only)	Sea Turtle Default WFA (kHz)	Marine Mammal Default WFA (kHz)
Attenuated Single strike level (dB)* (calculation done automatically)	0	0	0	150	0.15	2
Distance associated with single strike					WFA Weighting Factor Adjustment	

VIBRATORY

STEP 2: QUANTITATIVE PROJECT-SPECIFIC INFORMATION			
	METRIC		
1 sec SEL = RMS	RMS (NOT Peak)	WEIGHTING (WFA in kHz)	
Unattenuated Sound Pressure Level (dB) (see Proxy Level Tab for surrogate values; Copy, ONLY Paste Values (123), not formulas)		Sea Turtle Default WFA (kHz)	Marine Mammal Default WFA (kHz)
Attenuated Sound Pressure Level (dB)* (calculation done automatically)	0	0.15	2.5
Distance associated with sound			

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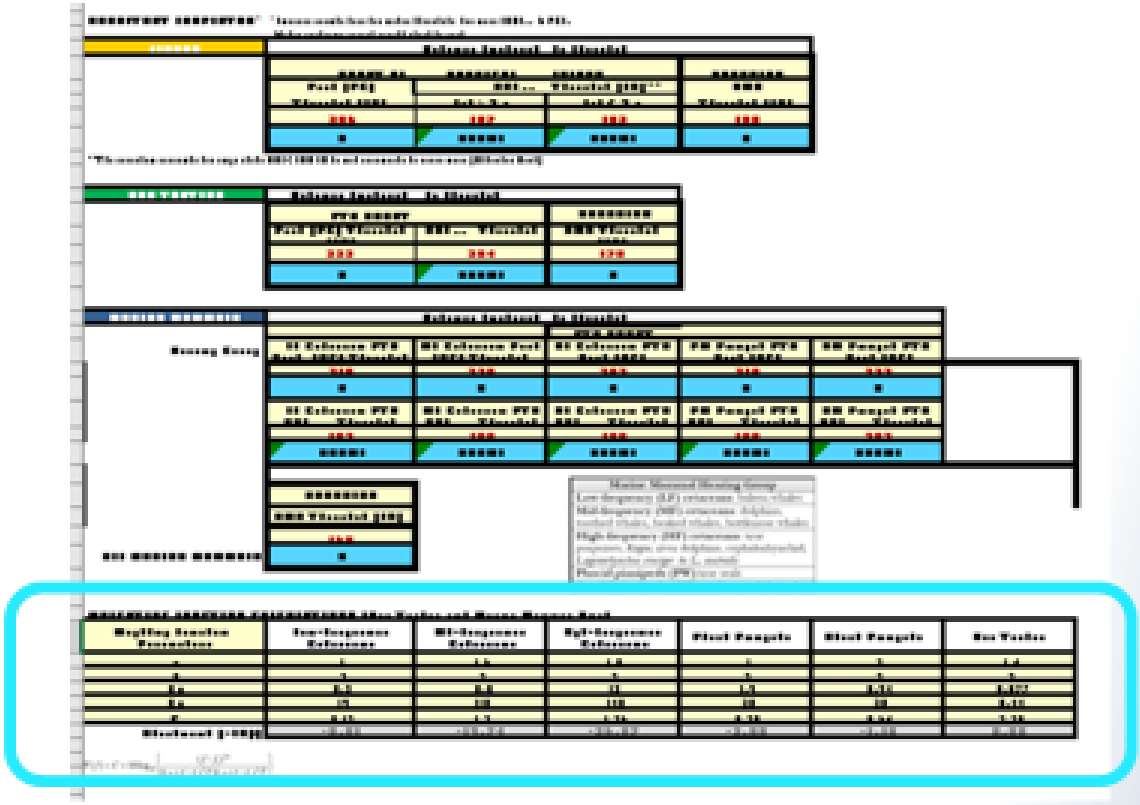
This slide simply illustrates that the default weighting is provided in Step 2 of both the Impact (outlined in hot pink) and Vibratory (outlined in turquoise) Calculator tabs.

NOAA FISHERIES

Advanced Features: Weighting



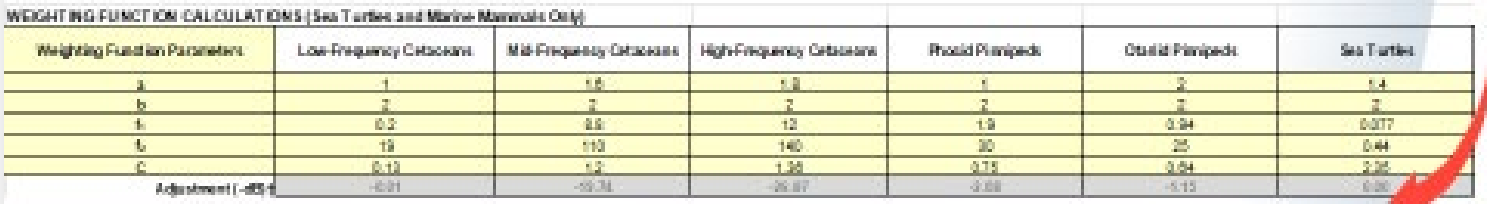
NOAA FISHERIES

If a spectrum is available for your particular pile size, material, and location. Default weighting may be adjusted at the bottom of the Calculator Tab, as illustrated by the turquoise box. For pile driving, it is particularly important to pay attention if the spectrum available is for an attenuated or an unattenuated pile and that the available spectrum matches your particular activity. Note, NMFS cautions using spectrum associated with bubble curtains, unless the exact same bubble curtain/settings is proposed for the specific project. The user should also note if a spectrum is being used and the associated details in Step 1.

NOAA FISHERIES

Advanced Features: Weighting

However, if the spectrum is available for the pile material/size, then these data can be used to override default weighting via gray cells below:



WEIGHTING FUNCTION CALCULATIONS | Sea Turtles and Marine Mammals Only

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	Sea Turtles
a	1	1.6	1.8	1	2	1.4
b	2	2	2	2	2	2
f1	0.2	8.8	12	1.9	0.94	0.077
f2	19	110	140	30	25	0.44
C	0.13	1.2	1.36	0.75	0.64	2.35
Adjustment (~dB)	-0.01	-10.74	-26.87	-3.68	-5.13	0.00

For specific instructions, see Instruction Manual for Optional User Spreadsheet tool (marine mammals), Section 3.2 (SPECTRUM (MULTIPLE FREQUENCIES) TO OVERRIDE WEIGHTING FACTOR ADJUSTMENT): https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance

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Spectrum data would be specifically entered in the gray cells, as illustrated by the red arrow. Inputs should always be negative numbers and are based on the difference between the unweighted SEL level and the marine mammal or sea turtle weighting function. For specific instructions on how to override default weighting, please see the Manual for the Optional User Spreadsheet Tool (marine mammals) found at the web site on this slide.

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Thanks for Viewing!

Questions?

- **Technical or Suggestions to improve Tool or Introduction:**
  - Amy Scholik-Schlomer (amy.scholik@noaa.gov)
- **Project Specific:**
  - HQ/Regional Analyst

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Thanks for viewing this presentation. If you have technical questions or suggestions to improve this Tool, please feel free to contact the person listed on this slide or if you have project-specific questions, please contact your Headquarter or Regional analyst.

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