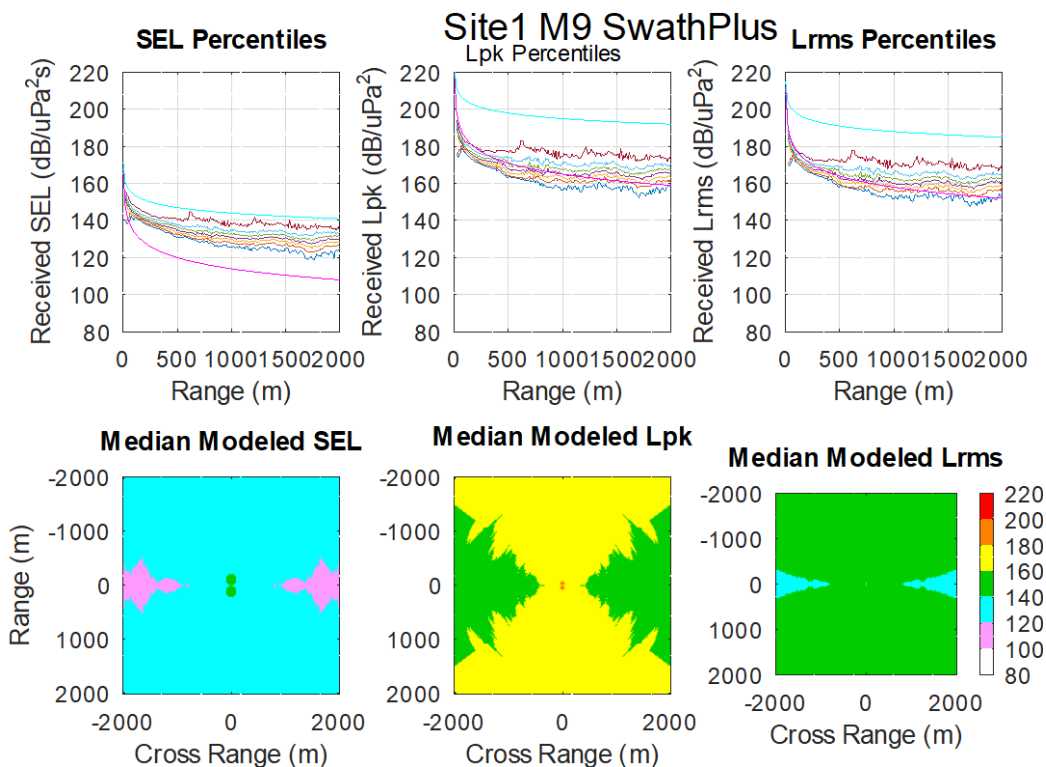


Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical Surveys: Acoustic Modeling Effort

Final Modeling Report



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DISCLAIMER

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ABOUT THE COVER

Cover graphic by Kevin Heaney represents sound levels from the SwathPlus at Site 1 across range and as plan view. The directionality of the source is depicted well.

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List of Acronyms, Symbols, and Abbreviations

3D	three-dimensional
10logR	cylindrical spreading
20logR	spherical spreading
μPa	micropascal
μs	microsecond
ϕ	phi (grain size)
AOS	Applied Ocean Sciences, LLC
BOEM	Bureau of Ocean Energy Management
CPA	closest point of approach
CSA	CSA Ocean Sciences Inc.
dB	decibel
dB re 1 $\mu\text{Pa m}$	decibel with reference to 1 micropascal meter
F	Frequency
GPS	global positioning system
HF	high-frequency
Hz	hertz
HRG	high-resolution geophysical
IFFT	inverse fast Fourier transform
ISO	International Organization for Standardization
J	joule
kg	kilogram
kHz	kilohertz
kJ	kilojoule
km	kilometer
LF	low-frequency
L_E	sound exposure level
L_{pk}	peak sound pressure level
L_{rms}	root-mean-square sound pressure level
m	meter
MF	mid-frequency
MSP	mean-square sound pressure
ms	millisecond
NUWC	Naval Undersea Warfare Center
p(t)	sound pressure time series
PE	parabolic equation
PL	propagation loss
RAM	range-dependent acoustic model
re	with reference to
rms	root-mean-square
RMSE	root-mean-square-error
s	second

SEL	sound exposure level
SEL _{ss}	single-strike sound exposure level
SEL _w	weighted sound exposure level
SL	source level
SNR	signal-to-noise ratio
SPL	sound pressure level
SPL _{rms}	root-mean-square sound pressure level
SSP	sound speed profile
TL	transmission loss
U.S.	United States
USGS	United States Geological Survey
VHF	very high-frequency

1 Introduction

Geophysical surveys are integral to many marine activities that support not only the marine energy sector (e.g., oil and gas, renewable) but also infrastructure (e.g., ports, cabling), restoration, environmental characterization and monitoring, identification of hazards, and detection of archaeological resources. Given the scientific uncertainty regarding potential acoustic impacts on marine life, many regulatory requirements include precautionary mitigation strategies to decrease acoustic impacts, even for surveys of a short duration and limited geographic extent.

CSA Ocean Sciences Inc. (CSA) was contracted by BOEM to use field-measured sound of commonly used high-resolution geophysical (HRG) sources to model and predict their three-dimensional (3D) exposure levels. The project is titled “Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical Surveys: Acoustic Modeling Effort.” Geophysical surveys employ sources that emit acoustic signals that are impulsive, tonal, or sweep through many frequencies. HRG sources for this study can be grouped into three categories: 1) broadband seismic sources (i.e., airguns/subbottom profilers) with most energy at low frequencies, 2) chirp sonars that are frequency sweeps with most energy at high frequencies, and 3) sonars (e.g., side scan, multi-beam) that emit high-frequency (HF) tones. For all three source types, operational frequencies range from 20 hertz (Hz) to approximately 900 kilohertz (kHz). These units operate at peak-to-peak sound pressure level (SPL) source levels (SLs) that range from 170 to 240 decibels with reference to 1 micropascal meter (dB re 1 μ Pa m).

1.1 Purpose

This project was conducted in support of the Bureau of Ocean Energy Management’s (BOEM’s) goal of ensuring acoustic mitigation requirements are scientifically supported and defensible, cost effective, practical, and effective at decreasing acoustic impacts to marine life, particularly in shallow-water environments where the understanding of acoustic dynamics is limited compared to deepwater environments. The acoustic modeling and comparison of model predictions with measurements in shallow-water field environments fill a critical knowledge gap regarding acoustic impacts. The measured HRG acoustic data serve as a basis for verifying and/or revising propagation model predictions used by industry to determine acoustic impacts from survey sources in shallow-water environments.

1.2 Background – Phase II Open-Water Testing Design

The BOEM project titled “Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical Surveys” was divided into three serial efforts. Phase I was Tank Testing (Crocker and Fratantonio, 2016); Phase II was Open Water Testing (Halvorsen and Heaney, 2018), and Phase III was the Acoustic Modeling Effort (this study).

The BOEM Phase II project titled “Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical Surveys: Open Water Testing” executed a field test plan that measured the sound fields generated by HRG source signals (Halvorsen and Heaney, 2018). During Phase II, there were significant challenges with the data-collection hardware at sea, and scientists and

engineers exerted extraordinary effort to obtain valid acoustic data, including extensive troubleshooting and multiple re-deployments of the data-collection buoys. Troubleshooting efforts resulted in a considerable amount of useful acoustic measurements, which were presented in the Phase II report (Halvorsen and Heaney, 2018).

A brief summary of the Phase II field methodology is included here to better understand the Phase III approach; a detailed description of Phase II is provided in Section 2 of the Halvorsen and Heaney (2018) report. Five test sites were selected to represent three water depths and two general sediment types. The characteristics of each site are listed in **Table 1-1**. Sites had different sediment compositions and relatively flat bathymetries, where the bottom sloped minimally for approximately 2 kilometers (km) around each test location.

Table 1-1. Test site characteristics

Site	Global Position Coordinates	Water Depth (m)	Substrate Type
Site 1	37.811110 N 075.424490 W	10	Mud
Site2	37.983515 N 075.133575 W	10	Sand
Site 3	36.920100 N 075.428100 W	30	Mud
Site 4	36.880215 N 075.274760 W	30	Sand
Site 5	38.0 N 074.1 W	100	Sandy Silt

To accurately measure a 3D sound field produced by HRG sources in the presence of a given seafloor type, an acoustic field array of acoustic acquisition buoys was deployed in the geometry shown in **Figures 1-1** and **1-2**. The array generally was composed of up to six acoustic recording buoys deployed at each test site (**Figure 1-1**). Four recording buoys (D, B, E, and F) were arranged in a line perpendicular to the source track approximately 0, 100, 1,000, and 4,000 meters (m) from the center of the source track (**Figure 1-1**). Relative to the line of four buoy positions (D, B, E, and F), buoys A and (sometimes) C were deployed 100 m perpendicular to the source track, positioned 2 km on either side of the perpendicular line of buoys (**Figure 1-1**). **Figure 1-2** is an underwater side view of the four recording buoy positions (D, B, E, and F) for sites 3 and 4.

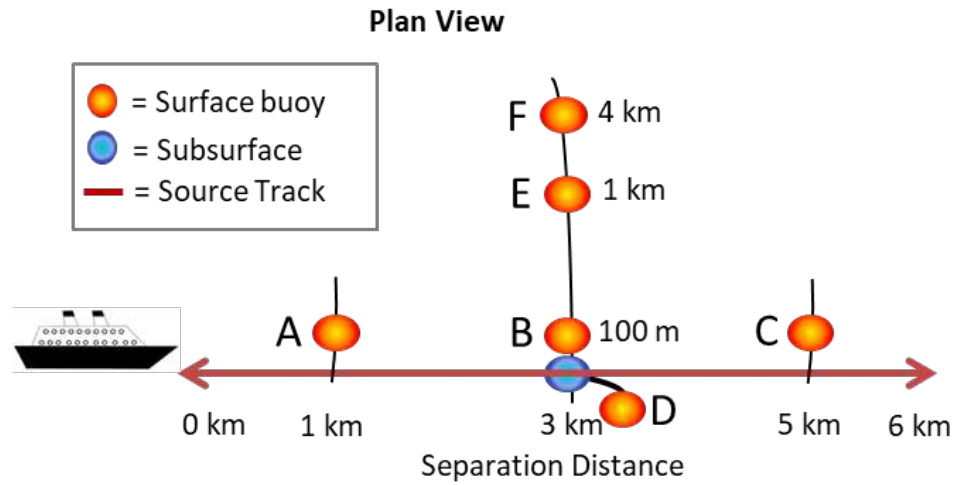


Figure 1-1. Design of the acoustic field array; Plan view

Position D had a (blue) subsurface, seafloor-mounted hydrophone beneath the vessel track and a surface buoy moored approximately 30 m from the vessel track. The line of the four buoys is marked in distances from the center (3-km mark) of the track line at 0, 100, 1,000, and 4,000 m. From: (Halvorsen and Heaney, 2018)

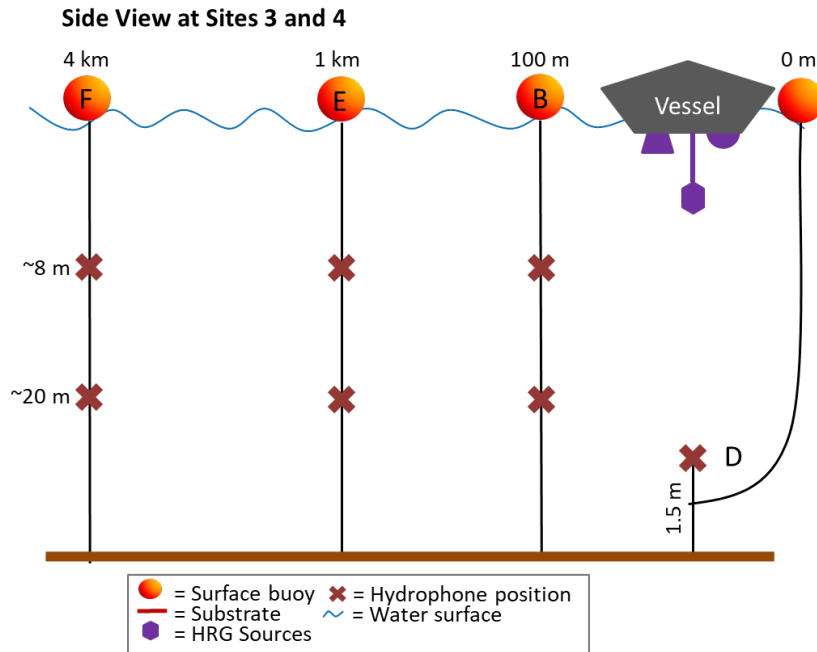


Figure 1-2. Illustration of the array layout (side view) at test sites 3 and 4 for 30-m water depth

Note that buoy D was located directly beneath the vessel track, 1.5 m above the seafloor. The approximate hydrophone depths are along the left side of the image. From: (Halvorsen and Heaney, 2018)

Each buoy had one to three pairs of hydrophones placed at specific water depths (depending on the test site). The hydrophone pairs consisted of one high-sensitivity and one low-sensitivity hydrophone to encompass the broad dynamic range of HRG signals. For buoy positions A, B, C, E, and F at Sites 1 and 2, each buoy was equipped with a single pair of hydrophones; at Sites 3 and 4, each buoy was equipped with two pairs of hydrophones (**Figure 1-2**); and at Site 5, each buoy was equipped with three pairs of hydrophones. At all sites, buoy position D had a subsurface tripod mount that held the hydrophone 1.5 m above seafloor and was placed directly beneath the vessel track (**Figure 1-2**). Each buoy was supposed to have a functioning onboard global positioning system (GPS); however, this feature did not function in some instances. The locations of all acoustic buoys were marked using the R/V *Hugh R. Sharp*'s GPS at deployment and recovery of each buoy. The location of each source was calculated using the vessel's GPS position and the x, y, z offset of the source relative to the GPS antenna provided by the United States Geological Survey (USGS). By using the known position of the source combined with each buoy's deployed position, the acoustic metrics were calculated for sound impulses.

For source measurements, the HRG sources were organized into operational pairings (i.e., two sources operated in alternation). For each HRG source, the source vessel transited along the approximately 5-km track line (called a run) through the field array (**Figure 1-1**) at low engine revolutions per minute (approximately 3 knots) to reduce masking of the HRG signals by vessel noise. Each HRG source was operated to transmit signals of their typical duration followed by a 1-second pause, then the other source was triggered to transmit followed by a 1-second pause, and so on. At the completion of each run, the HRG sources were set to new operational modes (e.g., frequencies, power levels, pulse lengths, deployment configurations) or swapped out for different HRG sources. Forty operational modes were measured in the field.

1.3 Phase II Field Challenge Summary

Challenges that arose in the field are described in the Halvorsen and Heaney (2018) report. The challenges and corresponding descriptions are found in Sections 2.5.1.1 Chronology of Issues Encountered, Section 2.6.3.1 Calibration Issues, and photographs in Appendix B - Photo Documentation of that report.

The biggest challenge was a design flaw in the recording systems, which left the collected data from Phase II incompletely calibrated. The GPS and internal communication systems in the receiver buoys were compromised for many of the measurements and often were non-functioning. This limited documentation of the exact locations of those recording buoys over time, so this information was not incorporated into the Phase II data; the solution was to use the buoy deployment positions from the vessel as a proxy. When GPS information was operational on the recording buoy, that information was incorporated into the Phase II data analysis. The shipboard and towed sonar source system positions are known, as is the timing of the received signals at the buoys, which comprise information that assisted in rectifying buoy positioning. For most of the five sites, the uncertainty of deployment positions or movement of the receivers after deployment was small (50 m or less), but a storm moved through the test area during the 30-m depth measurements, and some receivers moved up to approximately 600 m.

A combination of the relative positions of the recording buoys during each source run and the preliminary modeling effort of this Phase III project allowed for rectification of the receiver locations over each measurement run. This permitted calibration of the received signal levels as a function of range from the sources.

1.4 Phase III Modeling Objective

CSA was contracted by BOEM to use the field-measured 3D sound field produced by 17 commonly used HRG sources to model and predict the 3D exposure levels from each source in shallow water depths ranging from 10 to 100 m. The study objective was to provide reliable predicted sound field acoustic levels for the HRG sources to better assess potential acoustic impacts to marine fauna. The Naval Undersea Warfare Center (NUWC) near-field study (Crocker and Fratantonio, 2016) and the Phase II report by Halvorsen and Heaney (2018) were reviewed and incorporated into this Phase III modeling effort.

If Phase II had consistent data collection and equipment function, the results could have been presented as a table, enabling future users to simply look up the received levels for the respective sources in a particular environment at the observed bearing and range. However, due to the many engineering difficulties encountered during Phase II, the resulting data set was neither complete enough nor accurate enough (i.e., it included calibration errors) to permit this approach. Additional steps were taken to correct the data set and provide enough good measurements to validate acoustic models.

The goals of the Phase III modeling effort were to recommend an acoustic modeling approach, to best predict the acoustic sound field produced in shallow water during operation of the sound sources used during HRG surveys, and to compare the adjusted data from Phase II to these models for validation purposes. The specific goals and objectives of this effort included the following:

- Review and incorporate the results, as necessary, from the two previous and related technical reports by Crocker and Fratantonio (2016) and Halvorsen and Heaney (2018).
- Identify the positional locations of each functional acoustic buoy (within each source/pair run) at all five test sites.
- Estimate corrected ranges between sources and functional acoustic buoys.
- Acquire a best estimate of the measured *in situ* received level (thus generating a calibrated data set).
- Compare the calibrated measured data results to the simulated results from the most appropriate acoustic propagation model(s) (e.g., Peregrine, ray theory, parabolic equation [PE], normal mode, range-dependent acoustic model [RAM]) for 40 representative HRG sources at the five test sites.
- Determine acoustic propagation model(s), supporting environmental parameter databases, and other model inputs for modeling the HRG source propagations that produce reasonably accurate predictions at the five test sites.
- Recommend the most appropriate propagation model(s) for HRG sources in shallow-water conditions (<100 m).
- Document analytical methods, results, and acoustic propagation model recommendations in a final report that is understandable by both experts and non-experts.

1.5 Phase III Approach

To achieve the program objectives, five tasks were performed:

- Task 1: Project and data management
- Task 2: Final calibration of the acoustic data from Phase II
- Task 3: Draft and final calibration report
- Task 4: Comparison of the measured acoustic data to modeled results
- Task 5: Draft and final report

This approach yielded recommendations for propagation models that best predict HRG output signal propagation in shallow-water settings. Recommendations include the site-specific environmental parameters that influence acoustic propagation. To meet the project objectives, buoy positioning was rectified using Phase II data and compared to those with predictive modeling outputs. After the acoustic buoys were localized, the measured received levels were adjusted. The results of the model to data comparisons provide a scientifically defensible way forward for environmental agencies and contractors working with HRG sources to confidently predict acoustic propagation for these sources under similar environmental conditions.

1.6 Project Team

CSA worked cooperatively with Applied Ocean Sciences LLC (AOS) for this project. As prime contractor, CSA was responsible for overall project management and managed the compilation and drafting of the final report. AOS performed all data analysis, processing, modeling, and acoustic data presentation; drafted written reports; and generated a graphical user interface for accessing the model plots.

The project team for Phase II continued into this Phase III effort “Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical Surveys: Acoustic Modeling Effort.” The team continuity ensured the primary objectives of the continuation study were addressed. The team included the following members: Dr. Michele Halvorsen (co-primary investigator and technical lead), formerly at CSA and currently at the University of New Hampshire; Dr. Kevin Heaney (co-primary investigator) at AOS; Dr. Kerri Seger (acoustic analyst) and Mr. John Boyle (Tool and Process Engineer) at AOS; Ms. Kim Olsen (project manager) at CSA; Mr. Gerald Reynolds (data manager) at CSA; and Ms. Natalie Kraft (technical editor). The capabilities of each team member ensured the team efficiently addressed the primary objectives of the study and understood and addressed the results given the technical issues from the Phase II field effort.

2 Data Adjustment(s)

The objective of the data adjustment task was to determine and apply adjustment factors to the received signal levels. Adjustment factors were determined to address unresolved issues from Phase II related to hydrophone sensitivity, gain settings, and the occasional failed collection of GPS navigation data on the recording buoys. There were several instances when equipment settings were not documented for the hydrophones on one or more buoys during each run. Specifically, the two values not always documented, but needed for conversion from raw WAV file data to pascals, were recorder hardware gain and hydrophone sensitivity. Once these issues were addressed, adjustments were made to the recording buoy locations and received signal levels.

During analysis of the Phase II data, the recorder hardware gain setting errors were partially addressed. Each hydrophone channel on each buoy was compared to other hydrophones on that buoy (if possible) to verify individual gain settings. However, this simple data check was not capable of identifying the incorrectly documented gains across all channels on a buoy. Therefore, to ascertain whether all channels (hydrophones) on a buoy needed an adjustment factor on the recorder hardware gain, simple acoustic propagation modeling was incorporated into the adjustment factor decisions by making plots of sound exposure level (SEL) versus range.

For each recording buoy, there were two or more hydrophones with different sensitivities to capture the signal dynamic range. The basic design included one hydrophone of higher sensitivity and one of lower sensitivity at each recording depth (however, with the hardware challenges, one of these often did not function). The recording hardware had different channels programmed to include a gain of ± 10 dB. Each hydrophone was supposed to be plugged into a specific channel with the pre-programmed gain; however, this is where undocumented errors are known to have occurred. The 10-dB interval will be referred to later in this report as the “padding log error”. These issues resulted in a range of received level errors from 0 to ± 50 dB. For example, a single recording channel with an incorrect gain setting could result in a signal level adjustment factor that differed from the other channels. The combination of hydrophone sensitivity, gain setting, and incorrect channel selection led to overall received level errors between two hydrophones on the same buoy, with differences up to ± 50 dB. The sensitivity of any hydrophone that did not record signals would be difficult to determine. Therefore, if a hydrophone’s sensitivity was not documented, a few decibels could be added to the ambiguity of the system. Hydrophone sensitivity is an important variable in converting voltage to pascals and determining an adjustment factor; however, it may not be possible to isolate that value from the gain settings. The comingling of issues raised the level of uncertainty, but these nondeterminate issues will be circumscribed during the modeling step.

Another issue that occurred in the field was the occasional failure of the GPS devices on the buoys. Although a non-acoustic issue, these failures impacted the determination of the signal level relative to the passing sound source. The manufacturer’s settings on the hydrophones were assumed to be accurate, but without using a monitoring hydrophone for each source, there was no way to verify the hydrophone sensitivities for every buoy *in situ*. Ultimately, errors in buoy location affect the comparison of acoustic modeling versus measurements and increase the uncertainty. A higher than expected received sound level at any hydrophone on a buoy could be a result of incorrect gain settings (too high), incorrectly documented sensitivity of the hydrophone, and/or the unknown location of the recording buoy’s distance from the sound source. Although it would be ideal to use increments of ± 10 dB to determine adjustment

factors to ± 50 dB, it was found that increments of ± 5 dB better captured the combinations of gain, sensitivity, and location errors. Parsing out the position error versus the gain and sensitivity errors of each hydrophone was a challenging goal of this project.

2.1 Data Adjustment Interpretation

The objective of this chapter is to assign adjustment factors to each acoustically recorded HRG source mode at each of the five field test sites. To achieve this objective, stepwise efforts included 1) using model and inter-buoy comparisons to visually determine the necessity and amount of an adjustment factor, which is required to compensate for the combination of sensitivity and gain errors; and 2) using plotted models of the SEL fall-off with range and a cost function to determine buoy location. The results of these two steps were combined to generate the final received level adjustment factors needed to progress to the model-data comparison task of this project. The low-frequency (LF) and mid-frequency (MF) source calibration methods were the same. The HF source calibration methods did not follow LF and MF methods, but rather capitalized on the results.

Most buoys remained in their original positions; however, a storm occurred at Site 3 and there were strong currents that moved buoys at Site 5. These shifts were recognized and incorporated into buoy positions. Buoy positions were estimated using 1) GPS when available, 2) dead reckoning derived from buoy deployment/recovery positions, and 3) estimations from acoustic inversion when the data were available (i.e., position D was available for localization) (Halvorsen and Heaney, 2018).

There were outlying data that resulted in noise that are not true acoustic data (**Figure 2-1**). This noise was removed from analysis, but it sometimes was included in graphical representation so the reader could better understand the uncertainty and/or limitations of the measurement systems and field scenarios.

Figure 2-1 shows examples of acoustic data and noise within plots of SEL versus range. These data usually are shown by buoy-specific colors, but in these examples, noise is shown as red dots. The top graph shows a band of good data (black dots) and a lot of noise surrounding them. In the bottom graph, when data points flatten out, that data are in the noise floor. In other words, received levels of the sound sources were low enough to reach the noise floor of the system, so the system could no longer record the quieter received levels. As stated previously, the noise was filtered out of further modeling and processing steps.

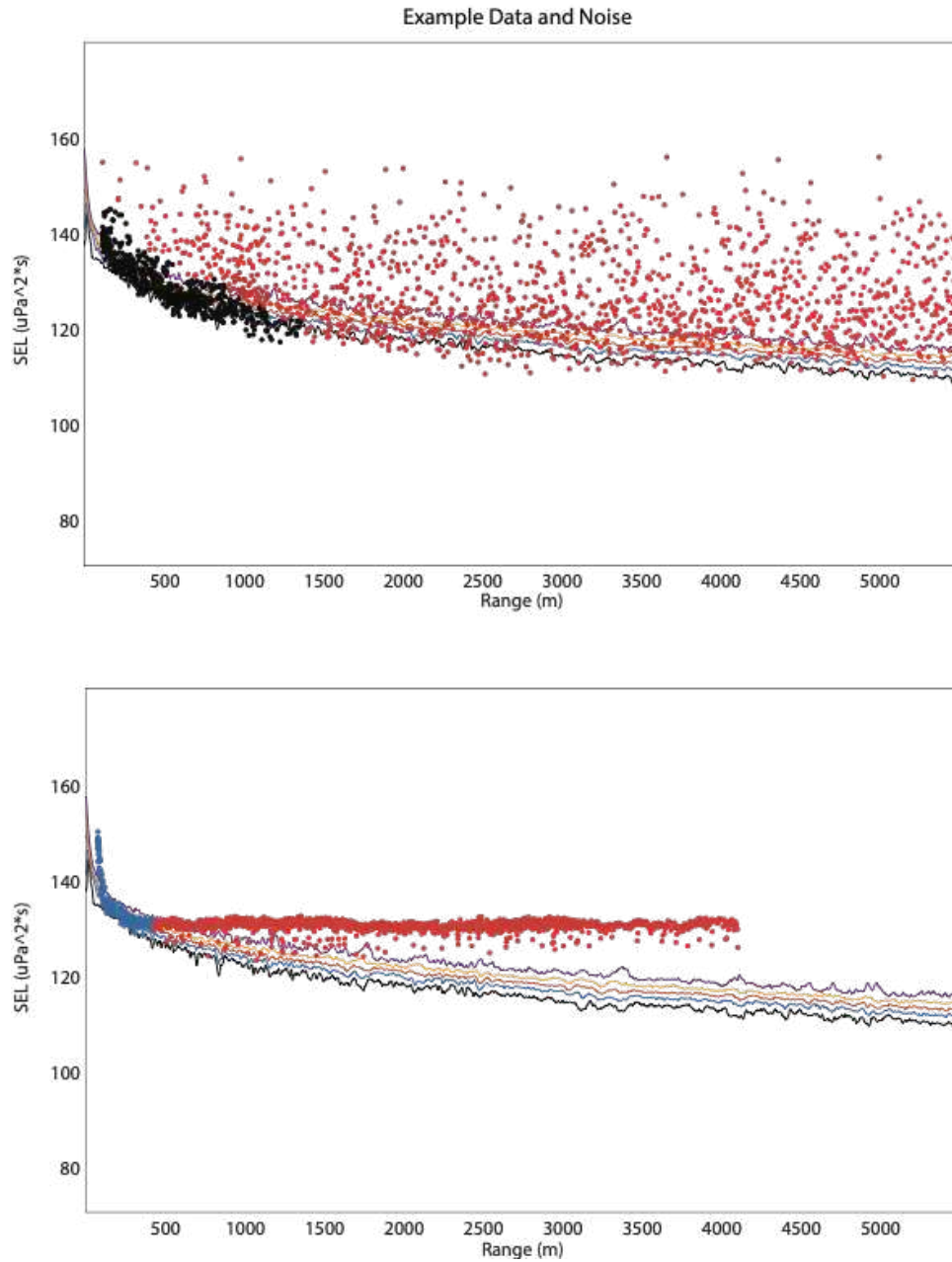


Figure 2-1. Examples of data and noise on buoys

Modeled (lines) versus measured data (dots) for a source. Top: Buoy with acoustic data (black dots) and noise (red dots). Bottom: Buoy with acoustic data (blue dots) and noise (red dots). The noise is within the noise floor and is identifiable by its flat presentation (i.e., there is no fall-off with range). The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental variability (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black).

2.2 Low-Frequency Sound Source Adjustment Factor Methods – Parabolic Equation, Percentiles, and GPS Cost Functions

LF sources had acoustic energy below 10 kHz. Custom bash and C scripts for each hydrophone systematically created plots to search for the errors mentioned in **Section 1.3**. This process was performed on each buoy during each run for every sound source at every site. The primary mechanism for determining adjustment factors on the acoustic measurements was inter-buoy comparison paired with the plots of SEL as a function of range at each site. The PE was the algorithm of choice to make these SEL versus range plots (**Section 3.1**). The most appropriate buoy position to compare *in situ* measurements with the PE model was at the closest point of approach (CPA) between the boat and sound source.

The spectral shape of each source was generated from the CPA measurement position data to calculate the signal's SEL. The SEL then was adjusted to match the NUWC's SL observations at 1-m measurement range (Crocker and Fratantonio, 2016). Environmental inputs to the PE included a summer sound speed profile (SSP) for the water column depths at each of the five sites (10 m for Sites 1 and 2, 30 m for Sites 3 and 4, and 100 m for Site 5), a flat seafloor (based on minimal signal propagation to 4 km), and appropriate grain sizes for each site. The appropriate grain sizes in phi (ϕ), based on the Wentworth chart, included 5 ϕ for mud (Sites 1 and 3), 3 ϕ for sandy silt (Site 5), and 1 ϕ for sand (Sites 2 and 4). For the PE model, a point source (for the LF sources) was positioned at 3 m depth. The acoustic propagation modeling also included uncertainty, particularly for sediment type (over a small range), source depth, and hydrophone position in both range and depth. The percentiles (5th, 25th, 50th, 75th, and 95th) were a visual way to depict this uncertainty in modeled SEL versus range. Thus, percentiles were computed 1) across hydrophone depth, from the surface to the seafloor; 2) at 20 m of range closer to or farther from the source; and 3) for sediment grain sizes $\pm 1 \phi$ to capture an expected amount of environmental variation. The percentiles were plotted and overlaid with the received SEL measurements (**Figure 2-2**). If a measurement was within the percentiles of expected error (uncertainty), it was scored as acceptable (i.e., no adjustment factor was needed). However, if the measurement was beyond the percentiles of expected error, it was scored as an error that needed an adjustment factor in gain, sensitivity, and/or position.

Figure 2-2 shows measured SEL data (dots) and the PE-modeled SEL percentiles (lines) that capture the uncertainty of the modeled sound field for the Mini Sparker (Mode 28) source at Site 3 (for each hydrophone, run 30, Deployment 3). The measured SEL data are from the Phase II analysis. Initial visual examination showed three buoys' data had very good agreement with the model: Buoy 11 (red; position B), Buoy 8 (yellow; position E), and Buoy 10 (yellow; position E), while three buoys showed poor agreement: Buoy 12 (black; position A), Buoy 6 (blue; position D), and Buoy 9 (purple; position F).

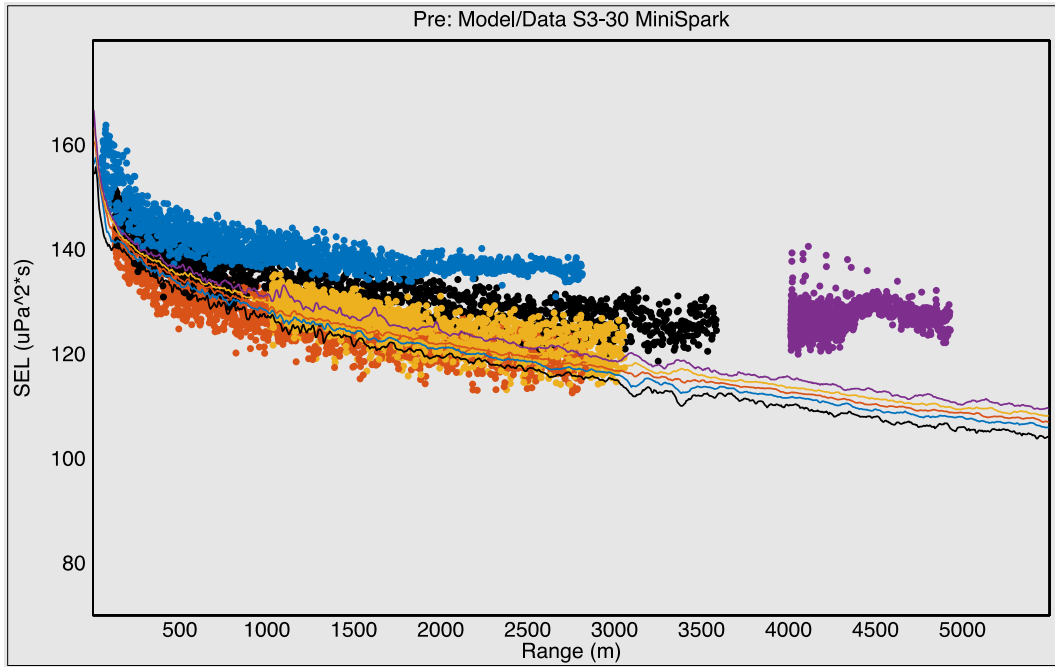


Figure 2-2. Modeled (lines) versus measured data (dots) for Mini Sparker, Mode 28, at Site 3, Deployment 3, Run 30

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental variability (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for six buoys (Buoy 6, blue; Buoys 8 and 10, yellow; Buoy 9, purple; Buoy 11, red; Buoy 12, black). Divergence of Buoys 6, 9, and 12 from the percentile range is visible.

Buoy 12 was 10 to 20 dB higher than Buoys 8, 10, and 11 as well as the model. Buoy 9, the farthest position, was more than 20 dB higher. Based on the consistency between the model results and the measurements for buoys at closer ranges, it is unlikely that the model was off by 10 to -20 dB beyond 1,000 m. Therefore, it was determined that Buoys 6, 9, and 12 required adjustment factors.

Buoy 6 was at position D, which had a CPA when the sound source passed directly over the hydrophone. As mentioned earlier, the hydrophone at the CPA is an important position to consider when assigning an adjustment factor. However, this buoy's data did not match the model at farther ranges. Beyond 500 m, the measured data amplitudes from Buoy 6 were too high relative to the model. In this example, as the Mini Sparker moved away from Buoy 6, the hydrophone did not record the lower-level signals and the signal-to-noise ratio (SNR) was poor. When considering the levels at only the short ranges, the data were still 10 dB higher than expected. Therefore, a -10 dB adjustment factor was applied, which is reflective of all the errors (recorder and hydrophone gain setting). The final observation regarding the Buoy 6 data was that the closing and opening of the ship (approaching and moving away from the receiver, respectively) had different received levels. Between 0 and 200 m, two clouds of blue dots, or two values at each range (one closing, one opening), existed when the expectation was for there to be matching values between opening and closing. The source signal was expected to be the same in azimuth; therefore, this difference indicated an error in the buoy's GPS location. When the buoy was not in its expected position, plotting received levels versus range illuminated those errors.

Figure 2-2 illustrates the confounding effect that navigation and settings errors had on the data, and there is inherent redundancy and overlap between the errors. It was difficult to determine if the issues lied in received levels (e.g., data were 10 dB too high), buoy position (e.g., if the receiver should be 200 m closer), or some combination of the two, because either justification would be equivalent for applying an adjustment factor of -10 dB. The primary evidence that disambiguated the gain and buoy position errors was the fall-off of the SEL slope with range. SEL plots and cost function plots (**Figures 2-2 and 2-3**) showing the most likely GPS position shift were investigated side by side for each buoy as a visualization tool.

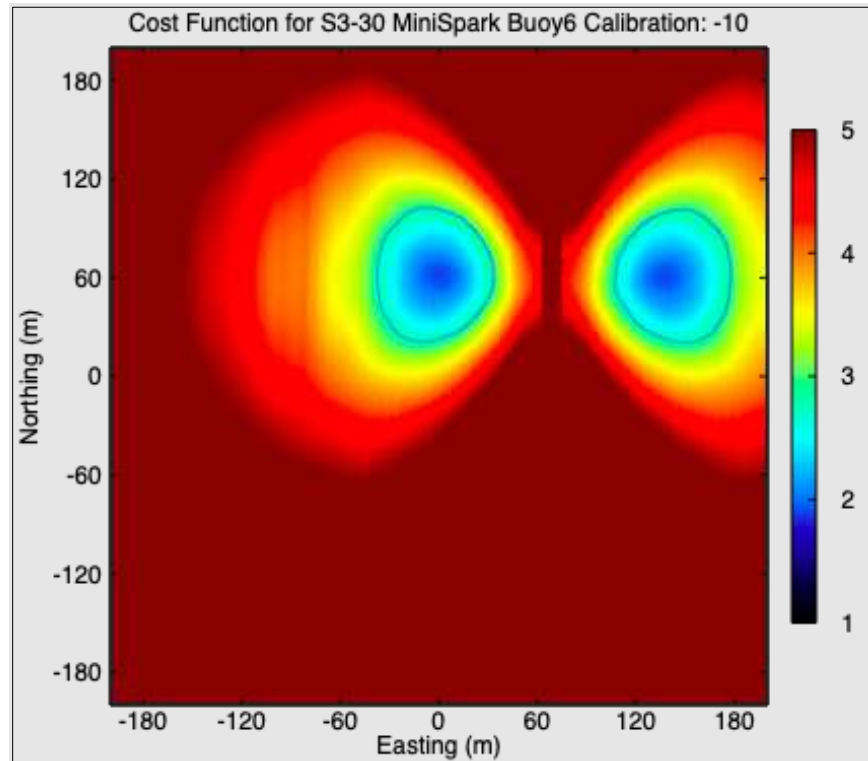


Figure 2-3. Example cost function for Mini Sparker, Mode 28, at Site 3, Deployment 3, Buoy 6, Run 30

Results indicate the root-mean-square-error between the model/data sound exposure level as a function of position after a -10 dB adjustment factor was applied. Depicted as meters in error to the north (vertical axis) and to the east (horizontal axis). Left-right ambiguity is expected for omnidirectional sources like the Mini Sparker.

Cost function plots (**Figure 2-3**) were made with an optimization search algorithm over a 400×400 m area centered on the expected GPS position. Within the grid, the measured SEL versus range in each 1×1 m cell was computed via a look-up table generated by the modeled SEL. The same 1×1 m cell was created for modeled SEL data and compared to the measured SEL data. This dual comparison of the measured and modeled SEL resulted in a cost function across the grid space that is the root-mean-square-error (RMSE) in decibels between the measured and modeled SEL for a given buoy position. The global minimum of the cost function (the best position match of the model and data based on that grid cell's lowest RMSE value) provided the best shift across latitude and/or longitude needed to adjust the buoy position for a given data set and applied adjustment gain factors.

A blue contour line at 1 dB RMSE above the global minimum was overlaid on the plot to illustrate relative uncertainty in range (meters) inherent to the cost function’s optimization search. A 1dB RMSE contour line 200 m wide has high positional uncertainty from east to west, while a 1dB RMSE contour line 10 m high would be interpreted as low uncertainty from north to south. For example, if a cost function plot (e.g., in **Figure 2-3**) had a 1-dB RMSE contour line of approximately 20 m in all directions from its global minimum, then confidence would be high in the location results across all bearings.

In the Mini Sparker cost function at Site 3 for Buoy 6, Deployment 3, run 30 (**Figure 2-4**), there was a well-defined minimum RMSE of approximately 1.5 dB at 60 m north and 0 m west of the original GPS location. There was ambiguity as to which side of the ship’s track line the source was on, but this was expected because of symmetry. The interpretation of **Figure 2-3** was the position that best matched the data’s SEL fall-off with range was 60 m north of the expected position, which was about a 2-dB difference and within the range of expected environmental error. Therefore, adjusting the buoy’s position was deemed unnecessary.

A model-data comparison plot of the Buoy 6 results before and after a -10 dB adjustment factor (and no buoy location adjustment) was applied and verified that -10 dB was the best possible adjustment factor (**Figure 2-4**). In **Figure 2-4**, the model is shown by the blue line, the pre-adjusted data are yellow dots, and the adjusted data are black dots. The pre-adjusted data were higher amplitude than the model, indicating an error in the received levels. The two separate clouds of yellow dots were a result of the approaching and receding source transits being different, an indication of GPS position error. The black dots are the adjusted data that included the navigation optimization algorithm, which removed the spread between the two clouds of dots, thus correcting for the difference in approaching and receding source transits.

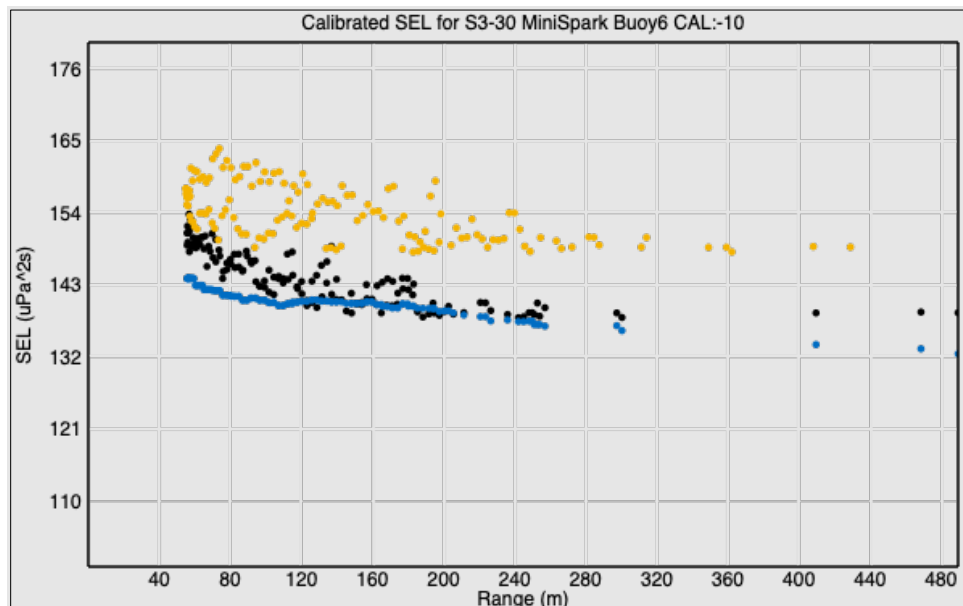


Figure 2-4. The modeled data for Mini Sparker (blue line), Mode 28, at Site 3, Deployment 3, Buoy 6, Run 30

Pre-adjusted (yellow dots) and adjusted (black dots) data with a -10 dB adjustment and buoy position shift of 60 m to the south.

Unfortunately, data from the other buoys were not as straightforward to resolve as the example provided by the closest buoy (Buoy 6). The recorded data from buoys farther from the sound source track line (**Figure 2-2**) were explored, but position estimation was more difficult. For example, Buoys 10 and 8 (both at position E) did not require gain adjustment factors, but they did need buoy location adjustments to align the data with the CPA range (**Figures 2-5** and **2-6**). The cost functions for these two buoy positions were vague because they had a high RMSE value and wide 1-dB contours relative to Buoy 6.

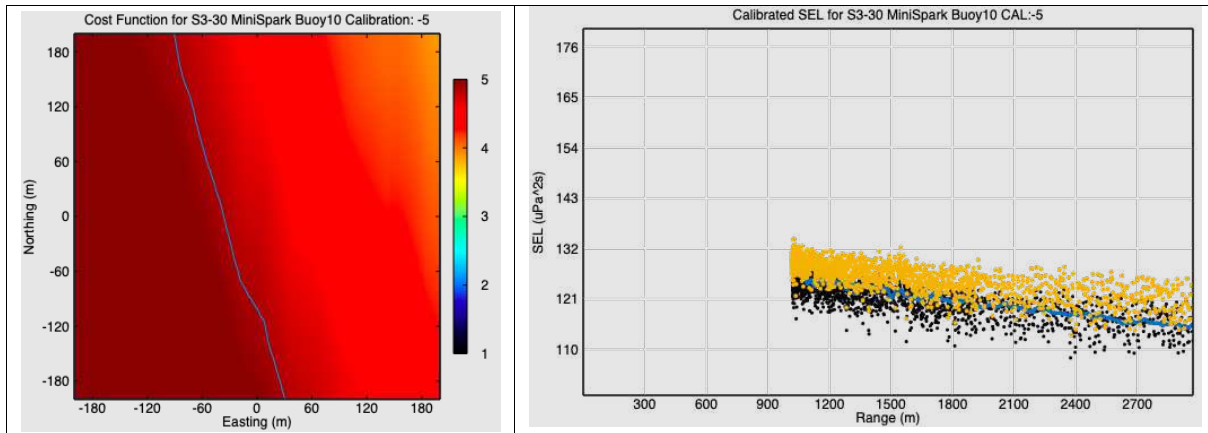


Figure 2-5. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 28, at Site 3, Deployment 3, Buoy 10, Run 30

Left: Buoy positional shift to the northeast. Right: Adjustment of the pre-adjusted data (yellow dots) to align the adjusted data (black dots) with the model (blue dots).

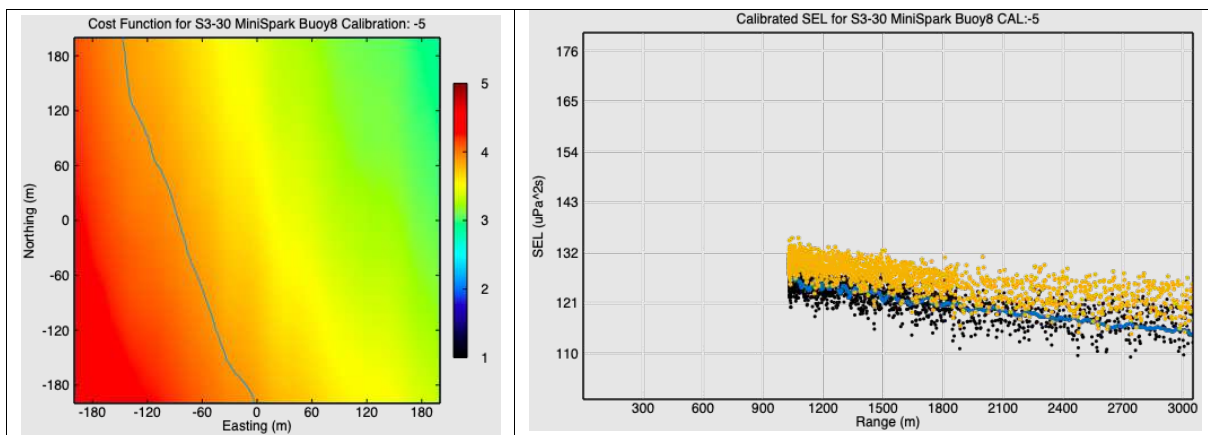


Figure 2-6. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 28, at Site 3, Deployment 3, Buoy 8, Run 30

Left: Buoy 8 was co-located with Buoy 10 and shows buoy positional shift to the northeast. Right: Adjustment of the pre-adjusted data (yellow dots) and alignment of the adjusted data (black dots) with the model (blue dots). The co-localization of buoys provided a check to the determined shift.

In the most extreme cases, the cost function failed to provide insight into navigation errors. For example, the Mini Sparker, Mode 28, Buoy 9, position F, at Site 3 for Deployment 3, run 30, showed poor (low RMSE) buoy position shift, likely because it was 4 km away from the sound source CPA (**Figure 2-7**). However, the measured data (yellow dots) had an error shown by being approximately 20 dB higher than

the model (blue dots; **Figure 2-7**). In this case, applying a -20 dB adjustment factor to the data (black dots) made it match the model because position error in the cost function was too high to glean valuable information.

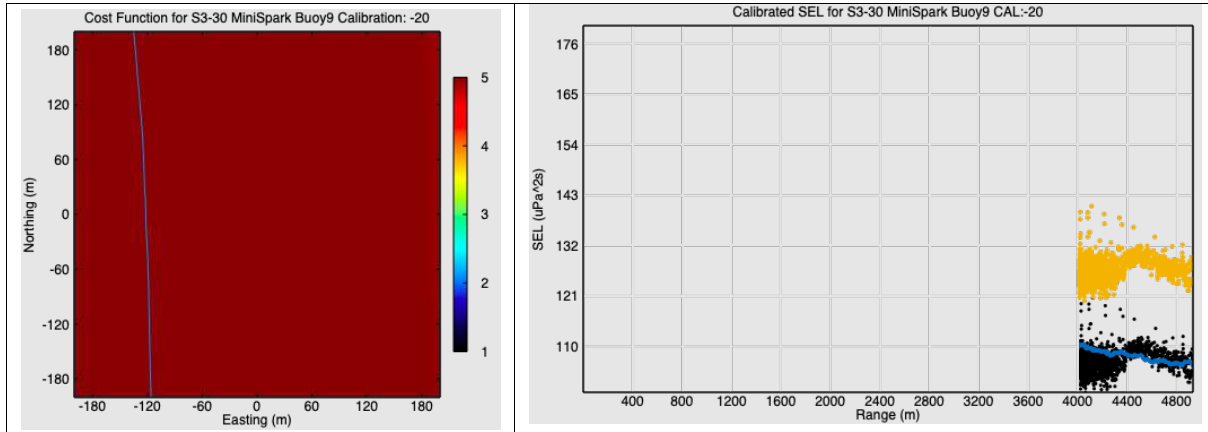


Figure 2-7. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 28, at Site 3, Deployment 3, Buoy 9, Run 30

Left: A cost function with no visible information for a buoy positional shift. The cost function root-mean-square error had a minimum of 4.91 dB (red in the color bar) at a 200-m east and north shift in position. Right: A -20 dB adjustment was applied to the pre-adjusted data (yellow dots), which mostly aligned the adjusted data (black dots) with the model (blue dots).

Buoy 11, position E, had a source receiver range extent from 200 m to 3,000 km, which provided robust information about the buoy position. The pre-adjustment data were a good model/data match (**Figure 2-8**). The cost function minimum was near 3 dB approximately 100 m north but difficult to determine from east to west. This cost function’s 1-dB contour was more than 100 m, making it highly uncertain and not trustworthy enough to warrant a GPS change.

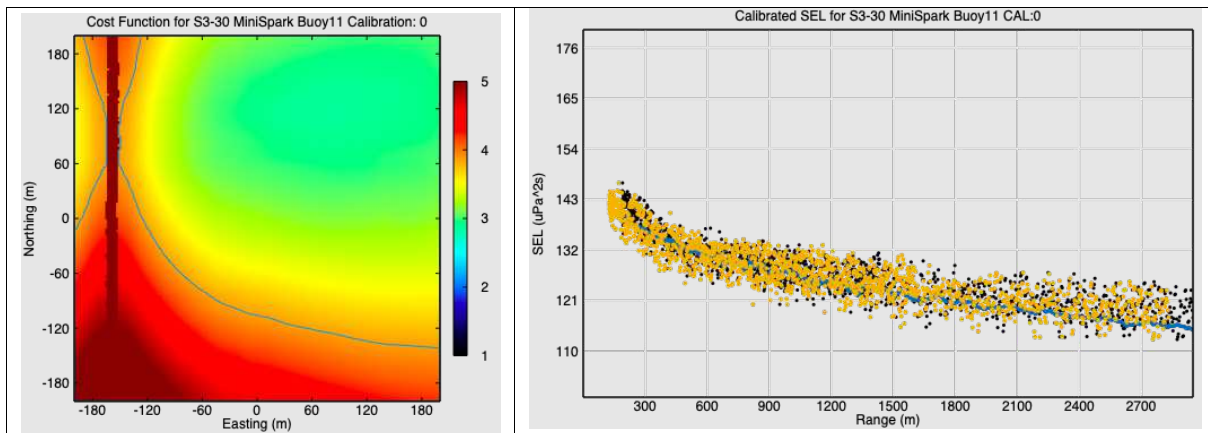


Figure 2-8. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 28, at Site 3, Deployment 3, Buoy 11, Run 30

Left: A broad cost function root-mean-square error minimum at 100 m north and 60 m east. The dark red line is the ship track. Right: No adjustment factor was applied to the pre-adjusted data (yellow dots); the adjusted data (black dots) are in alignment with the model (blue dots).

The Mini Sparker, Mode 28, Buoy 12, position E, at Site 3, Deployment 3, run 30, had a source receiver range extent from 200 m to 3,000 km, which provided robust information about the buoy position. An adjustment factor of -10 dB was required to match the Buoy 12 data to the model (**Figure 2-9**). The cost function had a minimum, but it was broadly eastward with a value greater than 4 dB RMSE, illustrating there was not much information in the position to provide a good estimate of the buoy position adjustment. The model/data comparison is shown in the right panel of **Figure 2-9**. Both the levels and the fall-off with range were well matched in the inversion.

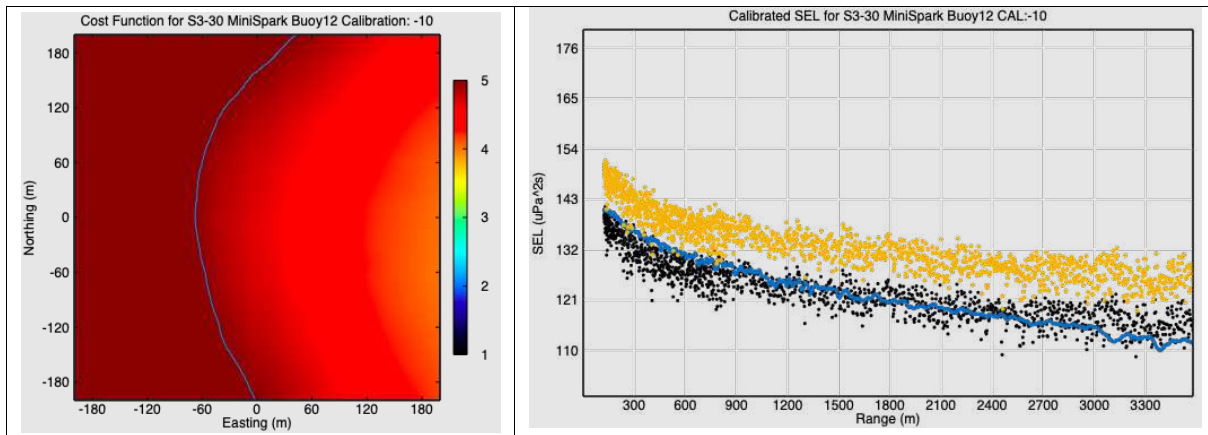


Figure 2-9. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 28, at Site 3, Deployment 3, Buoy 12, Run 30

Left: A cost function root-mean-square error of >4 dB for an eastward shift. Right: To help correct the pre-adjusted data (yellow dots), a -10 dB adjustment factor was applied to generate the adjusted data (black dots), which align with the model (blue dots).

After applying the gain adjustment factors and navigational buoy shifts to the pre-adjusted data of the six buoys, the adjusted data were plotted together (**Figure 2-10**). The results verify that the adjusted data fit within the expected model uncertainty (percentile range). The agreement between the adjusted measured and modeled SEL shows that although the data needed adjustments (there were three buoys with 0 dB adjustment factors), the fall-off of SEL with range was well matched by the model. Note that Buoy 6 data (blue) were filtered to include only signals above a certain threshold (140 dB) to eliminate SNR errors. The resulting adjustment factors, location shifts, 1-dB contour distances, and RMSE decibel values are presented in **Appendix A.1**, Table A.1-1.

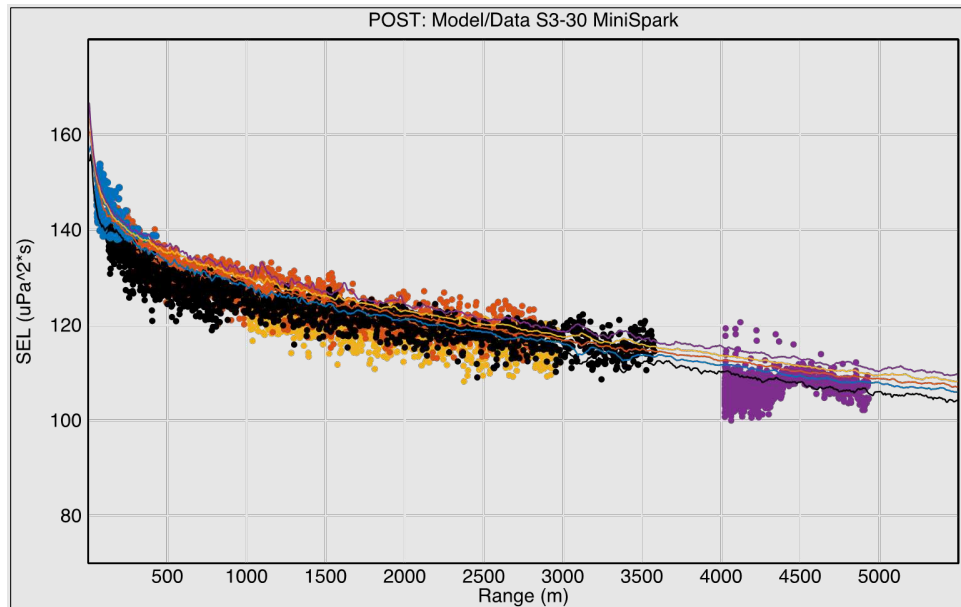


Figure 2-10. Adjusted data for Mini Sparker, Mode 28, at Site 3, Deployment 3, Run 30
Six buoys (dots)—Buoys 6 and 10, blue; Buoy 8, yellow; Buoy 9, black; Buoy 11, red; and Buoy 12, black—plotted over the percentiles of expected errors (lines) from environmental influence to visually verify that applied adjustment factors were accurate and effective.

Simultaneous gain and navigation adjustments were applied and presented for every run at every site for LF omnidirectional sources, which were expected to be the least challenging sources for which to determine adjustment factors (Modes 28 to 41). Methodology to determine adjustment factors for the MF and HF sources are addressed in **Sections 2.3** and **2.4**, respectively. Final adjustment factors and average buoy position shifts are provided in **Appendix A.1**, Table A.1-1.

2.3 Mid-Frequency Sound Source Adjustment Factor Methods – Parabolic Equation, Percentiles, and Extrapolated GPS Positions

MF sources had acoustic energy between 0.5 and 24 kHz. Custom bash and C scripts systematically created plots for determination of adjustment factors following the same methodology of matching data to modeled uncertainty percentiles as the calibration of the LF sources. The plots were created for each hydrophone on each buoy during each run for every MF sound source at every site. One difference existed between the LF and MF methods. To determine LF adjustment factors, all *in situ* data were adjusted to match the entire SEL fall-off with range contour using a point-source model. This meant data from the CPA and data out to 5 km from the LF sound source were used to determine the adjustment factors. However, to determine MF adjustment factors, only the *in situ* data from the CPA were used because the MF sound sources are directional by nature and there was a high possibility that the recording captured only the in-beam signals. Therefore, the reliable data are from as close to the receiver as possible (i.e., the CPA). To explain further, data received from greater distances capture energy that likely is outside the main lobe of the directional beamform signal, which would provide unreliable information. Therefore, to avoid using data from a side lobe of the signal beam, data were only considered from the CPA. The received signals at the CPA presumably were most representative of the levels transmitted on-axis from a directional MF transducer. It also was assumed that received signals from greater distances

likely were outside the main lobe of the beam pattern and, therefore, too unreliable to compare against the SEL fall-off with range contour plotted in the model. The buoy-by-buoy methods from the LF calibration section will not be repeated here because the methodology was the same. Furthermore, a summary of the adjustment factors per deployment is provided in in **Appendix A.2**, Table A.2-1.

The GPS position determination was similar to the LF methods. If an LF source was tested during the same run as an MF source, then the LF GPS position adjustment was applied to the MF source. This extrapolation of LF GPS positions to concurrent MF positions was needed because MF sources are naturally more directional; thus, the LF GPS cost functions were more reliable. However, if an MF source occurred during a run when no LF sources were tested, then the same GPS cost function method was used to determine a more accurate position of the MF buoy. Final adjustment factors and average buoy position shifts are provided in **Appendix A.2**, Table A.2-1.

2.4 High-Frequency Sound Source Adjustment Factor Methods – Extrapolating Low- and Mid-Frequency Results

HF sources had acoustic energy above 38 kHz, and are highly directional, more so than MF sources. Therefore, data at the CPA were less likely to be sufficient to apply adjustment factors to HF sources, particularly for distant buoys. For most deployments, several LF and MF adjustment factors were used to extrapolate HF adjustment factors. In a few cases, LF and/or MF sources were tested during the same run as HF sources. HF adjustment factors, therefore, were determined by applying the same adjustment factor that occurred most often (mode) or on average (median) for LF and MF sources during the same run (when possible) or deployment at the same site. The statistical mode and median were calculated instead of mean because these represented not only the most common adjustment factor but also eliminated any sources that had extremely different and/or potentially false positive signal adjustments. If mode and median adjustment factor values were not the same, preference was given to adjustment factors that were 10-dB intervals over 5-dB intervals because the logging pad error interval was 10 dB.

HF GPS position shifts for each buoy were calculated from the average location shift of the same buoy for LF and MF sources during the same deployment at the same site. The statistical mean was used instead of the median and mode because distance was a continuous variable instead of a categorical variable (i.e., there were no interval requirements, like the 5- or 10-dB adjustment factor intervals).

Calculating modes and medians for HF adjustment factors, instead of comparing data to the model, meant there were no model (blue) lines plotted in the adjustment factor figures as there were for the LF and MF sources. Rather, the HF figures are plots of pre-adjusted (yellow) and adjusted (black) data over range. Also, no cost functions were calculated and, therefore, are not included in the HF adjustment figures. Final adjustment factors and average buoy position shifts are provided in **Appendix A.3**, Table A.3-1.

2.5 Summary of Data Adjustment

In the LF data adjustment task, the contour of the sound level with range was used to add adjustment factors to the measurement data. In several instances, there was insufficient contouring. In those cases, only the peak received level at the CPA was used to apply an adjustment. When the contour was

insufficient, no improved model incorporating environmental uncertainty and/or a starter field would have gleaned additional information. When the contour was sufficient, additional information was obtained using non-point source modeling and/or a more complex environmental uncertainty model. Data are presented by deployment and site.

In the MF data adjustment task, only the peak received sound level at the CPA was used to add adjustment factors to the measurement data because of the directionality of MF sources. Data are presented by deployment and site.

In the HF data adjustment task, the medians or (sometimes) modes of adjustment factors from LF and MF runs during the same deployment at the same site were used to adjust the HF measurement data. This was more fully described in **Section 2.4**. Because HF sources are highly directional, this adjustment factor was only applied to the CPA and not the contour of any of the data when compared to the models.

One difference existed for adjustment factors in the custom bash and C scripts for LF and MF sources. For LF sources, all *in situ* data were adjusted to match the entire SEL fall-off with range contour using a point-source model. For MF adjustment factors, only *in situ* data from the CPA were used as received signals at the CPA were assumed to be most representative of the levels transmitted on-axis from a directional transducer. It also was assumed that received signals from farther distances likely were outside the main lobe of the beam pattern and too unreliable to compare against the SEL fall-off with range contour plotted in the model. HF sources were too directional to replicate the MF calibration methods; thus, the median adjustment factors from LF and MF sources from the same deployment were used.

Data Adjustment Procedures

In summary, the following procedure was established to estimate the adjustment factor (per buoy) needed to address the combined gain and GPS errors. LF methods served as the basis for this summary. Any changes for MF-specific methods are in *italics*, and HF-specific methods are in **bold**.

1. Plot all pre-adjusted data over the environmental error (uncertainty) percentiles.
2. Select a buoy with measured data outside the expected modeled SEL variability and assign an adjustment factor in intervals of ± 5 dB that would most likely close the gap between the data and model.
 - a. *Only use buoys with measured data at the CPA that were outside the expected modeled SEL variability at the CPA for MF sources.*
 - b. **Skip to Step 4 for HF sources.**
3. Identify and filter out the SNR.
4. Using adjusted data (from Step 2), apply the optimization search algorithm (i.e., the GPS cost function) to compute the most likely distances and direction the buoy should be shifted for the data to align with the model. Estimate the average radius from the global minimum of the cost function to the 1-dB contour to determine how much relative uncertainty is present.
5. Document the adjustment factor, latitudinal or longitudinal position shifts, and average 1-dB radius in a table and move onto the next buoy.
 - a. **Use the documented adjustment factors for LF and MF sources to calculate the median and mode adjustment factors.**
 - i. **When median and mode are the same, document this value as the HF adjustment factor for all sources at the same deployment.**

- ii. **When median and mode are not the same, use the most common value in 10-dB increments for the HF adjustment factors for all sources at the same deployment.**
 - b. *Use the documented GPS position shifts to calculate average latitudinal and longitudinal shifts at each buoy position per deployment and use the means as the values for MF and HF buoy position shifts at the same deployment.*
6. After all buoys are complete, replot data with all applied gain adjustment factors and positional buoy shifts to ensure all adjusted measured data match the model.
- a. *Ensure all adjusted measured data at the CPA match the model at the CPA for MF sources.*
 - b. **Only replot the data for HF sources to illustrate the adjustment factors.**

Thirteen LF sources and their results plots, one from each of the 12 deployments, were adjusted following this methodology and displayed as examples per deployment. For the 12 MF sources, adjustment factor determinations were only at the CPA; thus, plots document each buoy before and after the adjustment factors were applied. Fifteen HF sources were adjusted following this methodology, one from each of the 12 deployments, and their results plots are presented in **Appendix A.3** as examples per deployment. Results tables in **Appendix A** for all sources: LF sources (Table A.1-1), MF sources (Table A.2-1), and HF sources (Table A.3-1) list the adjustment factors for every buoy, run, and mode at each site, as outlined in **Figure 2-11** from the Phase II report (Halvorsen and Heaney, 2018).

Table 3.0-1. Compilation of HRG data acquisition status identified by buoy number and buoy position for each site.

	Buoy Position in the Acoustic Field Array									
	A-HS	A-LS	B-HS	B-LS	C-HS	C-LS	D-LS	E-HS	E-LS	F-HS
Site 1										
Deployment 1		11		12			6	5	8	9
Site 2										
Deployment 1	12			11			6	10		9
Deployment 2	8		5	11			6	10	12	9
Site 3										
Deployment 1	9	11	5	12			8	10	7	6
Deployment 2		5		12			8		7	6
Deployment 3	12		7	11			6	10	8	9
Site 4										
Deployment 1	6	6	7	7	5	5	8	9	9	11
Deployment 2	6	6	7	7			8	9	9	11
Deployment 3		7		12			8	6		5
Site 5										
Deployment 1		12	5	11			6	9	8	10
Deployment 2		12	5	11			6	9	8	10
Deployment 3		12		11			6	9	8	10

HRG = high-resolution geophysical; HS = high-sensitivity hydrophone; LS = low-sensitivity hydrophone.
 Green = buoy deployed, acoustic data recorded; red = buoy deployed, but no data recorded; gray = no buoy deployed; numbers (5-12) inside cells = buoy number.
 Note: D-HS and F-LS hydrophones were not included during any testing.

Figure 2-11. Table of deployments at each site from the Phase II report
 From: (Halvorsen and Heaney, 2018)

3 Acoustic Modeling Methodologies

The goal of this modeling task was to determine the acoustic propagation models, supporting databases, and other model inputs (e.g., source characteristics) capable of reasonably modeling HRG sources in shallow water (i.e., less than 200 m deep) and then recommend which inputs to use.

The skill of each acoustic propagation model is documented to produce reasonable values of the acoustic metrics SEL, peak sound pressure level (L_{pk}), and root-mean-square sound pressure level (L_{rms}) based on the Phase II open-water field measurements. A combination of data calibration and model uncertainty analysis was performed due to challenges with the experiment as well as unknowns in the field test environment and ranges/depths. Following the demonstration of acoustic propagation modeling skill, a compiled reference of the acoustic metric levels is provided within five shallow-water environments for the LF omnidirectional HRG sources. To determine the metric levels—including addressing the effects of SL, frequency and bandwidth, vertical and horizontal directionality, and propagation—modeling results were compared to a select set of high-quality measured data across the set of HRG sources.

This chapter outlines the acoustic modeling methodology used. Different modeling was performed for LF and MF sources than for HF sources. For each LF sound source at each site, a set of LF models (SEL, L_{pk} , and L_{rms}) with range were generated for a single slice 90° from the vessel (the CPA of the main lobe of the sound source's beamform to the buoy array) compared with observations of *in situ* data, when available. For LF sources, *in situ* data were compared across the entire model range. For MF sources, *in situ* data were compared only at the CPA. The LF plan-view figures were cylindrically symmetrical because they were the single 90° slice rotated 360° around the sound source location. Plan-view figures display how sound could spread from each sound source given each site's environmental parameters. The HF source plan views are not cylindrically symmetrical because the HF sources are highly directional and faced downward at the seafloor. The broad side (90° from the direction of travel) of the plan views depicts the most intense part of the signal compared to other bearings around the ship.

Environmental inputs included a summer SSP for the water column depths at each of the five test sites (10 m for Sites 1 and 2, 30 m for Sites 3 and 4, and 100 m for Site 5), a flat seafloor (based on minimal signal propagation to 4 km), and appropriate grain sizes for each site. The grain sizes included 5 ϕ for mud (Sites 1 and 3), 4 ϕ for sandy silt (Site 5), and 1 ϕ for sand (Sites 2 and 4).

For the model, a point source was positioned 2 ± 0.5 m below the water, a range that captured the general movement of the sources while being towed. If the source was not being towed or its attachment to the vessel was differently documented, the depth of the source was adjusted in the model to replicate the documentation as closely as possible. Acoustic propagation modeling was performed to include effects of uncertainty in sediment type (over a small range) and receiving hydrophone position for both range and depth. Percentiles (5th, 20th, 35th, 50th, 65th, 80th, and 95th) were computed 1) across hydrophone depths, from the surface to the seafloor; 2) at 20 m of range closer to or farther from the source; and 3) for sediment grain sizes $\pm 1 \phi$ to capture an expected amount of environmental variation. The percentiles were plotted and overlaid with received acoustic metric measurements. Lines for cylindrical and spherical spreading were overlaid to illustrate how these commonly used transmission loss models compared to the PE percentiles used for this project. Additional modeling parameters necessary to consider for MF sources involved directionality.

3.1 Parabolic Equation Propagation Model

There are several options for modeling sound in shallow water, including ray tracing, normal modes, and the PE. For efficiency and to handle seafloor interaction and range dependence, the PE is the model of choice for LF and MF propagation modeling. The PE model solves the wave equation using a paraxial approximation. This modeling approach is computationally efficient and can address range-dependent environments. The computational time of the PE model increases linearly with water depth and frequency squared; therefore, the PE often is avoided for HF modeling in deep water. The PE model is the industry standard for full-wave propagation of LF sound (usually up to 1 kHz). Within the acoustics community, the primary PE model used is the RAM, developed by Collins (1993, 1996). PE models are limited in vertical angle support, limiting their utility where steep angles prevail (e.g., at ranges less than the water depth).

A full-wave RAM was needed that could efficiently handle 10 to 20,000 Hz in shallow water (<110 m) at high-resolution range stepping (meters). For this project, the PE model was able to address propagation within the sediment, range-dependent bathymetry, high-angle support, and frequency range. Specifically, a refined version of RAM named Peregrine (Heaney and Campbell, 2013) has increased efficiency. Major improvements in Peregrine include increased processing speed and efficiency in the environmental databases, enabling rapid computation of the sound field as a function of 3D position around a single point source. Peregrine also can accommodate frequencies up to 20 kHz using the PE model, applying a scaling of the frequency-dependent volume attenuation. Peregrine is written in a C-language version of RAM called Seahawk, which computes the acoustic field and subsequent acoustic metrics (SEL, L_{pk} , and L_{rms}). The combination of shallow water (only Site 5 was deep at 100 m, and there were no HF sources operated at Site 5) and moderately short-range measurements made this modeling approach feasible. The PE also is well suited to sources with vertical directivity and a custom field starter.

To generate model results for L_{pk} and L_{rms} , the received time-series signal had to be computed. The PE provided a frequency domain solution, which had to be converted to a time series by running a broad band of frequencies and then performing an inverse fast Fourier transform (IFFT) on the complex pressure to generate a real time series. For each site (and ensemble member, looping over source depth and sediment type), the complex pressure was computed in decidecade bands for each band from 5 Hz to 9 kHz at a 2 Hz spacing. For a given source, the decidecade bands were converted to a time series (via the IFFT), the decidecade band SL (from the NUWC report by Crocker and Fratantonio [2016] and manufacturer specifications in absence of NUWC measurements) was added, and the time series were summed across bands. This produced a received time series in micropascals (μPa), which could be processed for SEL, L_{pk} , and L_{rms} . The MF modeling had two differences: 1) vertical directionality was incorporated into the starter field; and 2) horizontal shading was applied to the plan-view, model-only figures.

3.1.1 Starter Field Methodology

A starter field is a mathematical function that represents the acoustic field at 1 m, or sometimes closer, from a sound source. The starter field is an input to the PE and is propagated outward in space to determine how far acoustic energy is expected to travel through the water column. For LF omnidirectional sources, custom starter fields are not needed because the pressure is the same at all angles from the source. In addition, omnidirectional sources can be modeled as a point source, which commonly is

referred to as a Green's starter field (Green, 1984; Collins, 1993). For each MF source, the measured directivity patterns from Crocker and Fratantonio (2016) were used to estimate an equivalent source field based on the analytical expression for acoustic directivity of an ideal baffled circular piston. The factor ka in that expression parameterizes directivity in terms of the source frequency (wavenumber k) and source radius (a). Small values of ka describe an omnidirectional source. A parameter search over ka was performed for each source, and the parameter that gave the directivity most closely matching the measured directivity was selected. From there, the pressure field of a baffled circular piston with that ka value was calculated and normalized to the on-axis pressure (perpendicular to the source face). This pressure field was the starter field (source) input for PE modeling.

3.1.2 Geoacoustics

Based on the five test sites (**Table 1-1**), the appropriate sediment type was used in the acoustic propagation modeling by defining the geoacoustic parameters used in the PE model. Sediment was modeled as a single, acoustically deep (meaning many wavelengths), homogenous, unconsolidated sediment. Based on Hamilton (1980), this assumption permits the use of sediment grain size as a single input parameter to define compressional speed, sediment density, and sediment attenuation as a function of depth below the water-sediment interface.

Acoustic transmission loss (TL) was modeled with uncertainty, spanning the plausible ranges of source depth, water depth, receiver range and depth, and sediment type. For each site, a central sediment grain size parameter, ϕ , associated with mud/sand was selected. The model was run with a range of $\pm 1\phi$ from that mud or sand value.

3.1.3 Depth Dependence

In shallow water, sound waves in the acoustic field interact multiple times with the ocean surface and seafloor. The coherent interference of sound, as well as occasional structures (e.g., ducts) within the SSP, can lead to different received levels, depending on where in the water column the receiver is positioned. This depth dependence on receiver position in the water column is one cause for differences in measured acoustic received levels.

For Phase II, position and receiver depth were not recorded with enough precision to confidently determine depth dependence of the receiver in the acoustic field. Therefore, receiver depth was incorporated into the acoustic model results as another variable, with a range of plausible values for the uncertainty percentile representation of the acoustic field.

Because many TL models use simple cylindrical or spherical spreading, these two simple spreading models were plotted alongside the uncertainty percentiles for comparison. Incorporating plausible uncertainty ranges for several model inputs such as receiver depth provides a framework that encompasses reasonable acoustic measurements at each site for each source and compares those measurements to cylindrical and spherical spreading models.

3.2 BELLHOP Propagation Model

3.2.1 Source Model

Source directivity for HF sources was modeled in BELLHOP by applying an angular amplitude shading to the acoustic rays. BELLHOP is the model of choice for HF propagation modeling. The expression for a baffled circular piston was used to compute the shading versus the angle. The specific directivity parameter was selected for each source by a parameter search comparing the baffled circular piston directivity with the measured directivity.

3.2.2 Geoacoustics

Based on the five test sites (**Table 1-1**), the appropriate sediment types were used in the acoustic propagation modeling by defining the geoacoustic parameters. Sediment was modeled as a single, acoustically deep (i.e., many wavelengths), homogenous, unconsolidated sediment. The sediment model presented in Applied Physics Laboratory – University of Washington (1994) Technical Report 9407 was used. It relates sediment grain size as a single input parameter to define compressional speed, sediment density, and sediment attenuation.

3.2.3 Depth Dependence of Receivers

Depth dependence for the HF sources was the same for the LF and MF sources stated above.

3.3 Low-Frequency Omnidirectional Sources

LF (below 10 kHz) sources (**Table 3-1**) largely are omnidirectional and may be modeled as ideal point sources; however, two sources could have some directionality in the azimuthal direction and were explored more diligently. Specifically, according to the HRG open-water testing report (Halvorsen and Heaney, 2018), the LF sources with minor directivity were the 252 S-Boom and 251 Boomer. Upon further exploration, the anticipated directionality was deemed inconsequential.

3.4 Mid-Frequency Directional Sources

MF (between 0.5 and 24 kHz) sources (**Table 3-1**) are not omnidirectional and must be modeled differently than the LF sources. The directivities of the MF sources were measured and reported by Crocker and Fratantonio (2016). The data were compared to the directivity of an ideal equivalent source, the baffled circular piston (**Figure 3-1**).

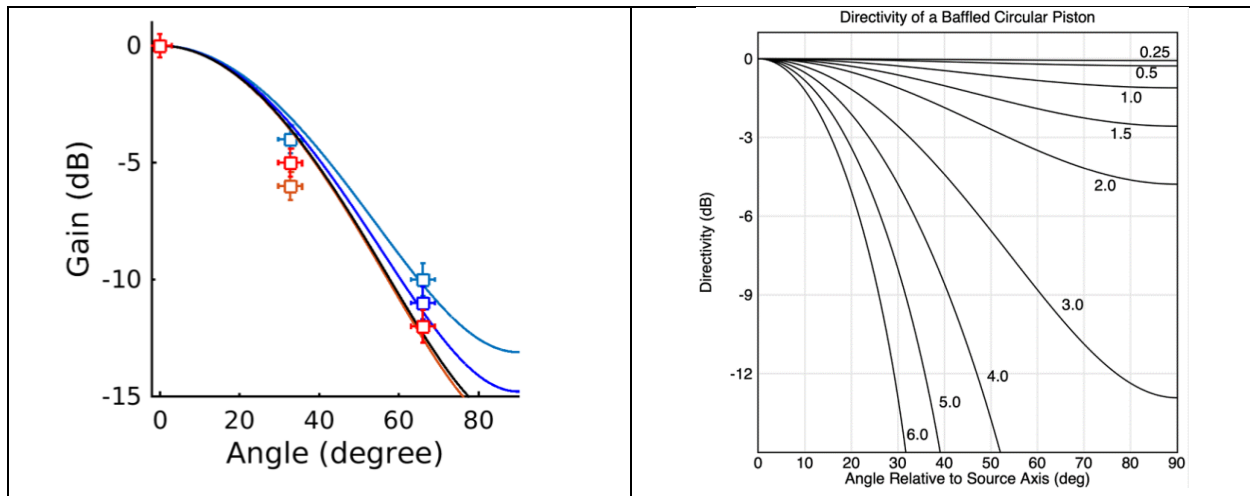


Figure 3-1. Applied Acoustics S-Boom

Left: The triple plate for 300 (cyan), 400 (orange), 500 (green), 600 (blue), and 700 (red) joules. Black indicates an overlap of two or more colors. Right: Plot of ka values for a baffled circular piston and their predicted directivity at angles from 0° to 90° .

From: Crocker and Fratantonio, 2016, Figure 20.

How the acoustic field's interactions with the seafloor and water surface were considered in a shallow-water environment was discussed in detail in **Section 3.1.3**. For the modeled to measured data comparison of MF HRG sources, the starting fields were computed from the expression for a baffled circular piston using the values of ka reported by Crocker and Fratantonio (2016). **Table 3-2** summarizes the values of ka used to compute the starter field for each source.

3.5 High-Frequency Directional Sources

The directivity of HF (above 38 kHz) sources (**Table 3-1**) was modeled as a baffled circular piston. For each source, the available directivity data were compared to pressure fields of varying directivity computed from the expression for a baffled circular piston. A best match was determined, and the chosen directivity parameter value is reported in the model results for each source.

The adjusted data, when available, were compared to model results from acoustic time series computed by the acoustic ray model BELLHOP (Porter, 2011) in the marine environment at each of the five test sites.

Like the LF and MF sources, uncertainty in the model output was calculated using the expected ranges of environmental and situational variables (**Table 3-2**). BELLHOP models were run through 11 different single value grain sizes, 11 source depth values, and receiver positions that were grouped in 20-m ranges over all depths. The use of BELLHOP instead of the PE was the primary difference for HF sources versus LF and MF sources.

3.6 Parameter Inputs

Table 3-1 provides the classification of sources by this project for modeling methodology applications. **Table 3-2** lists the ranges of input parameter values that were used in the modeling steps.

Table 3-1. HRG sources classified by frequency

HRG Source	Mode	Frequency	ka
Reson 7125	1	HF	4
Reson 7125	2	HF	4
Reson 7111	3	HF	3.8
Reson 7111	4	HF	3.8
Klein 3000	5	HF	4
Klein 3000	6	HF	4
Edgetech 4200	7	HF	4
Edgetech 4200	8	HF	4
SwathPlus	9	HF	3
SwathPlus	10	HF	3
SwathPlus	11	HF	3
SwathPlus	12	HF	3
EK60	13	HF	3.8
EK60	14	HF	3.8
EK60	15	HF	3.8
Edgetech 424 3100P	16	MF	3.15
Edgetech 424 3100P	17	MF	3.15
Edgetech 424 3200XS	18	MF	3.15
Edgetech 424 3200XS	19	MF	3.15
Edgetech 512i	20	MF	3.2
Edgetech 512i	21	MF	3.2
Edgetech 512i	22	MF	3.2
Knudsen3260	23	MF	3.5
Knudsen3260	24	MF	3.5
Knudsen3260	25	MF	3.5
252 S-Boom	26	MF	2.6
252 S-Boom	27	MF	2.6
Mini Sparker	28	LF	NA
Mini Sparker	29	LF	NA
251 Boomer	30	MF	2.7
251 Boomer	31	MF	3.8
Bubble Gun	32	LF	NA
Bubble Gun	33	LF	NA
Mini GI Airgun	34	LF	NA
Mini GI Airgun	35	LF	NA
Mini GI Airgun	36	LF	NA
Mini GI Airgun	37	LF	NA
Mini GI Airgun	38	LF	NA
Delta Sparker	39	LF	NA
Delta Sparker	40	LF	NA

HF = high frequency; HRG = high-resolution geophysical; ka = the ratio of the size of the piston to the acoustic wavelength, where "k" is $2\pi/\text{acoustic wavelength } (\lambda)$ and "a" is the radius of the piston; LF = low frequency; MF = mid-frequency; NA = not applicable.

Table 3-2. Model input value ranges used in the random parameter selection

Site	Bathymetry Maximum Depth (m)	Grain Size (phi)	Transmitter Depth (m)	Receiver Depth (m)	Receiver Range Extent (m)
HF input ranges					
Site 1	11	4–6	1.5–2.5	0–10	50
Site 2	17	0–2	1.5–2.5	0–10	50
Site 3	31	4–6	1.5–2.5	0–30	50
Site 4	35	0–2	1.5–2.5	0–30	50
Site 5	110	3–5	1.5–2.5	0–100	50
LF and MF input ranges					
Site 1	11	4–6	0–3	0–10	50
Site 2	17	0–2	0–3	0–10	50
Site 3	31	4–6	0–3	0–30	50
Site 4	35	0–2	0–3	0–30	50
Site 5	110	3–5	0–3	0–100	50

HF = high frequency; HRG = high-resolution geophysical; LF = low frequency.

3.7 Measured Data Comparison Methodology

Modeling the TL of LF sources was relatively straightforward as LF sources are omnidirectional. Therefore, the bearing from the source was not as important as for MF and HF directional sources. Modeling the TL of MF and HF sources was not as straightforward as the TL of an omnidirectional LF source. Because MF and HF sources are directional, a specific bearing from the source must be chosen that best represents the data to compare. At the CPA of a passing source in relation to a relatively stationary buoy, as in the field study for this report, 90° was the bearing most appropriate to model TL and compare it with the *in situ* data at CPA.

The MF and HF sources pointed downward, so the TL fell off much faster with range than pure spherical spreading ($20\log(r)$). The modeled to measured data comparison for MF and HF sources first applied calibration adjustments to the data, then plotted the measured and modeled acoustic metrics as a function of range. The modeled and measured data were plotted against range so the fall-off of data as a function of range could be noted. This was used to determine the horizontal shading pattern of the source. Finally, the horizontal shading pattern was applied to the model plan-view output figures.

Comparisons of modeled acoustic TL to measured data were based on a fixed set of environmental parameters. For this project, the predicted TL values were calculated from a computational grid (over the water column) at several ranges for fixed acoustic receiver depths (**Figures 1-1 and 1-2**). The source depth used in the model also was fixed. However, for any *in situ* measurement, source and receiver positions were not as exact as a model would depict. An example of potential receiver movement is a surface-buoyed vertical cable with attached hydrophones placed in an area with strong currents. The hydrophones could be drawn deeper into the water by many tens of meters and/or move in a roughly circular pattern.

Variations in acoustic source depth due to wave action can be captured by computing several model iterations, each with a random source depth within the expected value range (**Table 3-1**). Furthermore, comparing receiver data to TL modeled at a single range and depth would better match the real-world scenario if computational TL grid points of a single model iteration could be gathered from larger regions. Therefore, the TL values were gathered across iterations in the same receiver regions. The spatial variability of ocean sediments is highly uncertain. However, it can be captured by performing several different model iterations using random sediment parameter values within the expected range.

Combining these uncertainties can be expedited during the modeling process. Instead of performing several iterations varying only the sediment, followed by iterations varying only the source depth, and so on, a single set of model iterations (100 or more) was performed, and in each individual iteration, a random selection of each relevant parameter was used. The TL values within the range and depth bins across all iterations were gathered, sorted, and down sampled. The remaining values captured the cumulative uncertainty of TL across the given environmental and spatial parameters. They were plotted as equally spaced percentiles (5th, 20th, 35th, 50th, 65th, 80th, and 95th) versus range. By being equally spaced, the percentiles show how environmental and spatial sampling should affect the spread of the measured values. The median (50th percentile) best represents the overall field structure and can be plotted to provide an image similar to a single model TL slice plot. Together, a plot of the median TL field paired with a plot of the interquartile distance of the field uncertainty provide enough information to understand the measured data and the utility of the uncertainty-inclusive model used in this report.

3.8 Model Validation

Chapter 4 presents a selection of modeled to measured data comparison results for the HRG sources. The selection of sites and sources displays a broad range of success in the results. Few sites had successful recordings from all deployed buoys, and many sites had fewer than three successful recordings. Adjustment factors applied to the data were determined and are presented in **Chapter 2** and **Appendix A**. Because comparing data with the model at the CPA for LF sources is more effective than with range for MF and HF sources, the plots only extend to 2 km (or 1 km when requested by the USGS) to provide better visibility near the source, making any data from buoy F unviewable. For each plot, the model percentiles (5th to 95th, evenly spaced every 15%) are shown as colored lines and the adjusted received level measurements (*in situ* data) are overlaid as points for three metrics: L_{pk} , SEL, and L_{rms} . If data for a source were available from more than one run at any site, data were plotted from all runs together. The data adjustment factors (-50 to 50 dB) were applied consistently across each deployment and equally to each acoustic metric.

In many plots, the peaks of the CPA data are within the uncertainty percentiles of the model, but the contour of the data has a quicker fall-off with range than the model. This is because the data are from the passing horizontal beam pattern, so the SL decreases substantially once the receiver is no longer directly in the broadside beam of the source. This fall-off with range from a passing broadside beam occurs rapidly at close ranges and more gradually at long ranges. This is explained by geometry, as the change in an angle near a source is more drastic than at longer ranges from the source. The modeled to measured data comparisons for all the HRG sources are presented in **Appendix A**.

3.8.1 Modeled to Measured Data Comparison Reliability Legends

The amount and quality of *in situ* data varied among runs because of aforementioned problems in the field tests. Ideally, every deployed buoy would have collected enough data to compare to the modeled TL with range percentile plots; however, this was not the case. To visualize how much data and of what quality each HRG source had for comparison to the models, reliability legends were placed in each figure (Figure 3-2). Green circles indicate the buoy collected sufficient data to compare to the model at and beyond the CPA. Yellow circles indicate the buoy collected sufficient data to compare to the model only at the CPA. Red circles indicate the buoy collected data that were too poor to compare with the model at the CPA and at range. Circles with an X indicate the buoy was not deployed for any run at that site for that source. Because the adjustment factors relied on knowing buoy position, asterisks beside the circles indicate that GPS data on that buoy were sufficient for validating buoy position. Comparing the reliability legends across different figures helps the reader understand the quality of the data being compared to the models.

The reliability legends were used for data comparison to depict the data quality of buoys used to ground truth the models. The only difference lies in the HF sources, in that no asterisks were used to denote GPS accuracy. This is because no cross-correlation of the GPS files was done to evaluate their reliability. Therefore, the GPS positions during HF runs were assumed to be similar to those when the LF and MF source runs were operated.

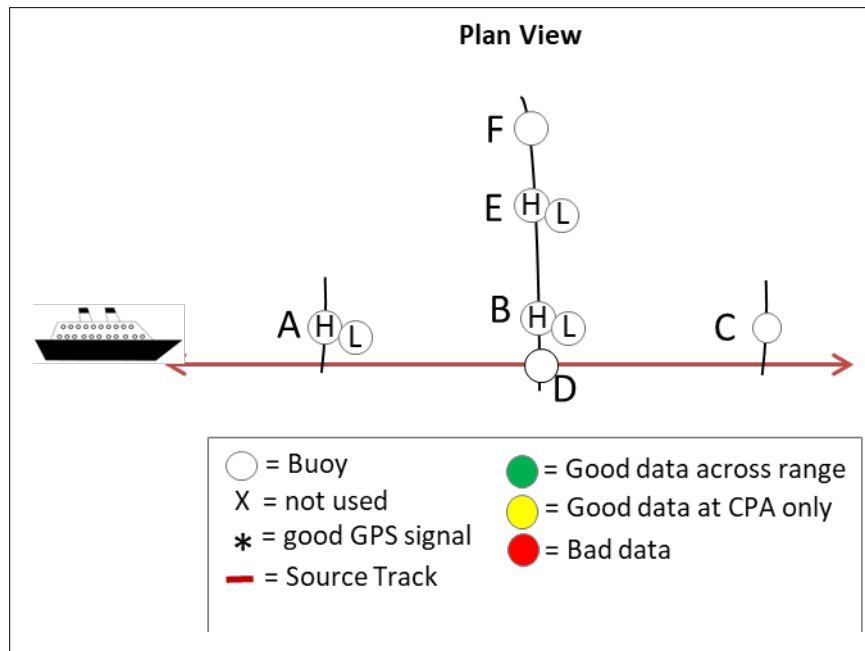


Figure 3-2. Key for reliability legends in data plots by buoy position

Each buoy position is symbol- and/or color-mapped to qualify the data availability and quality of the data points displayed in the subsequent plots. H = high-sensitivity hydrophone buoy; L = low-sensitivity hydrophone buoy

Figure 3-3 is a key for the range results figures. The data points are color-mapped to the buoy position. For example, when blue data points are present in the figure, those points were captured from buoy D, directly below the vessel.

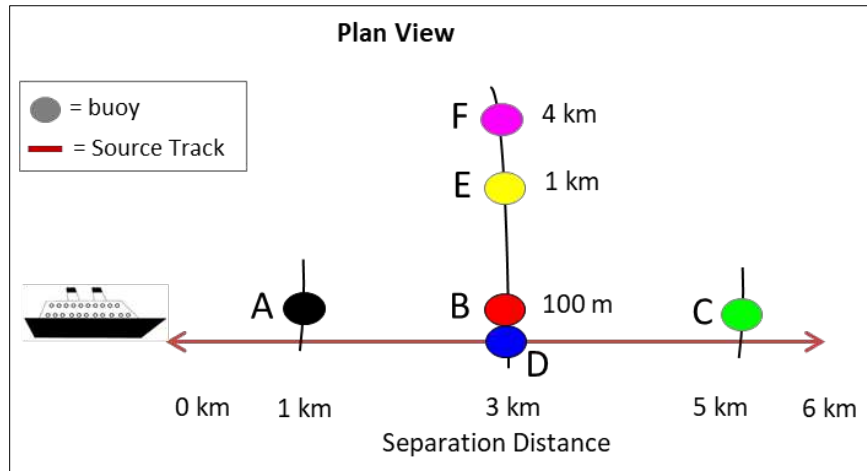


Figure 3-3. Color map of data to buoy position
Each buoy position is color-mapped to the data points found in the subsequent range plots.

4 Example Modeled to Measured Data Comparisons

4.1 Low-Frequency Source: Sparkers

4.1.1 SIG 2 Mini Sparker ELC 820, 700 J, Low Power (Mode 28); Site 1 – Mud, 10-m Depth

The first modeled to measured data comparison is for the Mini Sparker Mode 28 at Site 1, run 4. This location had three functional buoys. The data comparisons for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-1**. For each plot, the model percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. The model matched the fall-off with range for each measured metric, particularly from 100 m to 2 km (buoy positions D [blue] and E [yellow]). The far buoy (position F [pink, not shown]) may be noise limited and only matched the model at the CPA.

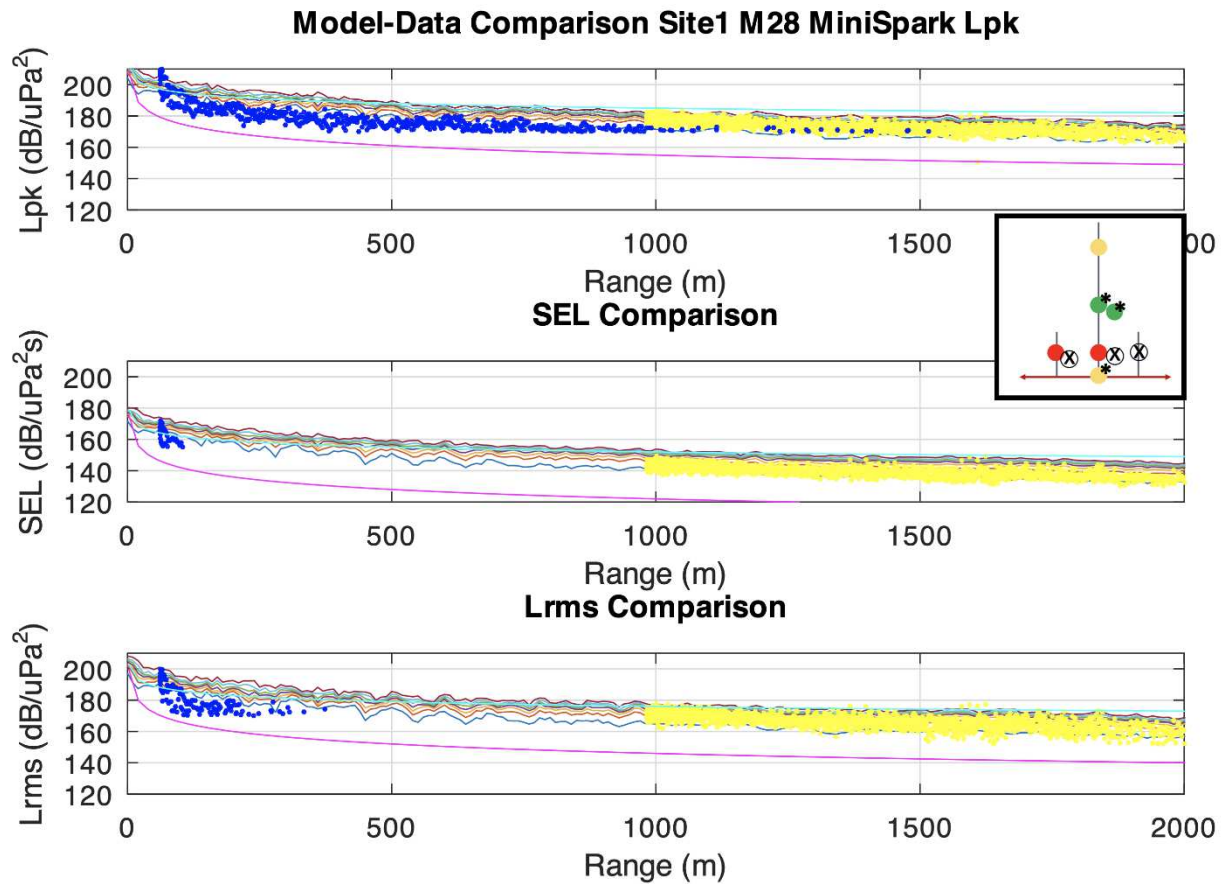


Figure 4-1. Mini Sparker Mode 28 Site 1 Run 4 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Data colors are for buoys D (blue), A (black), and E (yellow). Buoy F (pink) is not shown in this example. The reliability legend shows that data from buoys D and E only matched the model at the CPA, while data at buoy E followed the modeled contour with range. GPS data were good for buoys D and E, as denoted by the asterisks.

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.1.2 SIG 2 Mini Sparker ELC 820, 700 J, Low Power (Mode 28); Site 4 – Sand, 30-m Depth

The modeled to measured data comparisons for the Mini Sparker Mode 28 at Site 4, run 26 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-2**. This location had two functioning buoys. The model predicted the fall-off with range for each measured metric well, particularly from 100 m to 2 km (buoys B [red] and E [yellow]).

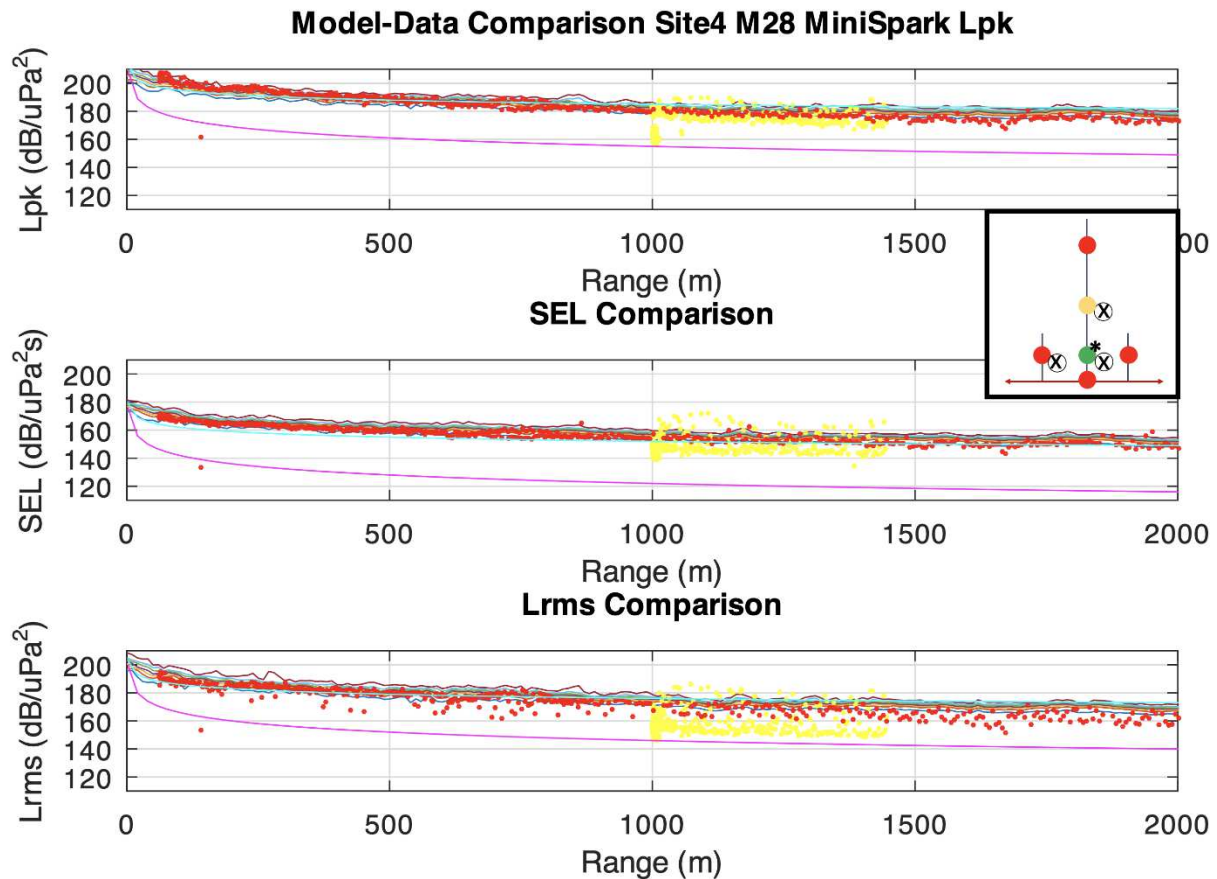


Figure 4-2. Mini Sparker Mode 28 Site 4 Run 26 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Data colors are for buoys B (red) and E (yellow), which matched the model along the range contour and only at the CPA, respectively.

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.1.3 Applied Acoustics Delta Sparker, 2.4 kJ, Low Power (Mode 39); Site 5 – Sandy Silt, 100-m Depth

The modeled to measured data comparisons for Delta Sparker, Mode 39 at Site 5, run 1 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-3**. This location had four functioning buoys. The model predicted the fall-off with range for each measured metric well, particularly from 100 m to 1 km (buoy positions B [red], A [black], and D [blue]). Buoy E (yellow, not shown) also followed the model contour well.

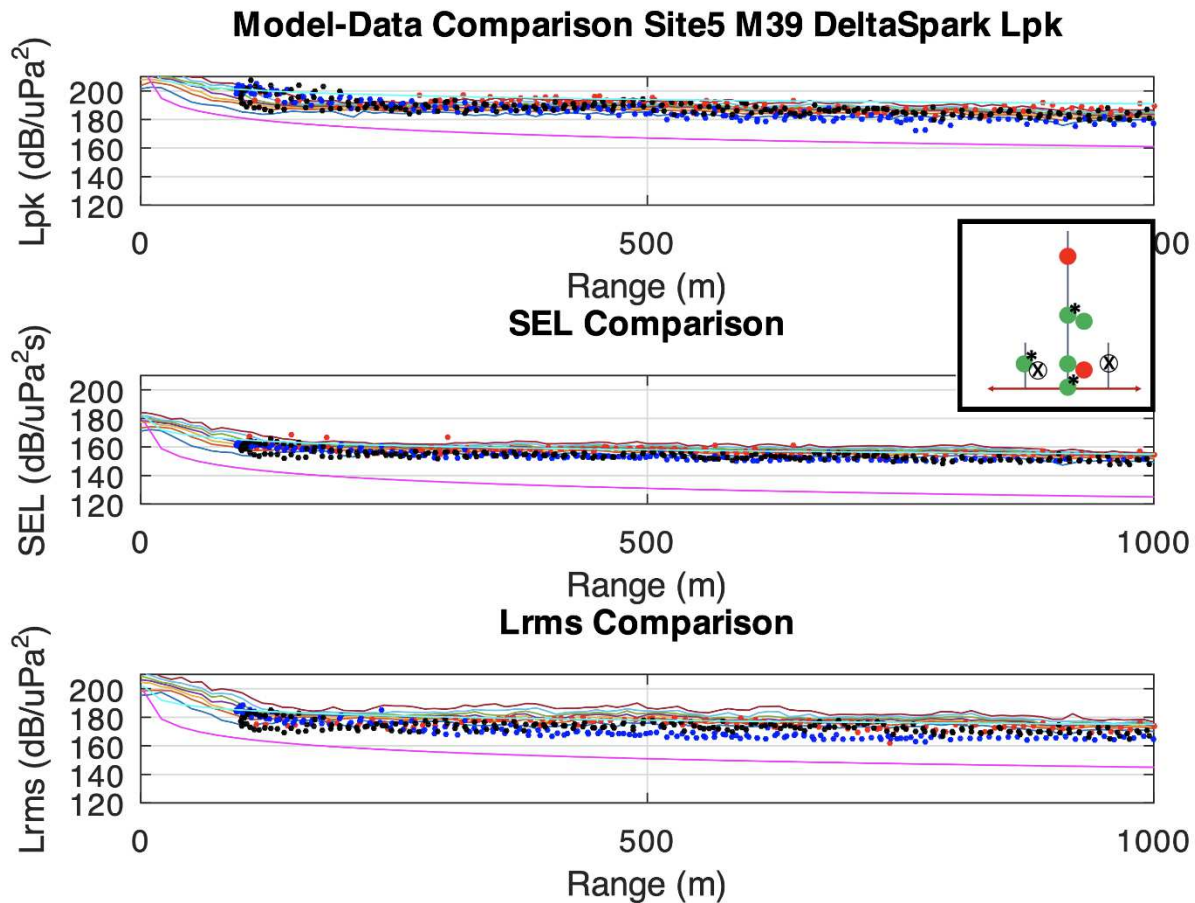


Figure 4-3. Delta Sparker Mode 39 Site 5 Run 1 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Data colors are for buoys D (blue), A (black), and B (red). Buoy E (yellow) is not shown due to the USGS request that the range limit be to 1 km; however, the data matched the model's contour as indicated by the reliability legend.

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level; USGS = United States Geological Survey.

4.2 Low-Frequency Source: Bubble Guns

4.2.1 FSI Bubble Gun, 0.1 to 2 kHz, Dual Plate (Mode 32); Site 2 – Sand, 10-m Depth

The modeled to measured data comparisons for the Bubble Gun, Mode 32 at Site 2, run 26 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-4**. This location had two functioning buoys. The model predicted the fall-off with range of each metric well, particularly from 100 m to 2 km (buoy positions D [blue] and B [red]).

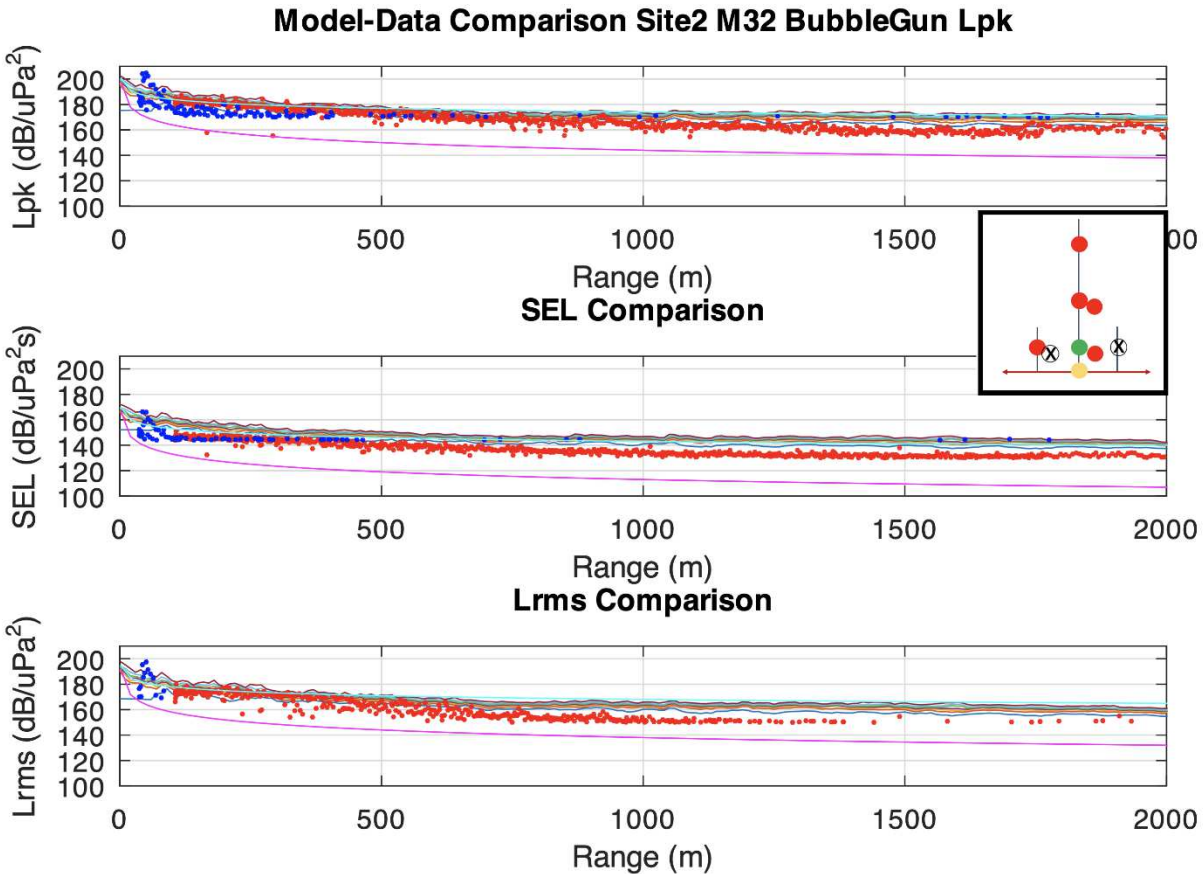


Figure 4-4. Bubble Gun Mode 32 Site 2 Run 26 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Data colors are for buoy positions D (blue) and B (red).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.2.2 FSI Bubble Gun, 0.1 to 2 kHz, Single Plate (Mode 33); Site 4 – Sand, 10-m Depth

The modeled to measured data comparisons for the Bubble Gun, Mode 33 at Site 4, run 28 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-5**. This location had one functioning buoy, position B (red). The model predicted the fall-off with range well.

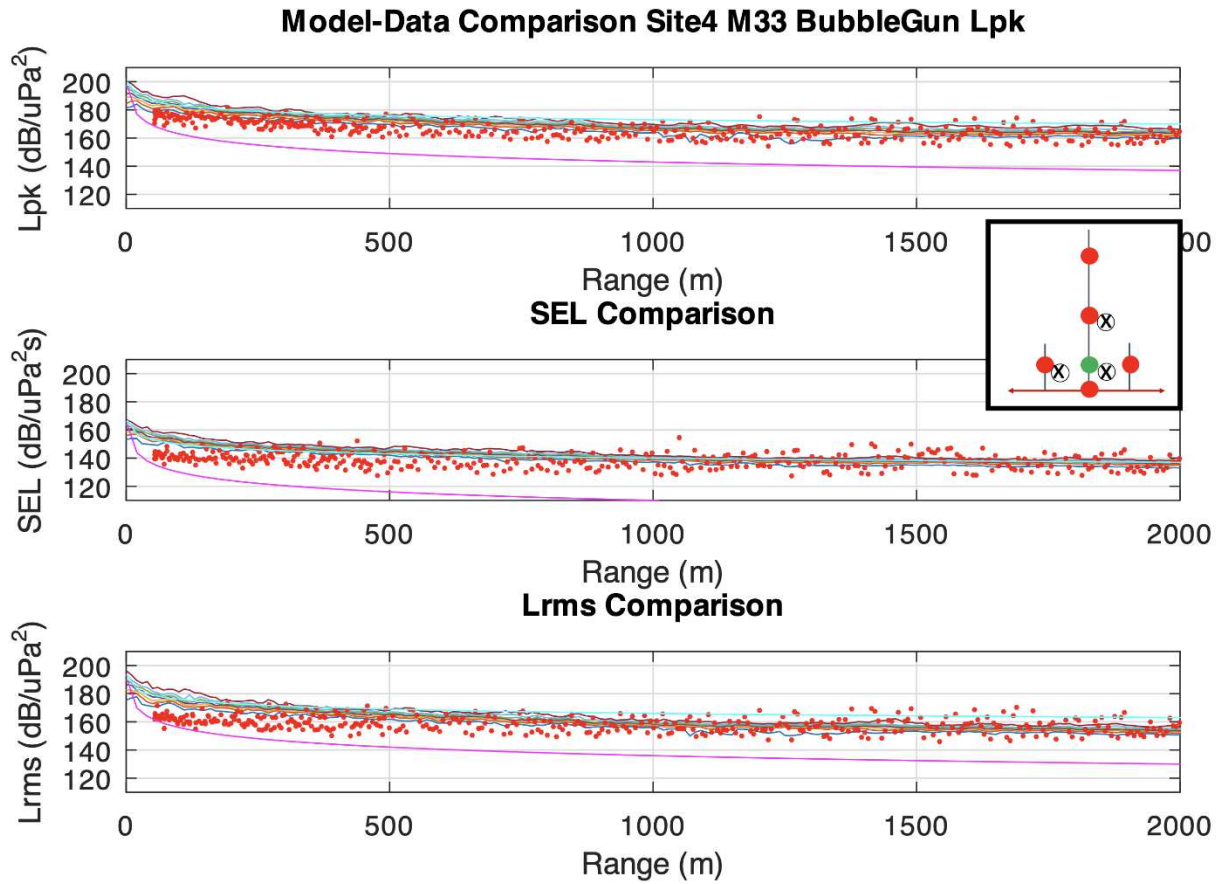


Figure 4-5. Bubble Gun Mode 33 Site 4 Run 28 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Data color is for buoy position B (red).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.3 Low-Frequency Source: Airguns

4.3.1 Sercel Mini GI (30/30), Dual Airguns, No Insert, 30-, 26-, and 24-second Shot Rates (Mode 34); Site 5 – Sandy Silt, 100-m Depth

The modeled to measured data comparisons for the Airgun, Mode 34 at Site 5, run 5 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-6**. Buoys D (blue), A (black), B (red), and E (yellow) had good measurements. For this source, the model matched the measured values exceptionally well out to 2 km.

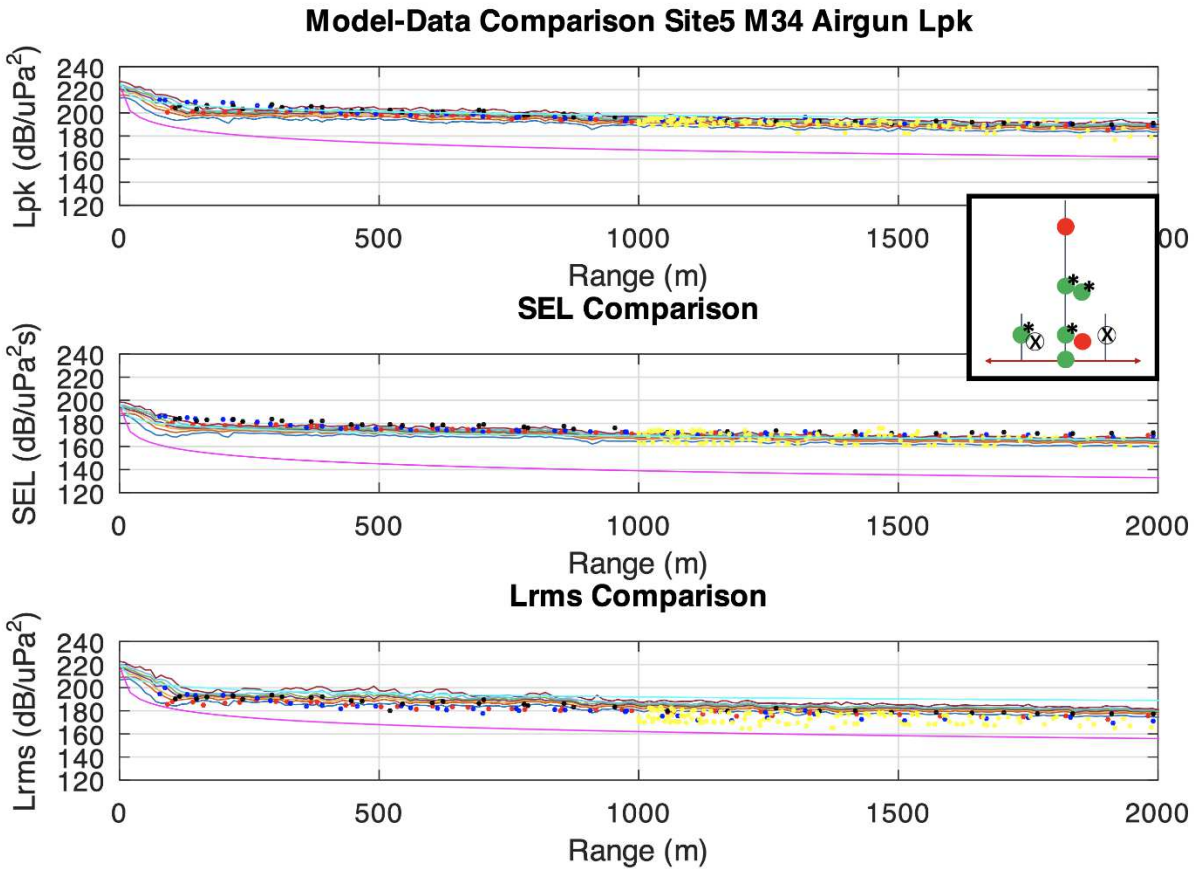


Figure 4-6. Airgun Mode 34 Site 5 Run 5 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Data colors are for buoys D (blue), A (black), B (red), and E (yellow).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.3.2 Sercel Mini GI (30/30), Single Airgun, 15-inch³ Inserts, 8-second Shot Rate (Mode 37); Site 5 – Sandy Silt, 100-m Depth

The modeled to measured data comparisons for the Airgun, Mode 37 at Site 5, run 18 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-7**. Buoys D (blue), A (black), and E (yellow) had good measurements. The model matched the measured values exceptionally well, especially for the first kilometer shown here.

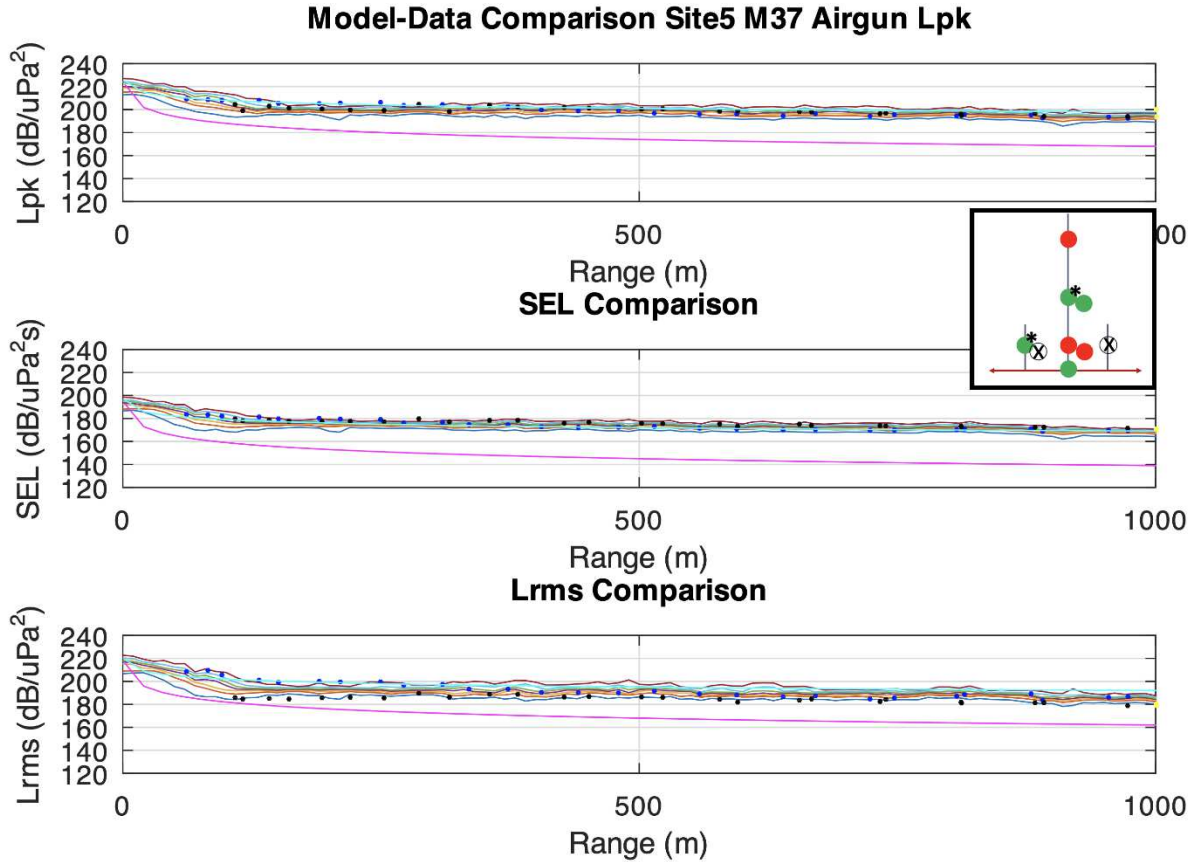


Figure 4-7. Airgun Mode 37 Site 5 Run 18 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Data colors are for buoys D (blue) and A (black). Buoy E (yellow) is not shown but also matched the data well per the reliability legend.

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.4 Mid-Frequency Source: Subbottom Profilers

4.4.1 Edgetech 424, 3100P, 4 to 24 kHz, 100 Percent Power, 10-ms Pulse (Mode 16), Site 1 – Mud, 10-m Depth

The modeled to measured data comparison plots for Mode 16 at Site 1, run 3 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-8**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. Mode 16 had two working buoys with three working hydrophones. The data from the CPA for both buoys are within the modeled percentile ranges. The contour of TL with range is only available for buoy E (yellow).

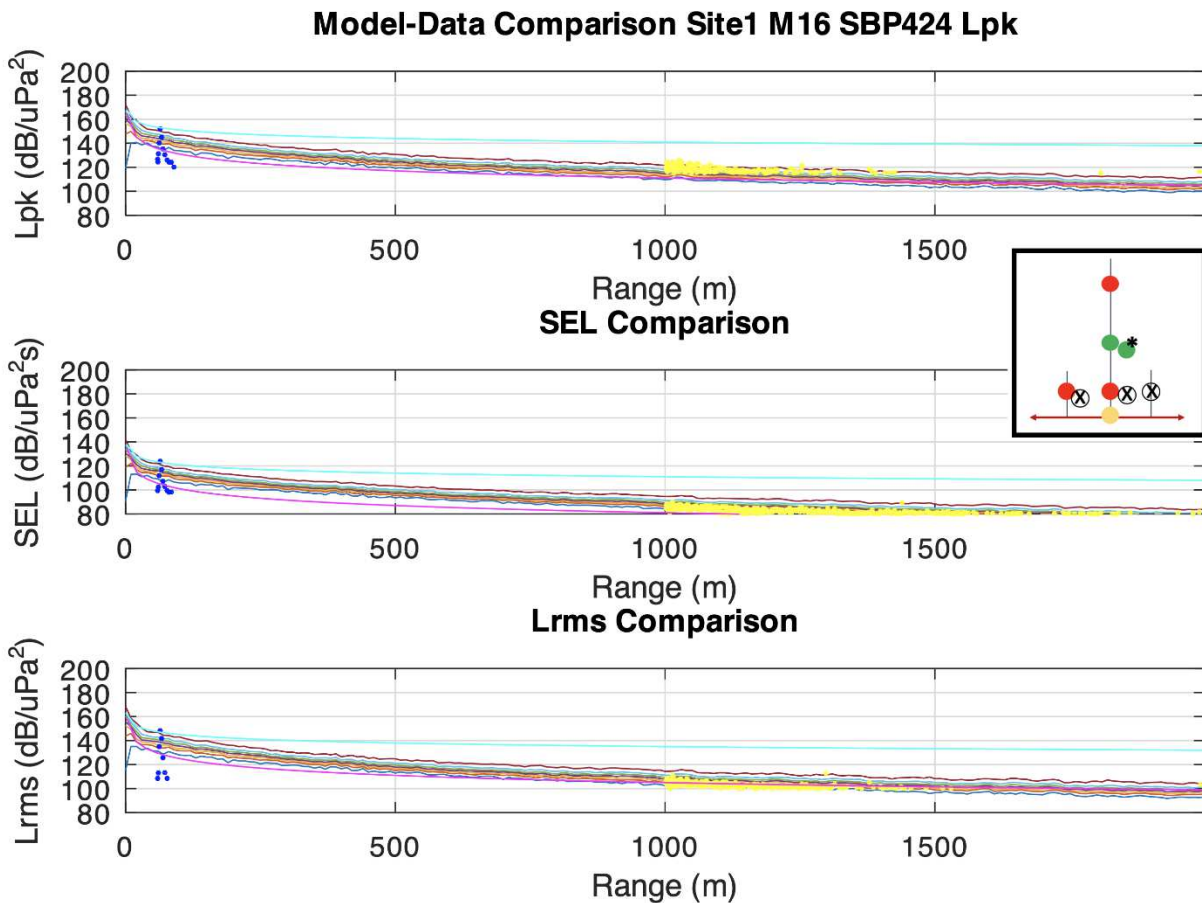


Figure 4-8. Edgetech 424 3100P Mode 16 Site 1 Run 3 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys D (blue) and E (yellow).

Inset: Buoy positioning relative to source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.4.2 Knudsen 3260, 3.3 to 5.6 kHz, Power Level 1, 8-ms Pulse (Mode 23); Site 2 – Sand, 10-m Depth

The modeled to measured data comparison plots for the Knudsen source, Mode 23 at Site 2, runs 1 and 29 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-9**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. Mode 23 had three working buoys with four working hydrophones. CPA data from buoy D (blue) were above the modeled uncertainty percentiles for all metrics. CPA data from buoys B (red) and E (yellow) were within the modeled uncertainty percentiles for all metrics. The contour of TL with range is available for all three buoys, and all data followed modeled uncertainty percentile ranges well out to 2 km.

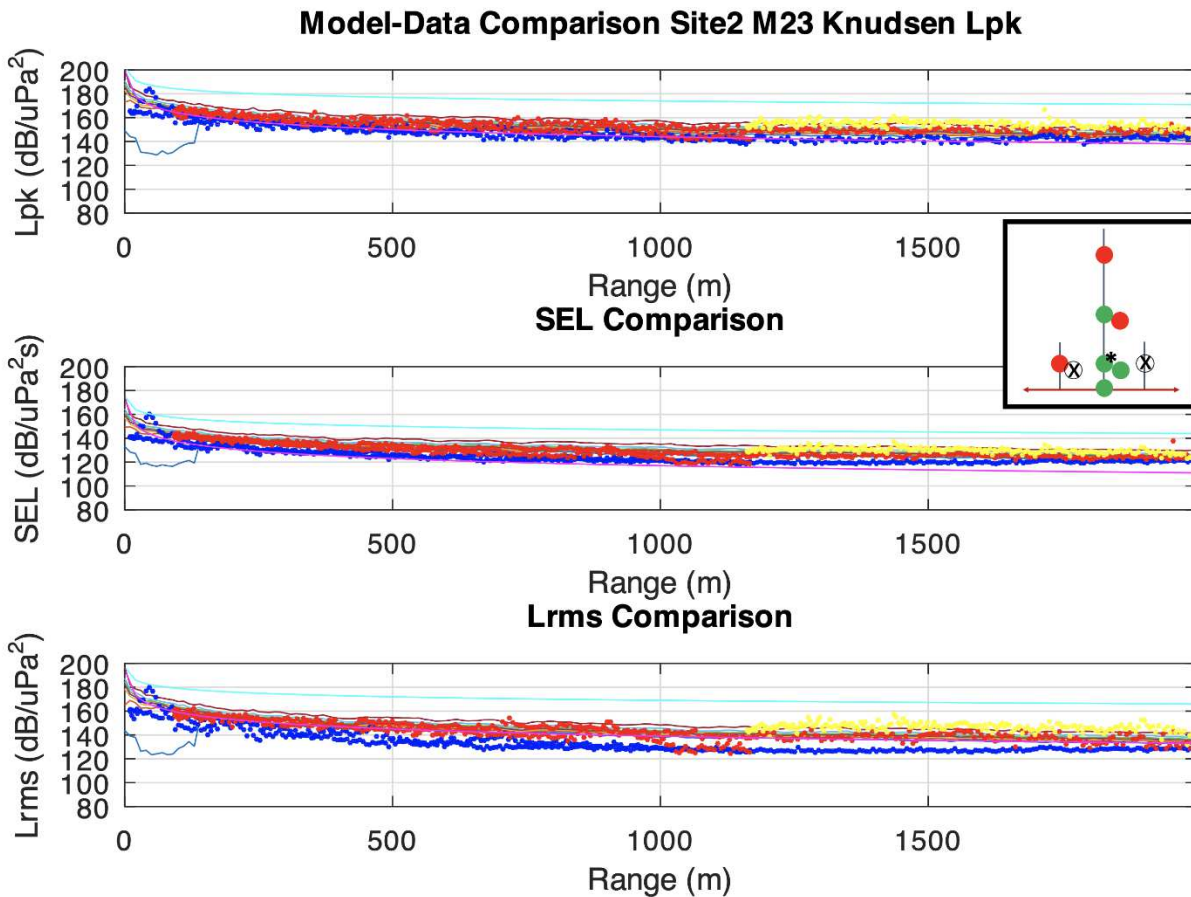


Figure 4-9. Knudsen Mode 23 Site 2 Runs 1 and 29 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys D (blue), B (red), and E (yellow).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS during at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.4.3 Edgetech 512i, 2 to 12 kHz, 100 Percent Power, 20-ms Pulse (Mode 21), Site 3 – Mud, 30-m Depth

The modeled to measured data comparison plots for the Edgetech 512i, Mode 21 at Site 3, runs 2 and 22 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-10**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. Mode 21 had four working hydrophones with five working buoys. CPA data from all buoys fell within modeled uncertainty percentiles for all metrics except past 300 m for the L_{rms} metric. The contour of TL with range is available for all buoys, and the data tend to drop off slightly faster than the modeled uncertainty percentile ranges and more closely followed the contour for spherical spreading (magenta line).

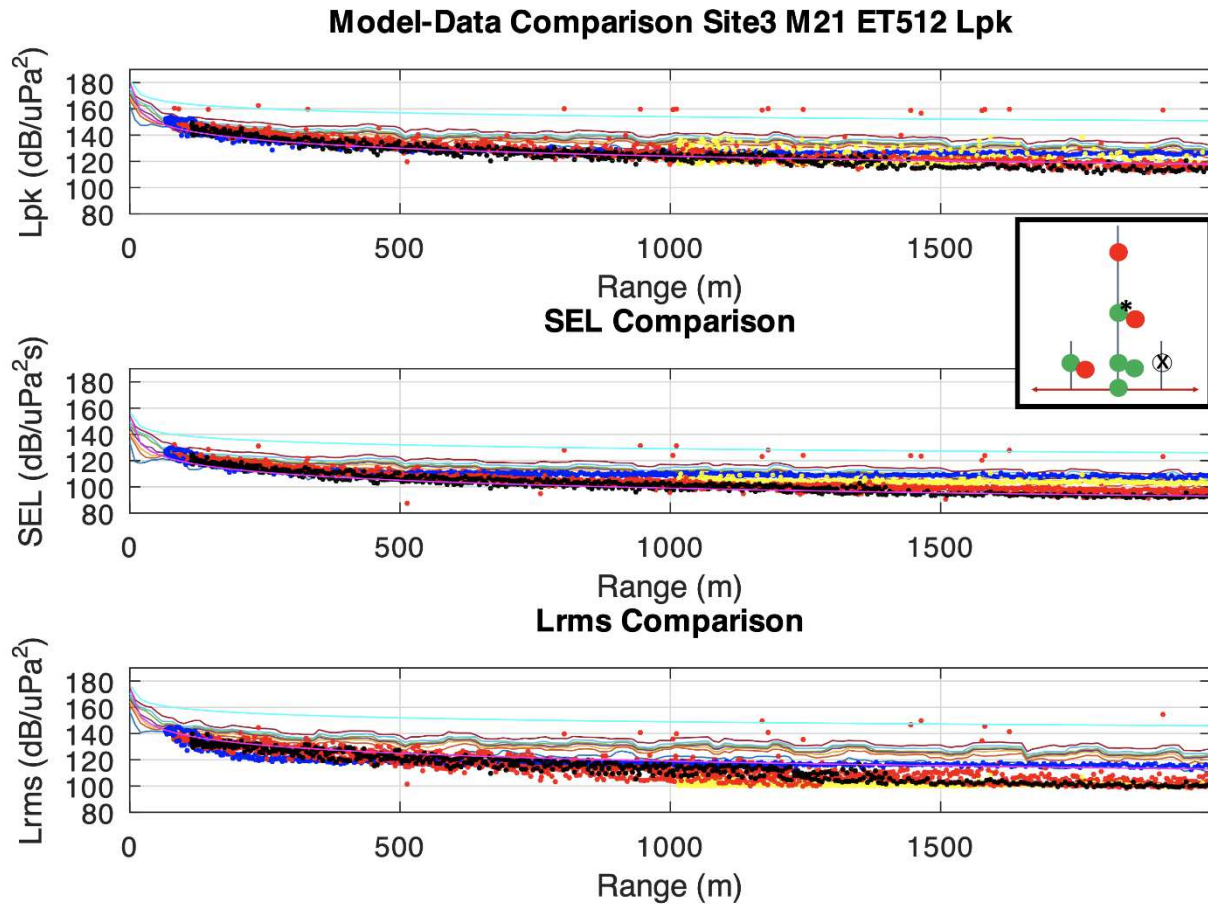


Figure 4-10. Edgetech 512i Mode 21 Site 3 Runs 2 and 22 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys D (blue), A (black), B (red), and E (yellow).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.4.4 Edgetech 512i, 2 to 12 kHz, 100 Percent Power, 20-ms Pulse (Mode 21); Site 4 – Sand, 30-m Depth

The modeled to measured data comparison plots for the Edgetech 512i, Mode 21 at Site 4, run 2 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-11**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. Mode 21 had three buoys with four working hydrophones. Data from buoys B (red), E (yellow), and C (green) were within the modeled uncertainty percentiles for all metrics except past 500 m for L_{rms} .

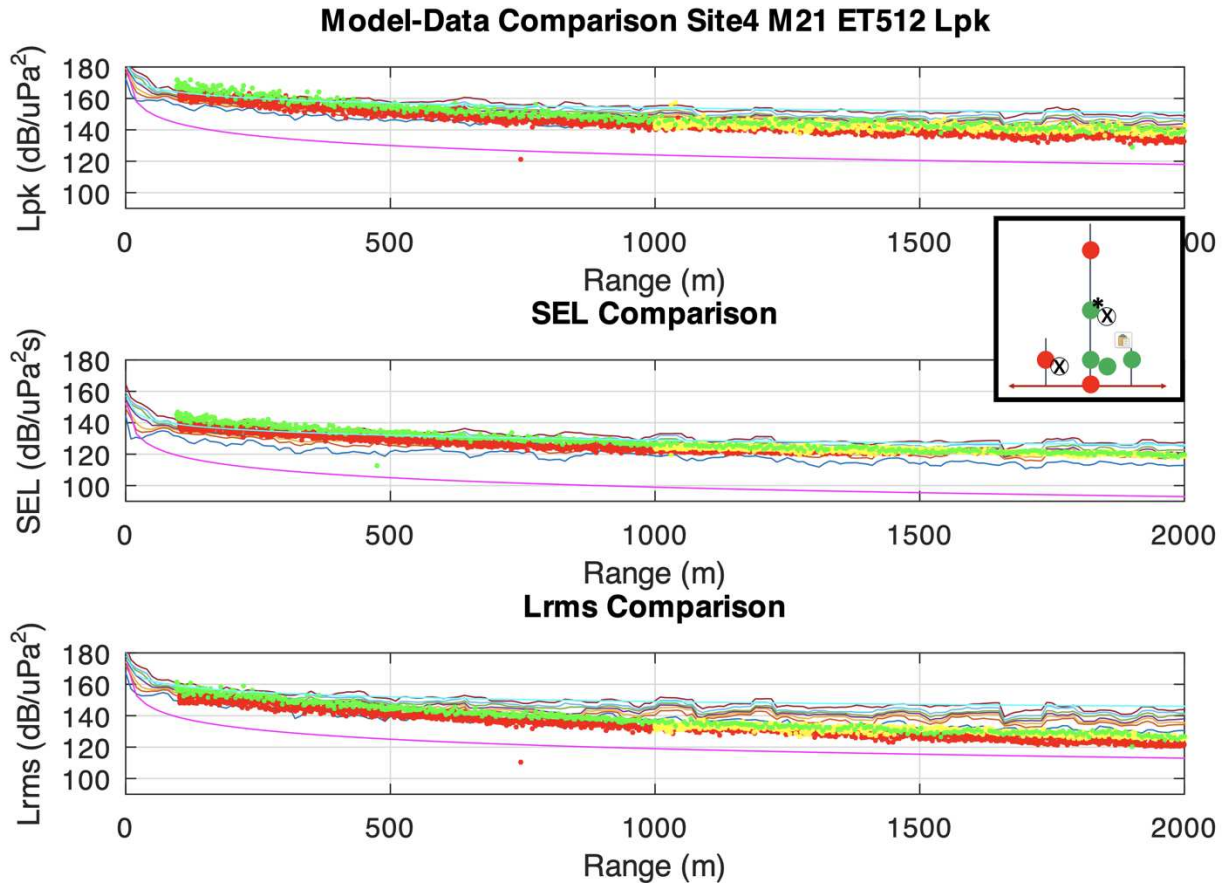


Figure 4-11. Edgetech 512i Mode 21 Site 4 Run 2 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys B (red), C (green), and E (yellow).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.4.5 Applied Acoustics 252 S-Boom, 0.1 to 5 kHz, 200 J, Low Power, Single Plate (Mode 27); Site 5 – Sandy Silt, 100-m Depth

The modeled to measured data comparison plots for the 252 S-Boom, Mode 27 at Site 5, runs 9 and 25 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-12**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. For Mode 27, there were five working buoys with six working hydrophones. Data for all buoys were within modeled uncertainty percentiles for SEL, and below modeled uncertainty percentiles for L_{pk} and L_{rms} .

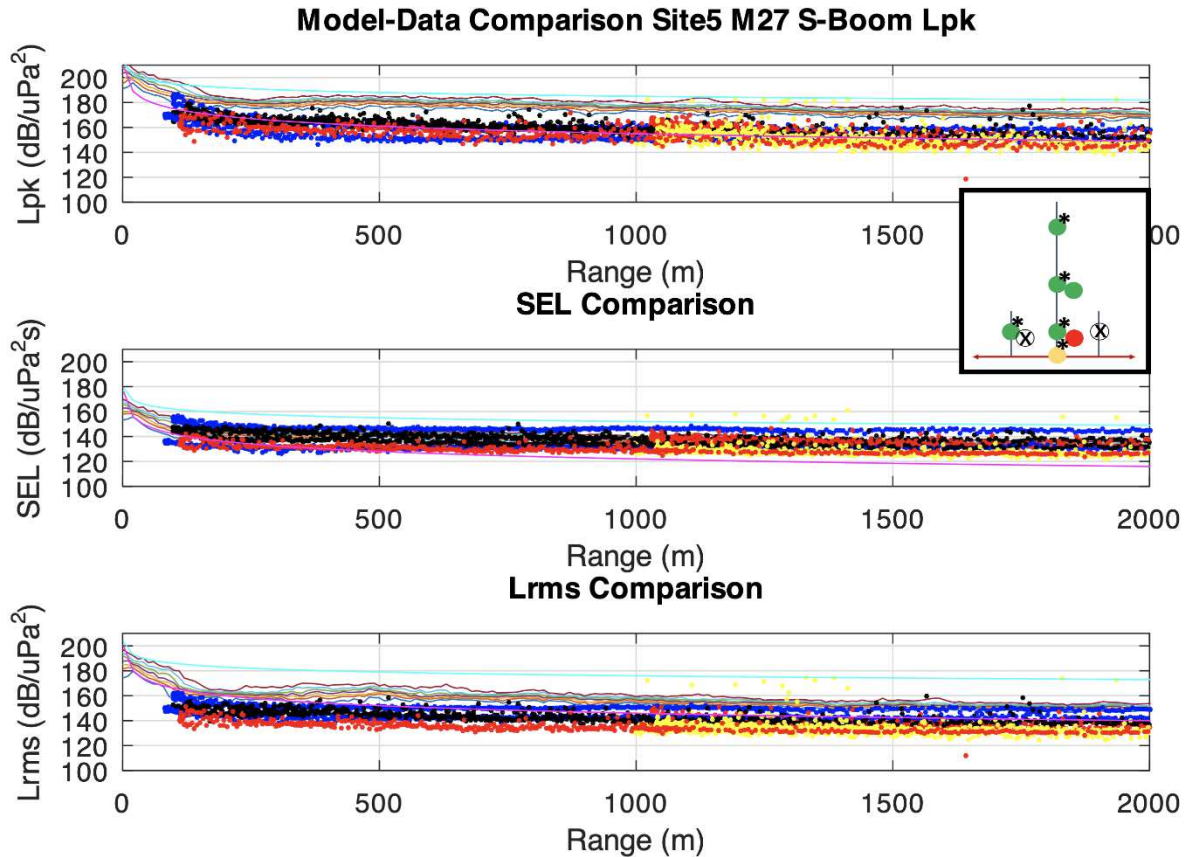


Figure 4-12. 252 S-Boom Mode 27 Site 5 Runs 9 and 25 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys D (blue), A (black), B (red), and E (yellow). Buoy F not shown.

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

All additional modeled to measured data comparison plots can be found in **Appendix A**.

4.5 High-Frequency Sources

4.5.1 Klein 3000, 132 kHz, 200- μ s Pulse, 400-ms Ping Rate, 200-m Range (Mode 6); Site 1 – Mud, 10-m Depth

The modeled to measured data comparisons for the Klein 3000, Mode 6 at Site 1, run 12 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-13**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. Buoy D (blue) had good measurements, but CPA data fell below modeled uncertainty percentiles.

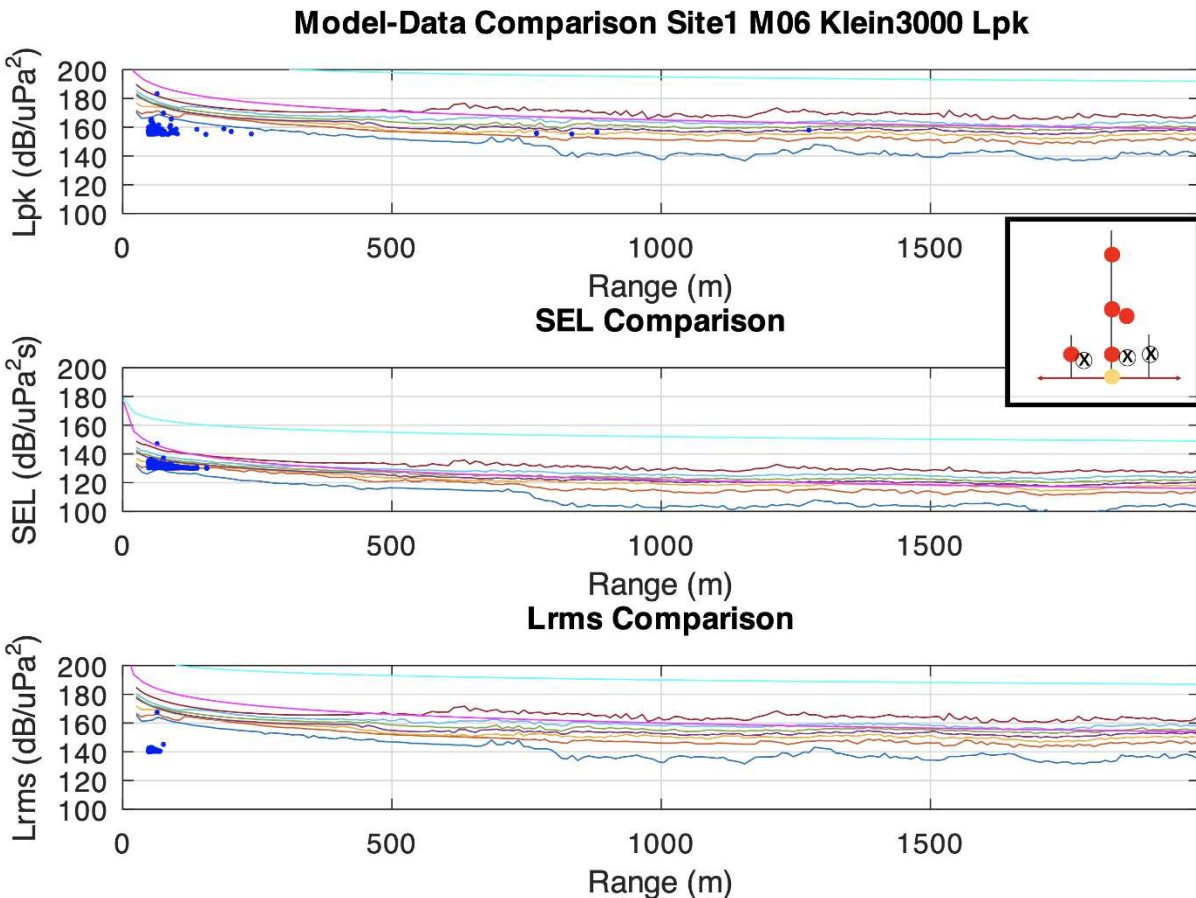


Figure 4-13. Klein 3000 Mode 6 Site 1 Run 12 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoy D (blue).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS during at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μ Pa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.5.2 Klein 3000, 132 kHz, 50- μ s Pulse, 4,000-ms Ping Rate, 400-m Range (Mode 5); Site 2 – Sand, 10-m Depth

The modeled to measured data comparisons for the Klein 3000, Mode 5 at Site 2, runs 14 and 40 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-14**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. This location had two functioning buoys, positions D (blue) and B (red). CPA data from the buoys fell just below or within modeled uncertainty percentiles for all metrics.

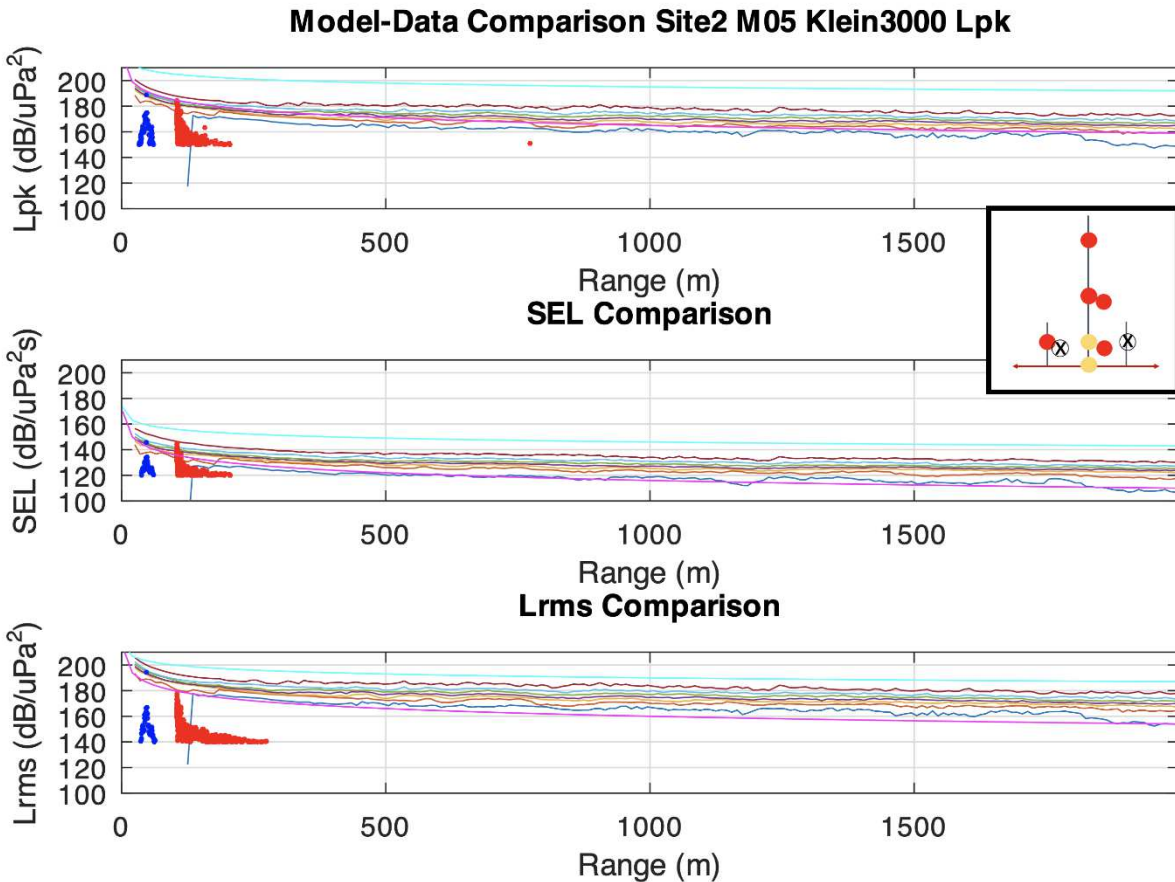


Figure 4-14. Klein 3000 Mode 5 Site 2 Runs 14 and 40 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys D (blue) and B (red).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μ Pa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.5.3 Simrad EK60, 30 kHz, 50 Percent Power, 512- μ s Pulse (Mode 15); Site 3 – Mud, 30-m Depth

The modeled to measured data comparisons for the EK60, Mode 15 at Site 3, run 2 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-15**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. Buoys D (blue) and B (red) had good measurements. CPA data from all buoys fell within modeled uncertainty percentiles for all metrics.

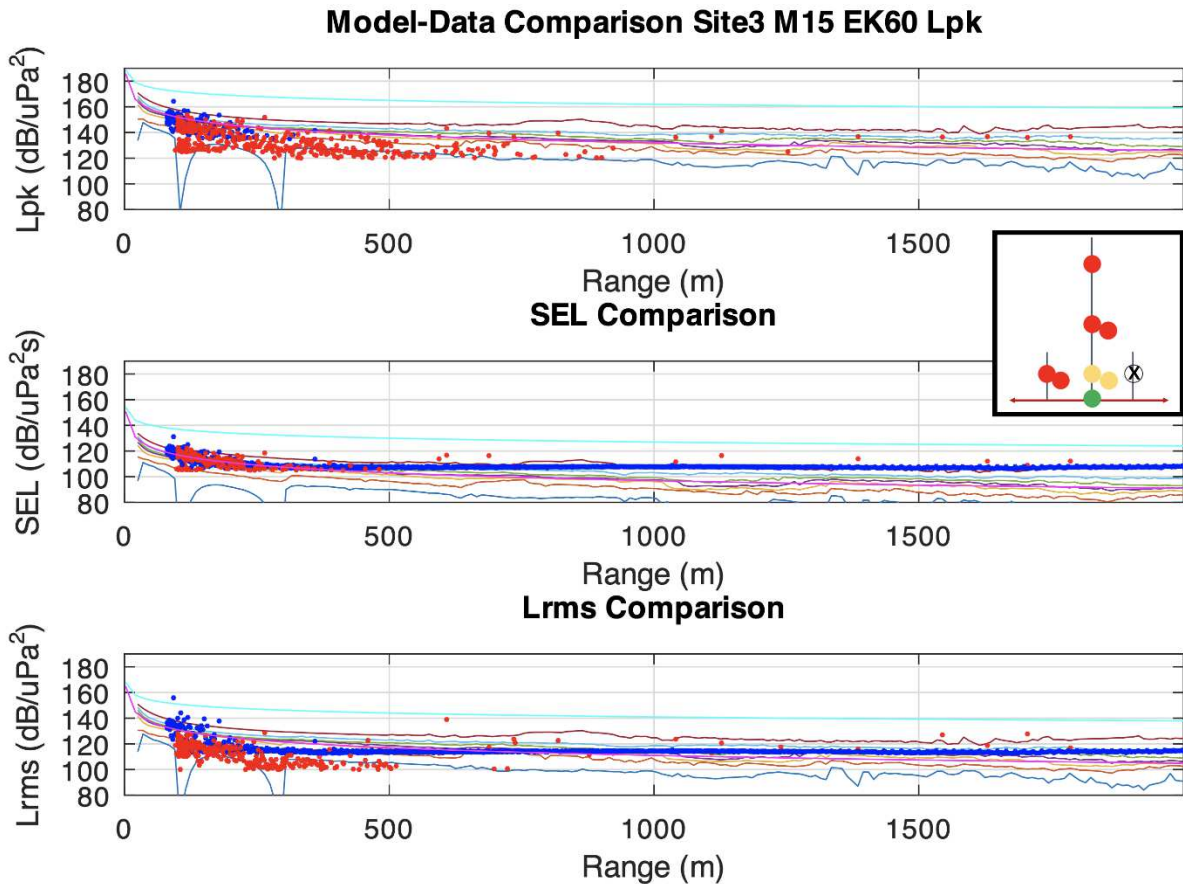


Figure 4-15. EK60 Mode 15 Site 3 Run 2 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys D (blue) and B (red).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μ Pa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.5.4 Reson 7111, 100 kHz, 200 dB, 0.17-ms Pulse, 1.5° (Mode 3); Site 4 – Sand, 30-m Depth

The modeled to measured data comparisons for the Reson 7111, Mode 3 at Site 4, run 4 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-16**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. Buoys A (black) and C (green) had good measurements only at the CPA, but they were below modeled uncertainty percentiles.

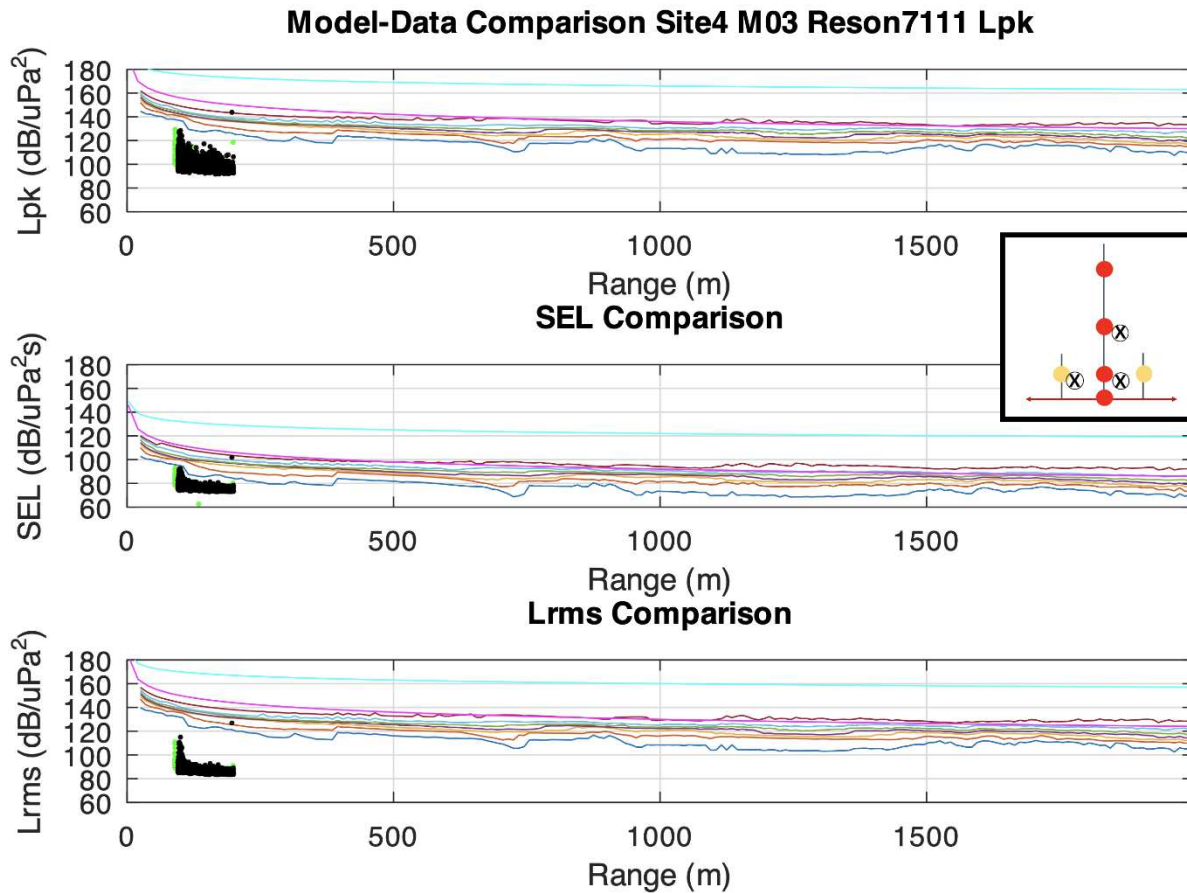


Figure 4-16. Reson 7111 Mode 3 Site 4 Run 4 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys A (black) and C (green).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS during at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

4.5.5 Reson 7125, 200 kHz, 220 dB, 100 Percent Power (Mode 1); Site 5 – Sandy Silt, 100-m Depth

The modeled to measured data comparisons for the Reson 7125, Mode 1 at Site 5, runs 12 and 26 for L_{pk} , SEL, and L_{rms} are shown in **Figure 4-17**. For each subplot, the modeled percentiles (5th to 95th) are shown as colored lines and the individual signal measurements are overlaid as dots. Buoys D (blue), A (black), and B (red) had good measurements at the CPA and were within modeled uncertainty percentiles.

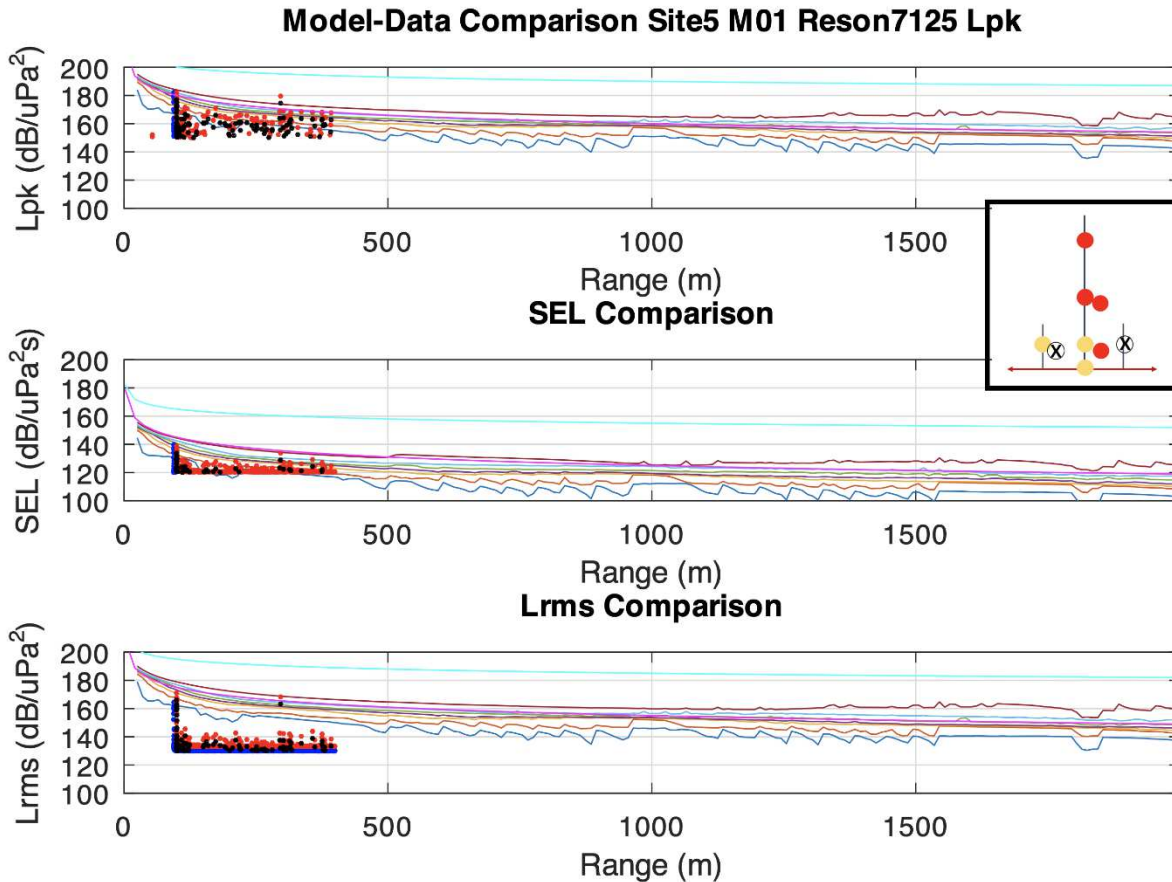


Figure 4-17. Reson 7125 Mode 1 Site 5 Runs 12 and 26 comparison results

Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoys D (blue), A (black), and B (red).

Inset: Buoy positioning relative to the source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS during at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5 Modeling Results

5.1 Reson 7125, 200 kHz, 220 dB, 100 Percent Power (Mode 1)

The Reson 7125 multibeam echosounder generates a single, very high-frequency (VHF) signal with a peak frequency at 196 kHz. The operational parameter settings for Mode 1 were a power setting of 220 dB for 100 percent power, 300-microsecond (μ s) pulse length, and 200-kHz output frequency. Measured source levels of the Reson T20P, as a proxy for the Reson 7125, are shown in **Table 5-1**.

Table 5-1. NUWC tank measurements of Reson T20P, as a proxy for Reson 7125 (Mode 1)

Source Settings			Source Level			
Power Level (%)	Power Level (dB)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	220	5	226	221	218	182

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-1**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-1**. Modeling results for each site are shown in **Figures 5-2 to 5-6**.

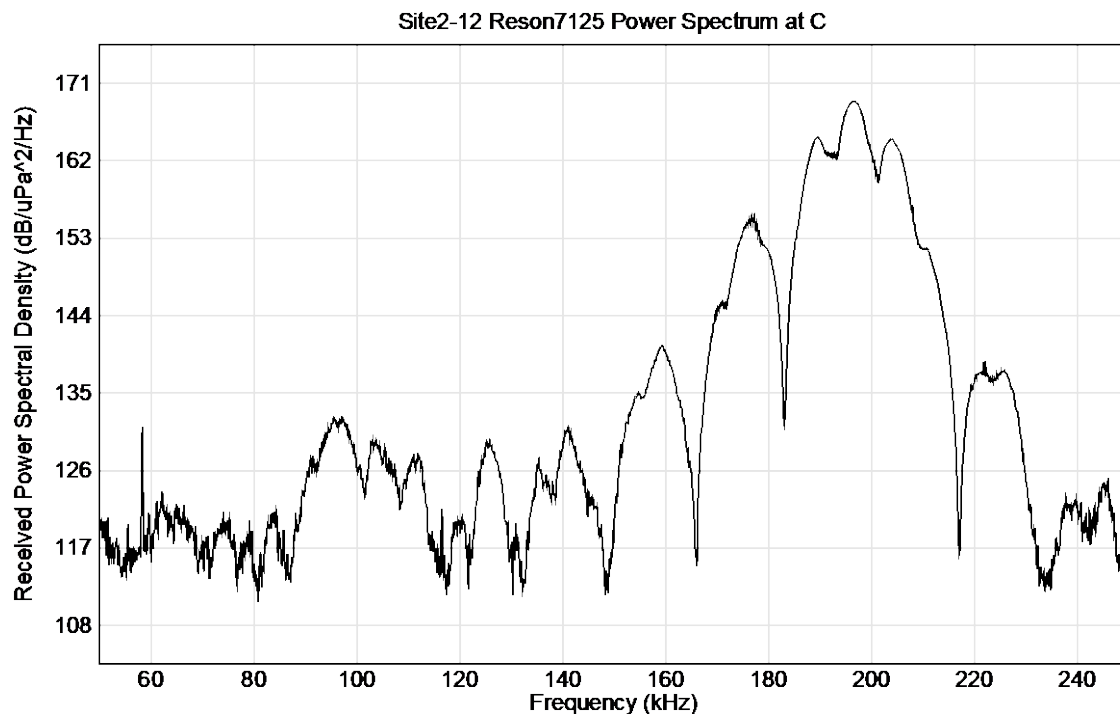


Figure 5-1. Reson 7125 Mode 1 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.1.1 Site 1 – Mud, 10-m Depth

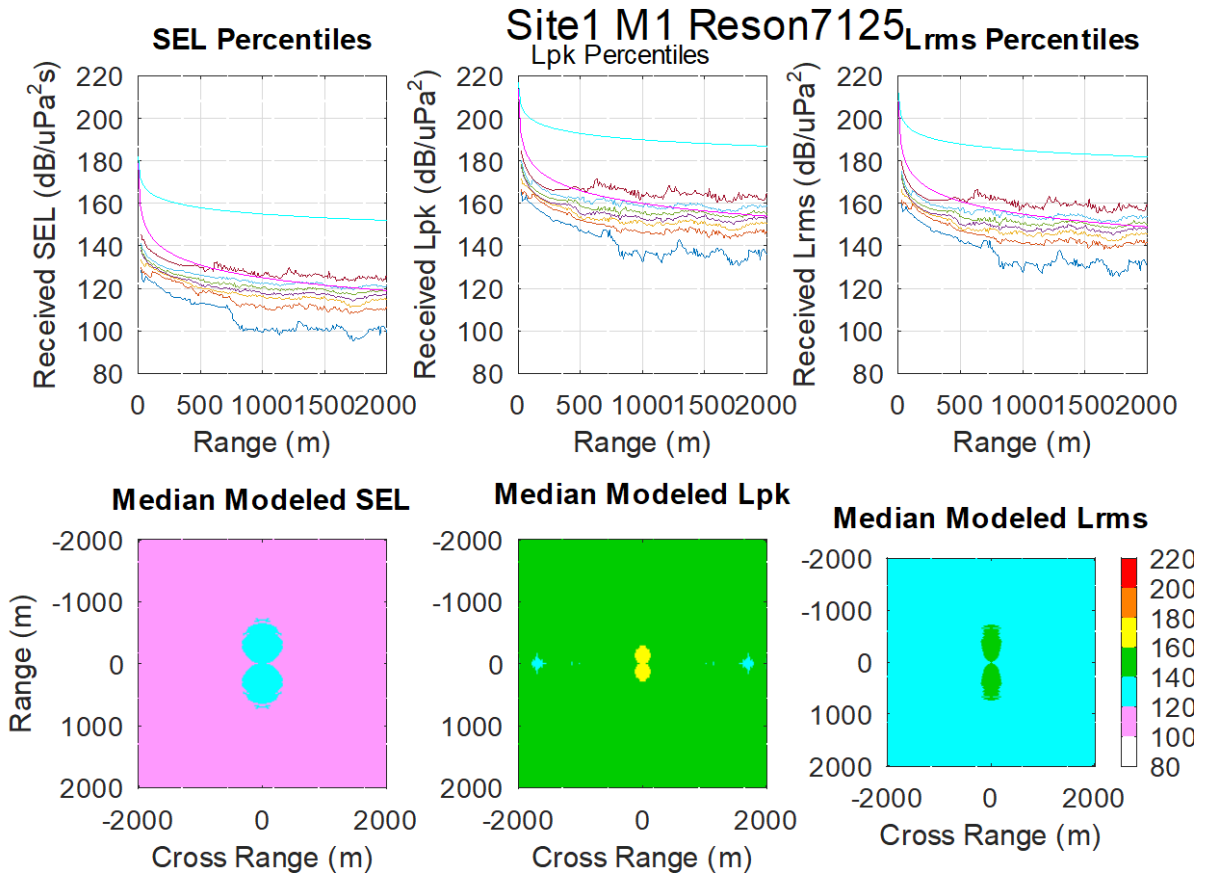


Figure 5-2. Reson 7125 Mode 1 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.1.2 Site 2 – Sand, 10-m Depth

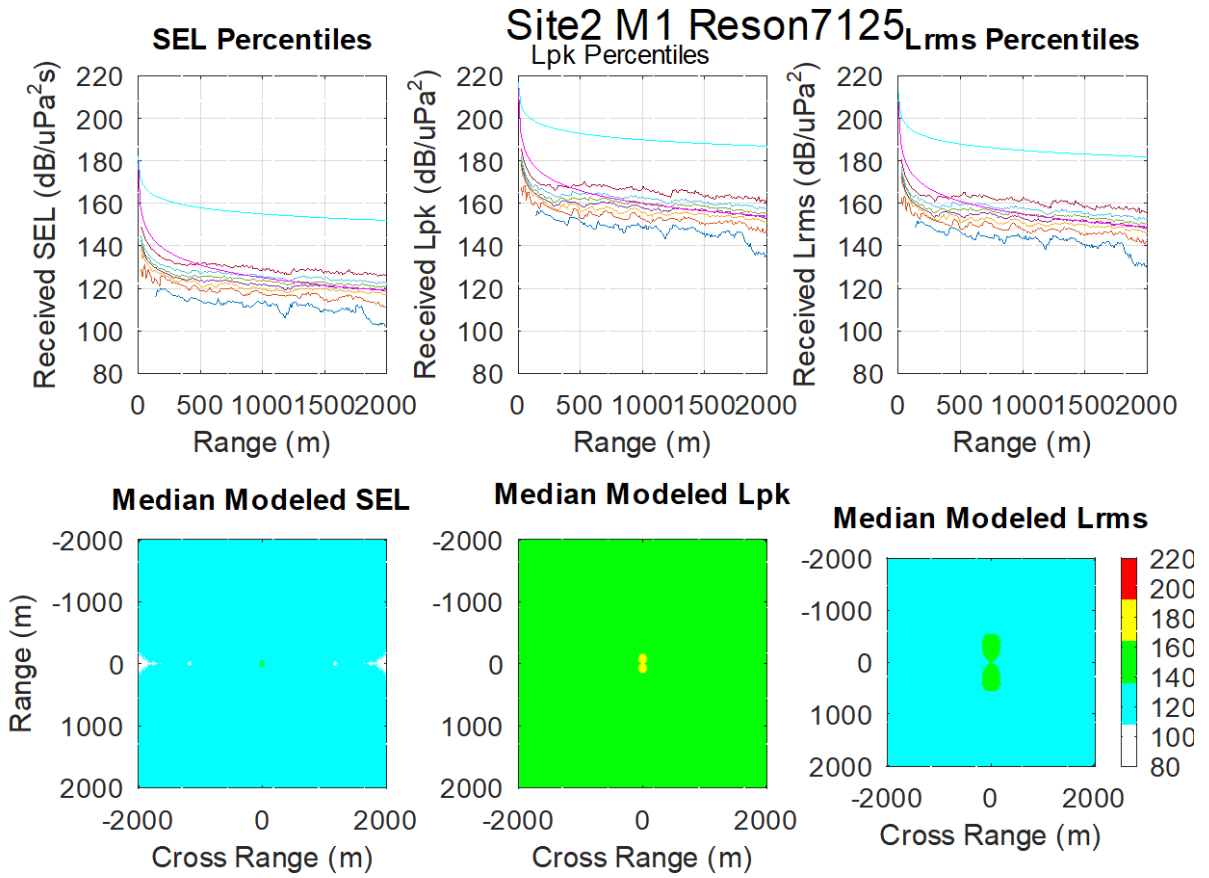


Figure 5-3. Reson 7125 Mode 1 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.1.3 Site 3 – Mud, 30-m Depth

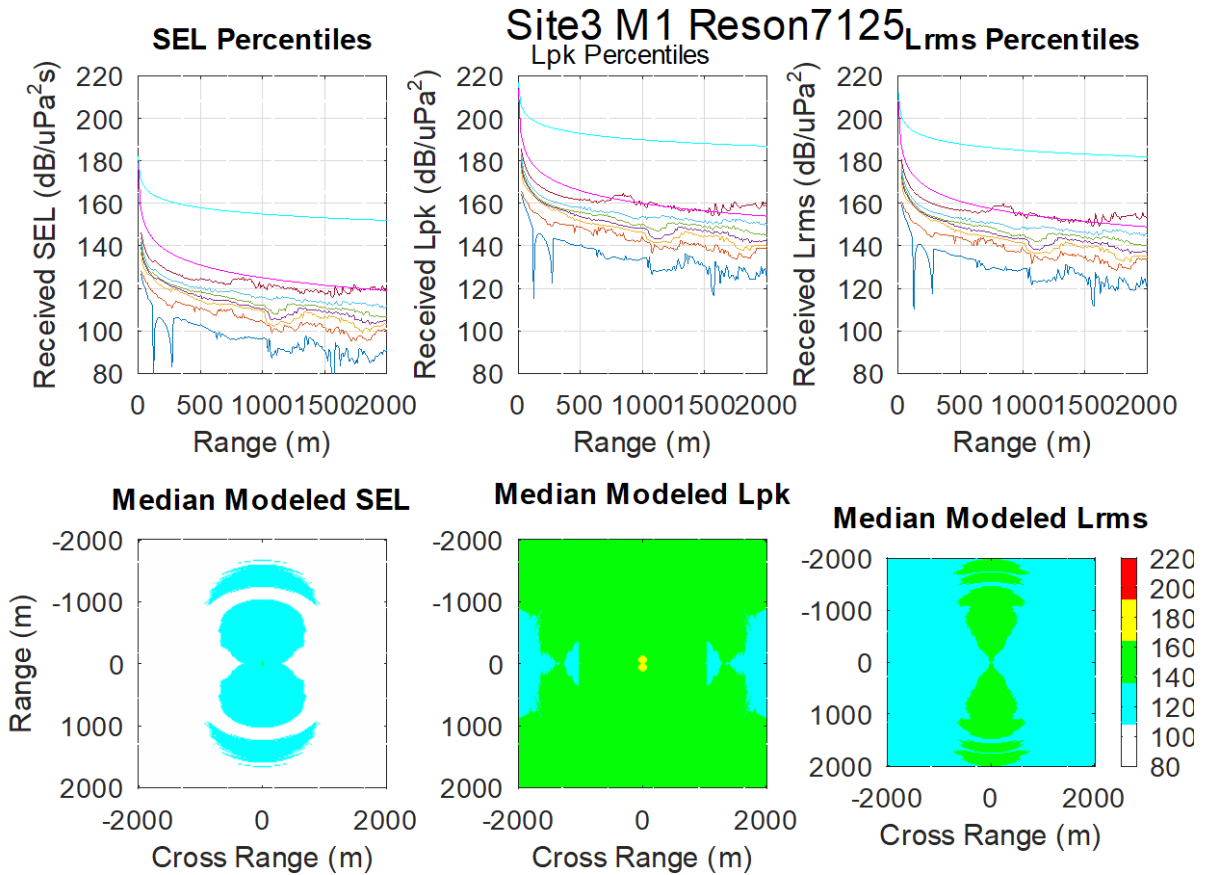


Figure 5-4. Reson 7125 Mode 1 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.1.4 Site 4 – Sand, 30-m Depth

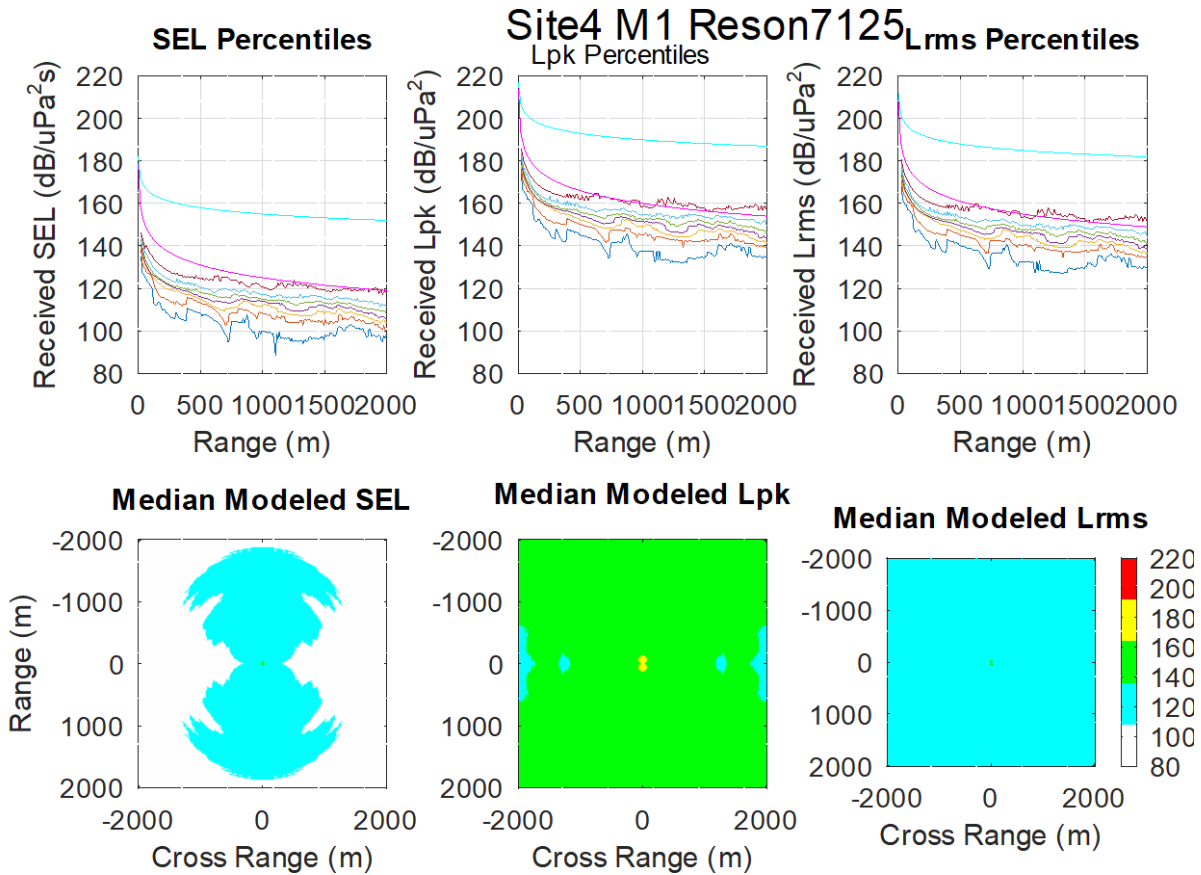


Figure 5-5. Reson 7125 Mode 1 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.1.5 Site 5 – Sandy Silt, 100-m Depth

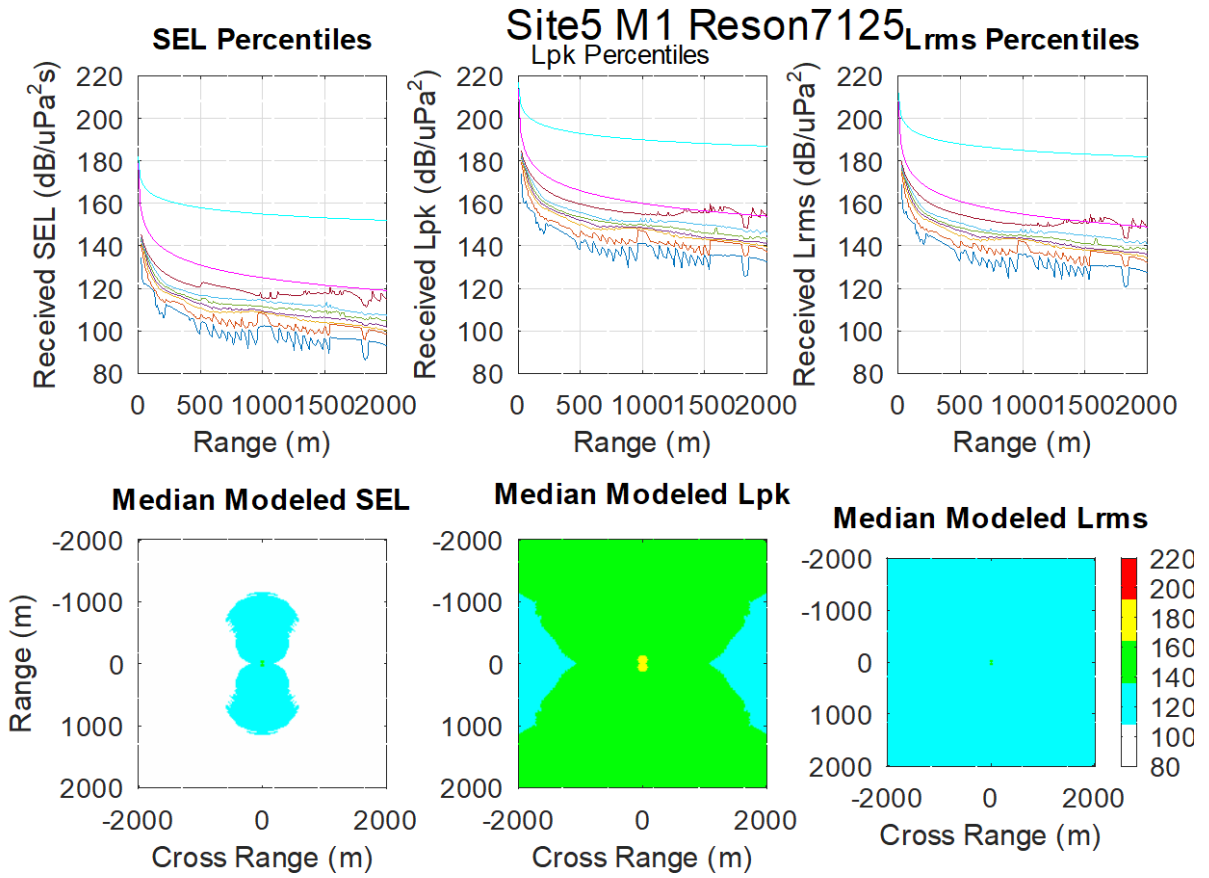


Figure 5-6. Reson 7125 Mode 1 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.2 Reson 7125, 200 kHz, 190 dB, 50 Percent Power (Mode 2)

The Reson 7125 multibeam echosounder generates a single VHF signal with a peak frequency at 200 kHz. The operational parameter settings for Mode 2 were a power setting of 190 dB for 50 percent power, 300- μ s pulse length, and 200-kHz output frequency. Measured source levels of the Reson T20P, as a proxy for the Reson 7125, are shown in **Table 5-2**.

Table 5-2. NUWC tank measurements of Reson T20P, as a proxy for Reson 7125 (Mode 2)

Source Settings			Source Level			
Power Level (%)	Power Level (dB)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
50	190	5	193	187	184	150

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-7**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-2**. Modeling results for each site are shown in **Figures 5-8 to 5-12**.

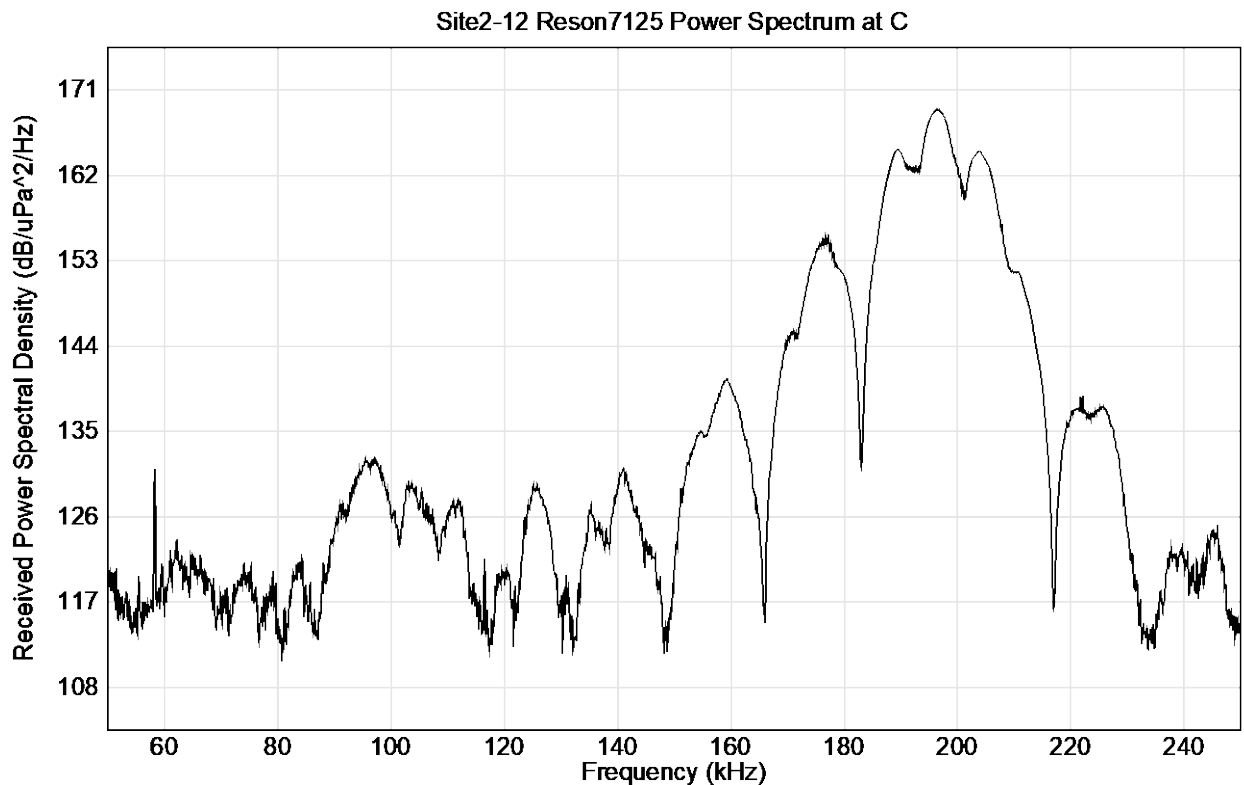


Figure 5-7. Reson 7125 Mode 2 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.2.1 Site 1 – Mud, 10-m Depth

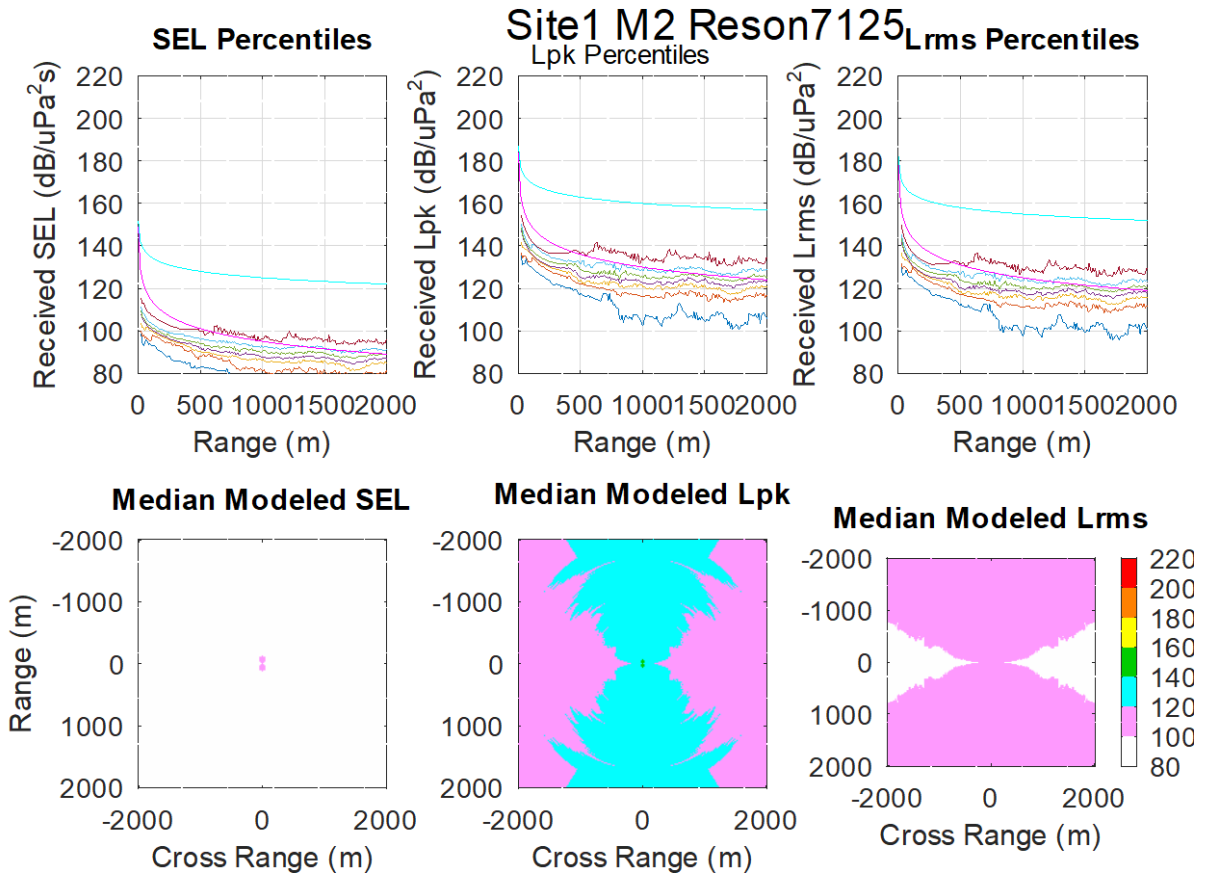


Figure 5-8. Reson 7125 Mode 2 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.2.2 Site 2 – Sand, 10-m Depth

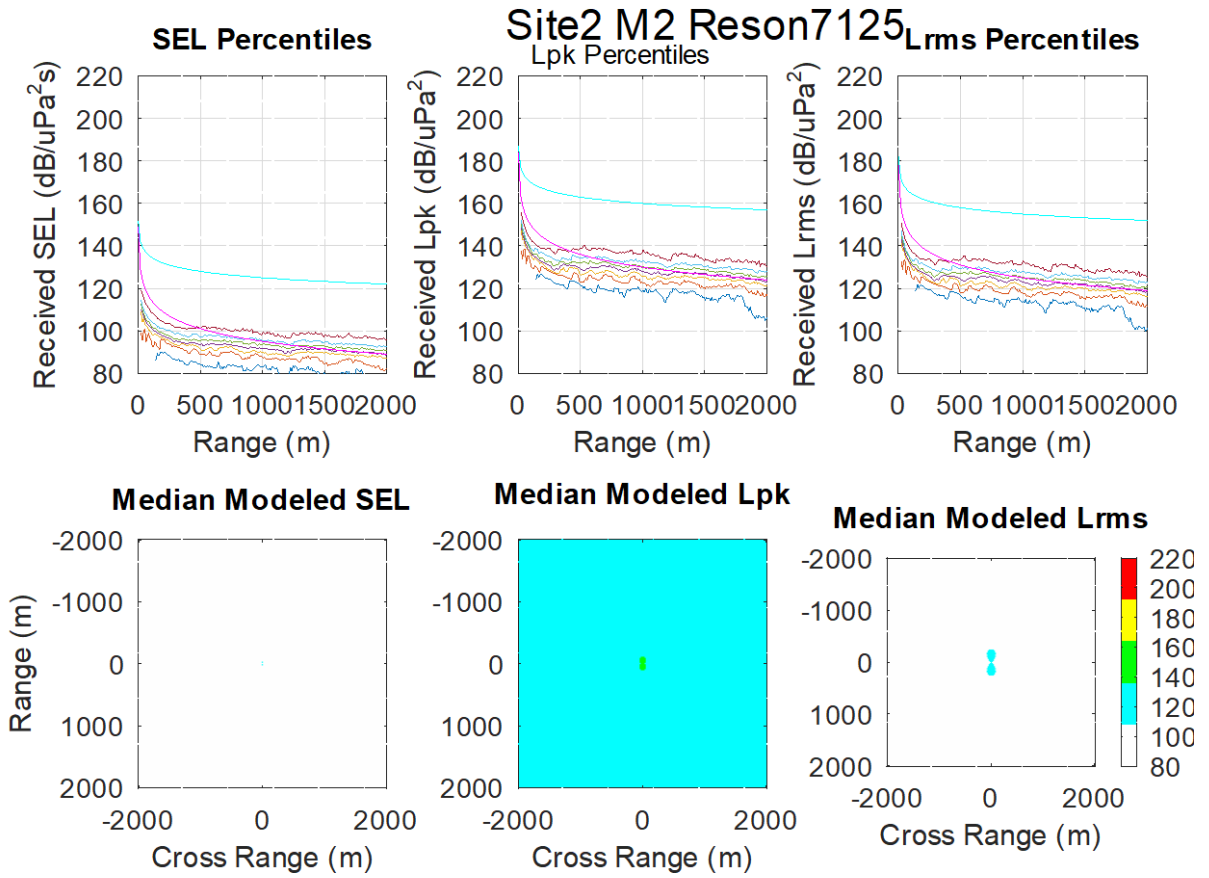


Figure 5-9. Reson 7125 Mode 2 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.2.3 Site 3 – Mud, 30-m Depth

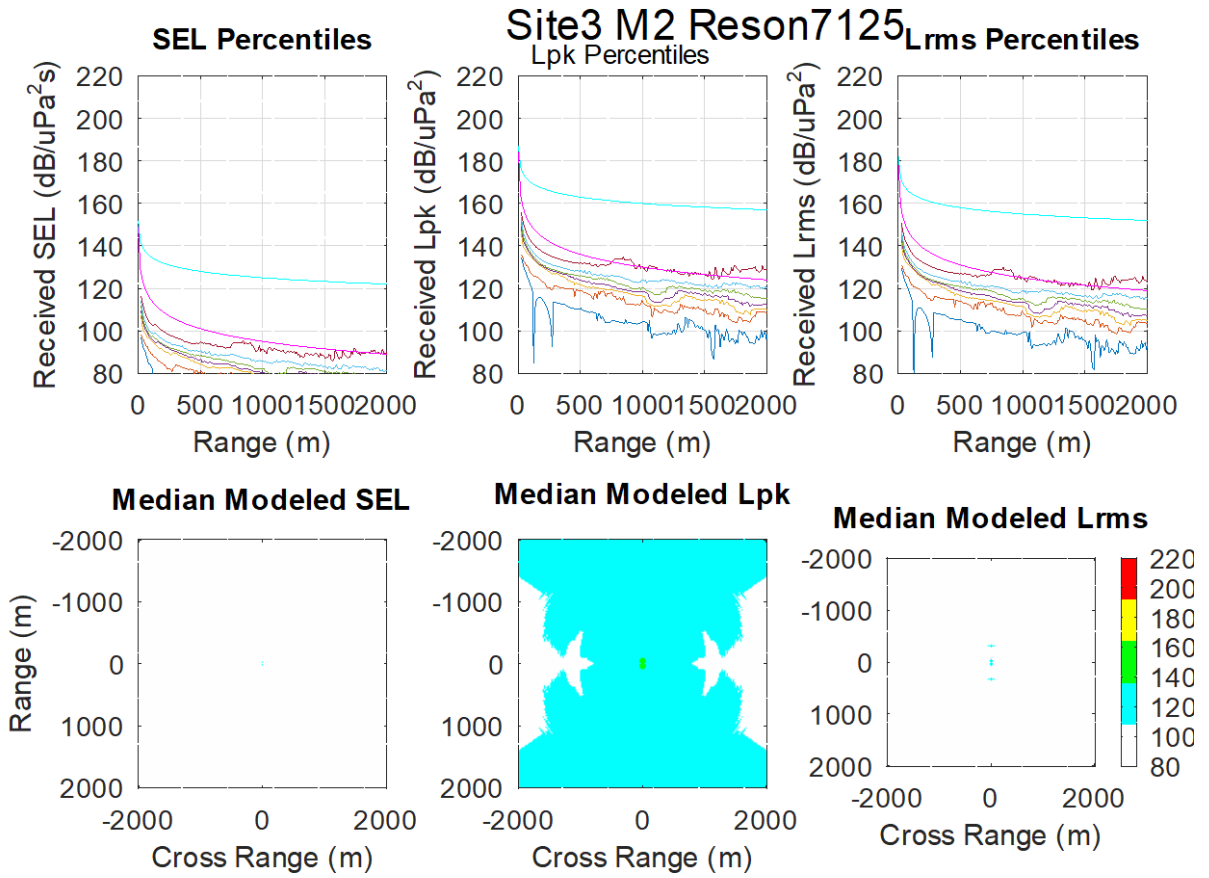


Figure 5-10. Reson 7125 Mode 2 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.2.4 Site 4 – Sand, 30-m Depth

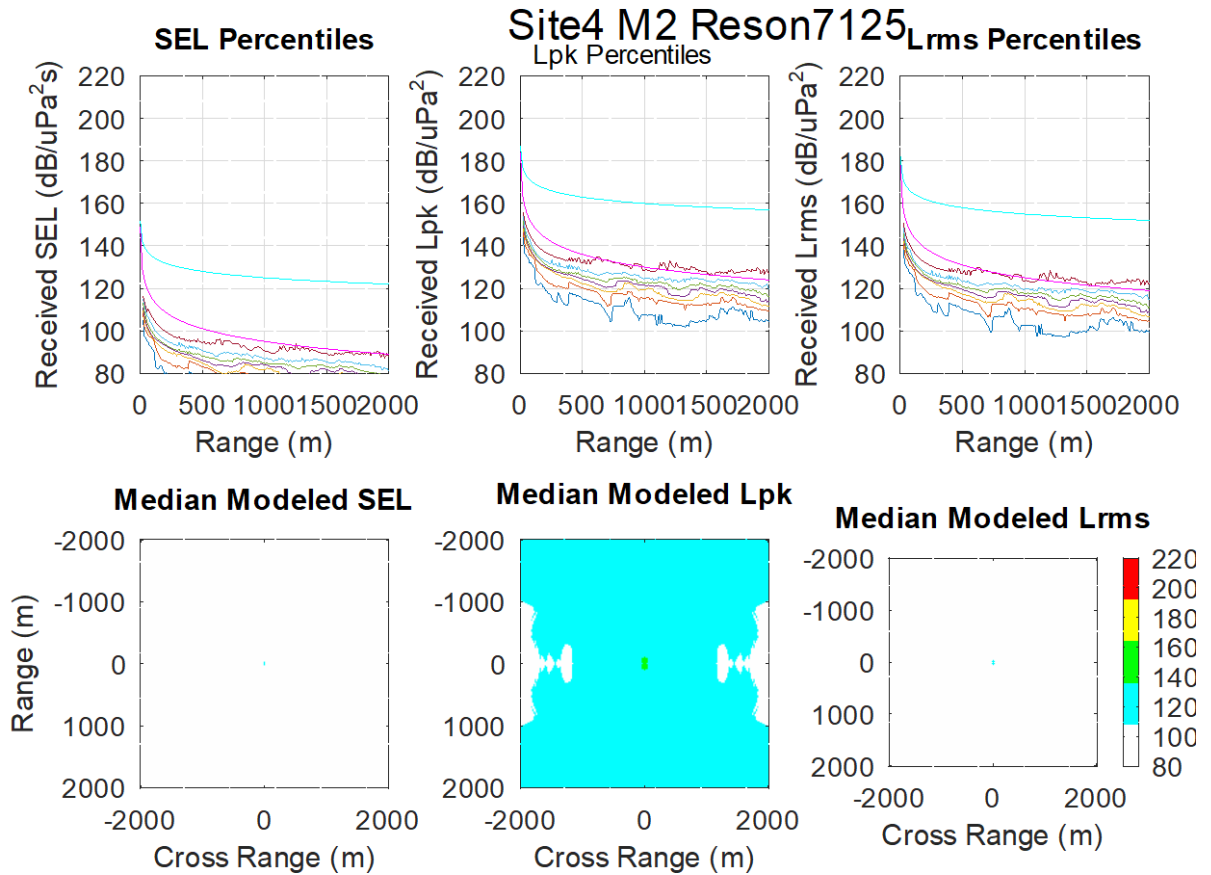


Figure 5-11. Reson 7125 Mode 2 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.2.5 Site 5 – Sandy Silt, 100-m Depth

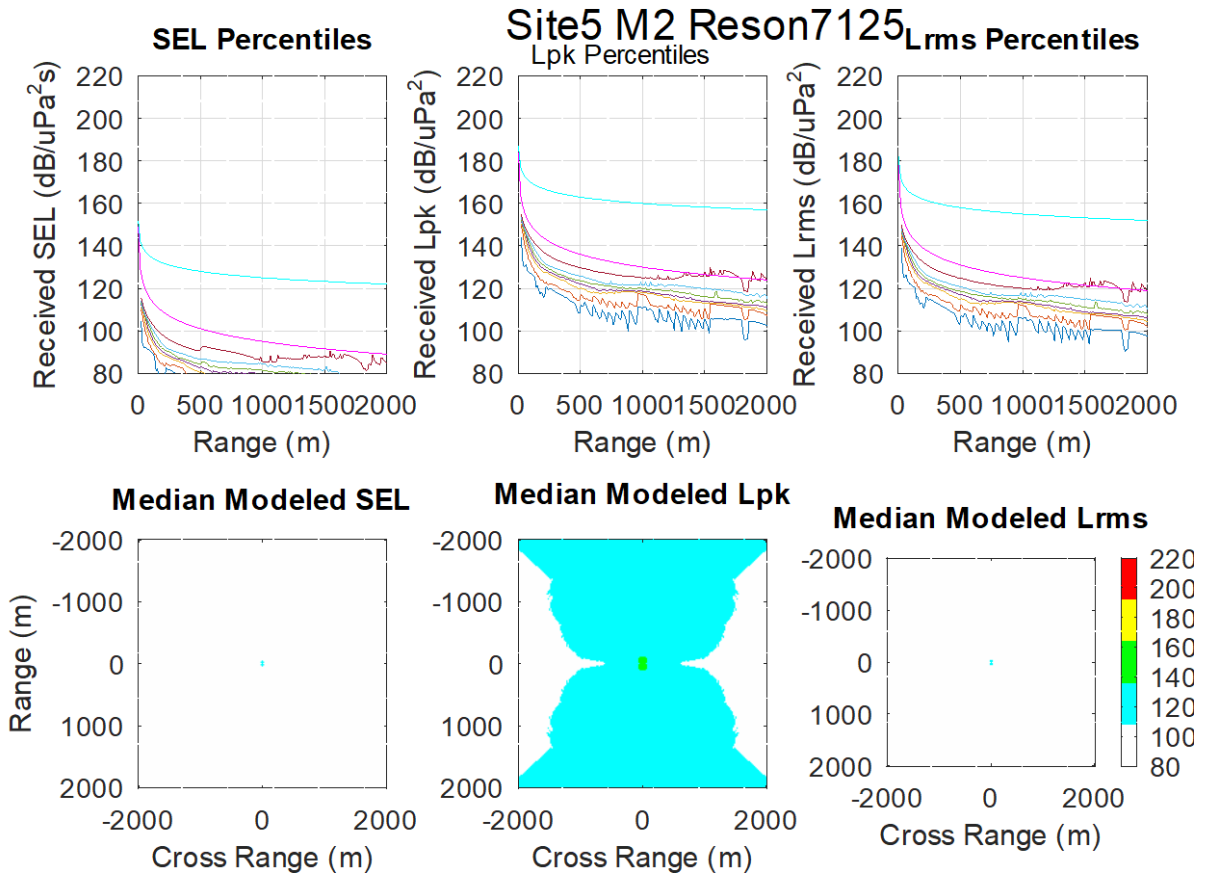


Figure 5-12. Reson 7125 Mode 2 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.3 Reson 7111, 100 kHz, 200 dB, 0.17-ms Pulse, 1.5° (Mode 3)

The Reson 7111 multibeam echosounder generates a single HF signal with a peak frequency at 100 kHz. The operational parameter settings for Mode 3 were a power setting of 200 dB, 0.17-millisecond (ms) pulse length, 1.5° beamwidth, and 100-kHz output frequency. Measured source levels are shown in **Table 5-3**.

Table 5-3. NUWC tank measurements of Reson 7111 (Mode 3)

Source Settings		Source Level			
Power Level (dB)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
200	2	201	196	190	152

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-13**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-3**. Modeling results for each site are shown in **Figures 5-14 to 5-18**.

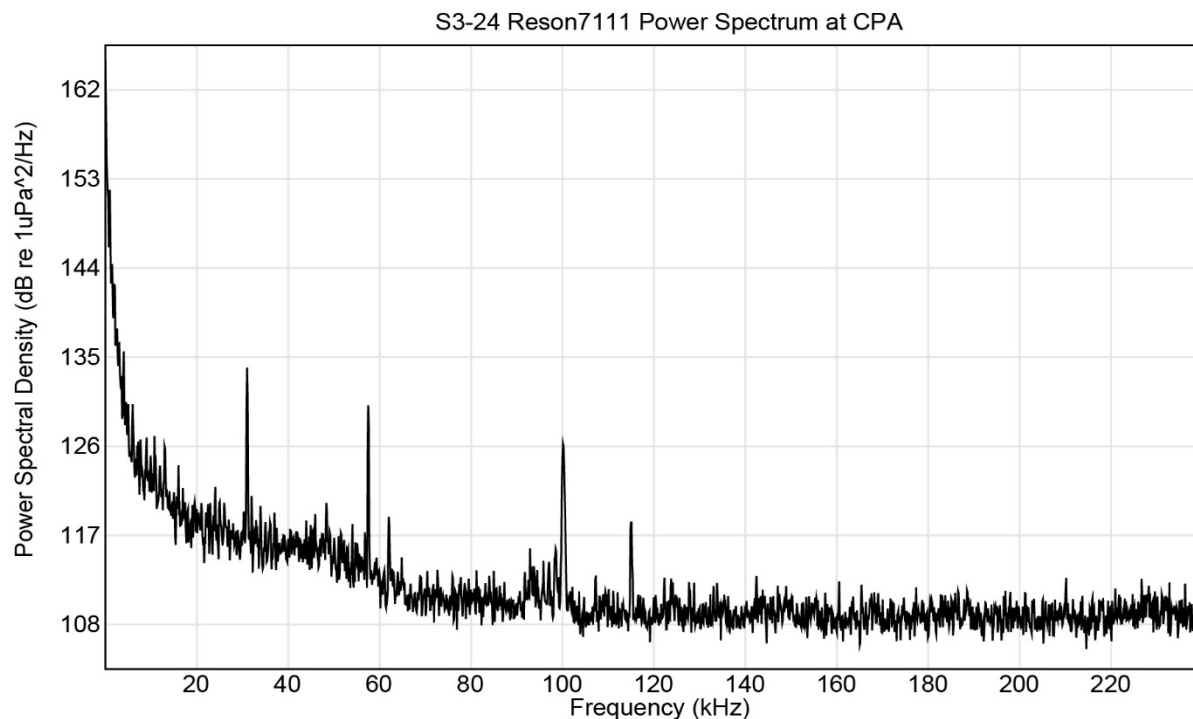


Figure 5-13. Reson 7111 Mode 3 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = with reference to.

5.3.1 Site 1 – Mud, 10-m Depth

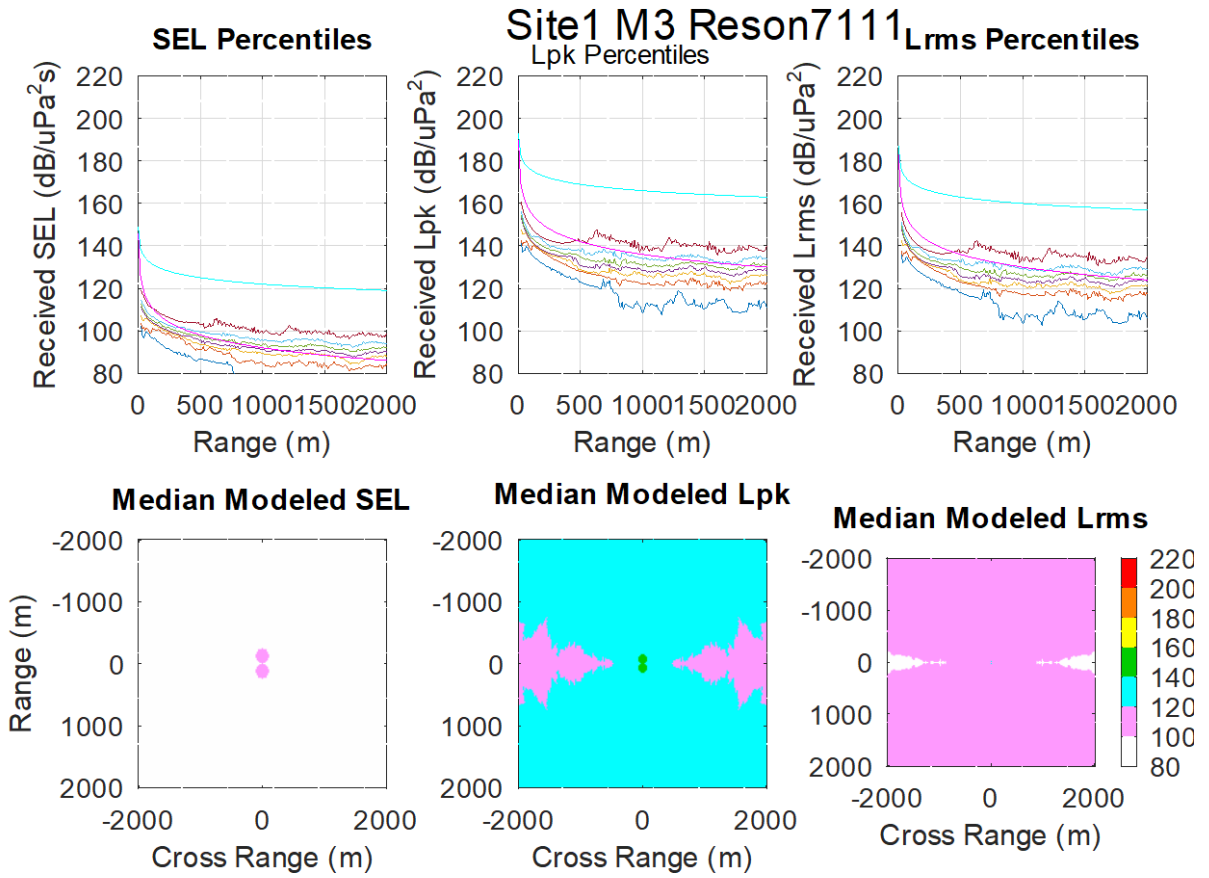


Figure 5-14. Reson 7111 Mode 3 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.3.2 Site 2 – Sand, 10-m Depth

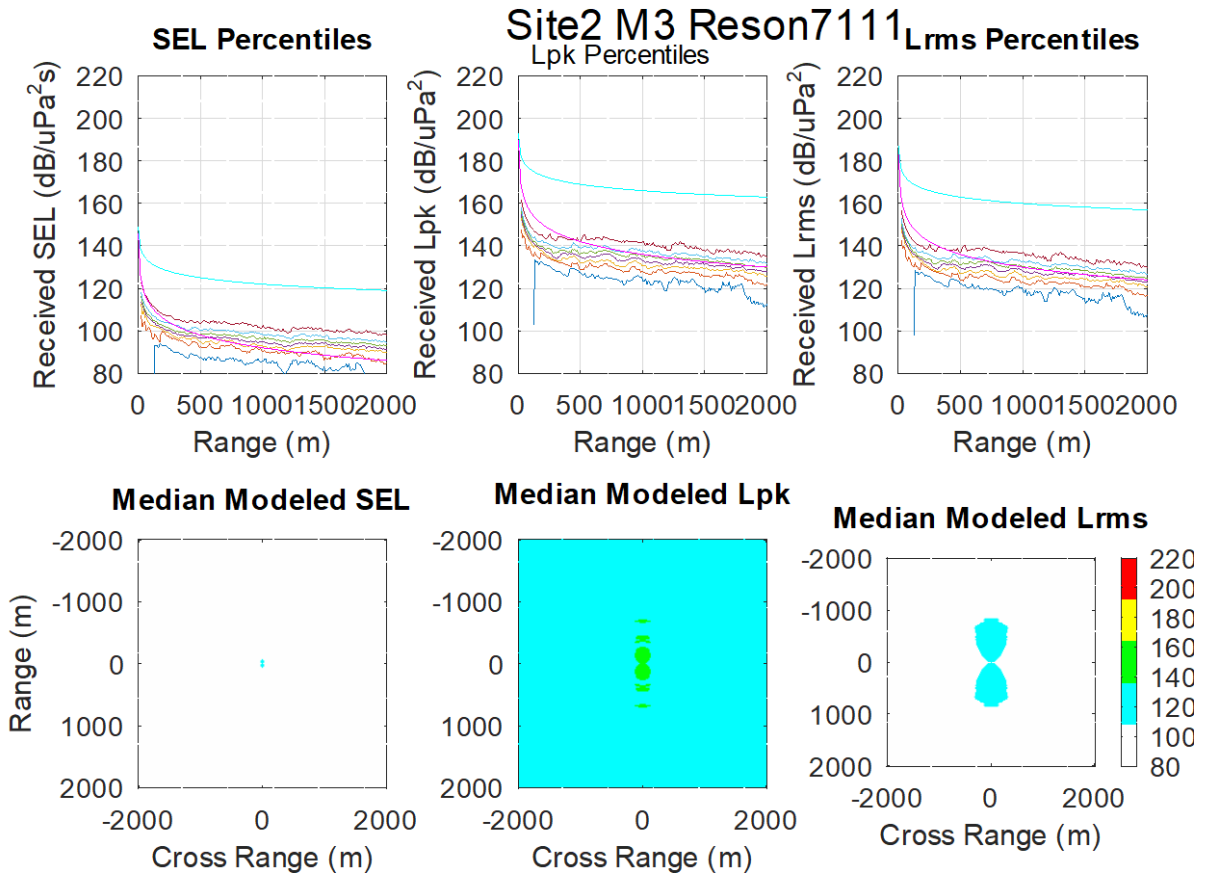


Figure 5-15. Reson 7111 Mode 3 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.3.3 Site 3 – Mud, 30-m Depth

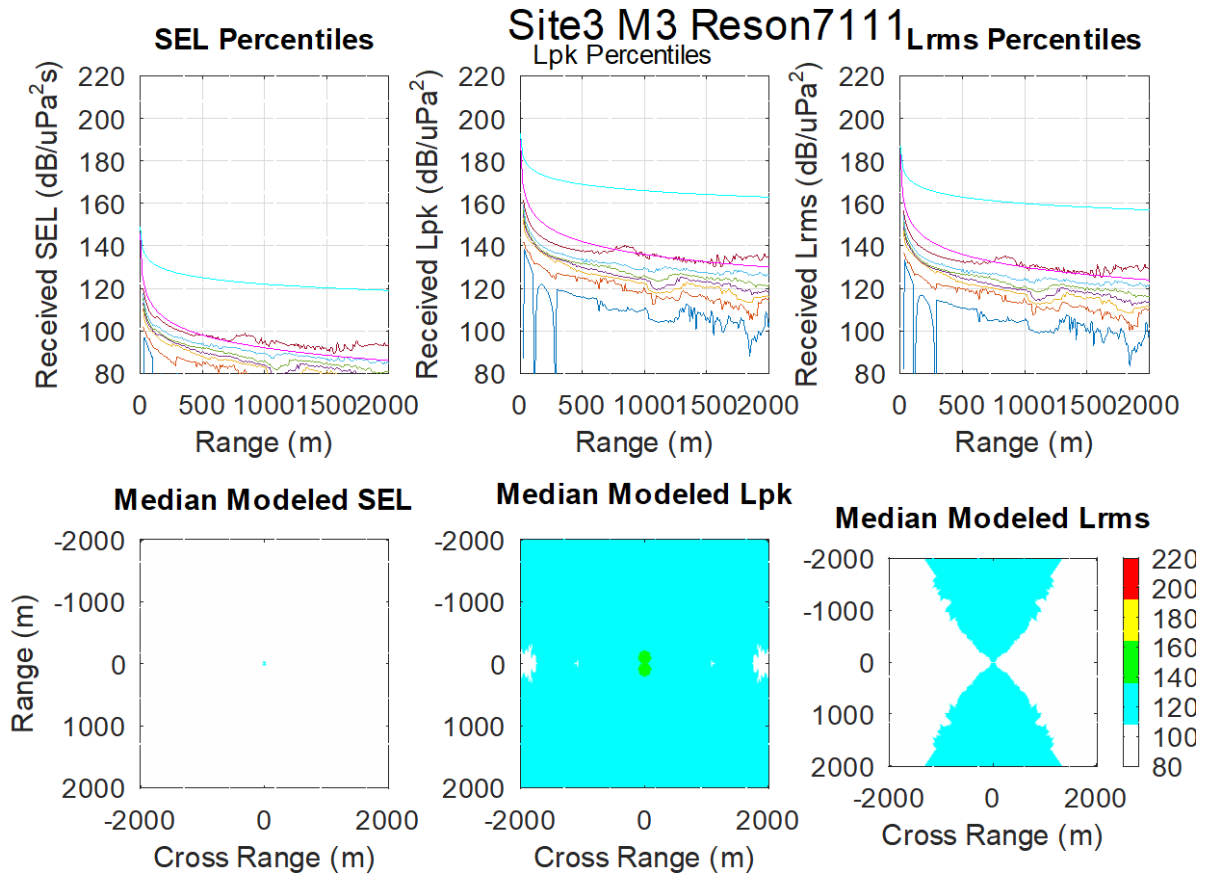


Figure 5-16. Reson 7111 Mode 3 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.3.4 Site 4 – Sand, 30-m Depth

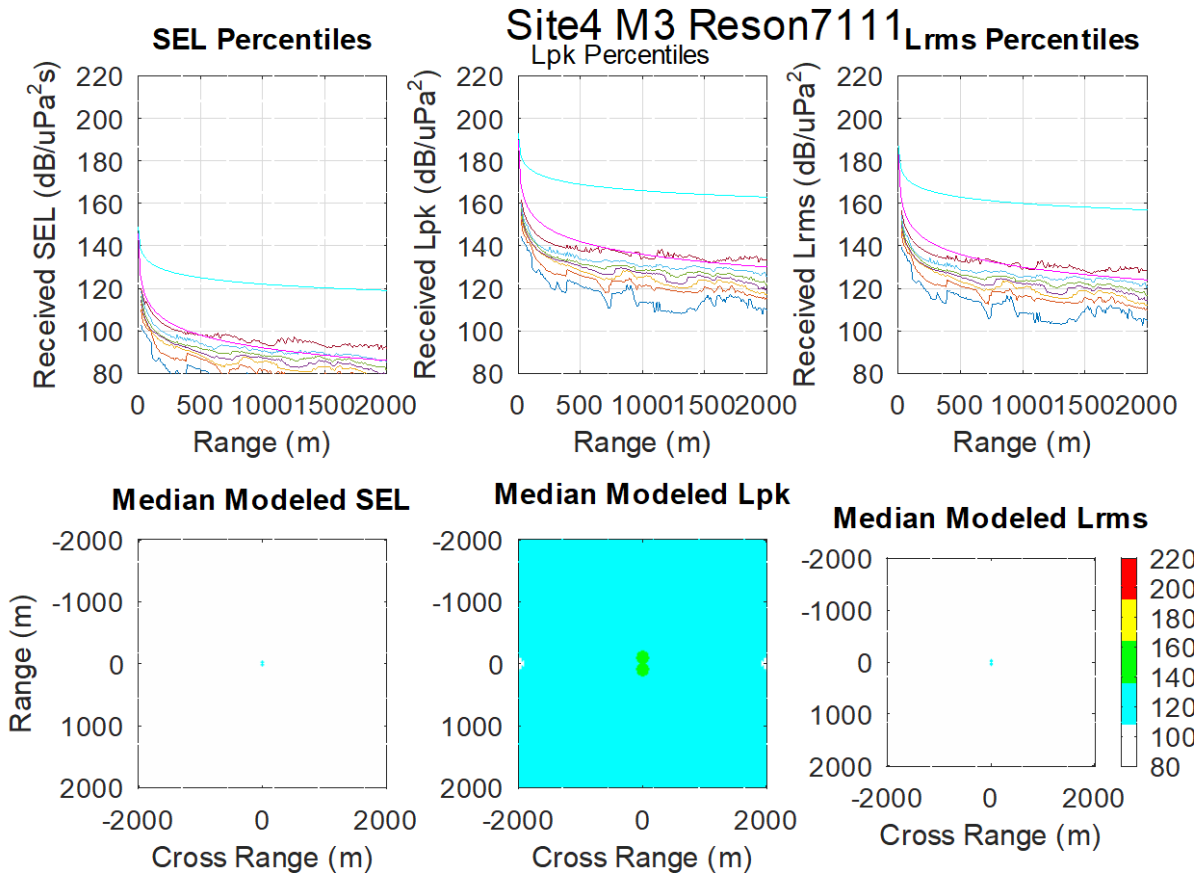


Figure 5-17. Reson 7111 Mode 3 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.3.5 Site 5 – Sandy Silt, 100-m Depth

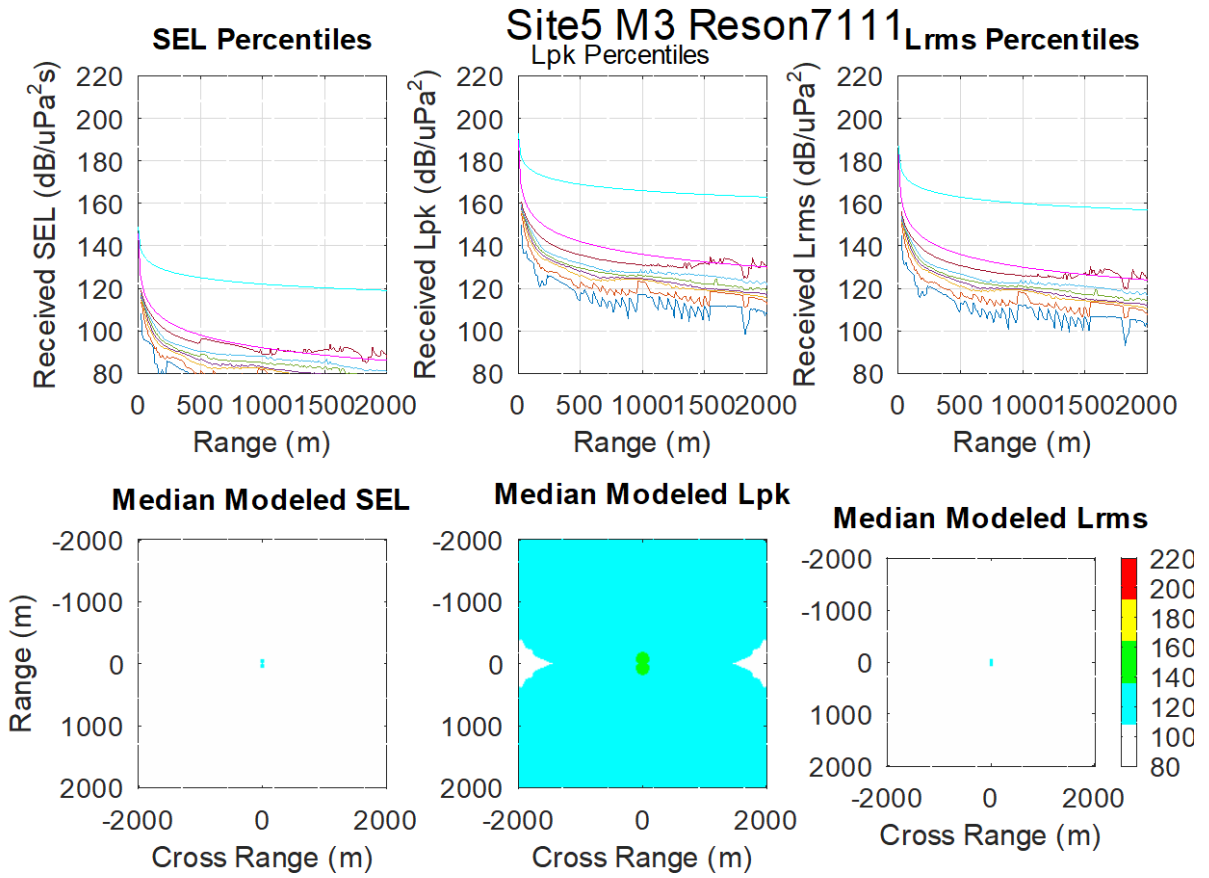


Figure 5-18. Reson 7111 Mode 3 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.4 Reson 7111, 100 kHz, 200 dB, 0.17-ms Pulse, 3° (Mode 4)

The Reson 7111 multibeam echosounder generates a single HF signal with a peak frequency of 100 kHz. The operational parameter settings for Mode 4 were a power setting of 200 dB, 0.17-ms pulse length, 3° beamwidth, and 100-kHz output frequency. Measured source levels are shown in **Table 5-4**.

Table 5-4. NUWC tank measurements of Reson 7111 (Mode 4)

Source Settings		Source Level			
Power Level (dB)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
200	2	206	200	196	158

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.

From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-19**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-4**. Modeling results for each site are shown in **Figures 5-20 to 5-24**.

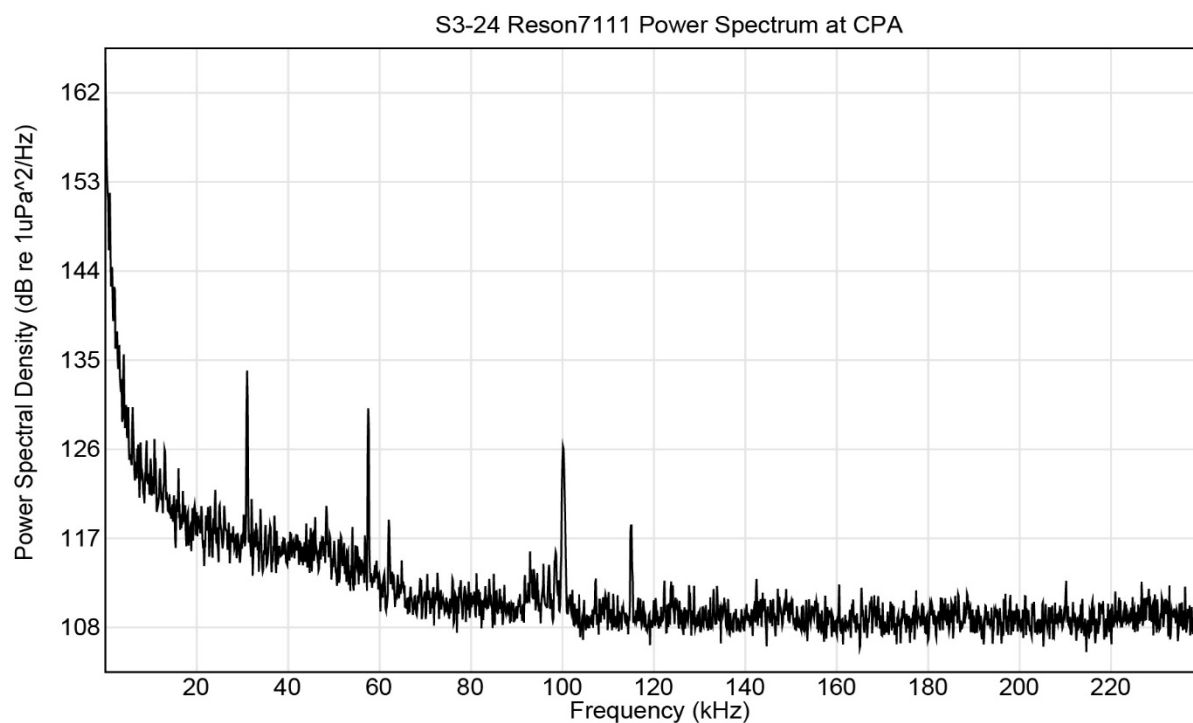


Figure 5-19. Reson 7111 Mode 4 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = with reference to.

5.4.1 Site 1 – Mud, 10-m Depth

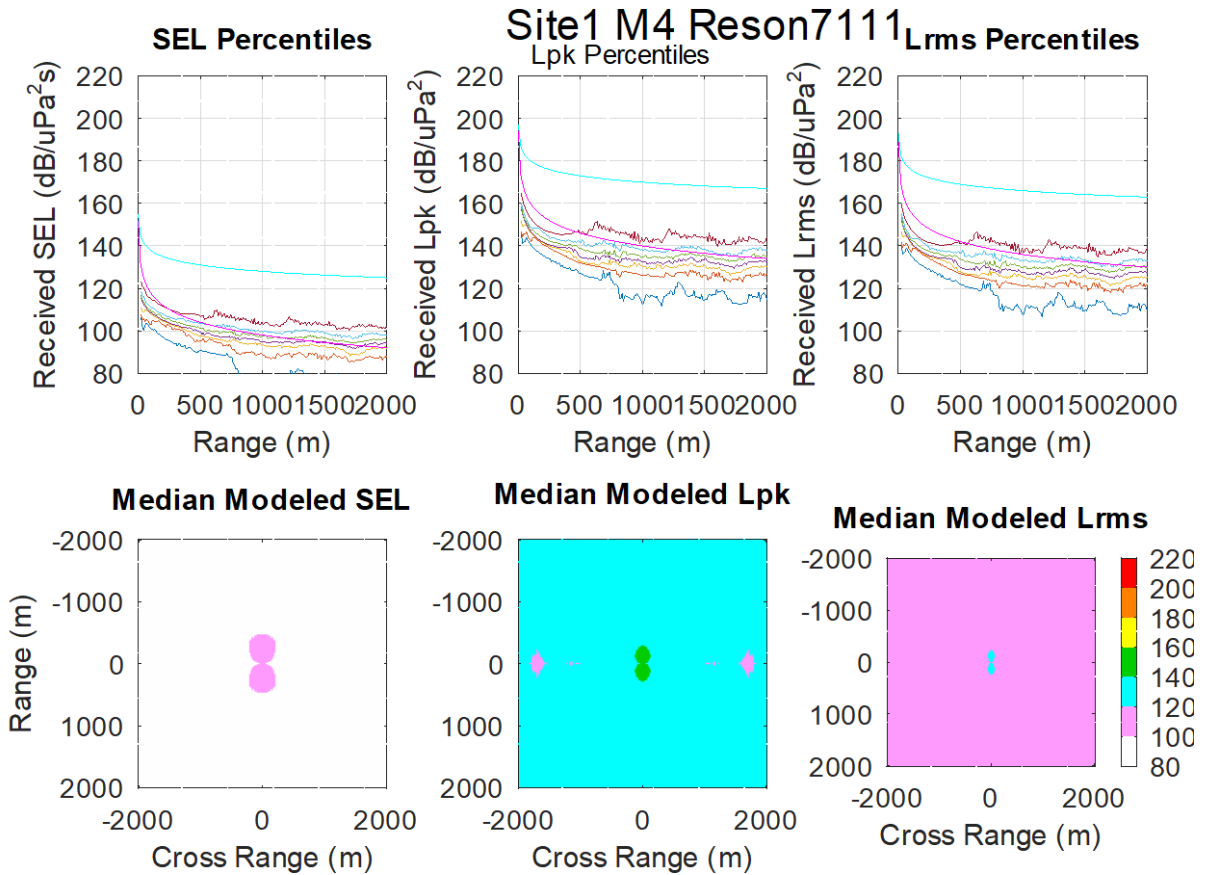


Figure 5-20. Reson 7111 Mode 4 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.4.2 Site 2 – Sand, 10-m Depth

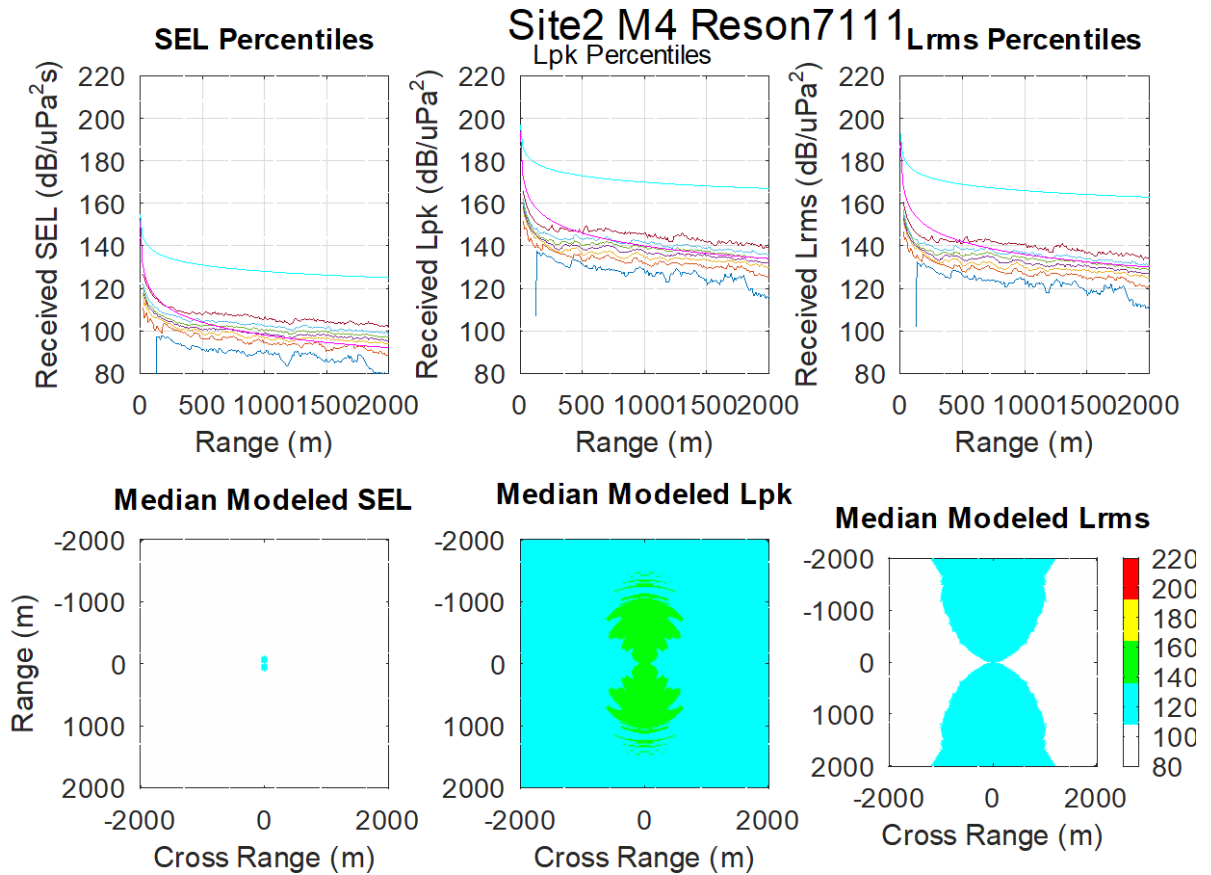


Figure 5-21. Reson 7111 Mode 4 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.4.3 Site 3 – Mud, 30-m Depth

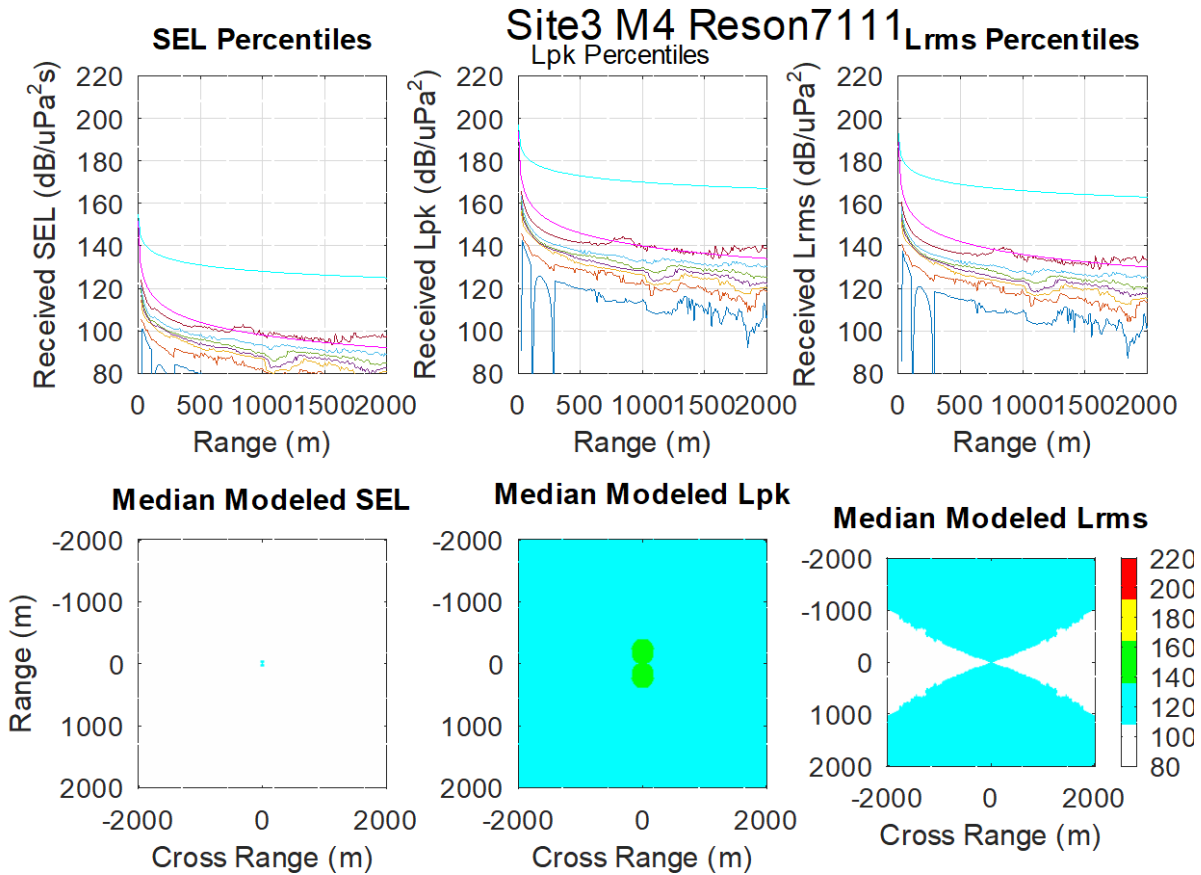


Figure 5-22. Reson 7111 Mode 4 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.4.4 Site 4 – Sand, 30-m Depth

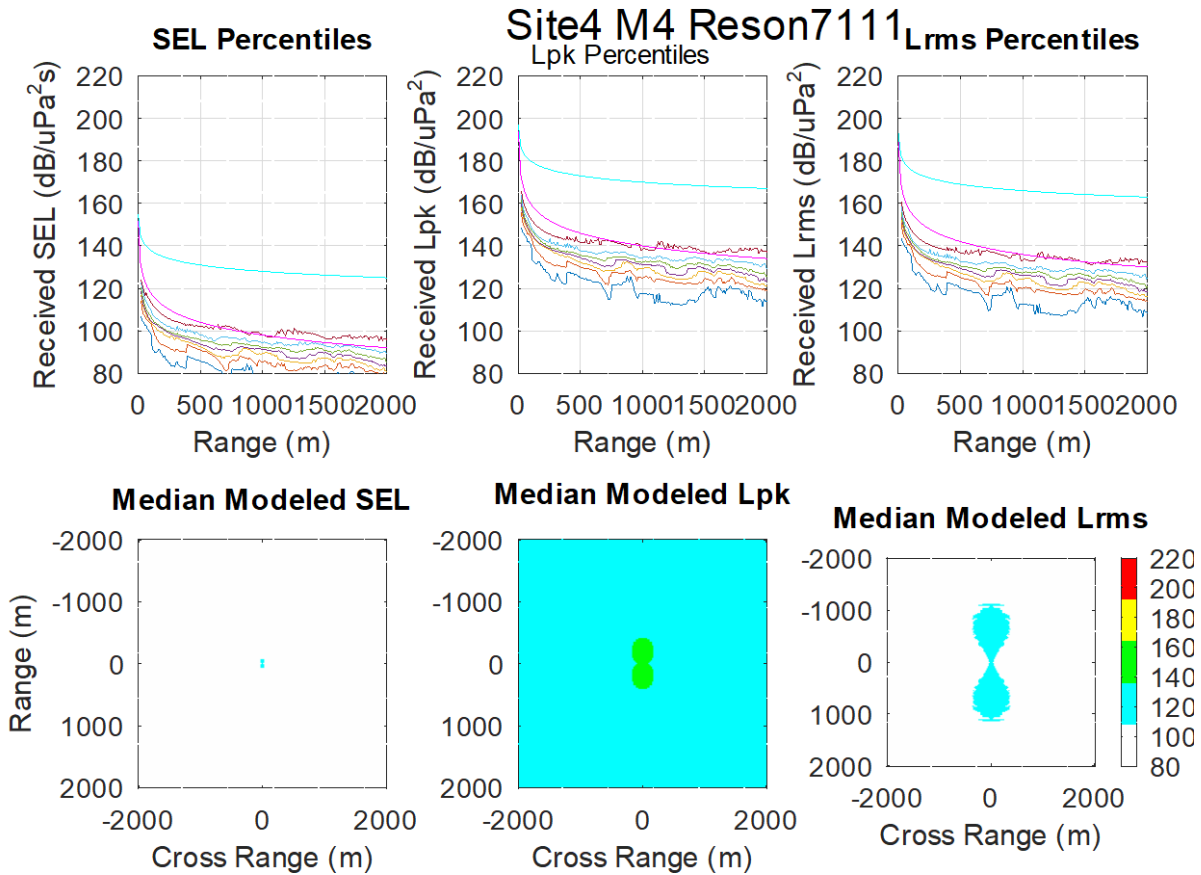


Figure 5-23. Reson 7111 Mode 4 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.4.5 Site 5 – Sandy Silt, 100-m Depth

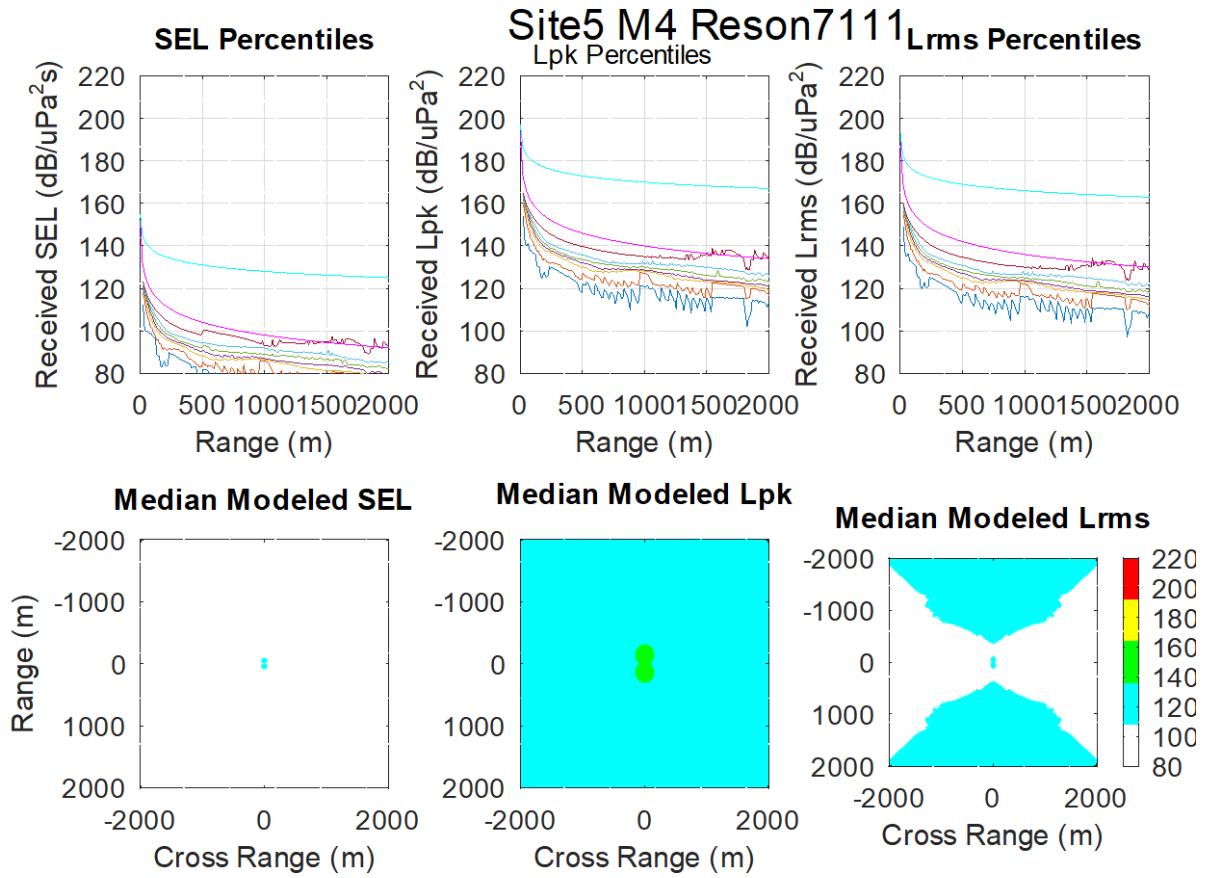


Figure 5-24. Reson 7111 Mode 4 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.5 Klein 3000, 132 kHz, 50- μ s Pulse, 400-ms Ping Rate, 400-m Range (Mode 5)

The Klein 3000 multibeam side-scan sonar generates a single HF signal with a peak frequency at 132 kHz. The operational parameter settings for Mode 5 were a 50- μ s pulse, 400-ms ping rate, and 400-m range. Measured source levels are shown in **Table 5-5**.

Table 5-5. NUWC tank measurements of Klein 3000 (Mode 5)

Source Settings				Source Level			
Frequency (kHz)	Pulse Width (μ s)	Range (m)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
132	50	400	5	230	223	220	176

μ Pa = micropascal; μ s = microsecond; dB = decibel; kHz = kilohertz; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-25**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-5**. Modeling results for each site are shown in **Figures 5-26 to 5-30**.

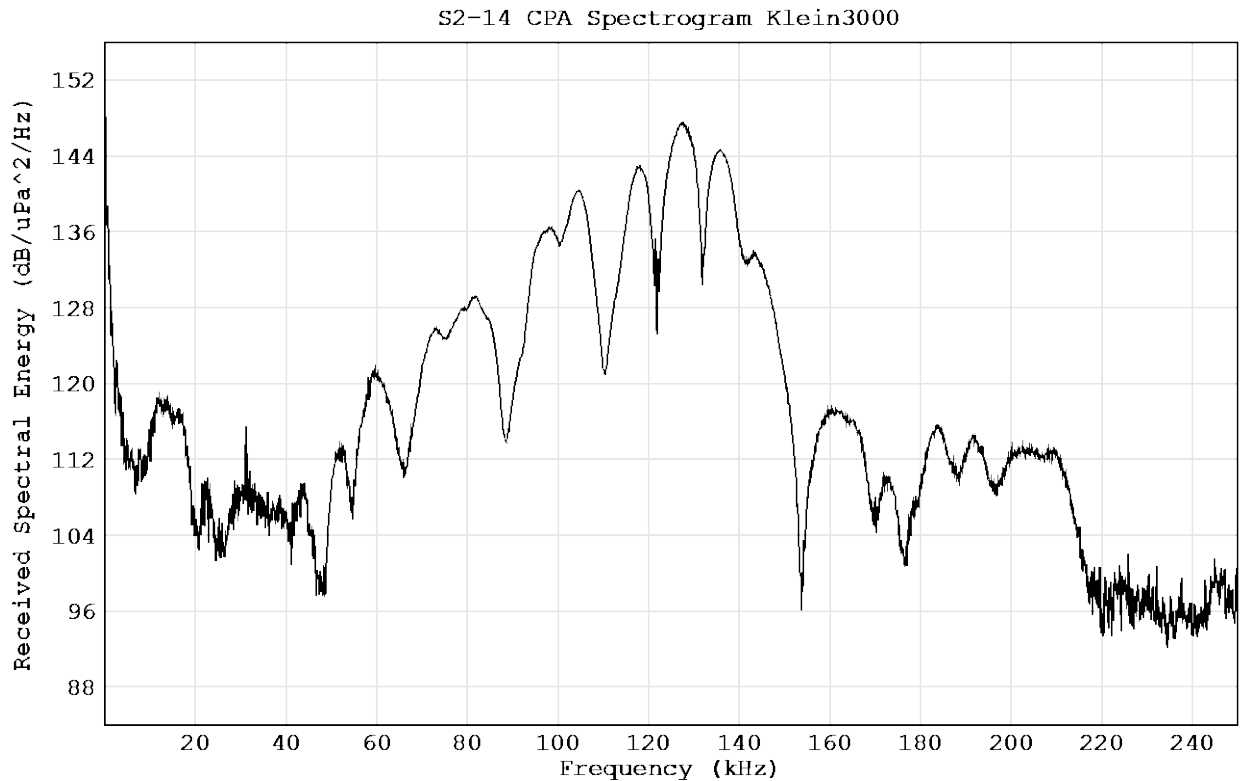


Figure 5-25. Klein 3000 Mode 5 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.5.1 Site 1 – Mud, 10-m Depth

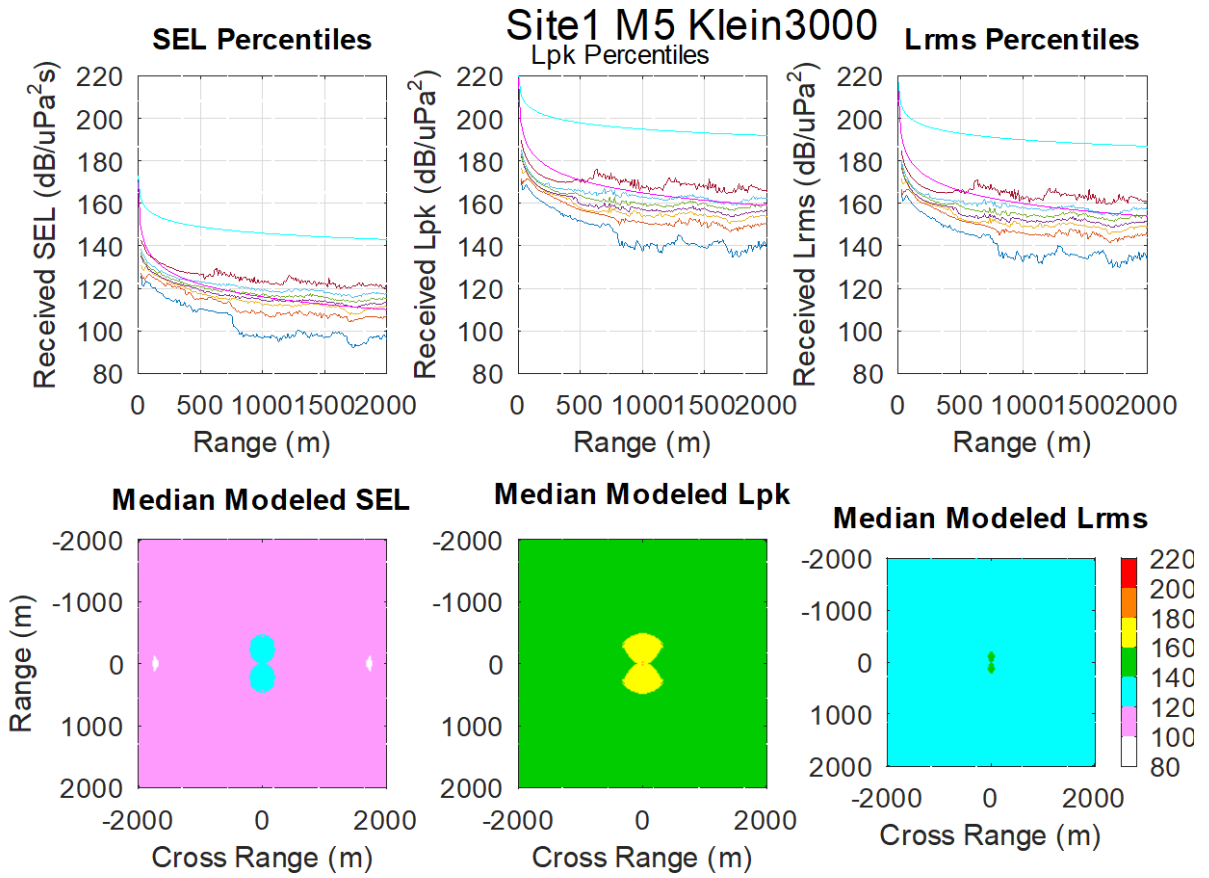


Figure 5-26. Klein 3000 Mode 5 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.5.2 Site 2 – Sand, 10-m Depth

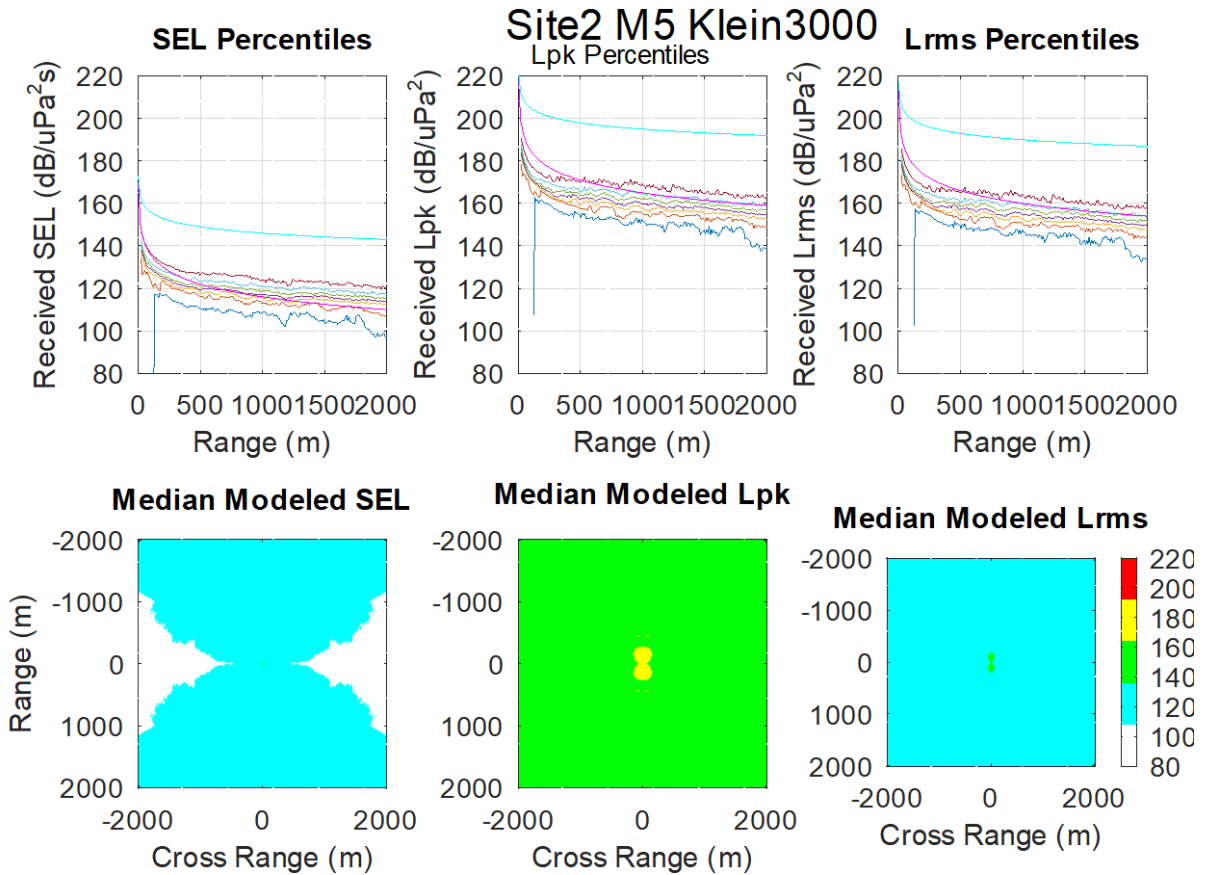


Figure 5-27. Klein 3000 Mode 5 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.5.3 Site 3 – Mud, 30-m Depth

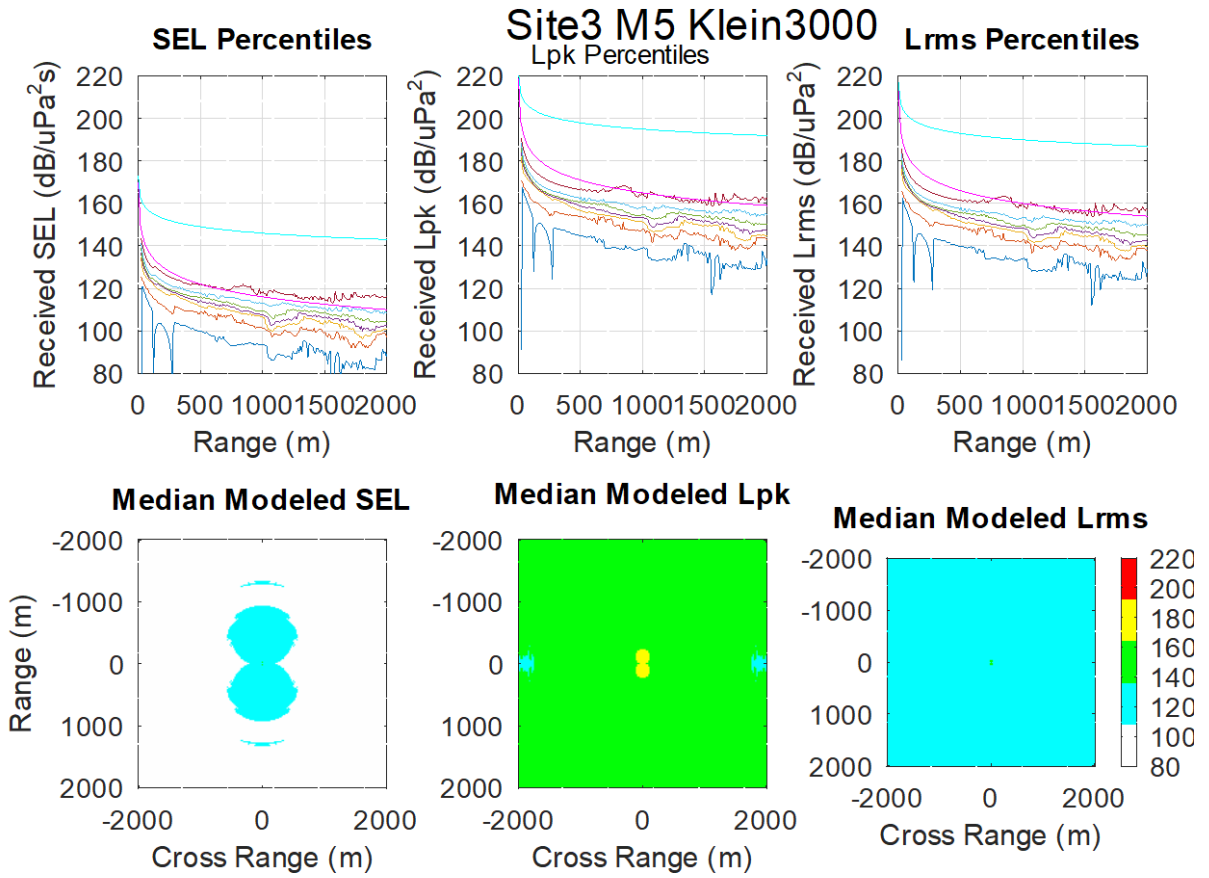


Figure 5-28. Klein 3000 Mode 5 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.5.4 Site 4 – Sand, 30-m Depth

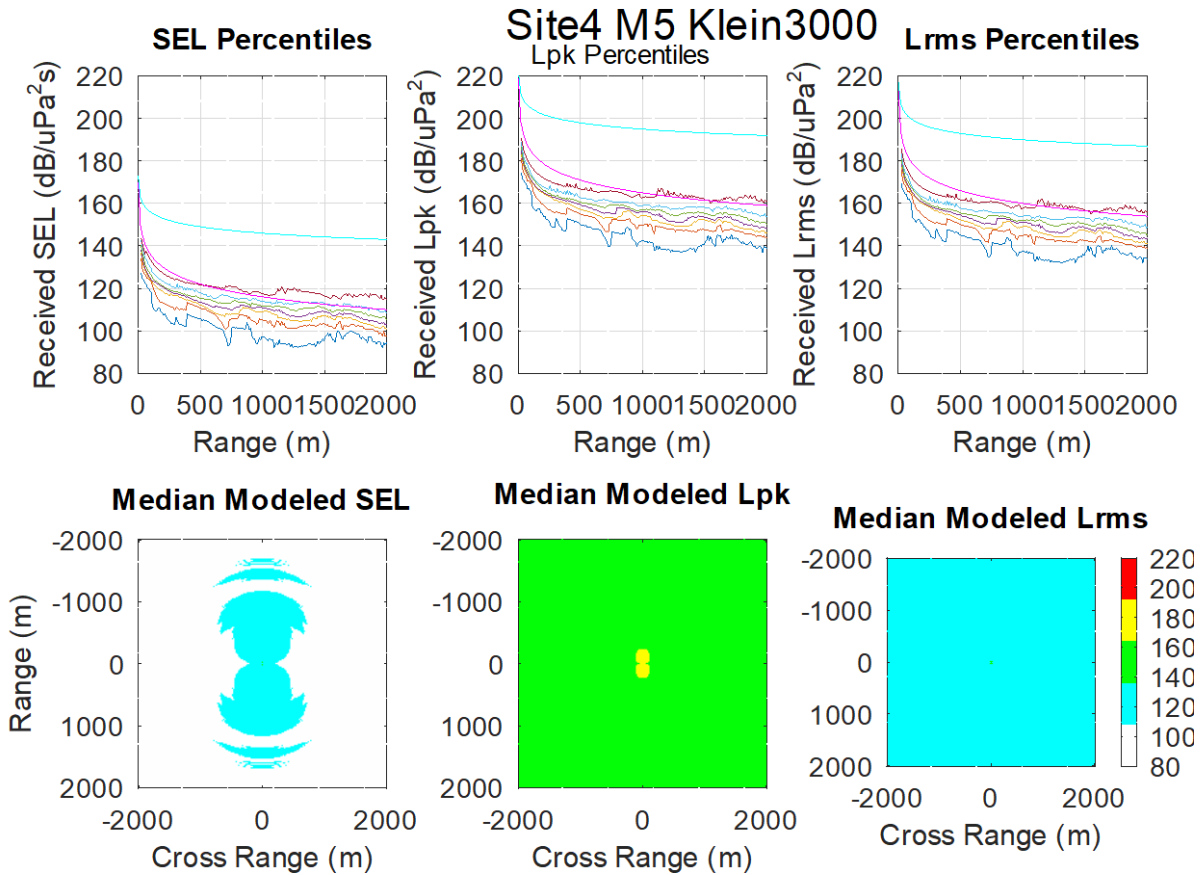


Figure 5-29. Klein 3000 Mode 5 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.5.5 Site 5 – Sandy Silt, 100-m Depth

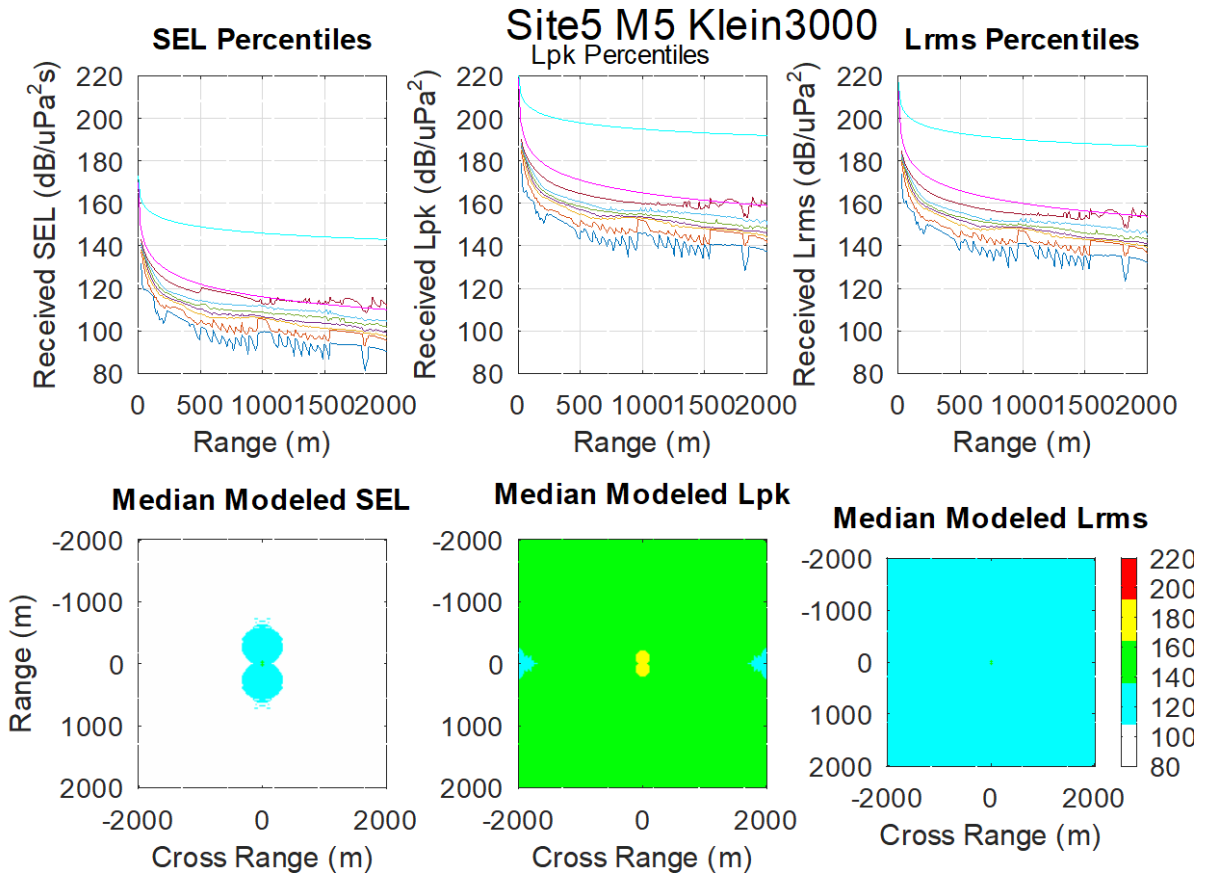


Figure 5-30. Klein 3000 Mode 5 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.6 Klein 3000, 132 kHz, 200- μ s Pulse, 400-ms Ping Rate, 200-m Range (Mode 6)

The Klein 3000 multibeam side-scan sonar generates a single HF signal with a peak frequency at 132 kHz. The operational parameter settings for Mode 6 were a 200- μ s pulse, 400-ms ping rate, and 200-m range. Measured source levels are shown in **Table 5-6**.

Table 5-6. NUWC tank measurements of Klein 3000 (Mode 6)

Source Settings				Source Level			
Frequency (kHz)	Pulse Width (μ s)	Range (m)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
132	200	200	5	230	225	220	182

μ Pa = micropascal; μ s = microsecond; dB = decibel; kHz = kilohertz; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-31**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-6**. Modeling results for each site are shown in **Figures 5-32 to 5-36**.

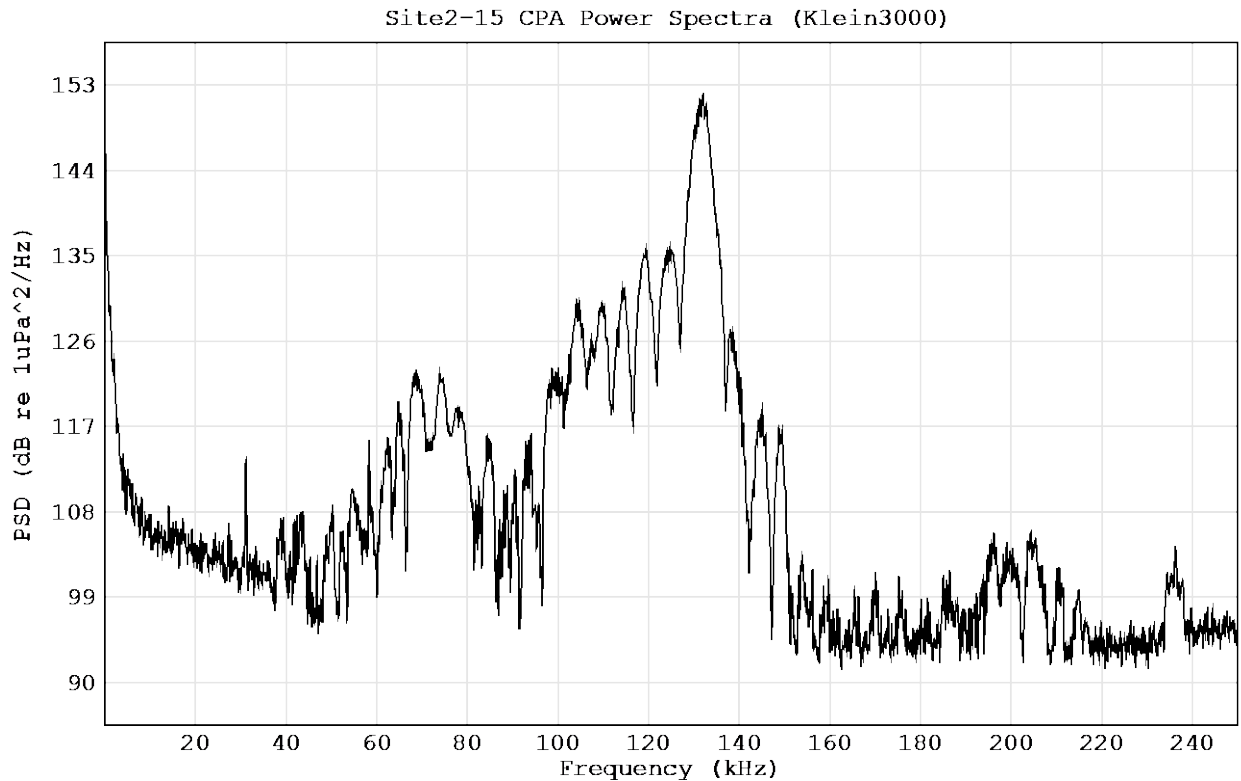


Figure 5-31. Klein 3000 Mode 6 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = with reference to.

5.6.1 Site 1 – Mud, 10-m Depth

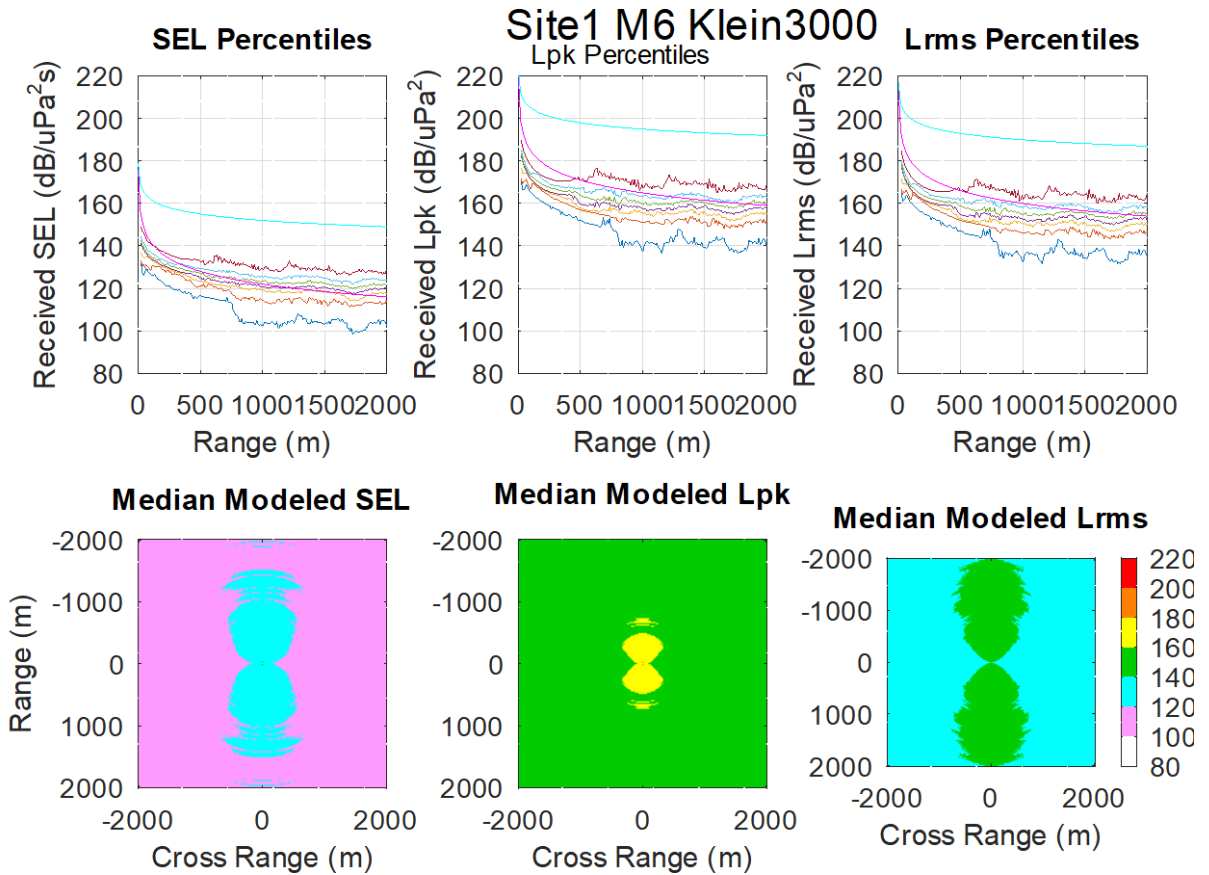


Figure 5-32. Klein 3000 Mode 6 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.6.2 Site 2 – Sand, 10-m Depth

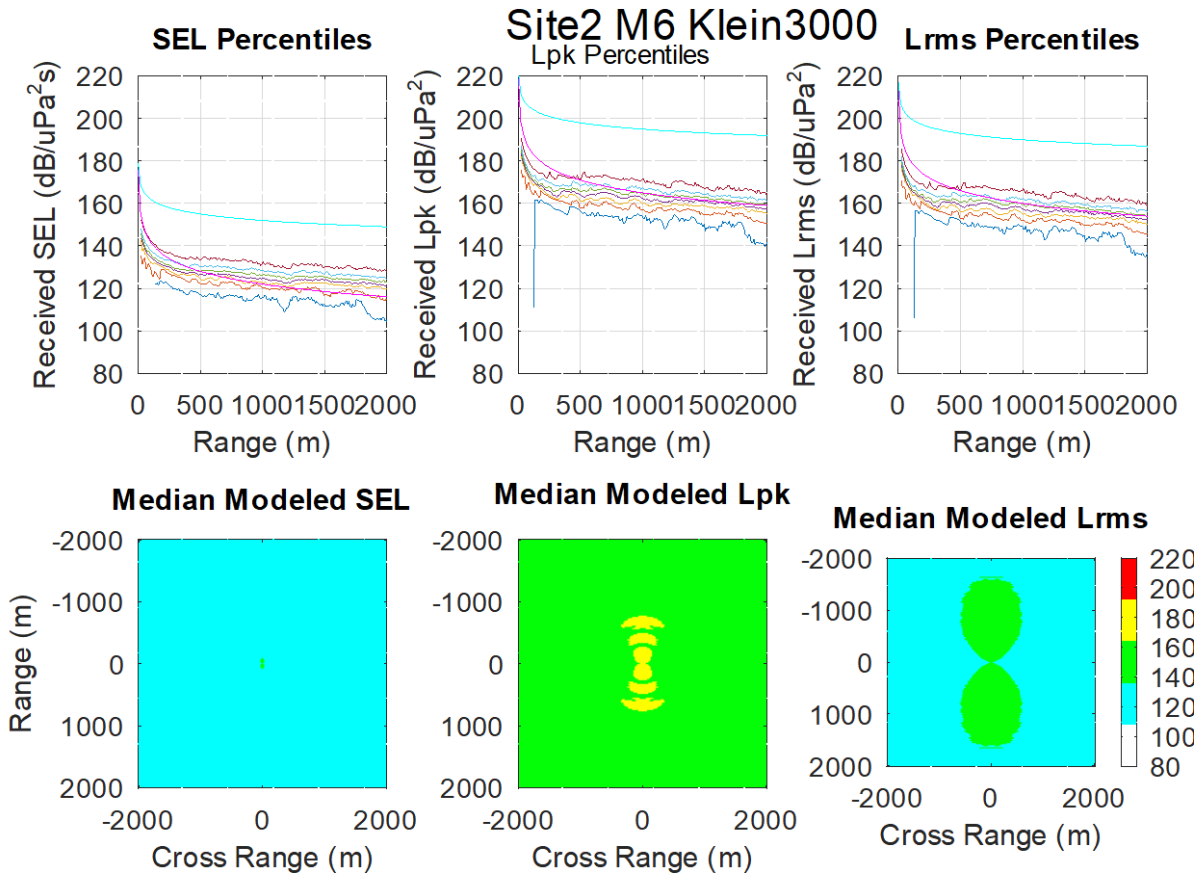


Figure 5-33. Klein 3000 Mode 6 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.6.3 Site 3 – Mud, 30-m Depth

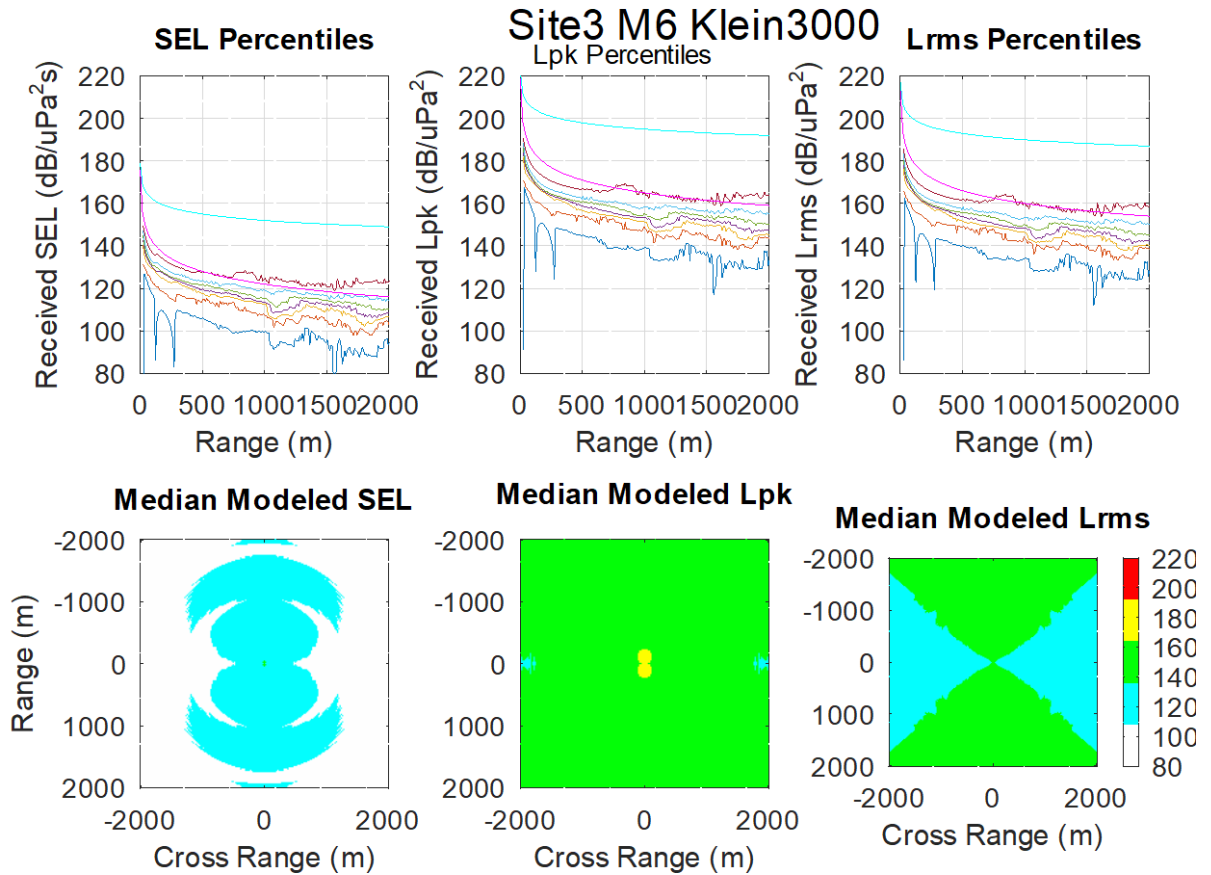


Figure 5-34. Klein 3000 Mode 6 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.6.4 Site 4 – Sand, 30-m Depth

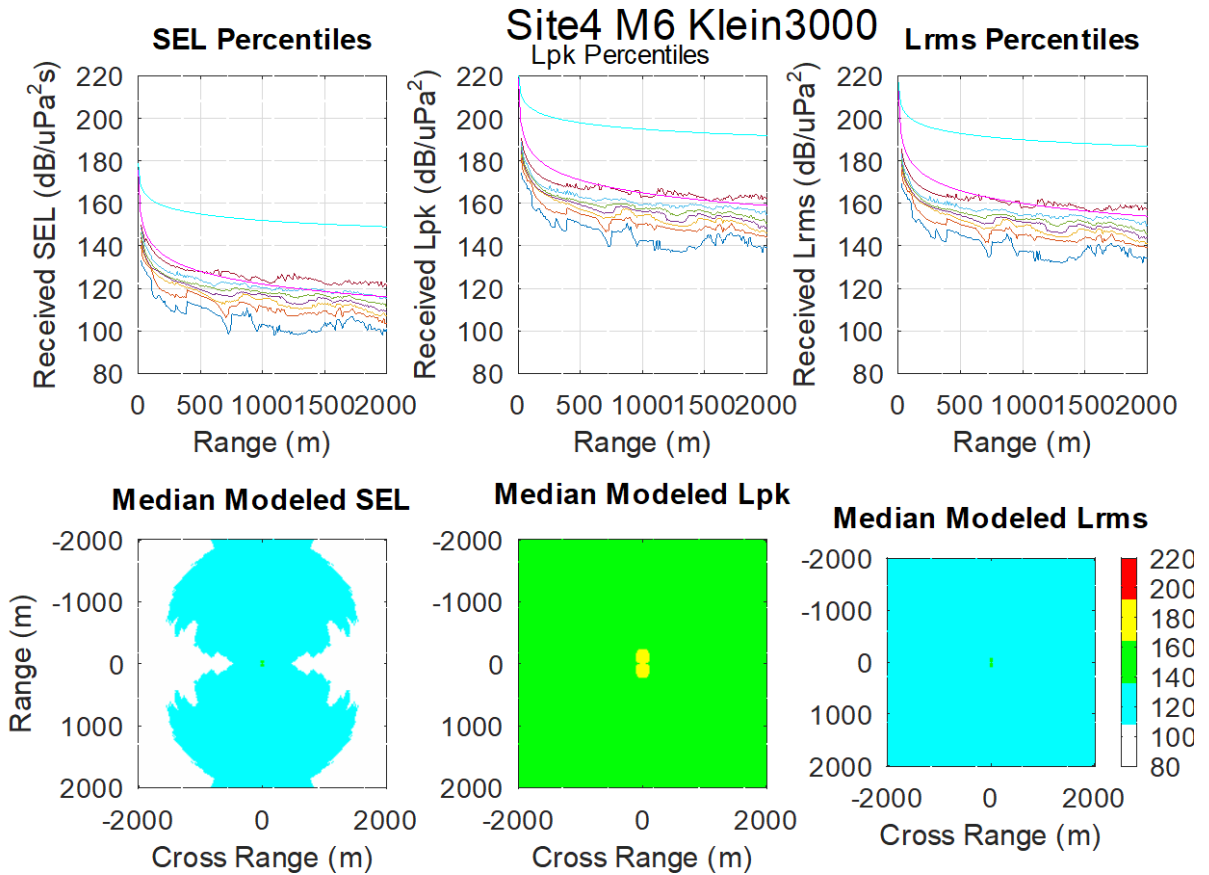


Figure 5-35. Klein 3000 Mode 6 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.6.5 Site 5 – Sandy Silt, 100-m Depth

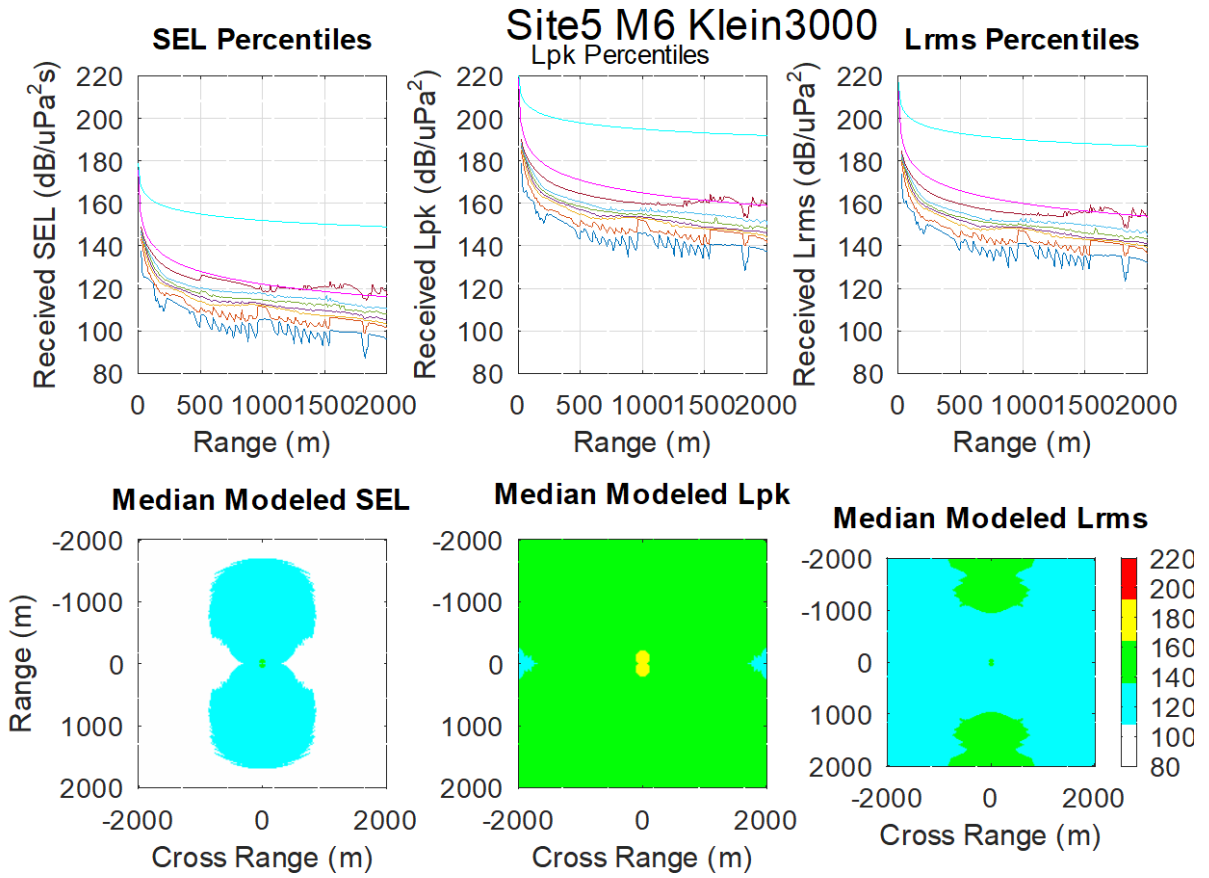


Figure 5-36. Klein 3000 Mode 6 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.7 EdgeTech 4200, 100 kHz, 500-ms Ping Rate, 50-m Range (Mode 7)

The EdgeTech 4200 side-scan sonar generates a single HF signal with a peak frequency at 125 kHz. The operational parameter settings for Mode 7 were 100 percent power, a 500-ms ping rate, and a 50-m range. Measured source levels are shown in **Table 5-7**.

Table 5-7. NUWC tank measurements of EdgeTech 4200 (Mode 7)

Source Settings				Source Level			
Frequency (kHz)	Power (%)	Range (m)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	100	50	5	212	206	201	171

μ Pa = micropascal; dB = decibel; kHz = kilohertz; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-37**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-7**. Modeling results for each site are shown in **Figures 5-38 to 5-42**.

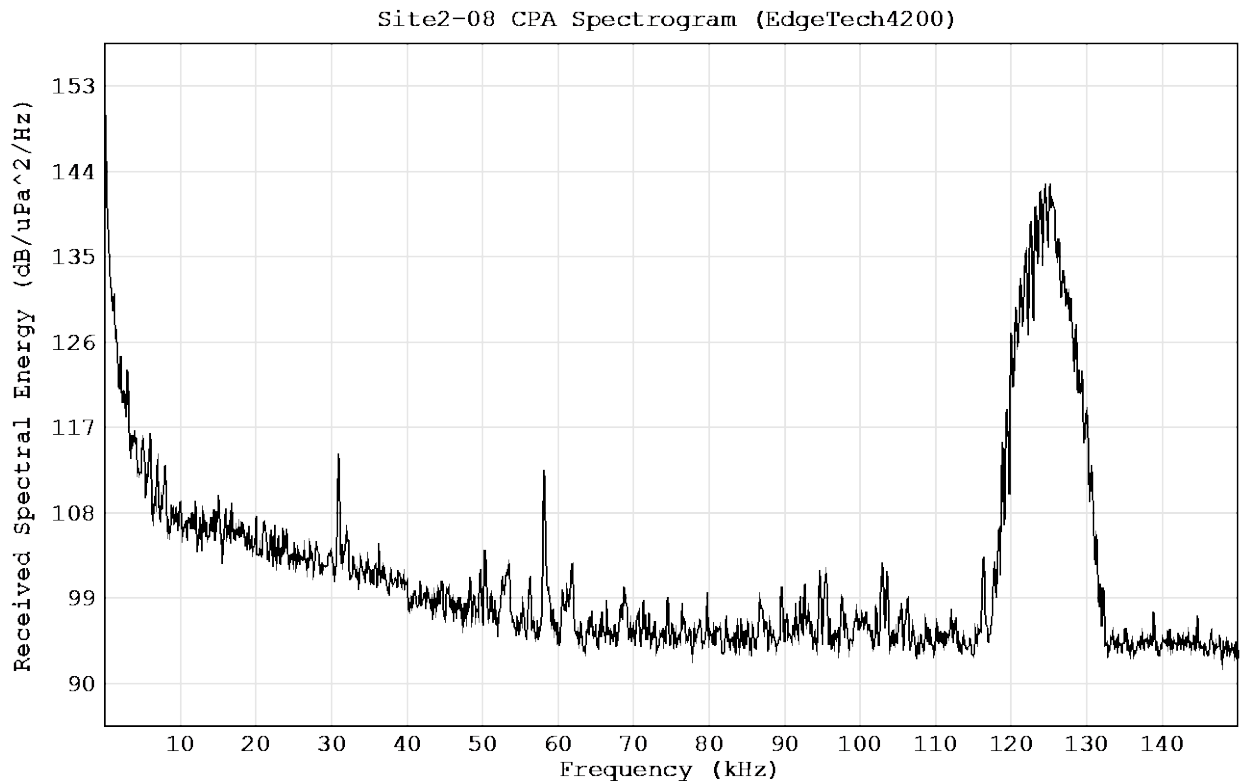


Figure 5-37. EdgeTech 4200 Mode 7 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.7.1 Site 1 – Mud, 10-m Depth

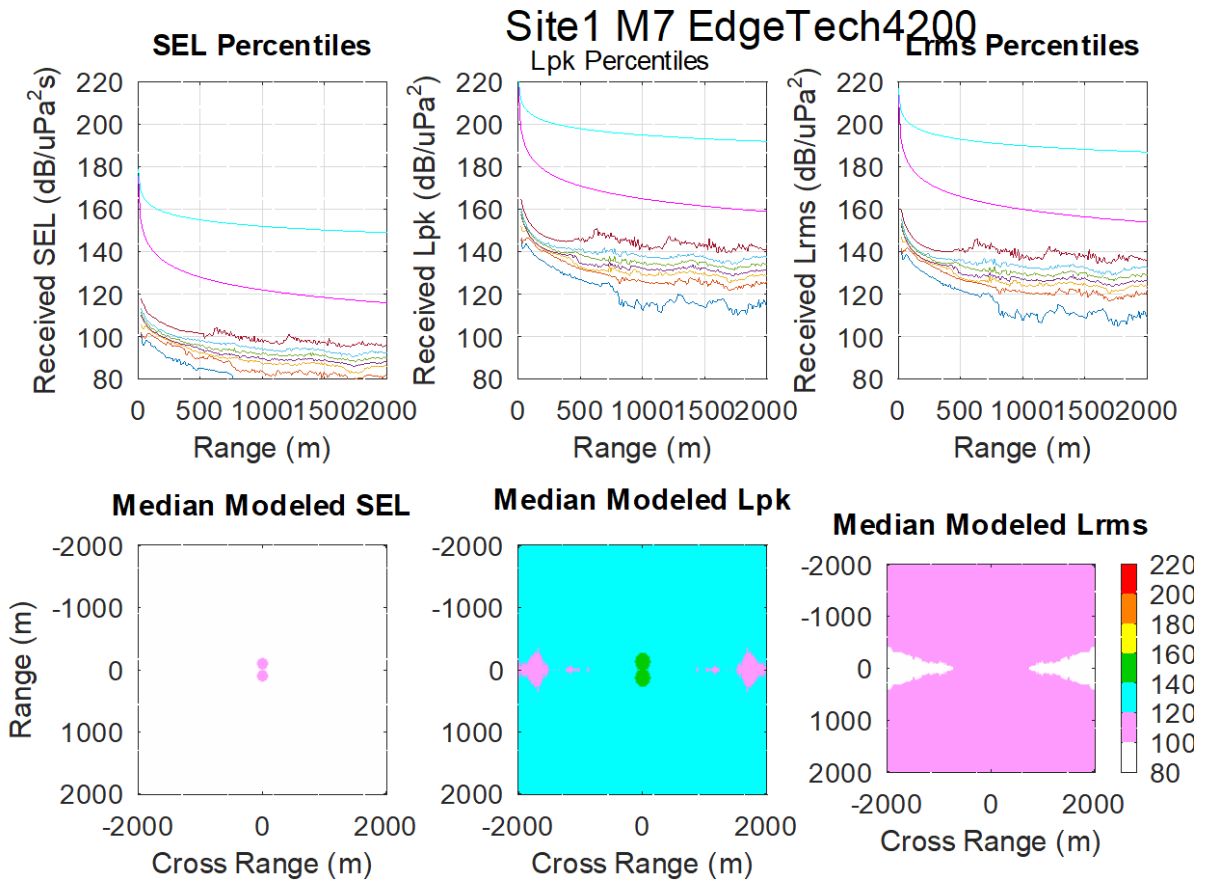


Figure 5-38. EdgeTech 4200 Mode 7 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.7.2 Site 2 – Sand, 10-m Depth

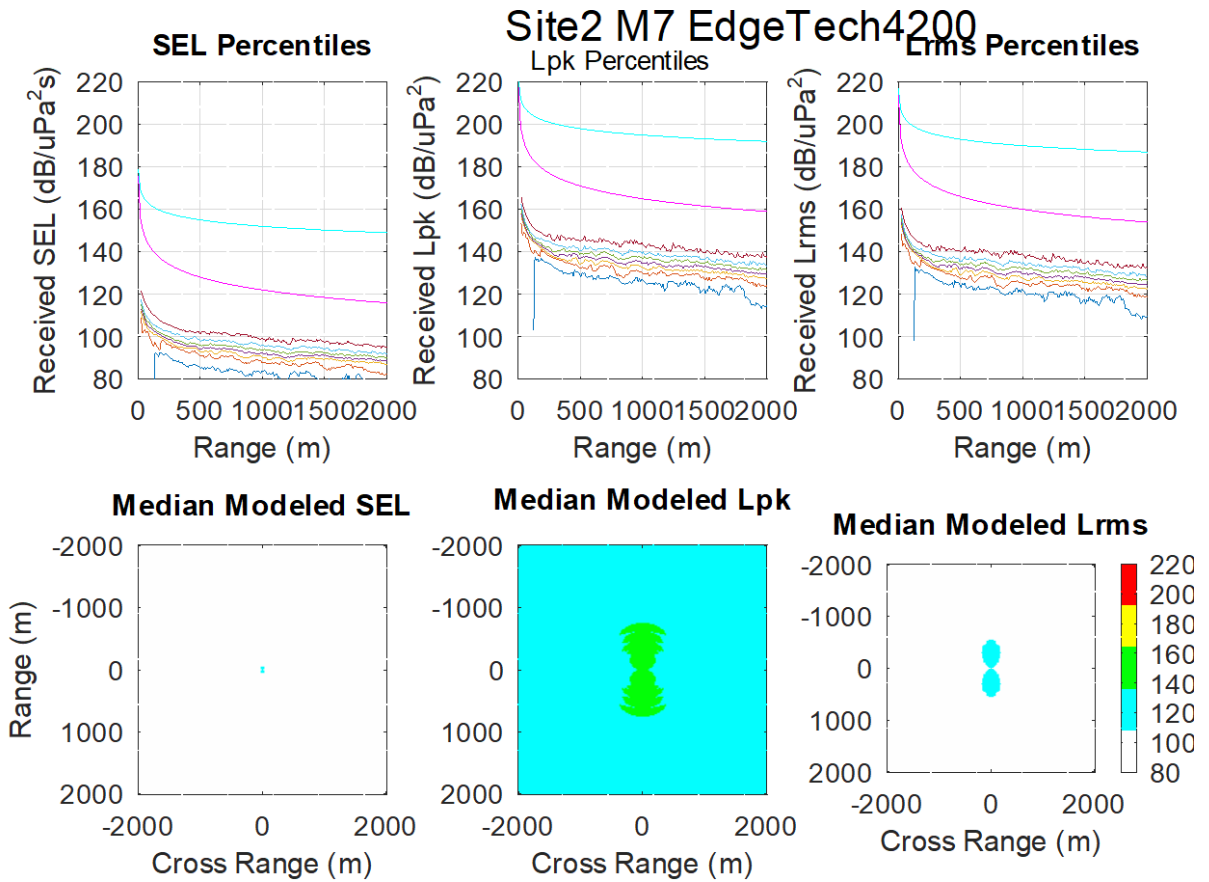


Figure 5-39. EdgeTech 4200 Mode 7 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.7.3 Site 3 – Mud, 30-m Depth

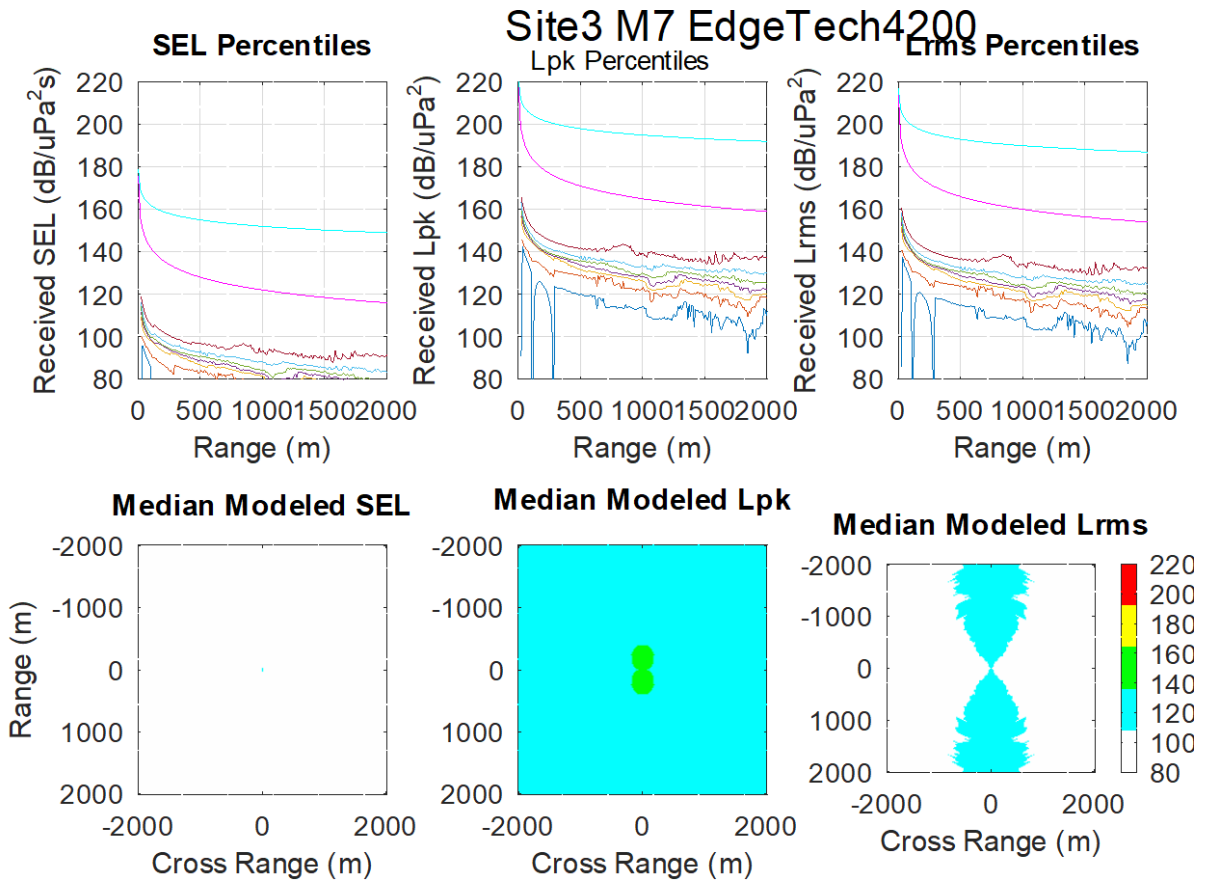


Figure 5-40. EdgeTech 4200 Mode 7 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.7.4 Site 4 – Sand, 30-m Depth

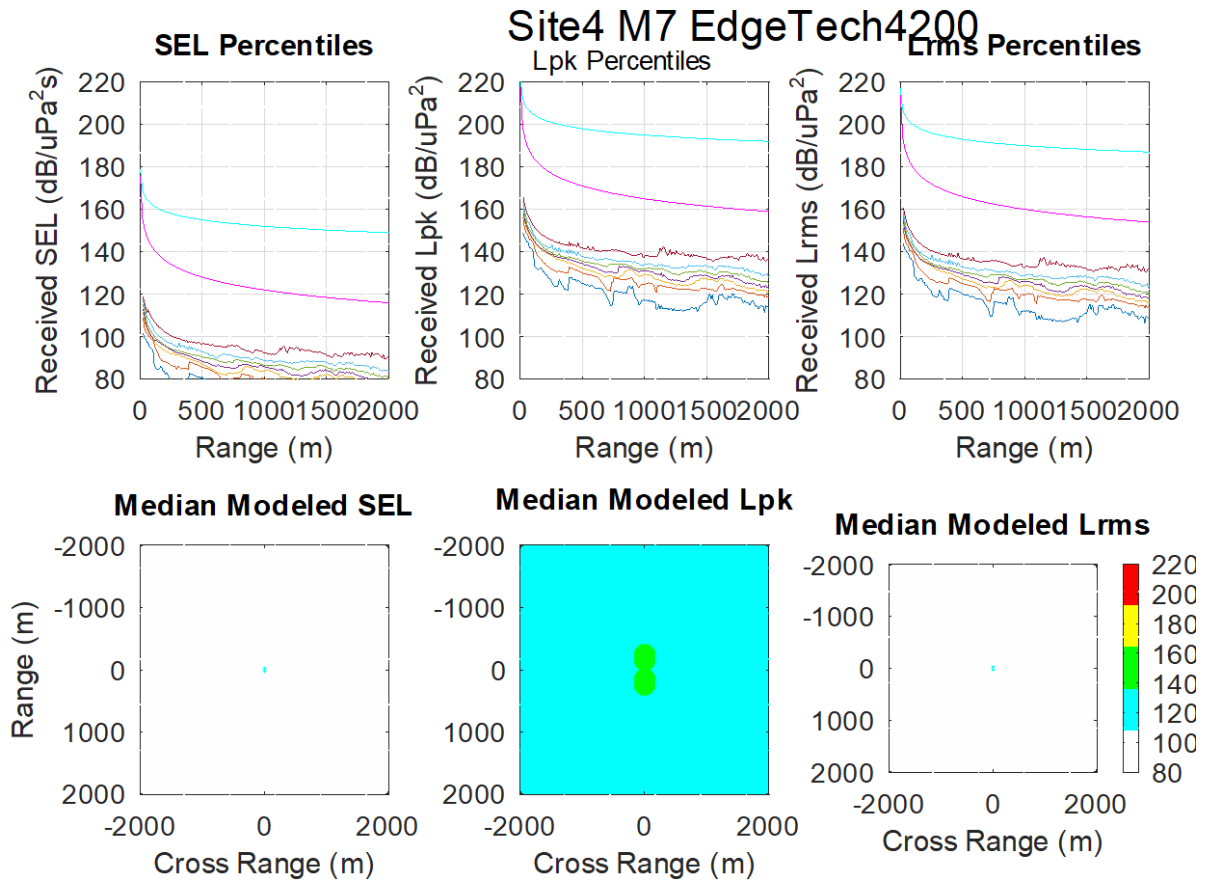


Figure 5-41. EdgeTech 4200 Mode 7 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.7.5 Site 5 – Sandy Silt, 100-m Depth

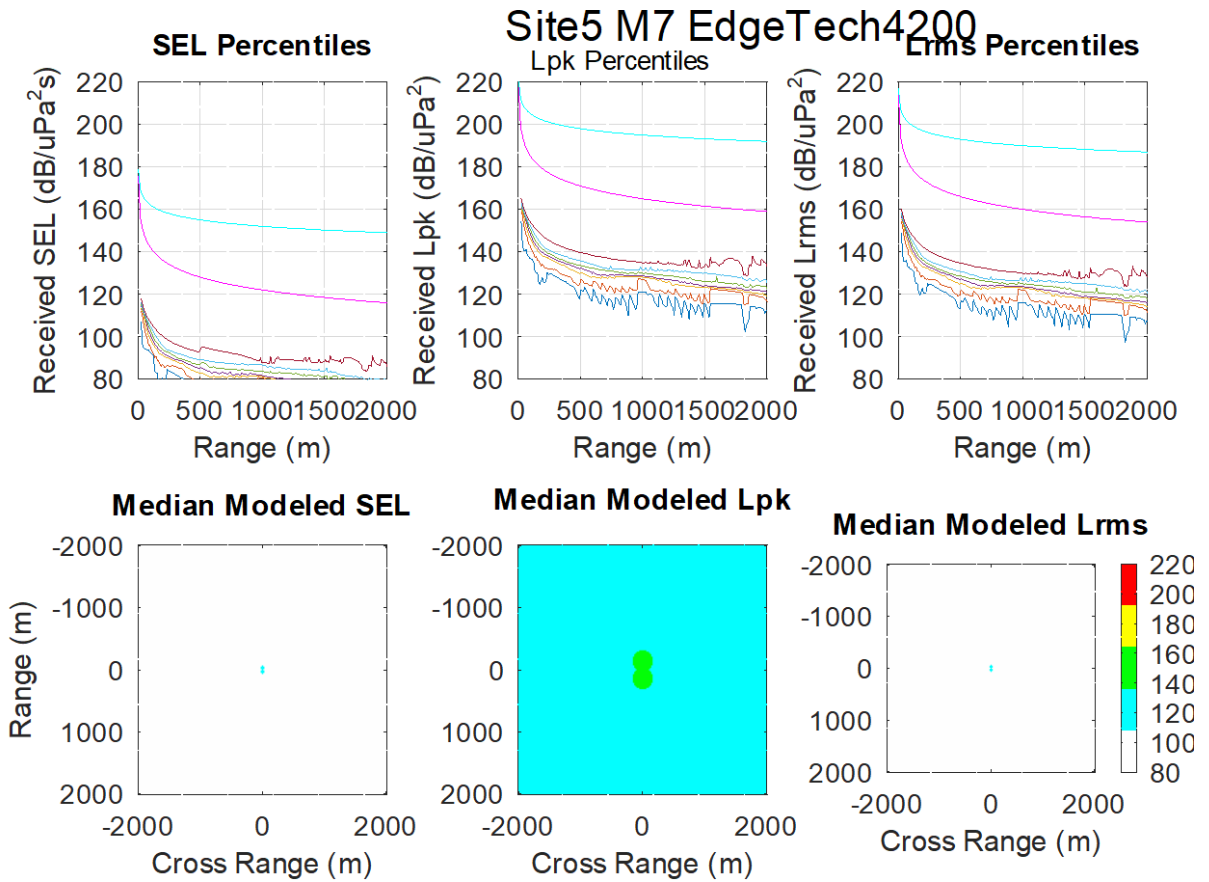


Figure 5-42. EdgeTech 4200 Mode 7 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.8 EdgeTech 4200, 100 kHz, 500-ms Ping Rate, 100-m Range (Mode 8)

The EdgeTech 4200 side-scan sonar generates a single HF signal with a peak frequency of 125 kHz. The operational parameter settings for Mode 8 were 100 percent power, a 500-ms ping rate, and a 100-m range. Measured source levels are shown in **Table 5-8**.

Table 5-8. NUWC tank measurements of EdgeTech 4200 (Mode 8)

Source Settings				Source Level			
Frequency (kHz)	Power (%)	Range (m)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	100	100	5	212	206	201	175

μ Pa = micropascal; dB = decibel; kHz = kilohertz; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-43**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-8**. Modeling results for each site are shown in **Figures 5-44 to 5-48**.

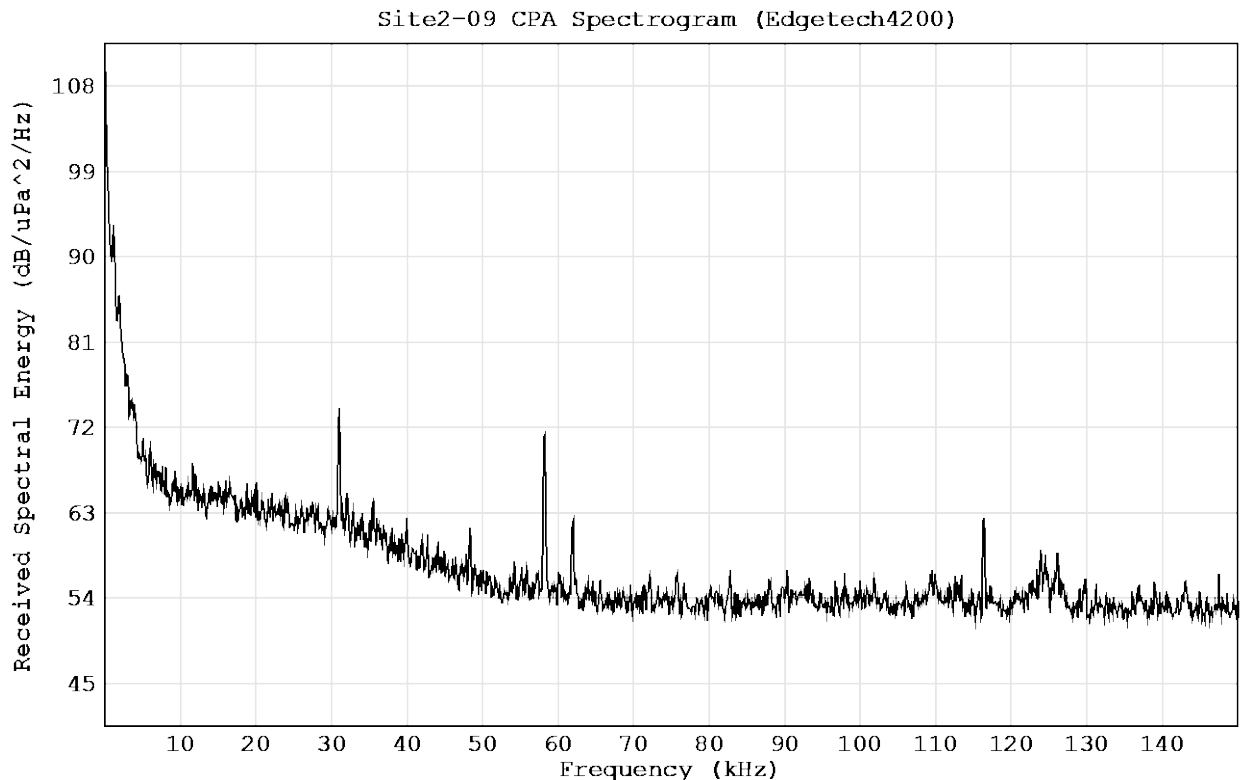


Figure 5-43. EdgeTech 4200 Mode 8 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.8.1 Site 1 – Mud, 10-m Depth

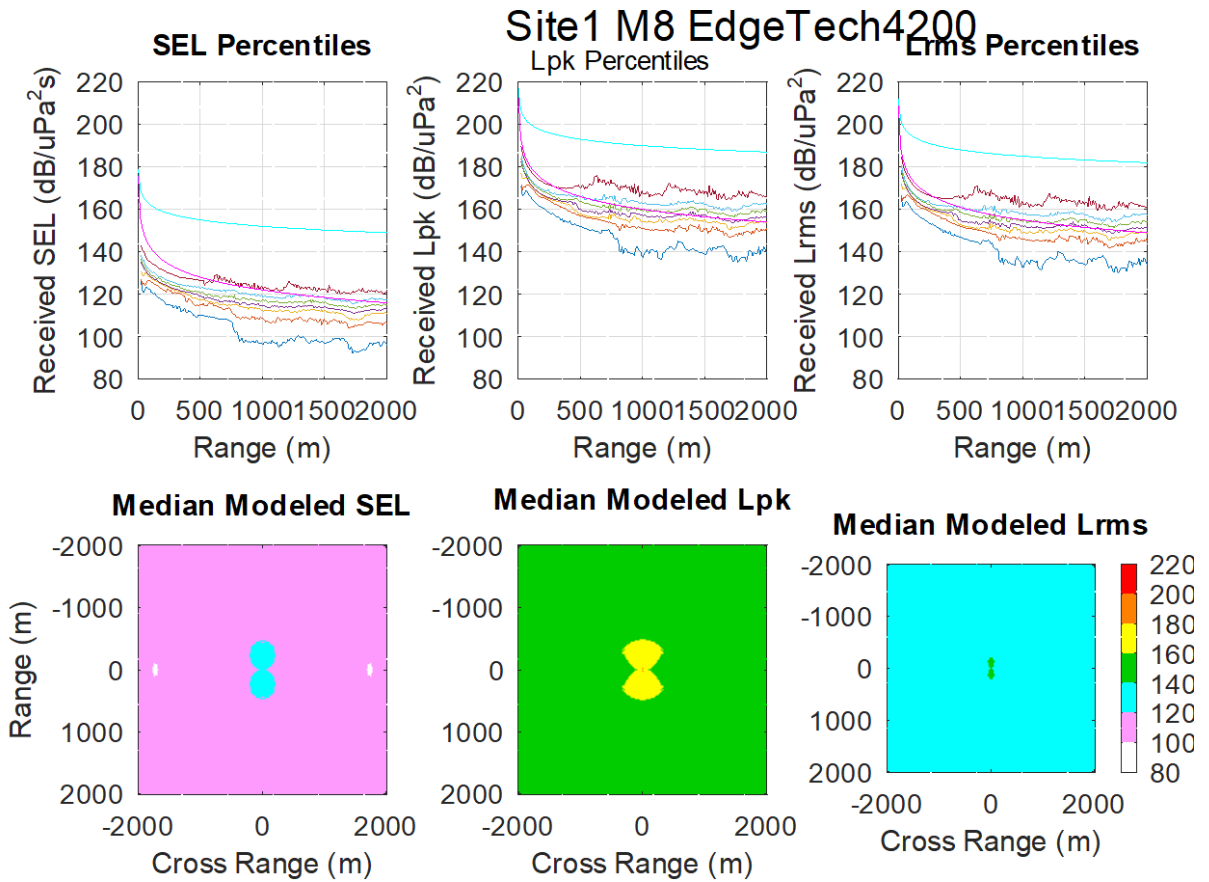


Figure 5-44. EdgeTech 4200 Mode 8 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.8.2 Site 2 – Sand, 10-m Depth

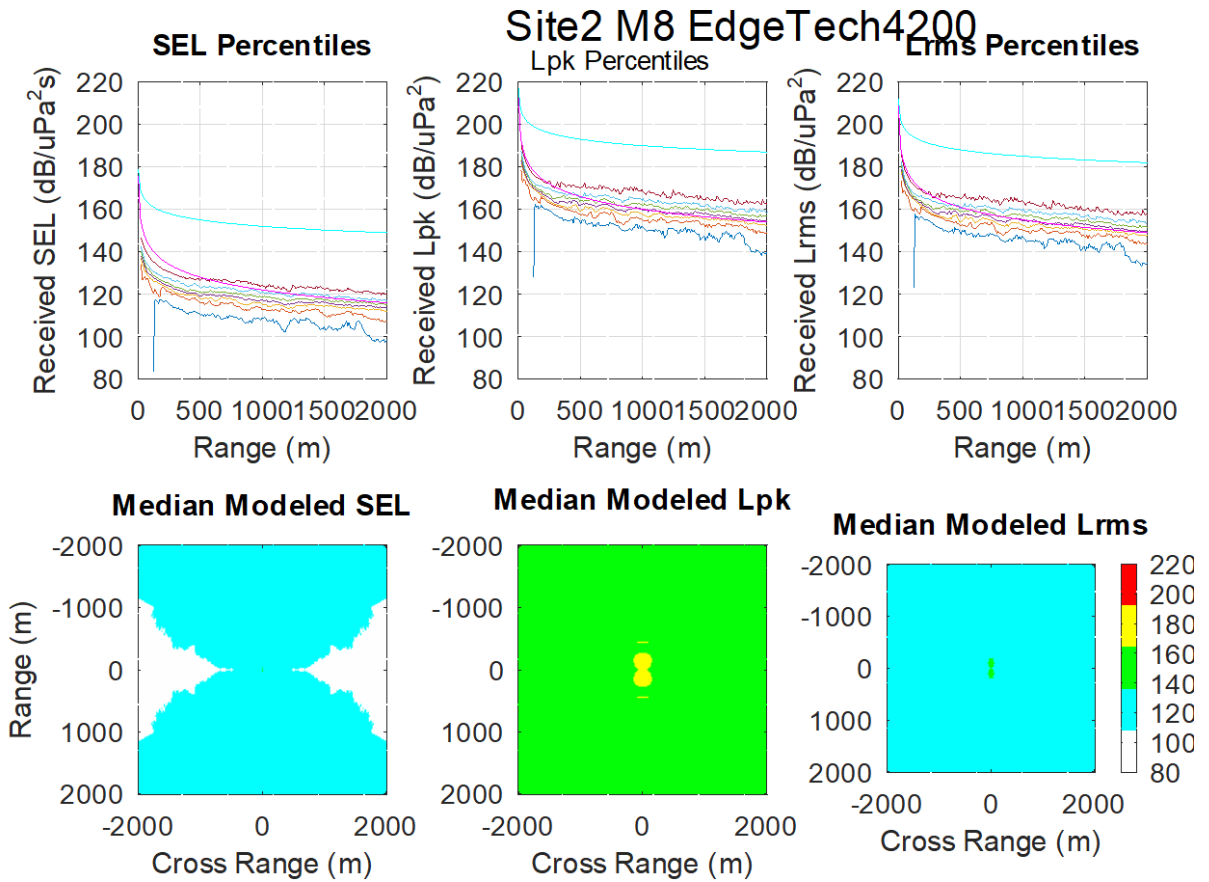


Figure 5-45. EdgeTech 4200 Mode 8 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.8.3 Site 3 – Mud, 30-m Depth

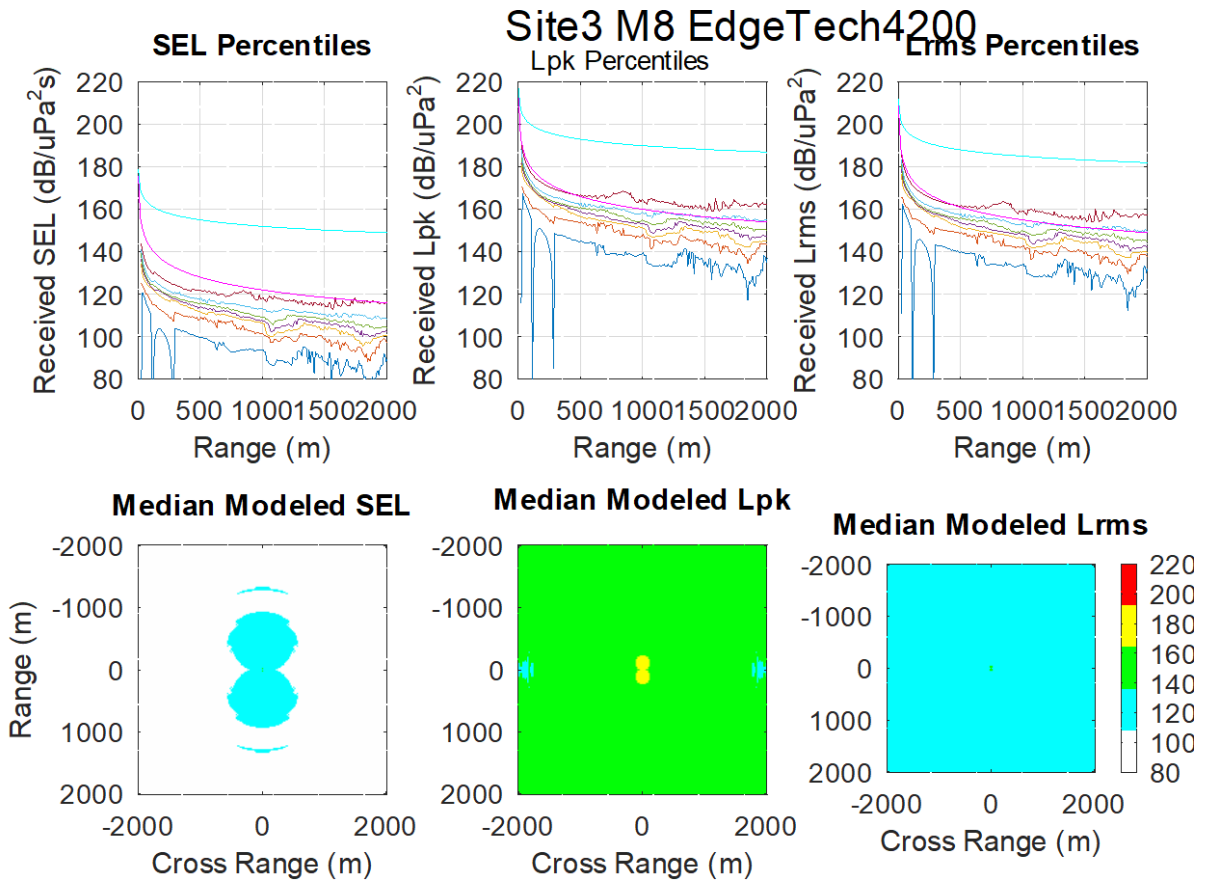


Figure 5-46. EdgeTech 4200 Mode 8 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.8.4 Site 4 – Sand, 30-m Depth

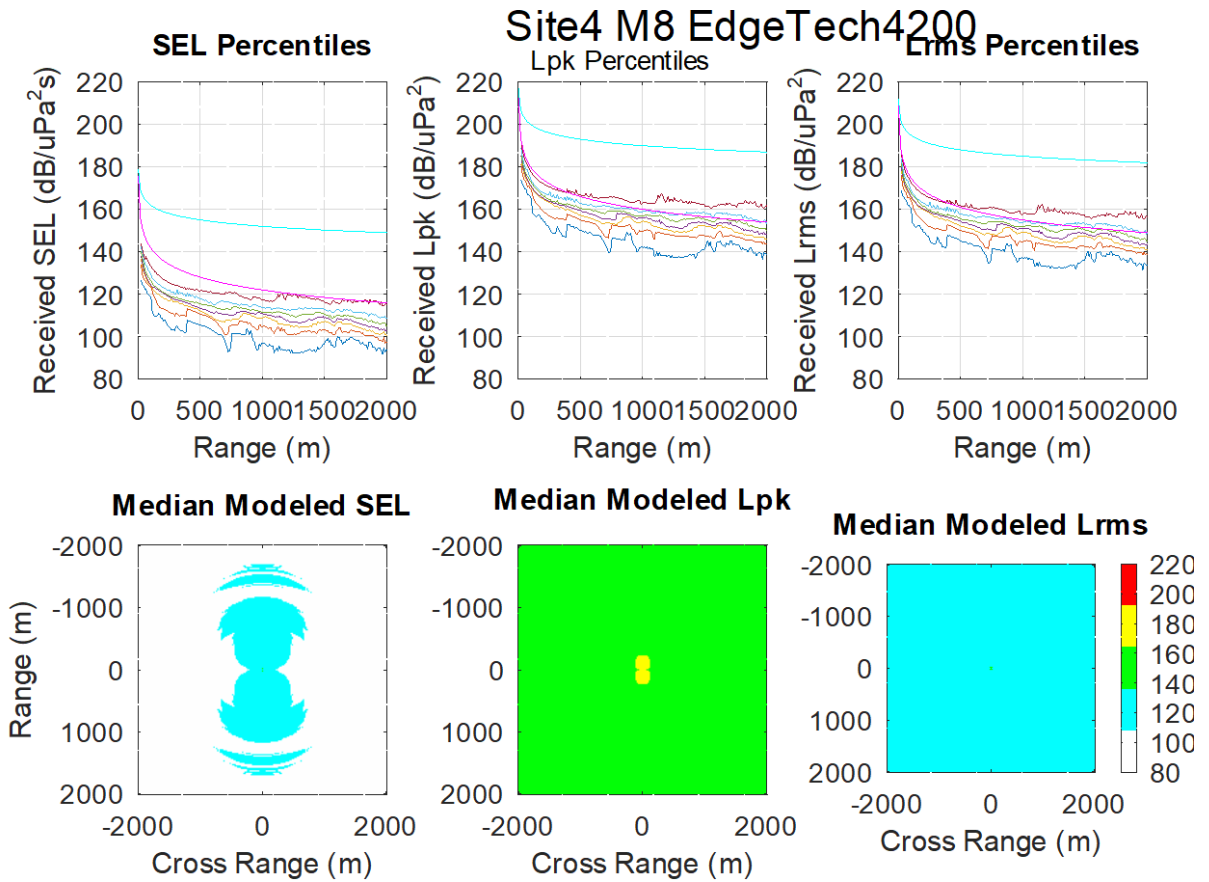


Figure 5-47. EdgeTech 4200 Mode 8 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.8.5 Site 5 – Sandy Silt, 100-m Depth

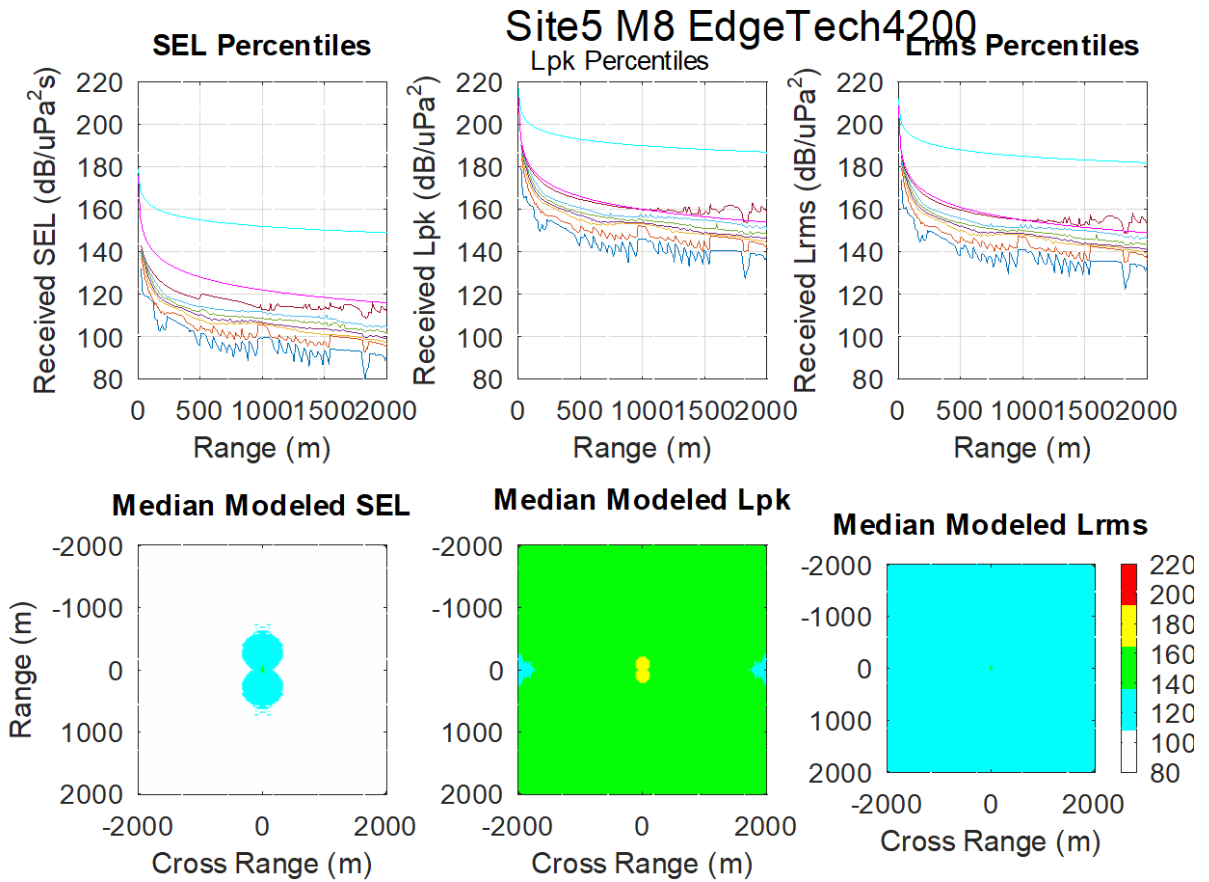


Figure 5-48. EdgeTech 4200 Mode 8 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.9 SEA SWATHPlus, 234 kHz, 100 Percent Power, 12 Cycles (Mode 9)

The SEA SWATHPlus multibeam echosounder generates a single VHF signal with a peak frequency of 234 kHz. The operational parameter settings for Mode 9 were 100 percent power and 12 cycles. Measured source levels are shown in **Table 5-9**.

Table 5-9. NUWC tank measurements of SwathPlus (Mode 9)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	5	230	225	218	174

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.

From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-49**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-9**.

Modeling results for each site are shown in **Figures 5-50 to 5-54**.

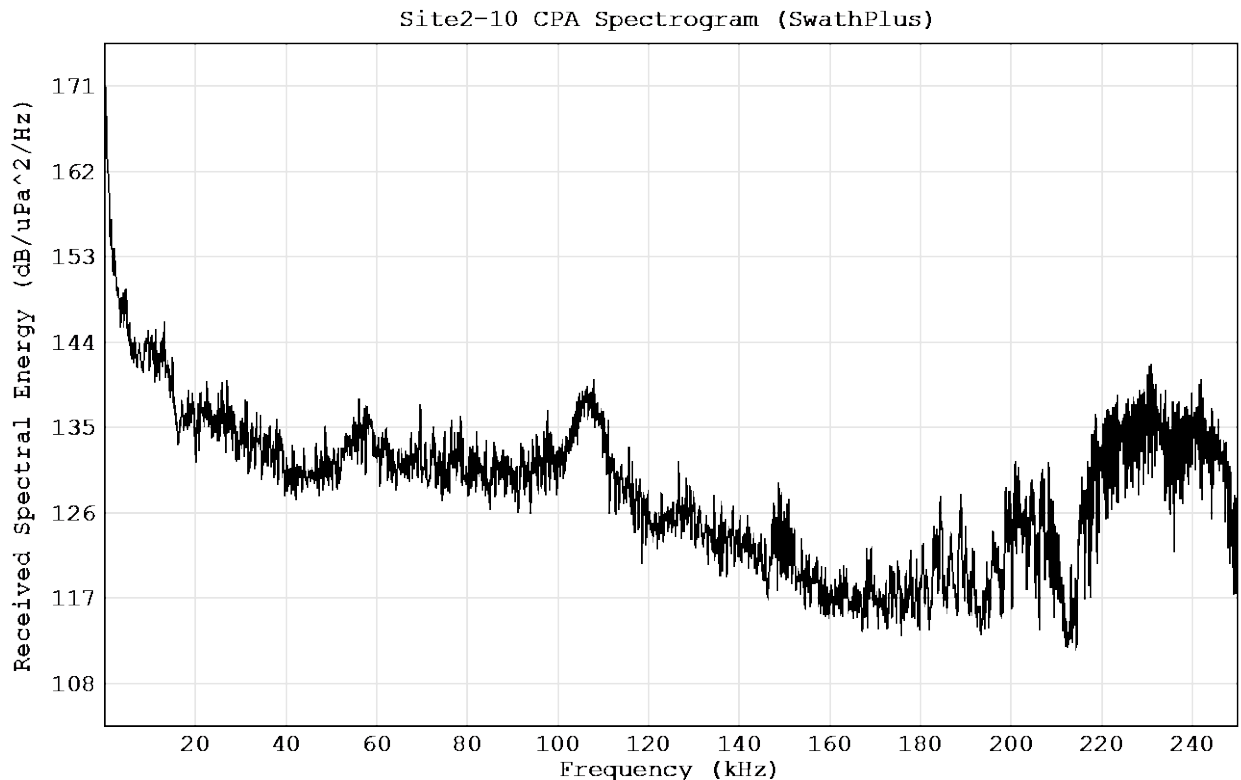


Figure 5-49. SEA SWATHPlus Mode 9 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.9.1 Site 1 – Mud, 10-m Depth

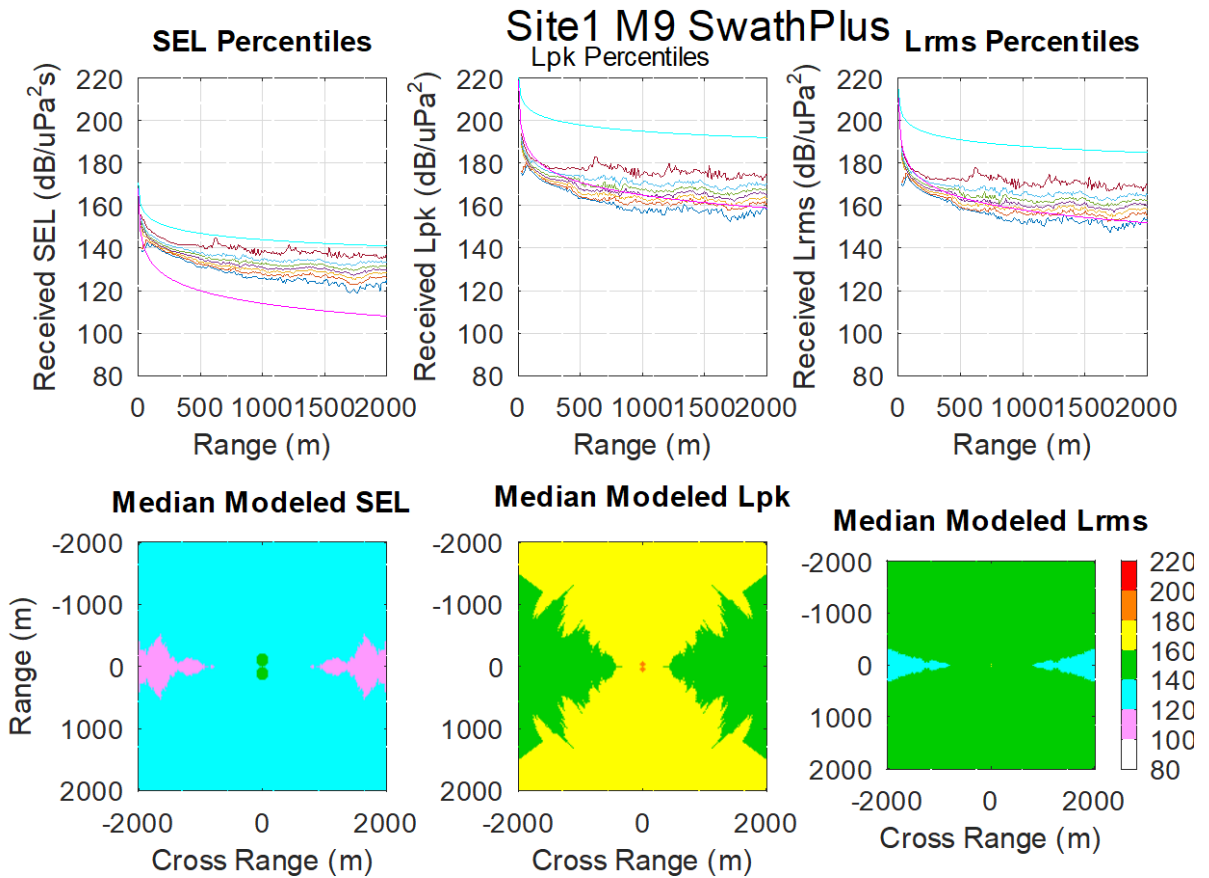


Figure 5-50. SWATHPlus Mode 9 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.9.2 Site 2 – Sand, 10-m Depth

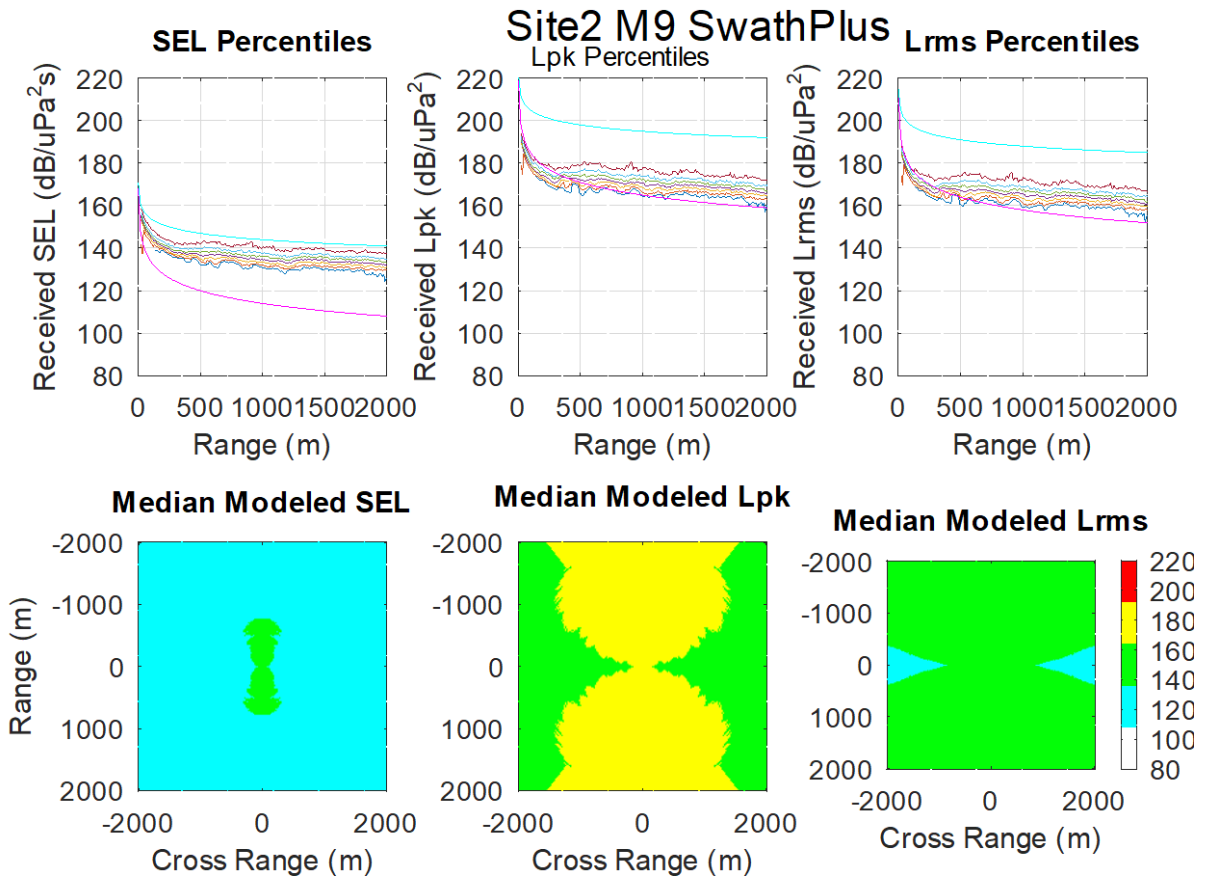


Figure 5-51. SWATHPlus Mode 9 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.9.3 Site 3 – Mud, 30-m Depth

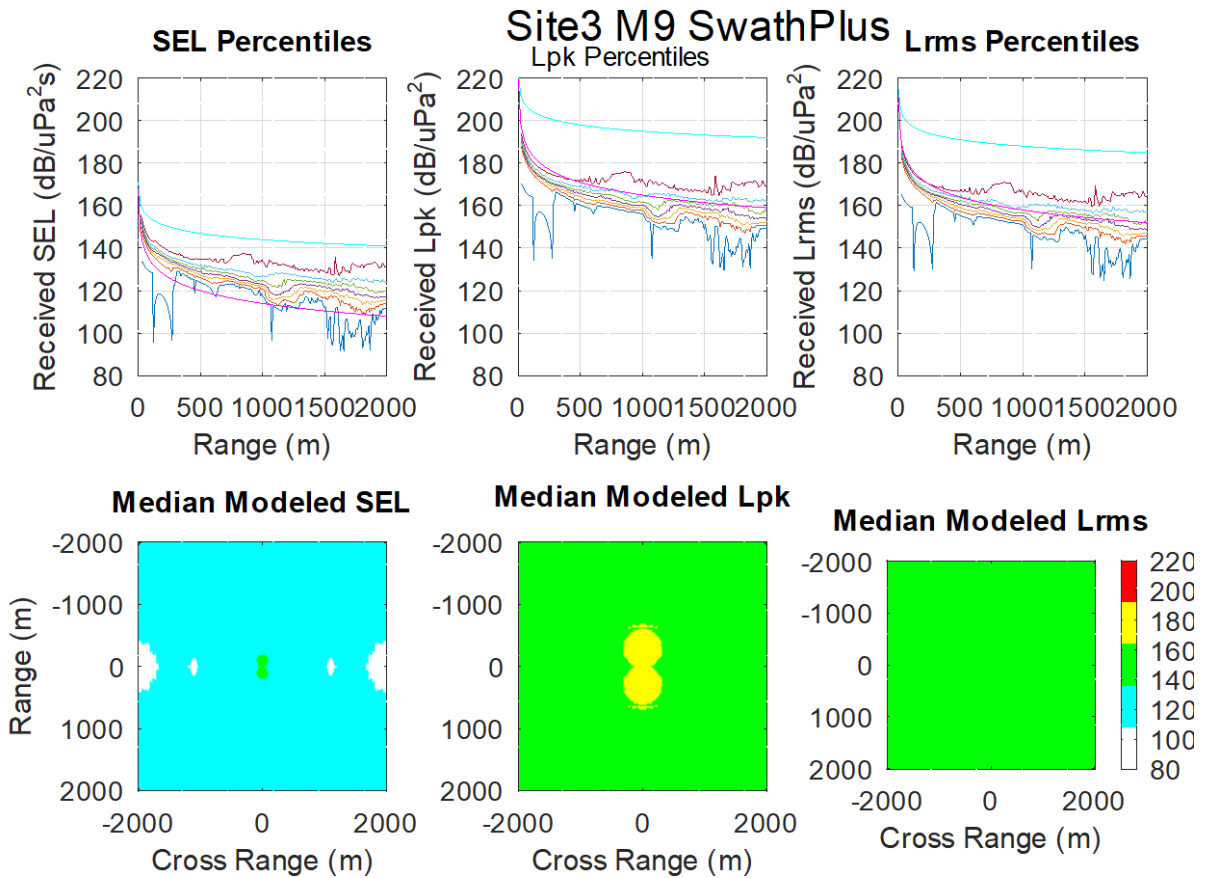


Figure 5-52. SWATHPlus Mode 9 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.9.4 Site 4 – Sand, 30-m Depth

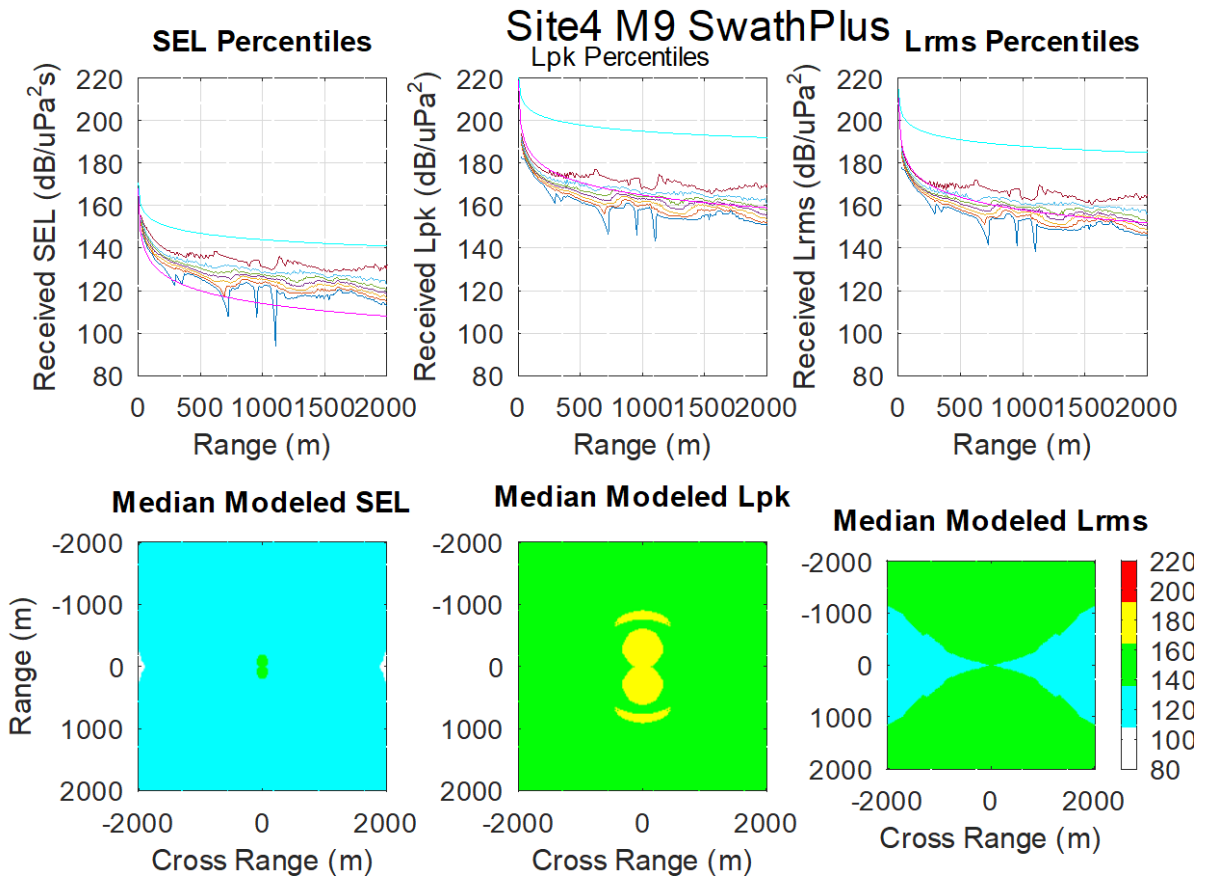


Figure 5-53. SWATHPlus Mode 9 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.9.5 Site 5 – Sandy Silt, 100-m Depth

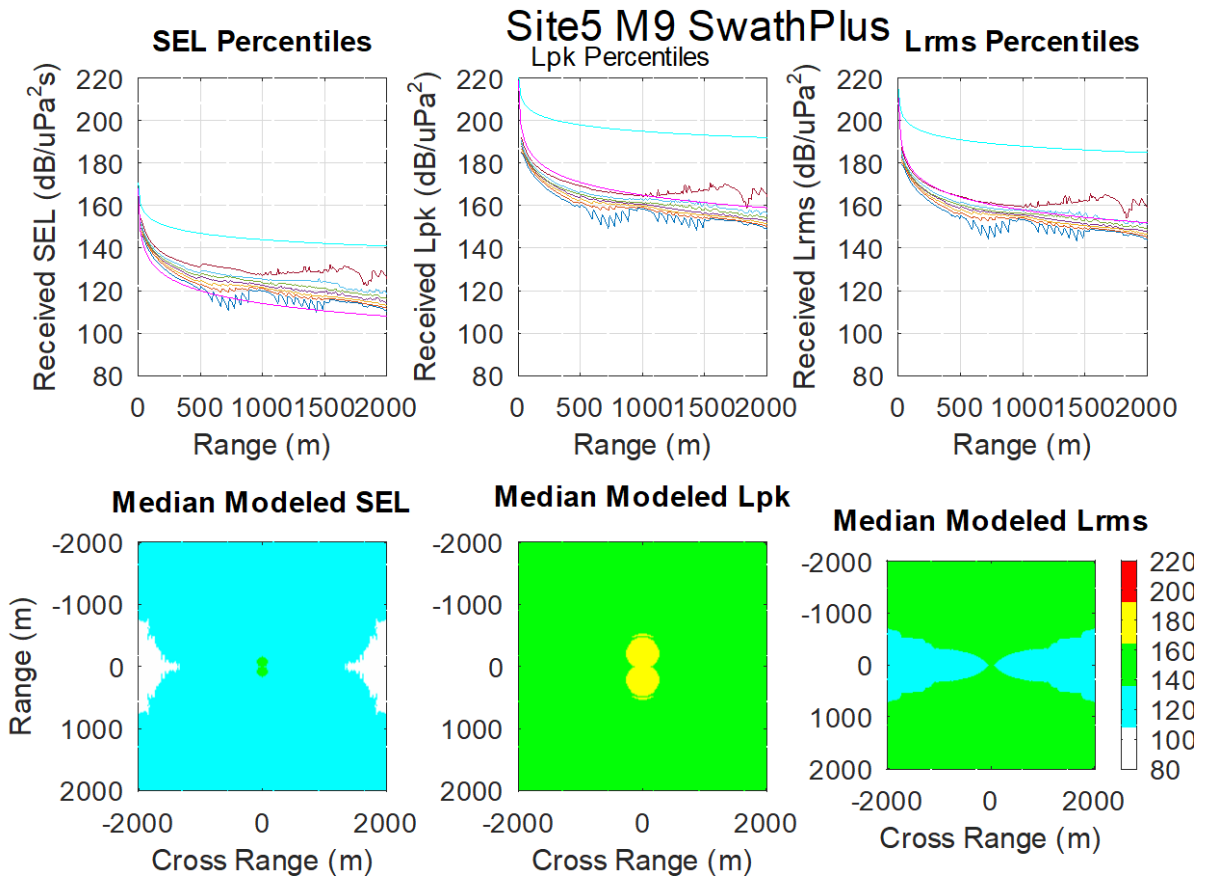


Figure 5-54. SWATHPlus Mode 9 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.10 SEA SWATHPlus, 234 kHz, 100 Percent Power, 60 Cycles (Mode 10)

The SEA SWATHPlus multibeam echosounder generates a single VHF signal with a peak frequency of 234 kHz. The operational parameter settings for Mode 10 were 100 percent power and 60 cycles. Measured source levels are shown in **Table 5-10**.

Table 5-10. NUWC tank measurements of SWATHPlus (Mode 10)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	5	228	223	218	180

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-55**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-10**. Modeling results for each site are shown in **Figures 5-56 to 5-60**.

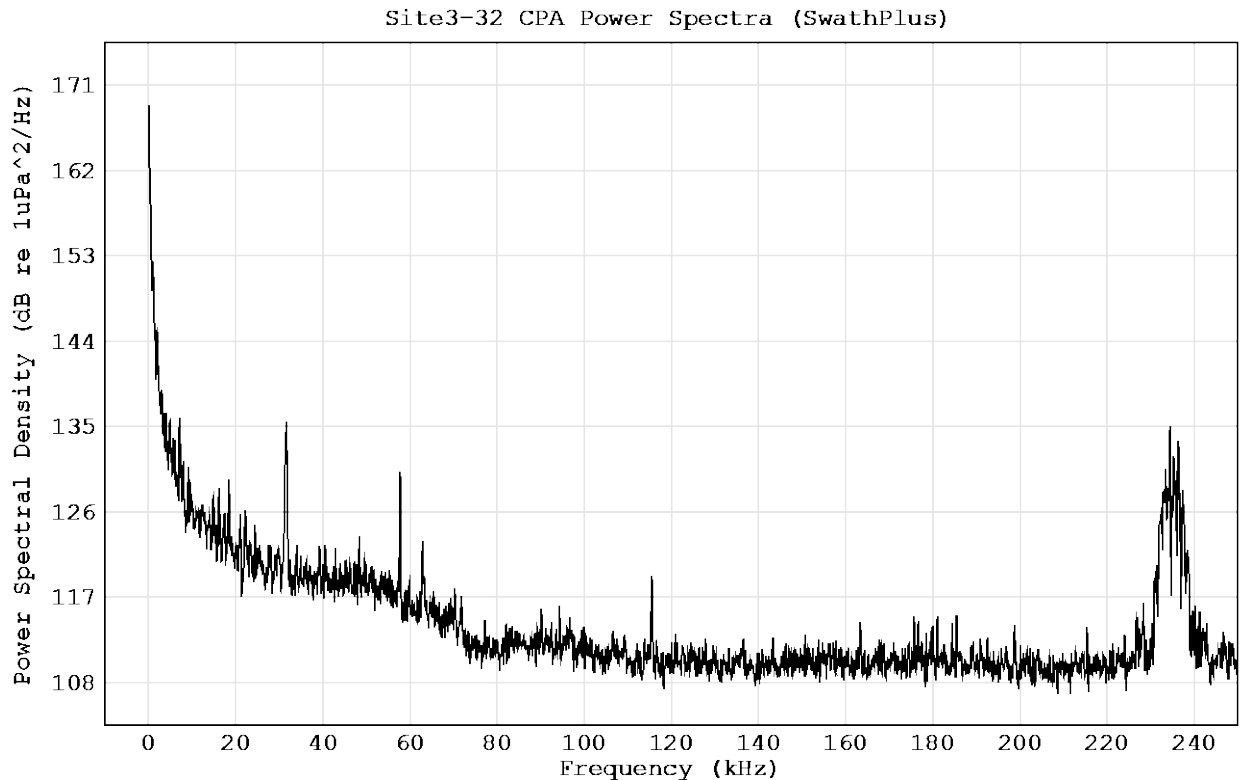


Figure 5-55. SEA SWATHPlus Mode 10 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = with reference to.

5.10.1 Site 1 – Mud, 10-m Depth

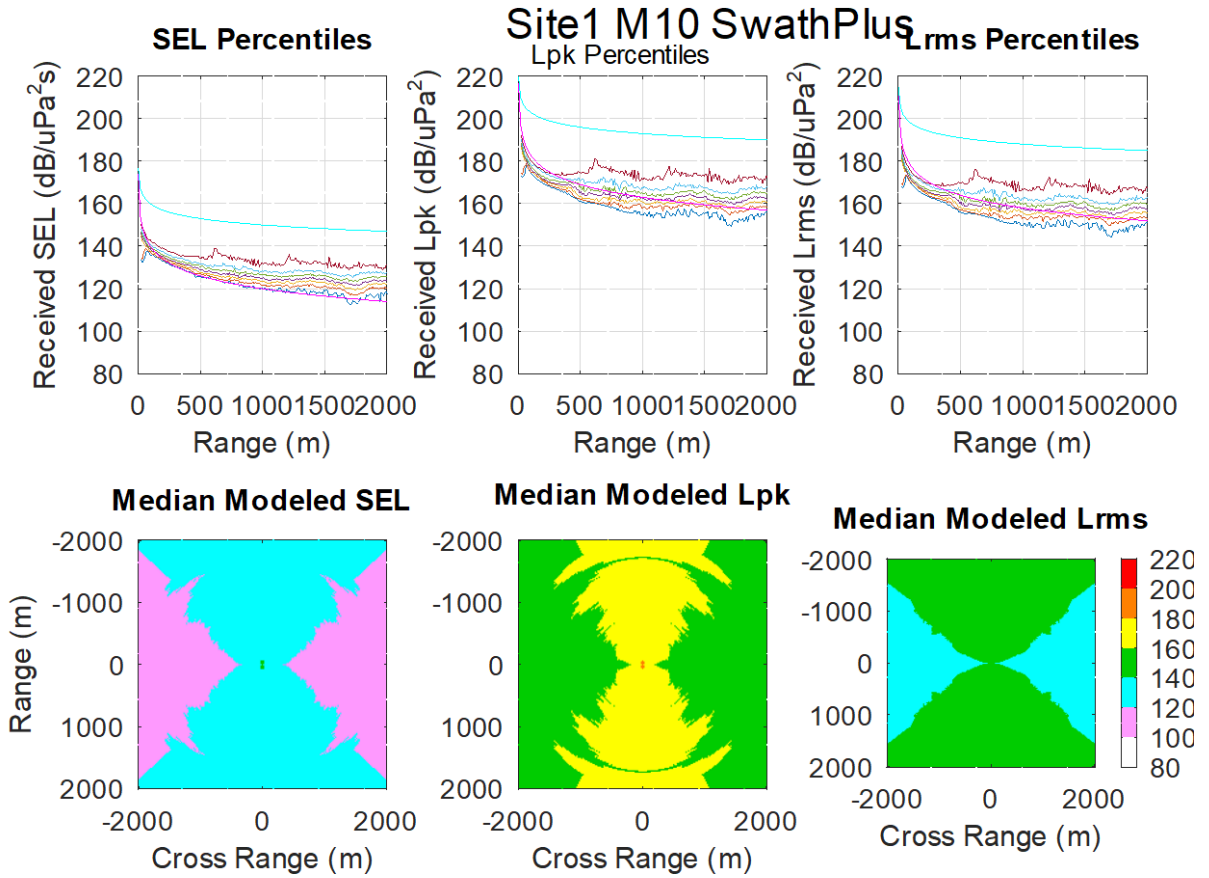


Figure 5-56. SWATHPlus Mode 10 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.10.2 Site 2 – Sand, 10-m Depth

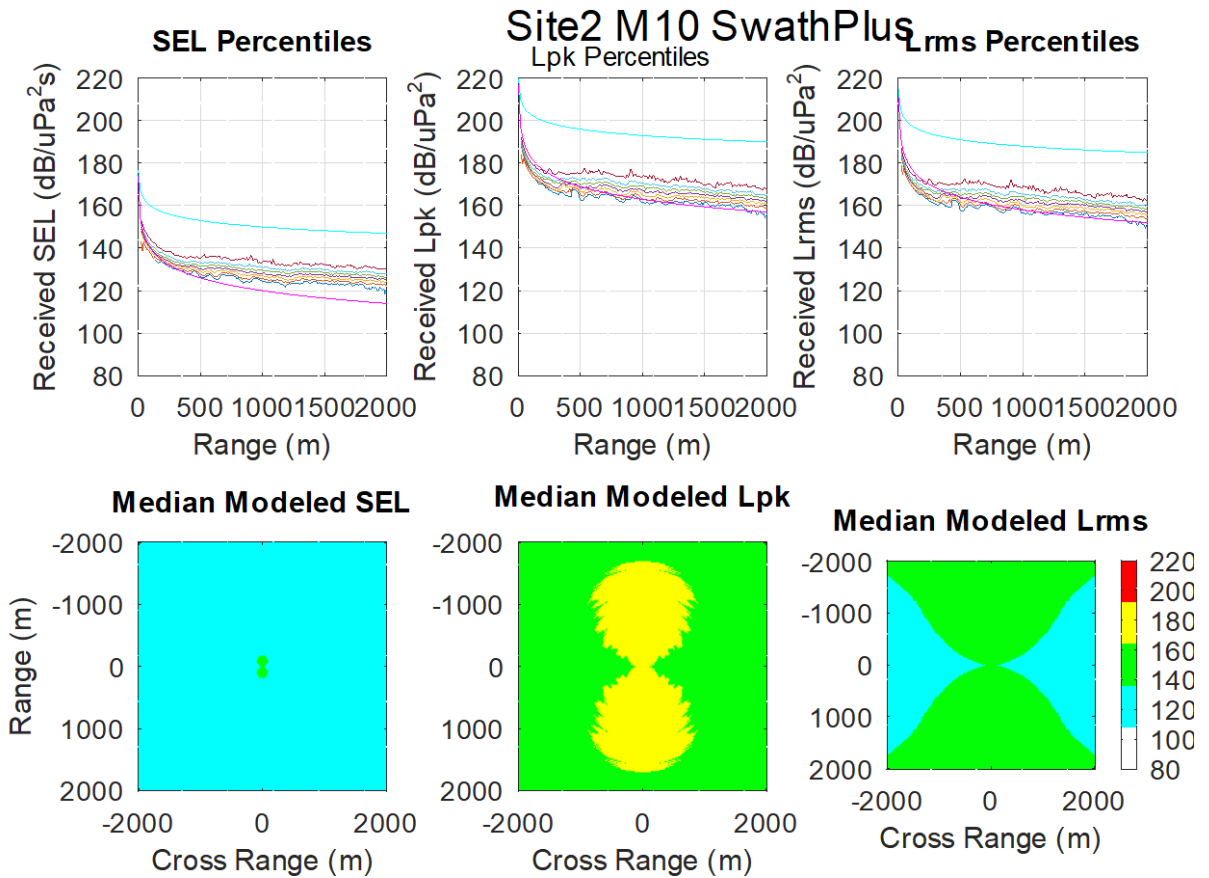


Figure 5-57. SWATHPlus Mode 10 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.10.3 Site 3 – Mud, 30-m Depth

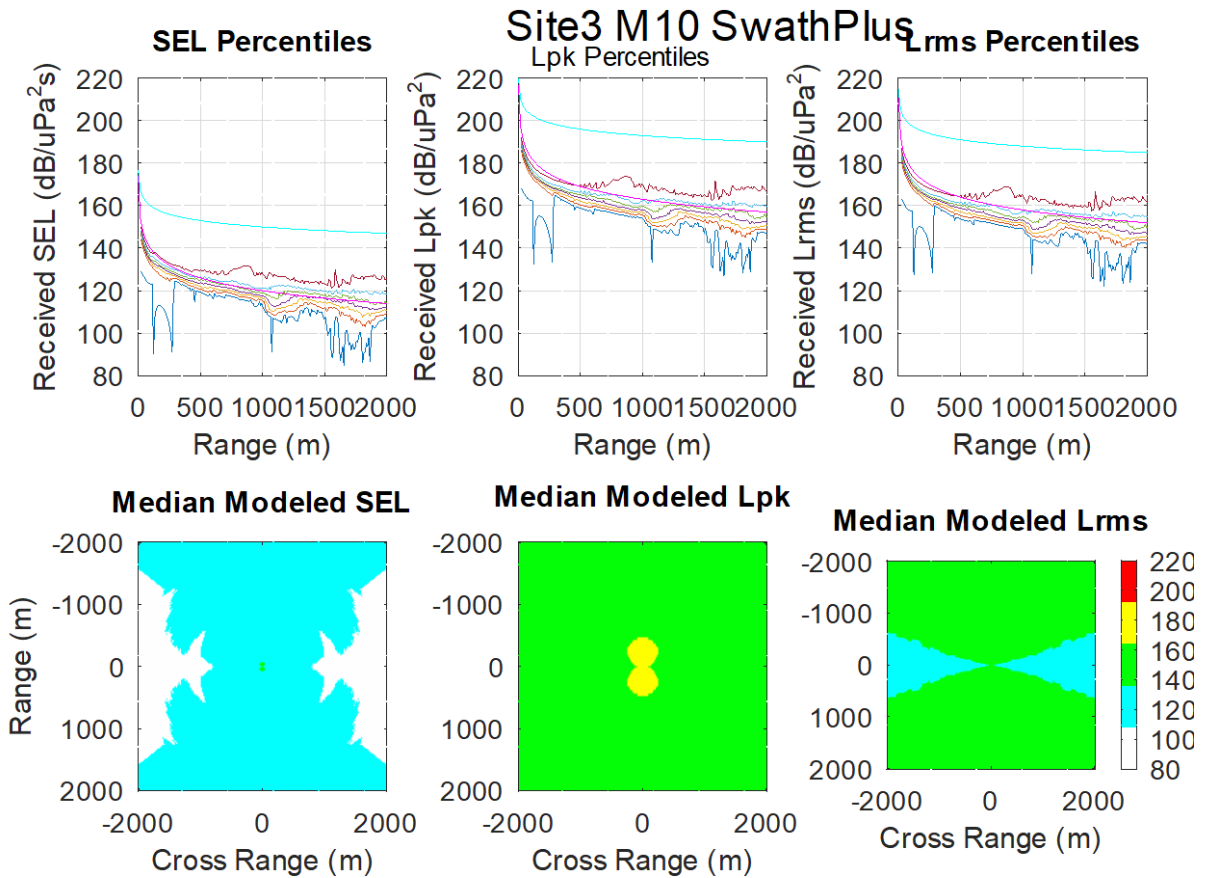


Figure 5-58. SWATHPlus Mode 10 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.10.4 Site 4 – Sand, 30-m Depth

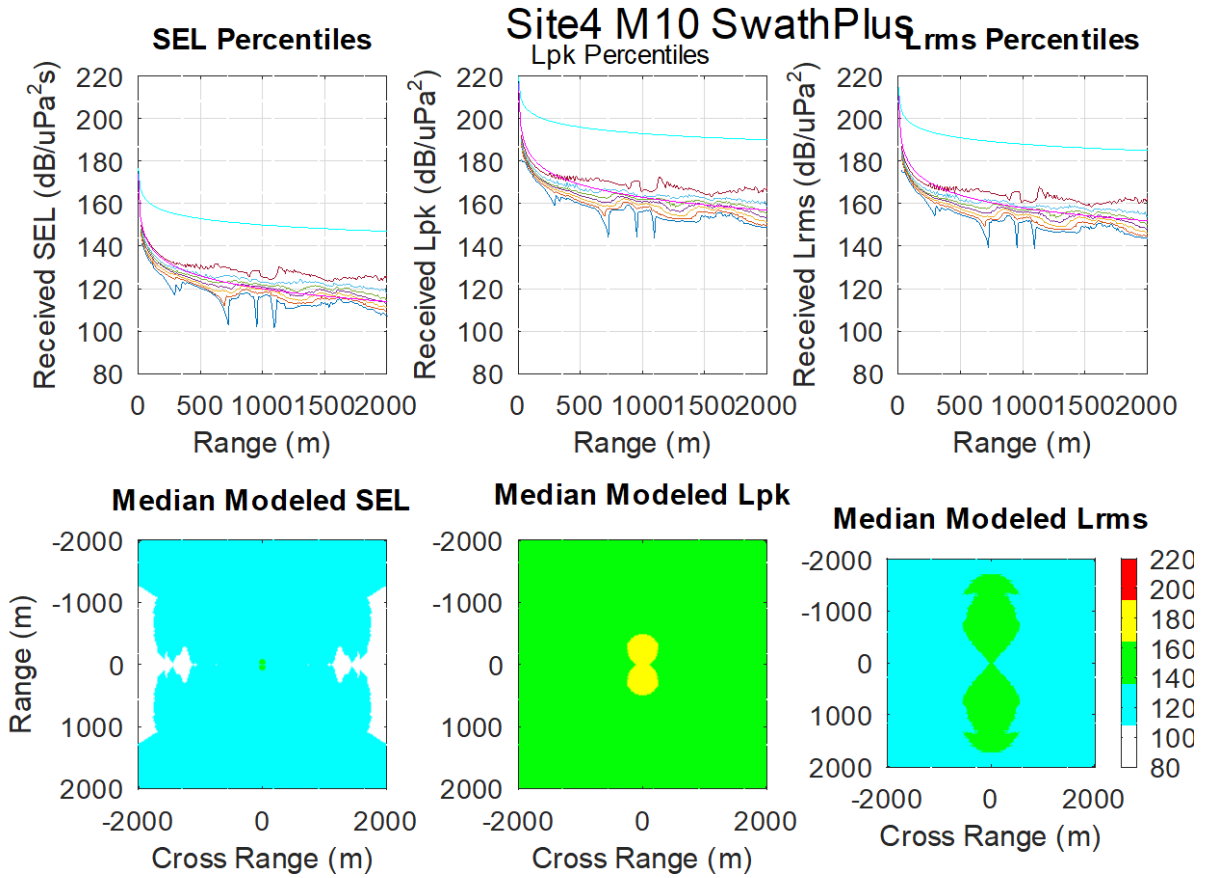


Figure 5-59. SWATHPlus Mode 10 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.10.5 Site 5 – Sandy Silt, 100-m Depth

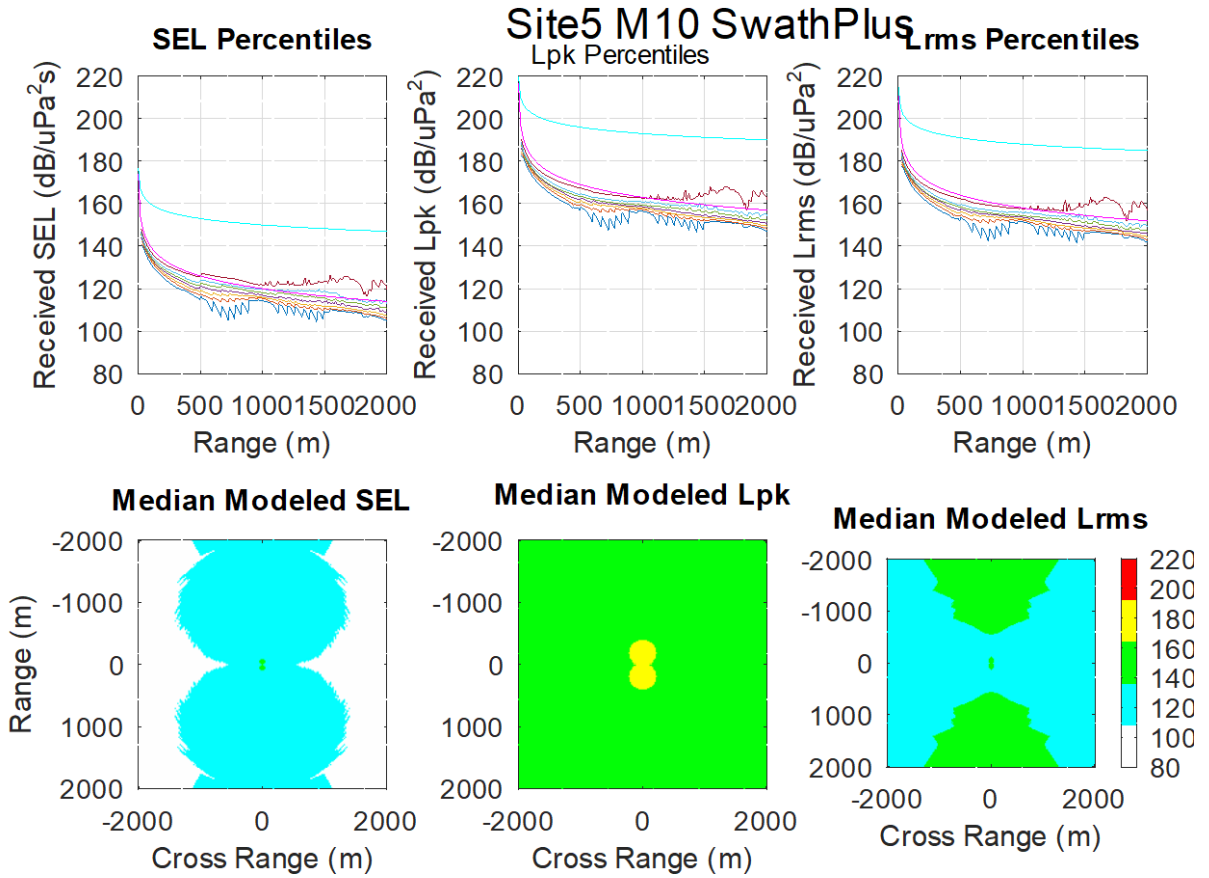


Figure 5-60. SWATHPlus Mode 10 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.11 SEA SWATHPlus, 234 kHz, 100 Percent Power, 50 Cycles (Mode 11)

The SEA SWATHPlus multibeam echosounder generates a single VHF signal with a peak frequency of 234 kHz. The operational parameter settings for Mode 11 were 100 percent power and 50 cycles. Measured source levels are shown in **Table 5-11**.

Table 5-11. NUWC tank measurements of SWATHPlus (Mode 11)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	5	228	223	218	180

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-61**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-11**. Modeling results for each site are shown in **Figures 5-62 to 5-66**.

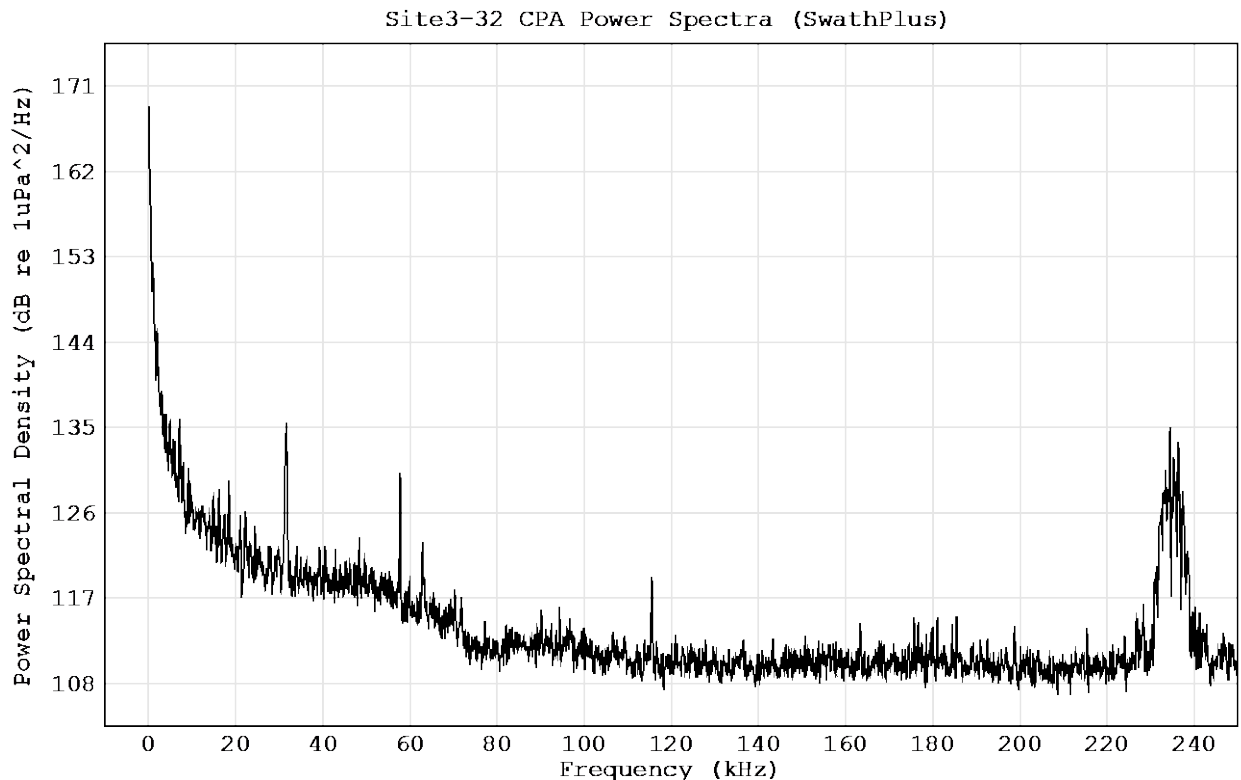


Figure 5-61. SEA SWATHPlus Mode 11 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = with reference to.

5.11.1 Site 1 – Mud, 10-m Depth

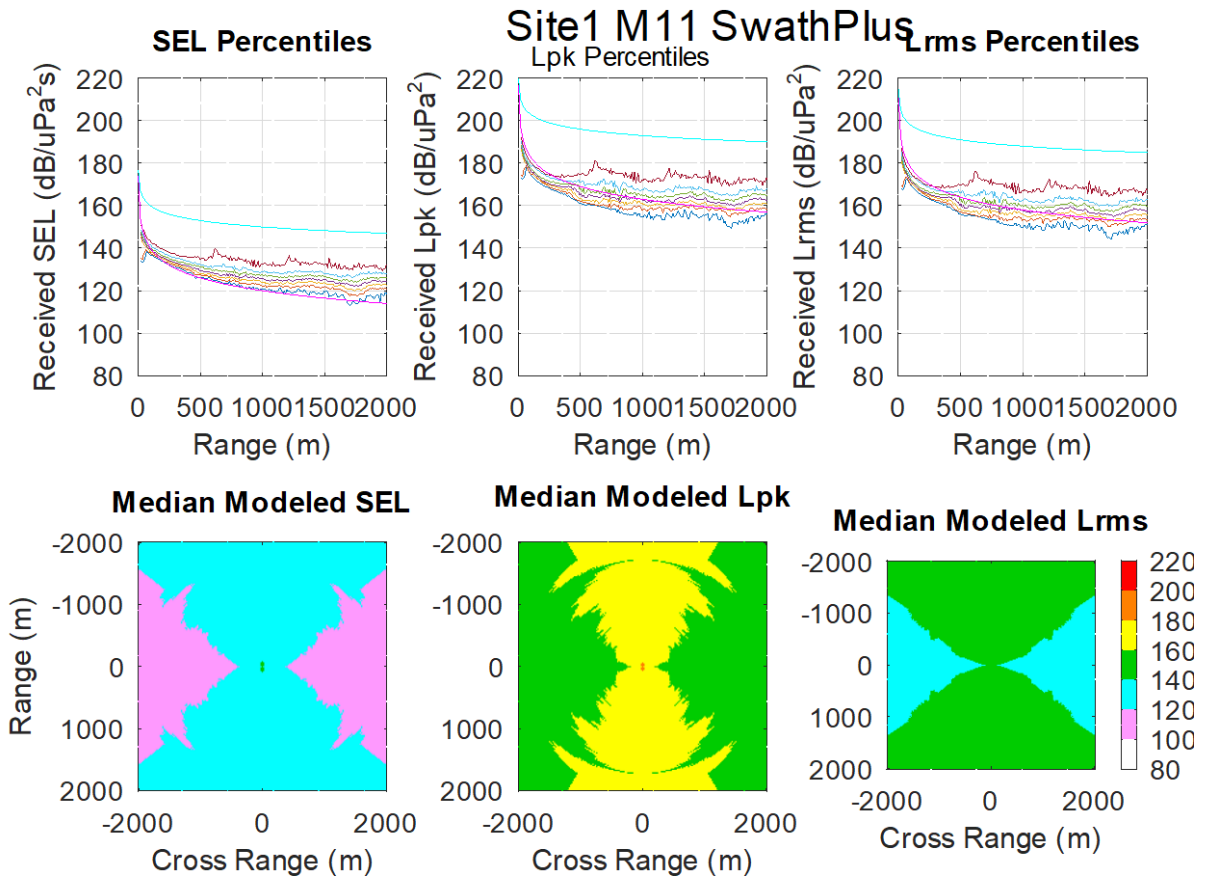


Figure 5-62. SWATHPlus Mode 11 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.11.2 Site 2 – Sand, 10-m Depth

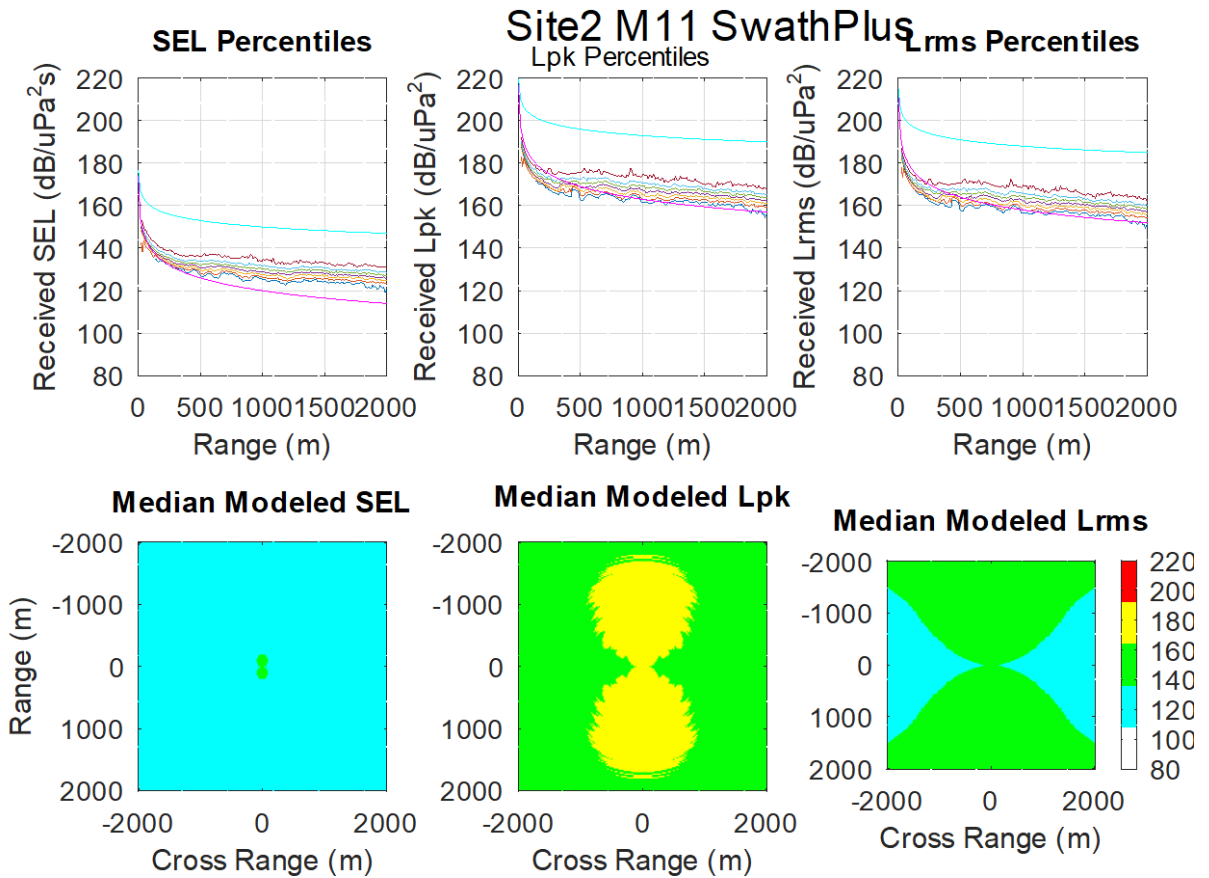


Figure 5-63. SWATHPlus Mode 11 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.11.3 Site 3 – Mud, 30-m Depth

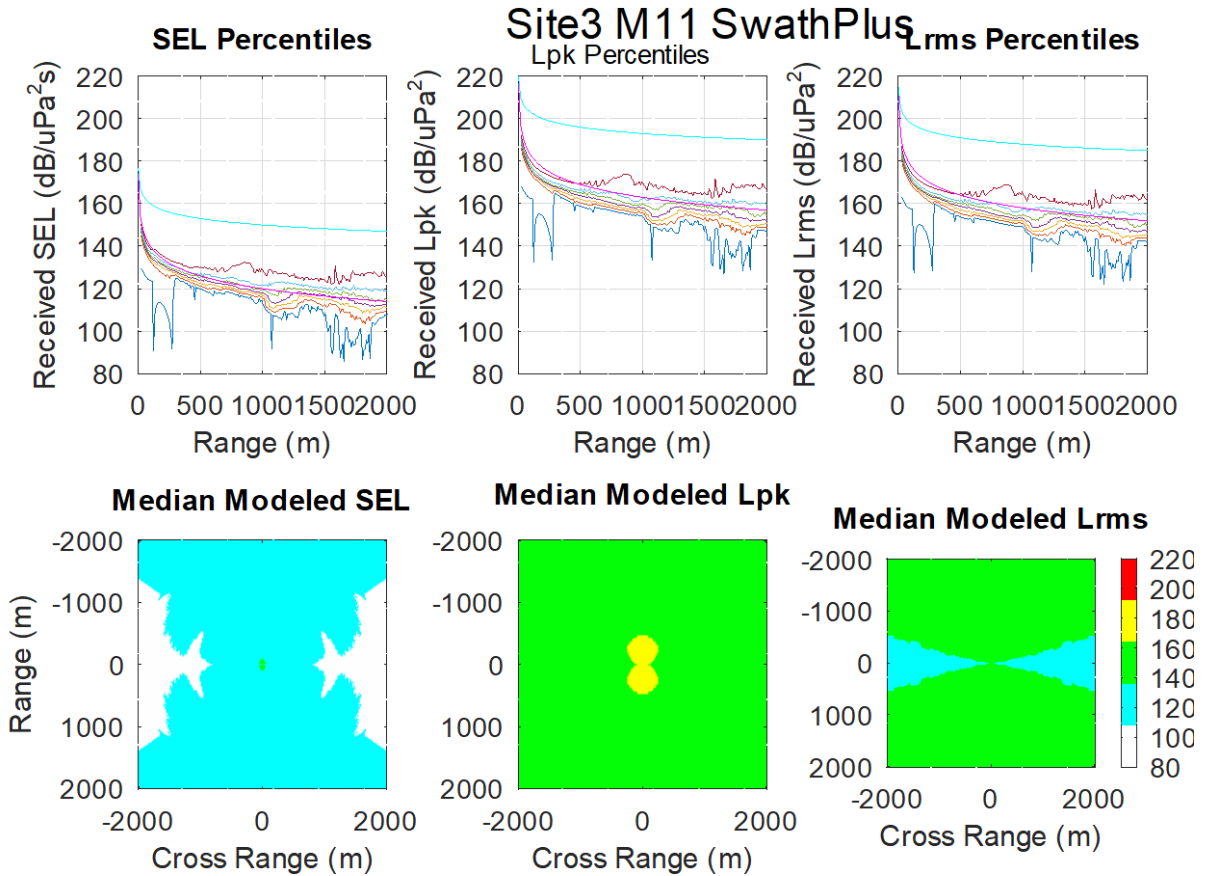


Figure 5-64. SWATHPlus Mode 11 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.11.4 Site 4 – Sand, 30-m Depth

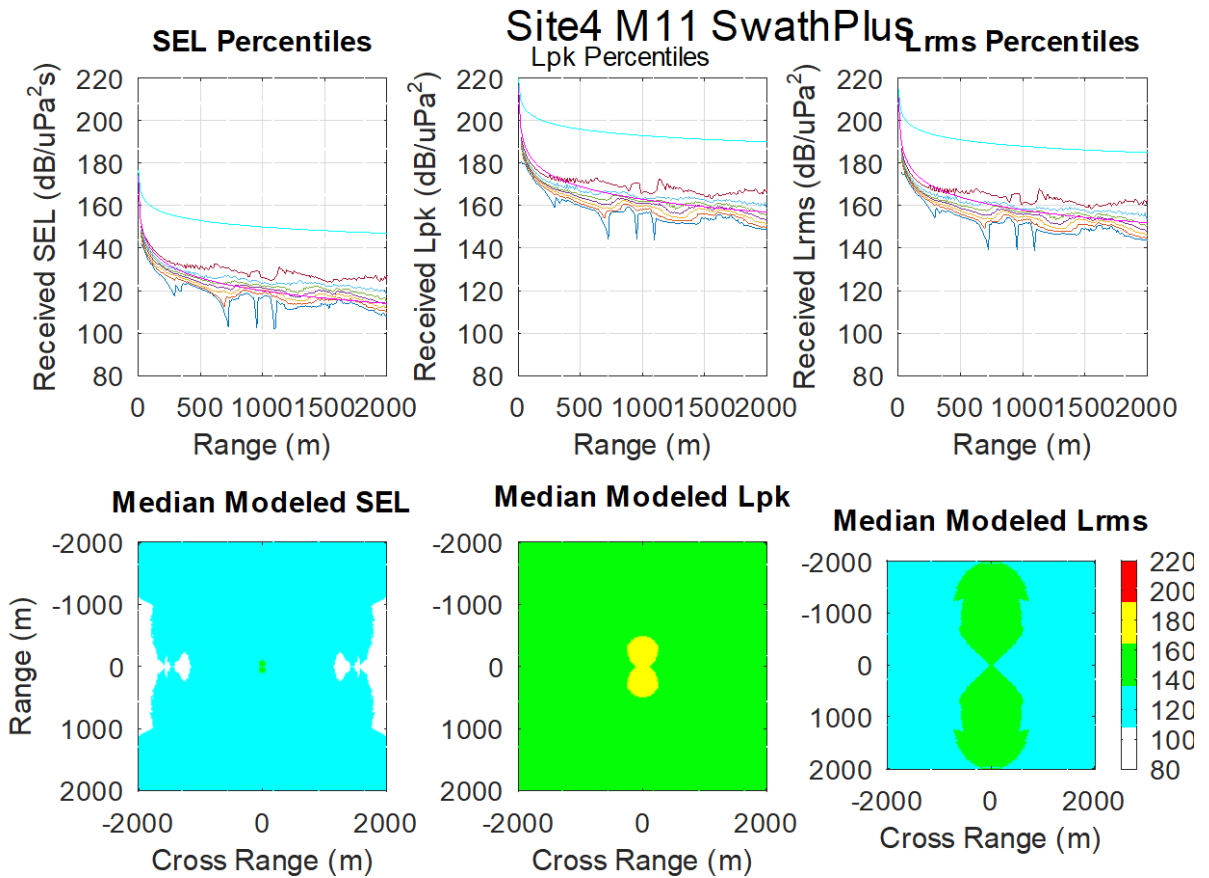


Figure 5-65. SWATHPlus Mode 11 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.11.5 Site 5 – Sandy Silt, 100-m Depth

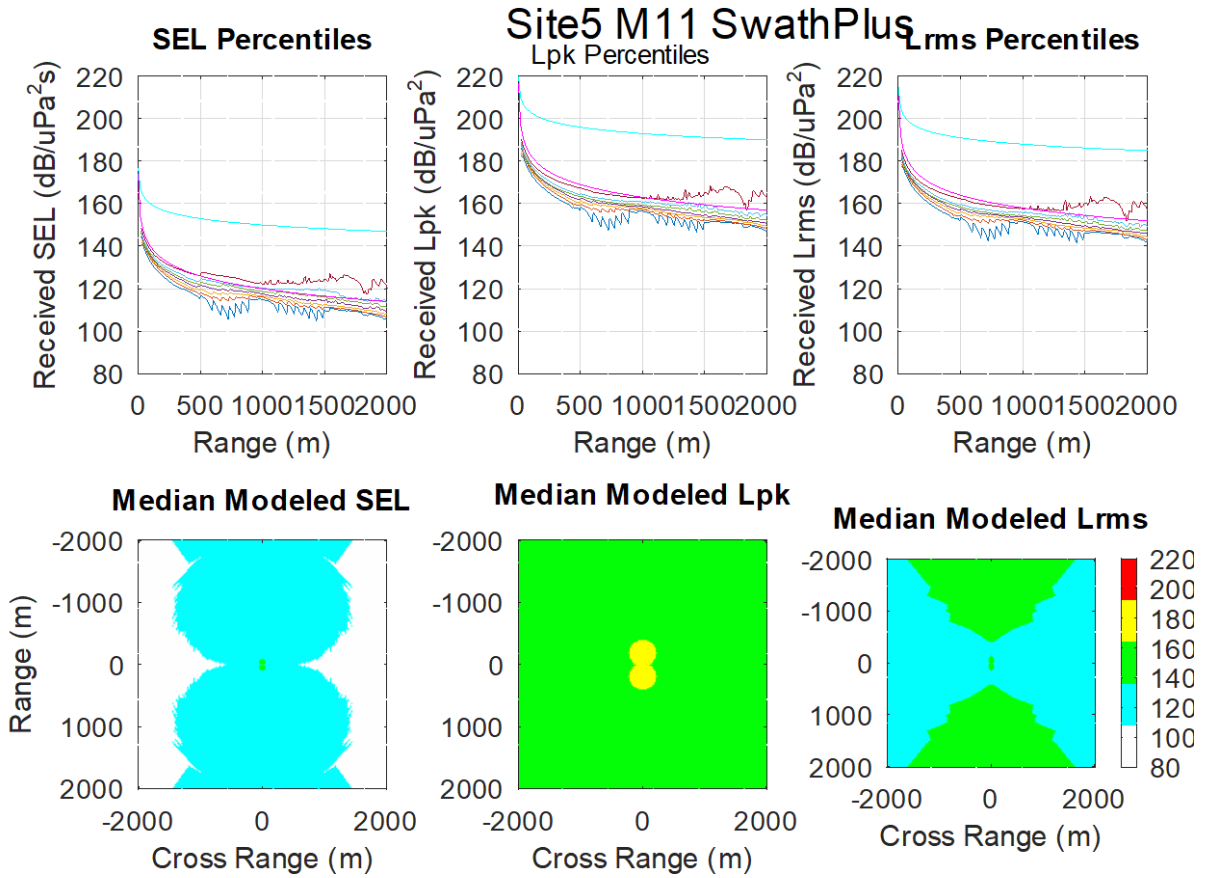


Figure 5-66. SWATHPlus Mode 11 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.12 SEA SWATHPlus, 234 kHz, 100 Percent Power, 250 Cycles (Mode 12)

The SEA SWATHPlus multibeam echosounder generates a single VHF signal with a peak frequency of 234 kHz. The operational parameter settings for Mode 12 were 100 percent power and 250 cycles. Measured source levels are shown in **Table 5-12**.

Table 5-12. NUWC tank measurements of SWATHPlus (Mode 12)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	5	217	211	207	177

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-67**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-12**. Modeling results for each site are shown in **Figures 5-68 to 5-72**.

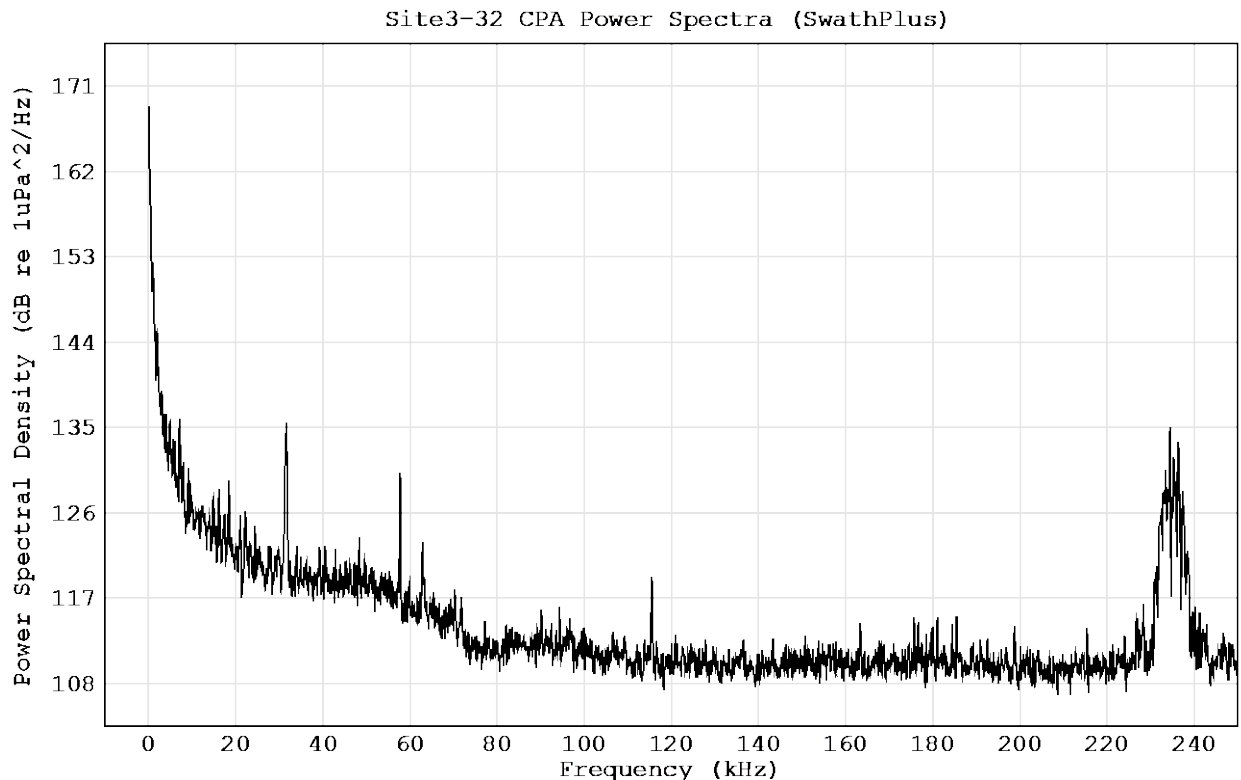


Figure 5-67. SEA SWATHPlus Mode 12 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = with reference to.

5.12.1 Site 1 – Mud, 10-m Depth

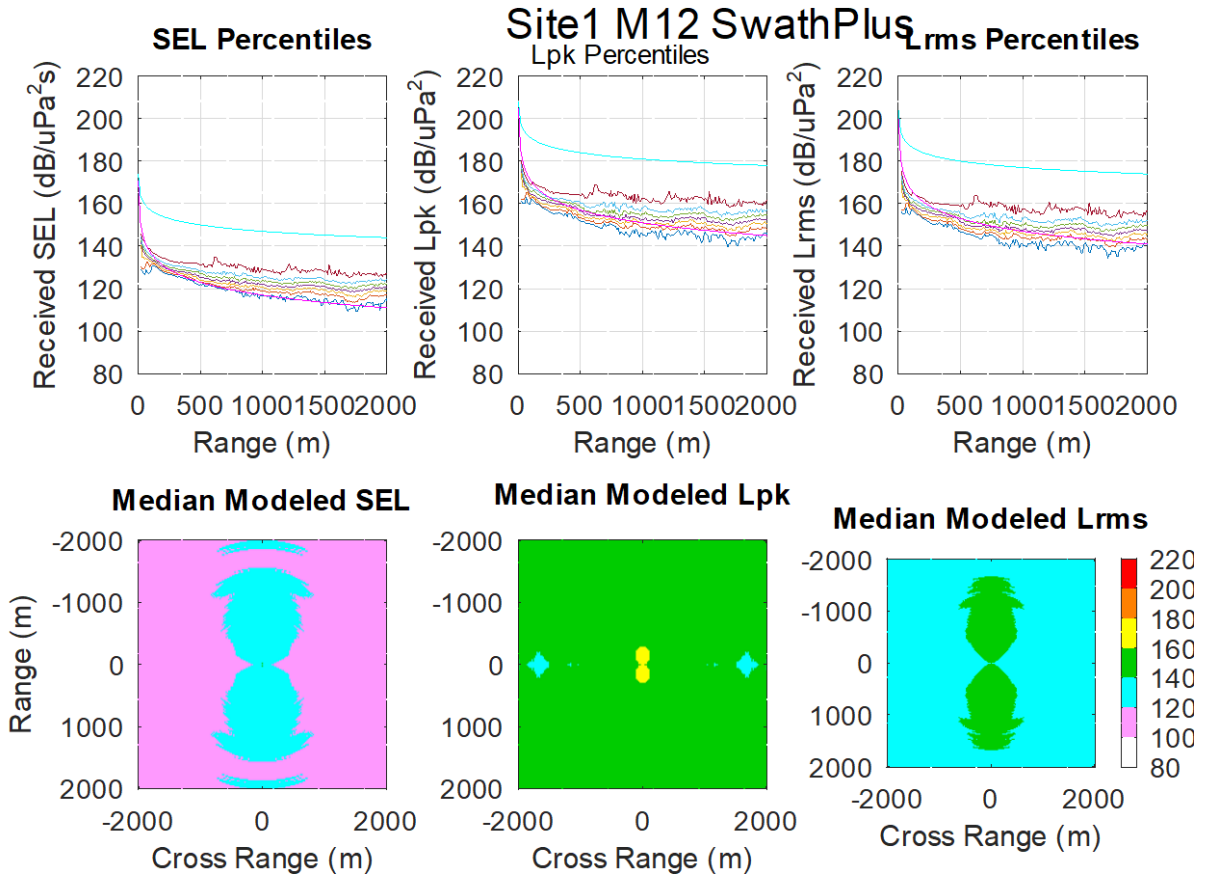


Figure 5-68. SWATHPlus Mode 12 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.12.2 Site 2 – Sand, 10-m Depth

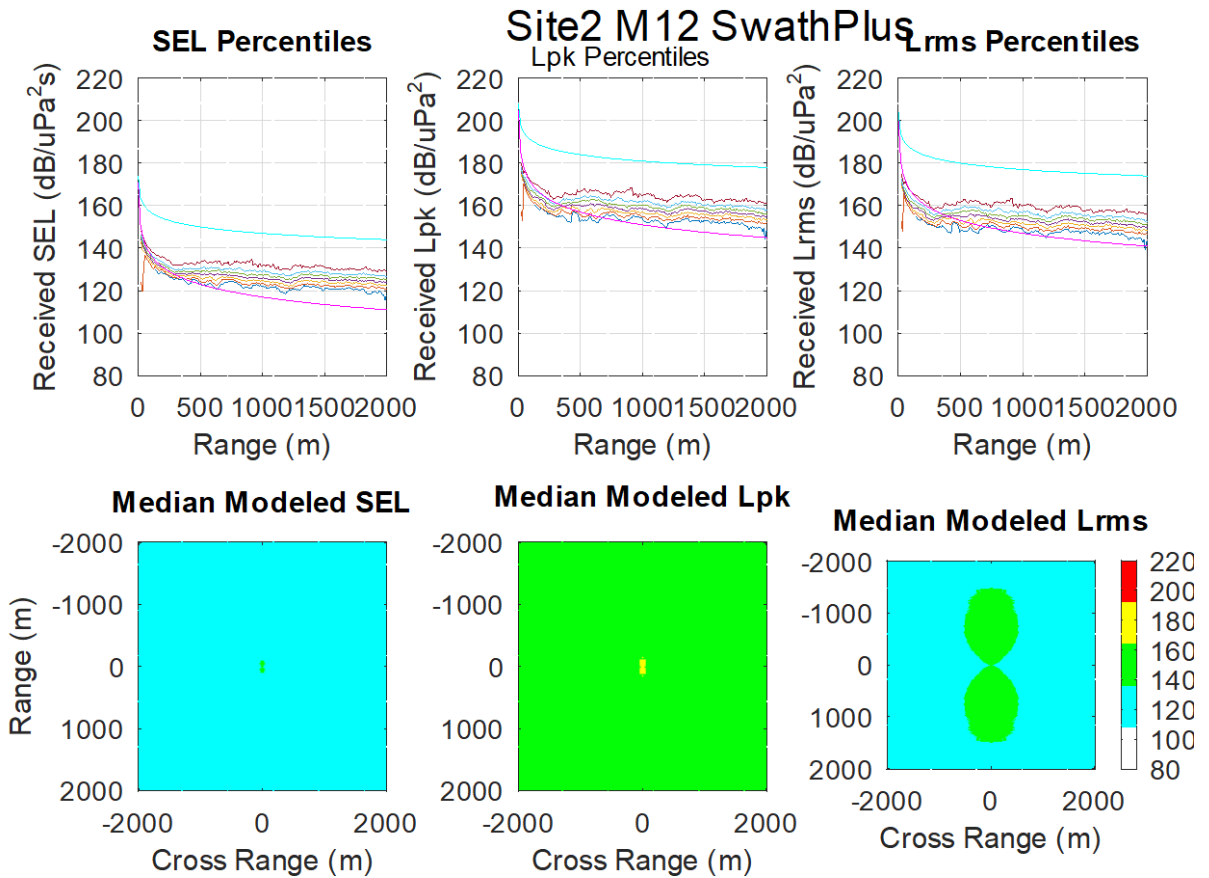


Figure 5-69. SWATHPlus Mode 12 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.12.3 Site 3 – Mud, 30-m Depth

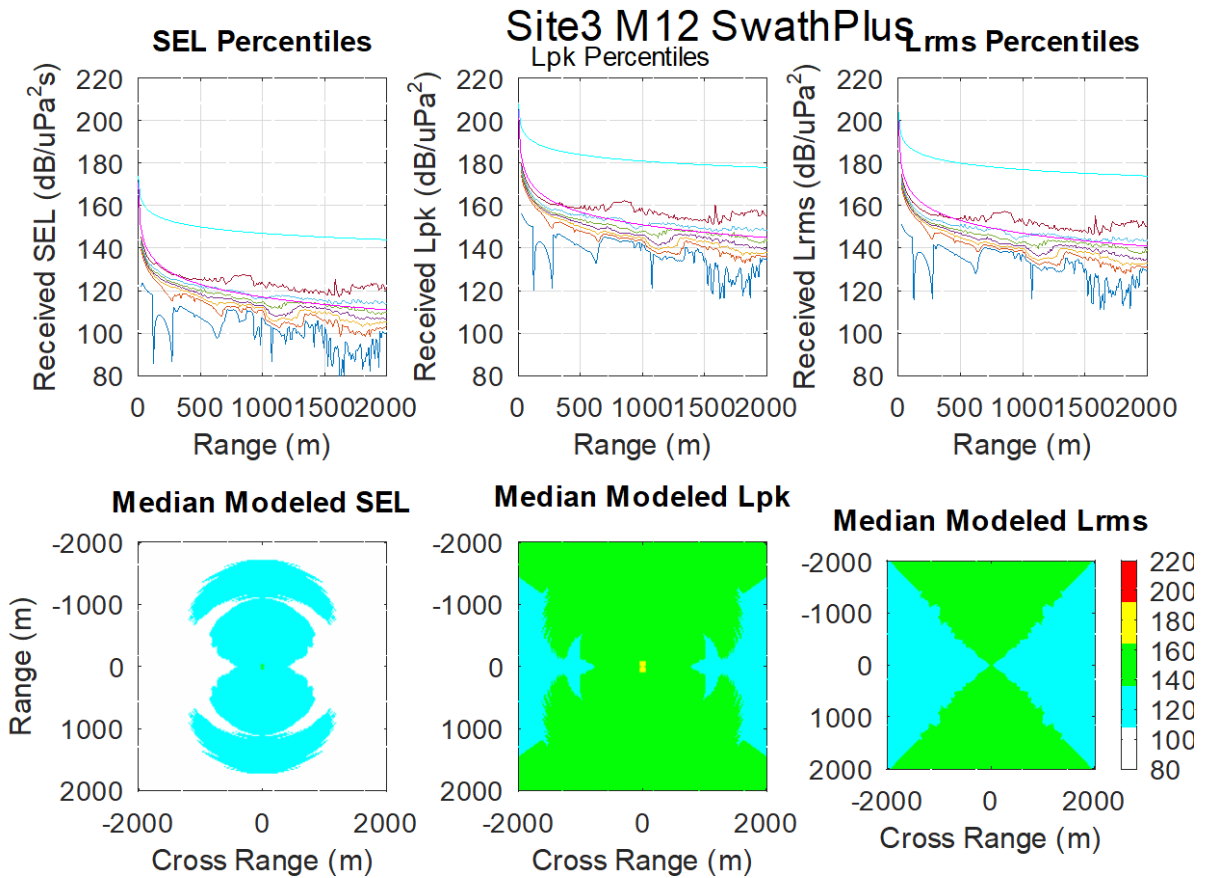


Figure 5-70. SWATHPlus Mode 12 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.12.4 Site 4 – Sand, 30-m Depth

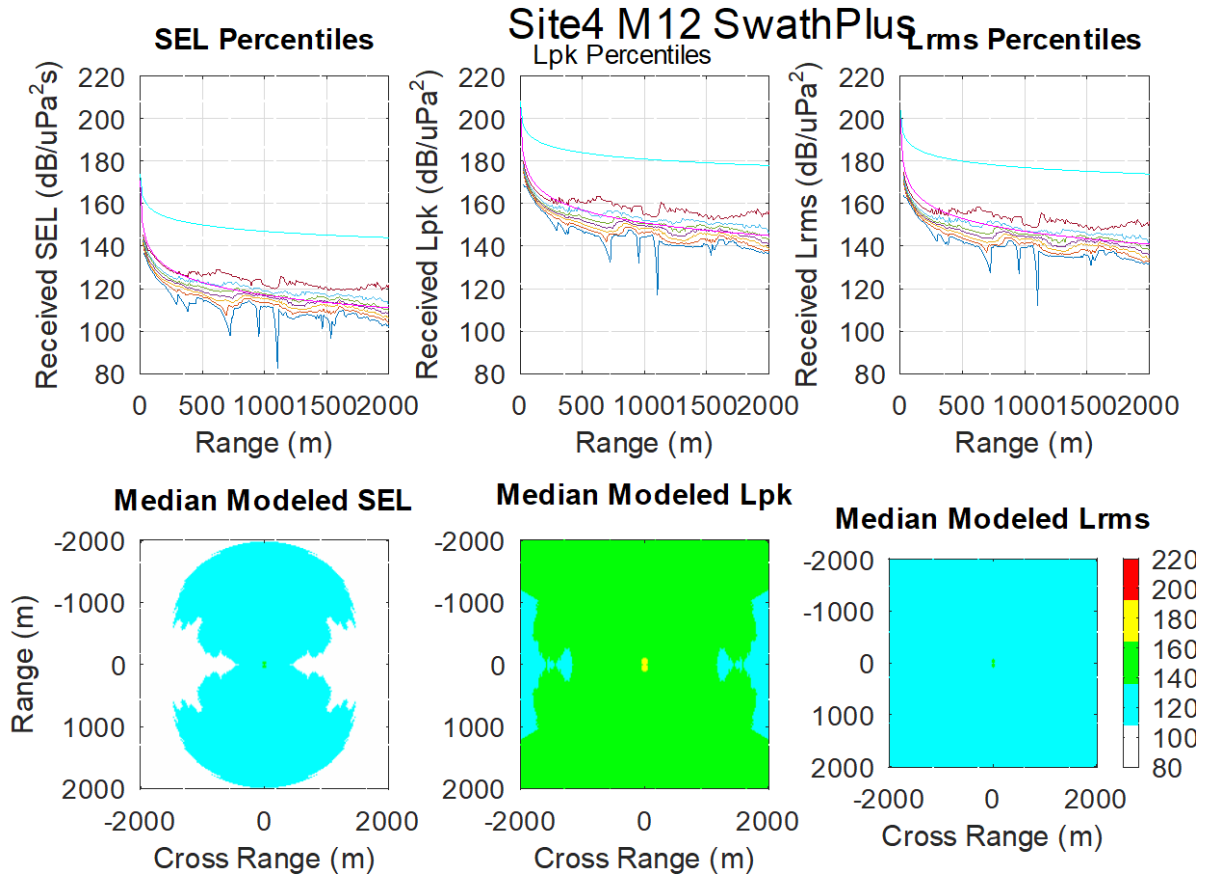


Figure 5-71. SWATHPlus Mode 12 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.12.5 Site 5 – Sandy Silt, 100-m Depth

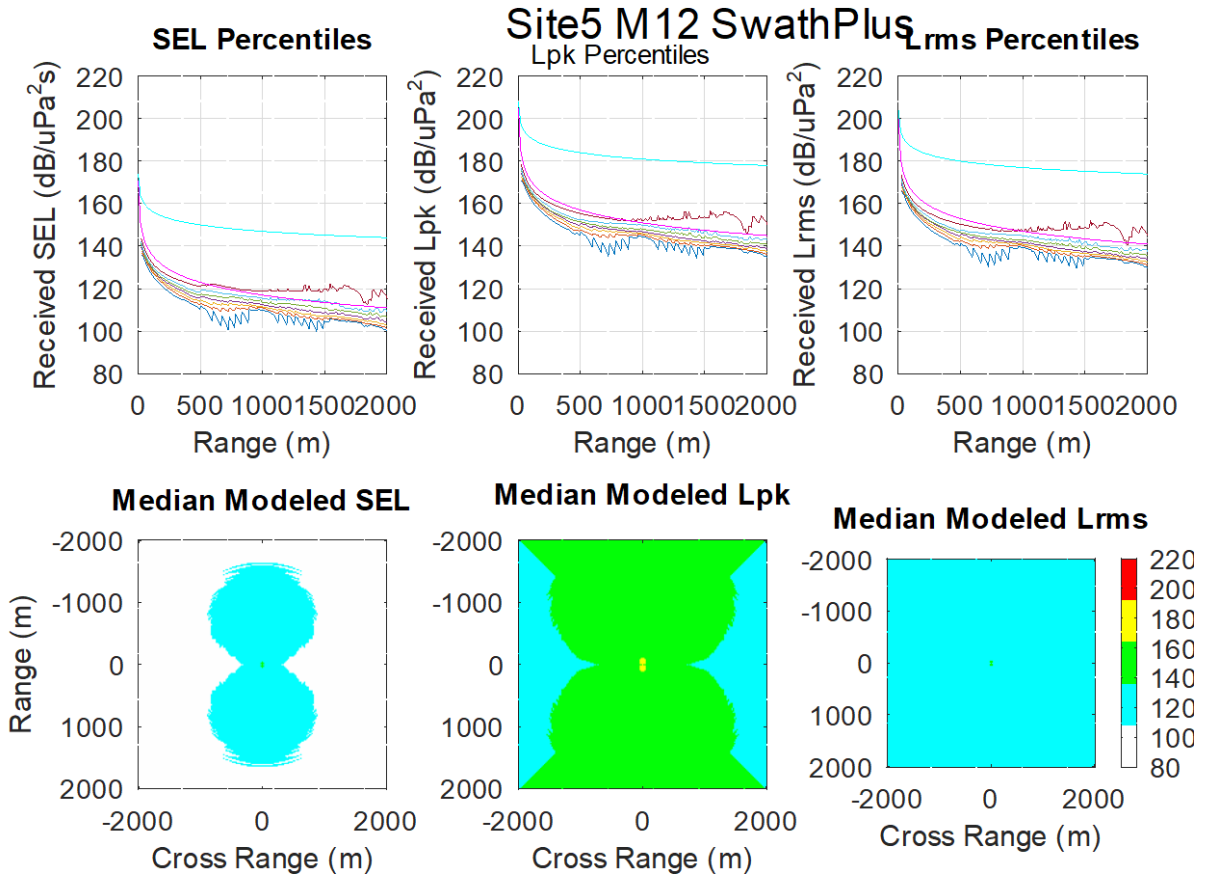


Figure 5-72. SWATHPlus Mode 12 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.13 Simrad EK60, 38 kHz, 100 Percent Power, 512- μ s Pulse (Mode 13)

The EK60 split-beam echosounder generates a single HF signal with a peak frequency of 38 kHz. The operational parameter settings for Mode 13 were 100 percent power, a 512- μ s pulse, and a 38-kHz output frequency. Measured source levels from Simrad (2015) are provided in **Table 5-13**.

Table 5-13. Scottish government measurements of EK60 (Mode 13)

Source Settings		Source Level		
Power Level (%)	Depth (m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	1.5	205	184	170

μ Pa = micropascal; dB = decibel; m = meter; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Simrad, 2015.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-73**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-13**. Modeling results for each site are shown in **Figures 5-74 to 5-78**.

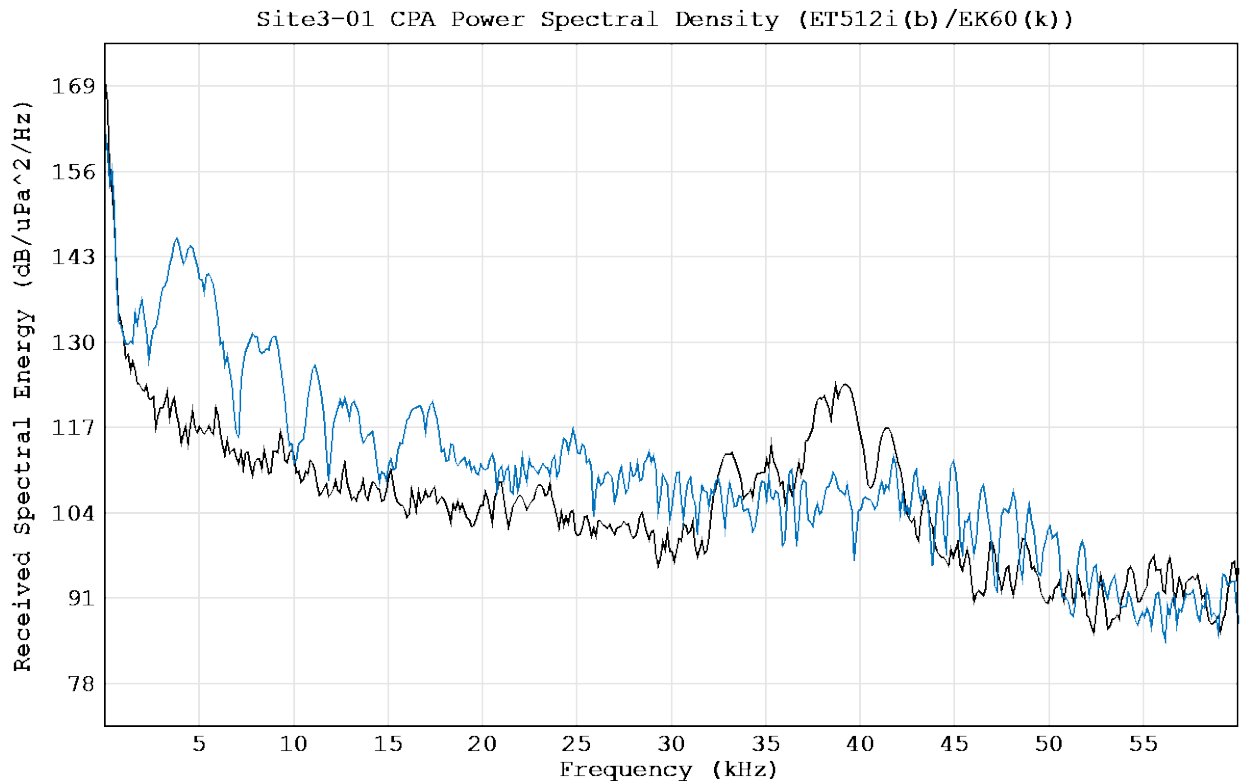


Figure 5-73. EK60 Mode 13 measured spectra at buoy position D (black).

The spectra for ET512 are included as the blue line. μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.13.1 Site 1 – Mud, 10-m Depth

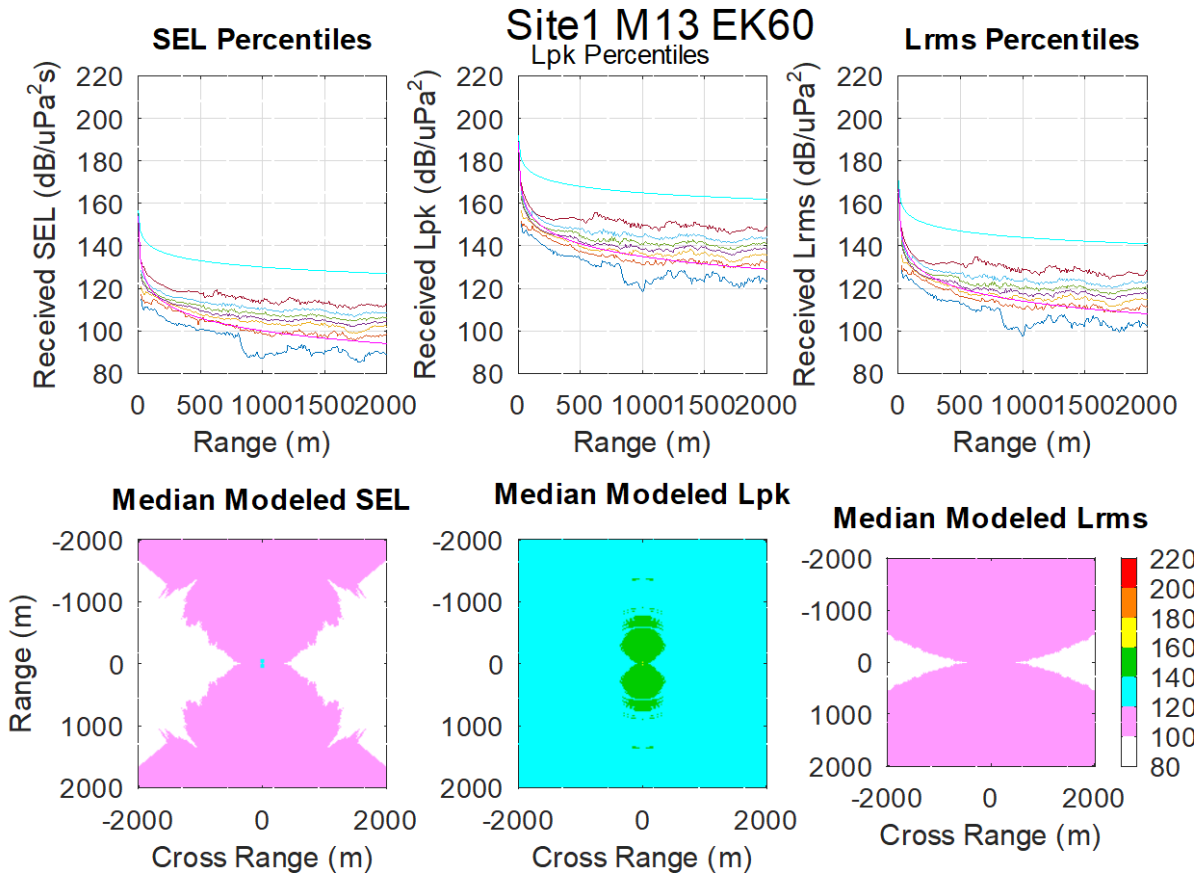


Figure 5-74. EK60 Mode 13 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.13.2 Site 2 – Sand, 10-m Depth

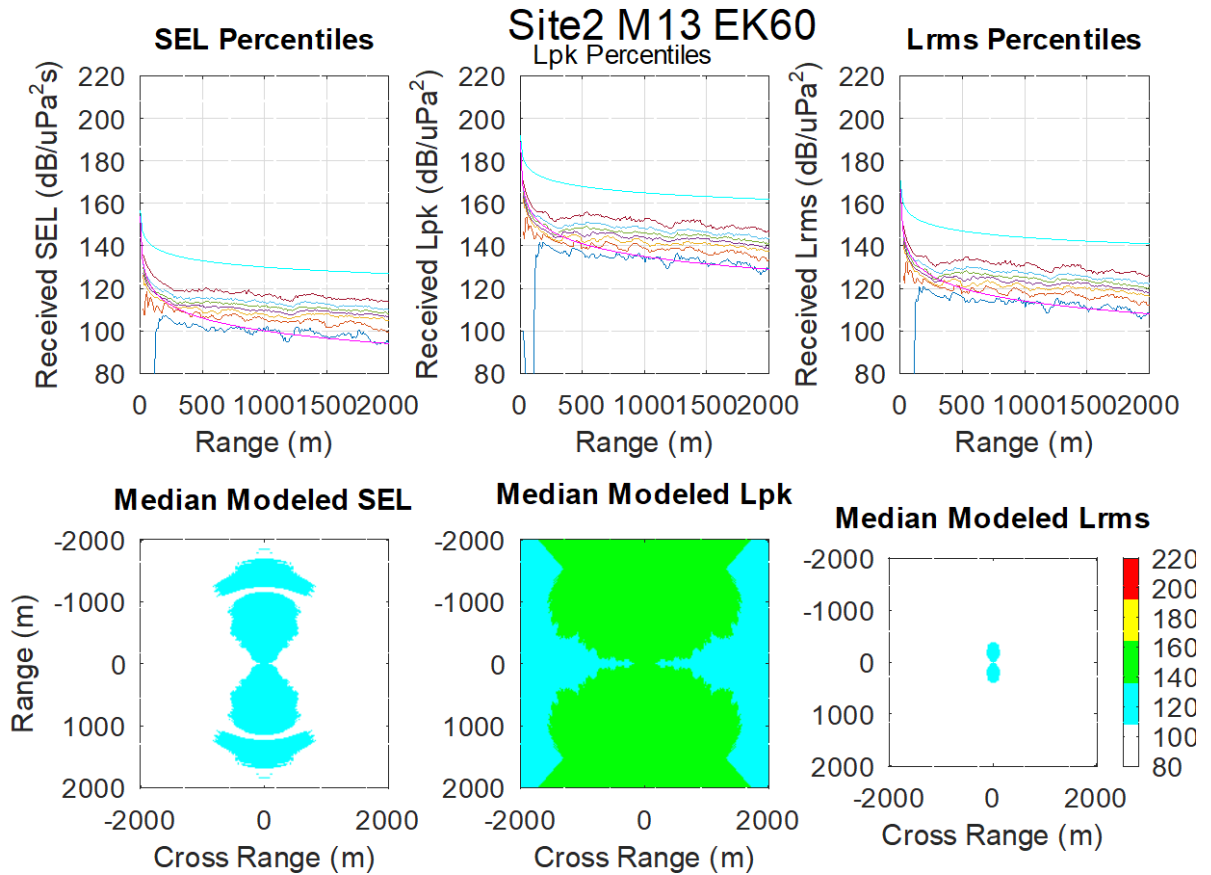


Figure 5-75. EK60 Mode 13 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.13.3 Site 3 – Mud, 30-m Depth

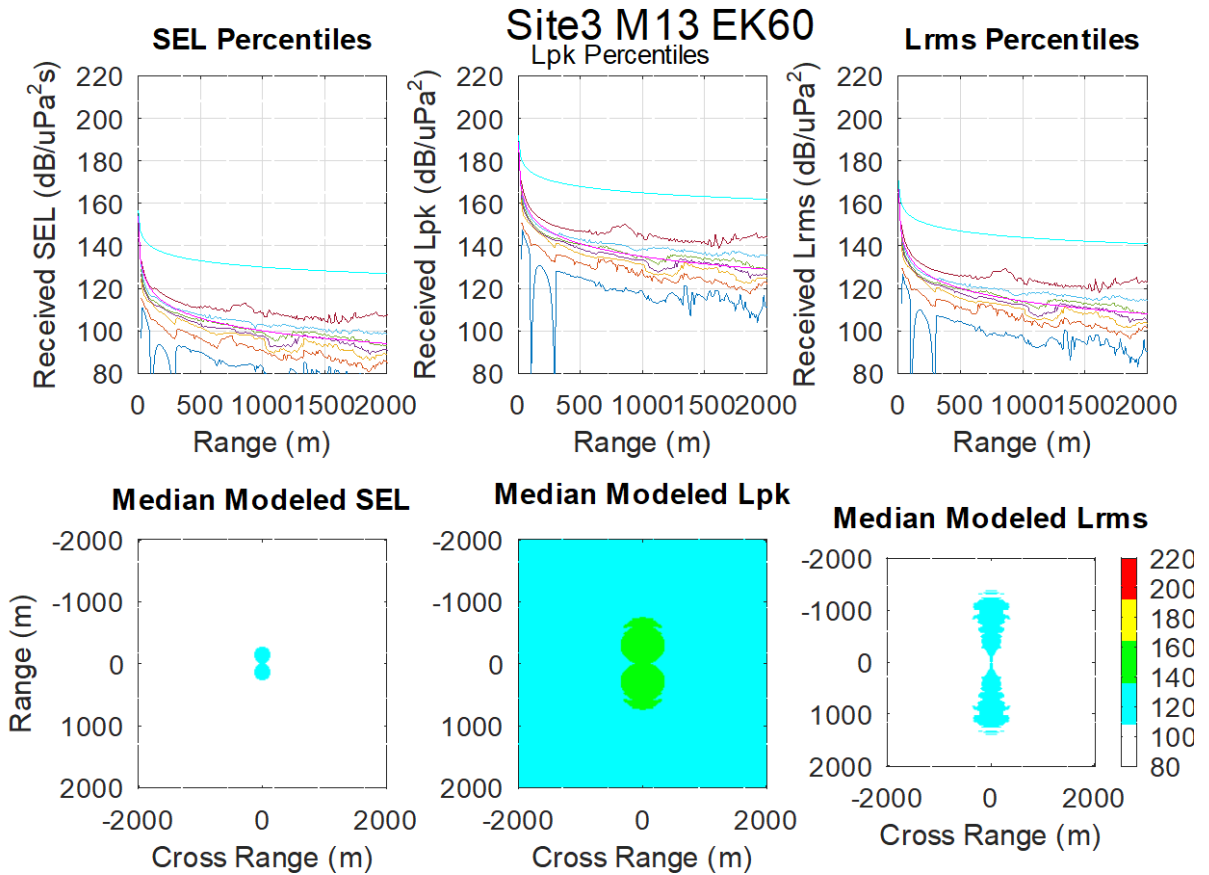


Figure 5-76. EK60 Mode 13 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.13.4 Site 4 – Sand, 30-m Depth

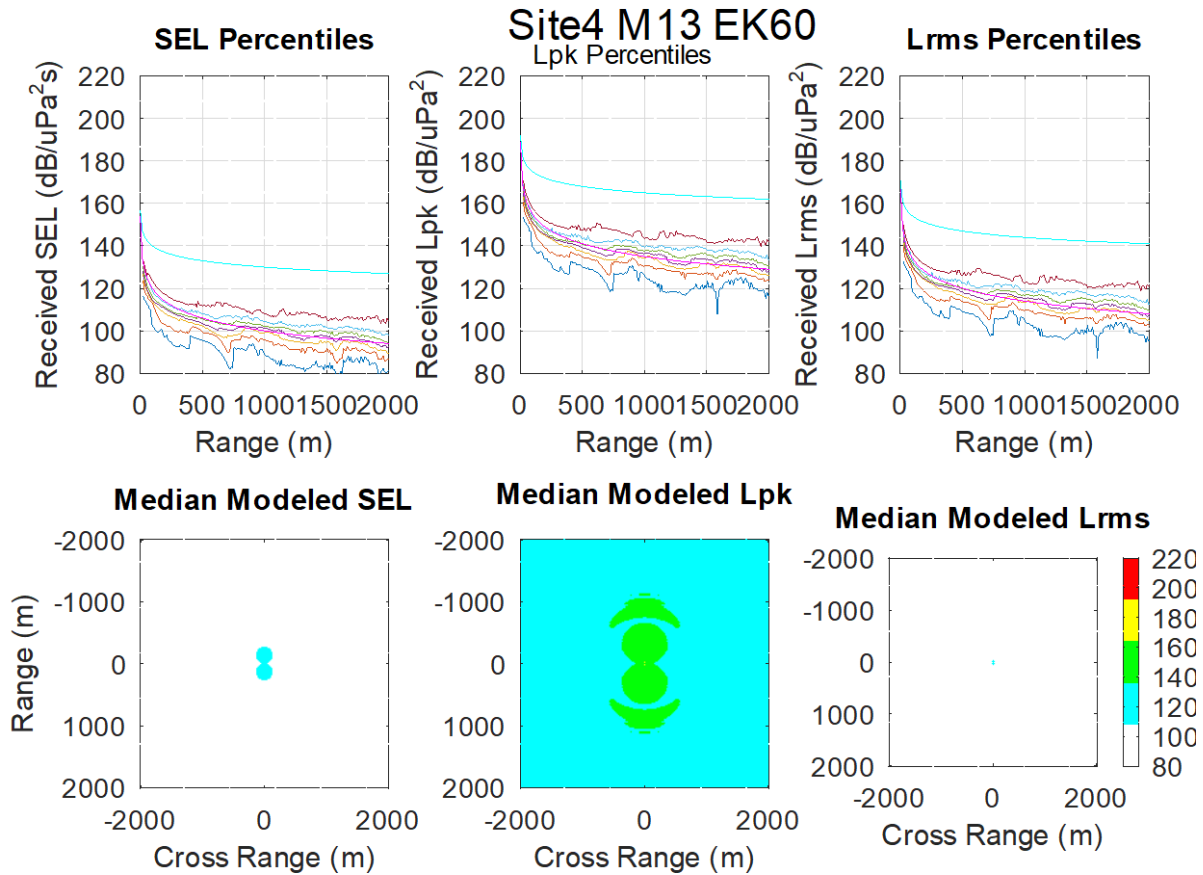


Figure 5-77. EK60 Mode 13 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.13.5 Site 5 – Sandy Silt, 100-m Depth

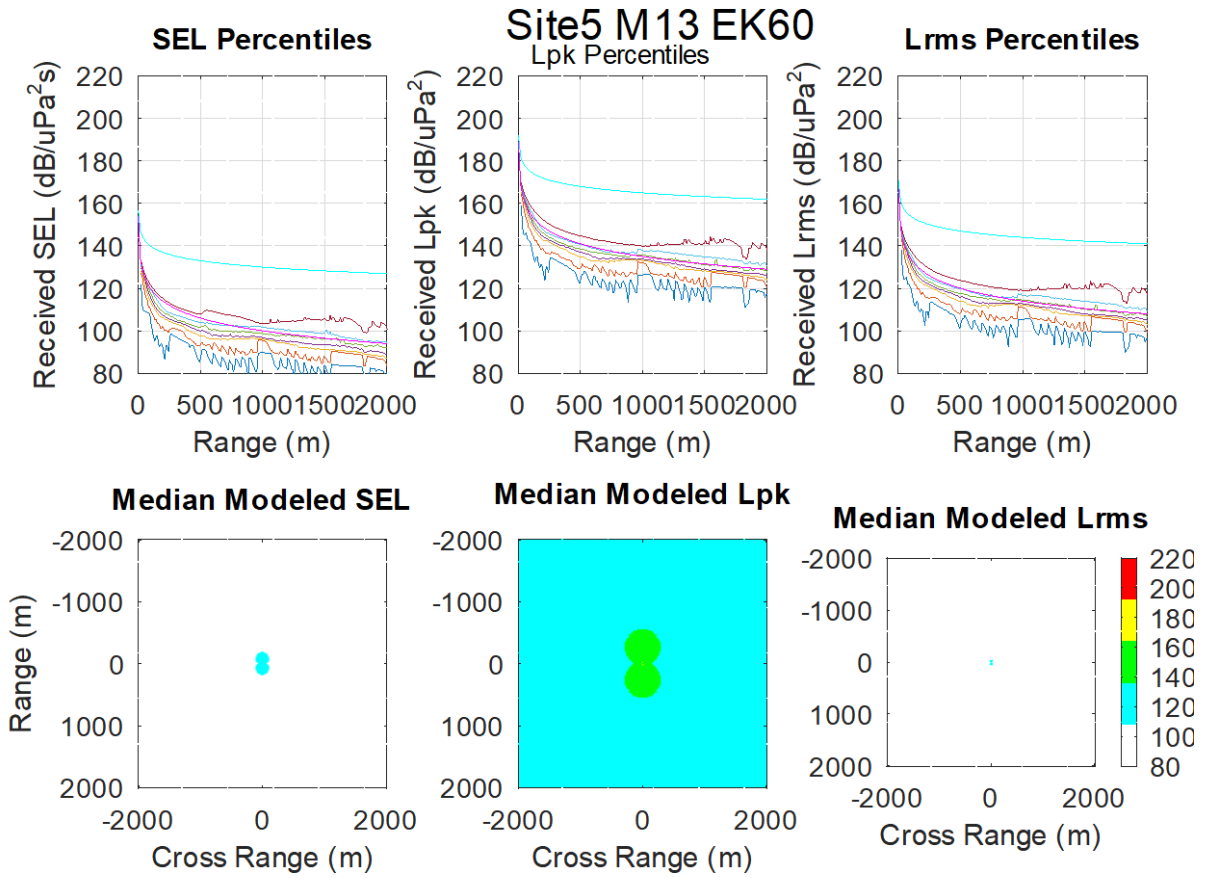


Figure 5-78. EK60 Mode 13 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.14 Simrad EK60, 38 kHz, 100 Percent Power, 1,024-μs Pulse (Mode 14)

The EK60 split-beam multibeam echosounder generates a single HF signal with a peak frequency of 38 kHz. The operational parameter settings for Mode 14 were 100 percent power, a 1,024-μs pulse, and a 38-kHz output frequency. Measured source levels from Simrad (2015) are provided in **Table 5-14**.

Table 5-14. Scottish government measurements of EK60 (Mode 14)

Source Settings		Source Level		
Power Level (%)	Depth (m)	Peak (dB re 1 μPa m)	rms (dB re 1 μPa m)	SEL (dB re 1 μPa ² m ² s)
100	1.5	205	184	170

μPa = micropascal; dB = decibel; m = meter; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.

From: Simrad, 2015.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-79**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-14**.

Modeling results for each site are shown in **Figures 5-80 to 5-84**.

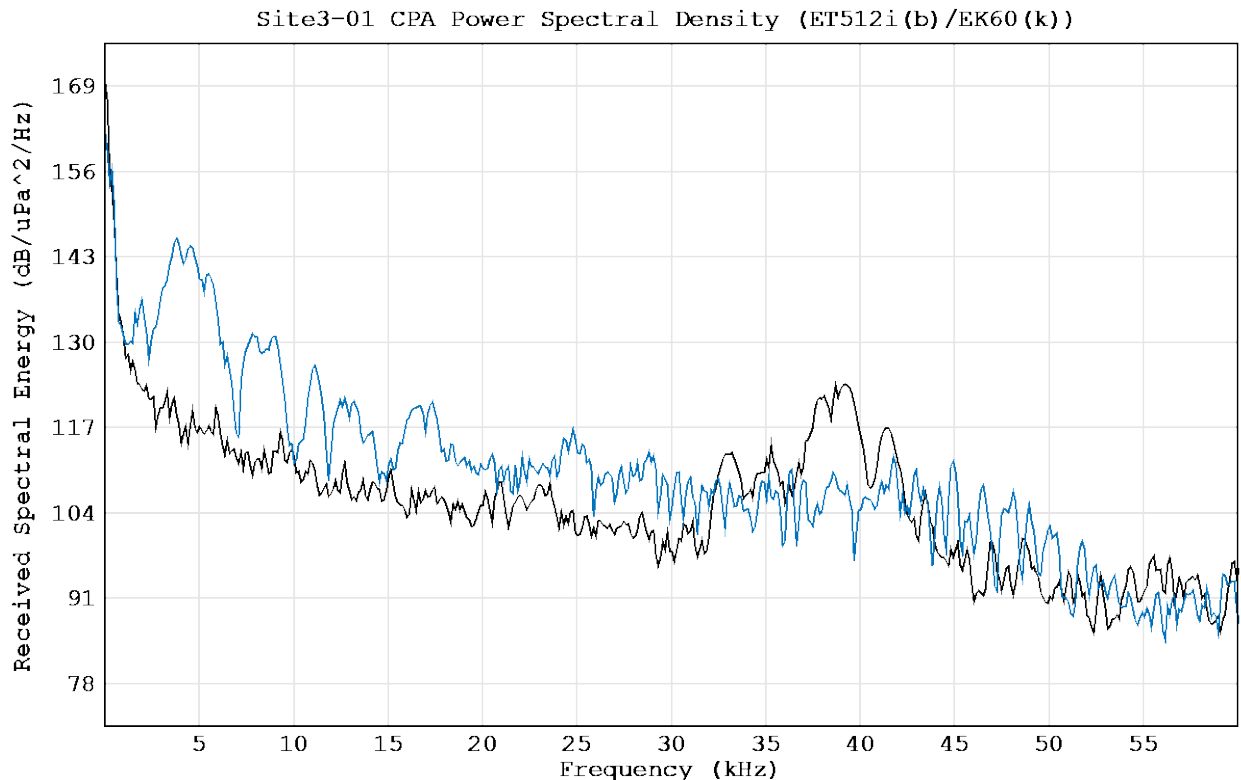


Figure 5-79. EK60 Mode 14 measured spectra at buoy position D (black)

The spectra for ET512 are included as the blue line. μPa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.14.1 Site 1 – Mud, 10-m Depth

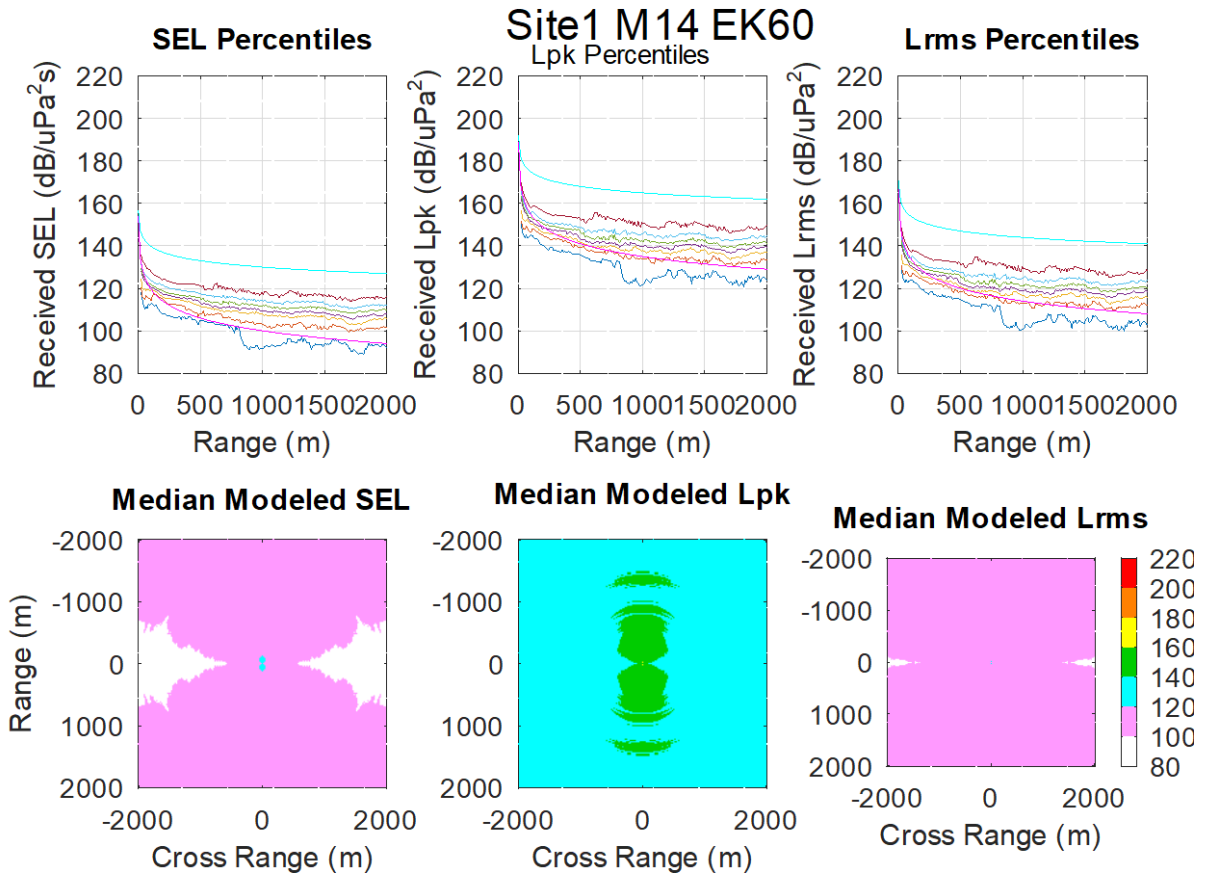


Figure 5-80. EK60 Mode 14 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.14.2 Site 2 – Sand, 10-m Depth

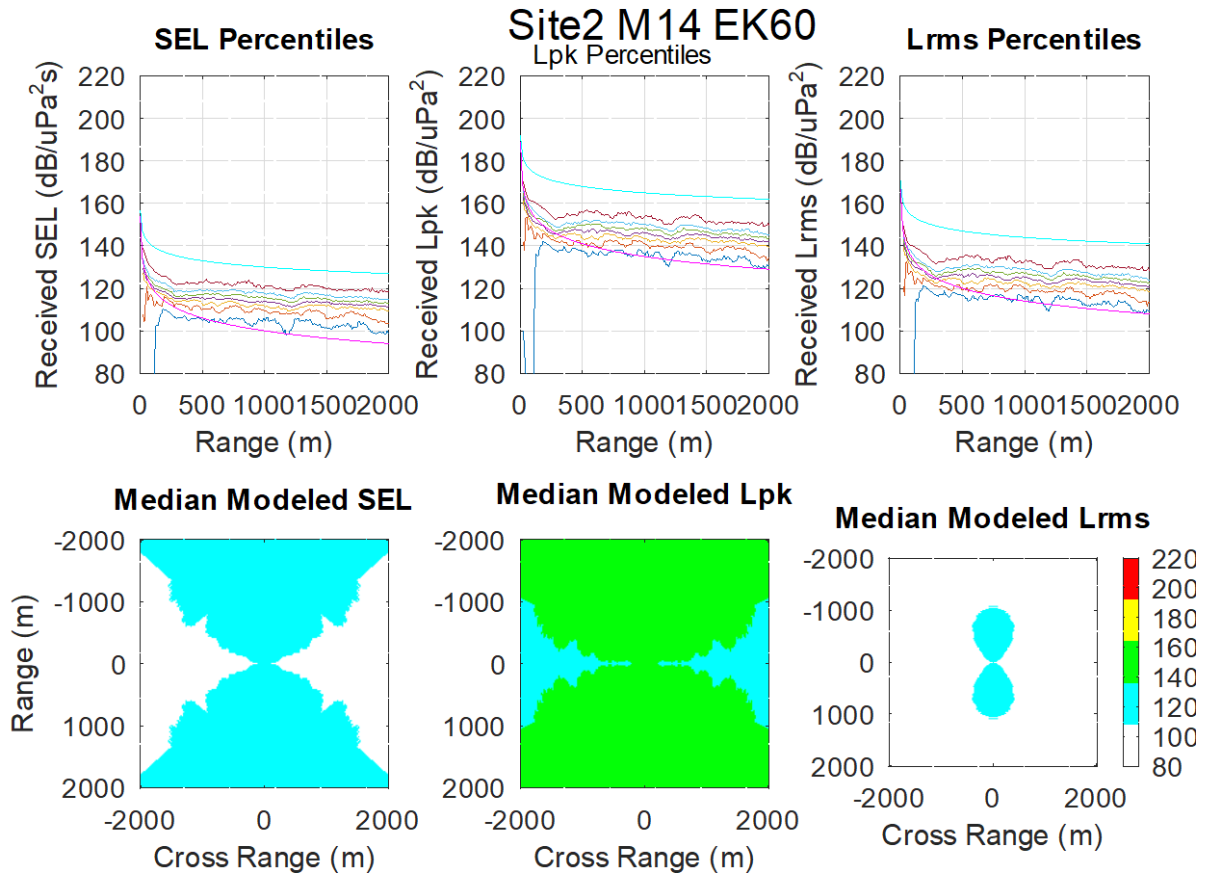


Figure 5-81. EK60 Mode 14 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.14.3 Site 3 – Mud, 30-m Depth

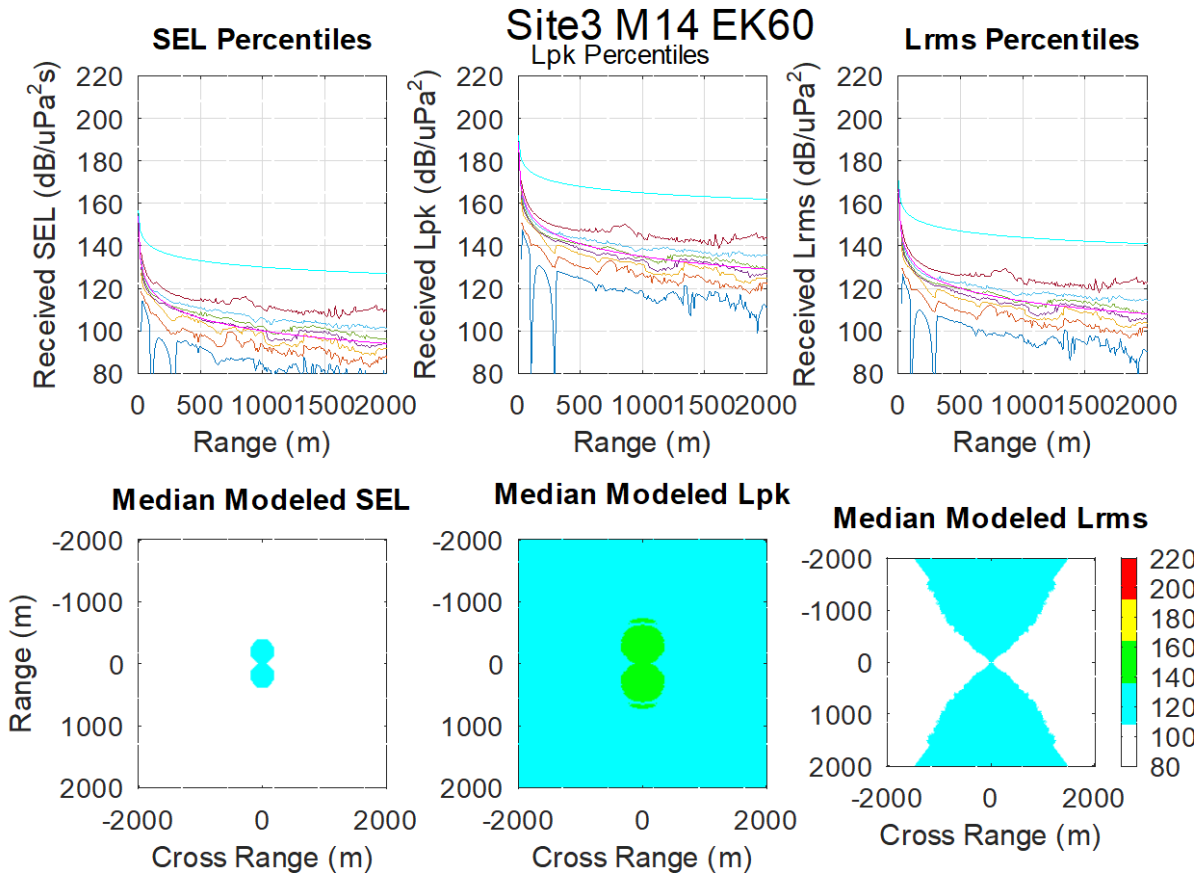


Figure 5-82. EK60 Mode 14 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.14.4 Site 4 – Sand, 30-m Depth

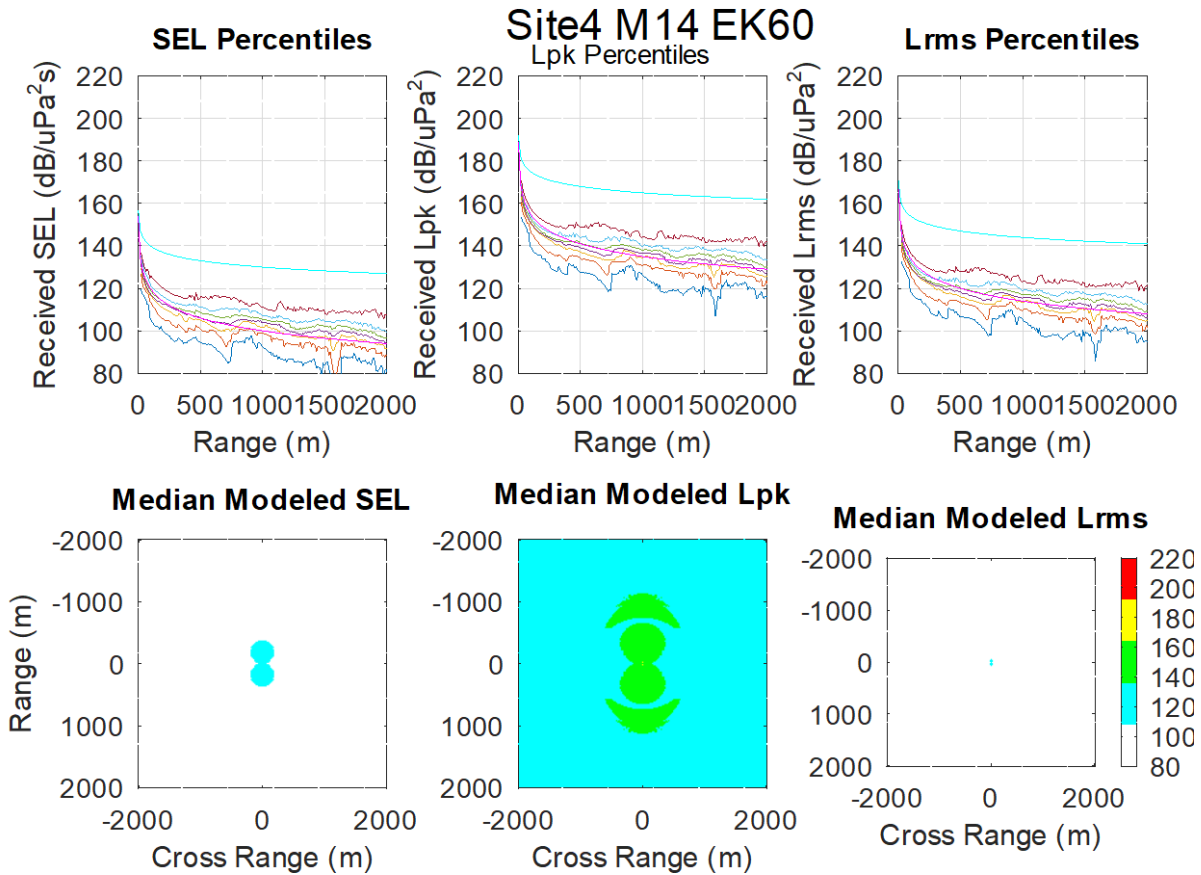


Figure 5-83. EK60 Mode 14 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.14.5 Site 5 – Sandy Silt, 100-m Depth

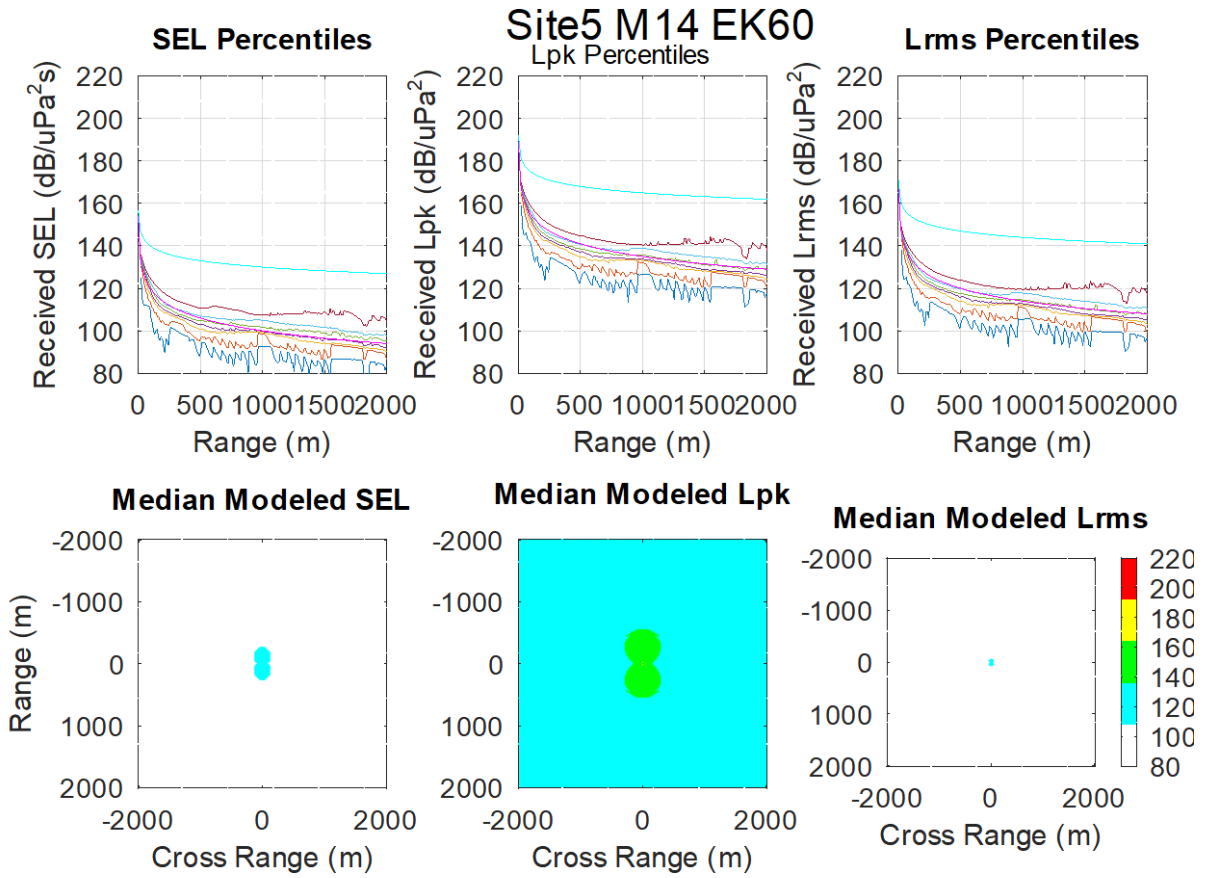


Figure 5-84. EK60 Mode 14 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.15 Simrad EK60, 38 kHz, 50 Percent Power, 512- μ s Pulse (Mode 15)

The EK60 split-beam multibeam echosounder generates a single HF signal with a peak frequency of 38 kHz. The operational parameter settings for Mode 15 were 50 percent power, a 512- μ s pulse, and a 38-kHz output frequency. Measured source levels from Simrad (2015) are provided in **Table 5-15**.

Table 5-15. Scottish government measurements of EK60 (Mode 15)

Source Settings		Source Level		
Power Level (%)	Depth (m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
50	1.5	202	181	167

μ Pa = micropascal; dB = decibel; m = meter; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Simrad, 2015.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-85**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-15**. Modeling results for each site are shown in **Figures 5-86 to 5-90**.

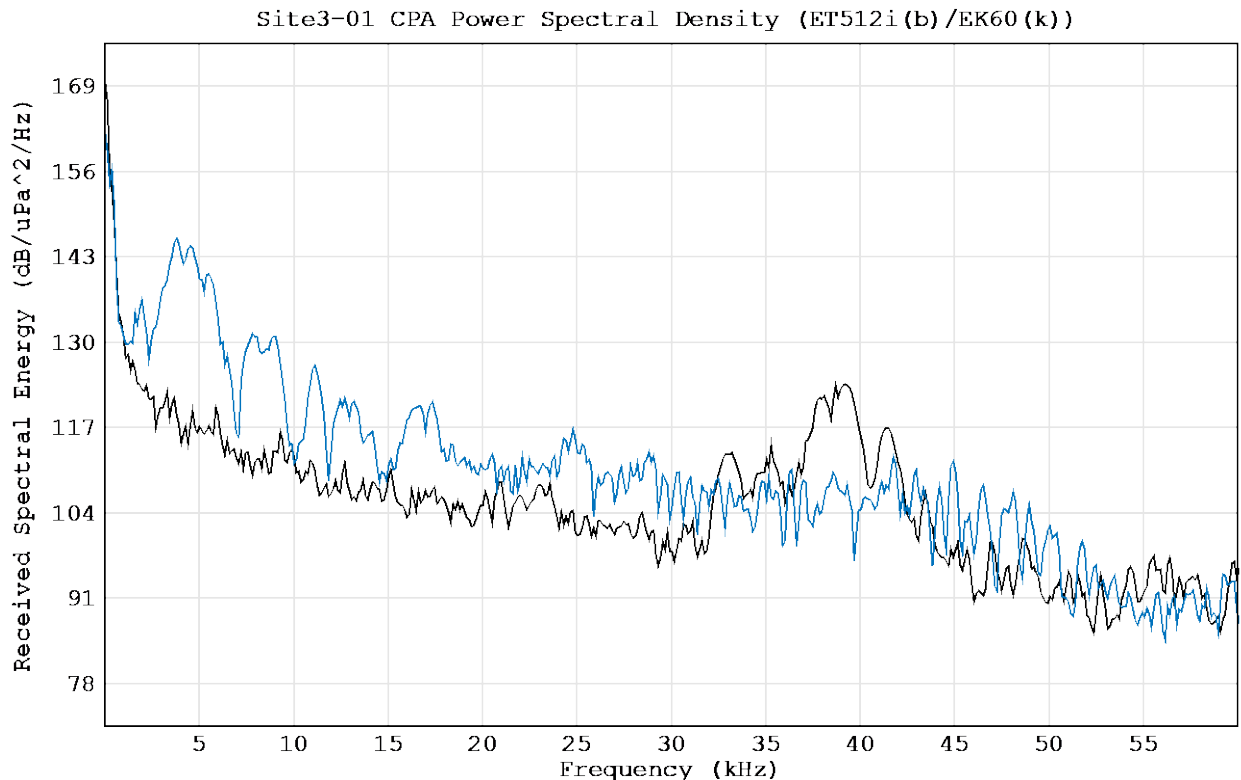


Figure 5-85. EK60 Mode 15 measured spectra at buoy position D (black)

The spectra for ET512 are included as the blue line. μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.15.1 Site 1 – Mud, 10-m Depth

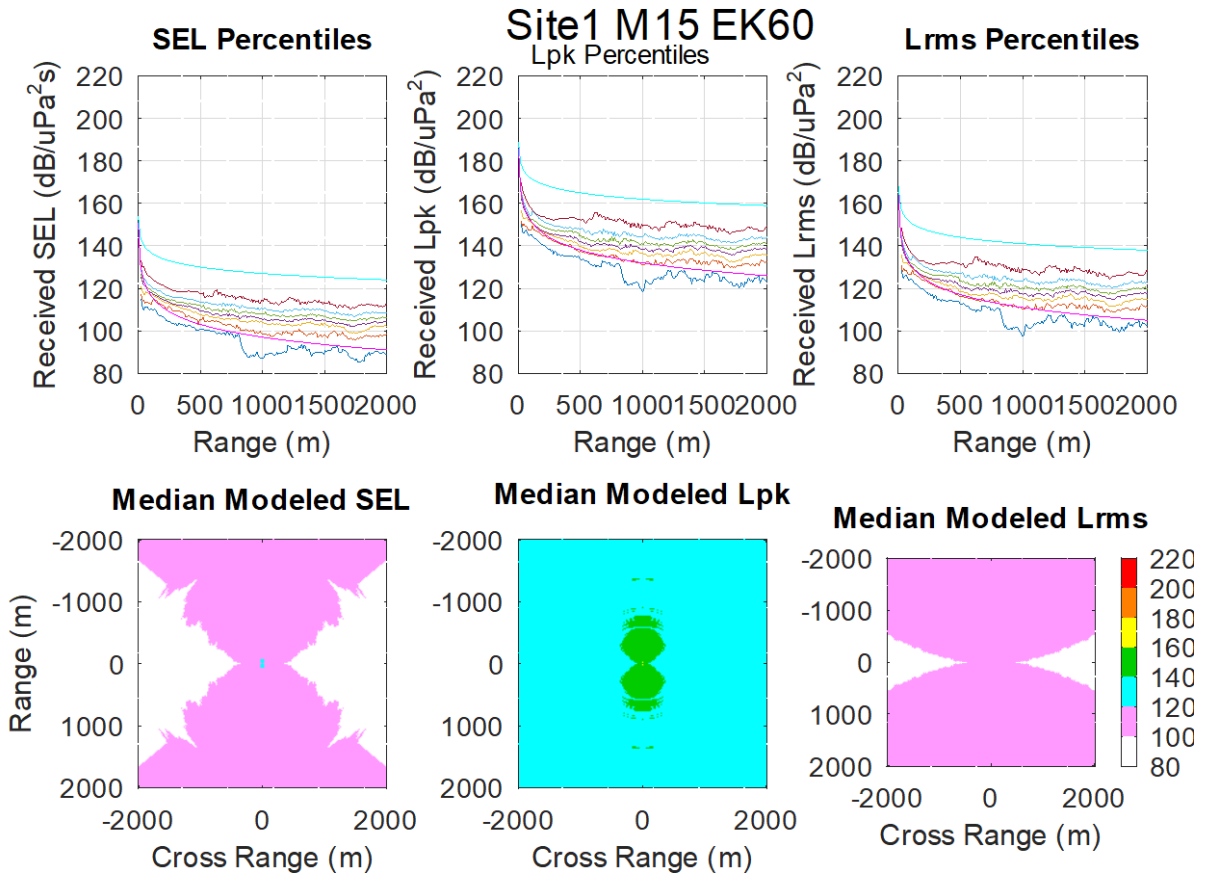


Figure 5-86. EK60 Mode 15 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.15.2 Site 2 – Sand, 10-m Depth

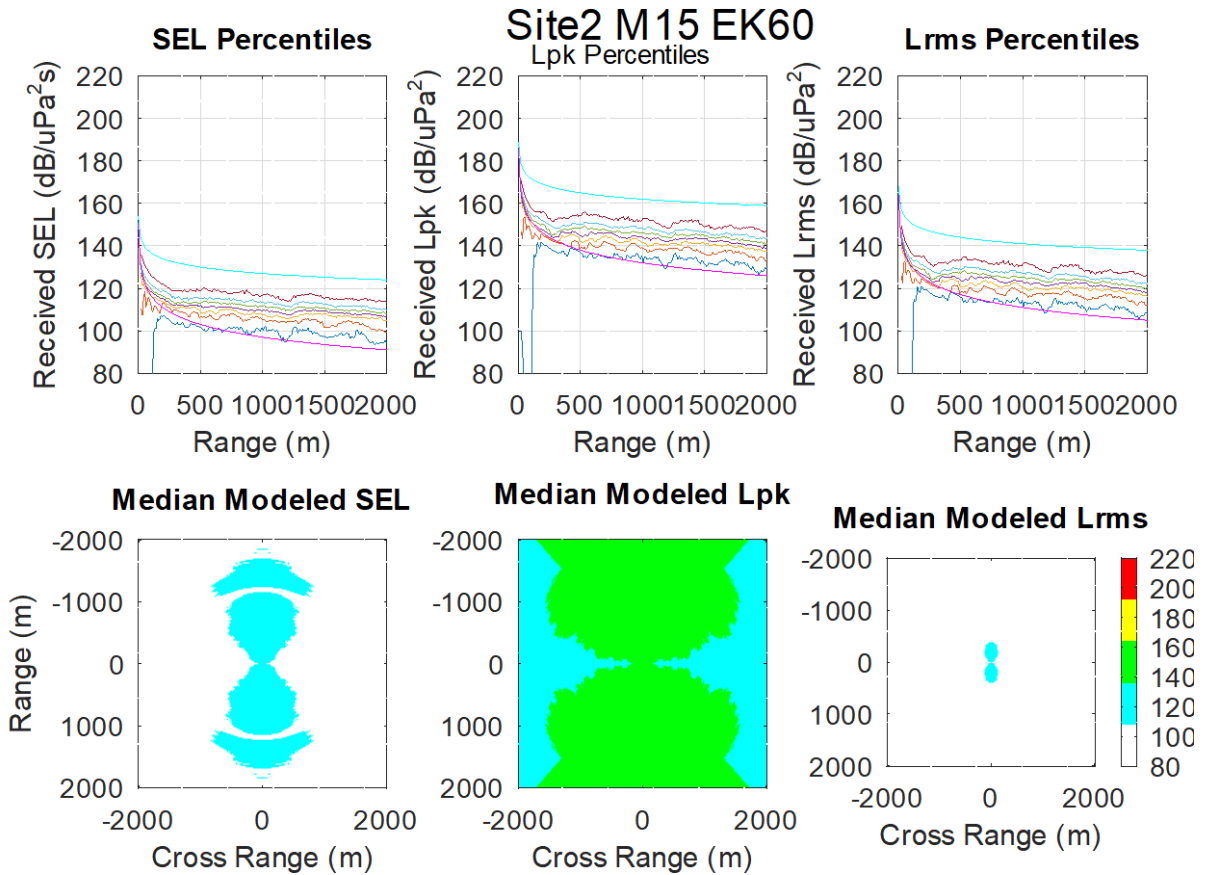


Figure 5-87. EK60 Mode 15 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.15.3 Site 3 – Mud, 30-m Depth

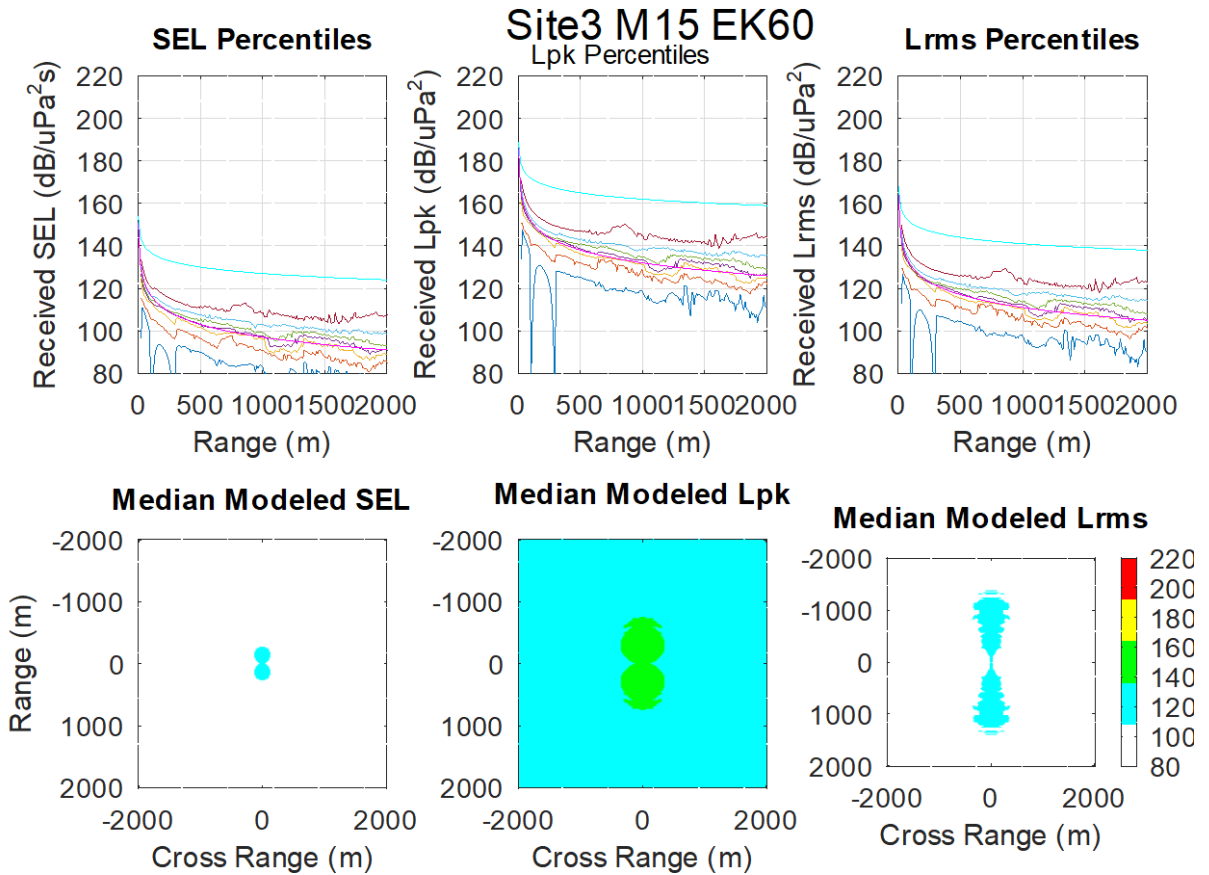


Figure 5-88. EK60 Mode 15 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.15.4 Site 4 – Sand, 30-m Depth

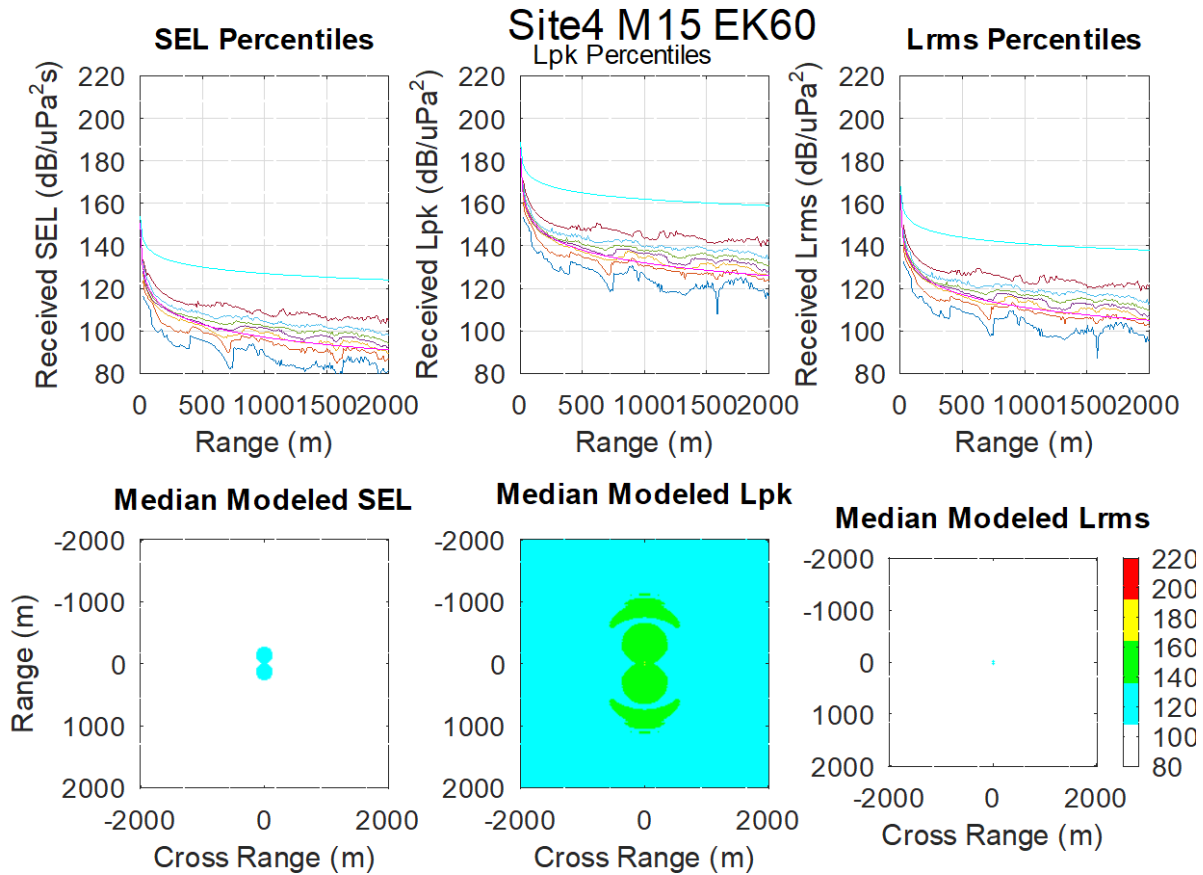


Figure 5-89. EK60 Mode 15 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.15.5 Site 5 – Sandy Silt, 100-m Depth

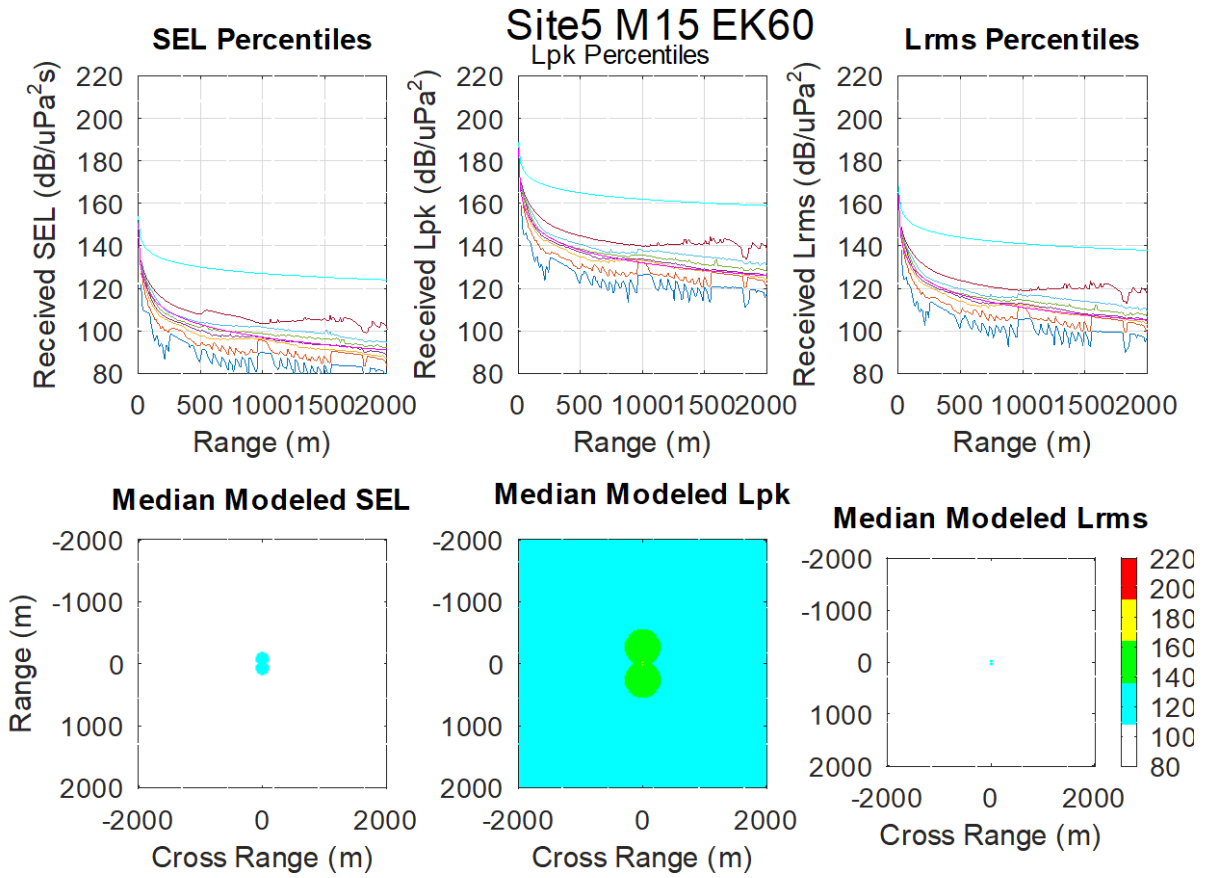


Figure 5-90. EK60 Mode 15 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.16 Edgetech 424 3100P, 4 to 24 kHz, 100 Percent Power, 10-ms Pulse (Mode 16)

The Edgetech 424 3100P subbottom profiler generates a single MF pulse signal, with a peak frequency of 13 kHz. The operational parameter settings for Mode 16 were 100 percent power, a 10-ms pulse, and a 4- to 24-kHz output frequency. Measured source levels are shown in **Table 5-16**.

Table 5-16. NUWC tank measurements of Edgetech 424 3100P (Mode 16)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	5	177	171	168	141

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.

From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-91**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-16**. Modeling results for each site are shown in **Figures 5-92 to 5-96**.

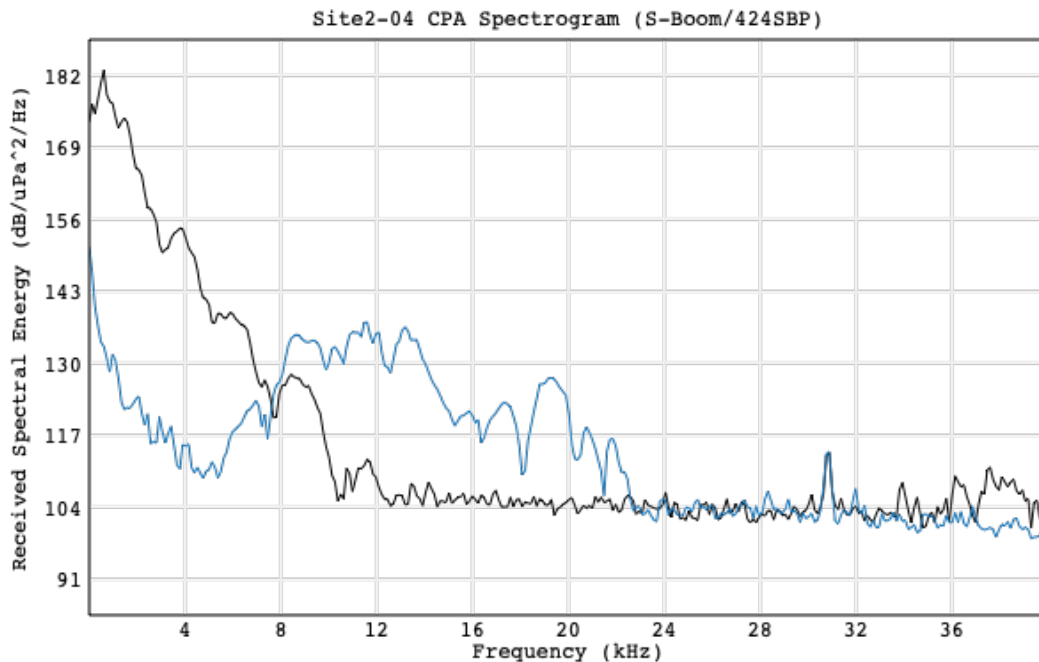


Figure 5-91. Edgetech 424 3100P Mode 16 (blue) decidecade band energy levels at buoy position D

S-Boom Mode 26 (black). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.16.1 Site 1 – Mud, 10-m Depth

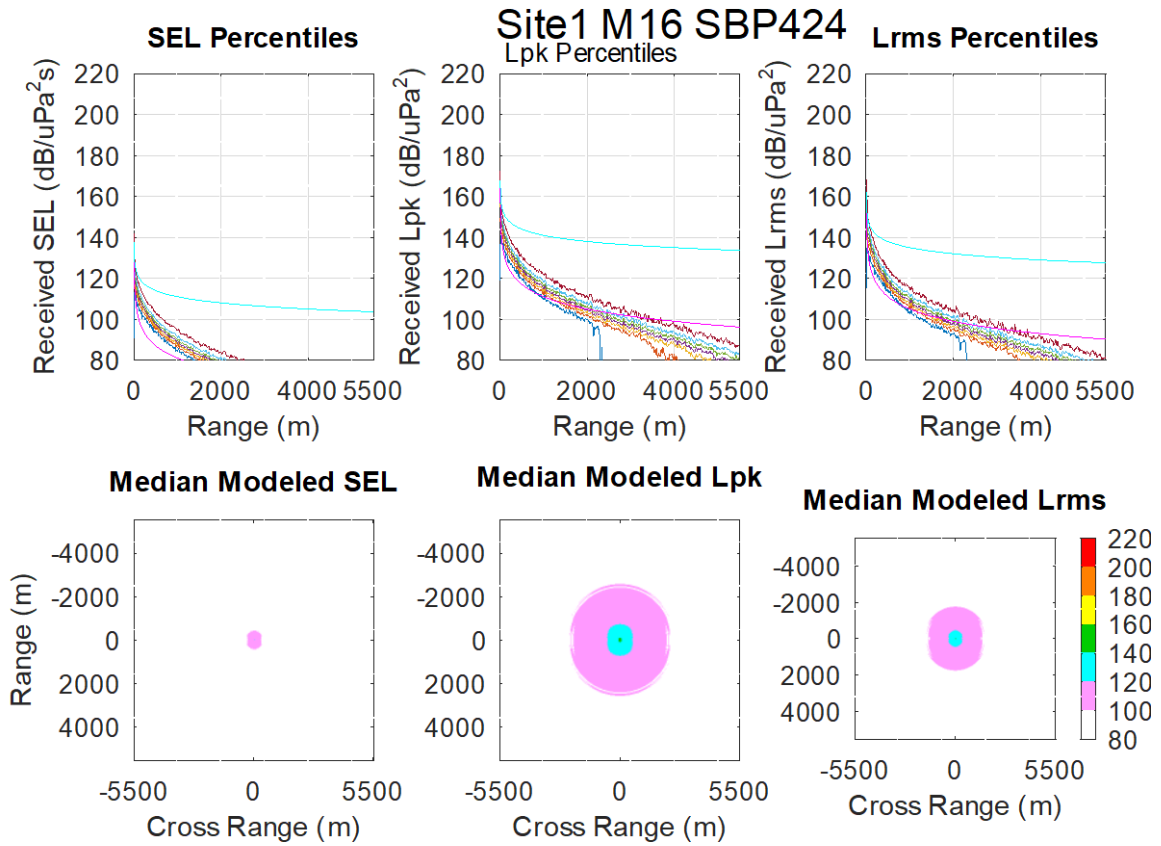


Figure 5-92. Edgetech 424 3100P Mode 16 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.16.2 Site 2 – Sand, 10-m Depth

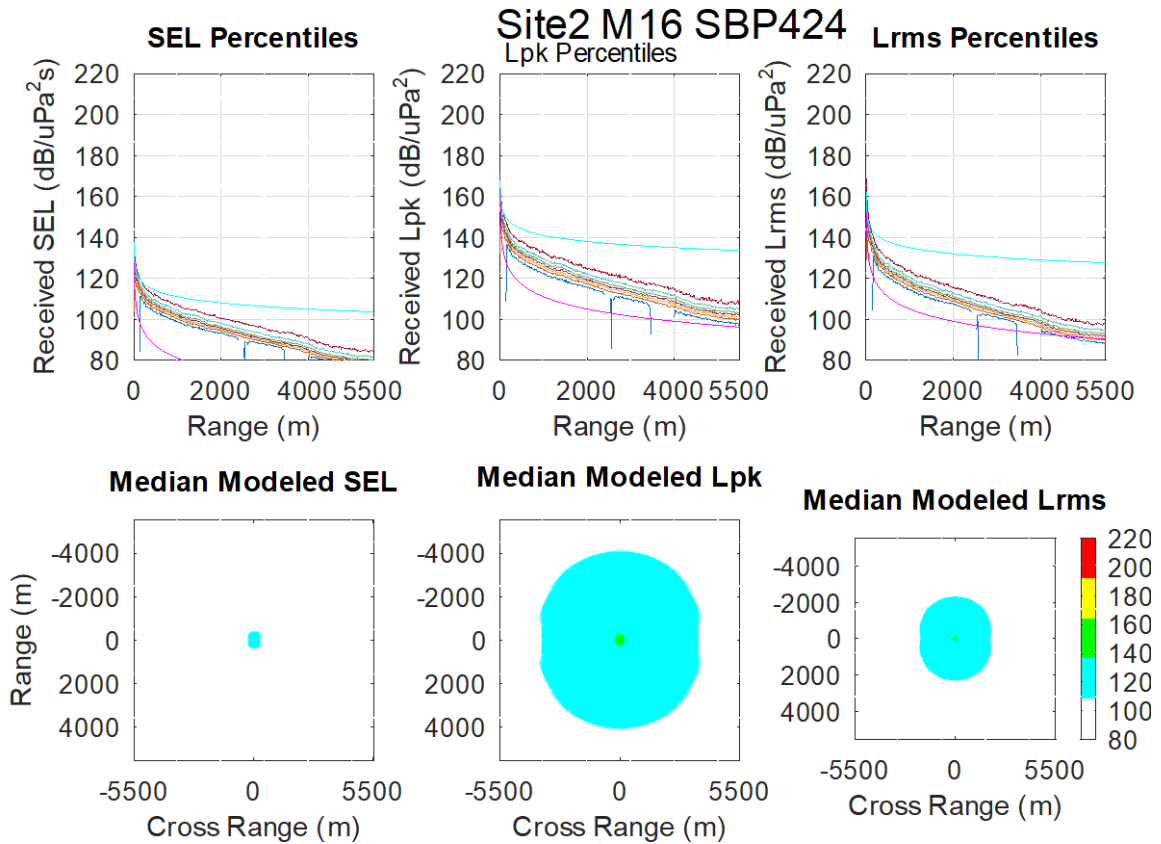


Figure 5-93. Edgetech 424 3100P Mode 16 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.16.3 Site 3 – Mud, 30-m Depth

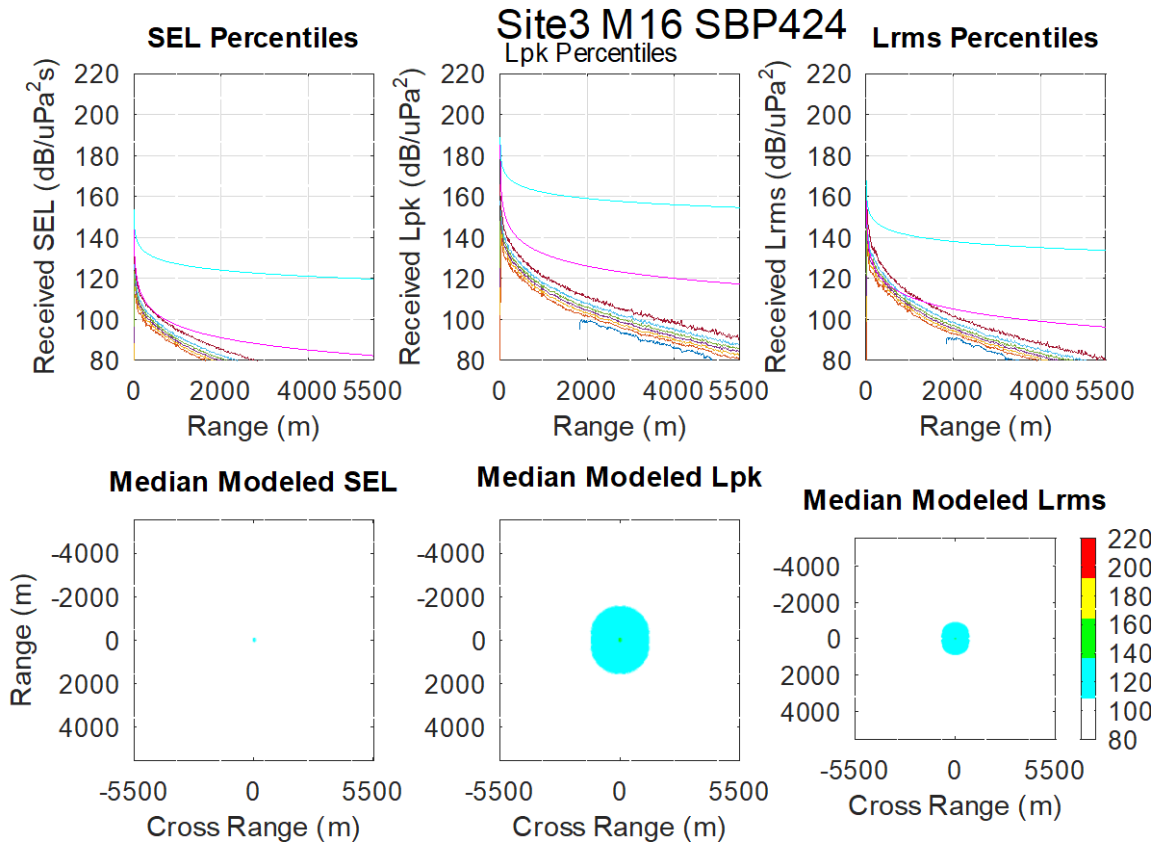


Figure 5-94. Edgetech 424 3100P Mode 16 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.16.4 Site 4 – Sand, 30-m Depth

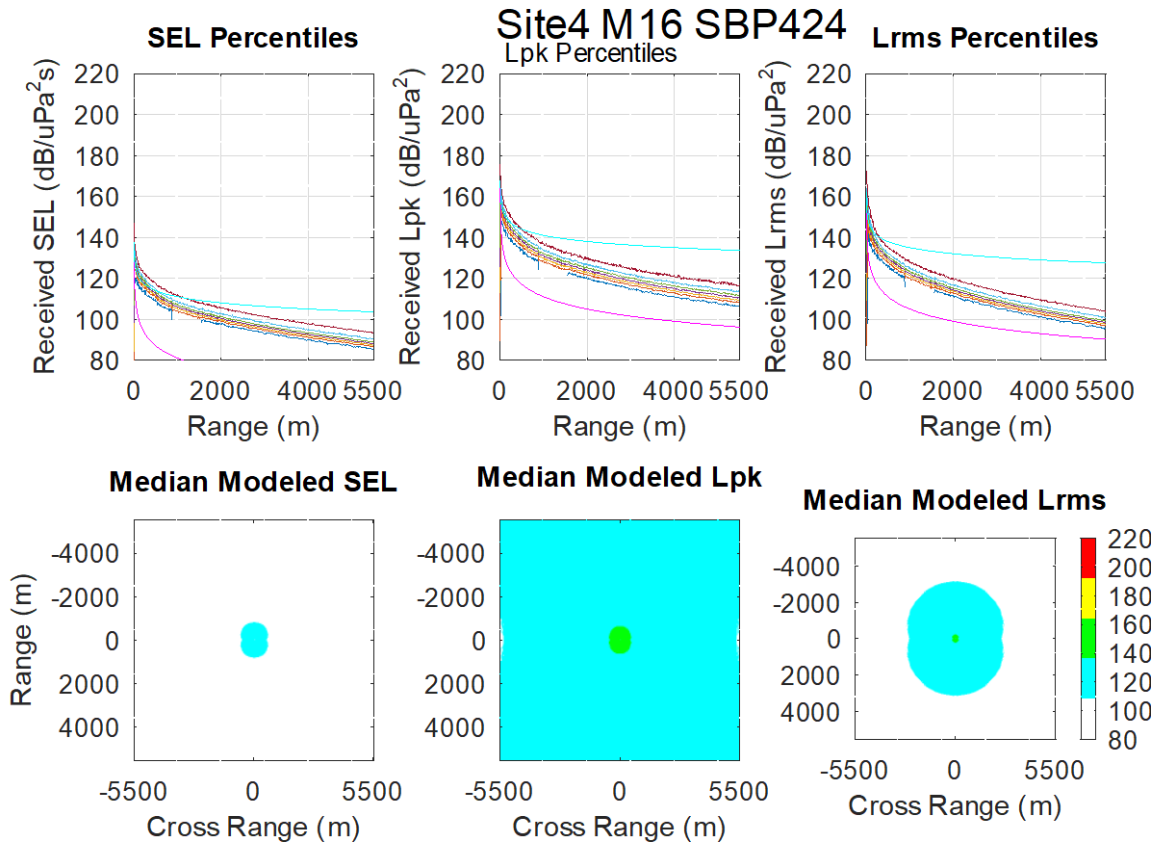


Figure 5-95. Edgetech 424 3100P Mode 16 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.16.5 Site 5 – Sandy Silt, 100-m Depth

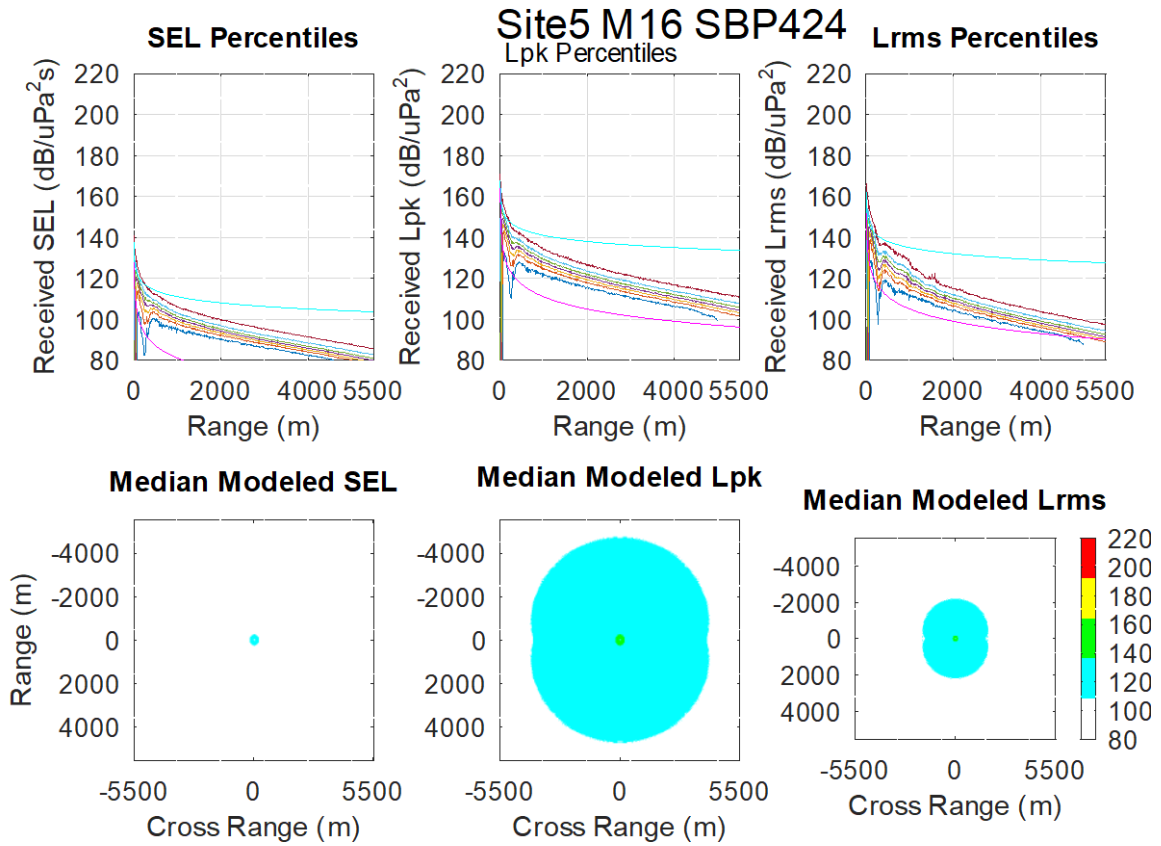


Figure 5-96. Edgetech 424 3100P Mode 16 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.17 Edgetech 424 3100P, 4 to 24 kHz, 100 Percent Power, 1-ms Pulse (Mode 17)

The Edgetech 424 3100P subbottom profiler generates a single MF pulse signal, with a peak frequency of 13 kHz. The operational parameter settings for Mode 17 were 100 percent power, a 1-ms pulse, and a 4- to 24-kHz output frequency. Measured source levels are shown in **Table 5-17**.

Table 5-17. NUWC tank measurements of Edgetech 424 3100P (Mode 17)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	5	178	172	166	134

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-97**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-17**. Modeling results for each site are shown in **Figures 5-98 to 5-102**.

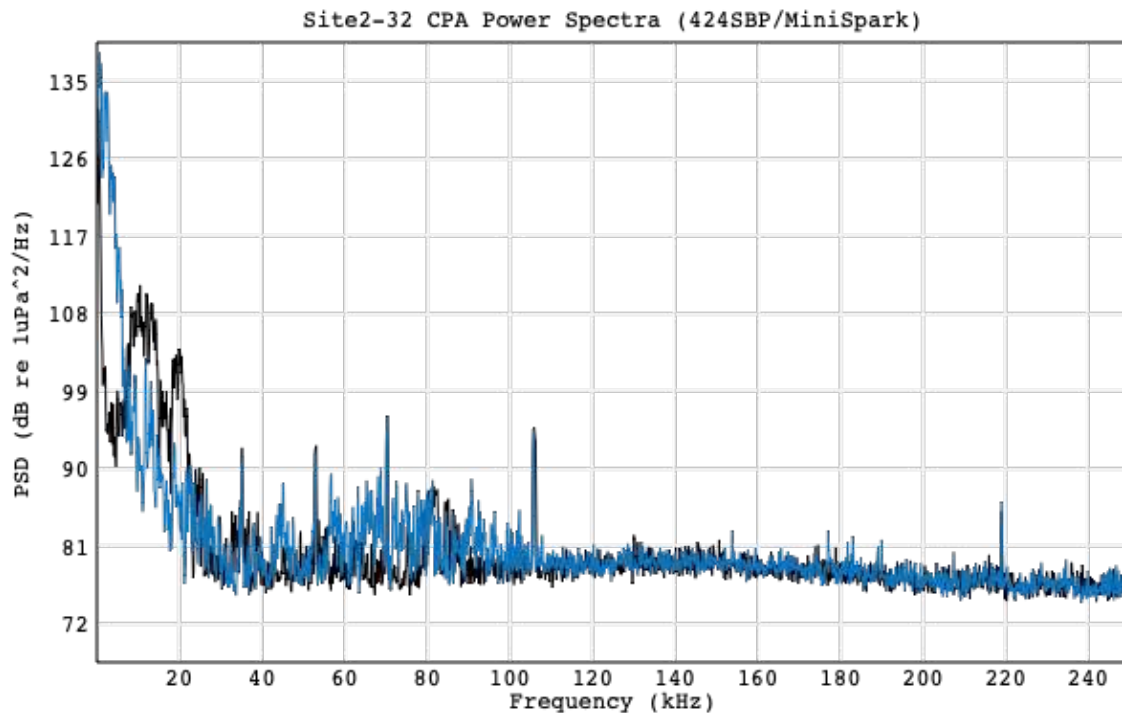


Figure 5-97. Edgetech 424 3100P Mode 17 (black) decidecade band energy levels at buoy position D

Minisparker Mode 28 (blue). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; PSD = power spectral density; re = with reference to.

5.17.1 Site 1 – Mud, 10-m Depth

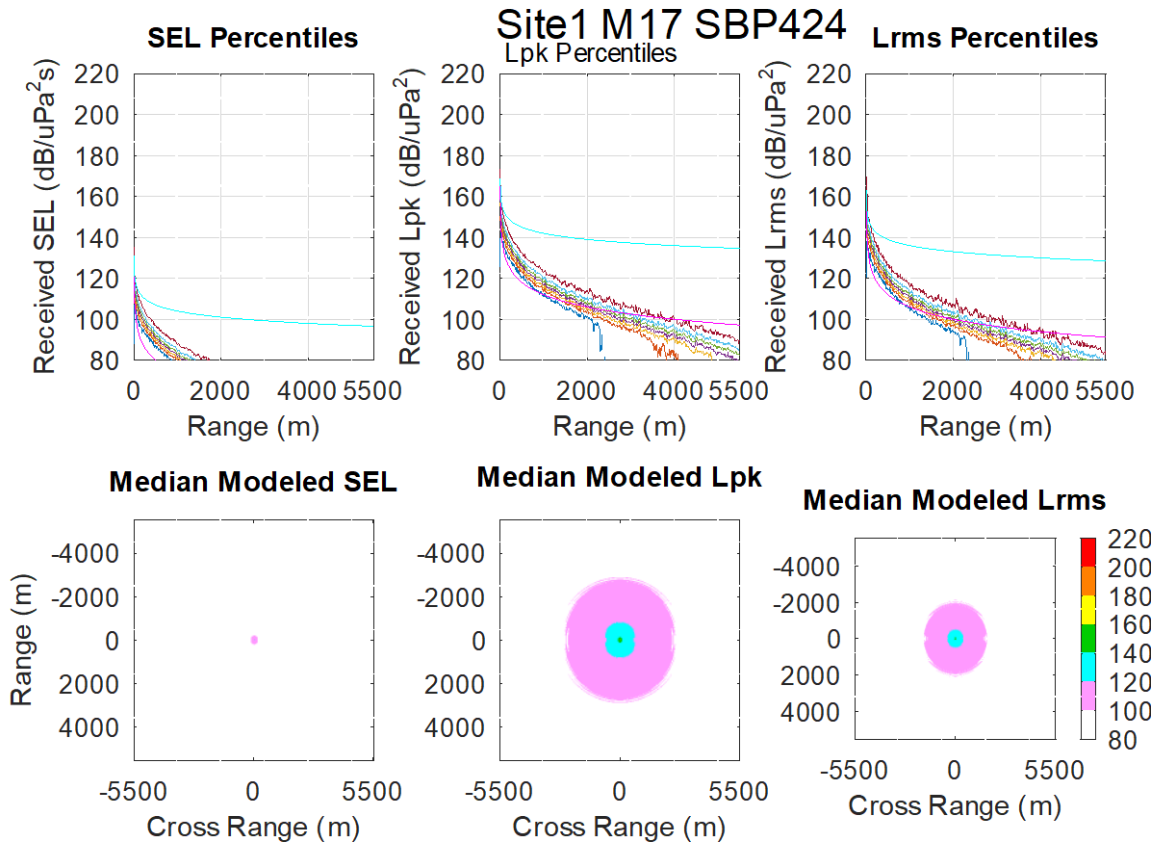


Figure 5-98. Edgetech 424 3100P Mode 17 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.17.2 Site 2 – Sand, 10-m Depth

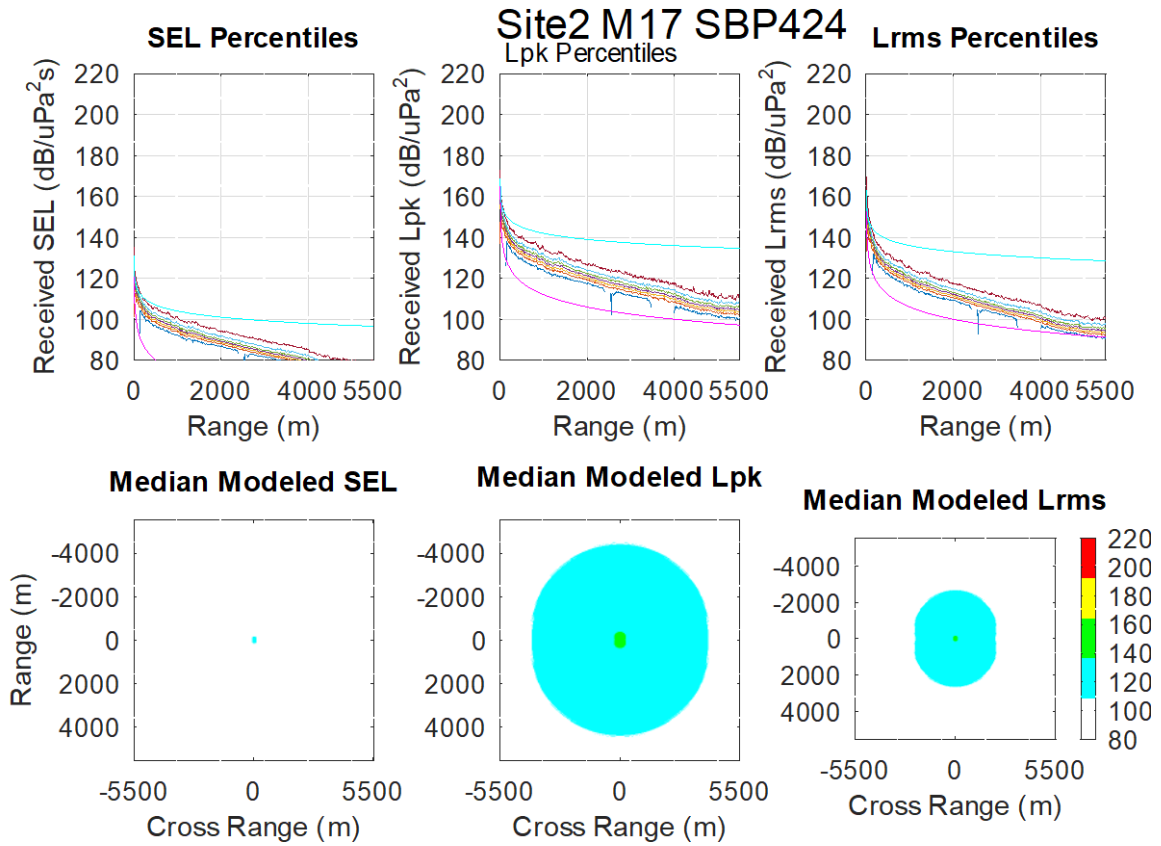


Figure 5-99. Edgetech 424 3100P Mode 17 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.17.3 Site 3 – Mud, 30-m Depth

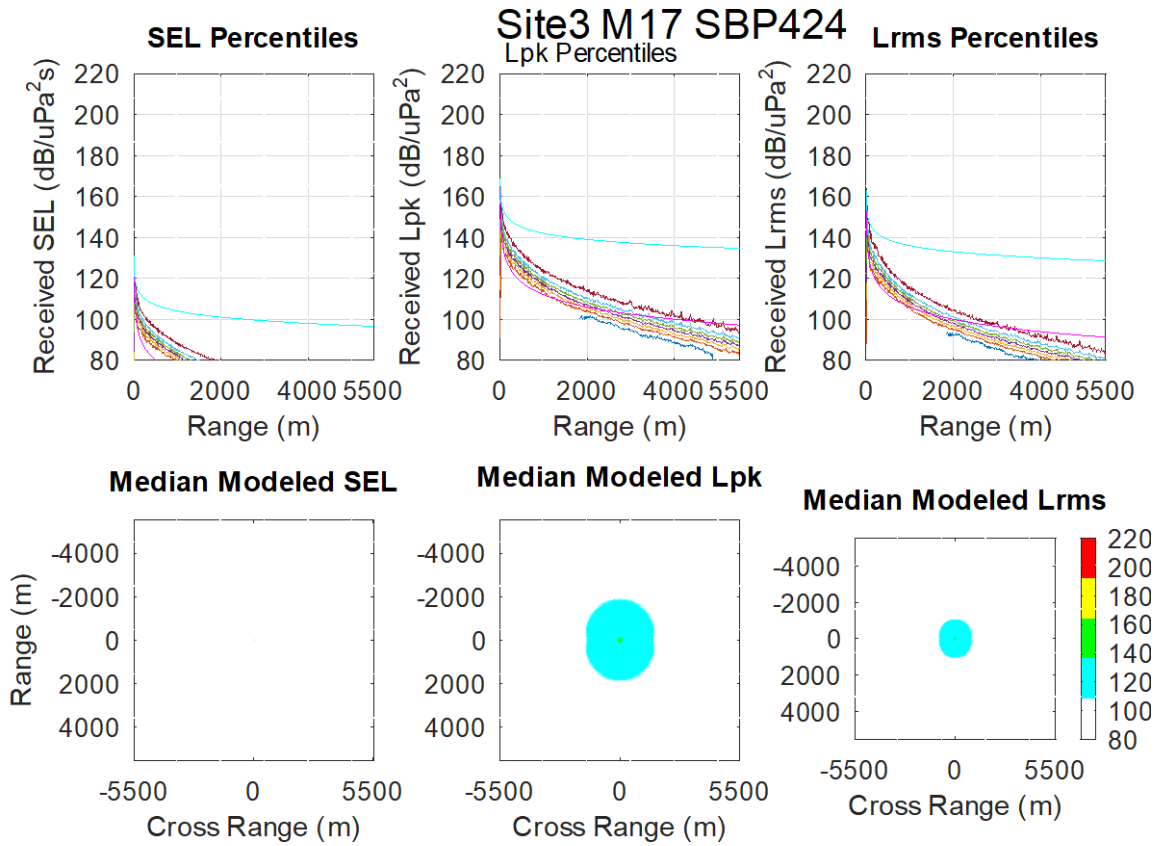


Figure 5-100. Edgetech 424 3100P Mode 17 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.17.4 Site 4 – Sand, 30-m Depth

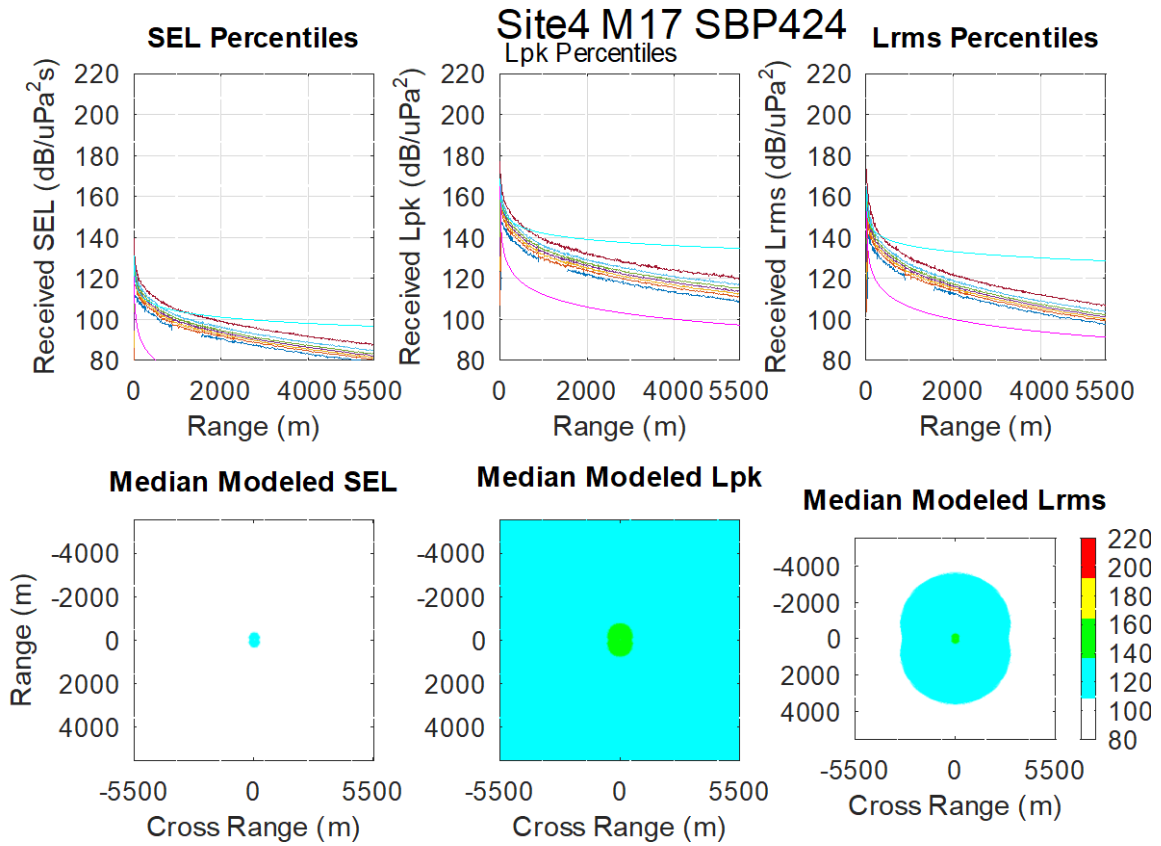


Figure 5-101. Edgetech 424 3100P Mode 17 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.17.5 Site 5 – Sandy Silt, 100-m Depth

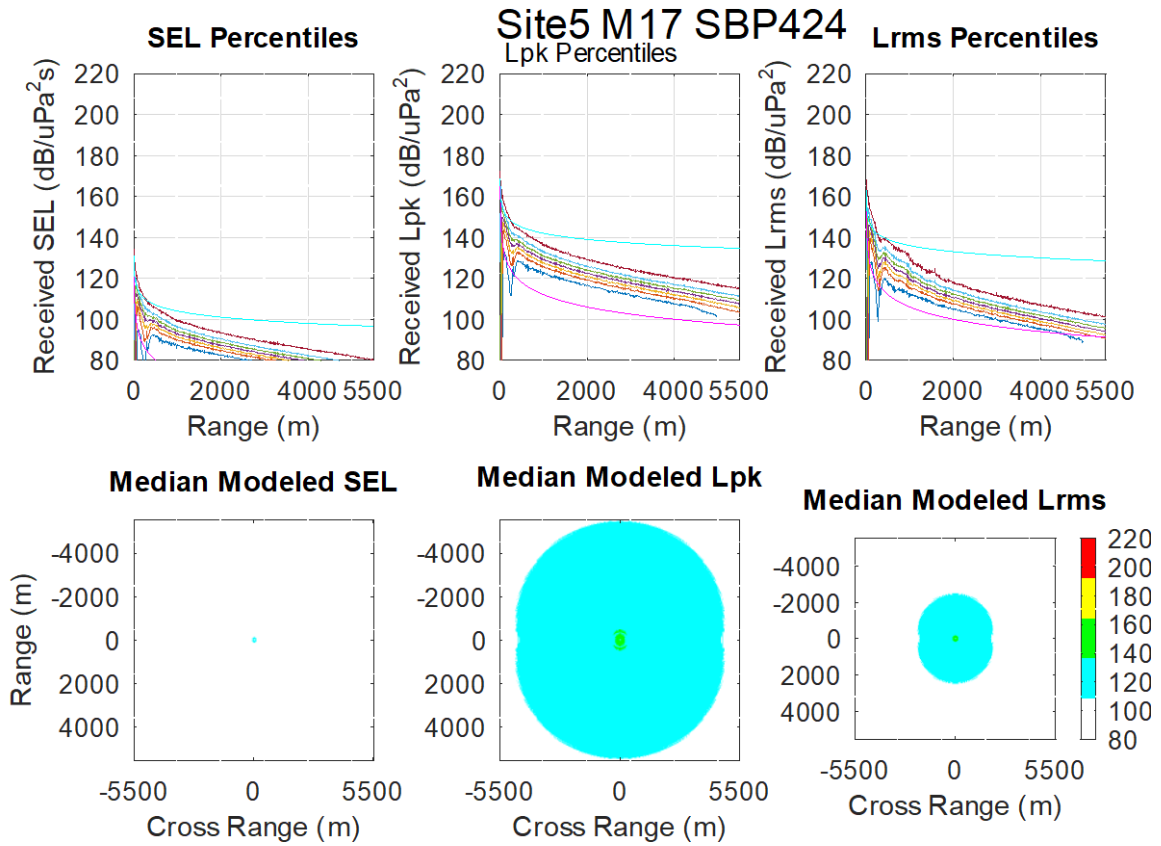


Figure 5-102. Edgetech 424 3100P Mode 17 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.18 Edgetech 424 3200XS, 4 to 24 kHz, 100 Percent Power, 10-ms Pulse (Mode 18)

The Edgetech 424 3200XS subbottom profiler generates a single MF signal, with a peak frequency of 13 kHz. The operational parameter settings for Mode 18 were 100 percent power, a 10-ms pulse, and a 4- to 24-kHz output frequency. Measured source levels are shown in **Table 5-18**.

Table 5-18. NUWC tank measurements of Edgetech 424 3200XS (Mode 18)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	5	177	171	165	141

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-103**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-18**. Modeling results for each site are shown in **Figures 5-104 to 5-108**.

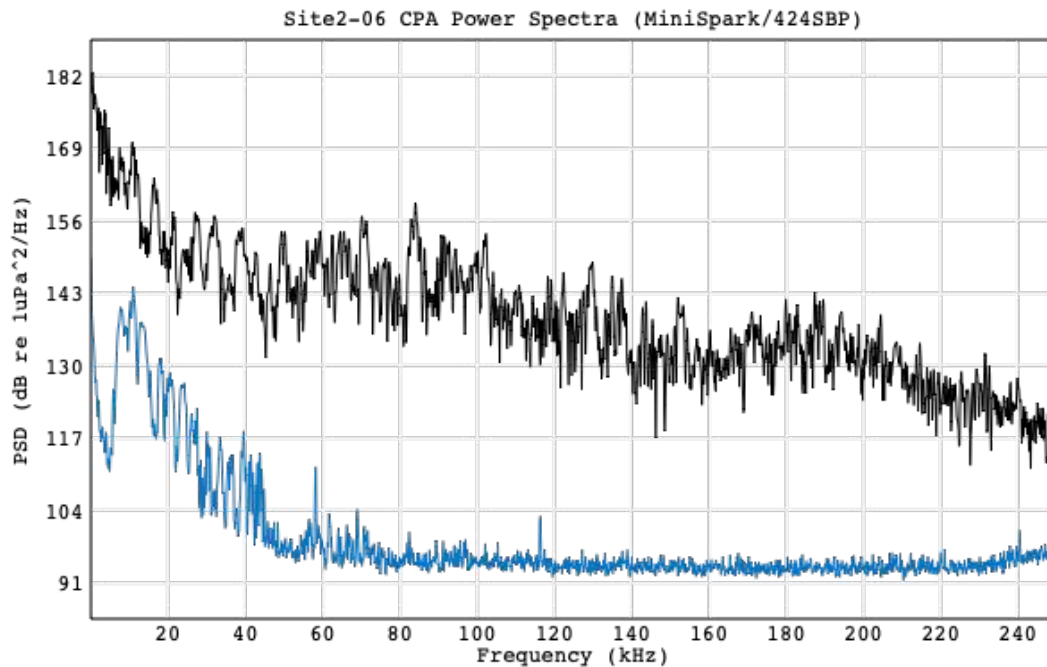


Figure 5-103. Edgetech 424 3200XS Mode 18 (blue) decidecade band energy levels at buoy position D

Minisparker Mode 28 (black). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; PSD = power spectral density; re = with reference to.

5.18.1 Site 1 – Mud, 10-m Depth

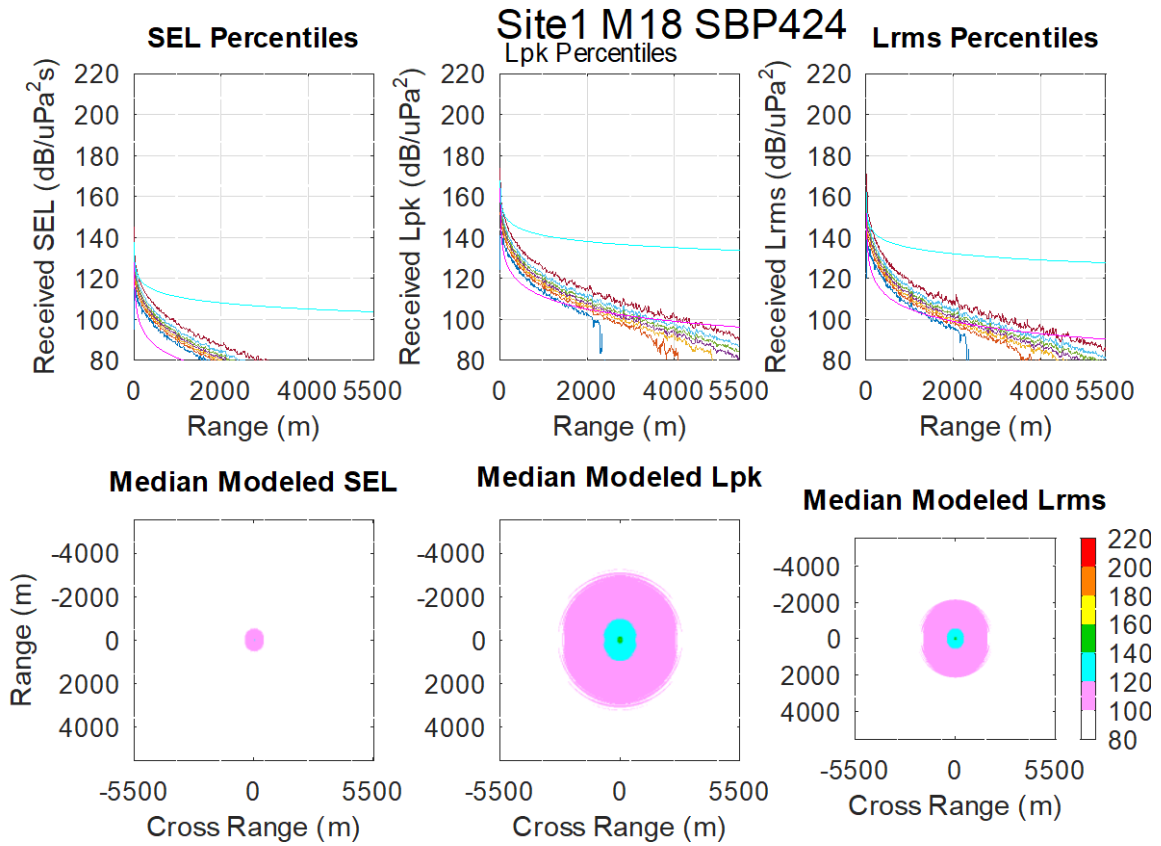


Figure 5-104. Edgetech 424 3200XS Mode 18 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.18.2 Site 2 – Sand, 10-m Depth

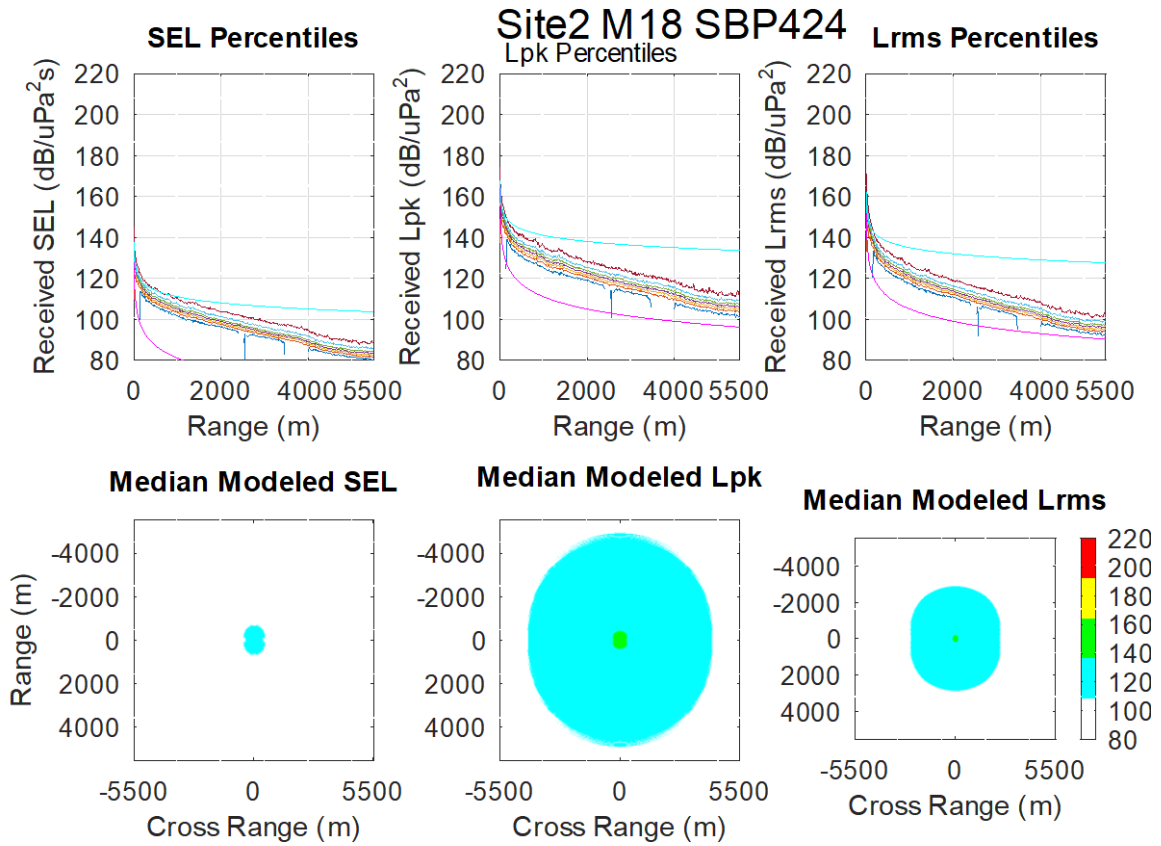


Figure 5-105. Edgetech 424 3200XS Mode 18 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.18.3 Site 3 – Mud, 30-m Depth

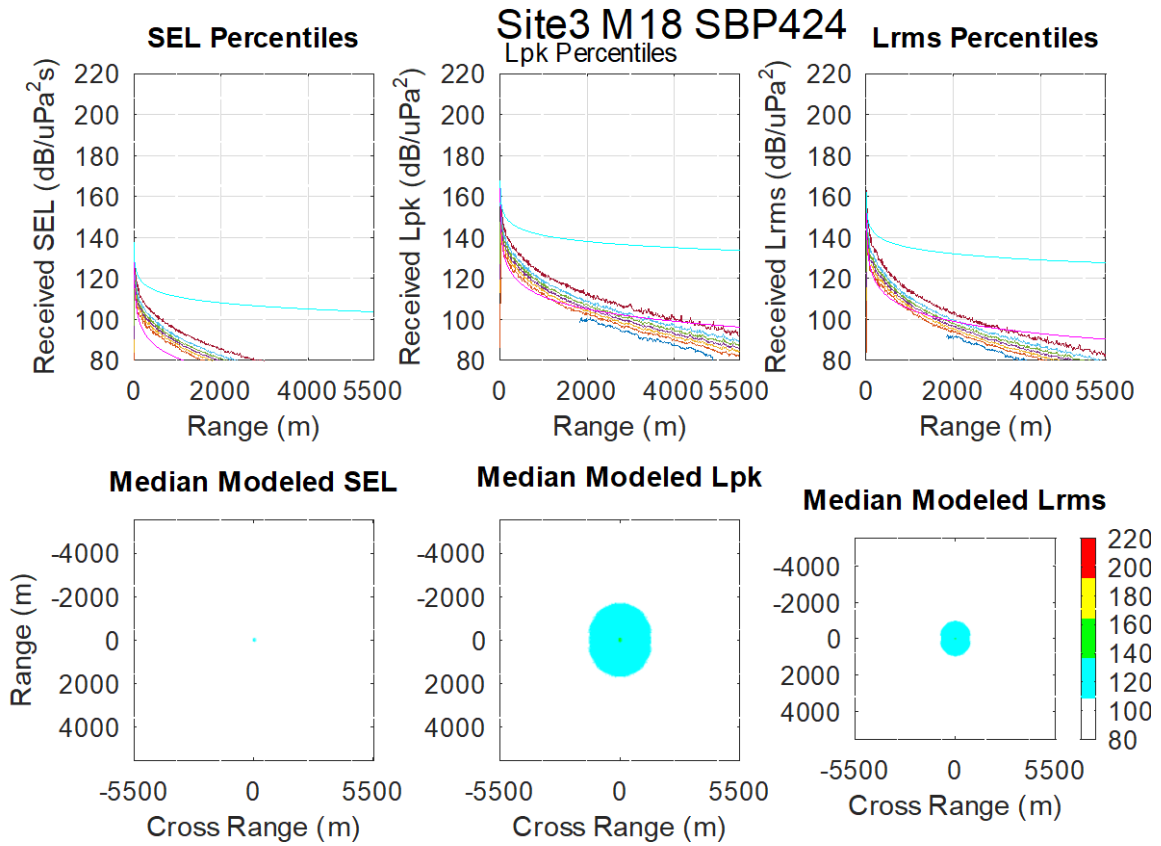


Figure 5-106. Edgetech 424 3200XS Mode 18 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.18.4 Site 4 – Sand, 30-m Depth

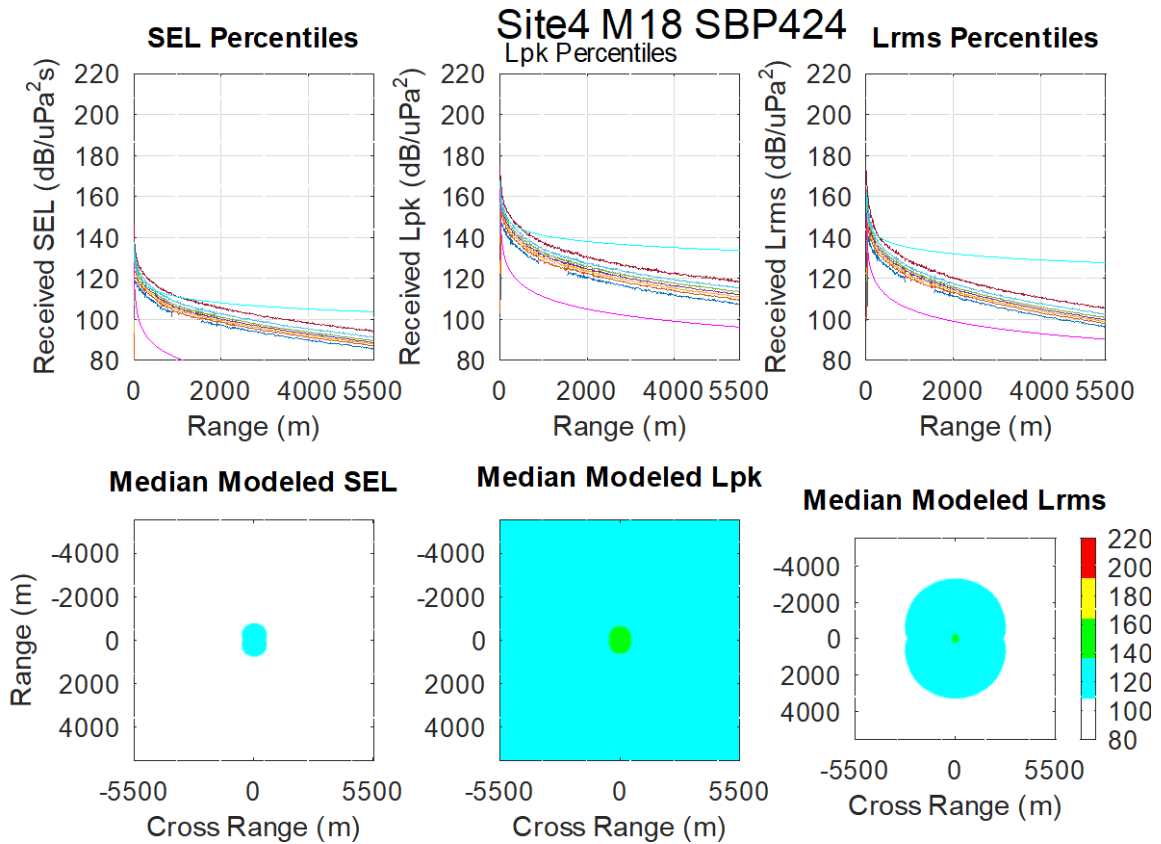


Figure 5-107. Edgetech 424 3200XS Mode 18 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.18.5 Site 5 – Sandy Silt, 100-m Depth

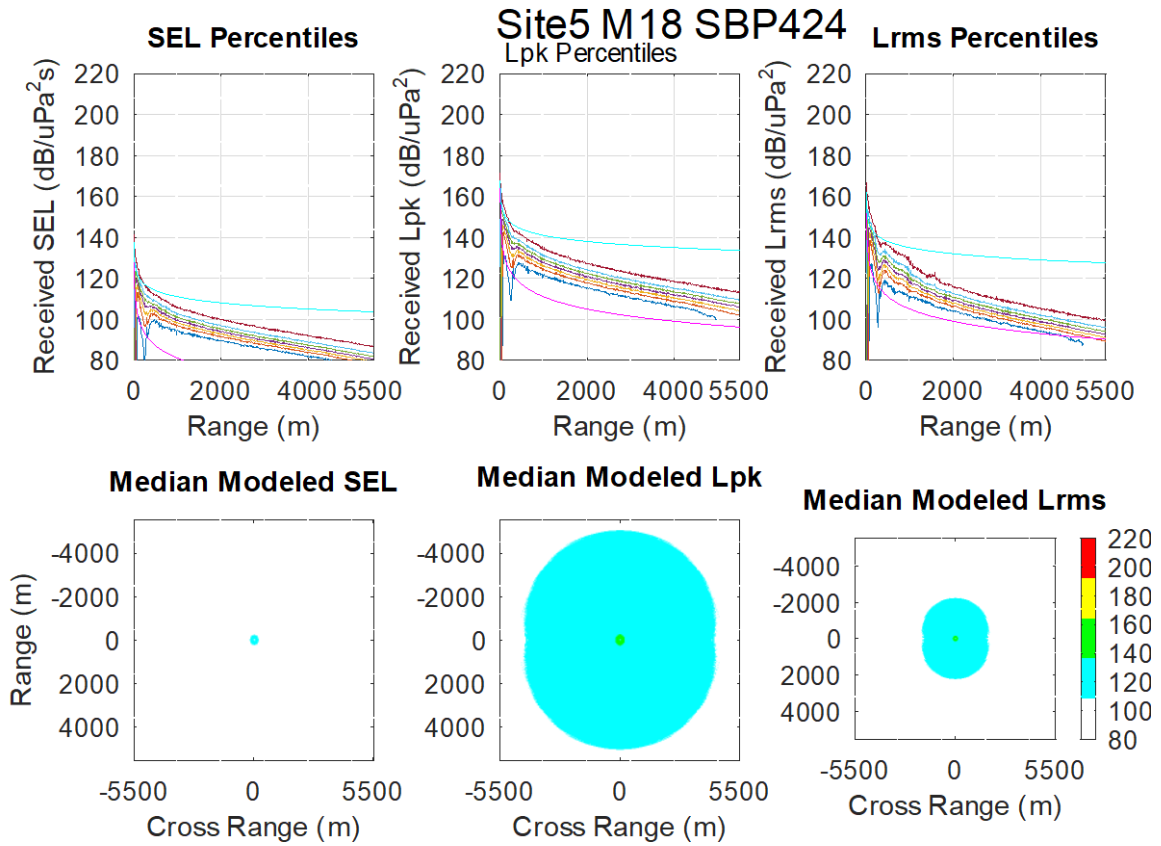


Figure 5-108. Edgetech 424 3200XS Mode 18 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.19 Edgetech 424 3200XS, 4 to 24 kHz, 100 Percent Power, 1-ms Pulse, (Mode 19)

The Edgetech 424 3200XS subbottom profiler generates a single MF signal, with a peak frequency of 9 kHz. The operational parameter settings for Mode 19 were 100 percent power, a 1-ms pulse, and a 4- to 24-kHz output frequency. Measured source levels are shown in **Table 5-19**.

Table 5-19. NUWC tank measurements of Edgetech 424 3200XS (Mode 19)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	5	178	172	166	134

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean_square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-109**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-19**. Modeling results for each site are shown in **Figures 5-110 to 5-114**.

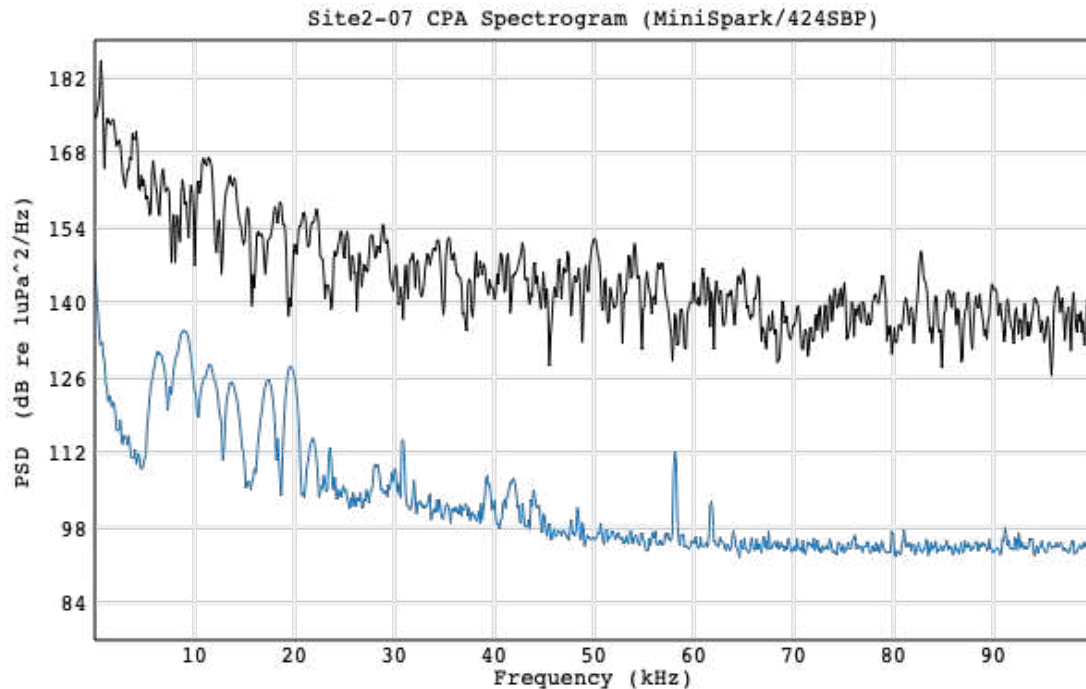


Figure 5-109. Edgetech 424 3200XS Mode 19 (blue) decidecade band energy levels at buoy position D

Minisparker Mode 29 (black). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; PSD = power spectral density; re = with reference to.

5.19.1 Site 1 – Mud, 10-m Depth

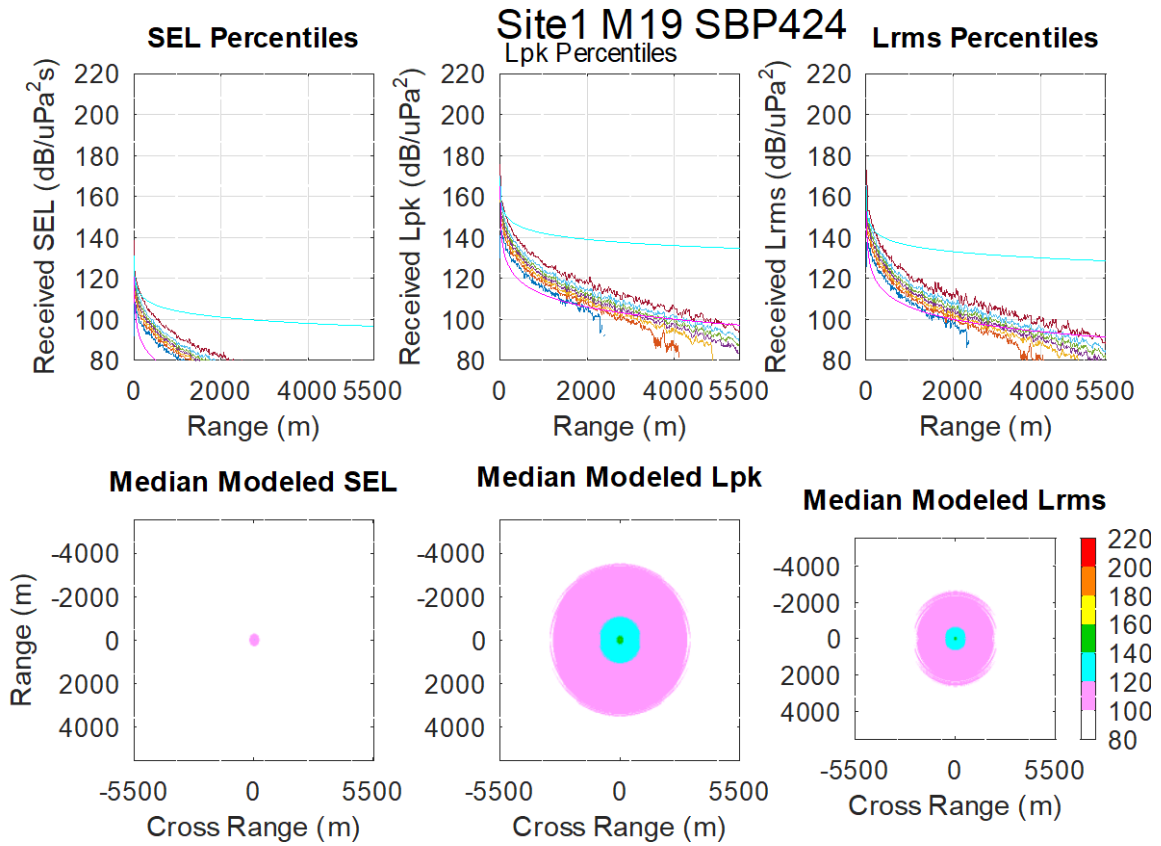


Figure 5-110. Edgetech 424 3200XS Mode 19 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.19.2 Site 2 – Sand, 10-m Depth

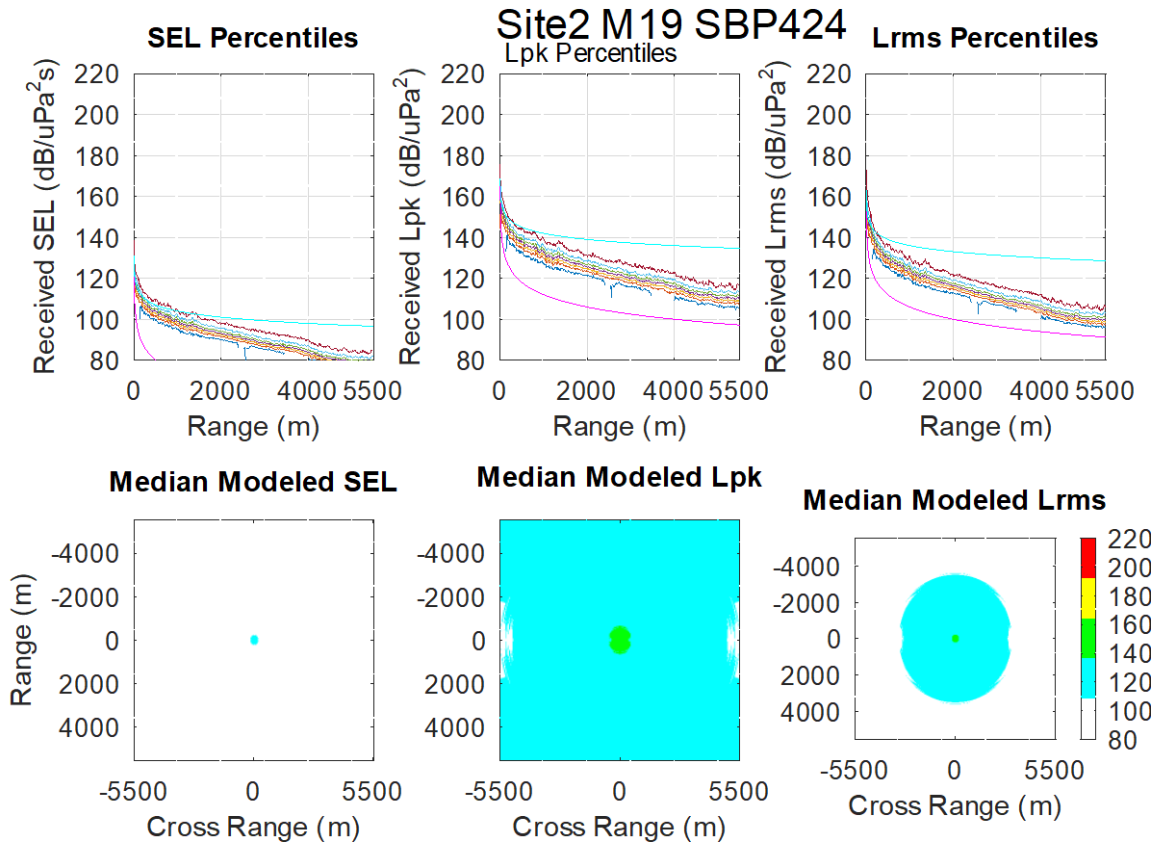


Figure 5-111. Edgetech 424 3200XS Mode 19 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.19.3 Site 3 – Mud, 30-m Depth

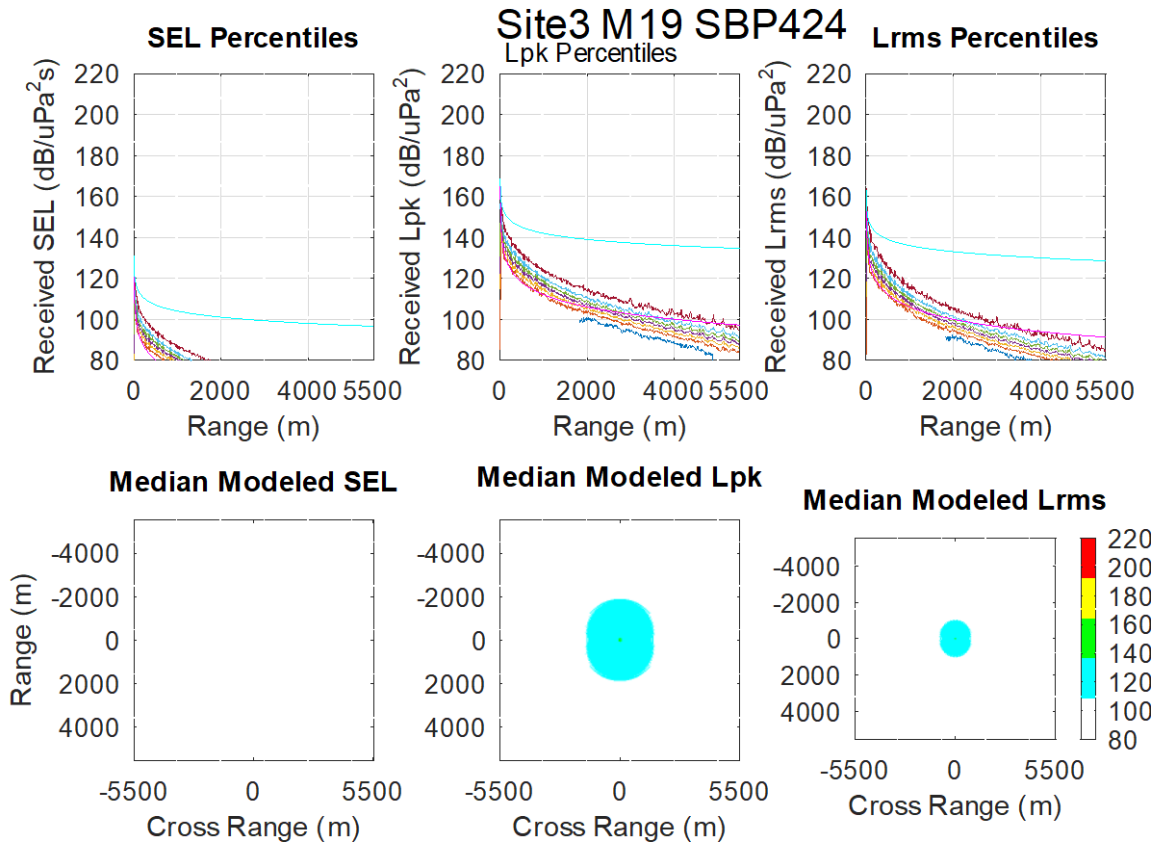


Figure 5-112. Edgetech 424 3200XS Mode 19 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.19.4 Site 4 – Sand, 30-m Depth

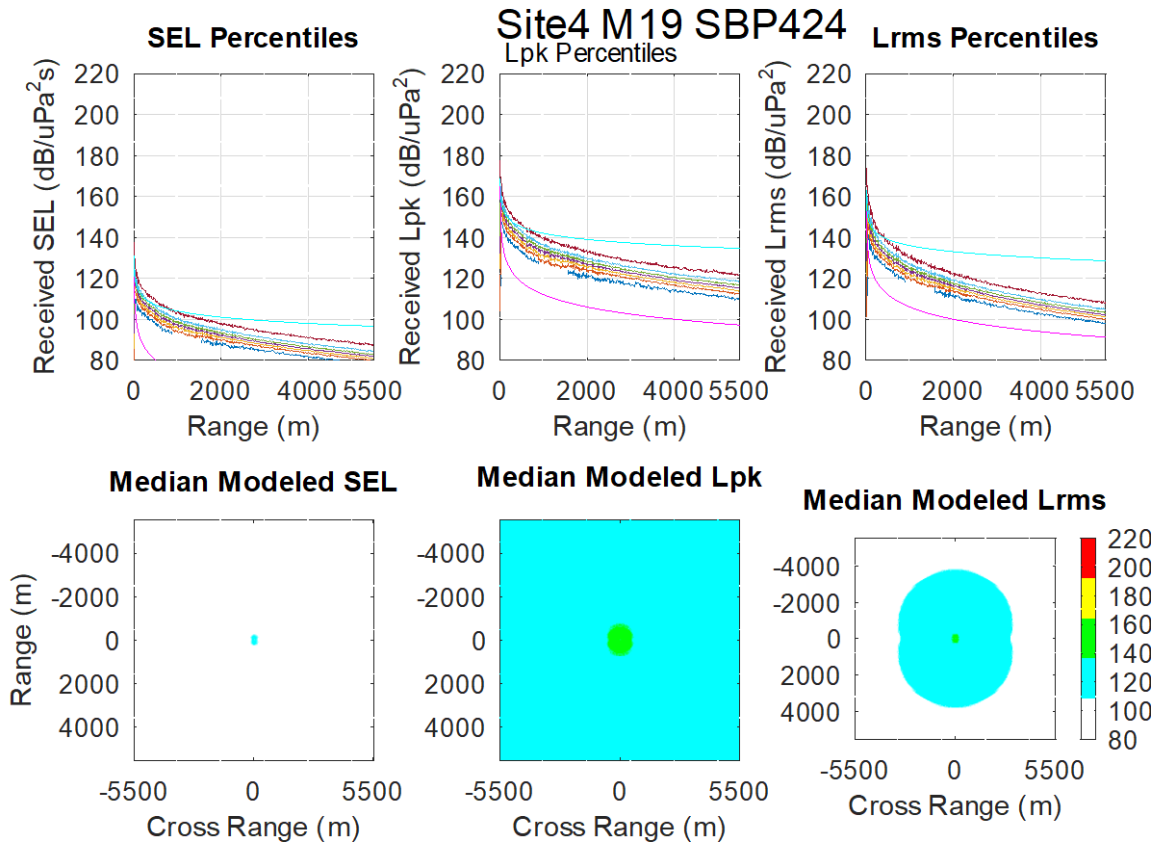


Figure 5-113. Edgetech 424 3200XS Mode 19 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.19.5 Site 5 – Sandy Silt, 100-m Depth

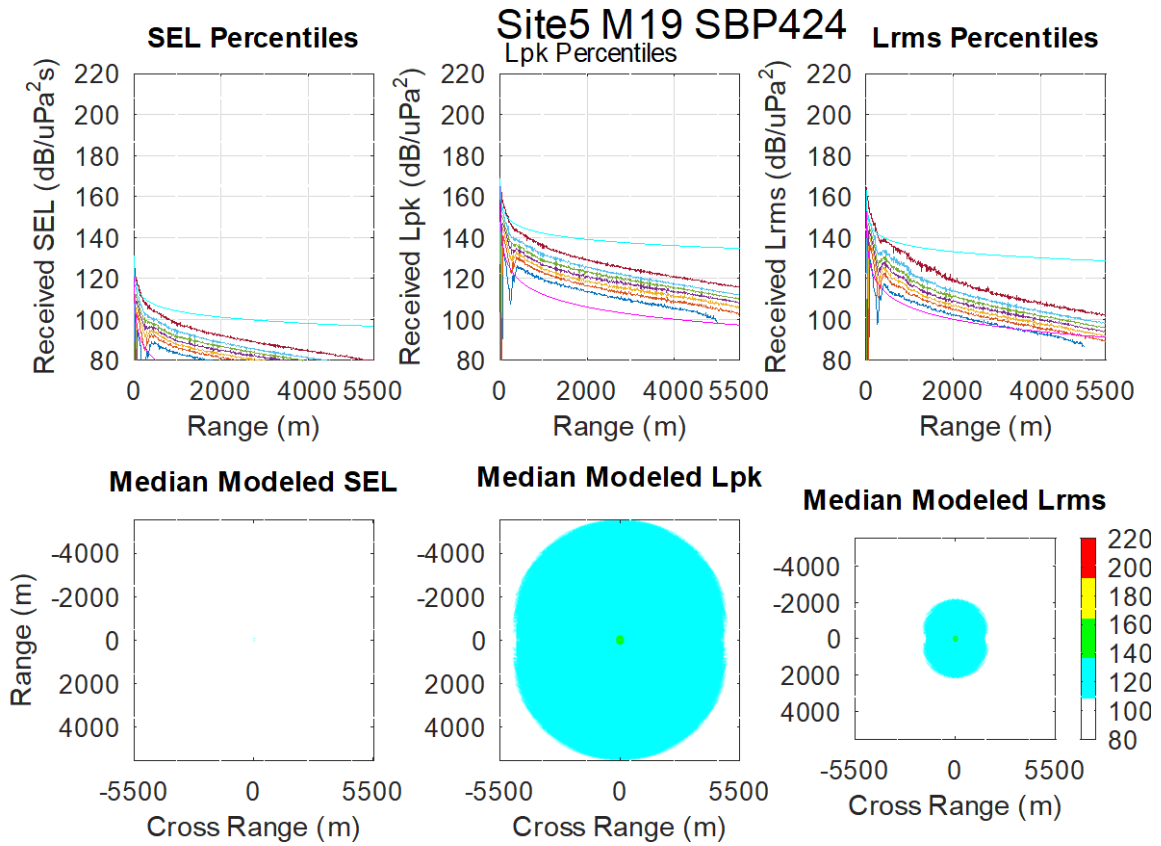


Figure 5-114. Edgetech 424 3200XS Mode 19 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.20 Edgetech 512i, 0.5 to 7.2 kHz, 100 Percent Power, 30-ms Pulse (Mode 20)

The Edgetech 512i subbottom profiler generates a single MF signal, with a peak frequency of 6 kHz. The operational parameter settings for Mode 20 were 100 percent power, a 30-ms pulse, and a 0.5- to 7.2-kHz output frequency. Measured source levels are shown in **Table 5-20**.

Table 5-20. NUWC tank measurements of Edgetech 512i (Mode 20)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	6	191	184	177	157

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.

From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-115**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-20**. Modeling results for each site are shown in **Figures 5-116 to 5-120**.

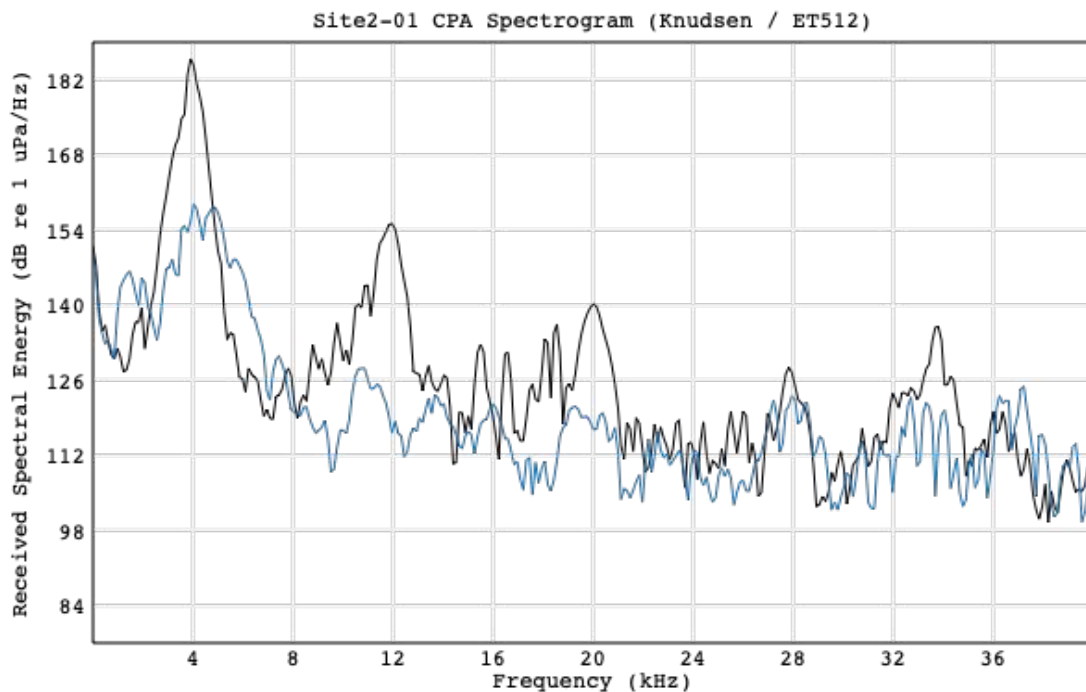


Figure 5-115. Edgetech 512i Mode 20 (blue) decidecade band energy levels at buoy position D Knudsen 3260 Mode 23 (black). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = with reference to.

5.20.1 Site 1 – Mud, 10-m Depth

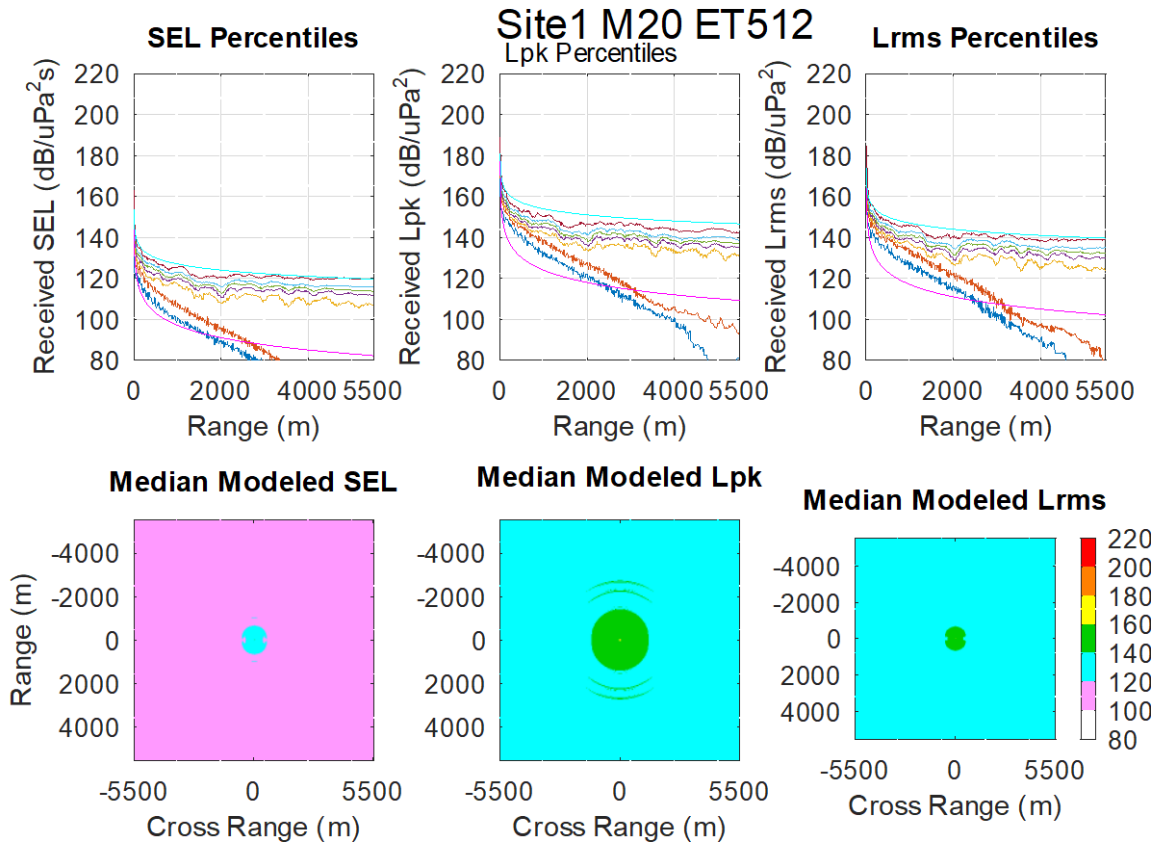


Figure 5-116. Edgetech 512i Mode 20 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.20.2 Site 2 – Sand, 10-m Depth

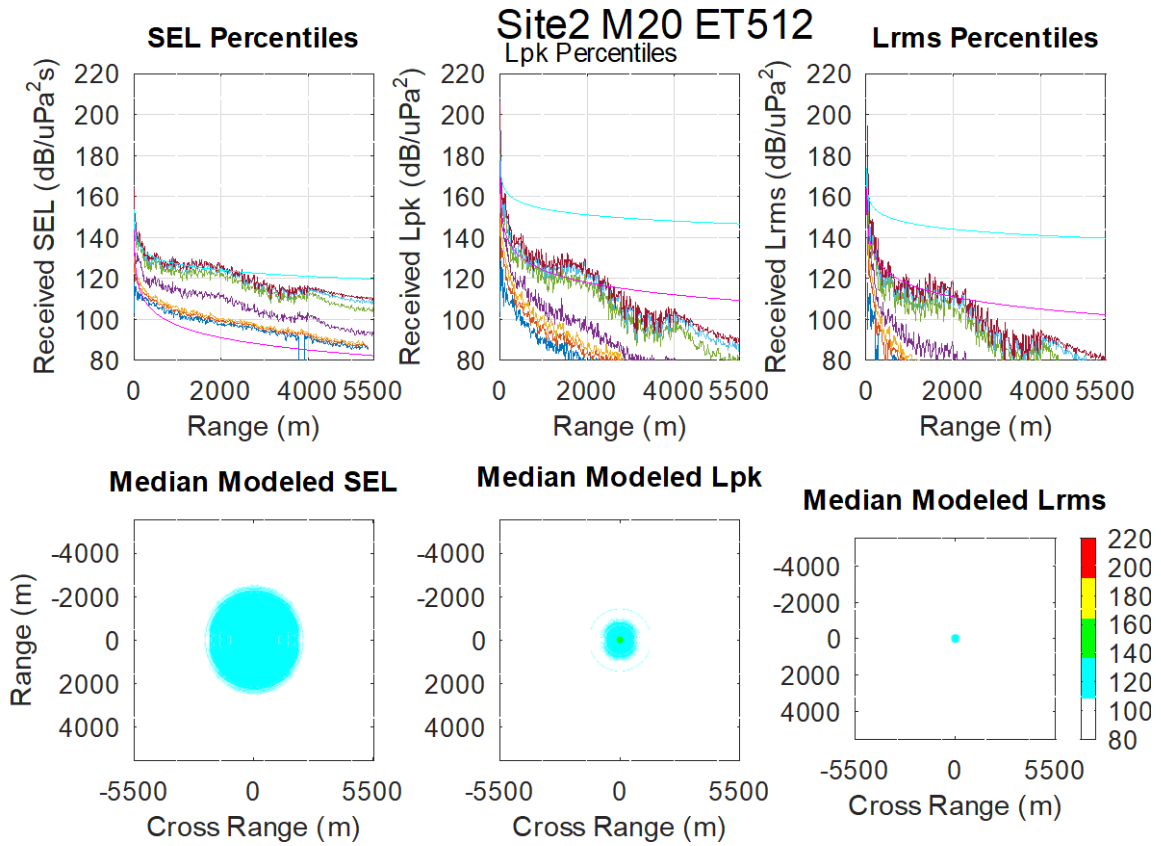


Figure 5-117. Edgetech 512i Mode 20 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.20.3 Site 3 – Mud, 30-m Depth

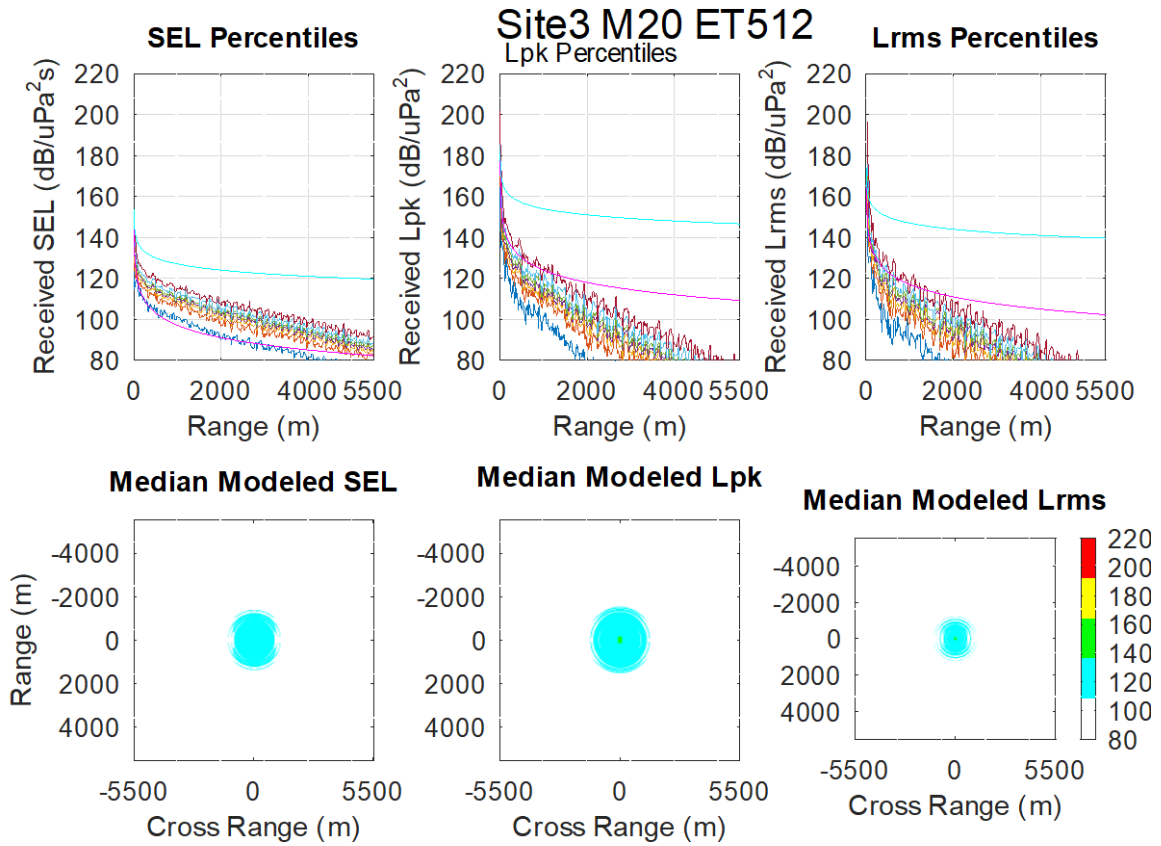


Figure 5-118. Edgetech 512i Mode 20 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.20.4 Site 4 – Sand, 30-m Depth

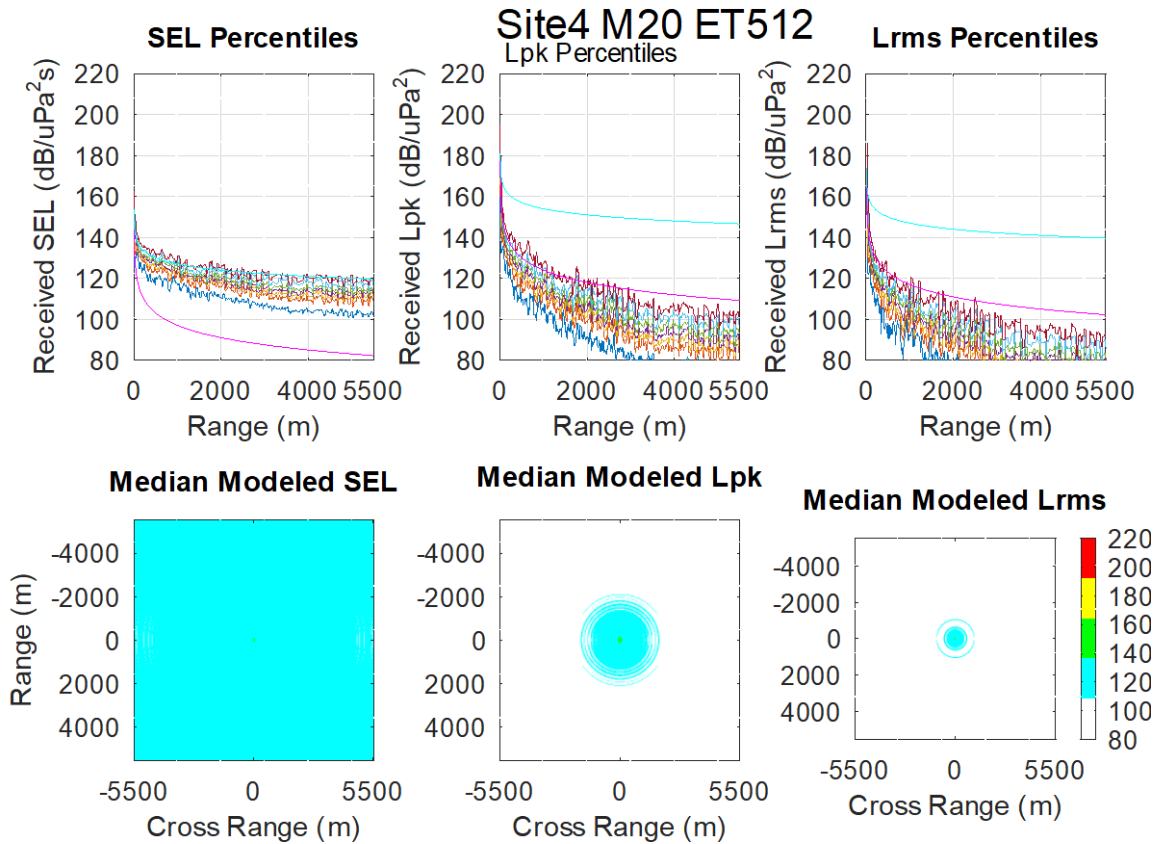


Figure 5-119. Edgetech 512i Mode 20 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.20.5 Site 5 – Sandy Silt, 100-m Depth

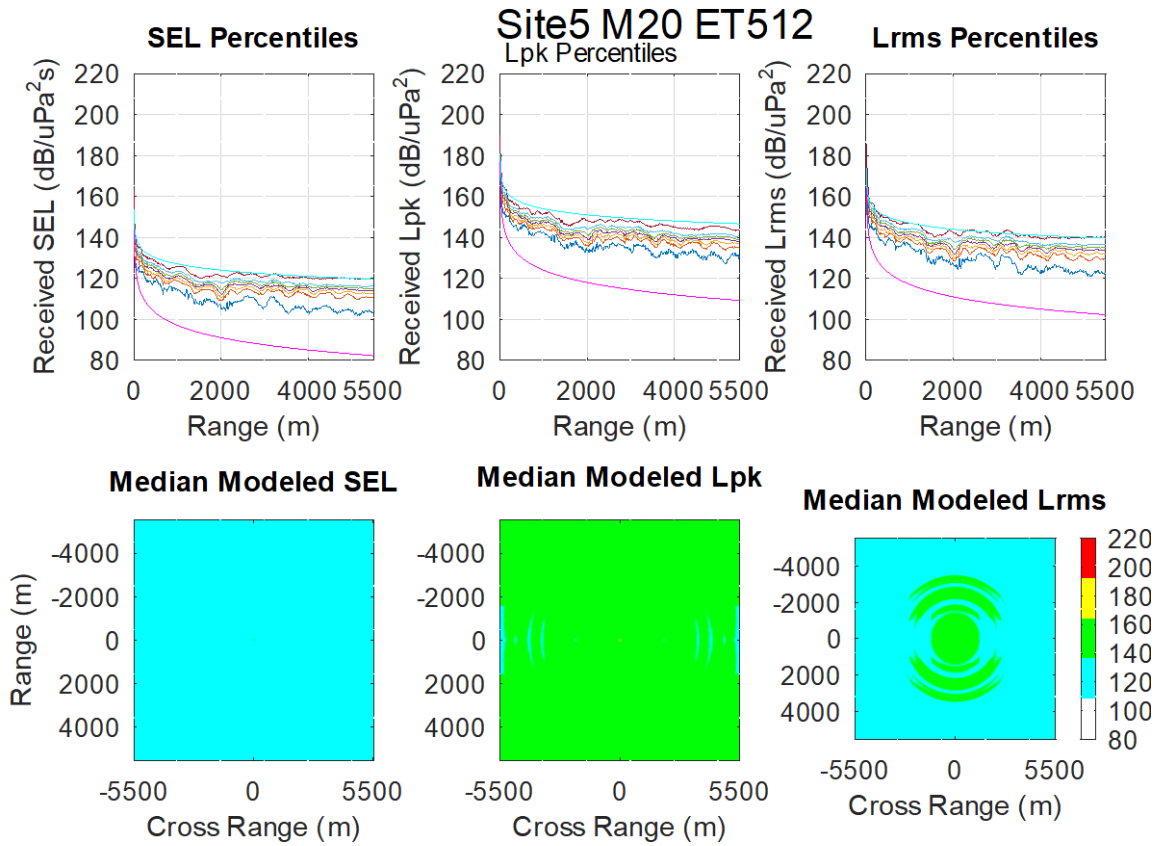


Figure 5-120. Edgetech 512i Mode 20 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.21 Edgetech 512i, 2 to 12 kHz, 100 Percent Power, 20-ms Pulse (Mode 21)

The Edgetech 512i subbottom profiler generates a single MF signal, with a peak frequency of 6 kHz. The operational parameter settings for Mode 21 were 100 percent power, a 20-ms pulse, and a 2- to 12-kHz output frequency. Measured source levels are shown in **Table 5-21**.

Table 5-21. NUWC tank measurements of Edgetech 512i (Mode 21)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	6	190	184	179	159

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-121**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-21**. Modeling results for each site are shown in **Figures 5-122 to 5-126**.

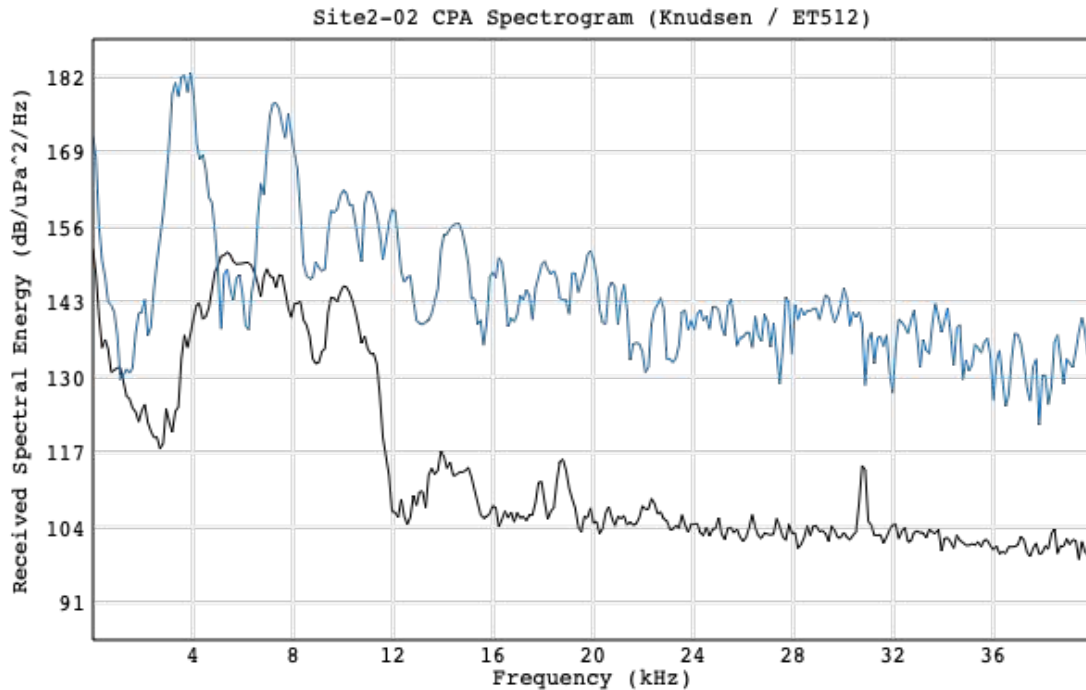


Figure 5-121. Edgetech 512i Mode 21 (blue) decidecade band energy levels at buoy position D Knudsen 3260 Mode 24 (black). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = reference to.

5.21.1 Site 1 – Mud, 10-m Depth

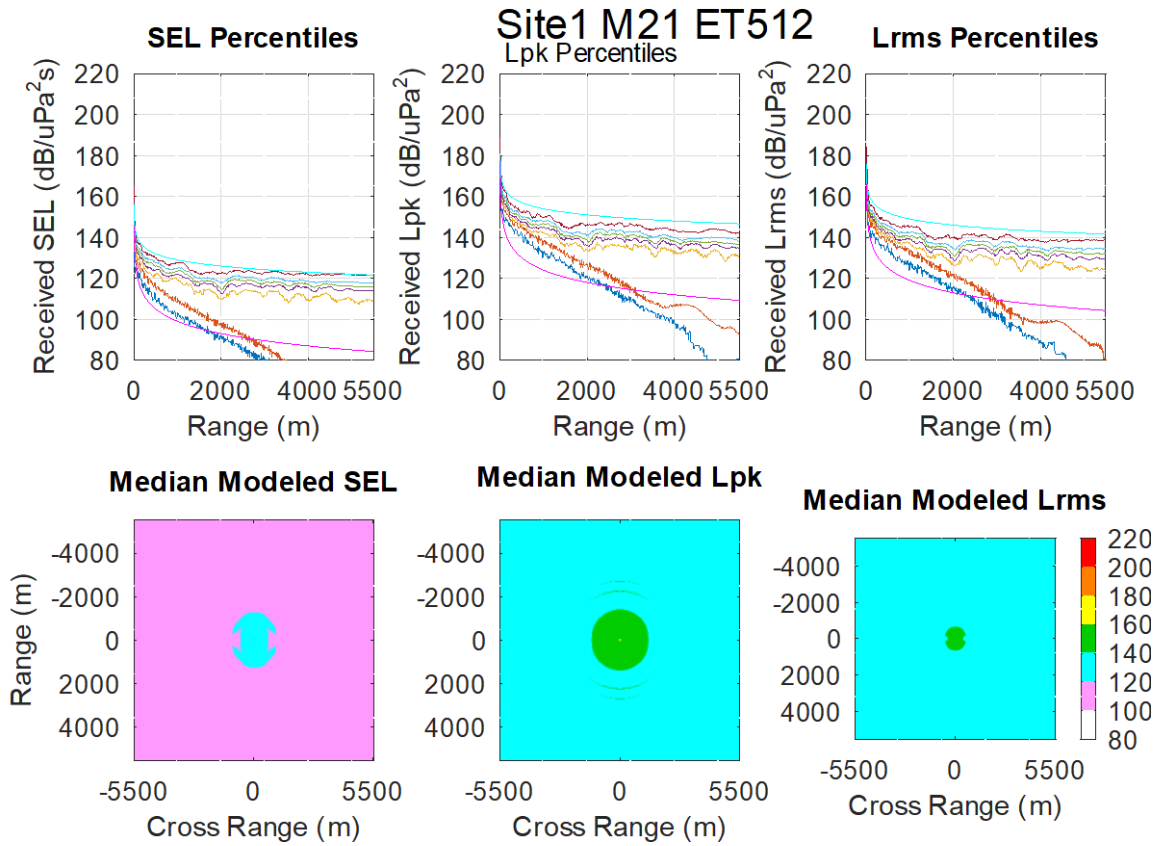


Figure 5-122. Edgetech 512i Mode 21 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.21.2 Site 2 – Sand, 10-m Depth

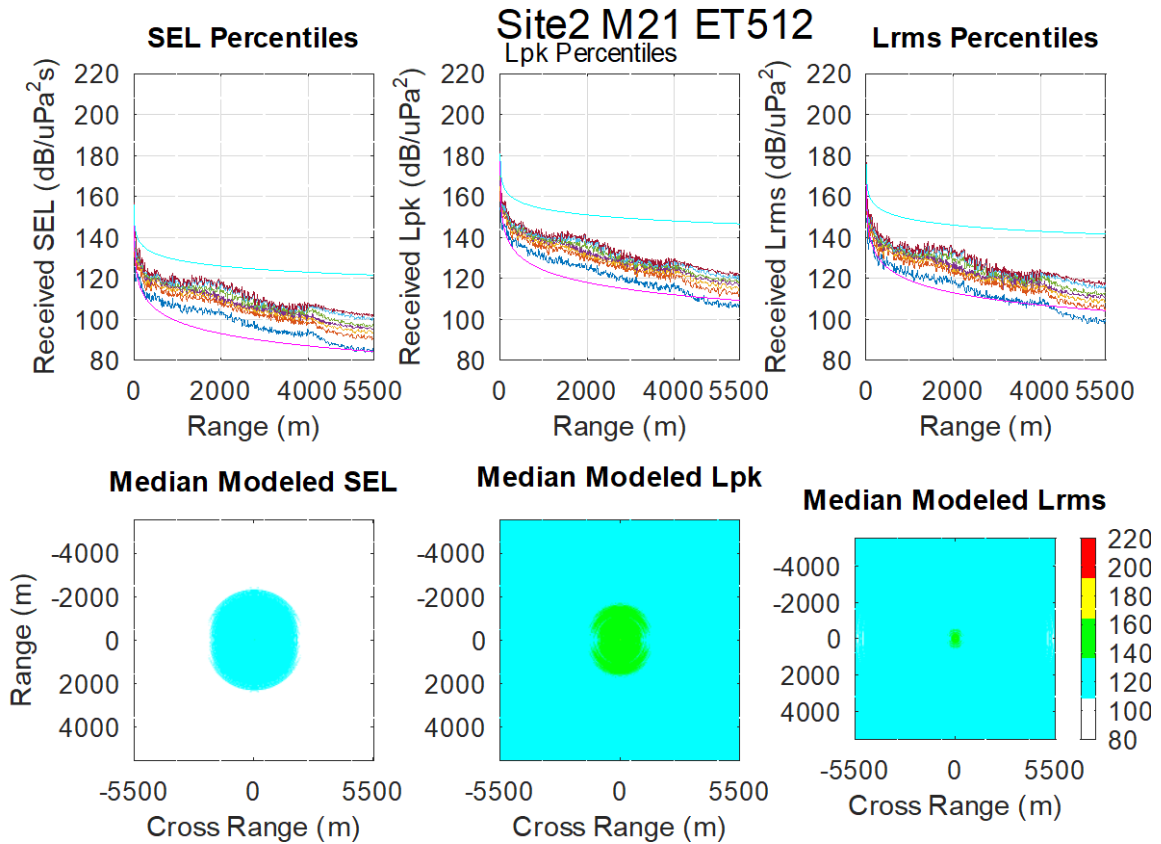


Figure 5-123. Edgetech 512i Mode 21 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.21.3 Site 3 – Mud, 30-m Depth

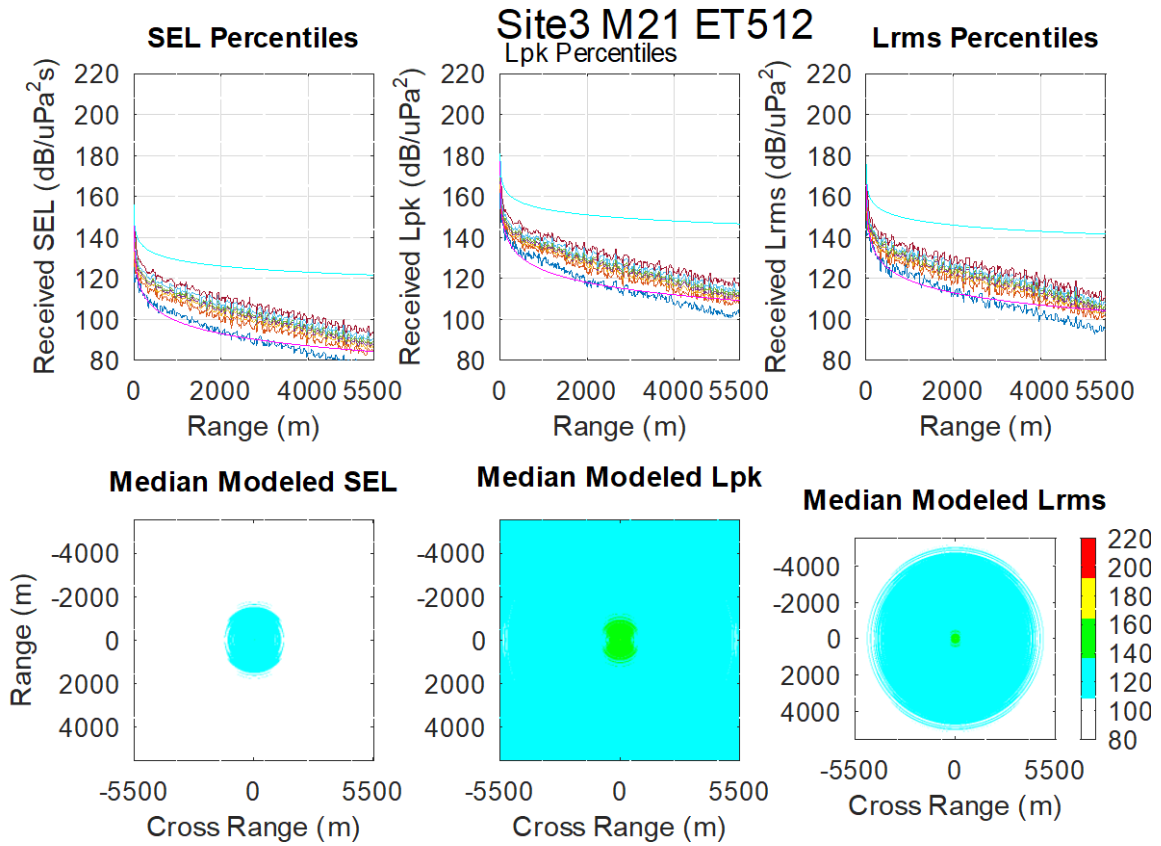


Figure 5-124. Edgetech 512i Mode 21 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.21.4 Site 4 – Sand, 30-m Depth

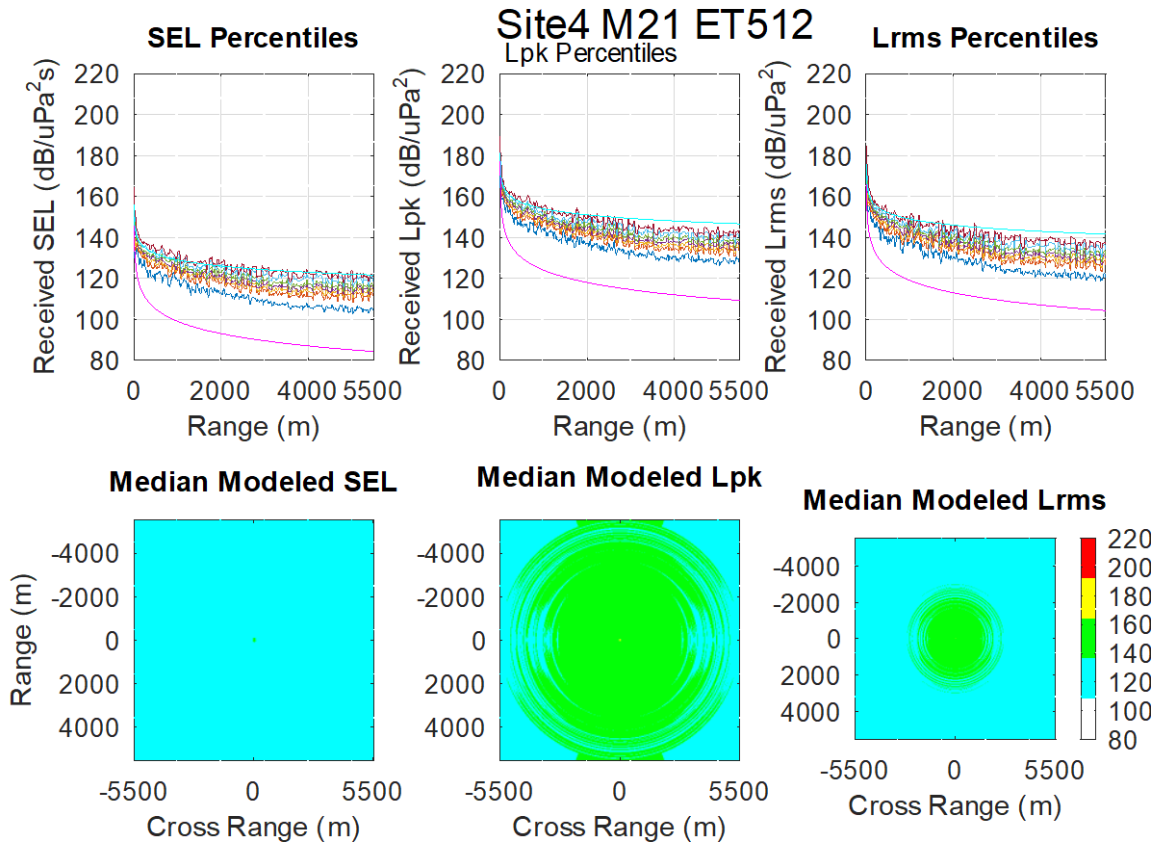


Figure 5-125. Edgetech 512i Mode 21 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.21.5 Site 5 – Sandy Silt, 100-m Depth

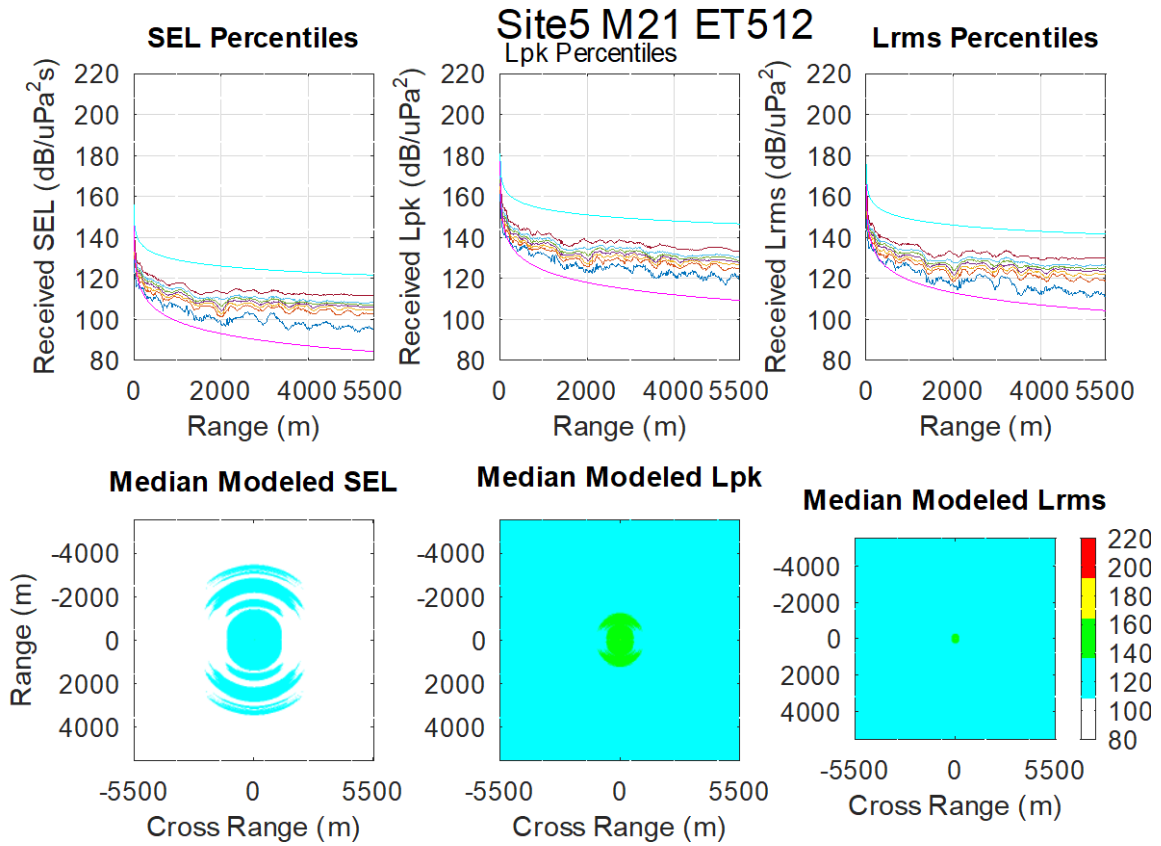


Figure 5-126. Edgetech 512i Mode 21 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.22 Edgetech 512i, 0.5 to 8 kHz, 100 Percent Power, 5-ms Pulse (Mode 22)

The Edgetech 512i subbottom profiler generates a single MF signal, with a peak frequency of 6 kHz. The operational parameter settings for Mode 22 were 100 percent power, a 5-ms pulse, and a 0.5- to 8-kHz output frequency. Measured source levels are shown in **Table 5-22**.

Table 5-22. NUWC tank measurements of Edgetech 512i (Mode 22)

Source Settings		Source Level			
Power Level (%)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	6	191	184	177	150

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.

From: Crocker and Fratantonio, 2016

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-127**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-22**. Modeling results for each site are shown in **Figures 5-128 to 5-132**.

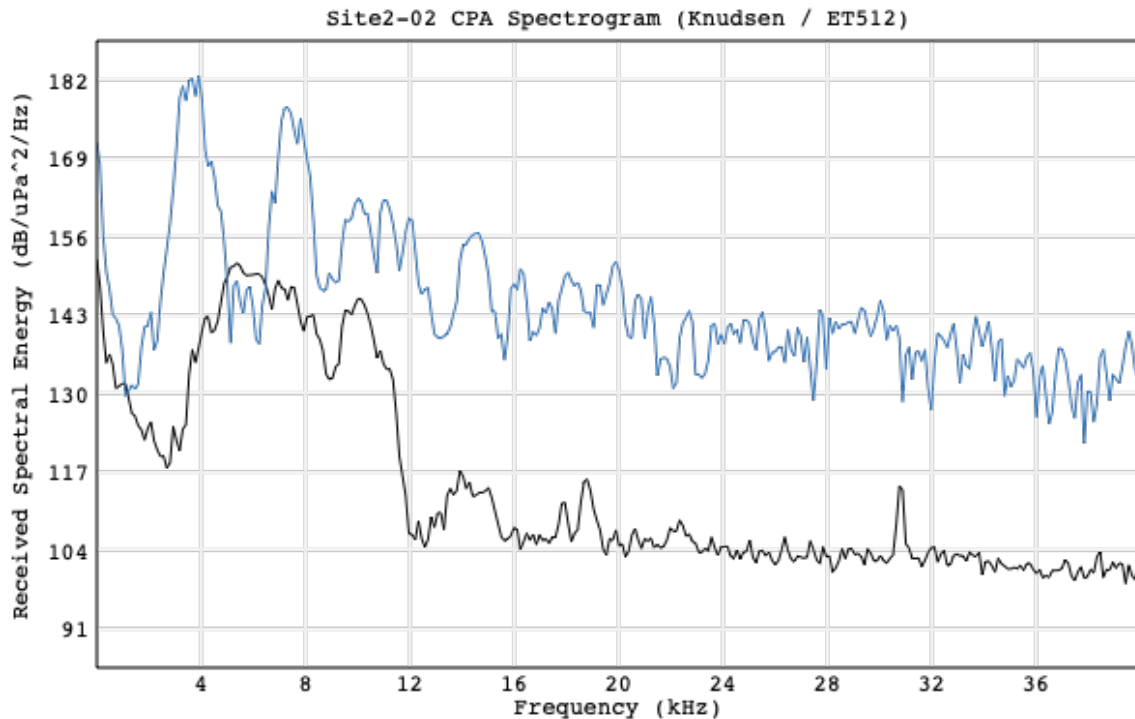


Figure 5-127. Edgetech 512i Mode 22 (blue) decidecade band energy levels at buoy position D Knudsen 3260 Mode 24 (black). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.22.1 Site 1 – Mud, 10-m Depth

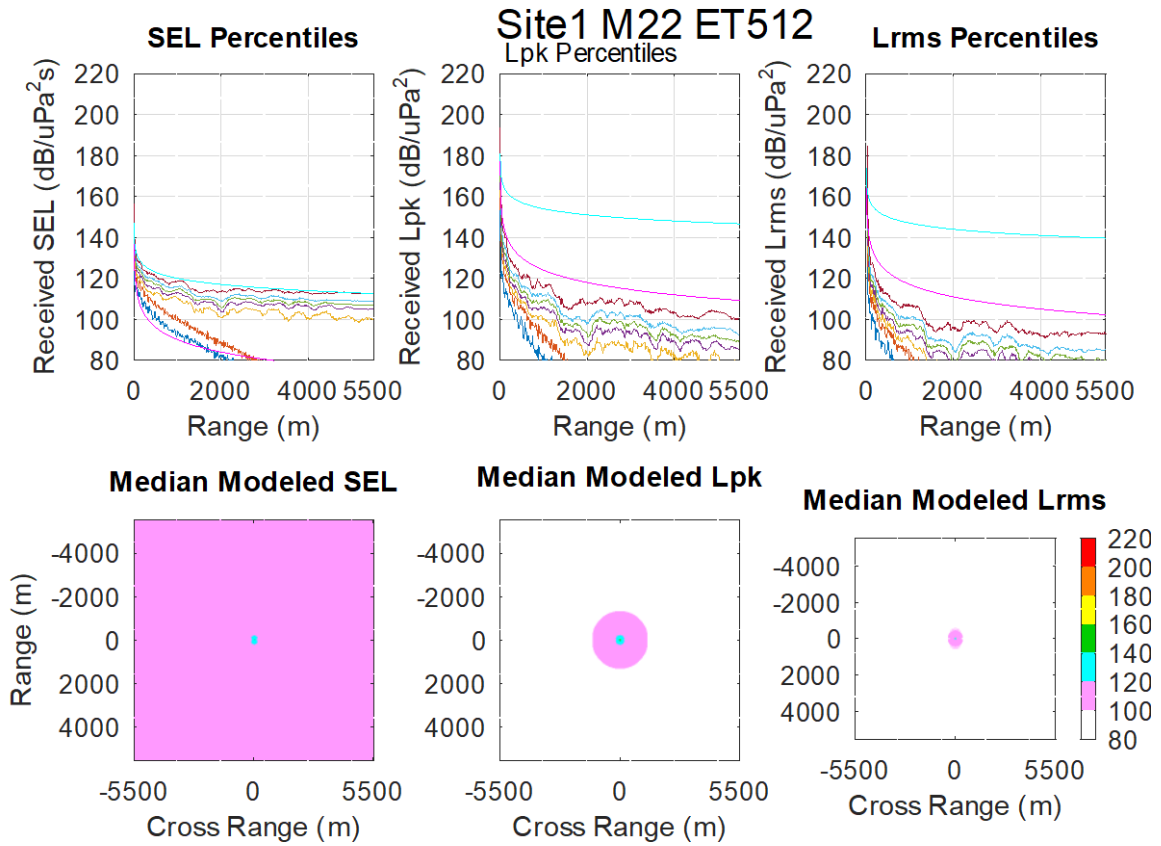


Figure 5-128. Edgetech 512i Mode 22 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.22.2 Site 2 – Sand, 10-m Depth

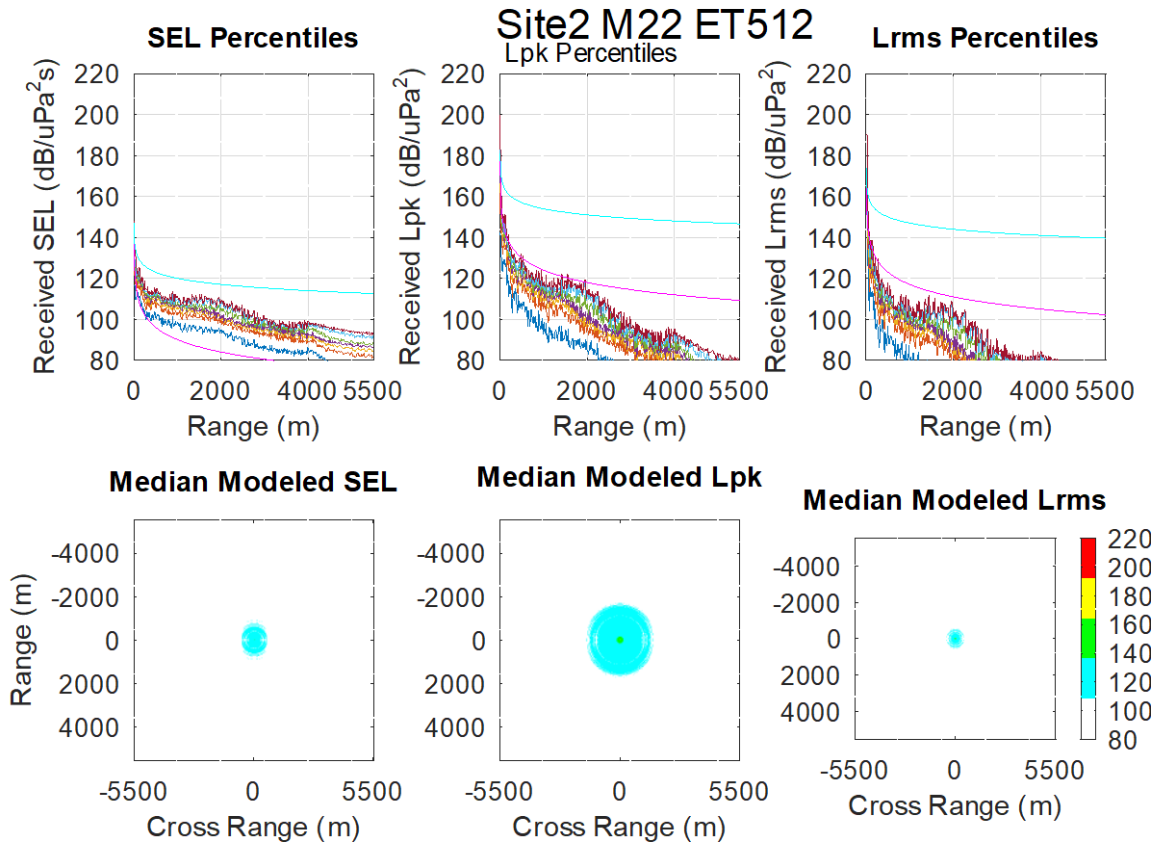


Figure 5-129. Edgetech 512i Mode 22 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.22.3 Site 3 – Mud, 30-m Depth

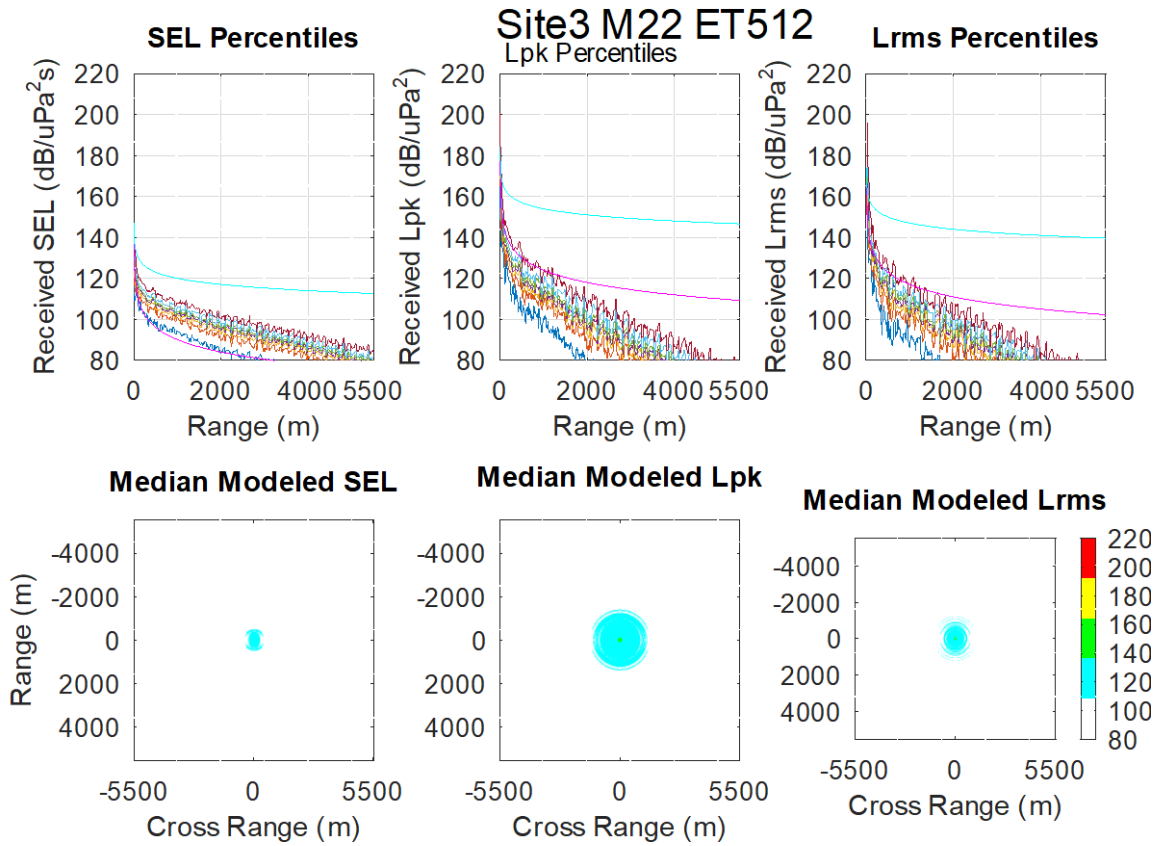


Figure 5-130. Edgetech 512i Mode 22 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.22.4 Site 4 – Sand, 30-m Depth

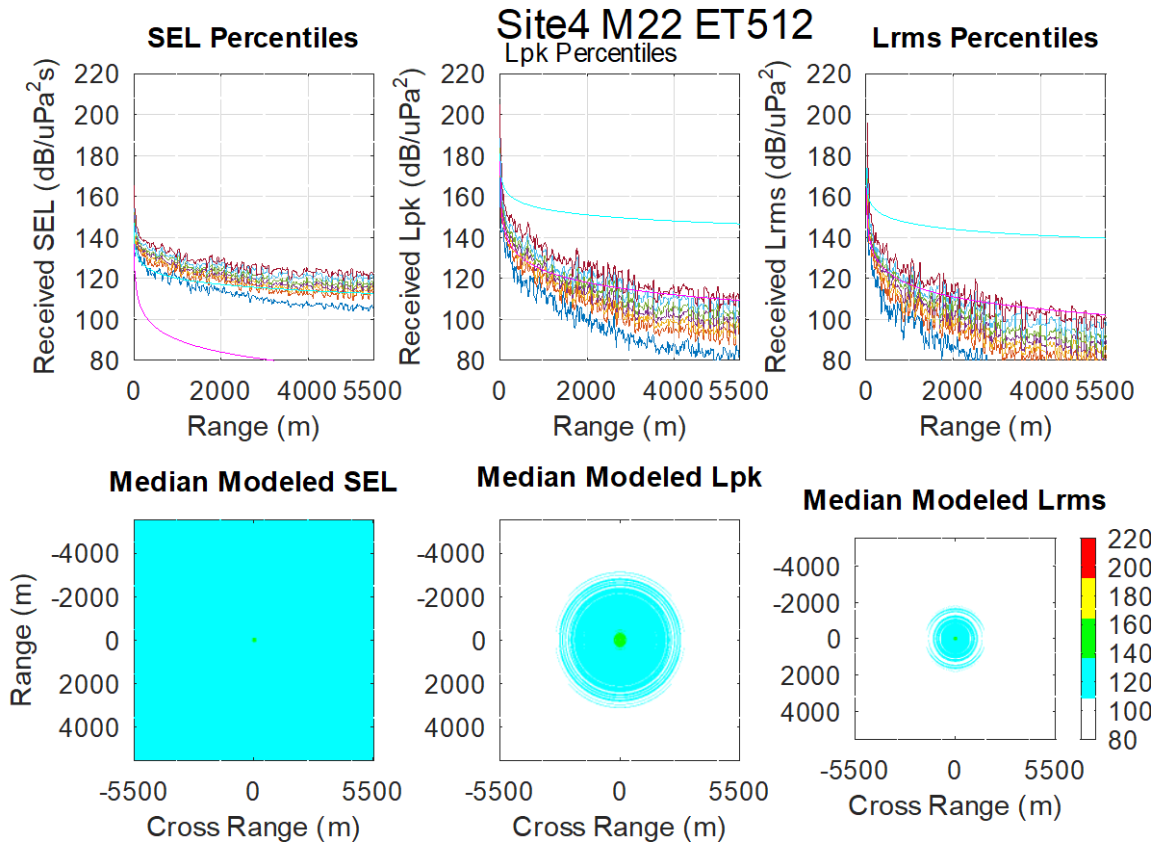


Figure 5-131. Edgetech 512i Mode 22 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.22.5 Site 5 – Sandy Silt, 100-m Depth

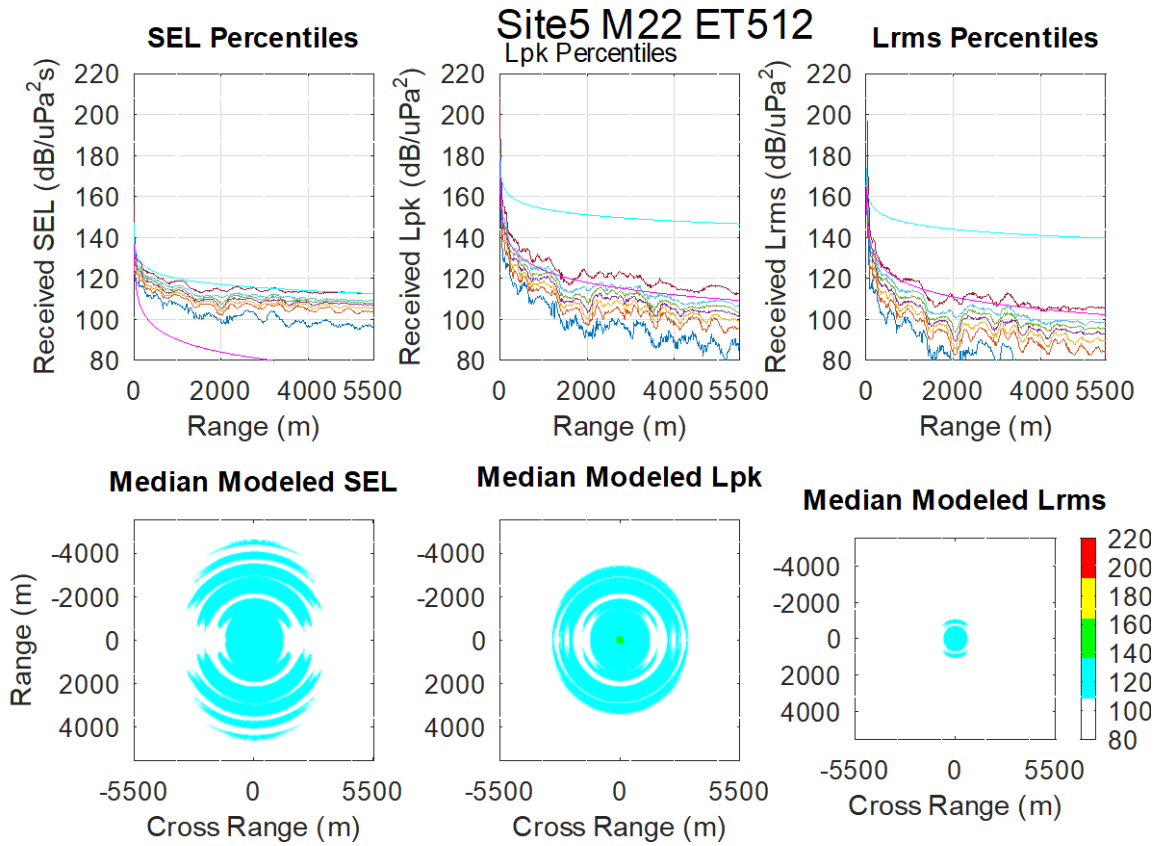


Figure 5-132. Edgetech 512i Mode 22 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.23 Knudsen 3260, 3.3 to 5.6 kHz, Power Level 1, 8-ms Pulse (Mode 23)

The Knudsen 3260 subbottom profiler generates a single MF signal, with a peak frequency of 4 kHz. The operational parameter settings for Mode 23 were a power level of 1, an 8-ms pulse, and a 3.3- to 5.6-kHz output frequency via 2×2 array (i.e., four transducers). Measured source levels are shown in **Table 5-23**.

Table 5-23. NUWC tank measurements of Knudsen 3260 (Mode 23)

Source Settings		Source Level			
Power Level	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
1	4	210	204	199	177

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-133**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-23**. Modeling results for each site are shown in **Figures 5-134 to 5-138**.

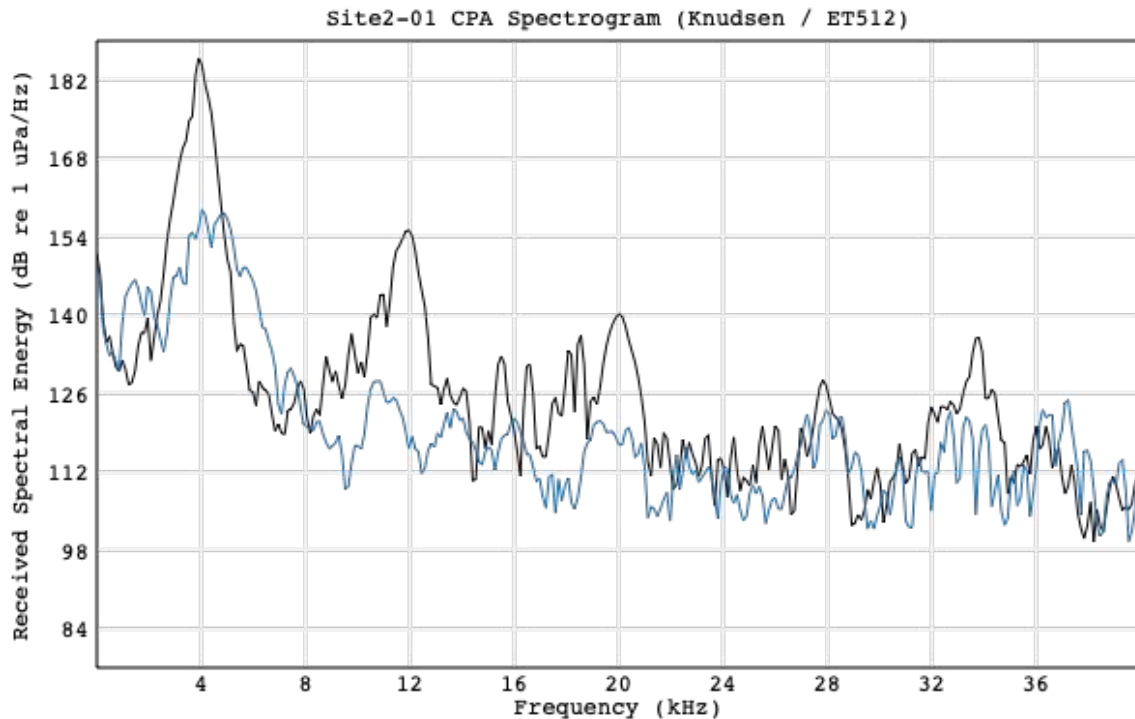


Figure 5-133. Knudsen 3260 Mode 23 (black) decidecade band energy levels at buoy position D Edgetech 512i Mode 20 (blue). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; re = with reference to.

5.23.1 Site 1 – Mud, 10-m Depth

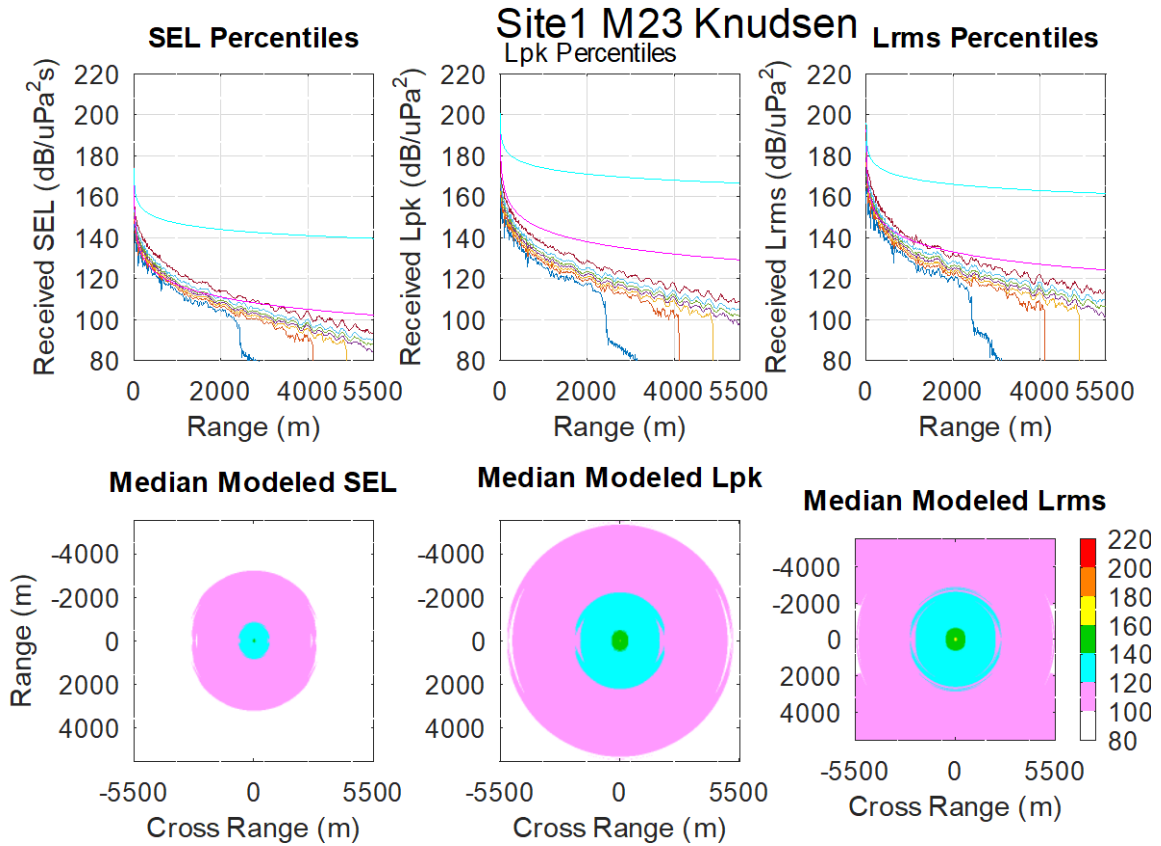


Figure 5-134. Knudsen 3260 Mode 23 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.23.2 Site 2 – Sand, 10-m Depth

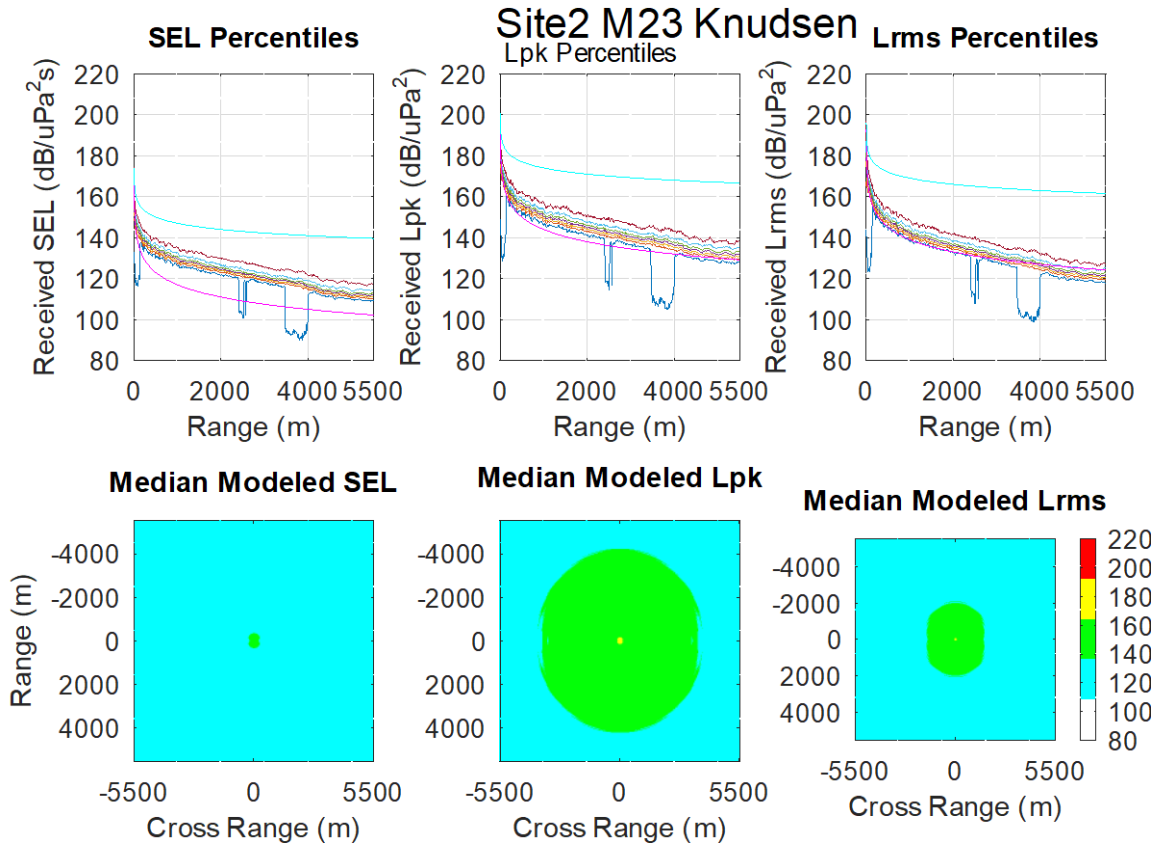


Figure 5-135. Knudsen 3260 Mode 23 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.23.3 Site 3 – Mud, 30-m Depth

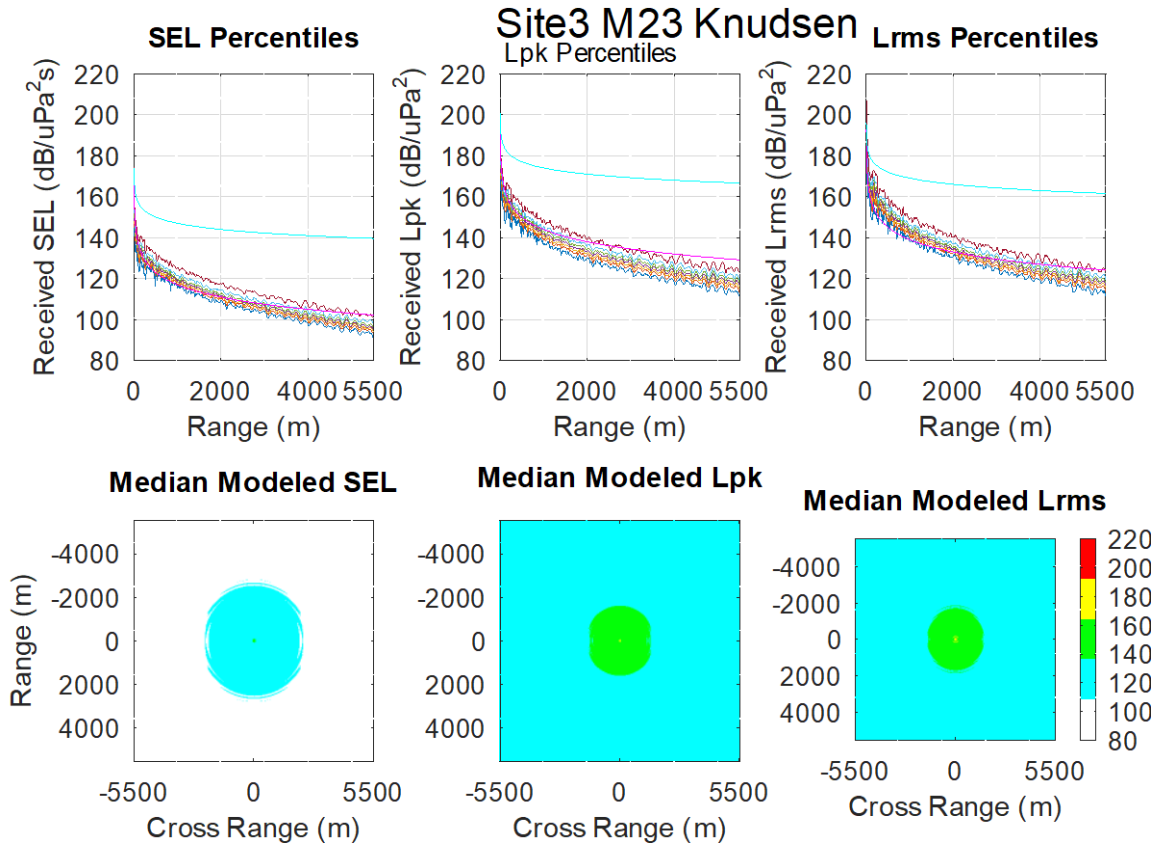


Figure 5-136. Knudsen 3260 Mode 23 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.23.4 Site 4 – Sand, 30-m Depth

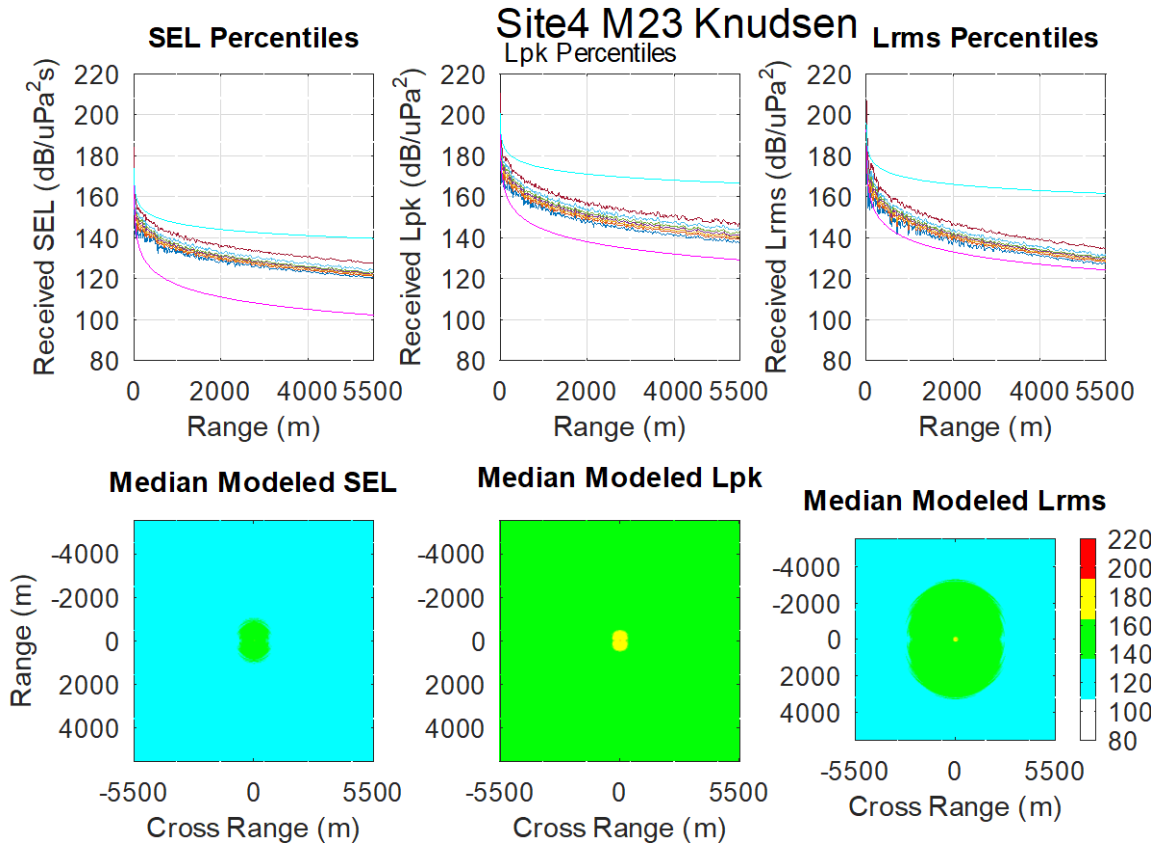


Figure 5-137. Knudsen 3260 Mode 23 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.23.5 Site 5 – Sandy Silt, 100-m Depth

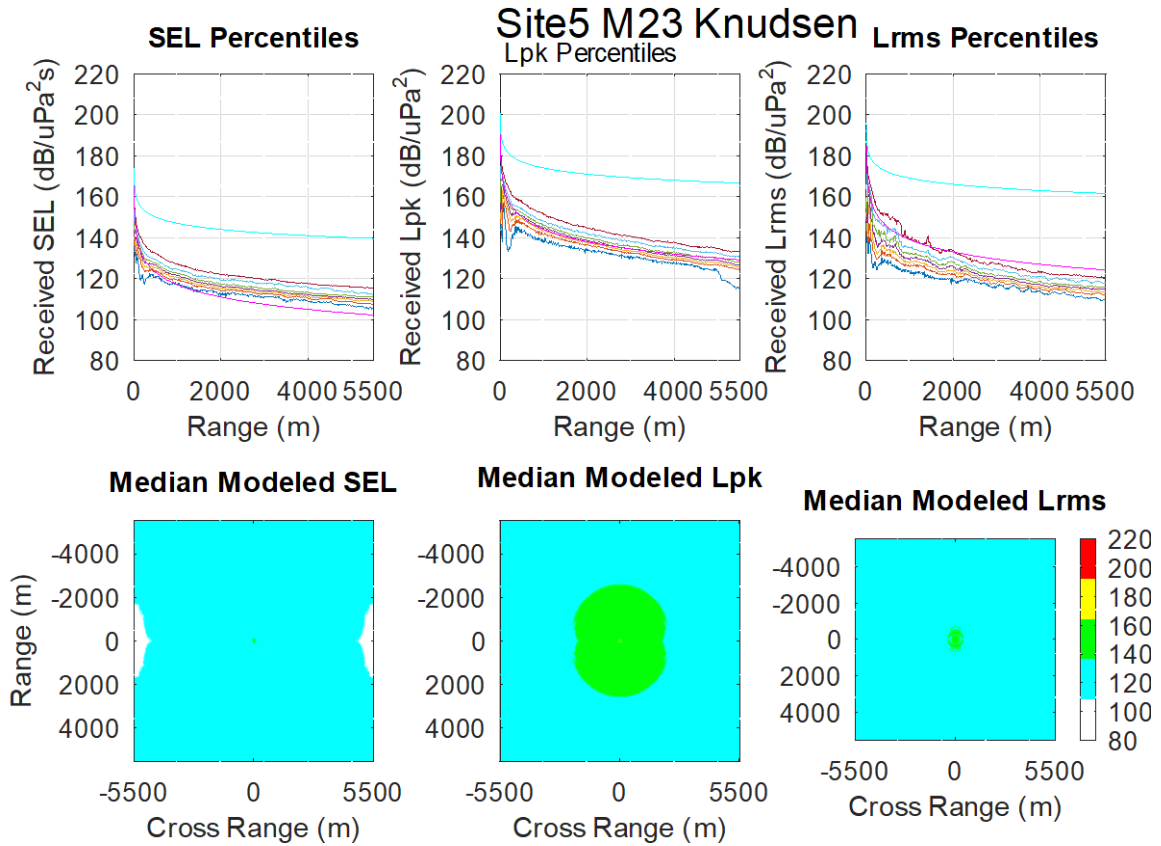


Figure 5-138. Knudsen 3260 Mode 23 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.24 Knudsen 3260, 3.3 to 5.6 kHz, Power Level 4, 32-ms Pulse (Mode 24)

The Knudsen 3260 subbottom profiler generates a single MF signal, with a peak frequency of 4 kHz. The operational parameter settings for Mode 24 were a power level of 4, a 32-ms pulse, and a 3.3- to 5.6-kHz output frequency via 2×2 array (i.e., four transducers). Measured source levels are shown in **Table 5-24**.

Table 5-24. NUWC tank measurements of Knudsen 3260 (Mode 24)

Source Settings		Source Level			
Power Level	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
4	4	217	211	207	190

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-139**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-24**. Modeling results for each site are shown in **Figures 5-140 to 5-144**.

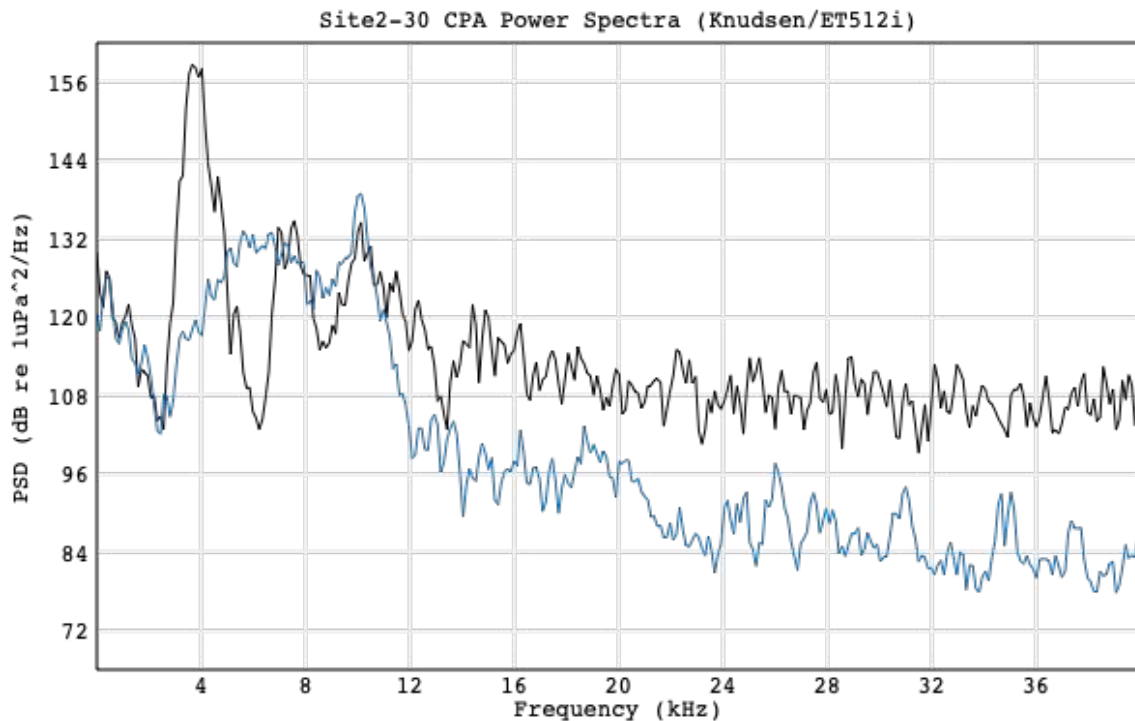


Figure 5-139. Knudsen 3260 Mode 24 (black) decidecade band energy levels at buoy position D Edgetech 512i Mode 21 (blue). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; PSD = power spectral density; re = with reference to.

5.24.1 Site 1 – Mud, 10-m Depth

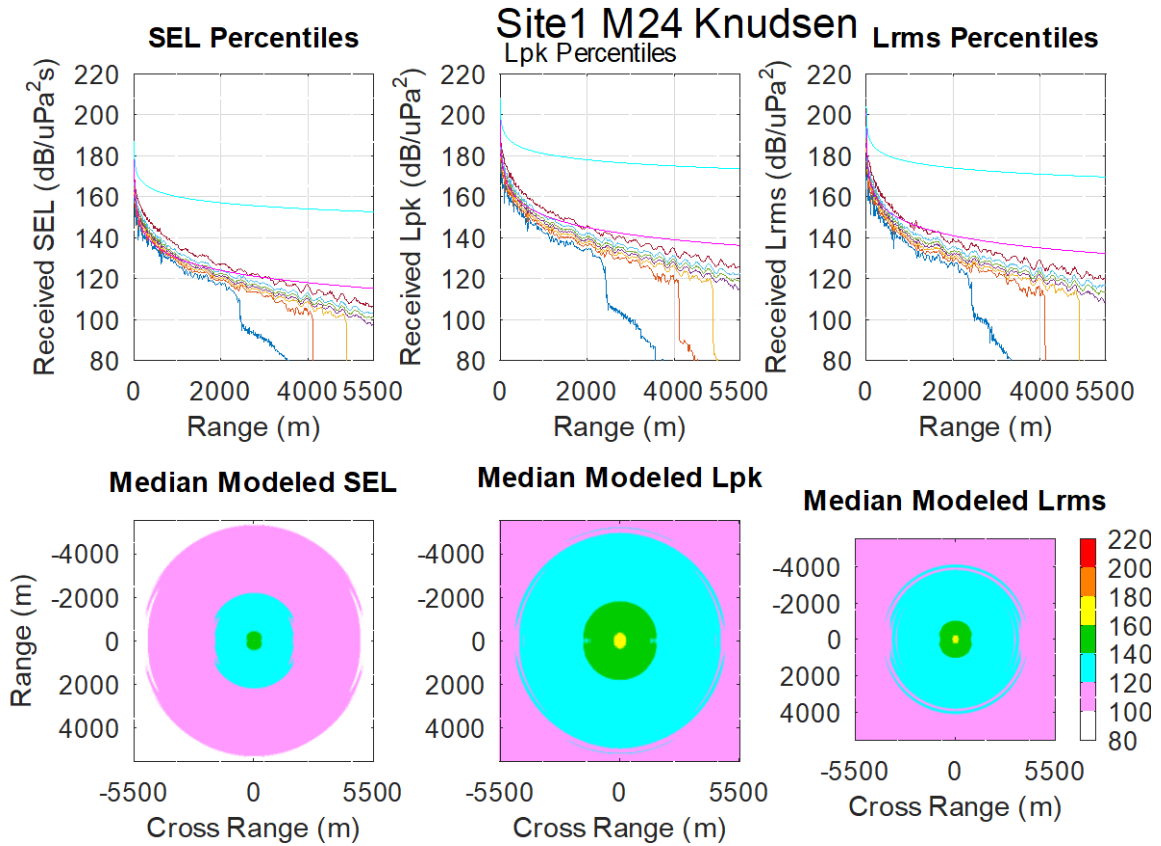


Figure 5-140. Knudsen 3260 Mode 24 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.24.2 Site 2 – Sand, 10-m Depth

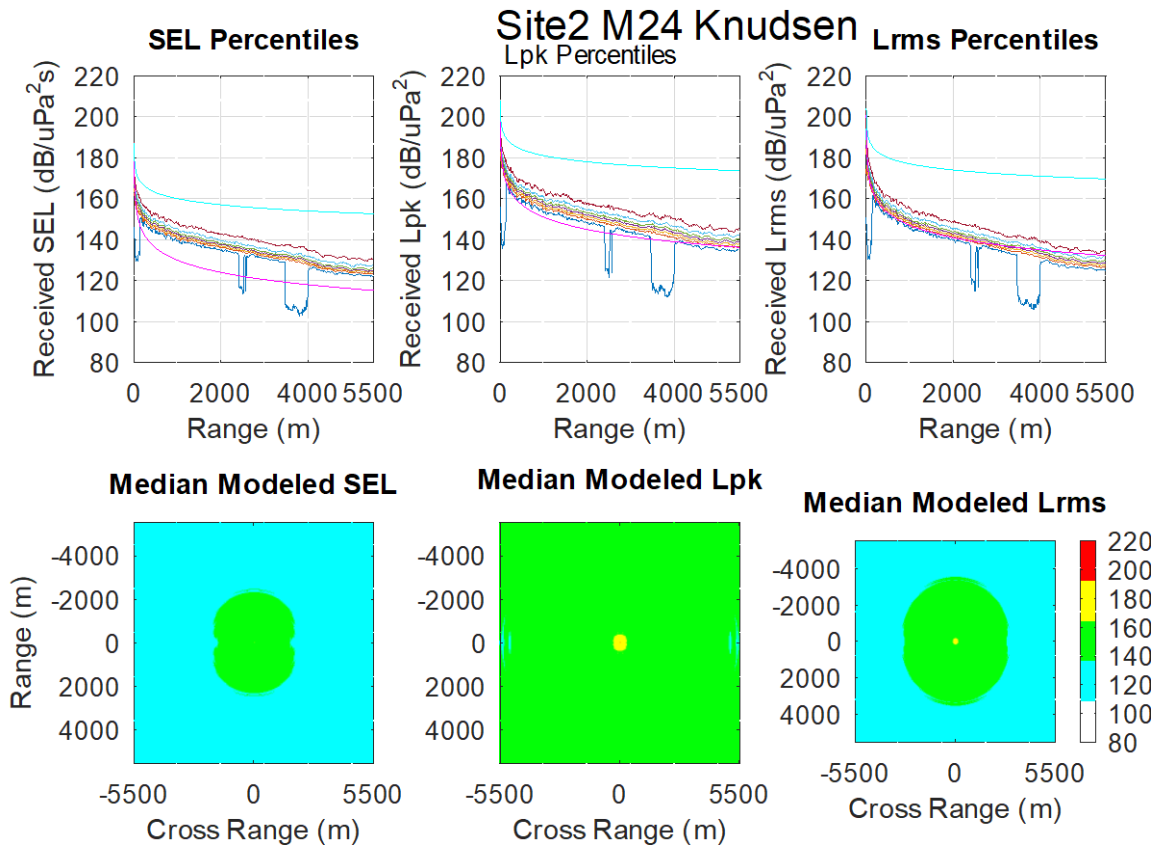


Figure 5-141. Knudsen 3260 Mode 24 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.24.3 Site 3 – Mud, 30-m Depth

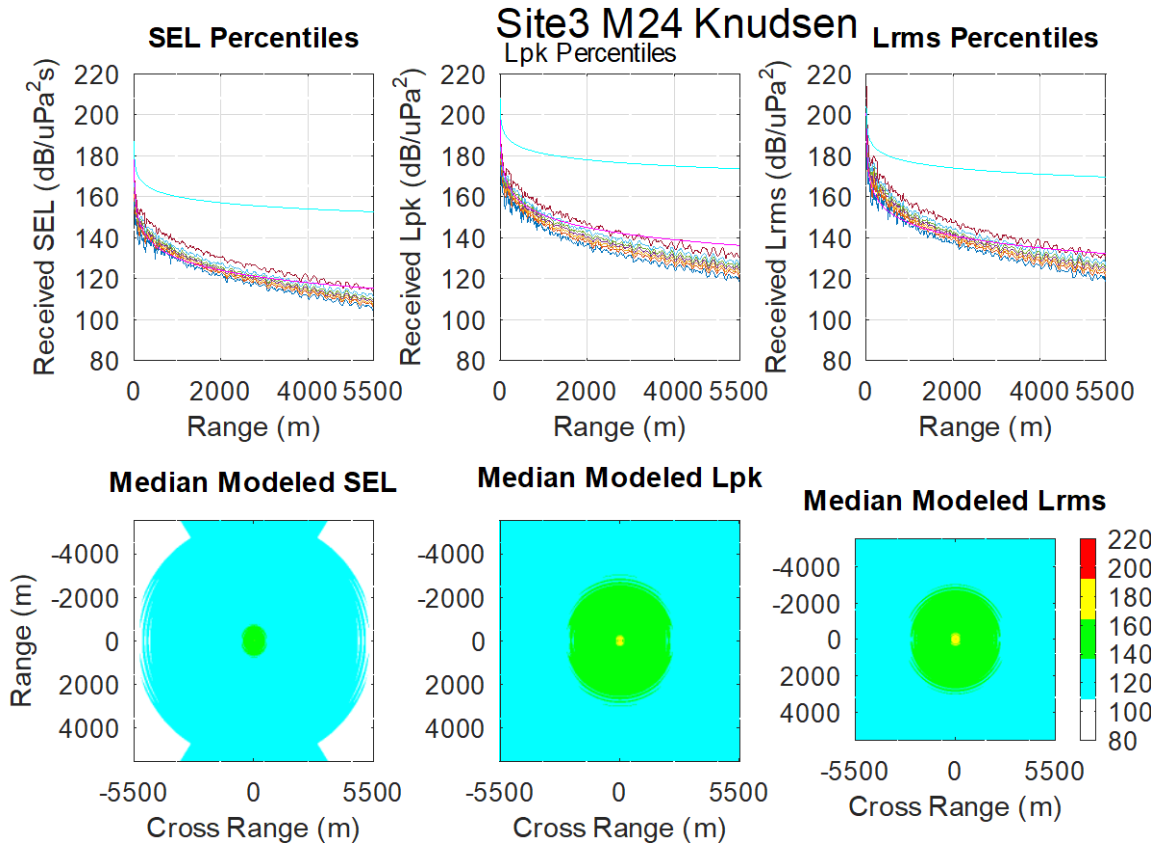


Figure 5-142. Knudsen 3260 Mode 24 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.24.4 Site 4 – Sand, 30-m Depth

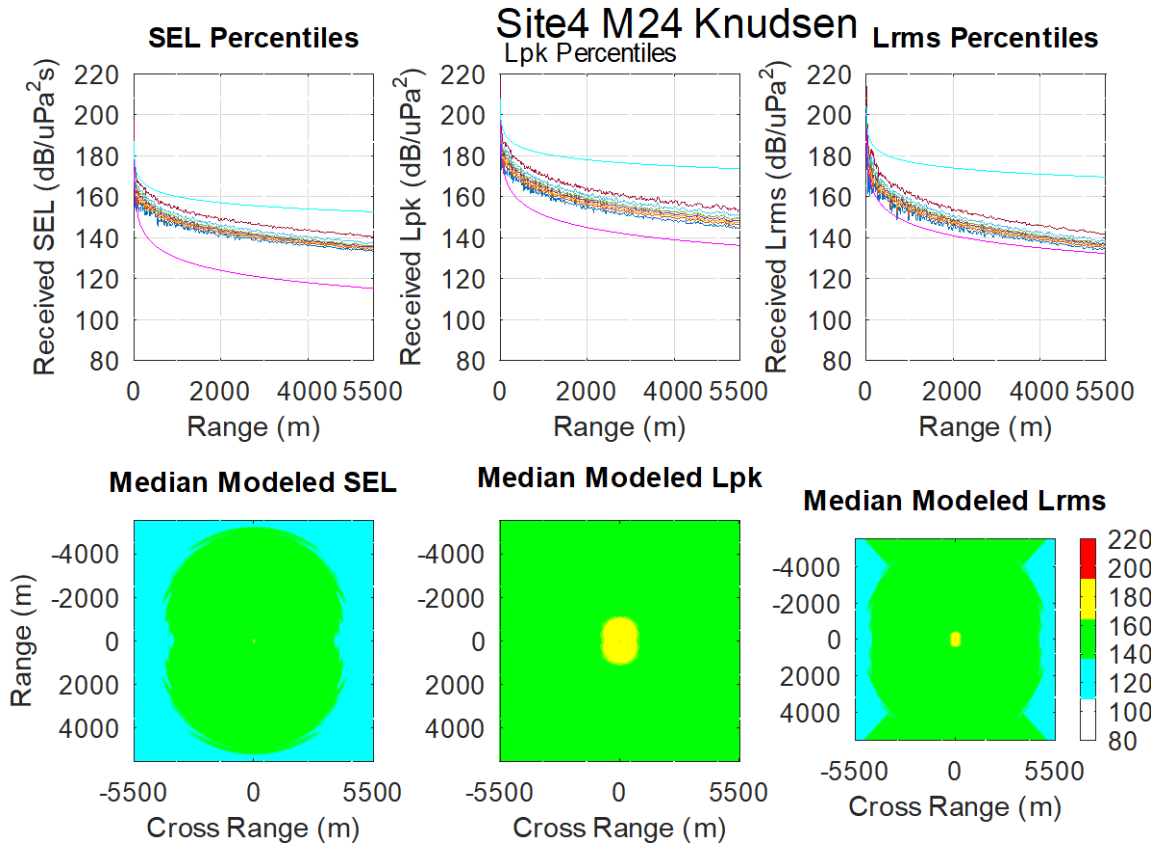


Figure 5-143. Knudsen 3260 Mode 24 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.24.5 Site 5 – Sandy Silt, 100-m Depth

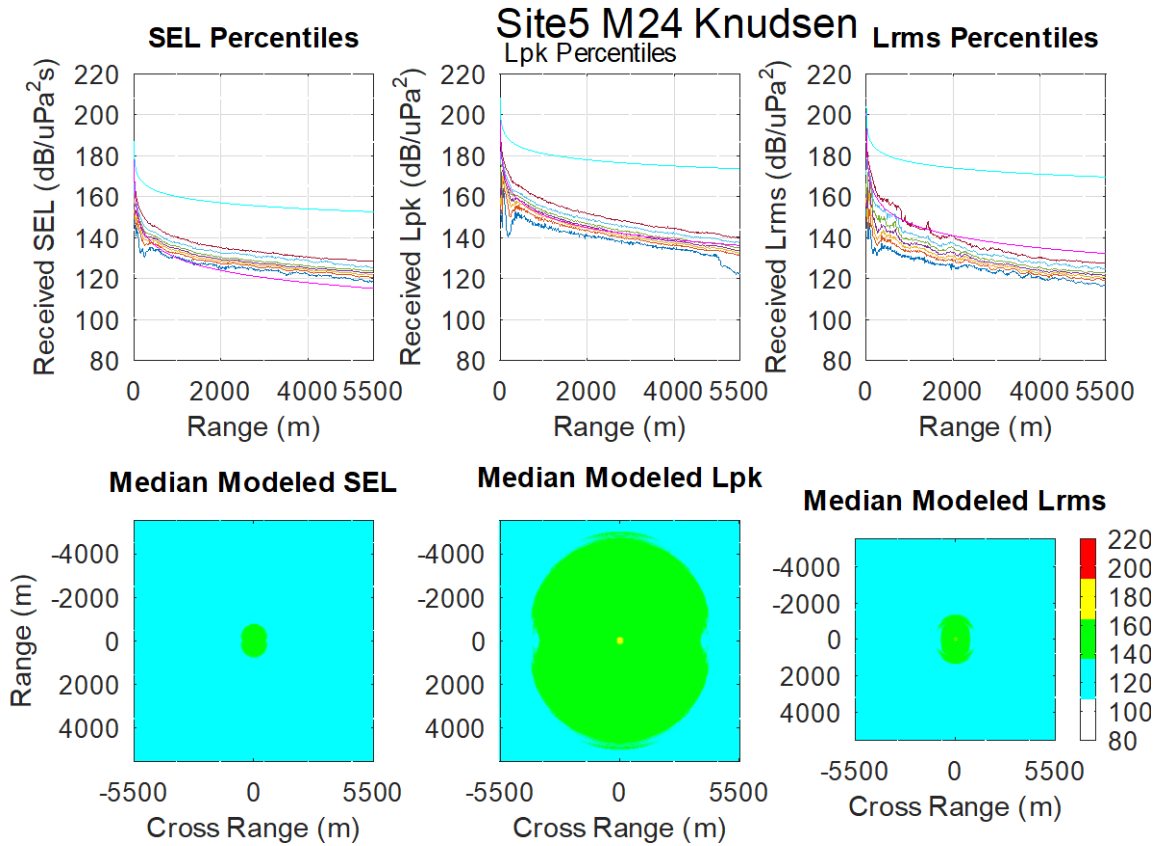


Figure 5-144. Knudsen 3260 Mode 24 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.25 Knudsen 3260, 3.3 to 5.6 kHz, Power Level 4, 64-ms Pulse (Mode 25)

The Knudsen 3260 subbottom profiler generates a single MF signal, with a peak frequency of 4 kHz. The operational parameter settings for Mode 25 were a power level of 4, a 64-ms pulse, and a 3.3- to 5.6-kHz output frequency via 2×2 array (i.e., four transducers). Measured source levels are shown in **Table 5-25**.

Table 5-25. NUWC tank measurements of Knudsen 3260 (Mode 25)

Source Settings		Source Level			
Power Level	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
4	4	217	211	207	190

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-145**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-25**. Modeling results for each site are shown in **Figures 5-146 to 5-150**.

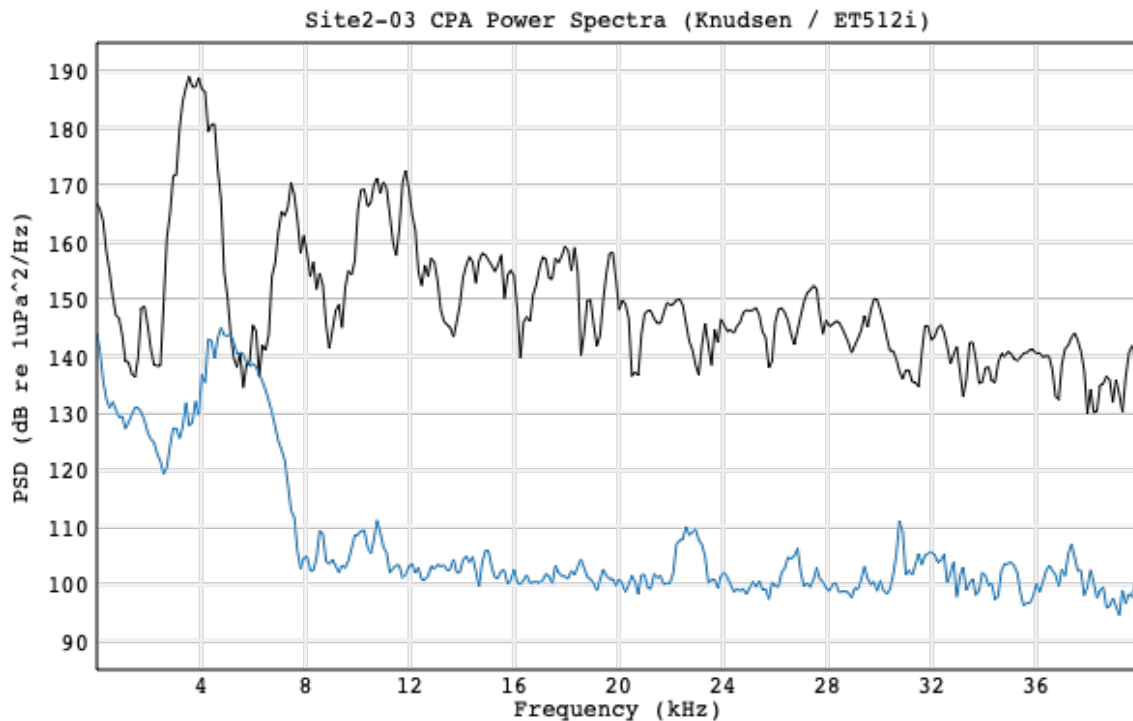


Figure 5-145. Knudsen 3260 Mode 25 (black) decidecade band energy levels at buoy position D Edgetech 512i Mode 22 (blue). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; PSD = power spectral density; re = with reference to.

5.25.1 Site 1 – Mud, 10-m Depth

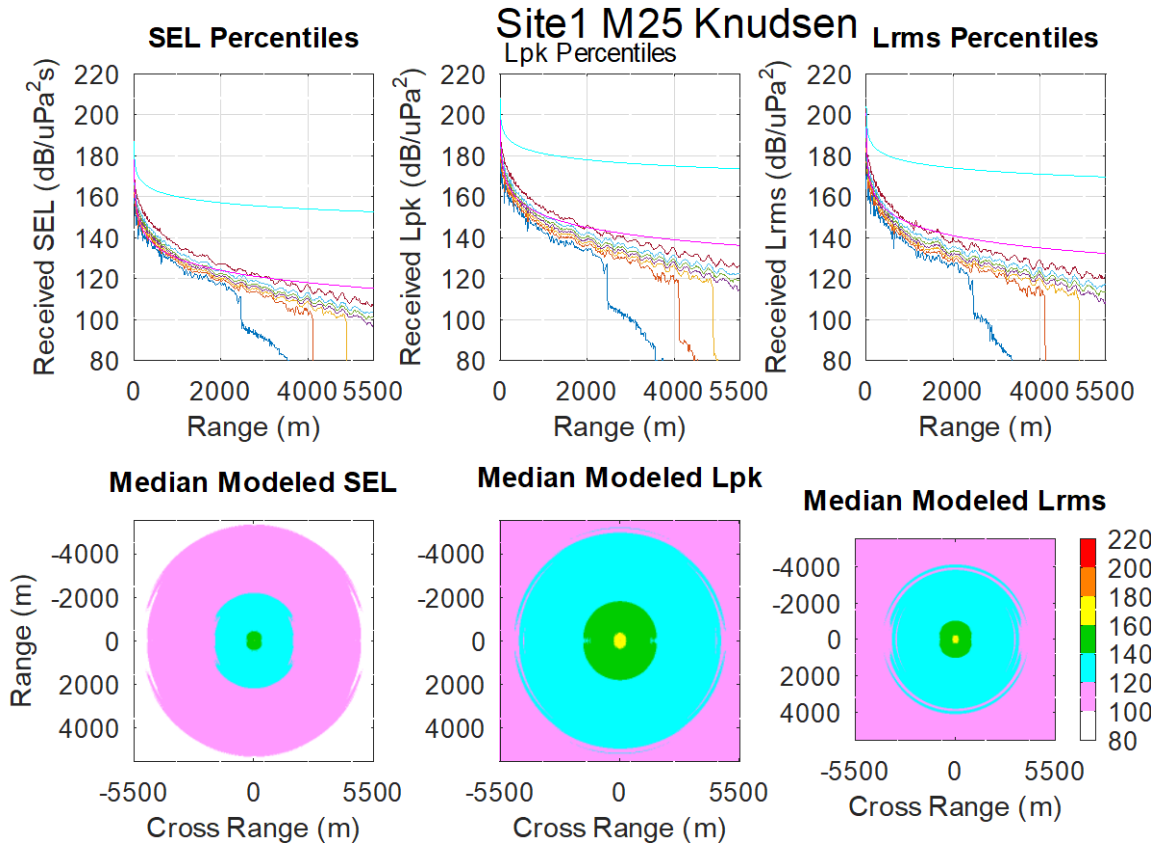


Figure 5-146. Knudsen 3260 Mode 25 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.25.2 Site 2 – Sand, 10-m Depth

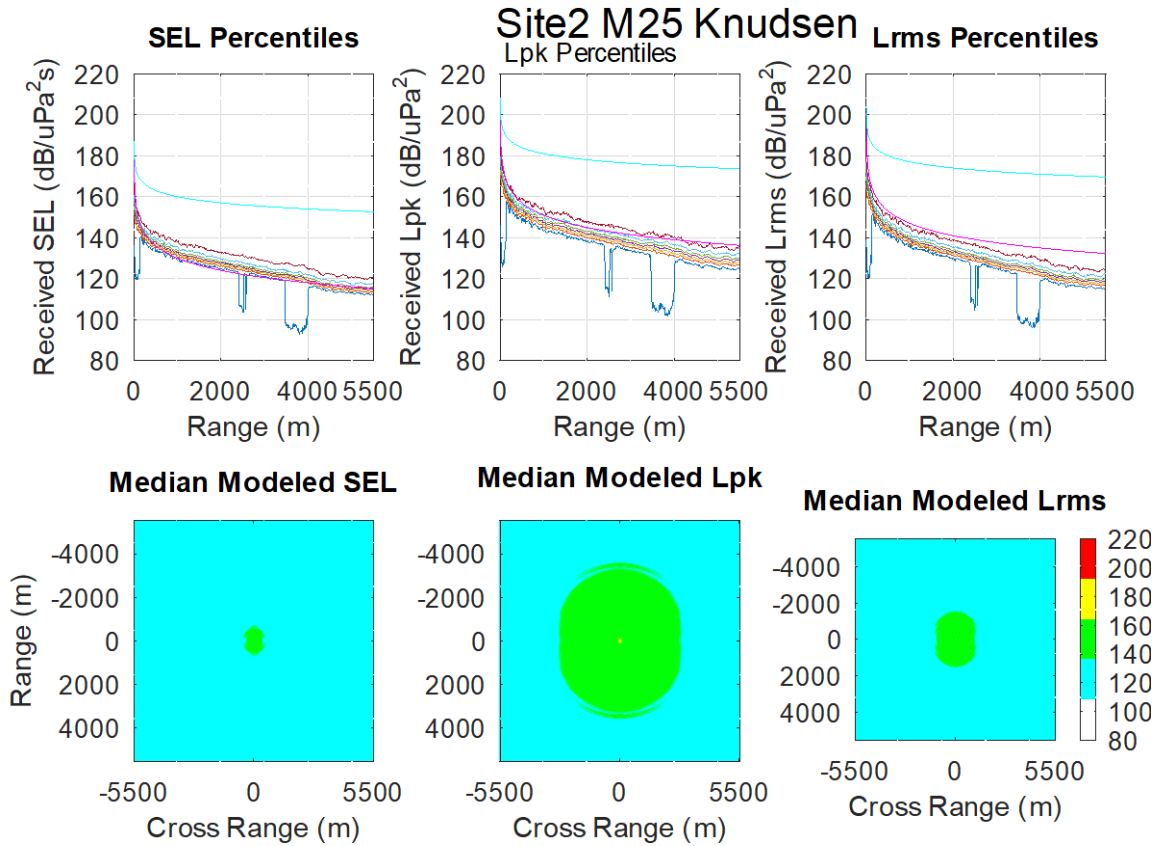


Figure 5-147. Knudsen 3260 Mode 25 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.25.3 Site 3 – Mud, 30-m Depth

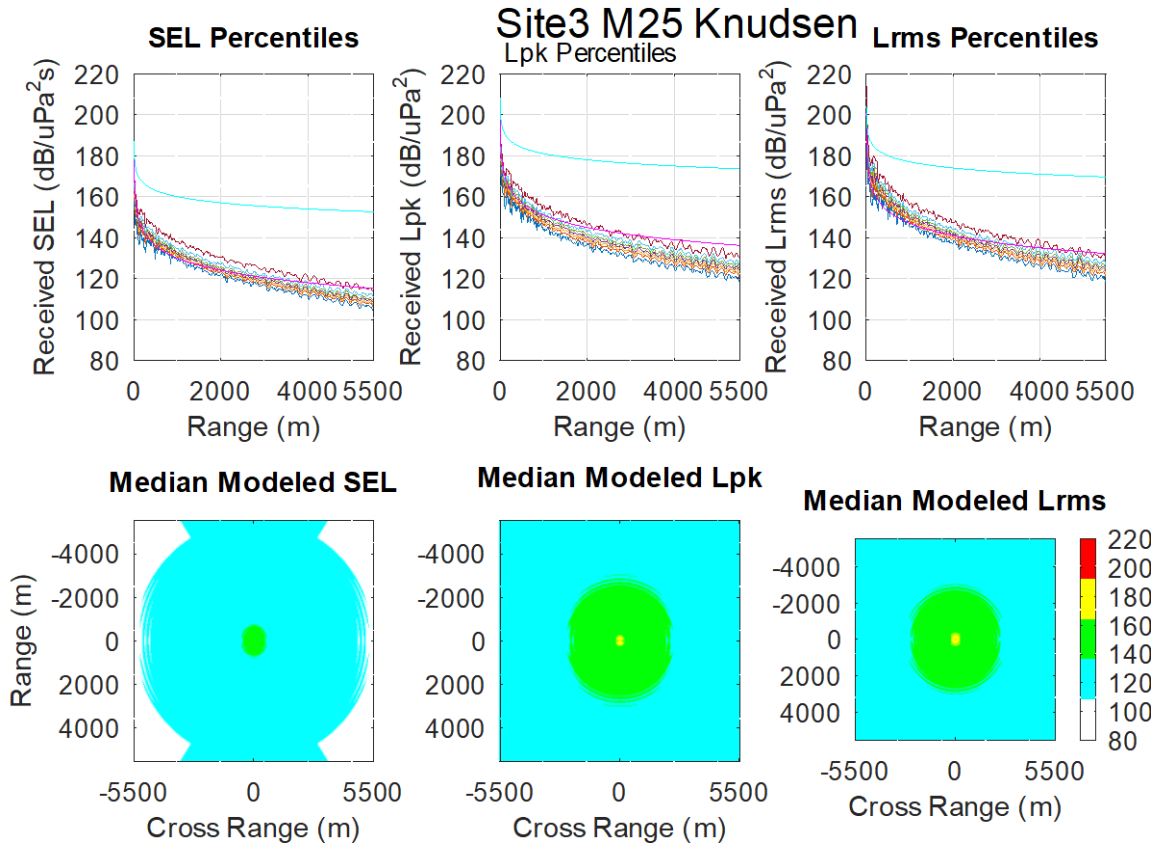


Figure 5-148. Knudsen 3260 Mode 25 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.25.4 Site 4 – Sand, 30-m Depth

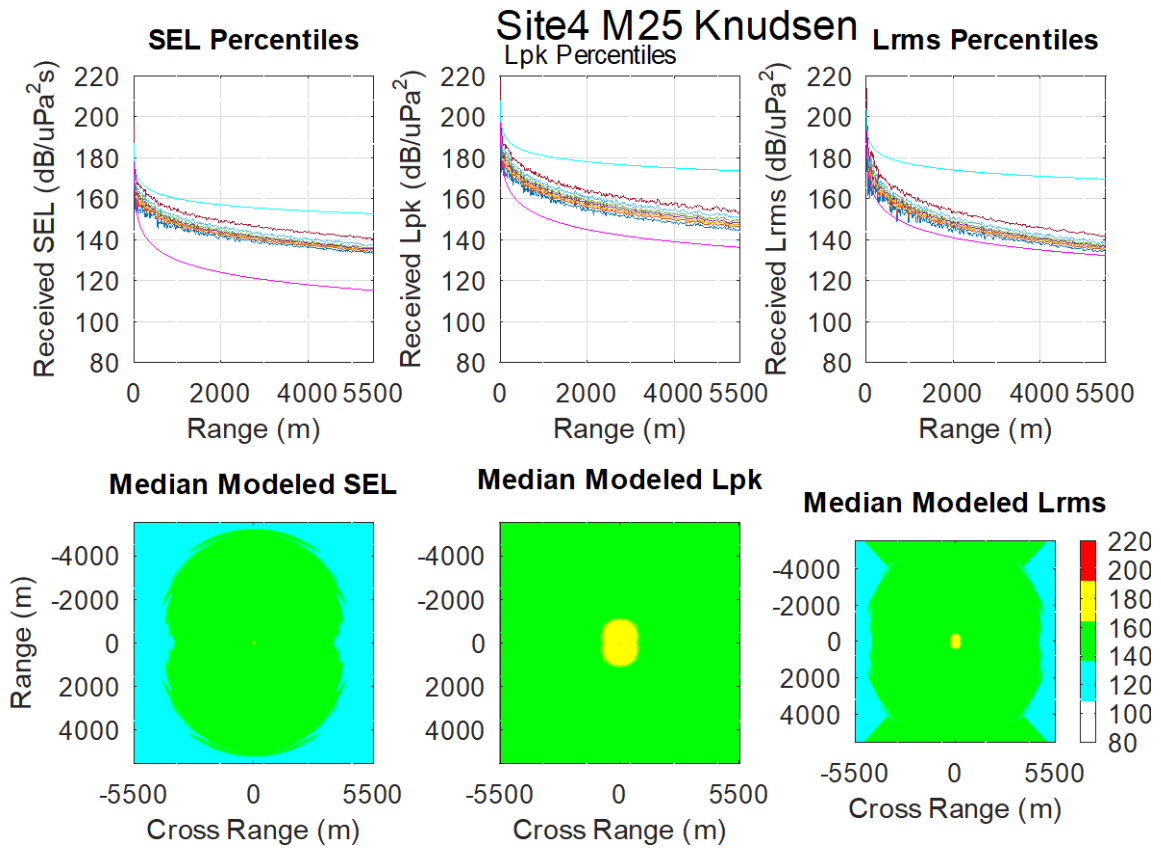


Figure 5-149. Knudsen 3260 Mode 25 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.25.5 Site 5 – Sandy Silt, 100-m Depth

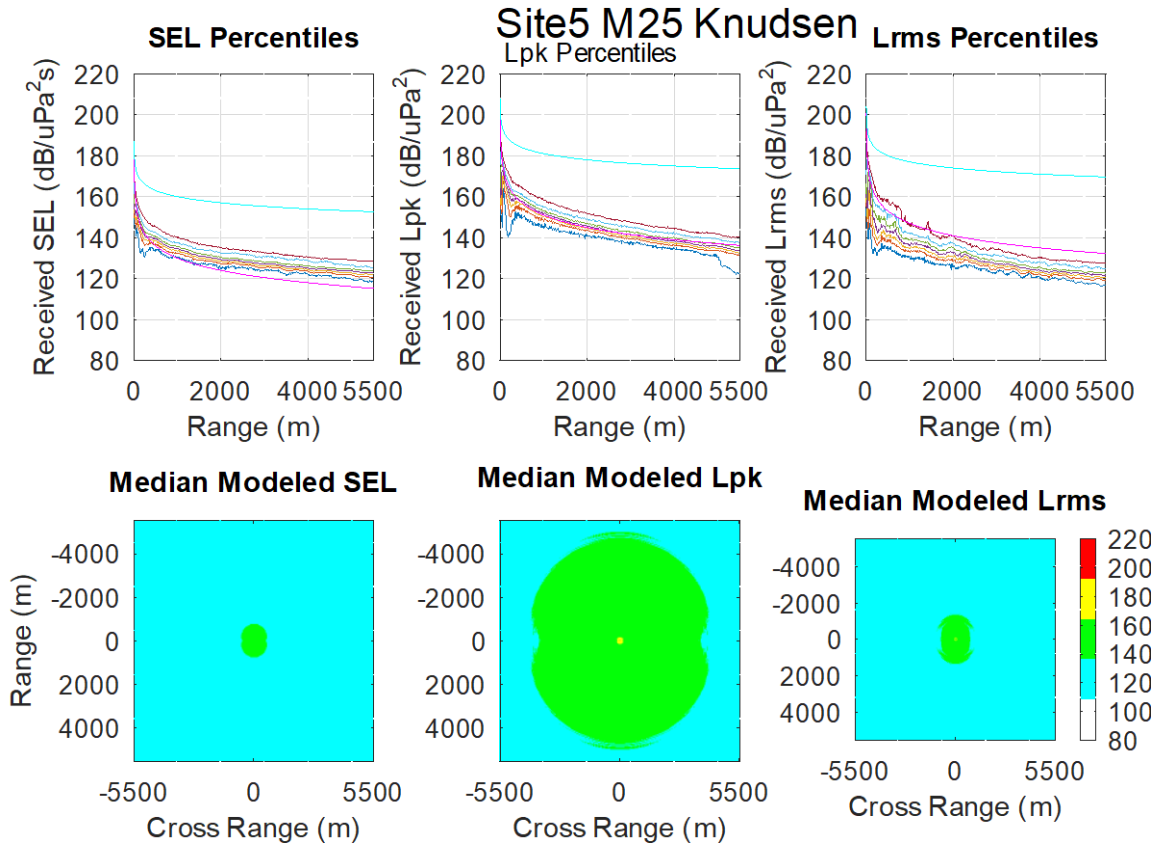


Figure 5-150. Knudsen 3260 Mode 25 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.26 Applied Acoustics 252 S-Boom, 0 to 6 kHz, 1 kJ, Low Power, Three Plates (Mode 26)

The Applied Acoustics 252 S-Boom generates a single MF signal, with a peak frequency of 1 kHz. The operational parameter settings for Mode 26 were 1 kilojoule (kJ), low power, three plates, and a 0.1- to 5-kHz output frequency. Measured source levels are shown in **Table 5-26**.

Table 5-26. NUWC tank measurements of 252 S-Boom (Mode 26)

Source Settings		Source Level			
Power Level	Depth	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
Low	Surface	212	207	198	176

μ Pa = micropascal; dB = decibel; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) was shown in **Figure 5-151**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-26**. Modeling results for each site are shown in **Figures 5-152 to 5-156**.

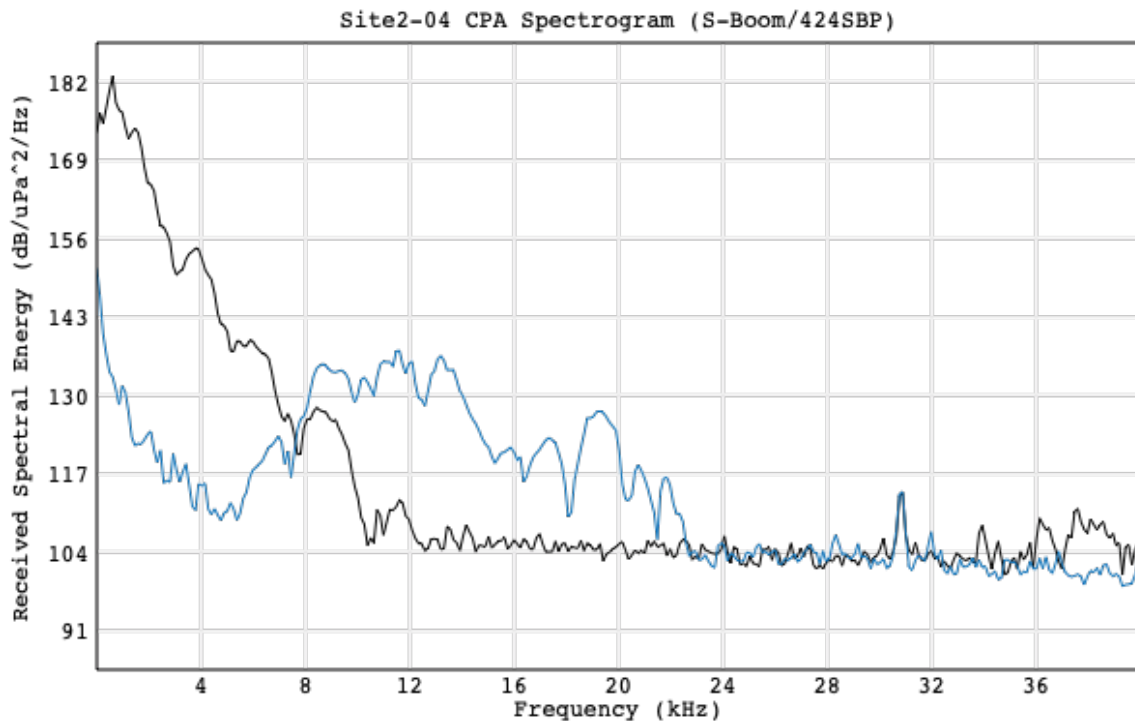


Figure 5-151. S-Boom Mode 26 (black) decidecade band energy levels at buoy position D Edgetech 424 3100P Mode 16 (blue). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.26.1 Site 1 – Mud, 10-m Depth

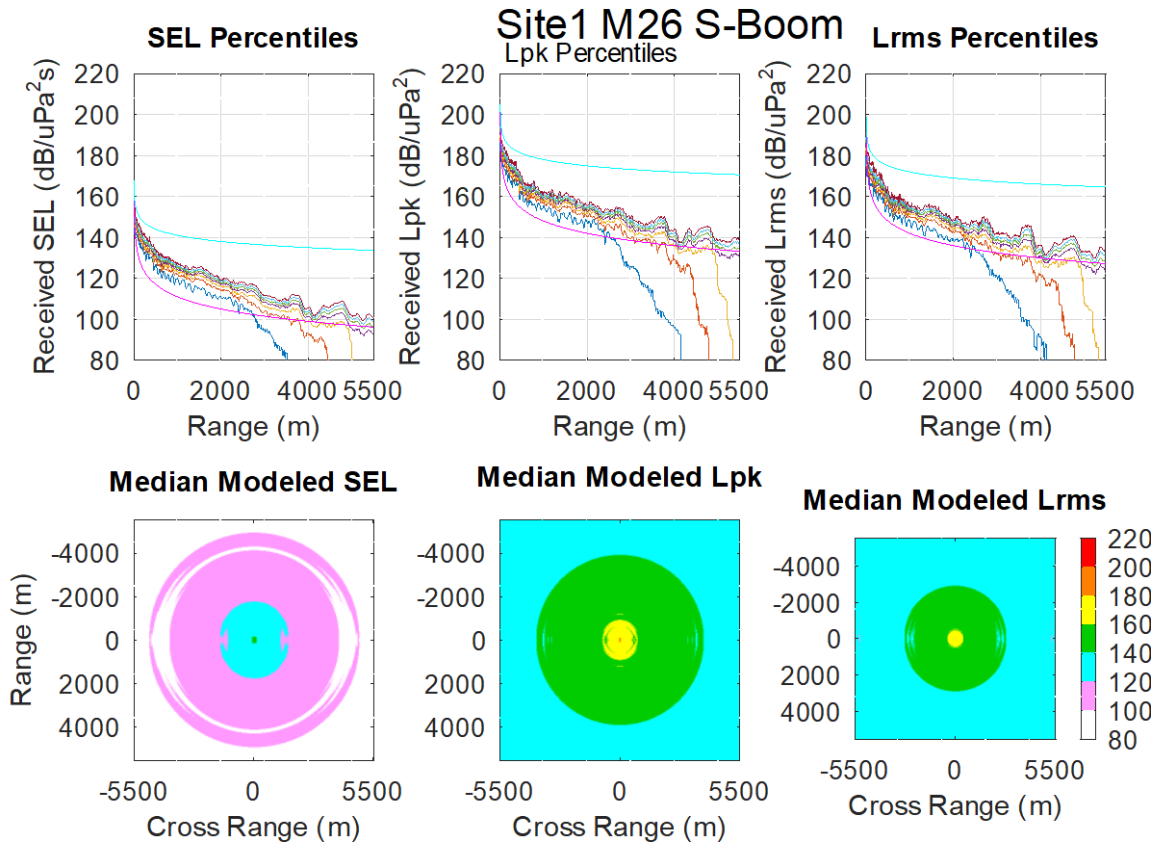


Figure 5-152. 252 S-Boom Mode 26 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.26.2 Site 2 – Sand, 10-m Depth

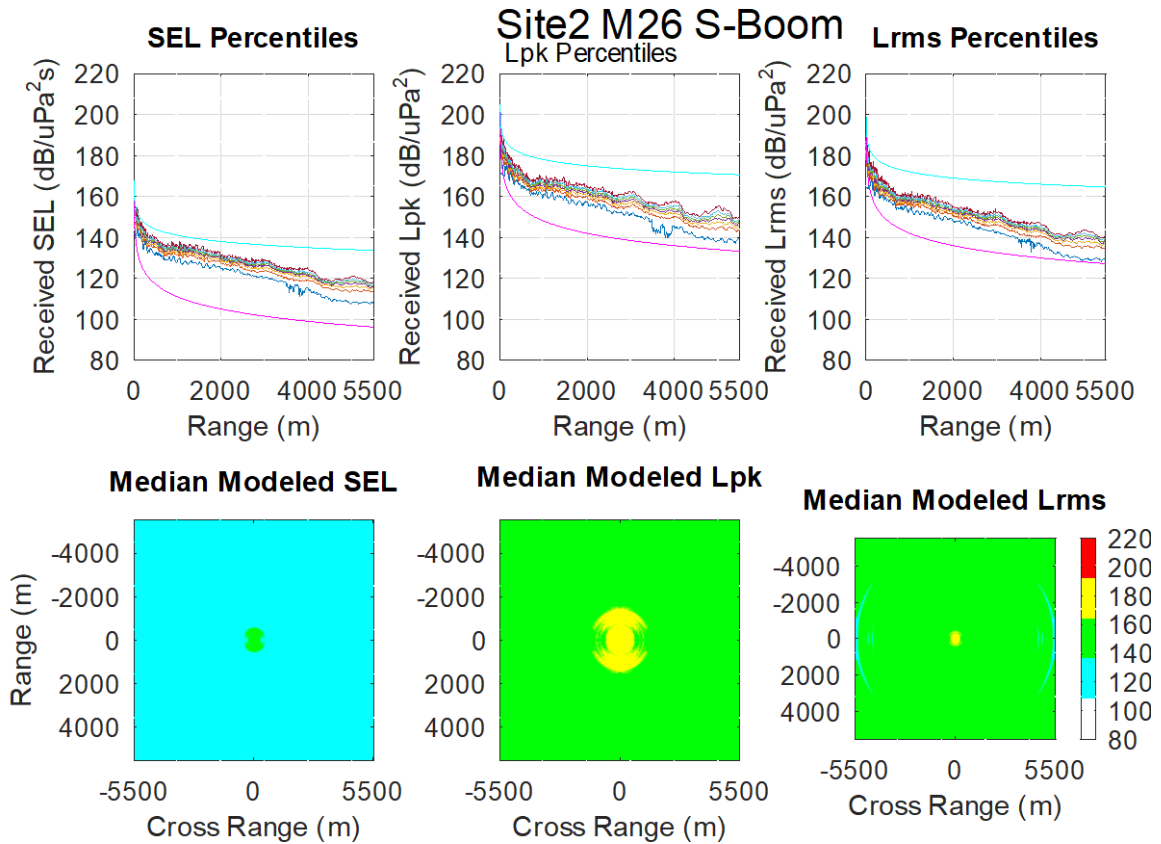


Figure 5-153. 252 S-Boom Mode 26 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.26.3 Site 3 – Mud, 30-m Depth

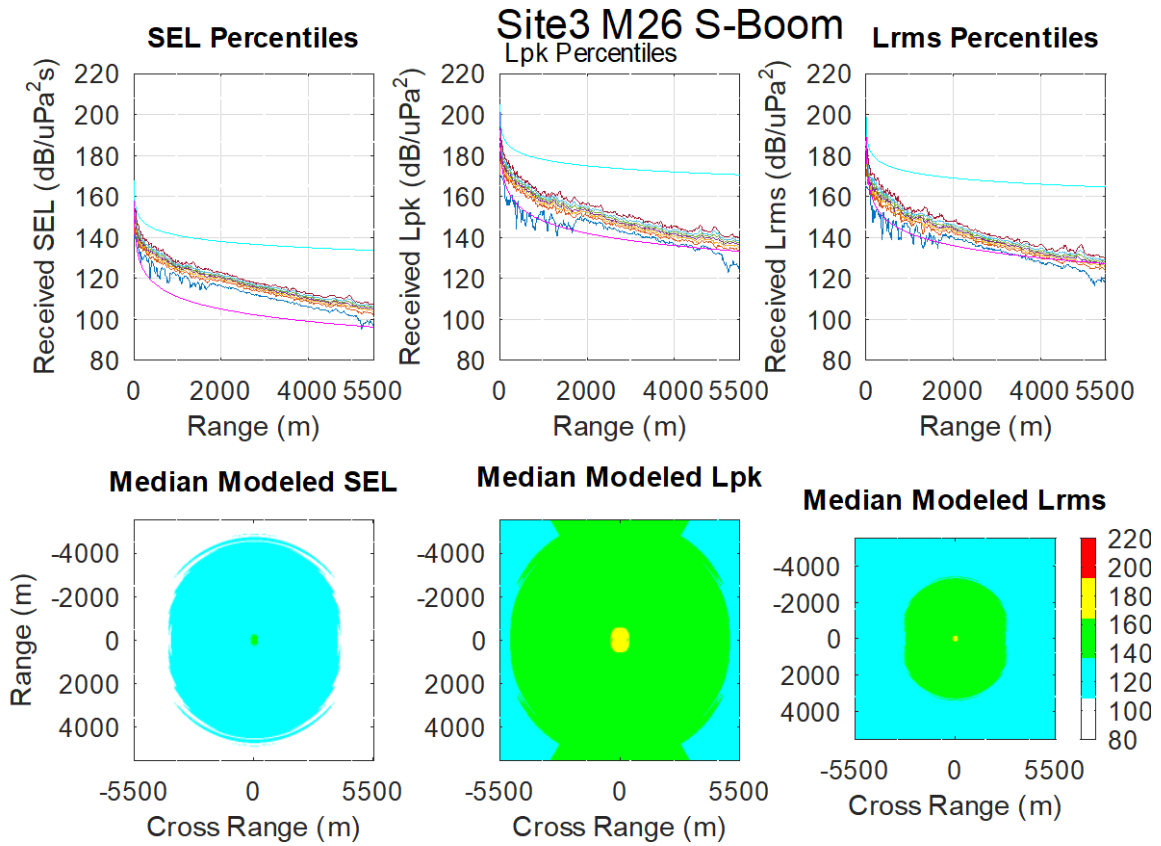


Figure 5-154. 252 S-Boom Mode 26 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.26.4 Site 4 – Sand, 30-m Depth

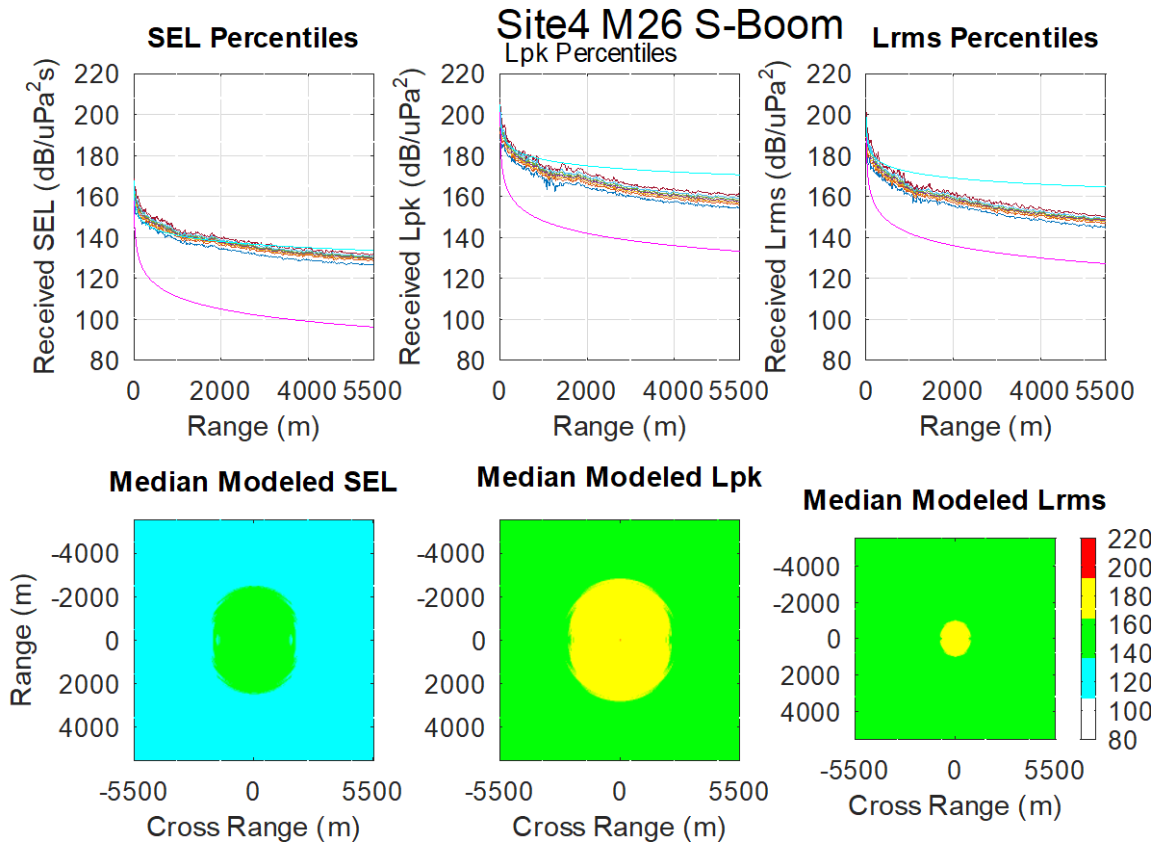


Figure 5-155. 252 S-Boom Mode 26 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.26.5 Site 5 – Sandy Silt, 100-m Depth

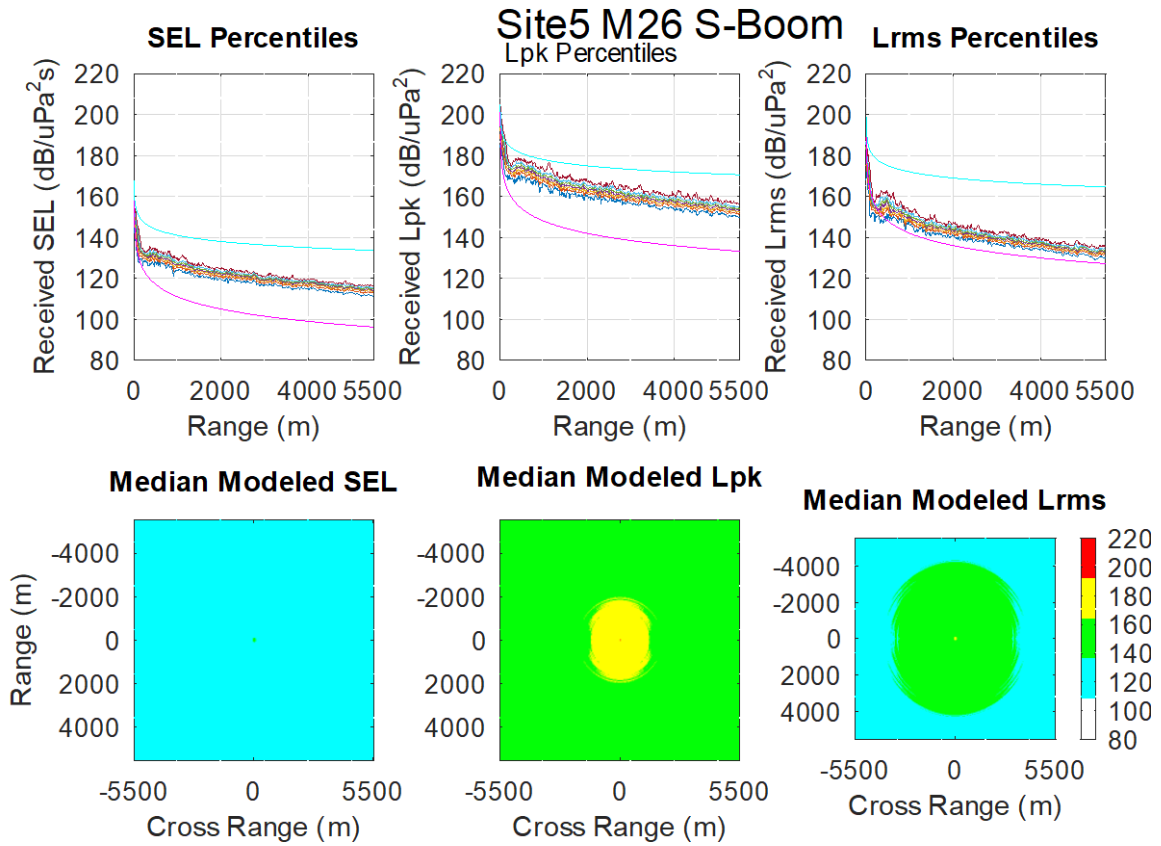


Figure 5-156. 252 S-Boom Mode 26 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.27 Applied Acoustics 252 S-Boom, 0 to 6 kHz, 200 J, Low Power, Single Plate (Mode 27)

The Applied Acoustics 252 S-Boom generates a single MF signal, with a peak frequency of 1 kHz. The operational parameter settings for Mode 27 were a power setting of 200 J, low power, a single plate, and a 0.1- to 5-kHz output frequency. Measured source levels are shown in **Table 5-27**.

Table 5-27. NUWC tank measurements of 252 S-Boom (Mode 27)

Source Settings		Source Level			
Power Level (J)	Depth	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
200	Surface	203	203	188	167

μ Pa = micropascal; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-157**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-27**. Modeling results for each site are shown in **Figures 5-158 to 5-162**.

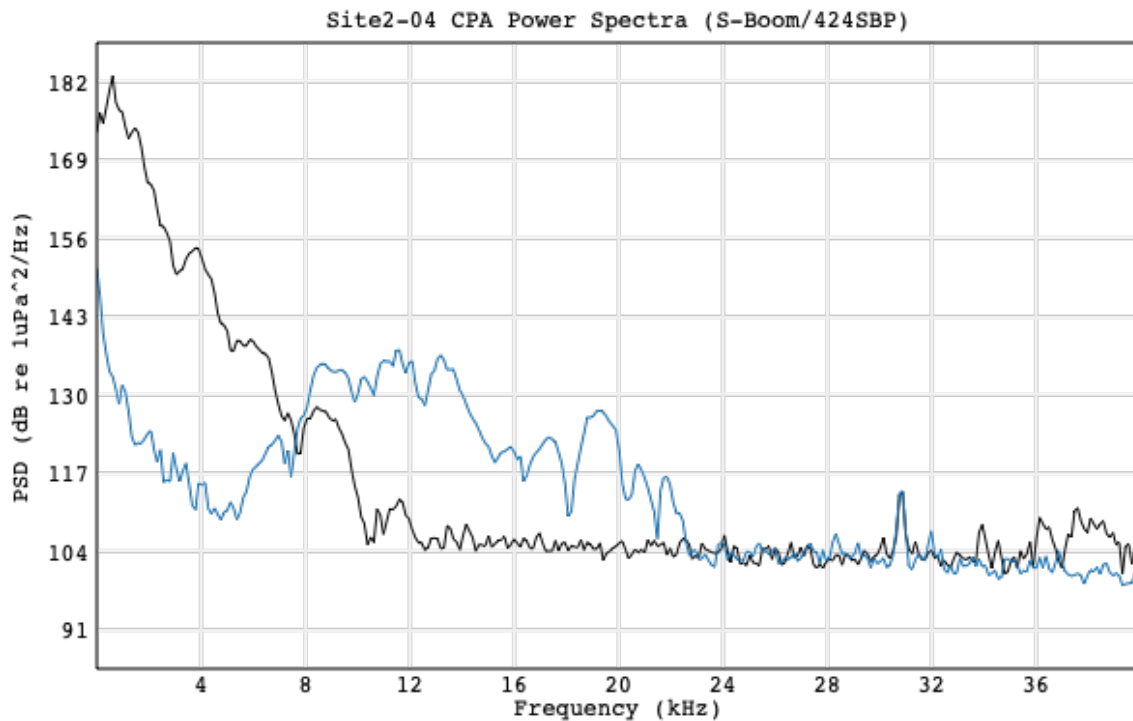


Figure 5-157. 252 S-Boom Mode 27 (black) decidecade band energy levels at buoy position D Edgetech 424 Mode 16 (blue). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz; PSD = power spectral density; re = with reference to.

5.27.1 Site 1 – Mud, 10-m Depth

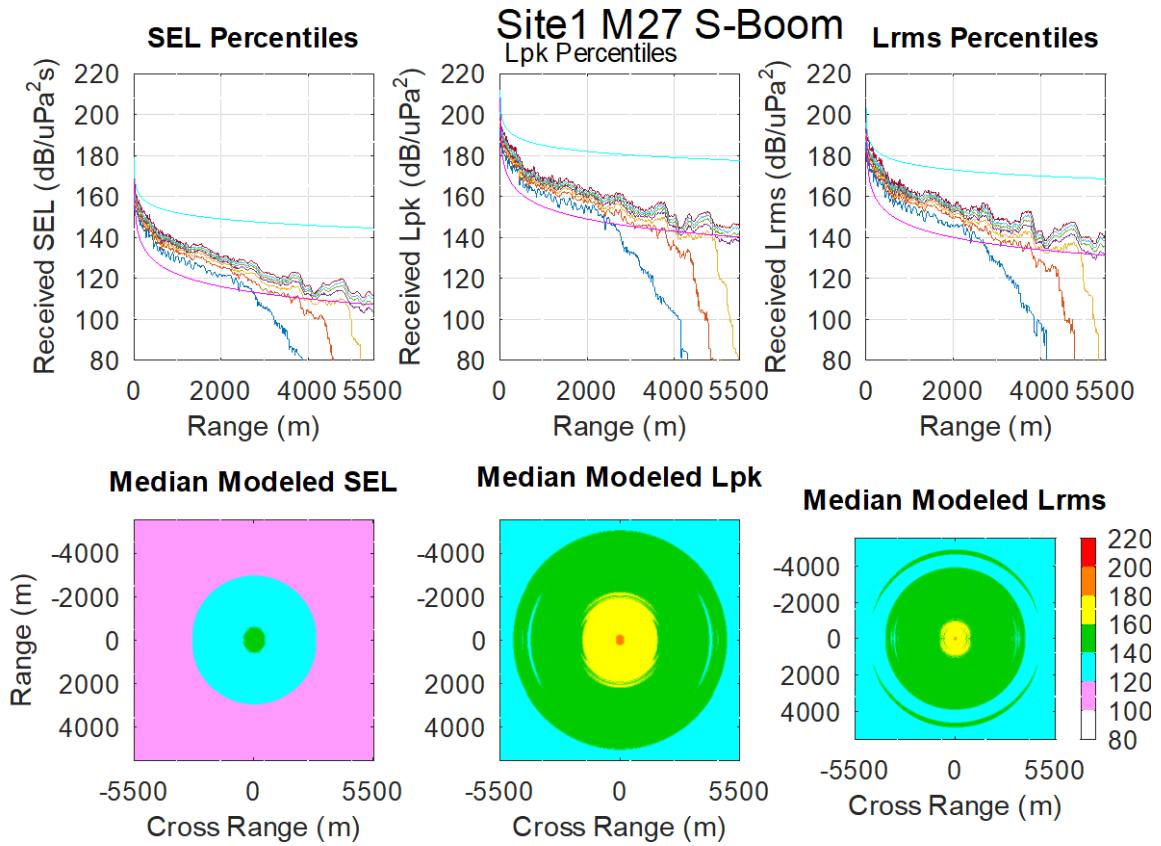


Figure 5-158. 252 S-Boom Mode 27 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.27.2 Site 2 – Sand, 10-m Depth

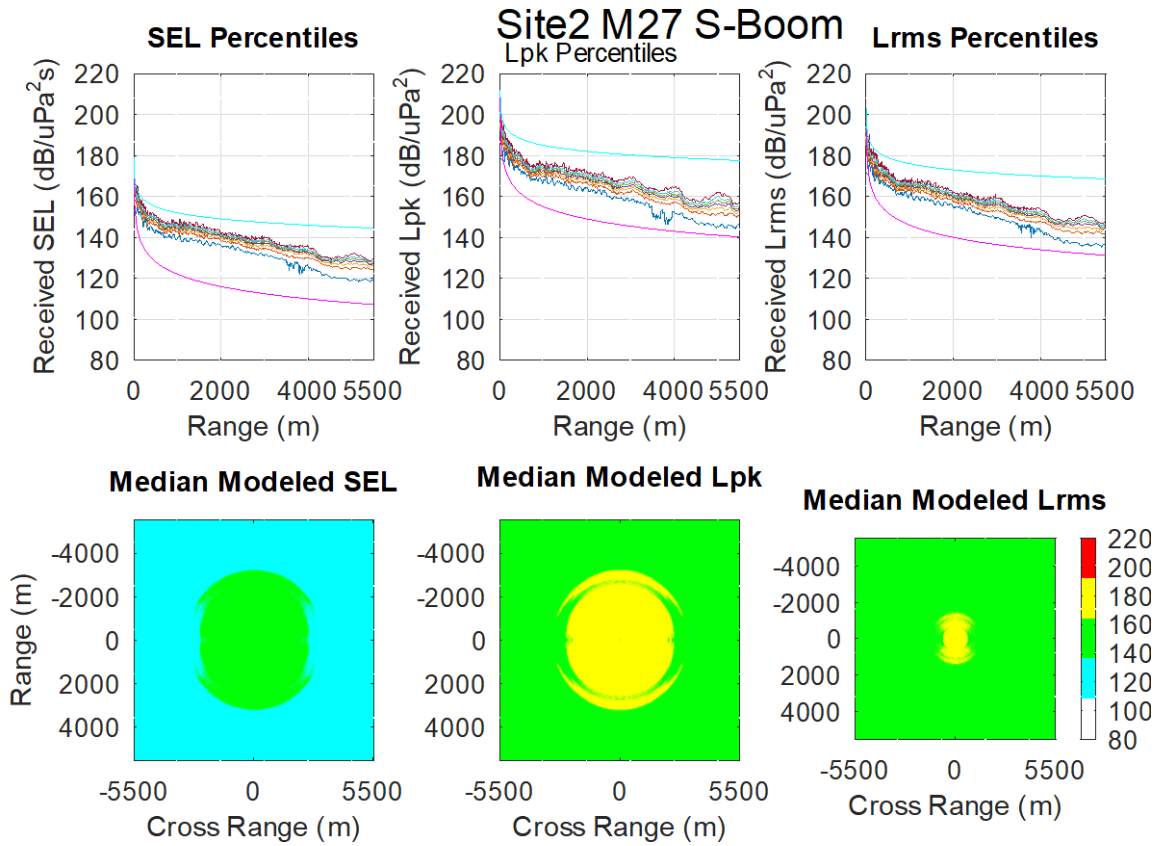


Figure 5-159. 252 S-Boom Mode 27 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.27.3 Site 3 – Mud, 30-m Depth

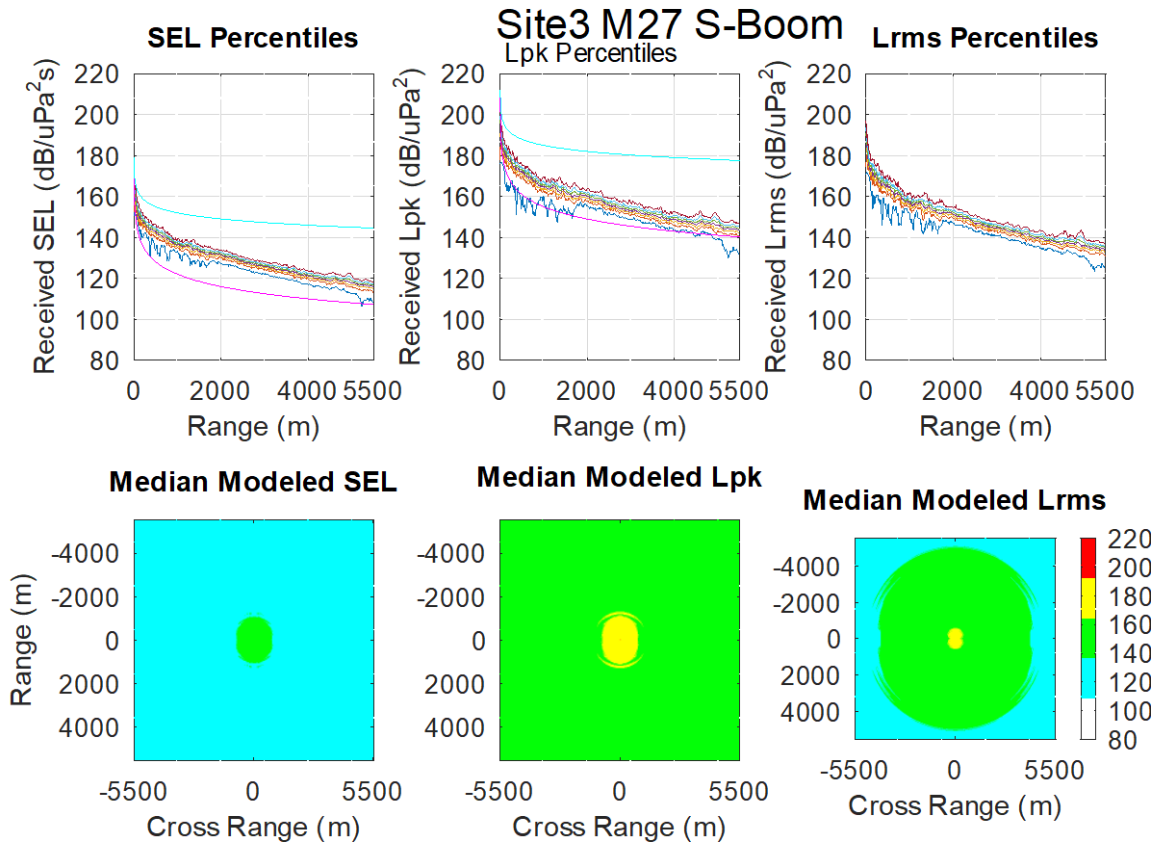


Figure 5-160. 252 S-Boom Mode 27 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.27.4 Site 4 – Sand, 30-m Depth

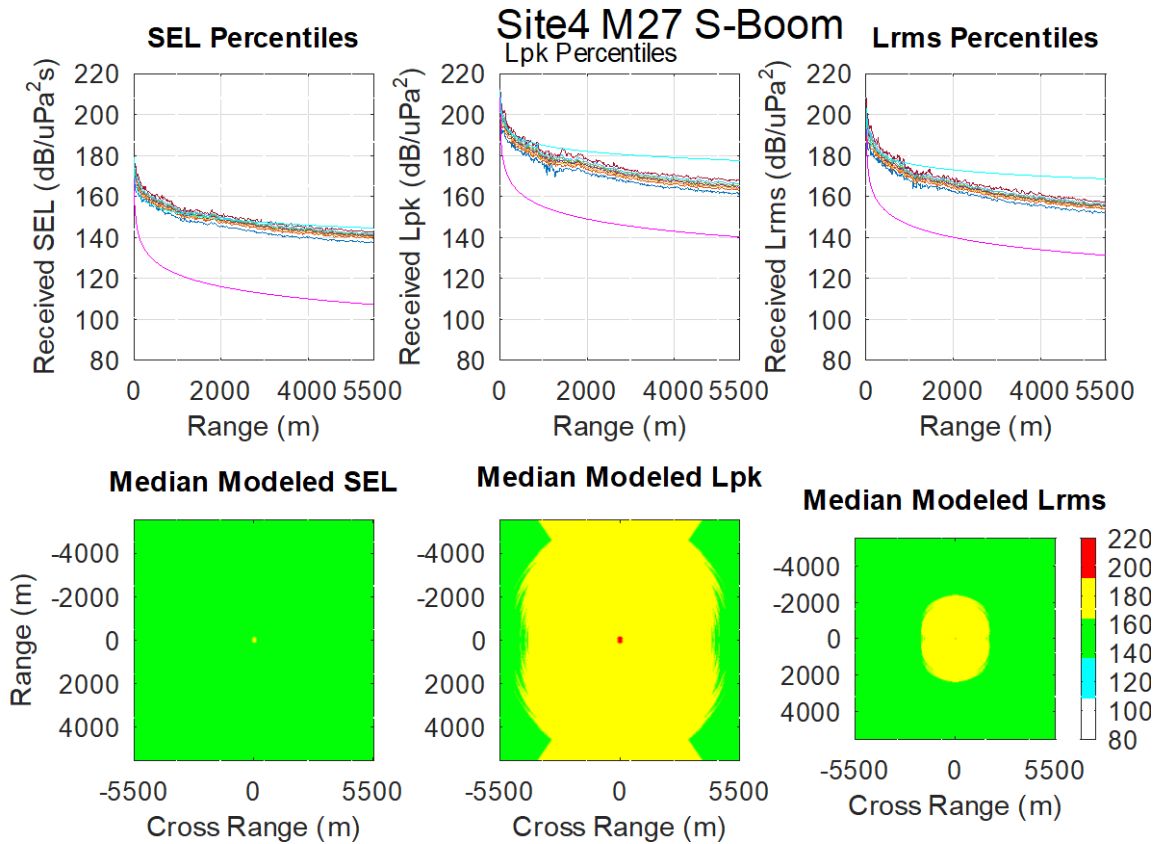


Figure 5-161. 252 S-Boom Mode 27 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.27.5 Site 5 – Sandy Silt, 100-m Depth

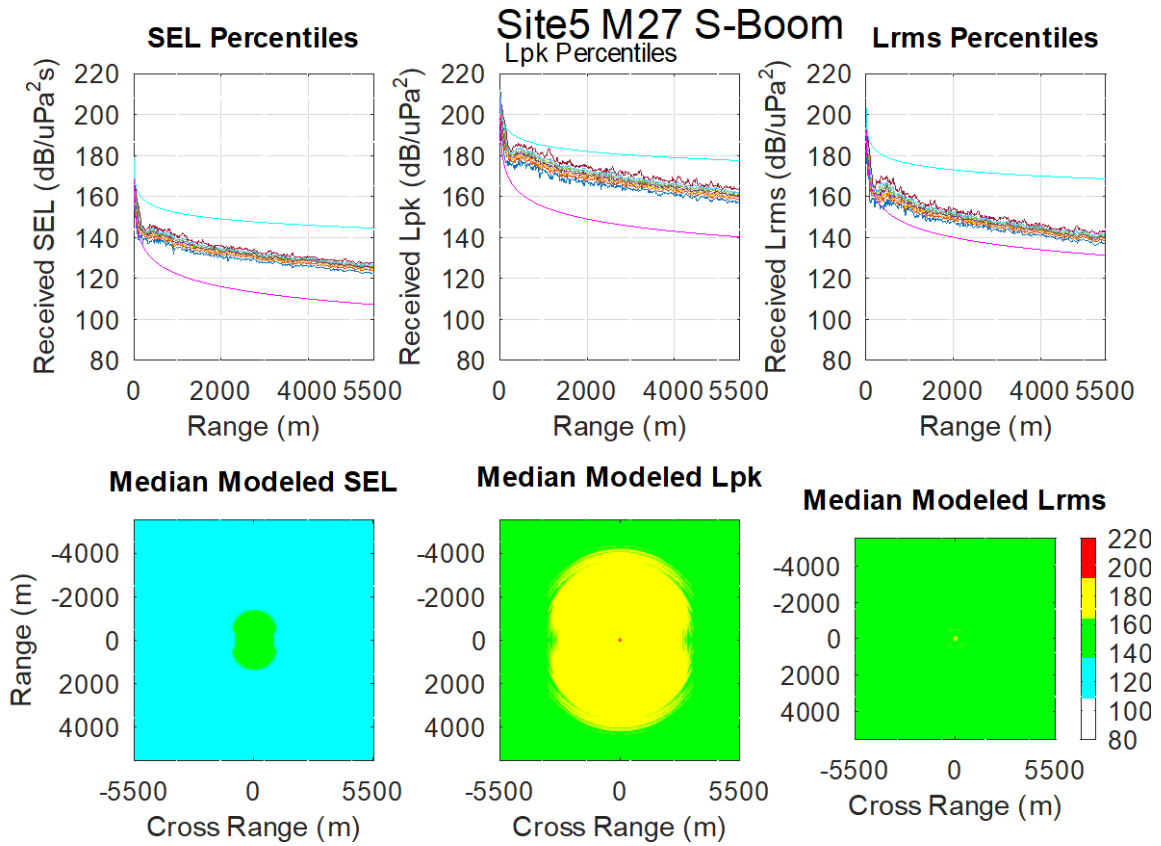


Figure 5-162. 252 S-Boom Mode 27 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; SEL = sound exposure level.

5.28 SIG 2 Mini Sparker ELC 820, 700 J, Low Power (Mode 28)

The Mini Sparker is a small, lightweight LF seismic source measuring 1.0 by 0.6 m with a mass of 1.8 kilograms (kg). The source is designed for towing behind a small survey vessel at shallow depth beneath the sea surface. The operational power setting for Mode 28 was 700 J (low power). Measured source levels are provided in **Table 5-28**.

Table 5-28. NUWC tank measurements of Mini Sparker (Mode 28)

Source Settings		Source Level			
Power Level (J)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
700 (low)	1	220	215	206	182

μ Pa = micropascal; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-163**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-28**. Modeling results for each site are shown in **Figures 5-164 to 5-168**.

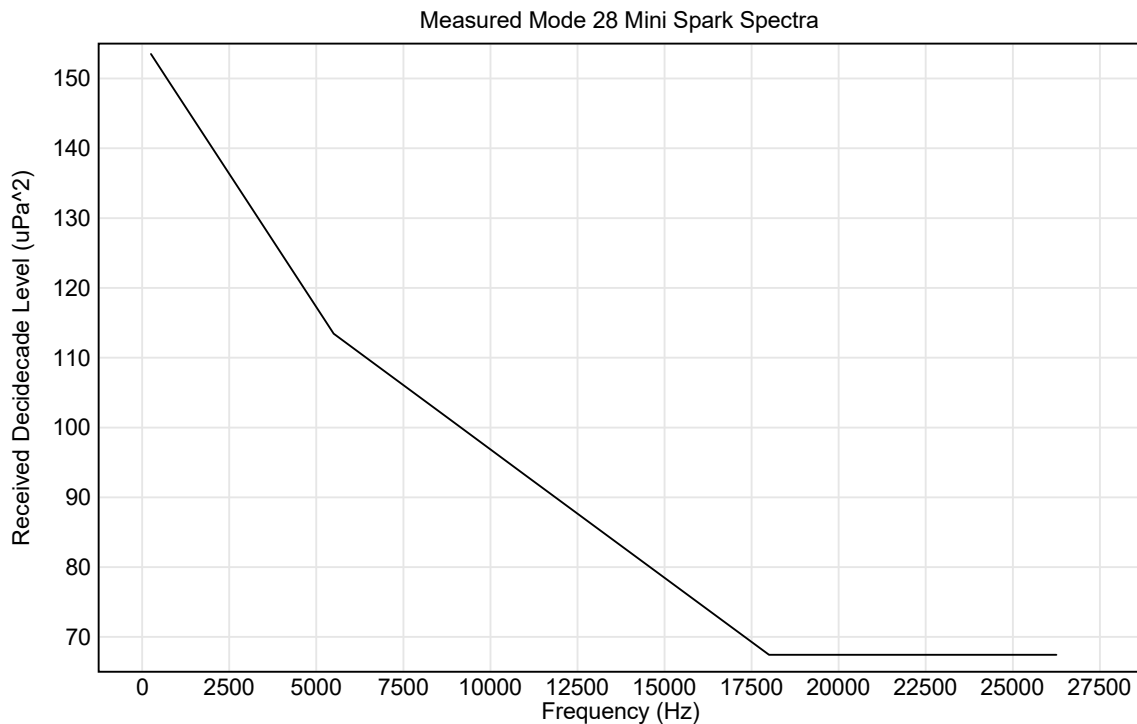


Figure 5-163. Mini Sparker Mode 28 measured spectra at buoy position D

μ Pa = micropascal; Hz = hertz.

5.28.1 Site 1 – Mud, 10-m Depth

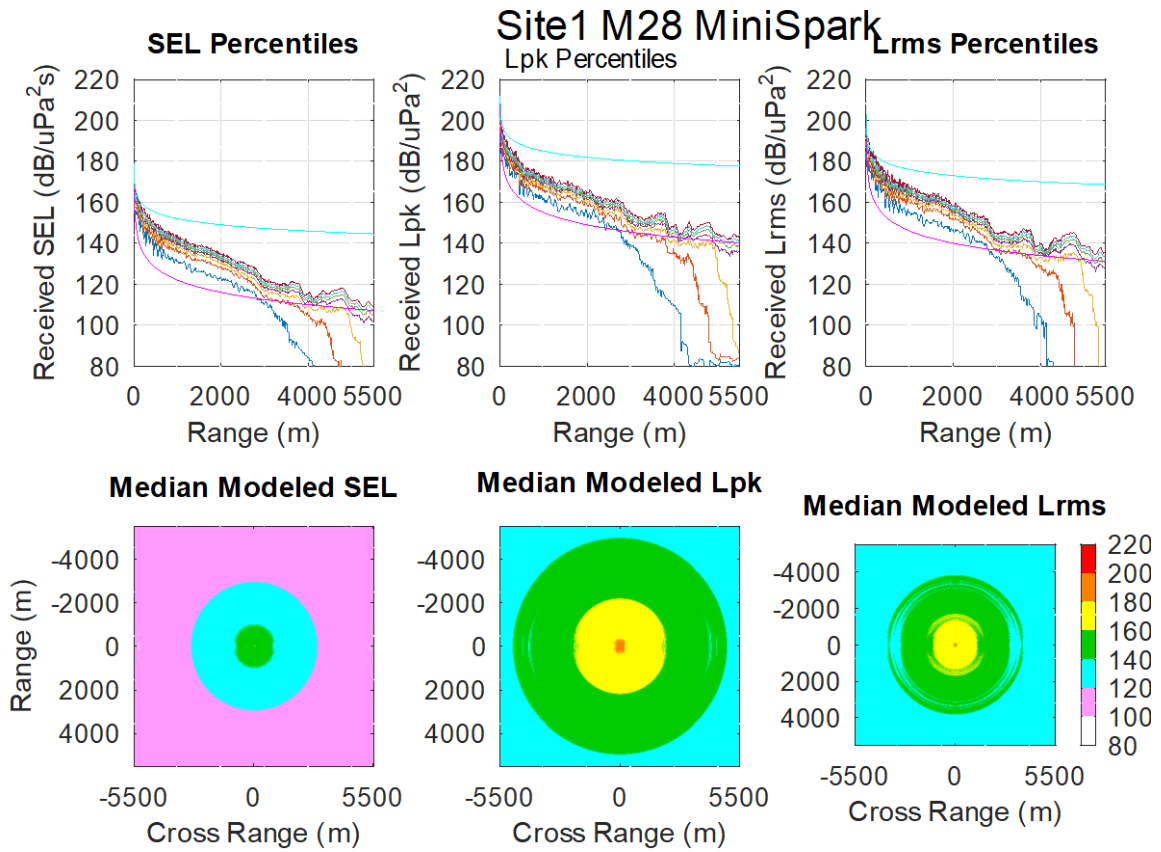


Figure 5-164. Mini Sparker Mode 28 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.28.2 Site 2 – Sand, 10-m Depth

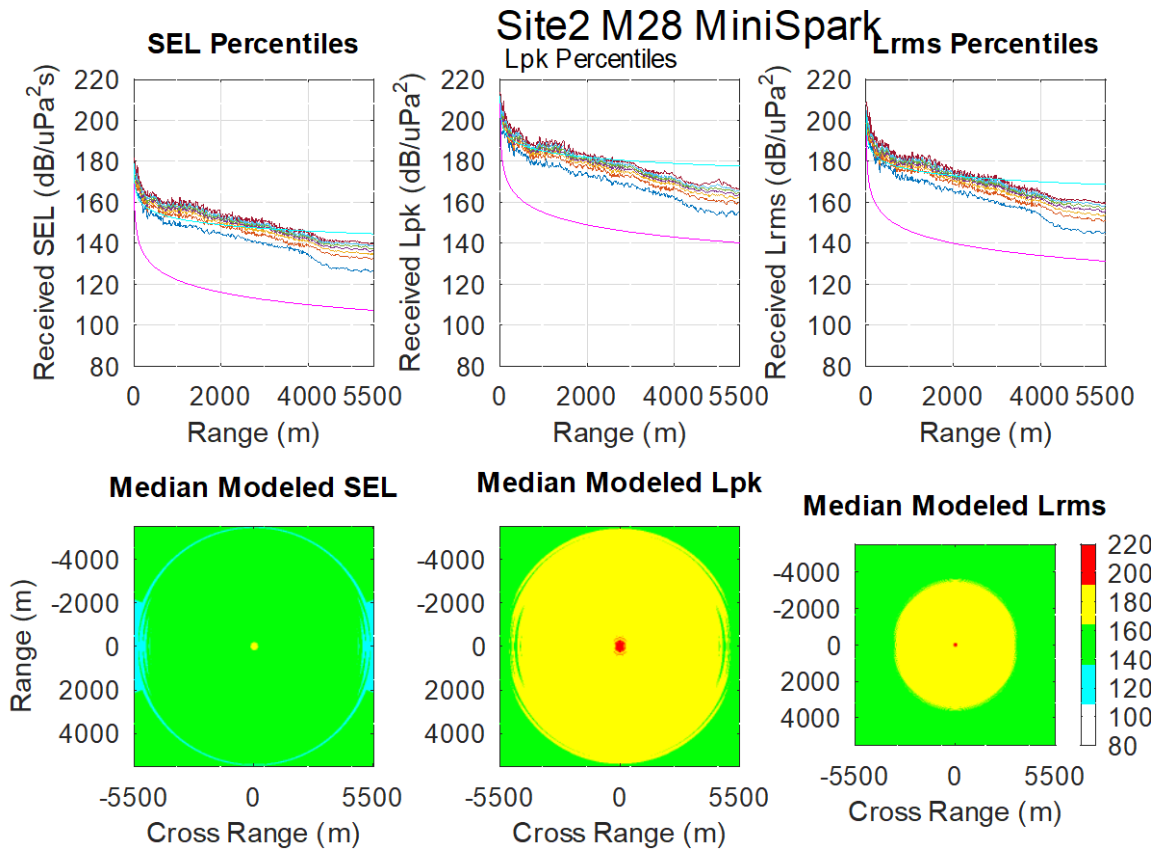


Figure 5-165. Mini Sparker Mode 28 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.28.3 Site 3 – Mud, 30-m Depth

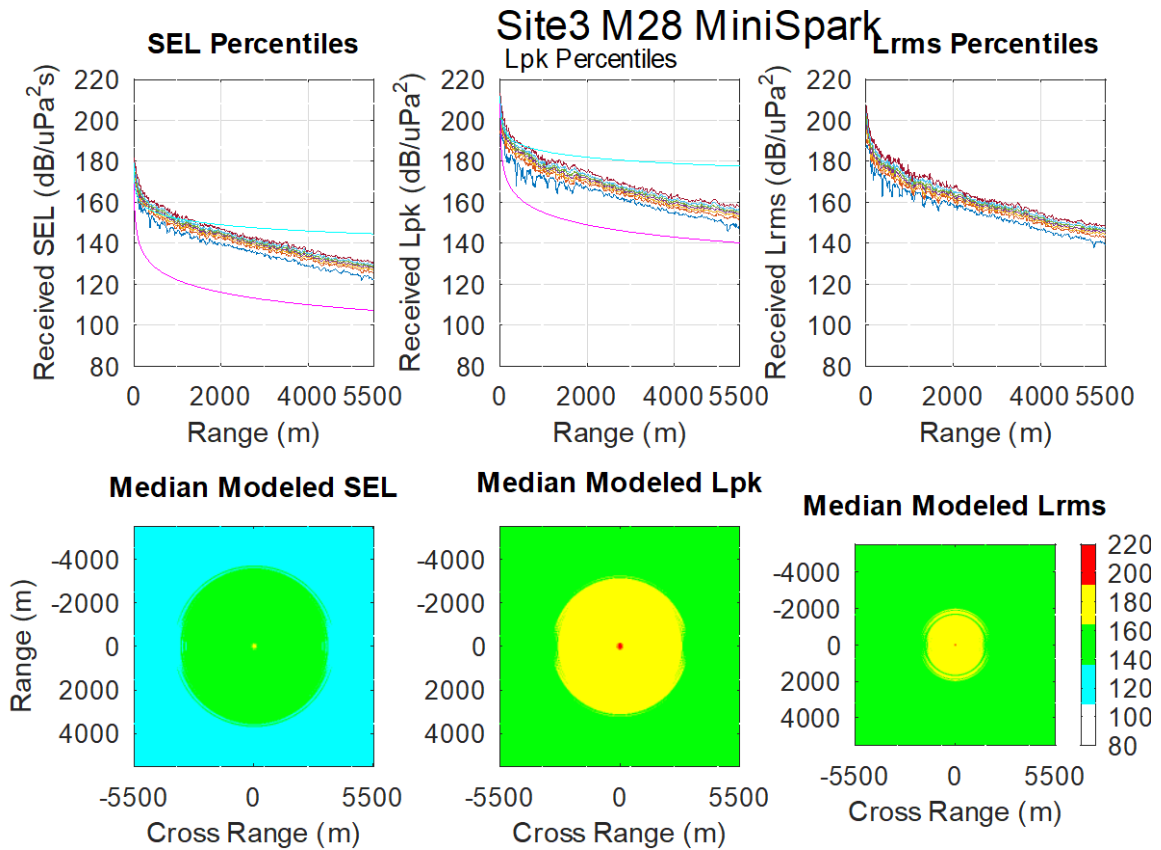


Figure 5-166. Mini Sparker Mode 28 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.28.4 Site 4 – Sand, 30-m Depth

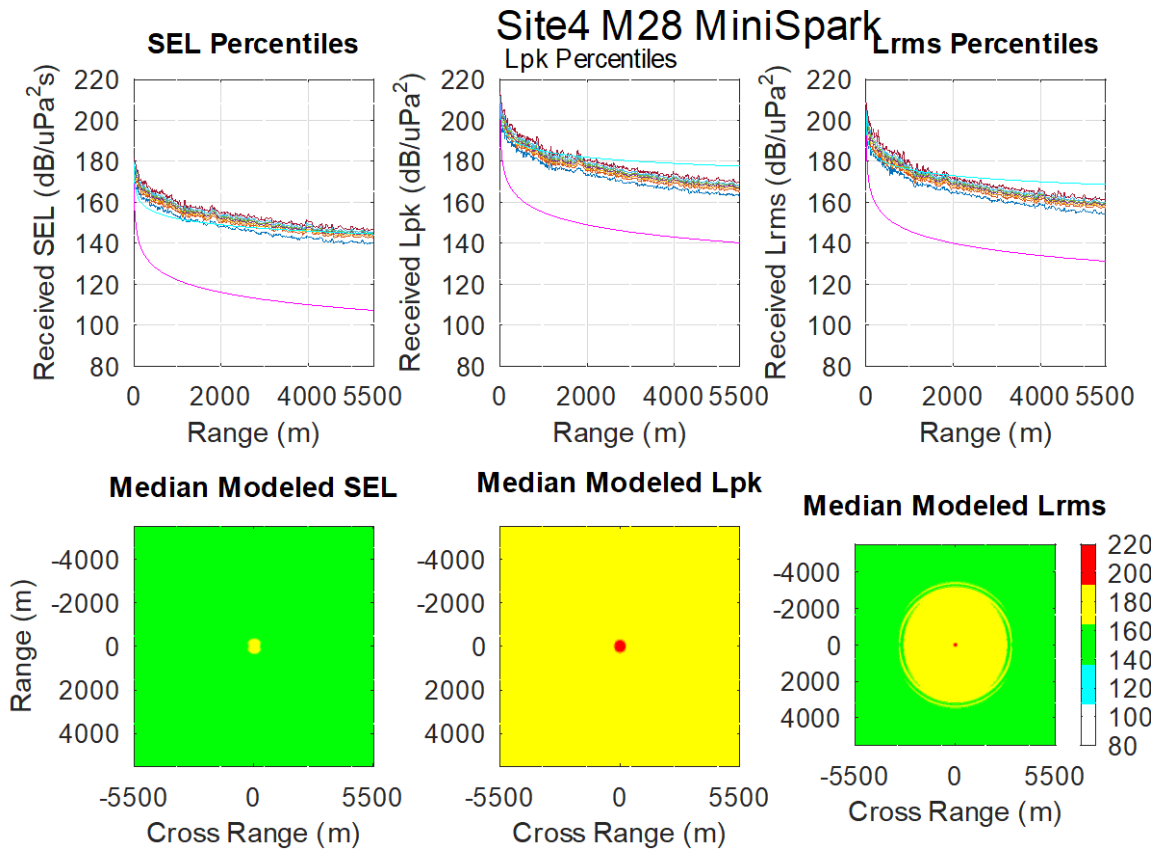


Figure 5-167. Mini Sparker Mode 28 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.28.5 Site 5 – Sandy Silt, 100-m Depth

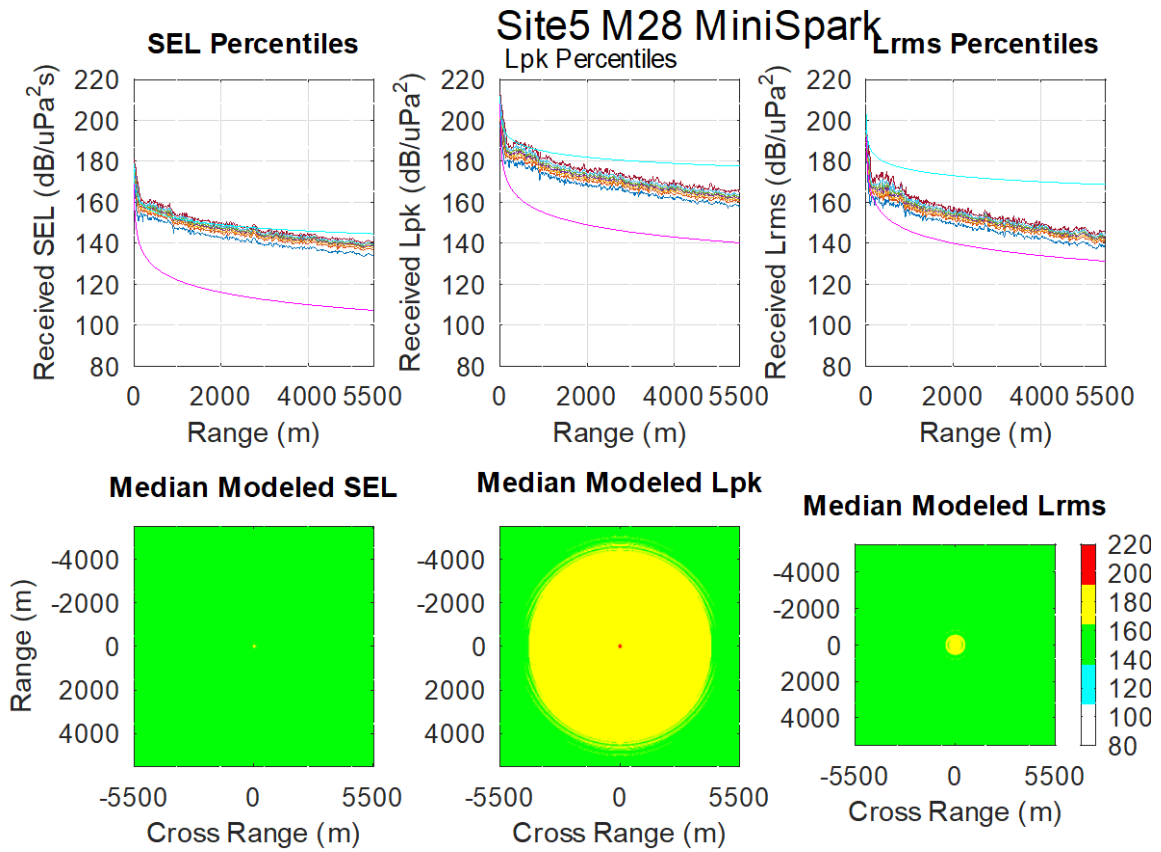


Figure 5-168. Mini Sparker Mode 28 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.29 SIG 2 Mini Sparker ELC 820, 500 J, High Power (Mode 29)

The Mini Sparker is a small, lightweight LF seismic source measuring 1.0 by 0.6 m with a mass of 1.8 kg. The source is designed for towing behind a small survey vessel at shallow depth beneath the sea surface. The operational power setting for Mode 29 was 500 J (high power). Measured source levels are provided in **Table 5-29**.

Table 5-29. NUWC tank measurements of Mini Sparker (Mode 29)

Source Settings		Source Level			
Power Level (J)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
500 (high)	1	215	210	201	177

μ Pa = micropascal; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-169**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-29**. Modeling results for each site are shown in **Figures 5-170 to 5-174**.

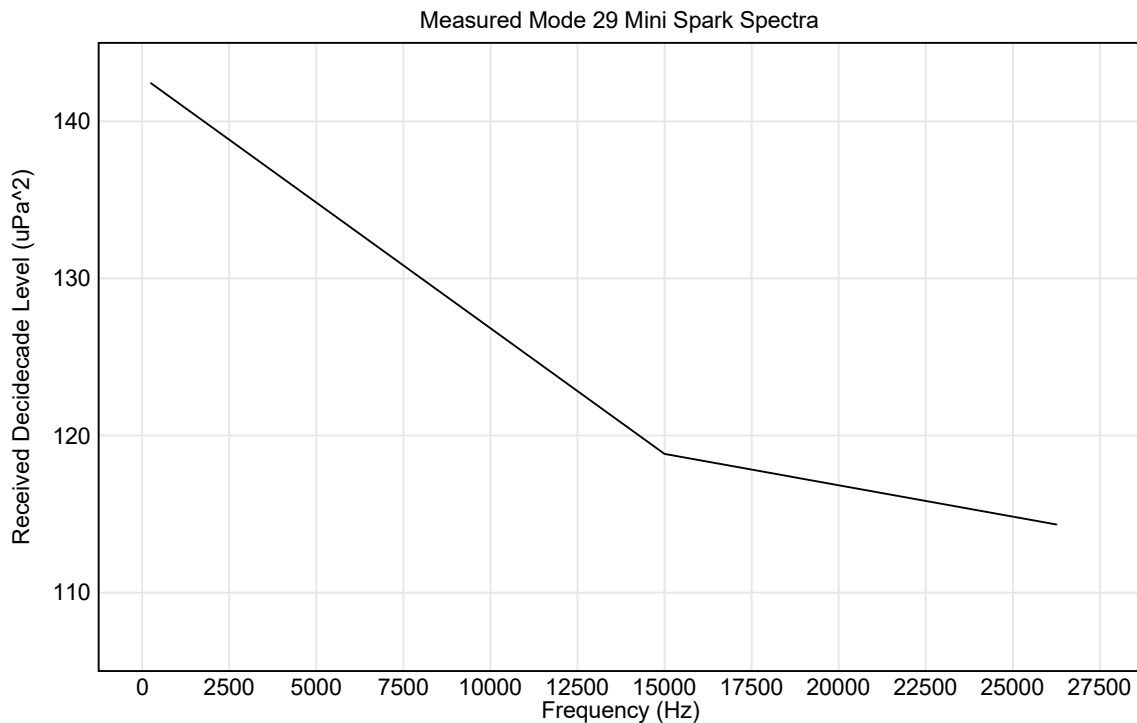


Figure 5-169. Mini Sparker Mode 29 measured spectra at buoy position D

μ Pa = micropascal; Hz = hertz.

5.29.1 Site 1 – Mud, 10-m Depth

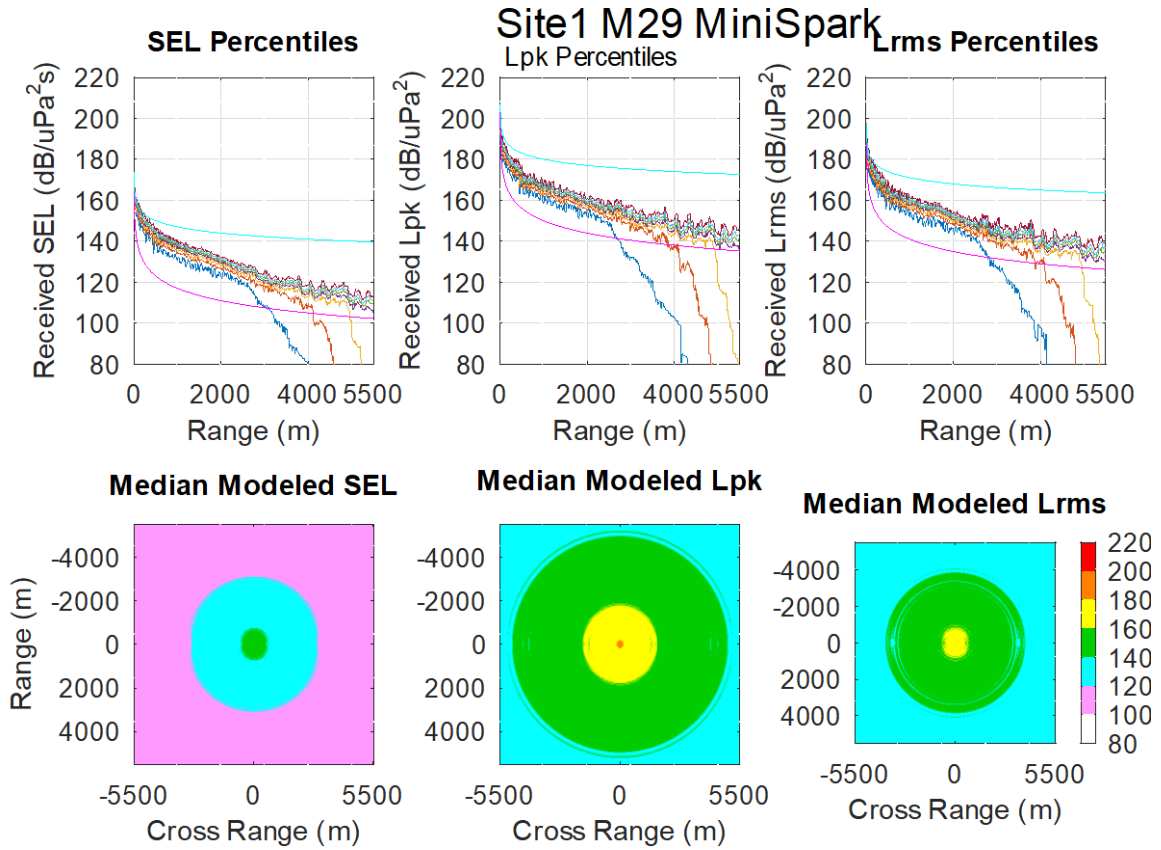


Figure 5-170. Mini Sparker Mode 29 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.29.2 Site 2 – Sand, 10-m Depth

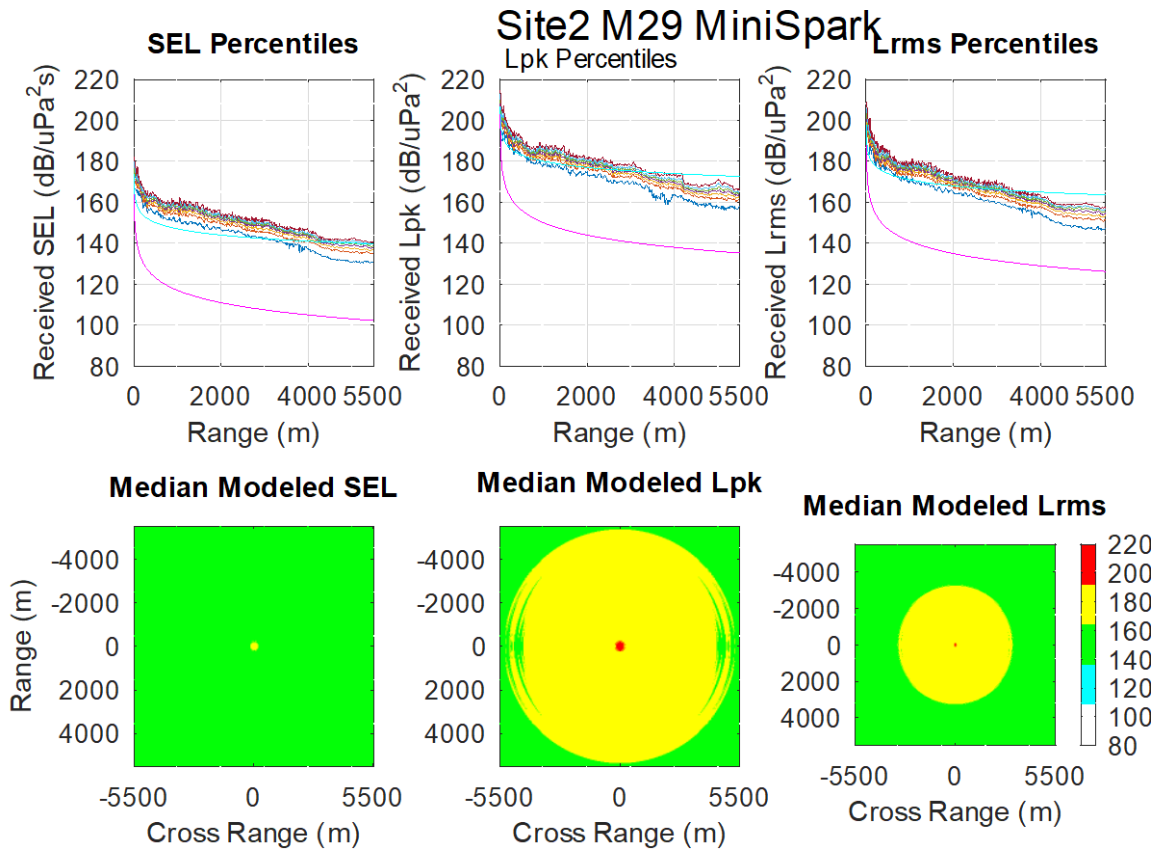


Figure 5-171. Mini Sparker Mode 29 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.29.3 Site 3 – Mud, 30-m Depth

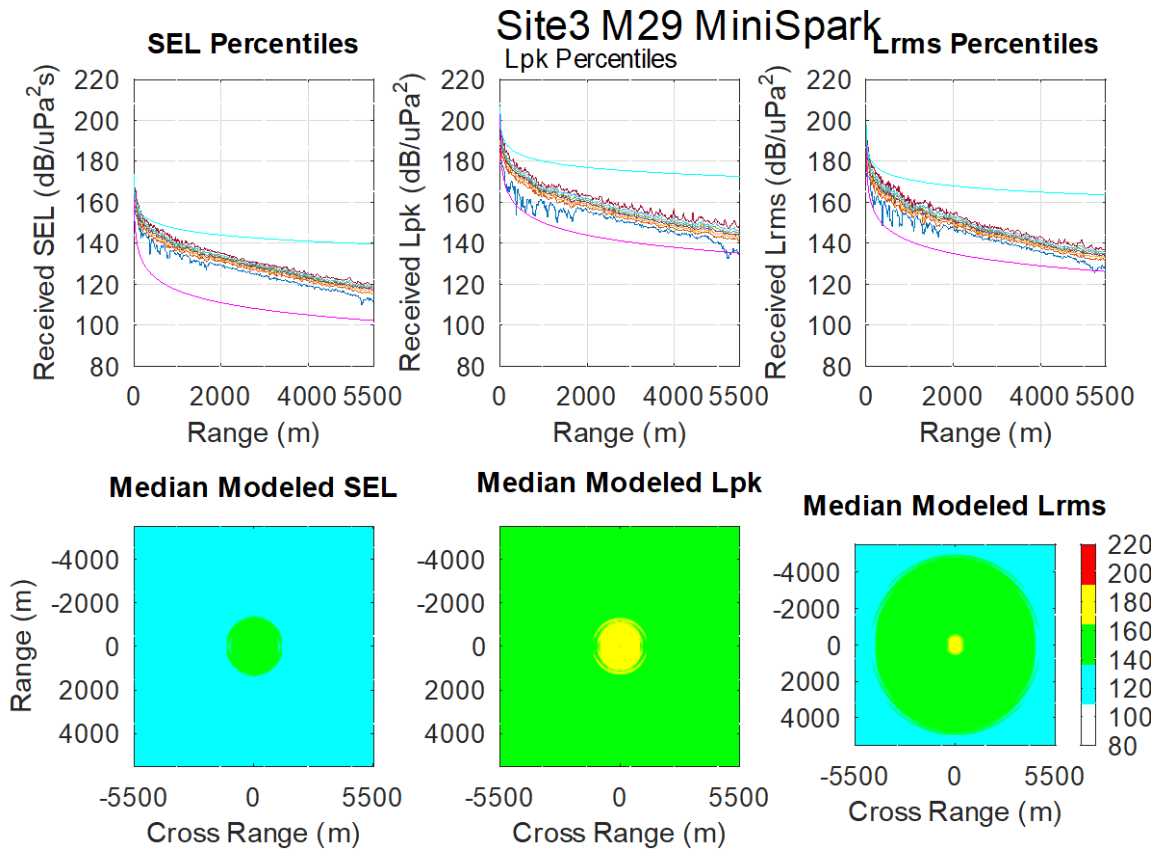


Figure 5-172. Mini Sparker Mode 29 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.29.4 Site 4 – Sand, 30-m Depth

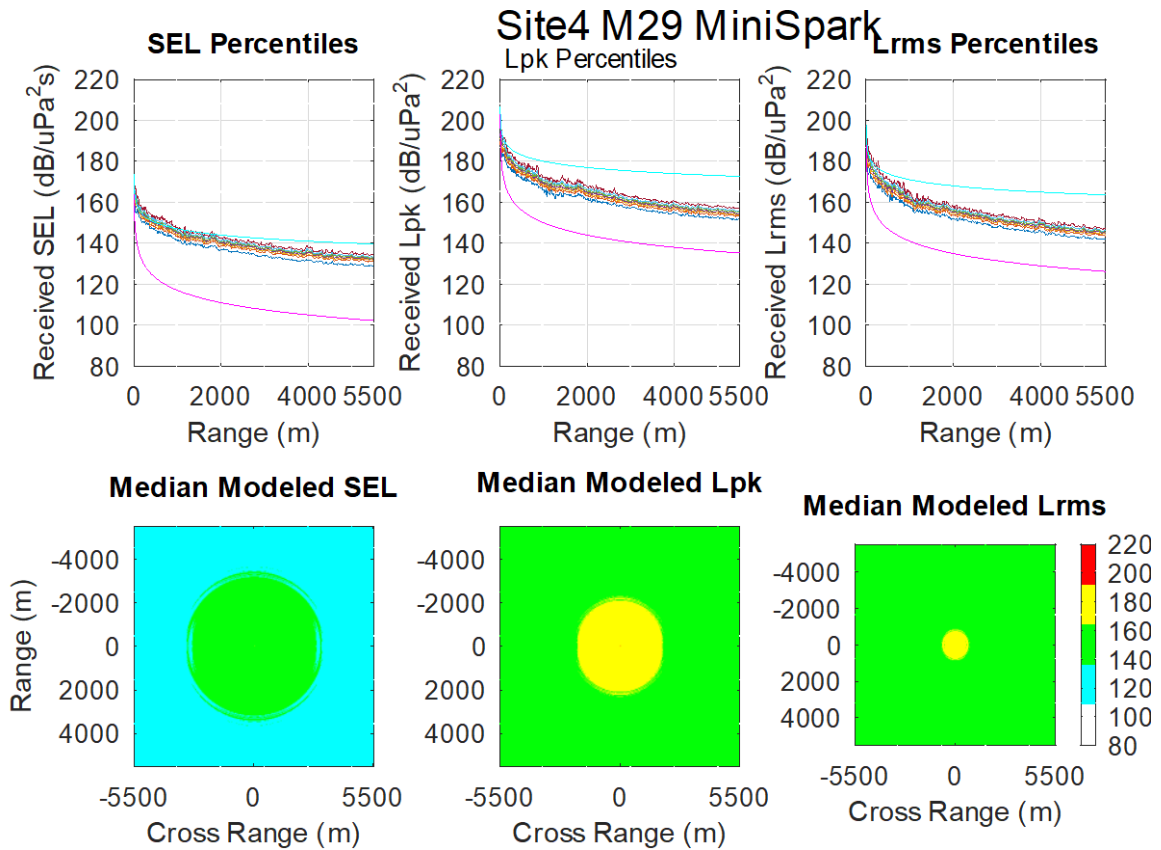


Figure 5-173. Mini Sparker Mode 29 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.29.5 Site 5 – Sandy Silt, 100-m Depth

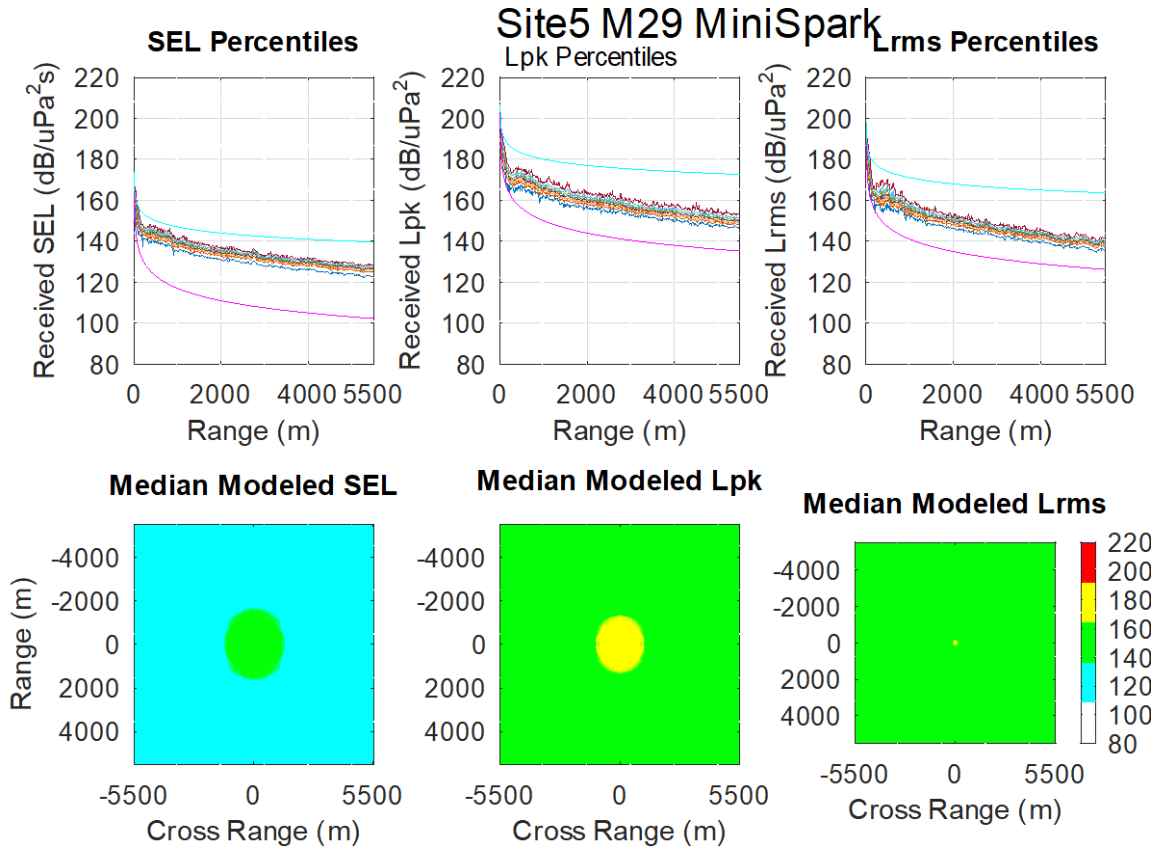


Figure 5-174. Mini Sparker Mode 29 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.30 Applied Acoustics 251 Boomer, 0.1 to 5 kHz, 200 J, Lower Power, Single Plate (Mode 30)

The 251 Boomer acoustic source generates a single MF broadband signal, with significant energy from 10 Hz to 5 kHz. The operational parameter settings for Mode 30 were a single plate, 200 J on lower power, and a 0.1- to 5-kHz output frequency. Measured source levels are shown in **Table 5-30**.

Table 5-30. NUWC tank measurements of 251 Boomer (Mode 30)

Source Settings		Source Level			
Power Level (J)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
200	Surface	210	206	198	167

μ Pa = micropascal; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-175**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-30**. Modeling results for each site are shown in **Figures 5-176 to 5-180**.

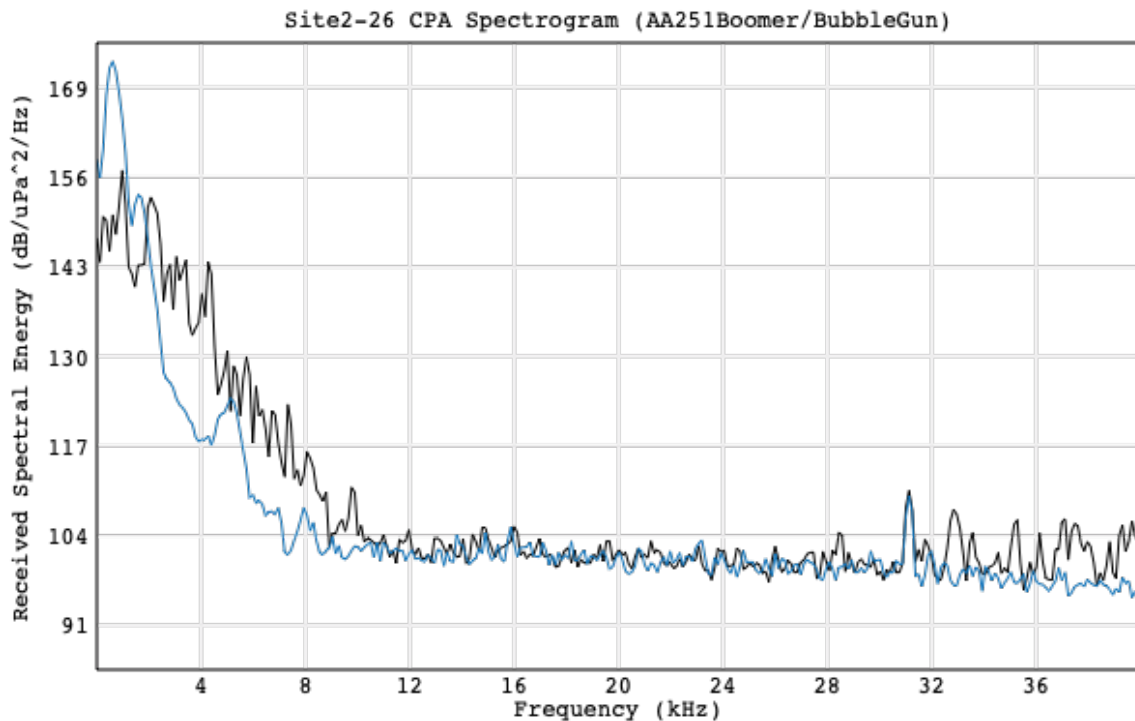


Figure 5-175. 251 Boomer Mode 30 (black) decidecade band energy levels at buoy position D Bubble Gun Mode 32 (blue). μ Pa = micropascal; dB = decibel; Hz = hertz; kHz = kilohertz.

5.30.1 Site 1 – Mud, 10-m Depth

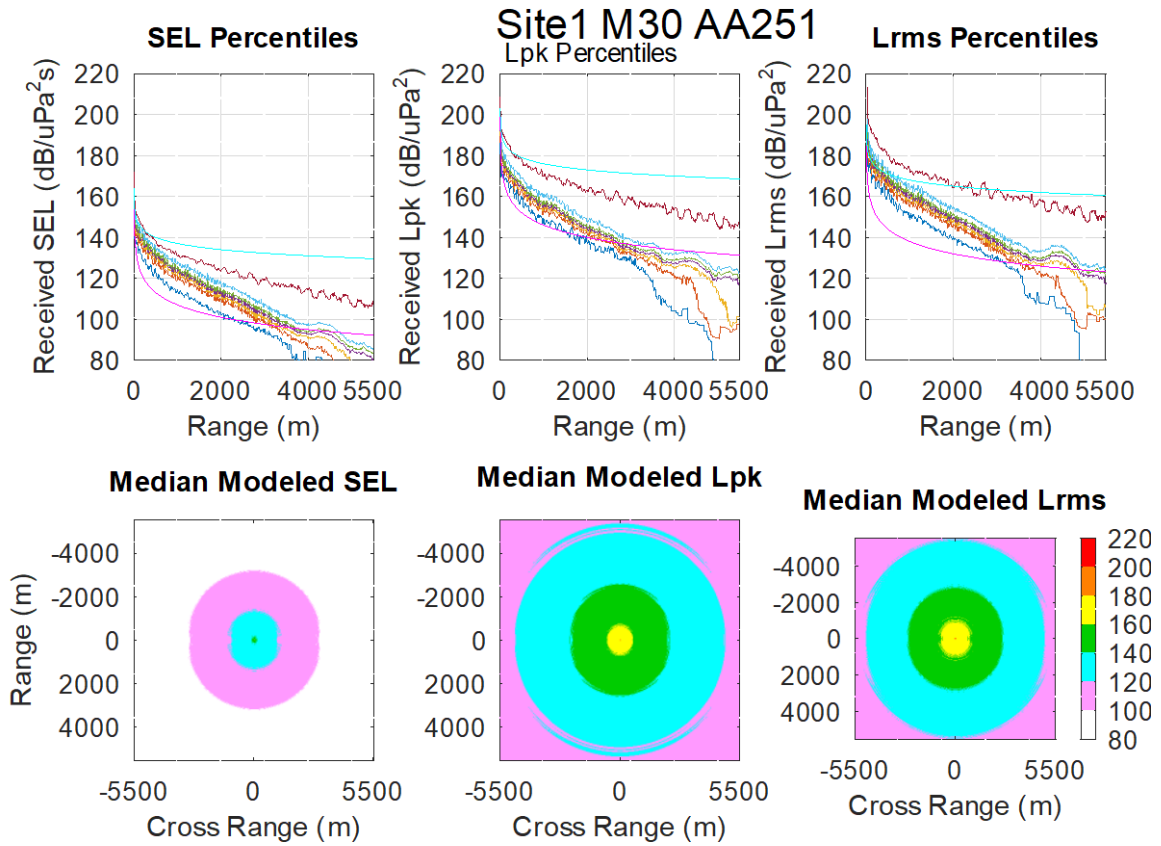


Figure 5-176. 251 Boomer Mode 30 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.30.2 Site 2 – Sand, 10-m Depth

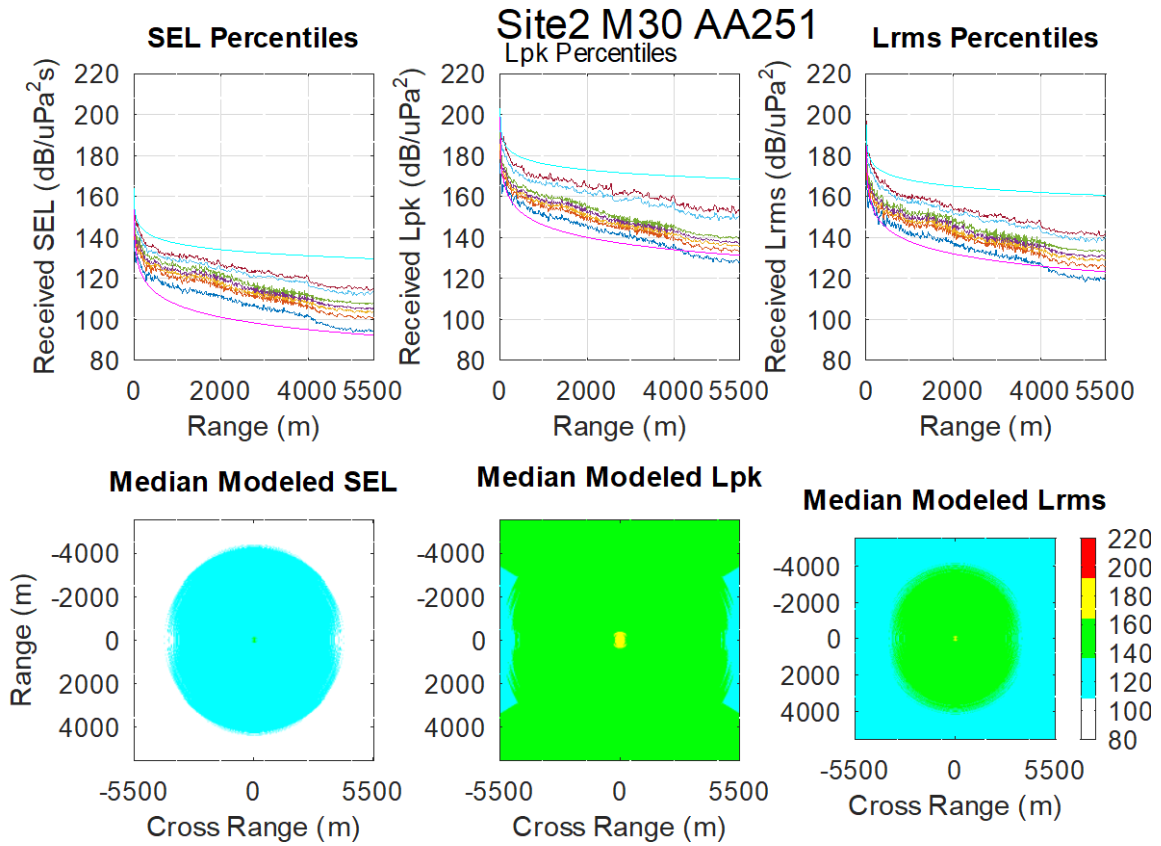


Figure 5-177. 251 Boomer Mode 30 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.30.3 Site 3 – Mud, 30-m Depth

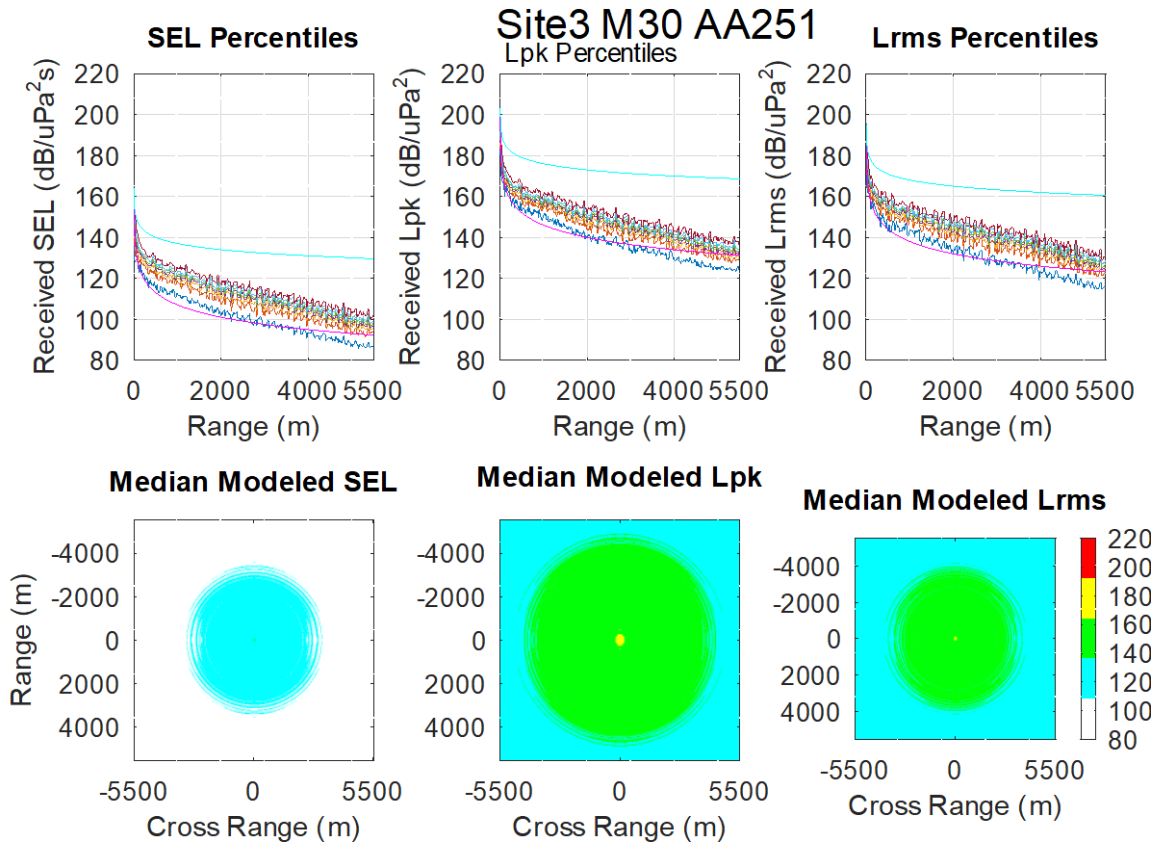


Figure 5-178. 251 Boomer Mode 30 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.30.4 Site 4 – Sand, 30-m Depth

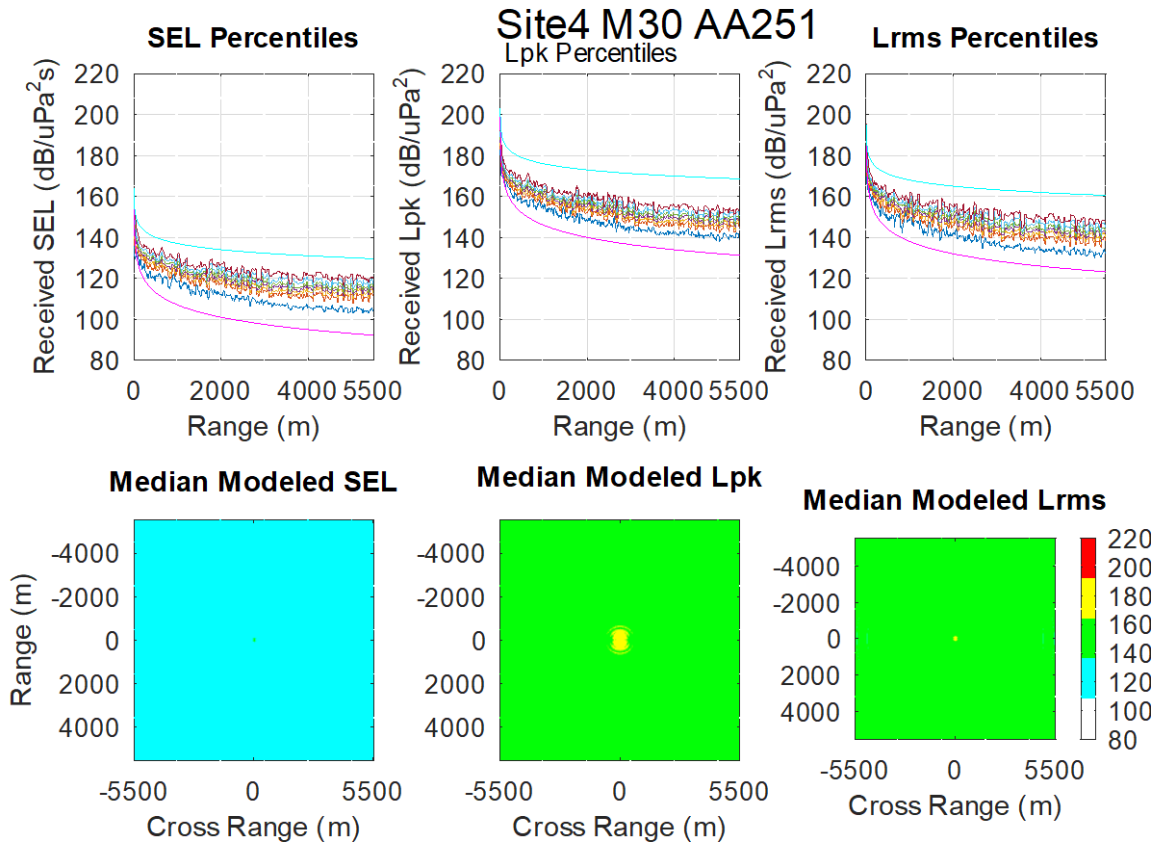


Figure 5-179. 251 Boomer Mode 30 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.30.5 Site 5 – Sandy Silt, 100-m Depth

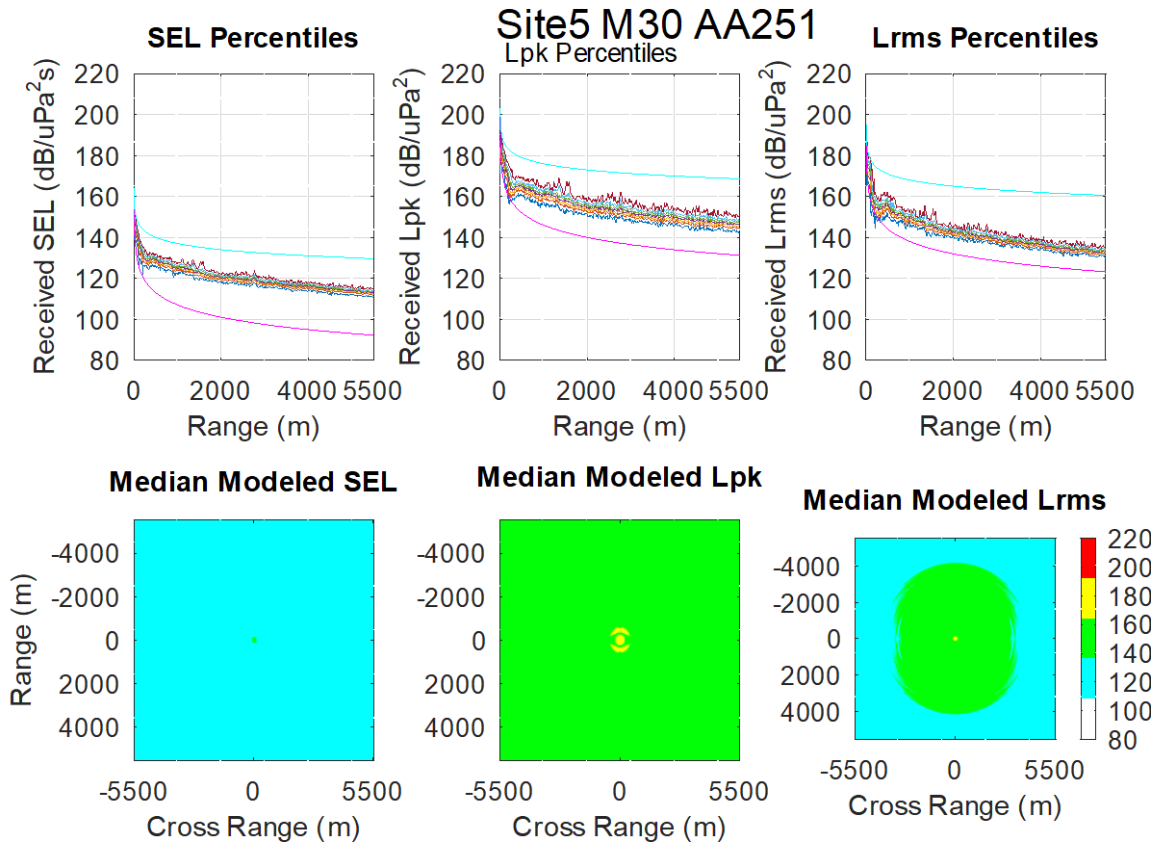


Figure 5-180. 251 Boomer Mode 30 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.31 Applied Acoustics 251 Boomer, 0.1 to 5 kHz, 100 J, Lower Power, Single Plate (Mode 31)

The 251 Boomer acoustic source generates a single MF signal, with a peak frequency between 10 Hz and 5 kHz. The operational parameter settings for Mode 31 were a single plate, 100 J on lower power, and a 0.1- to 5-kHz output frequency. Measured source levels are shown in **Table 5-31**.

Table 5-31. NUWC tank measurements of 251 Boomer (Mode 31)

Source Settings		Source Level			
Power Level (J)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
100	2	204	201	191	160

μ Pa = micropascal; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) for Mode 30 (**Figure 5-175**) was also used for Mode 31. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the NUWC measured levels in **Table 5-31**. Modeling results for each site are shown in **Figures 5-181 to 5-185**.

5.31.1 Site 1 – Mud, 10-m Depth

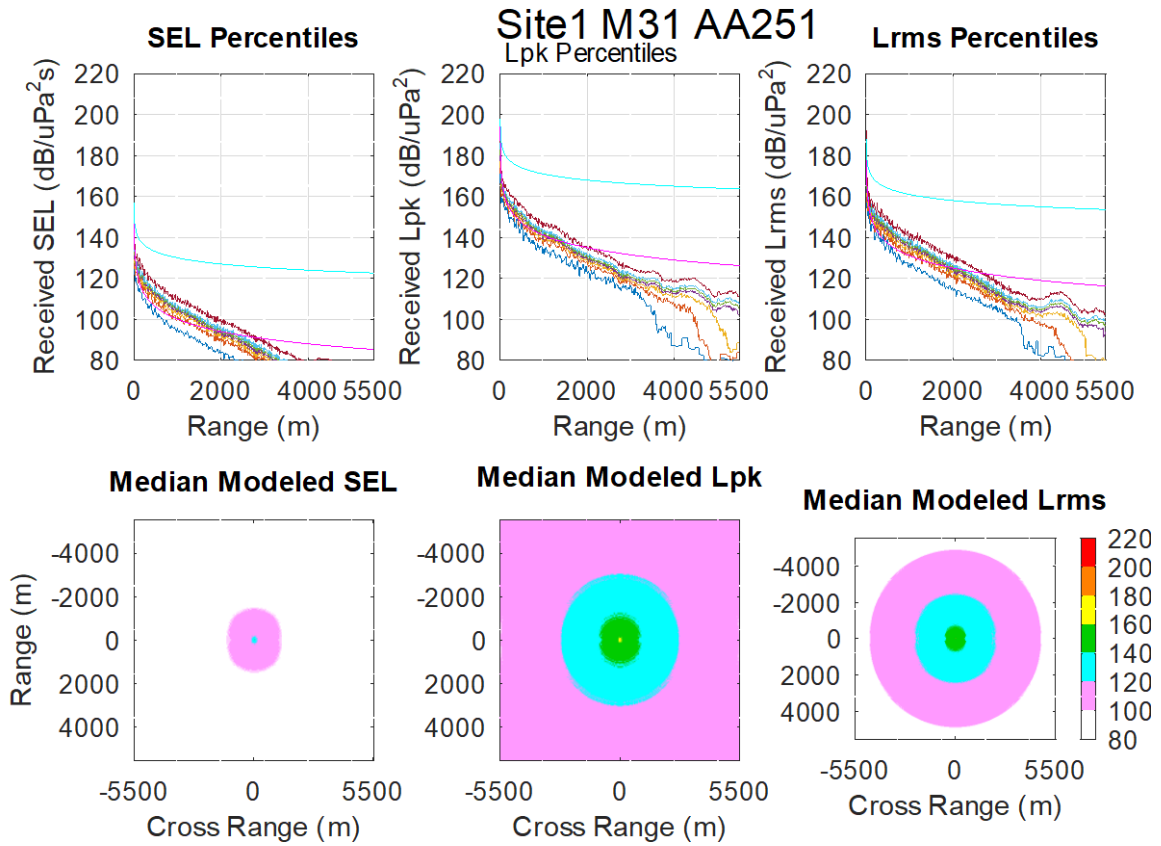


Figure 5-181. 251 Boomer Mode 31 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.31.2 Site 2 – Sand, 10-m Depth

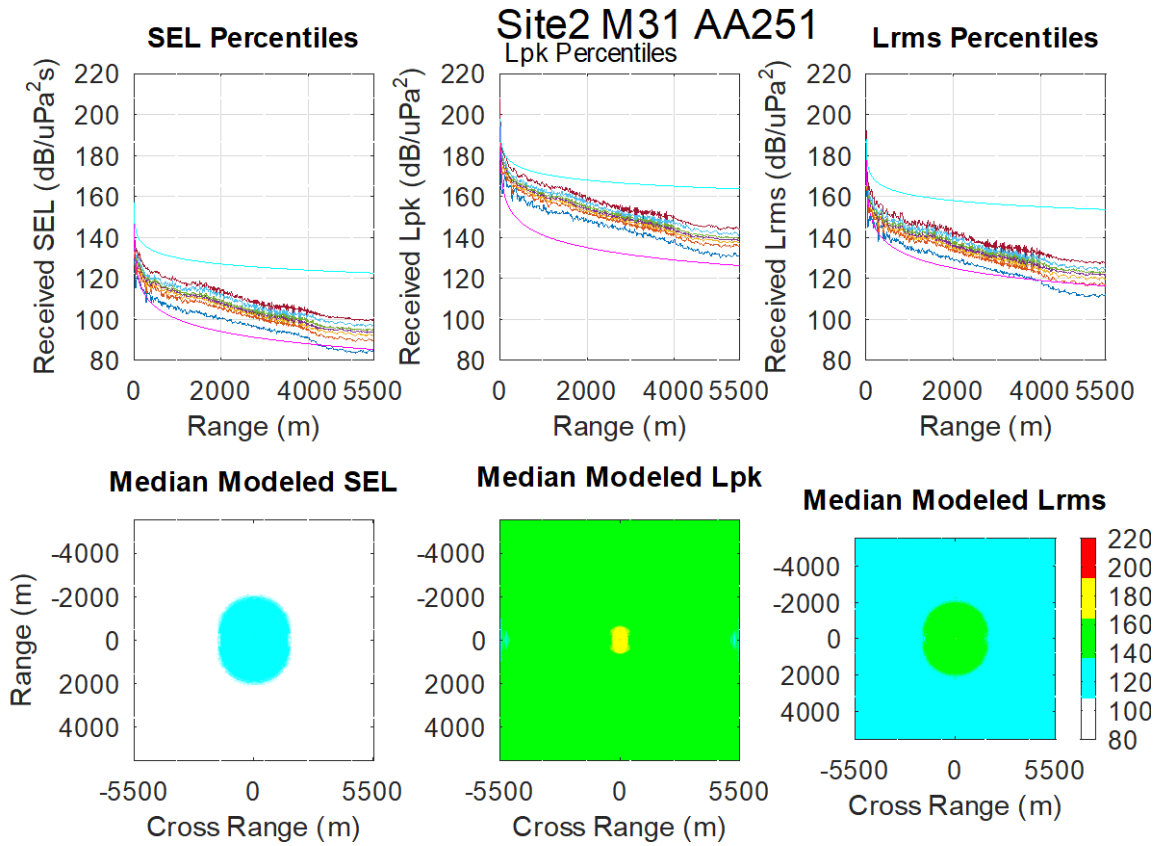


Figure 5-182. 251 Boomer Mode 31 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.31.3 Site 3 – Mud, 30-m Depth

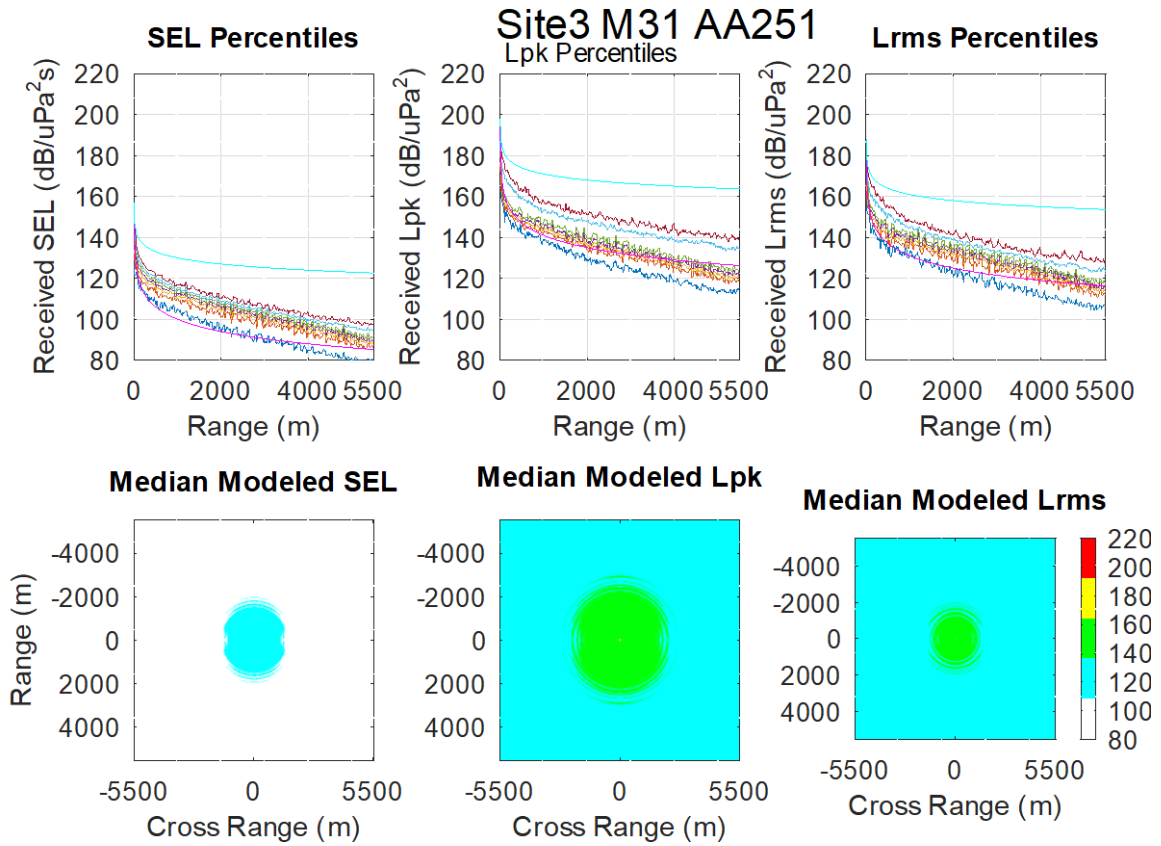


Figure 5-183. 251 Boomer Mode 31 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.31.4 Site 4 – Sand, 30-m Depth

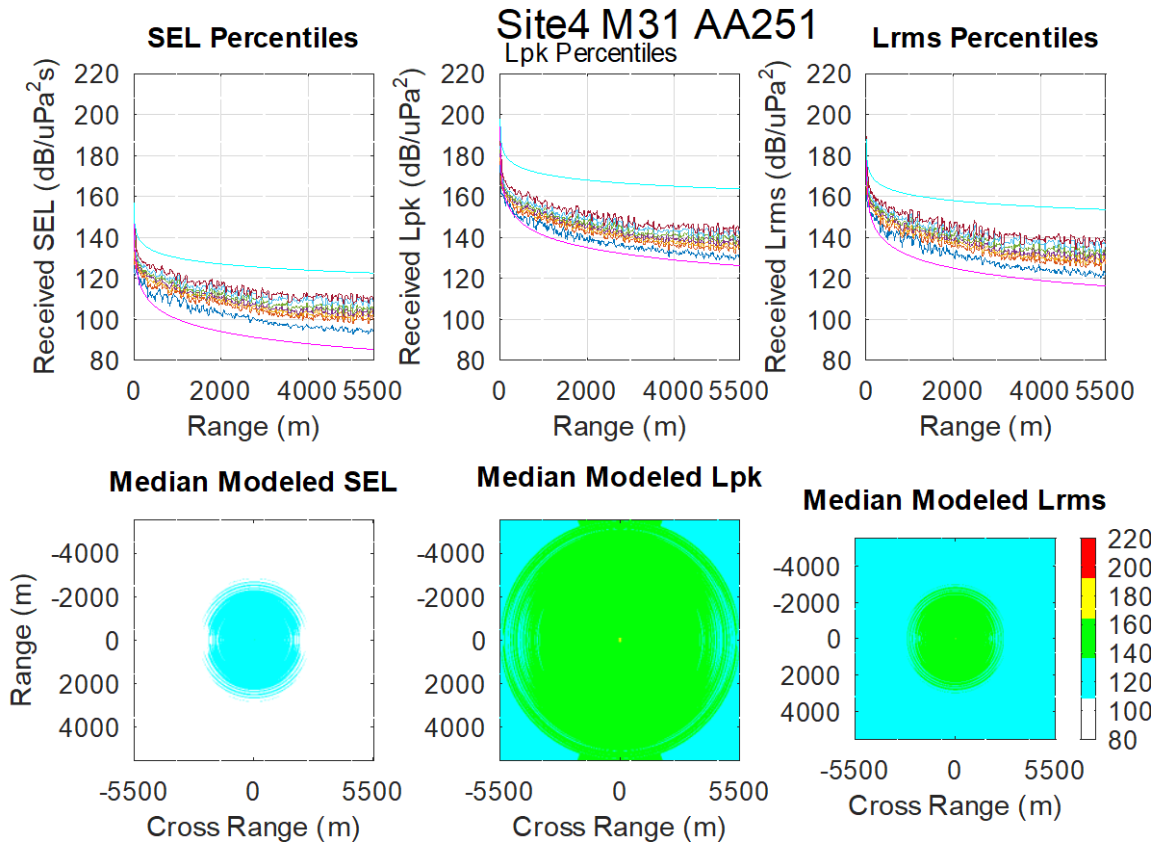


Figure 5-184. 251 Boomer Mode 31 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.31.5 Site 5 – Sandy Silt, 100-m Depth

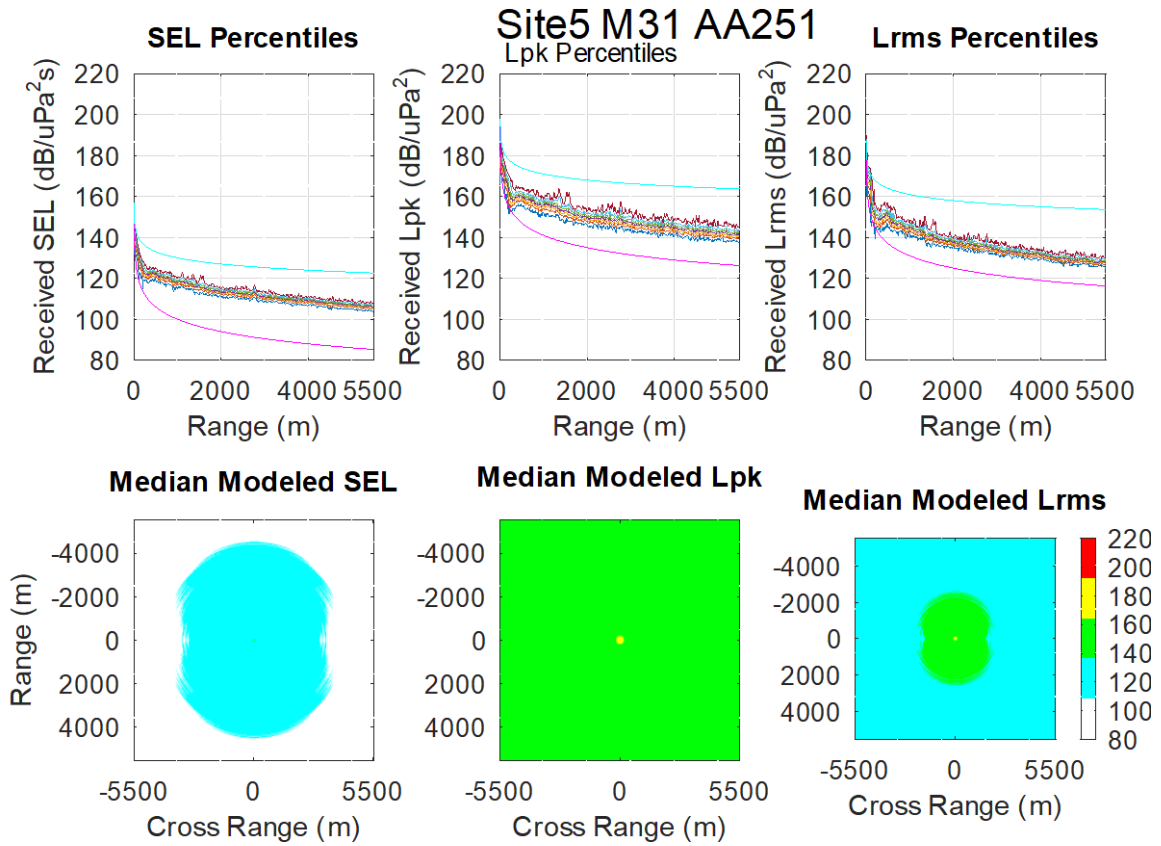


Figure 5-185. 251 Boomer Mode 31 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.32 FSI Bubble Gun, 0.1 to 2 kHz, Dual Plate (Mode 32)

The Falmouth Scientific HMS-602D is a dual-plate LF subbottom profiling seismic sound source. In Phases II (measurements) and III (modeling), the dual-plate source setting was used as Mode 32. Measured source levels are shown in **Table 5-32**. The Bubble Gun energy is concentrated below 3 kHz, with the measured 3-dB down point being 2.5 kHz. The Bubble Gun is considered omnidirectional.

Table 5-32. NUWC tank measurements of Bubble Gun (Mode 32)

Source Settings		Source Level			
Plate	Depth (cm)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
Dual	86	207	204	198	173

μ Pa = micropascal; cm = centimeter; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-186**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-32**. Modeling results for each site are shown in **Figures 5-187 to 5-191**.

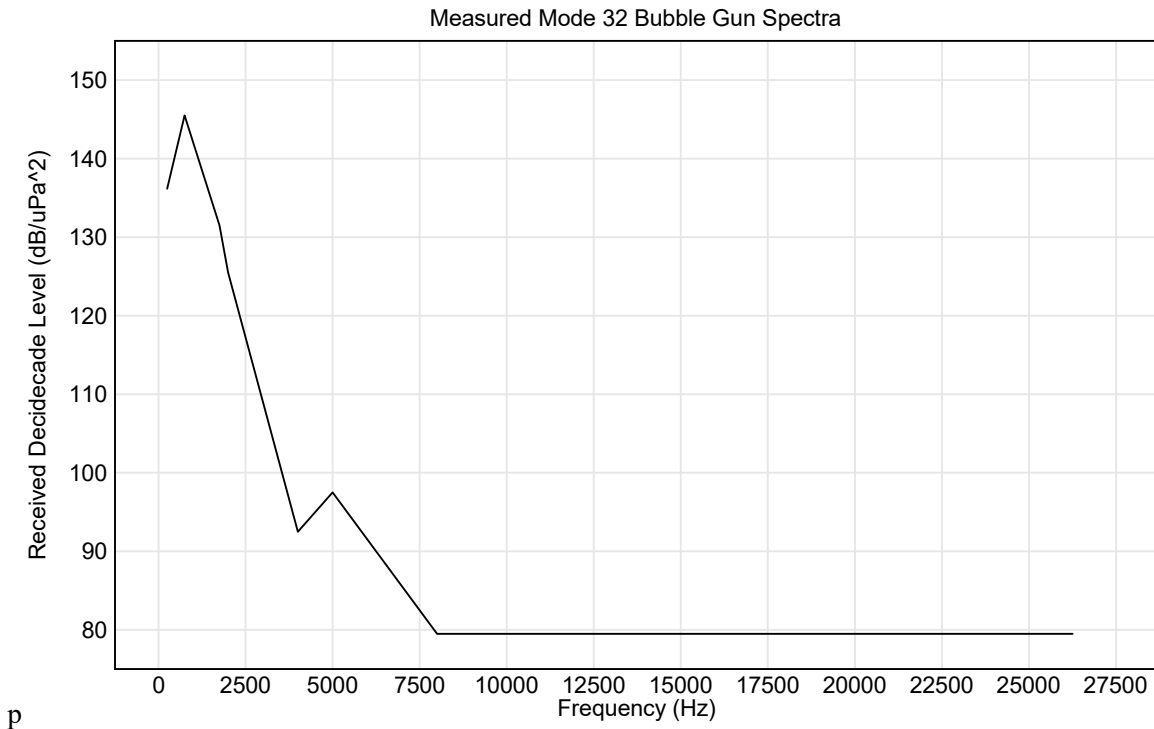


Figure 5-186. Bubble Gun Mode 32 measured spectra at buoy position D
 μ Pa = micropascal; dB = decibel; Hz = hertz.

5.32.1 Site 1 – Mud, 10-m Depth

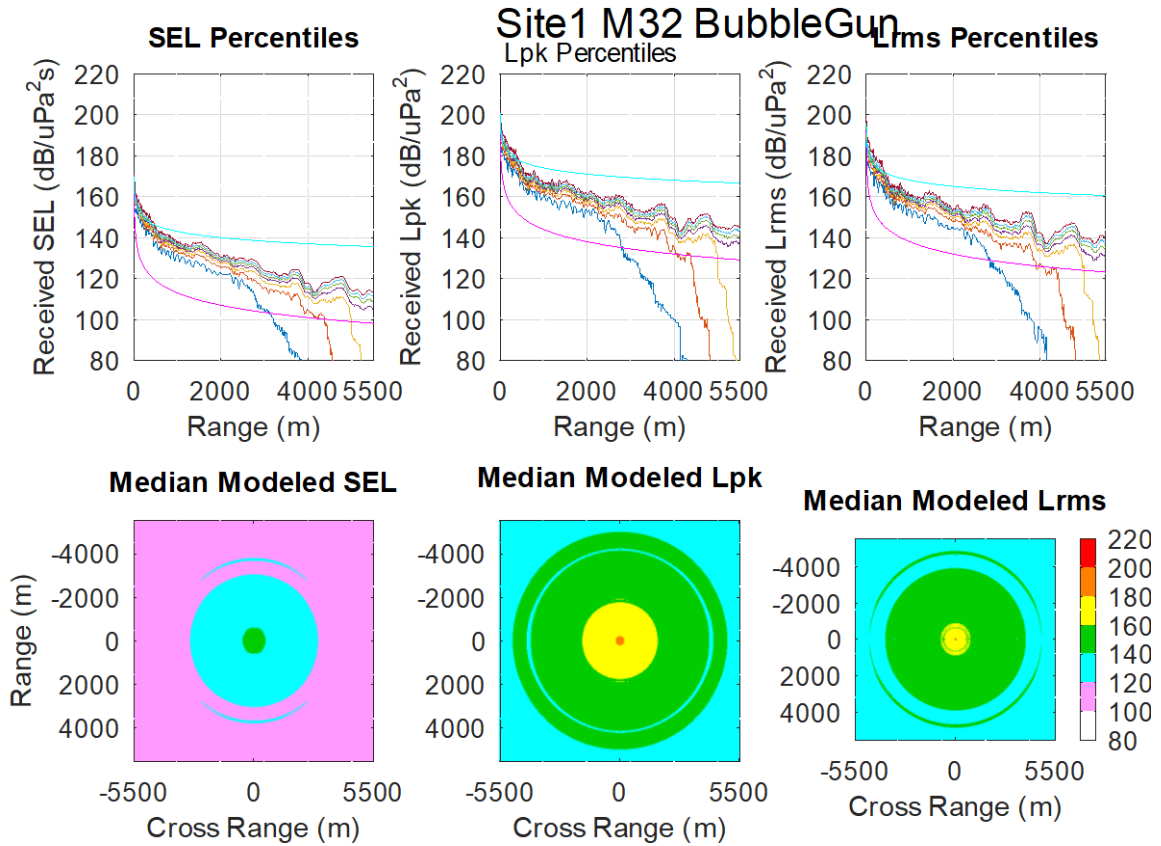


Figure 5-187. Bubble Gun Mode 32 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.32.2 Site 2 – Sand, 10-m Depth

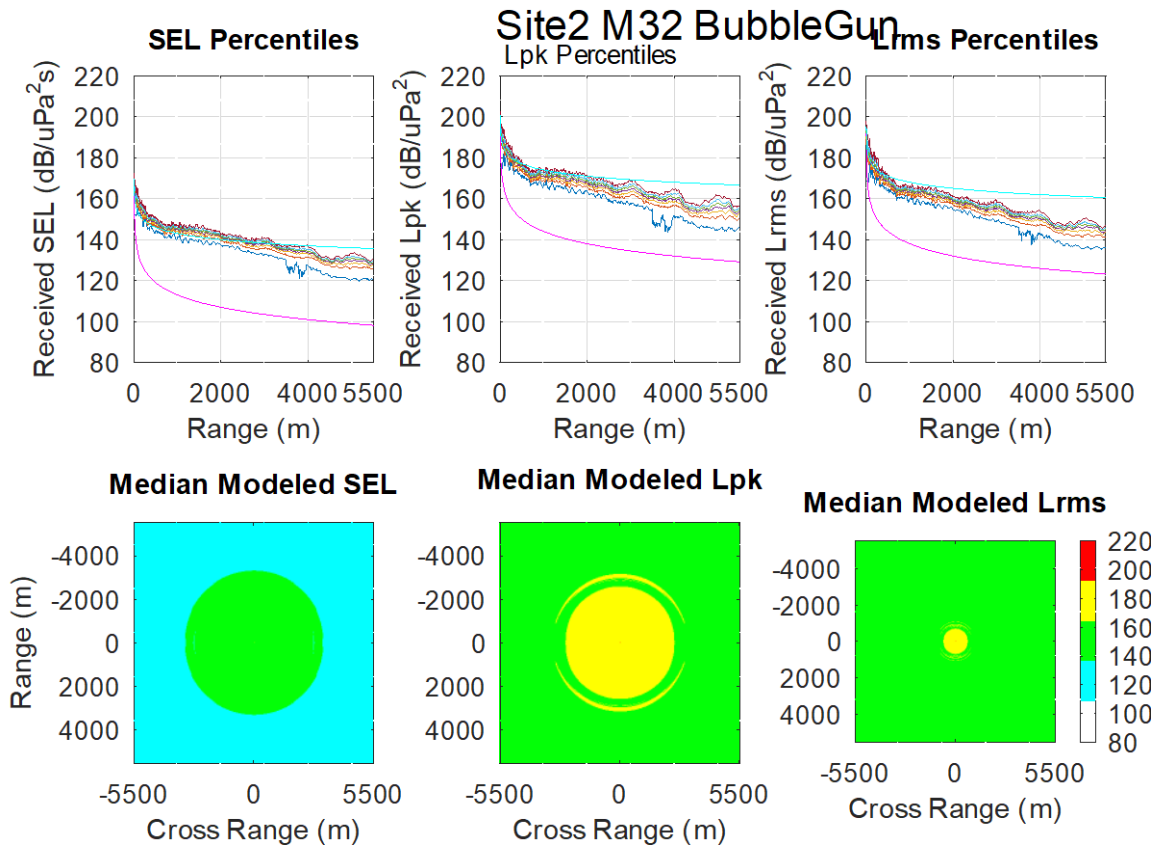


Figure 5-188. Bubble Gun Mode 32 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.32.3 Site 3 – Mud, 30-m Depth

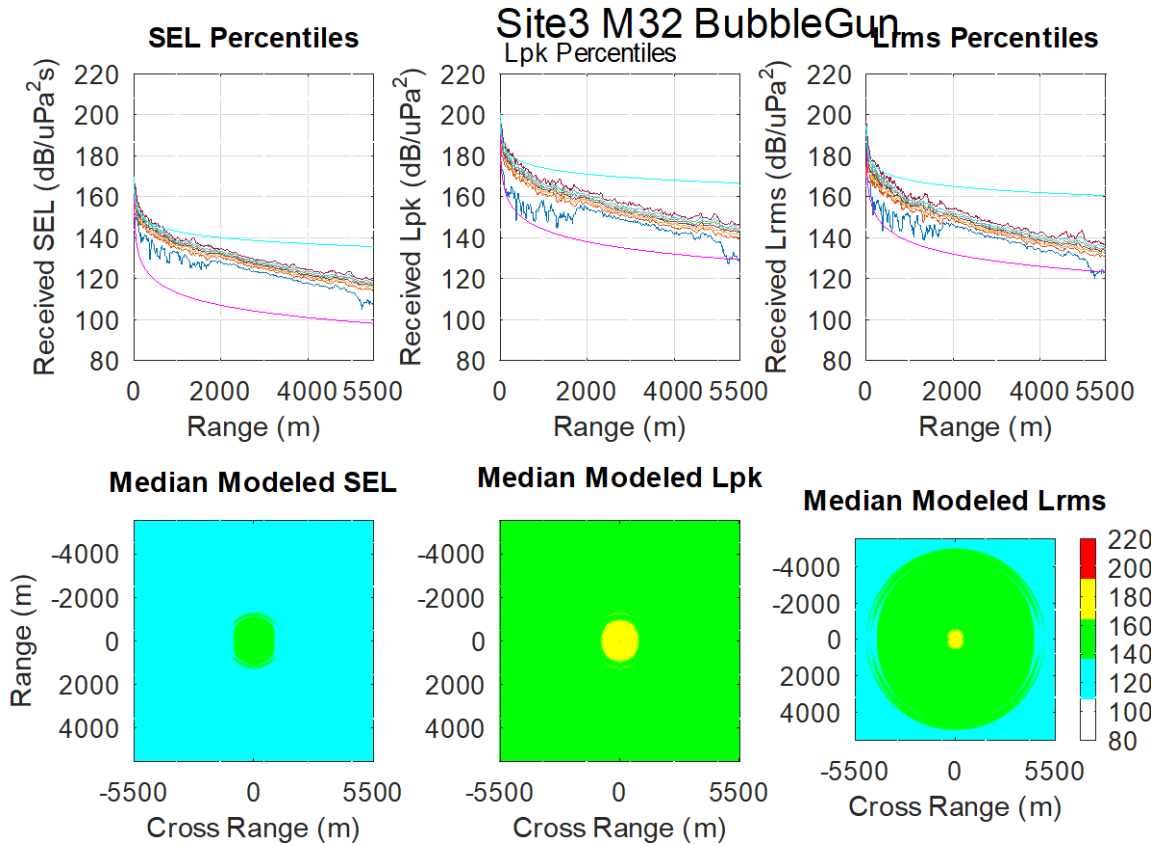


Figure 5-189. Bubble Gun Mode 32 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.32.4 Site 4 – Sand, 30-m Depth

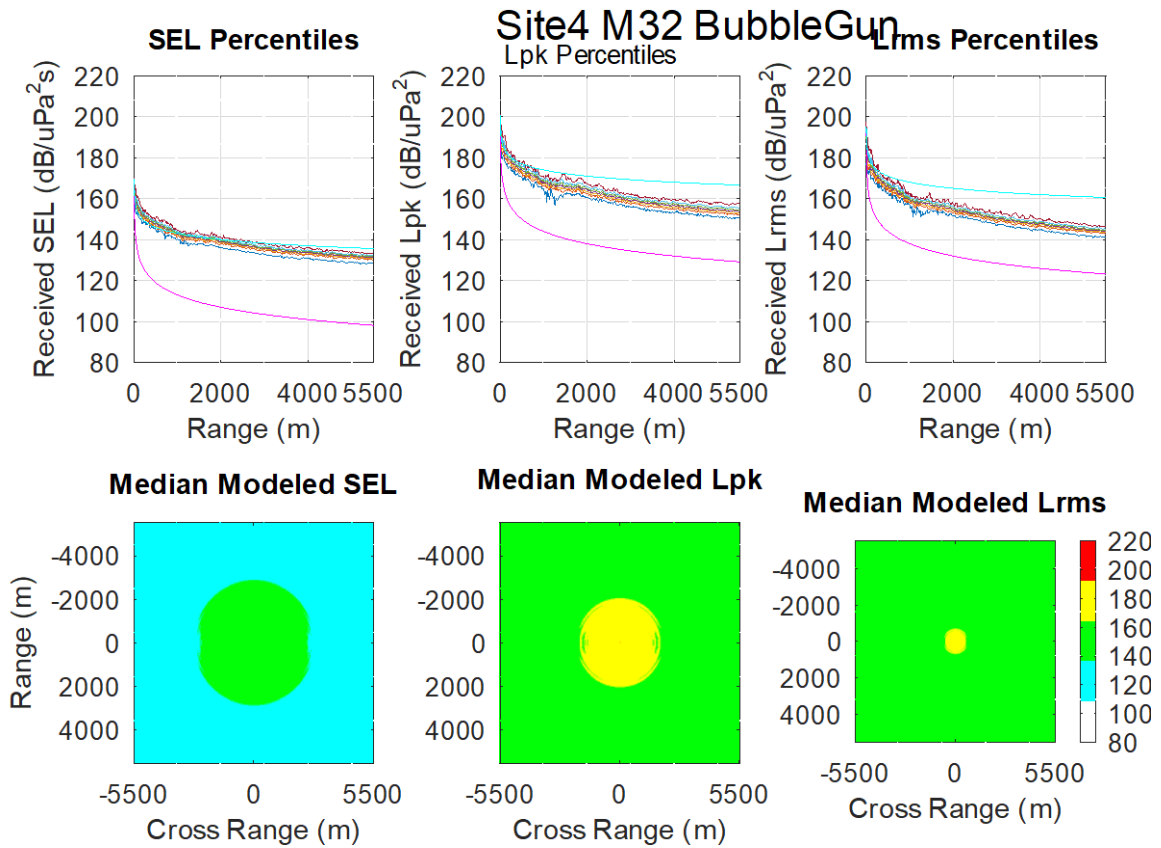


Figure 5-190. Bubble Gun Mode 32 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.32.5 Site 5 – Sandy Silt, 100-m Depth

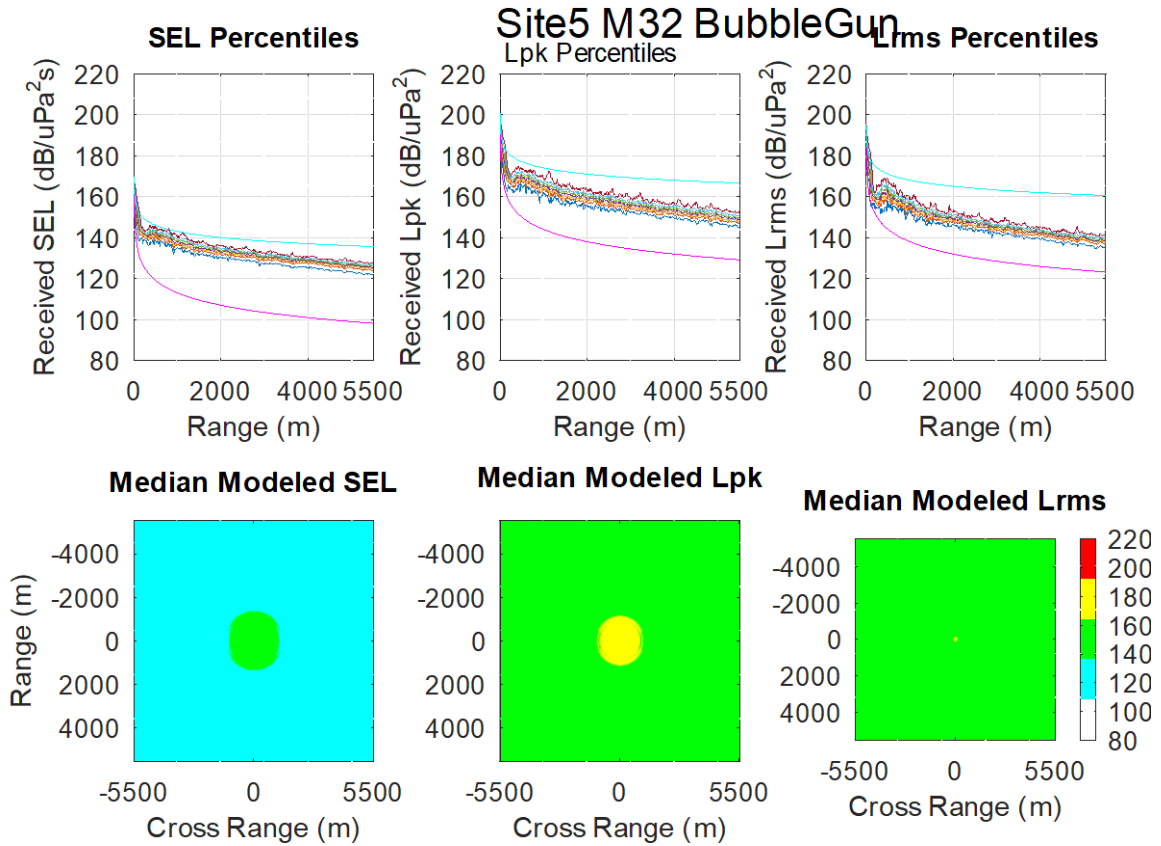


Figure 5-191. Bubble Gun Mode 32 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.33 FSI Bubble Gun, 0.1 to 2 kHz, Single Plate (Mode 33)

The Falmouth Scientific HMS-602D is a dual-plate LF subbottom profiling seismic sound source. In Phases II (measurements) and III (modeling), the single-plate source setting was used as Mode 33. Measured source levels are shown in **Table 5-33**. The Bubble Gun energy is concentrated below 3 kHz, with the measured 3-dB down point being 2.5 kHz. The Bubble Gun is considered omnidirectional.

Table 5-33. NUWC tank measurements of Bubble Gun (Mode 33)

Source Settings		Source Level			
Plate	Depth (cm)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
1	86	207	203	196	170

μ Pa = micropascal; cm = centimeter; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-192**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-33**. Modeling results for each site are shown in **Figures 5-193 to 5-197**.

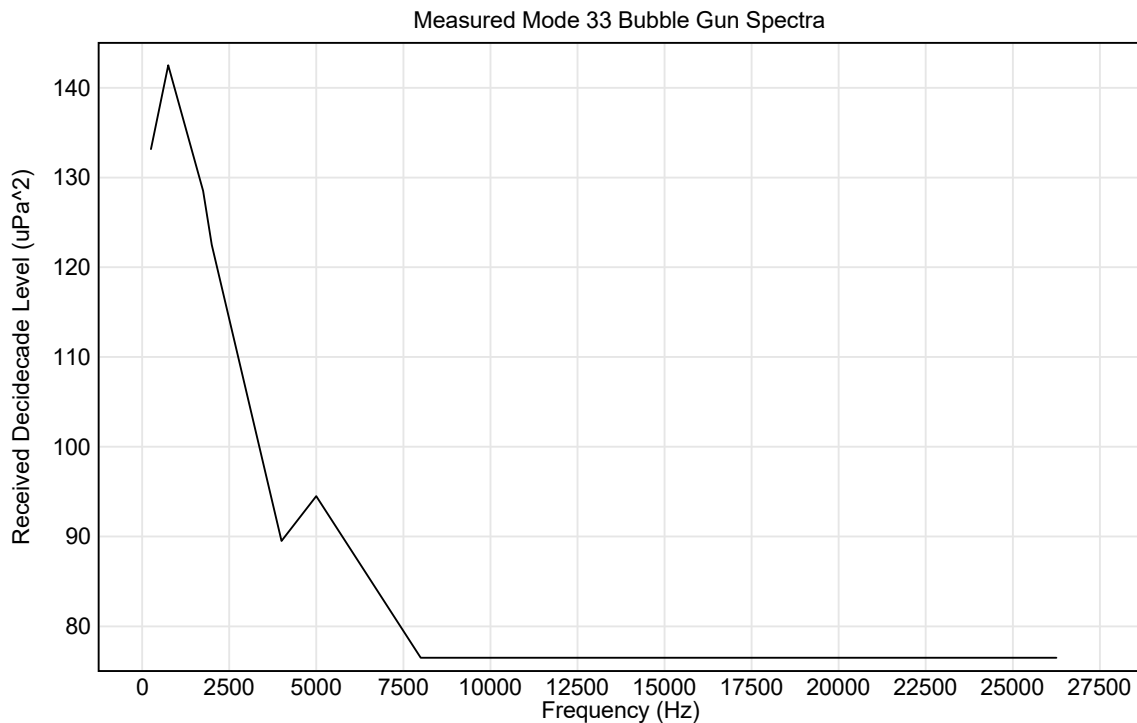


Figure 5-192. Bubble Gun Mode 33 measured spectra at buoy position D
 μ Pa = micropascal; Hz = hertz.

5.33.1 Site 1 – Mud, 10-m Depth

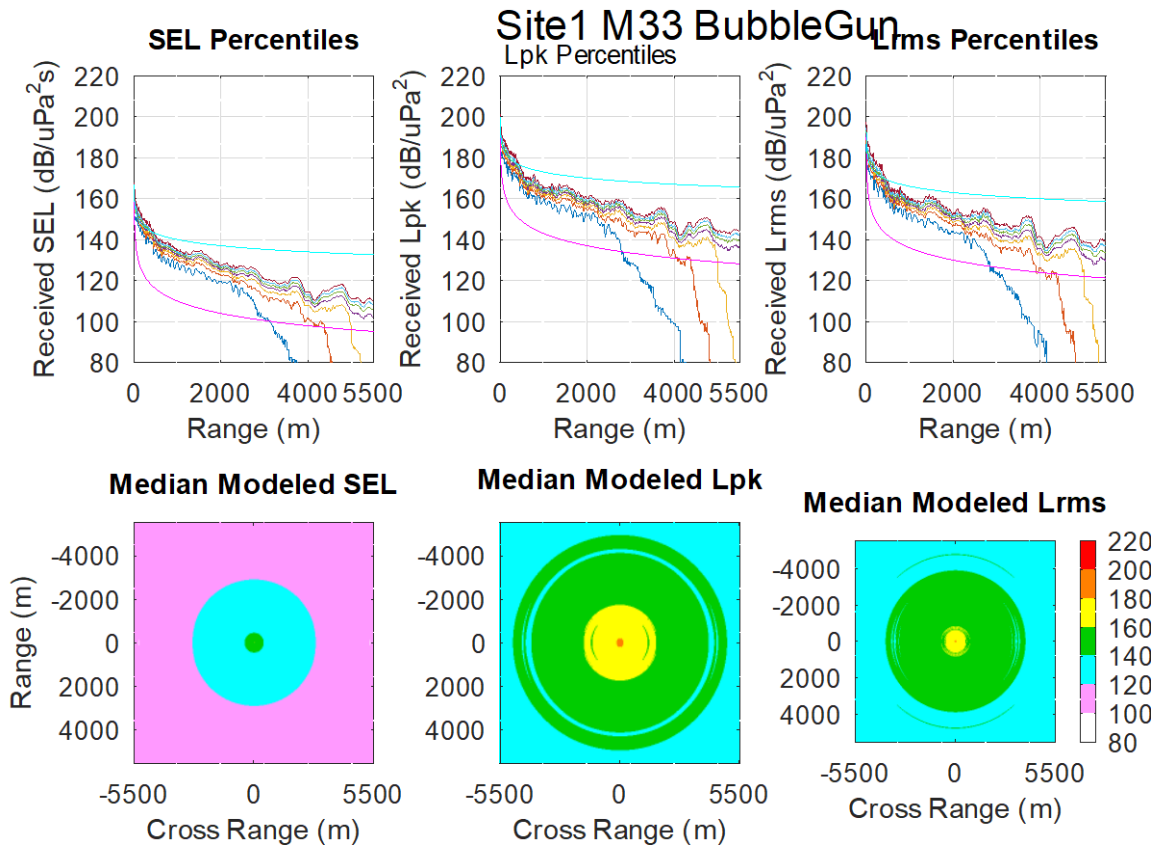


Figure 5-193. Bubble Gun Mode 33 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.33.2 Site 2 – Sand, 10-m Depth

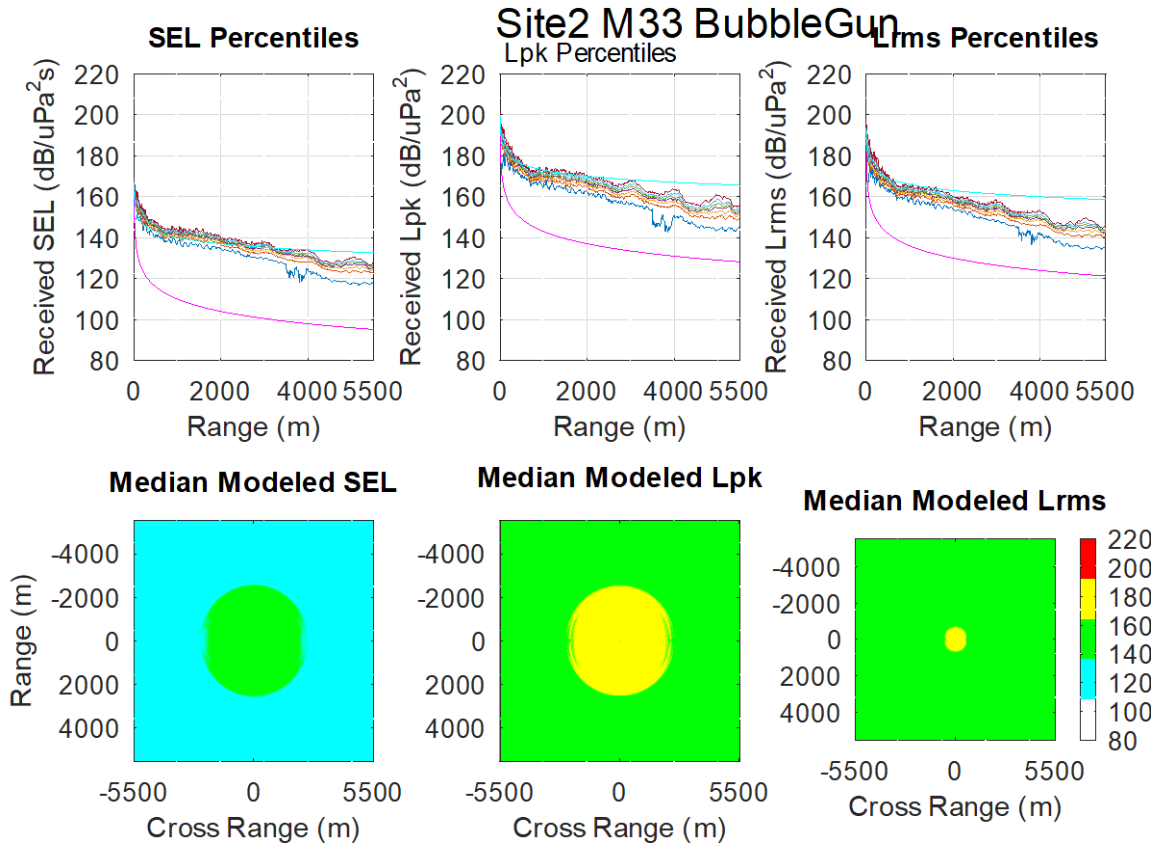


Figure 5-194. Bubble Gun Mode 33 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.33.3 Site 3 – Mud, 30-m Depth

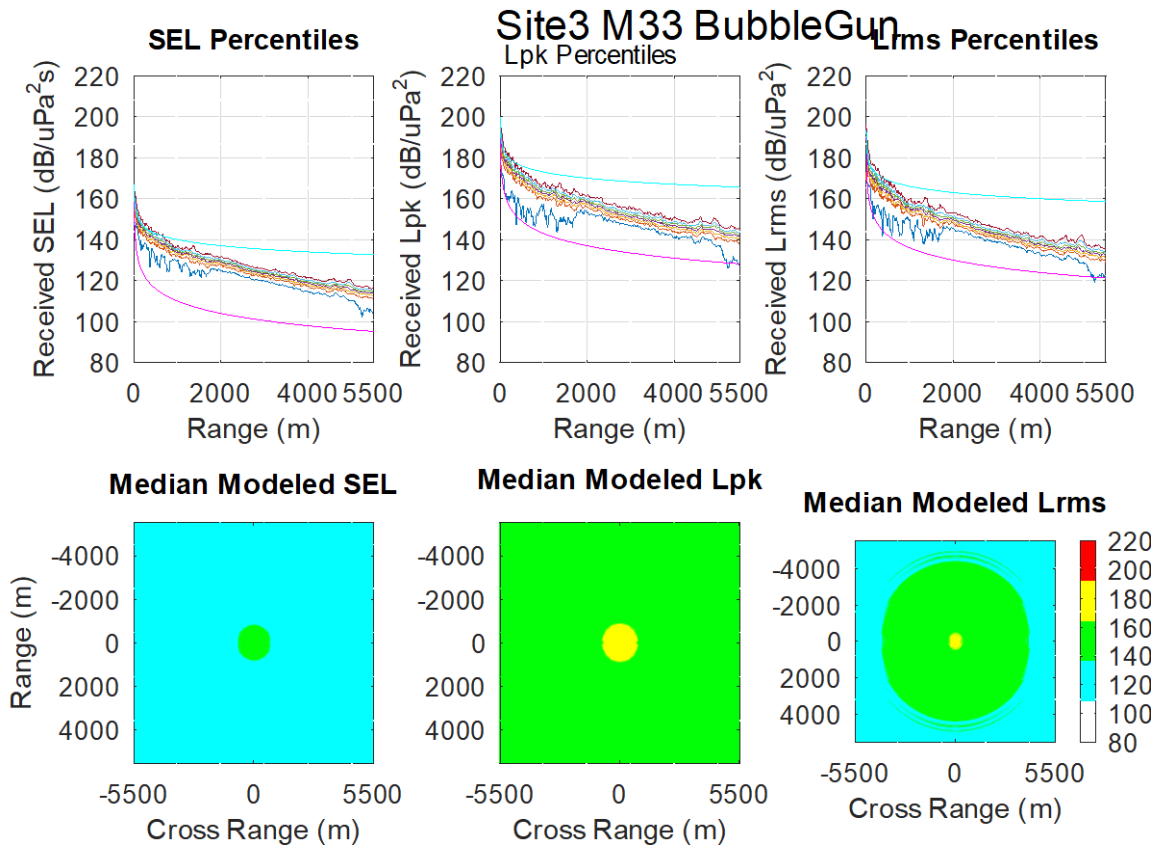


Figure 5-195. Bubble Gun Mode 33 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.33.4 Site 4 – Sand, 30-m Depth

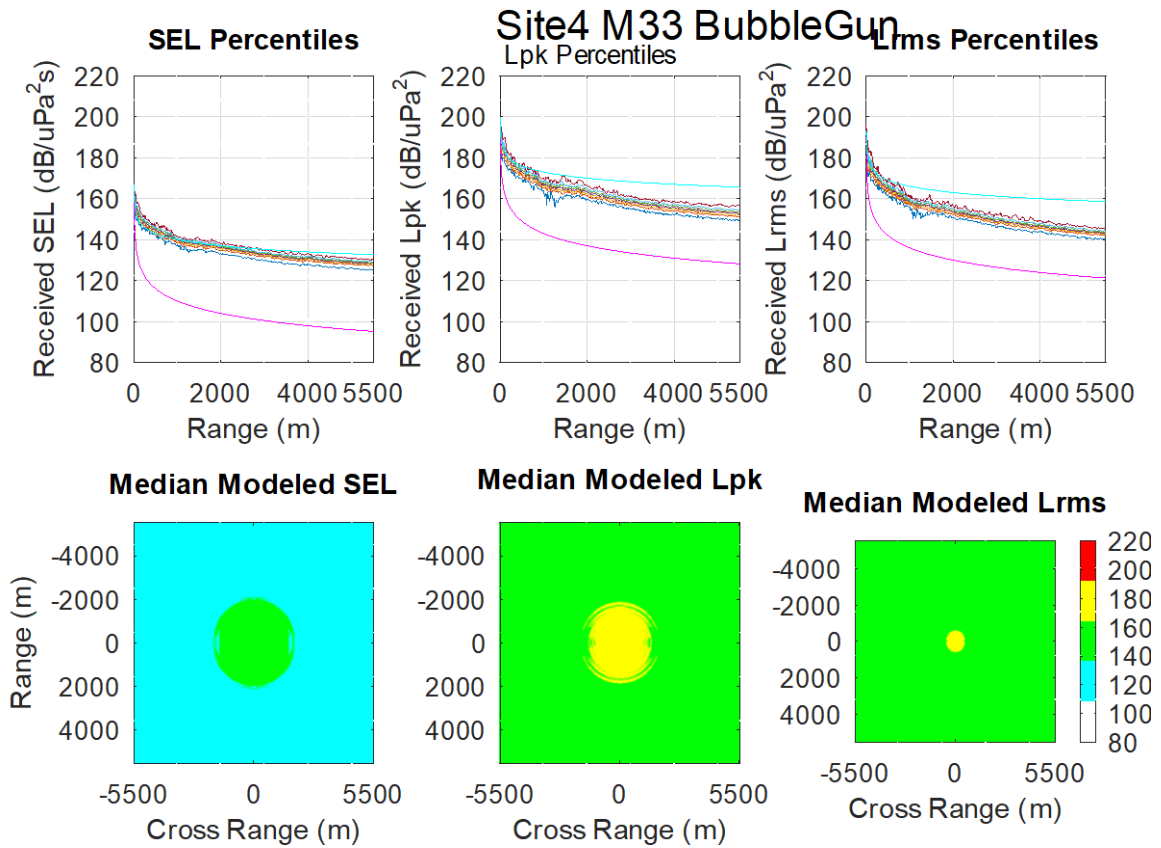


Figure 5-196. Bubble Gun Mode 33 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.33.5 Site 5 – Sandy Silt, 100-m Depth

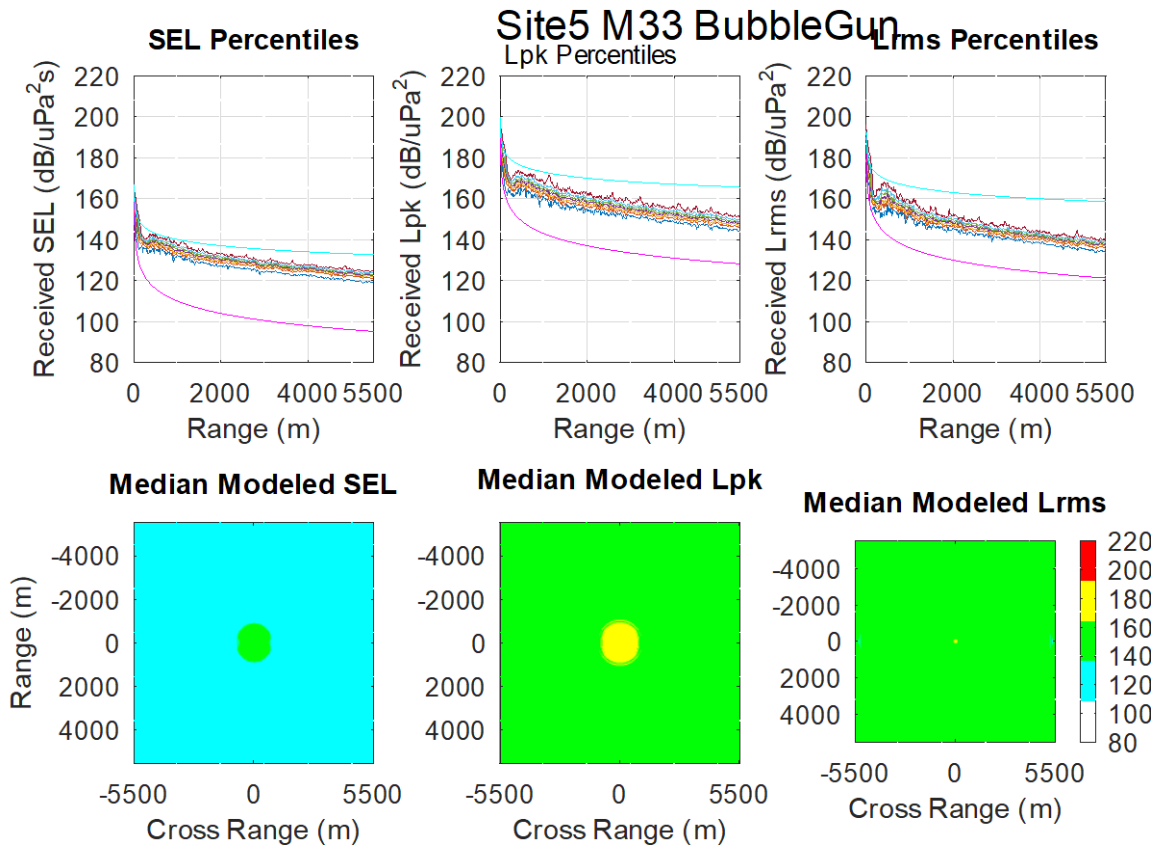


Figure 5-197. Bubble Gun Mode 33 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.34 Sercel Mini GI (30/30), Dual Airguns, No Insert, 30-, 26-, and 24-second Shot Rates (Mode 34)

The Mini GI Airgun is a small LF seismic source developed to reduce or suppress the bubble oscillations common with traditional seismic airguns. Measured source levels are shown in **Table 5-34**.

Table 5-34. NUWC tank measurements of Mini GI Airgun (Mode 34)

Source Settings				Source Level			
Power Level (J)	Pressure (MPa)	Pressure (psi)	Depth (m)	Peak-to-Peak (dB re 1 $\mu\text{Pa m}$)	Peak (dB re 1 $\mu\text{Pa m}$)	rms (dB re 1 $\mu\text{Pa m}$)	SEL (dB re 1 $\mu\text{Pa}^2 \text{ m}^2 \text{ s}$)
1	15.5	2,250	3.0	233	228	222	199

μPa = micropascal; dB = decibel; J = joule; m = meter; MPa = megapascal; NUWC = Naval Undersea Warfare Center; psi = pounds of force per square inch; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level. From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-198**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-34**. Modeling results for each site are shown in **Figures 5-199 to 5-203**.

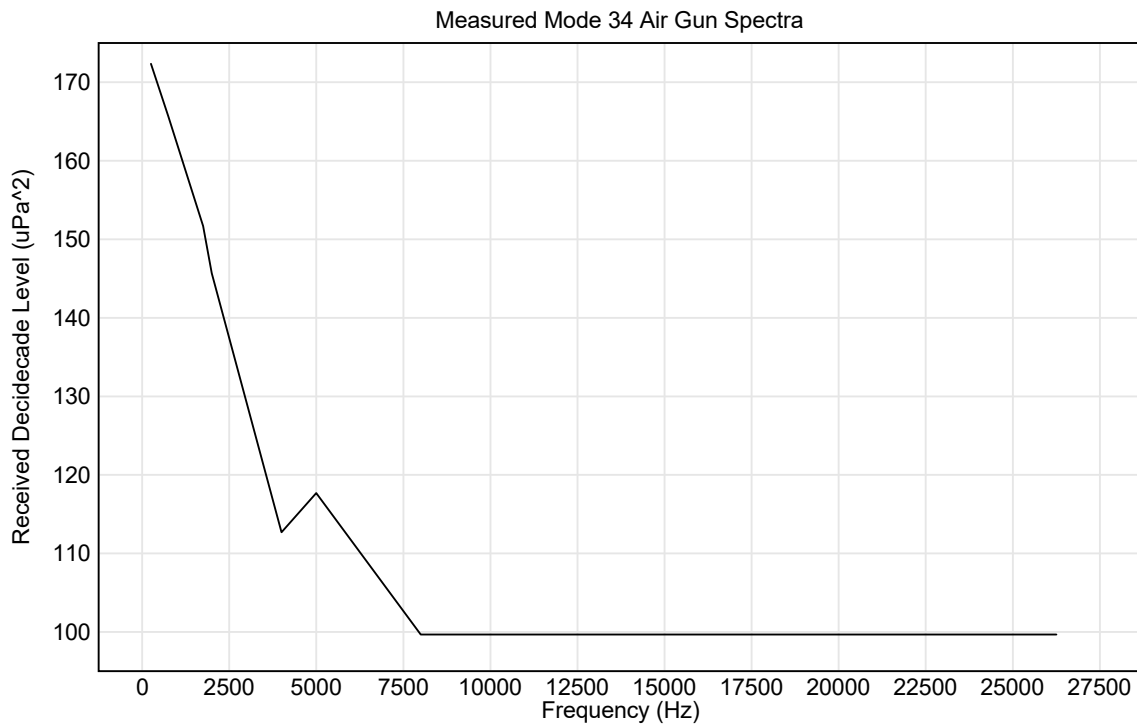


Figure 5-198. Mini GI Airgun Mode 34 measured spectra at buoy position D

μPa = micropascal; Hz = hertz.

5.34.1 Site 1 – Mud, 10-m Depth

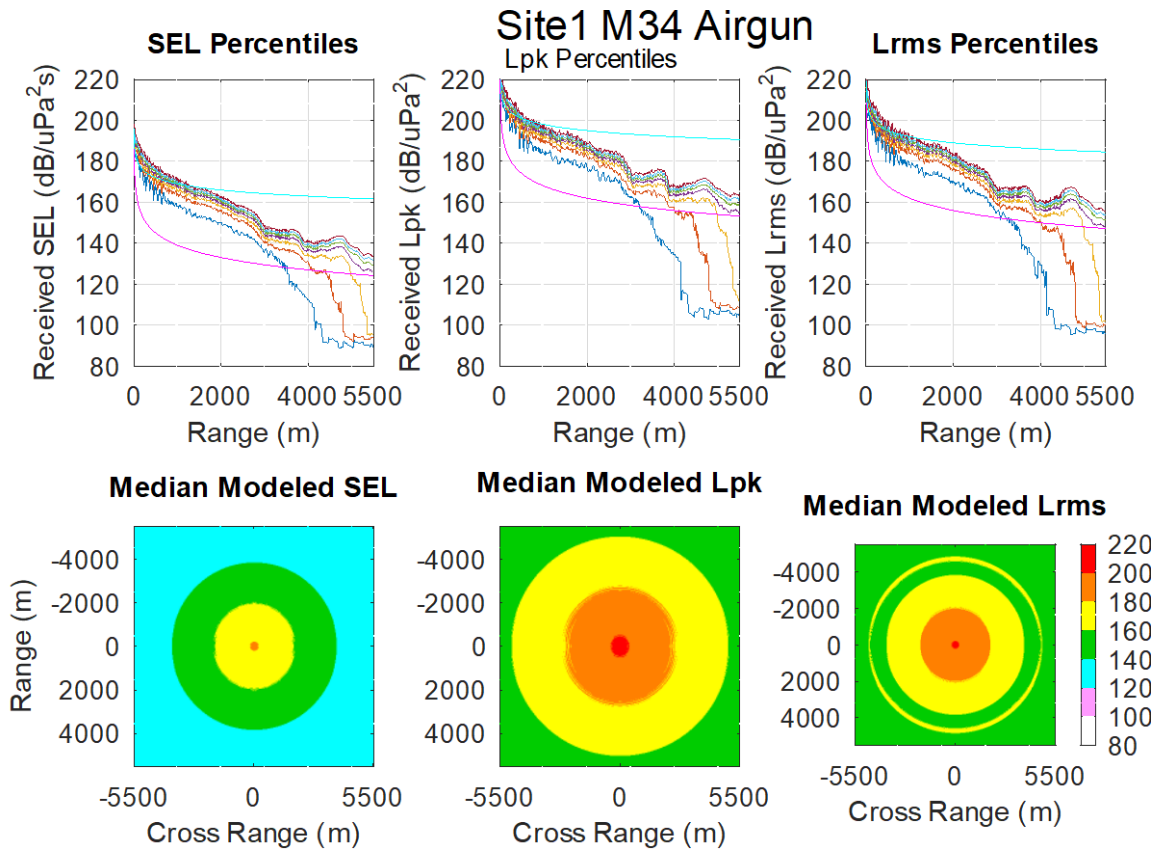


Figure 5-199. Mini GI Airgun Mode 34 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.34.2 Site 2 – Sand, 10-m Depth

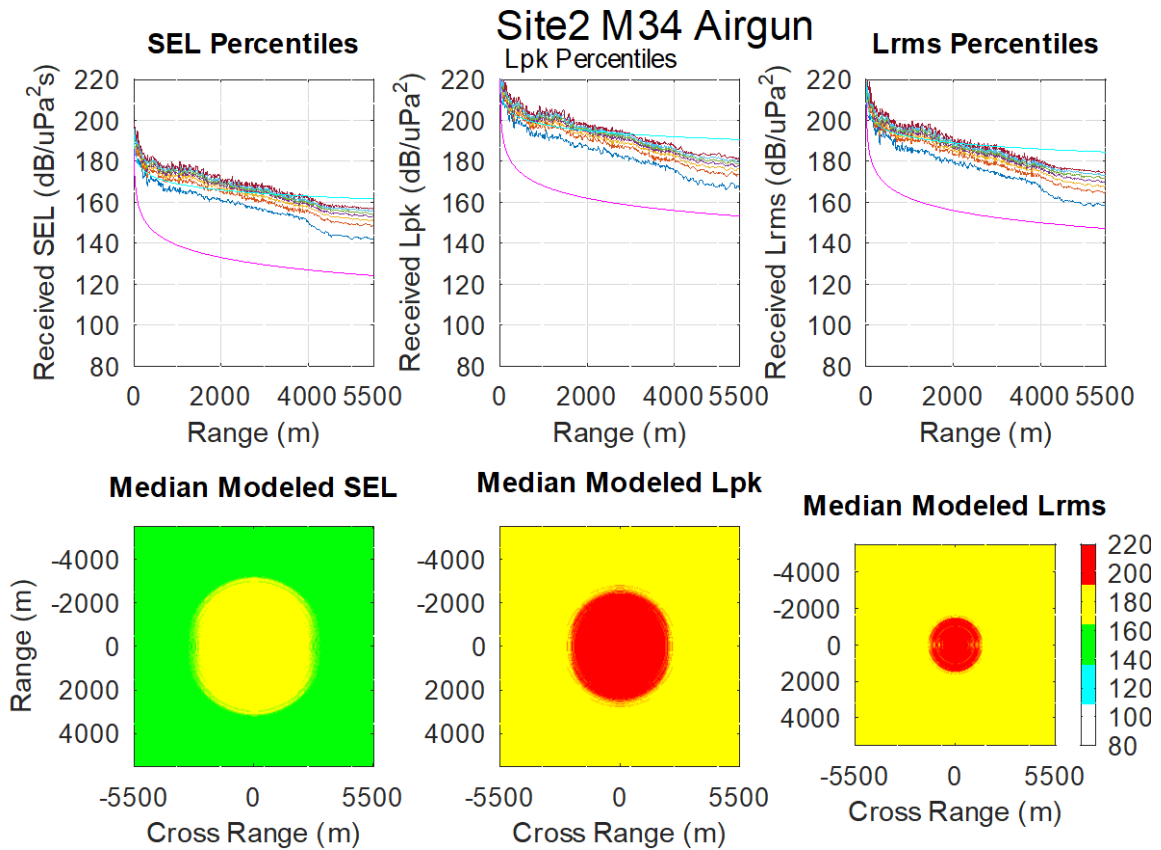


Figure 5-200. Mini GI Airgun Mode 34 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.34.3 Site 3 – Mud, 30-m Depth

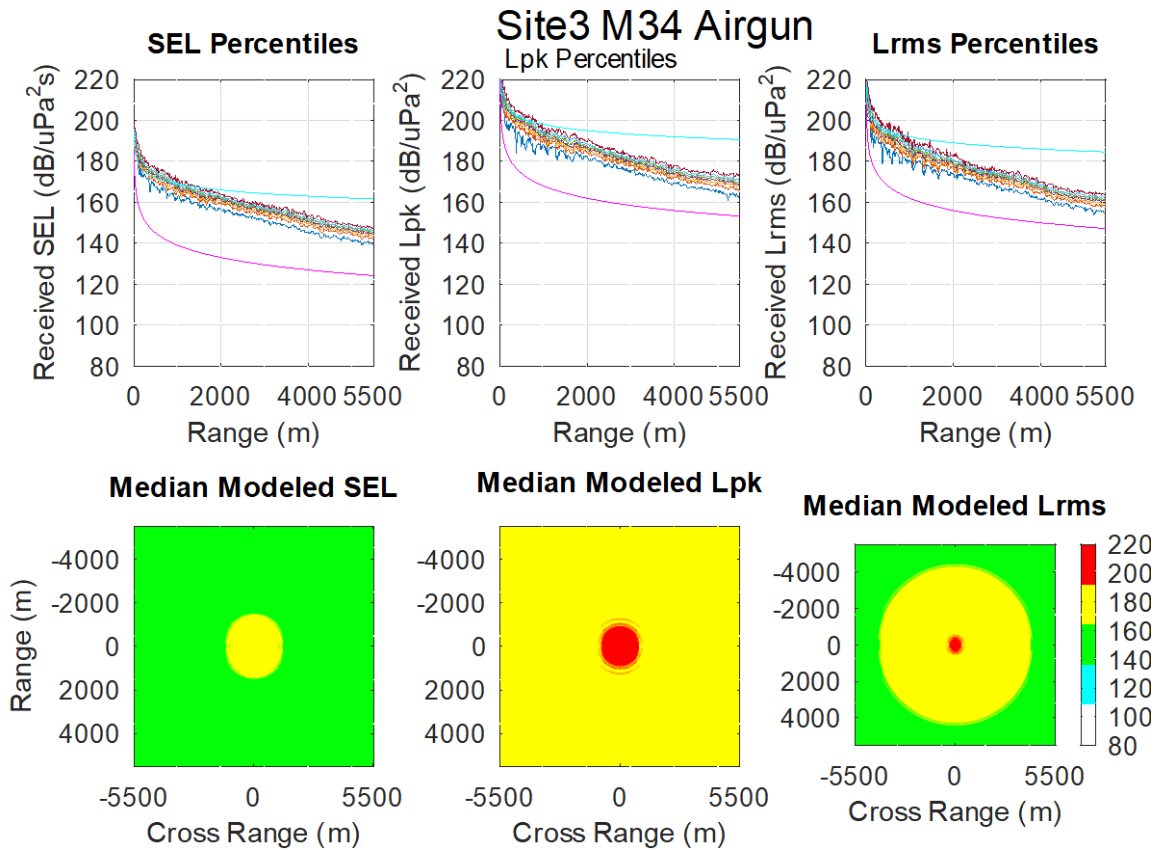


Figure 5-201. Mini GI Airgun Mode 34 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.34.4 Site 4 – Sand, 30-m Depth

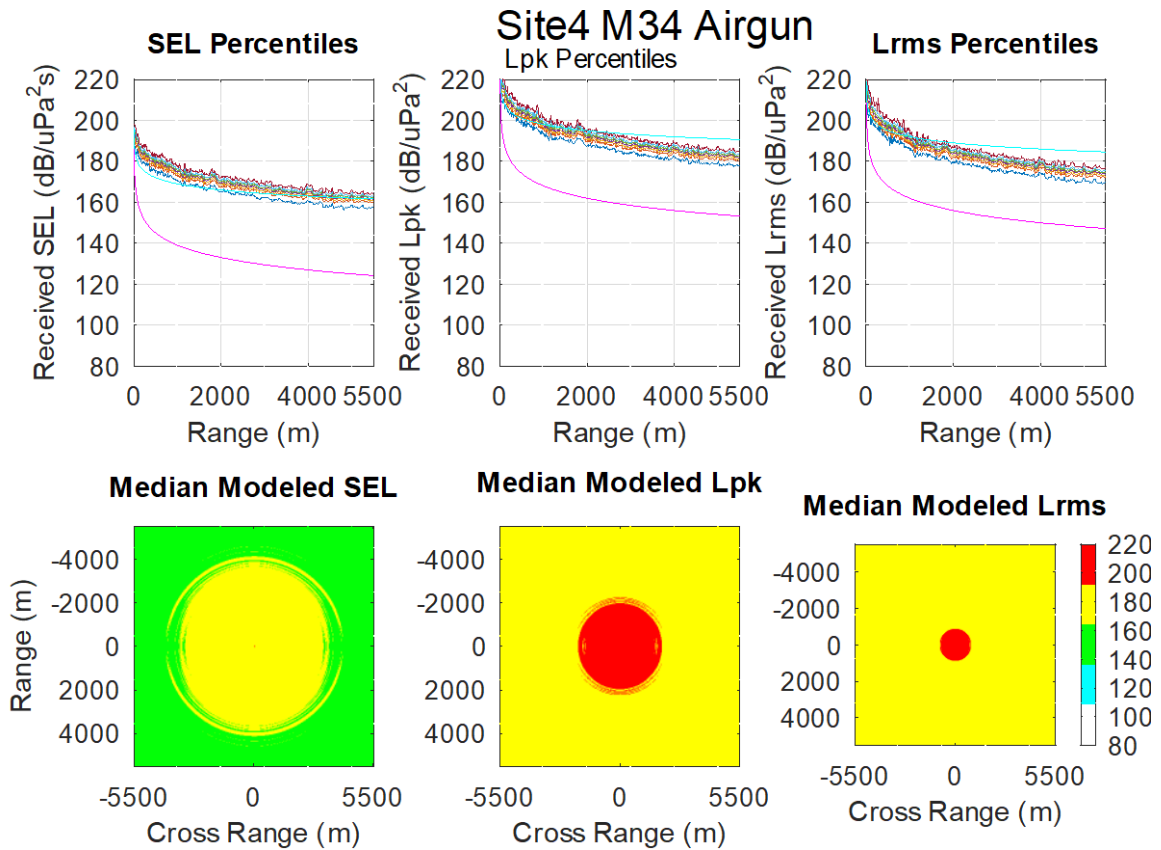


Figure 5-202. Mini GI Airgun Mode 34 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.34.5 Site 5 – Sandy Silt, 100-m Depth

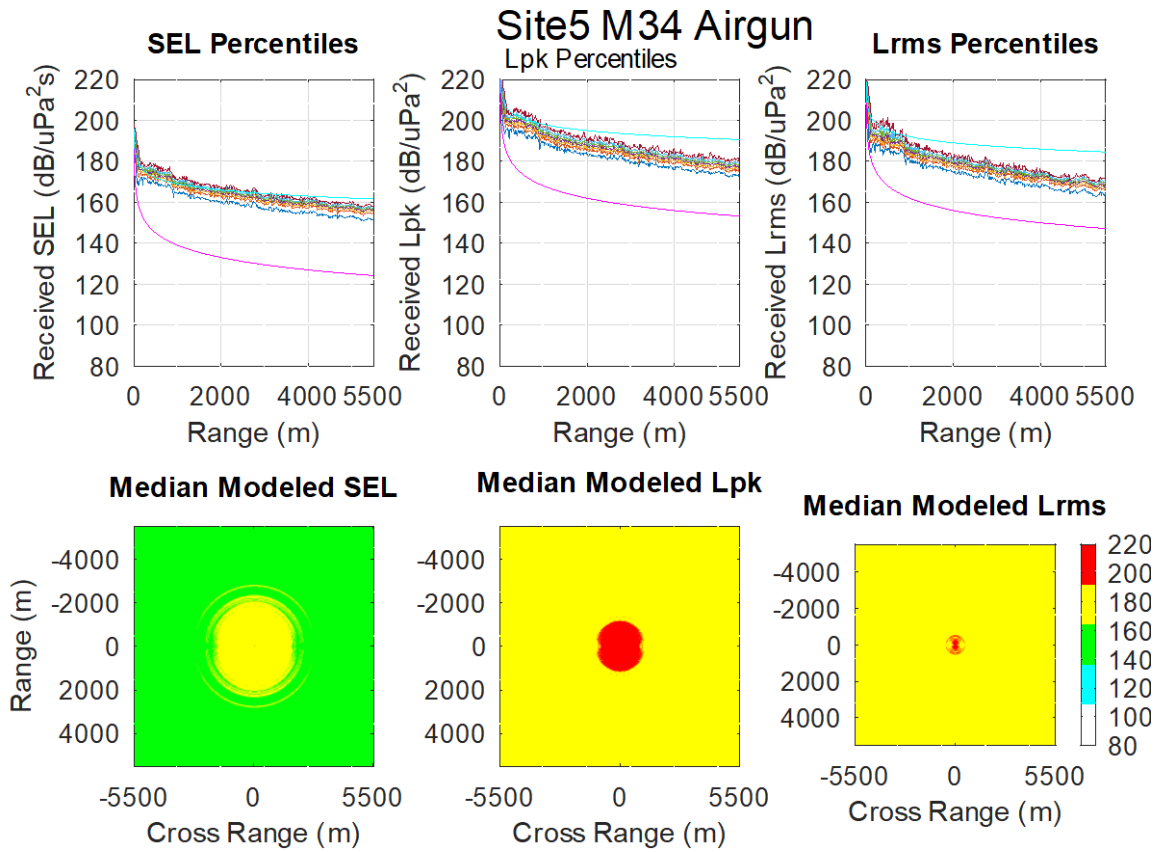


Figure 5-203. Mini GI Airgun Mode 34 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.35 Sercel Mini GI (30/30), Single Airgun #1, No Insert, 24-second Shot Rate (Mode 35)

The Mini GI Airgun is a small LF seismic source developed to reduce or suppress bubble oscillations common with traditional seismic airguns. Measured source levels are shown in **Table 5-35**.

Table 5-35. NUWC tank measurements of Mini GI Airgun (Mode 35)

Source Settings				Source Level			
Power Level (J)	Pressure (MPa)	Pressure (psi)	Depth (m)	Peak-to-Peak (dB re 1 $\mu\text{Pa m}$)	Peak (dB re 1 $\mu\text{Pa m}$)	rms (dB re 1 $\mu\text{Pa m}$)	SEL (dB re 1 $\mu\text{Pa}^2 \text{m}^2 \text{s}$)
1	15.5	2,250	3.0	233	228	222	199

μPa = micropascal; dB = decibel; J = joule; m = meter; MPa = megapascal; NUWC = Naval Undersea Warfare Center; psi = pounds of force per square inch; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-204**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-35**. Modeling results for each site are shown in **Figures 5-205 to 5-209**.

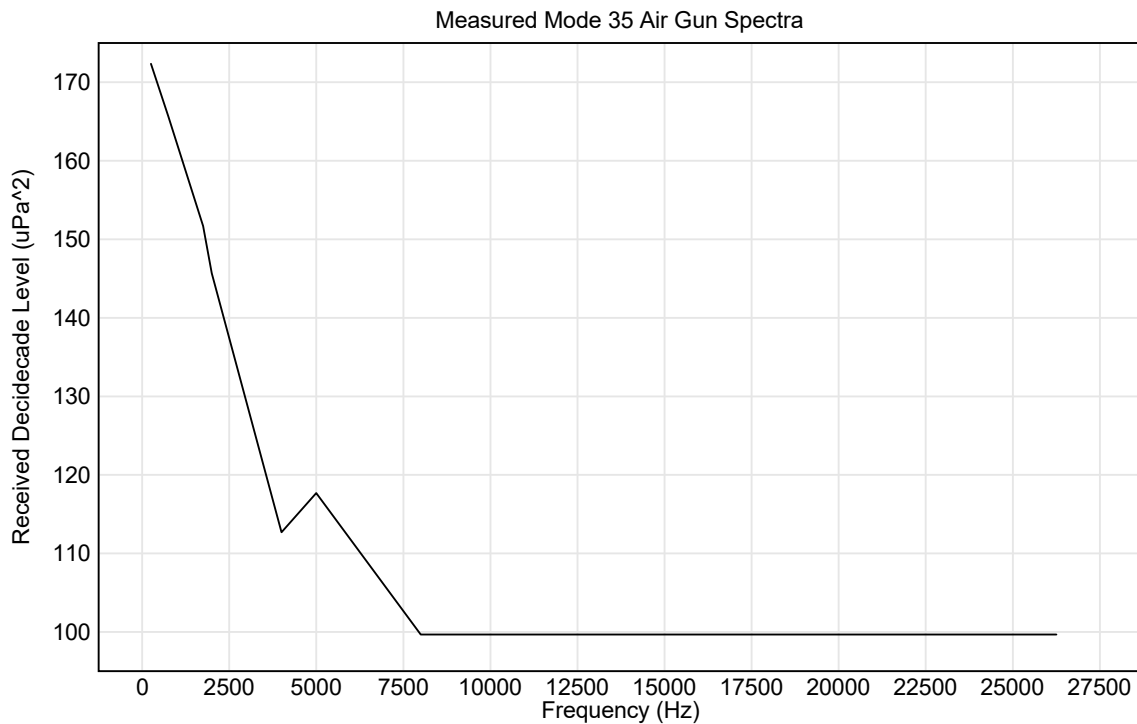


Figure 5-204. Mini GI Airgun Mode 35 measured spectra at buoy position D

μPa = micropascal; Hz = hertz.

5.35.1 Site 1 – Mud, 10-m Depth

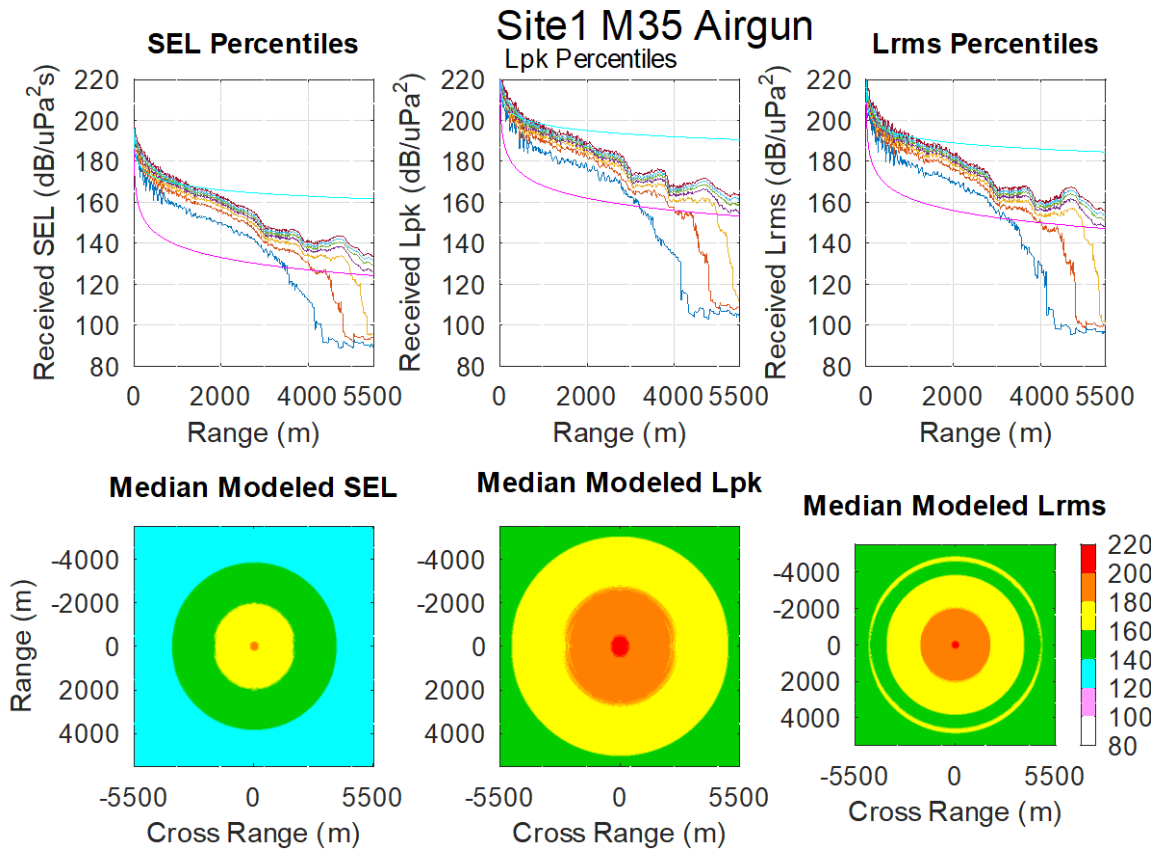


Figure 5-205. Mini GI Airgun Mode 35 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.35.2 Site 2 – Sand, 10-m Depth

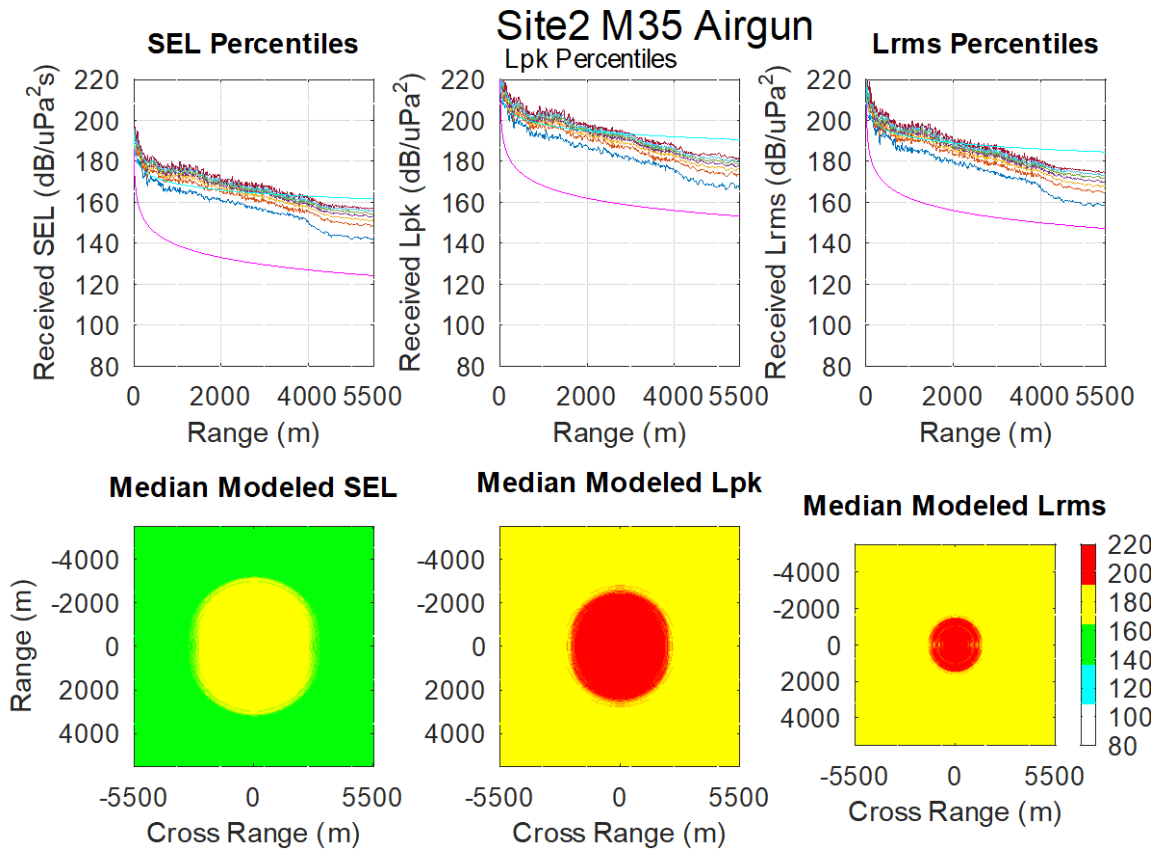


Figure 5-206. Mini GI Airgun Mode 35 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.35.3 Site 3 – Mud, 30-m Depth

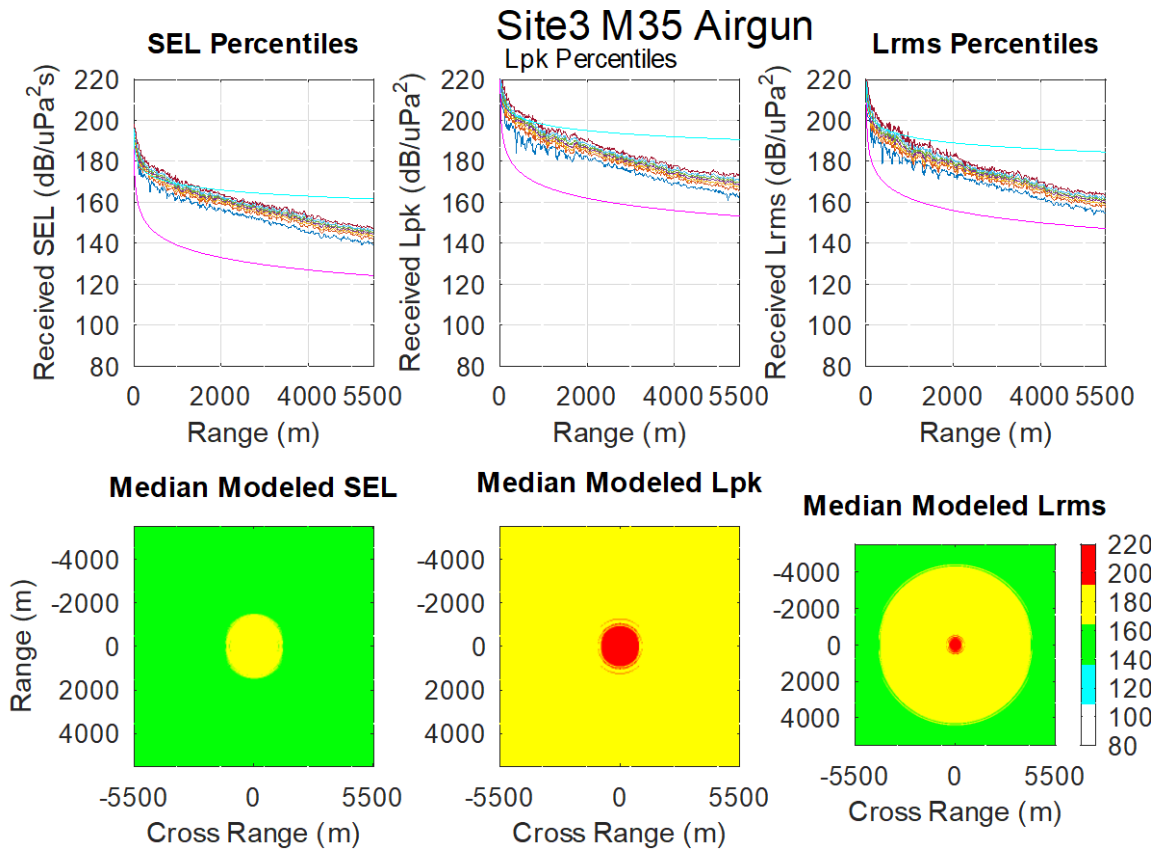


Figure 5-207. Mini GI Airgun Mode 35 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.35.4 Site 4 – Sand, 30-m Depth

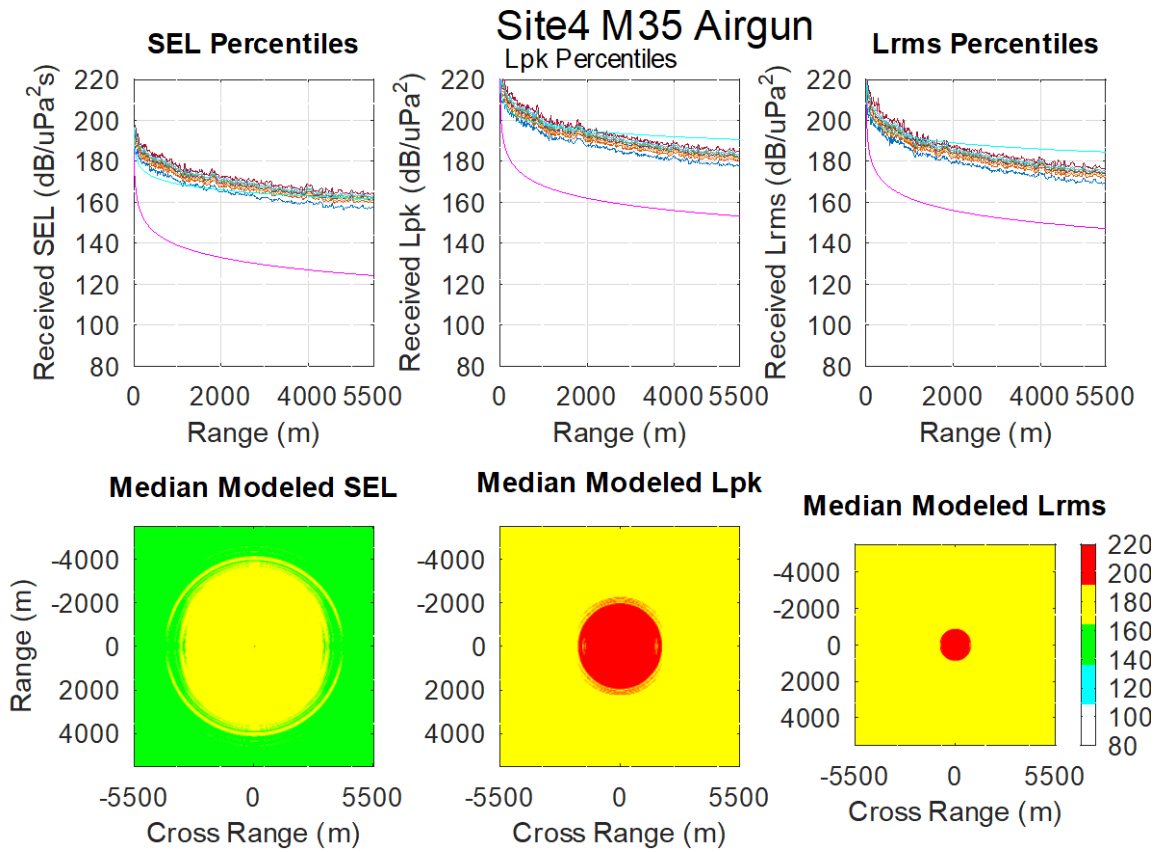


Figure 5-208. Mini GI Airgun Mode 35 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.35.5 Site 5 – Sandy Silt, 100-m Depth

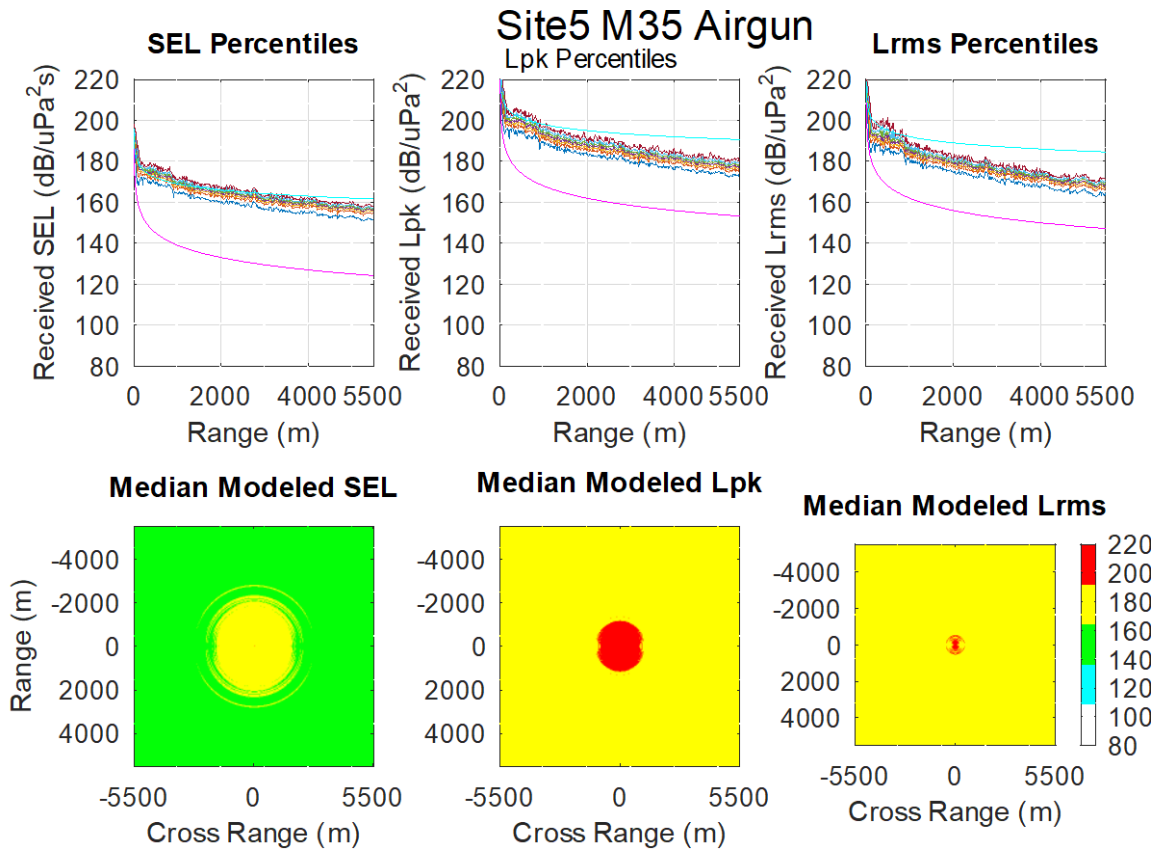


Figure 5-209. Mini GI Airgun Mode 35 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.36 Sercel Mini GI (30/30), Single Airgun #2, No Insert, 24-second Shot Rate (Mode 36)

The Mini GI Airgun is a small LF seismic source developed to reduce or suppress bubble oscillations common with traditional seismic airguns. Measured source levels are shown in **Table 5-36**.

Table 5-36. NUWC tank measurements of Mini GI Airgun (Mode 36)

Source Settings				Source Level			
Power Level (J)	Pressure (MPa)	Pressure (psi)	Depth (m)	Peak-to-Peak (dB re 1 $\mu\text{Pa m}$)	Peak (dB re 1 $\mu\text{Pa m}$)	rms (dB re 1 $\mu\text{Pa m}$)	SEL (dB re 1 $\mu\text{Pa}^2 \text{ m}^2 \text{ s}$)
1	15.5	2,250	3.0	233	228	222	199

μPa = micropascal; dB = decibel; J = joule; m = meter; MPa = megapascal; NUWC = Naval Undersea Warfare Center; psi = pounds of force per square inch; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level. From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-210**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-36**. Modeling results for each site are shown in **Figures 5-211 to 5-215**.

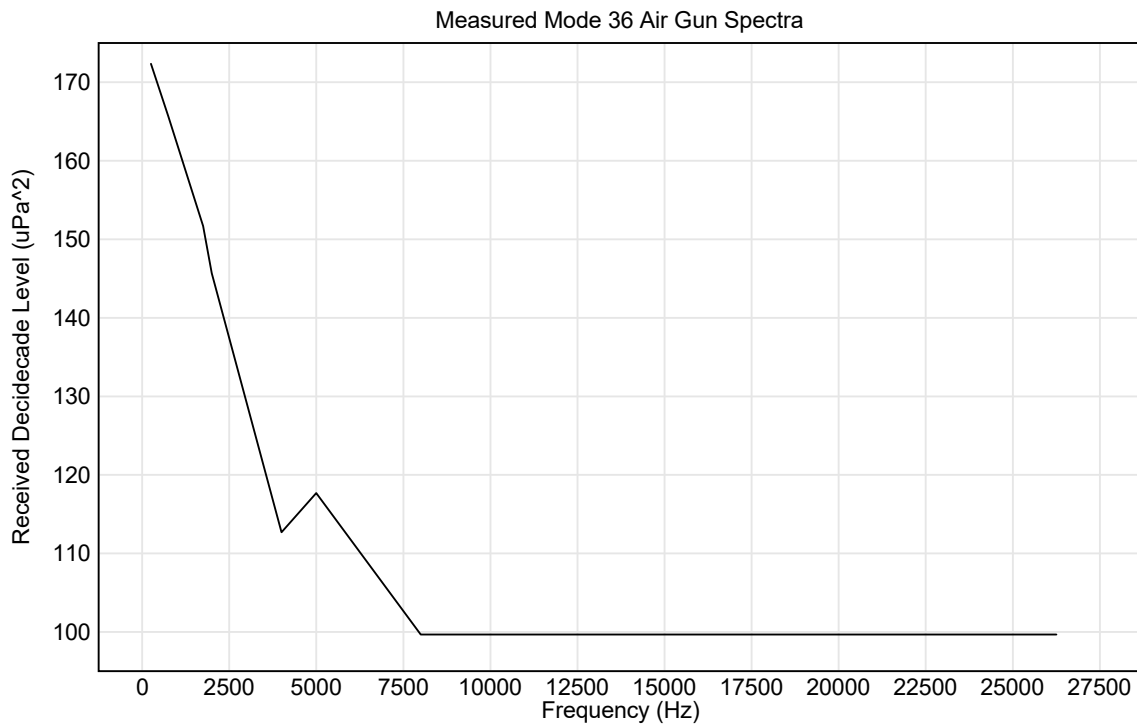


Figure 5-210. Mini GI Airgun Mode 36 measured spectra at buoy position D

μPa = micropascal; Hz = hertz.

5.36.1 Site 1 – Mud, 10-m Depth

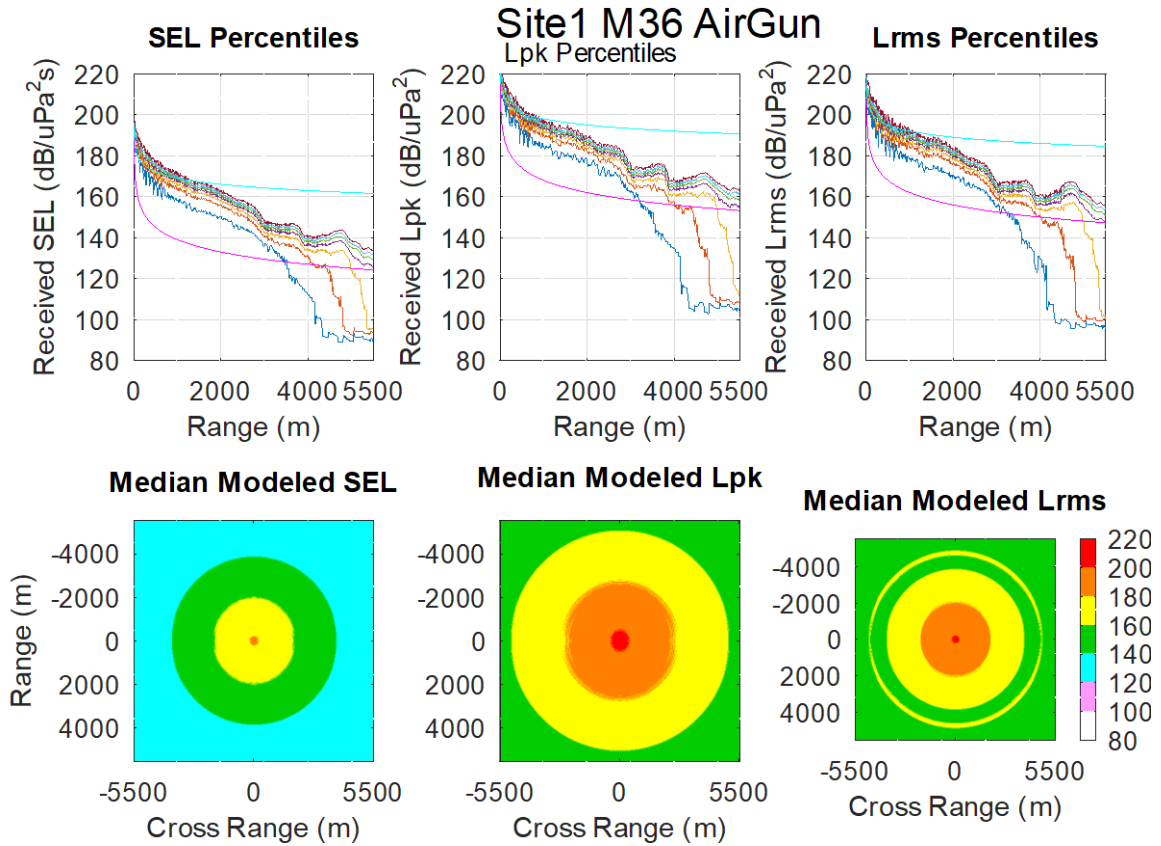


Figure 5-211. Mini GI Airgun Mode 36 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.36.2 Site 2 – Sand, 10-m Depth

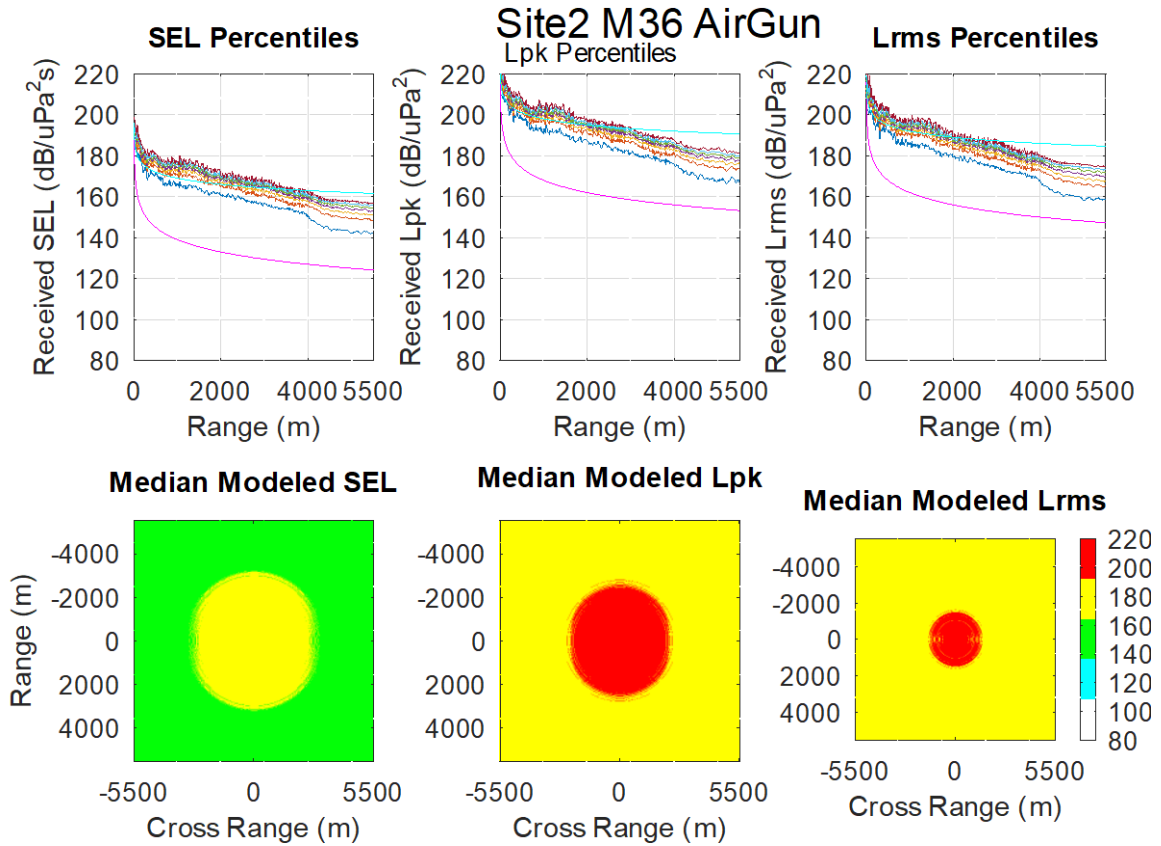


Figure 5-212. Mini GI Airgun Mode 36 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.36.3 Site 3 – Mud, 30-m Depth

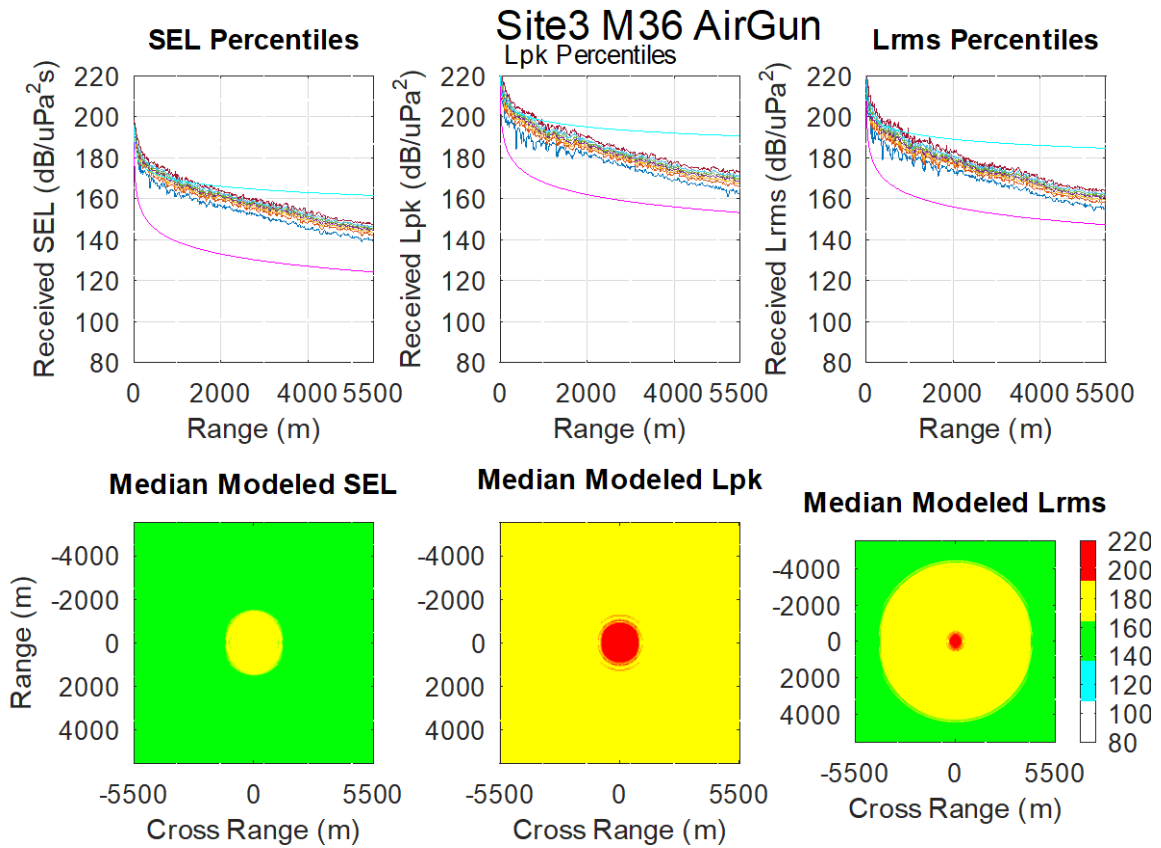


Figure 5-213. Mini GI Airgun Mode 36 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.36.4 Site 4 – Sand, 30-m Depth

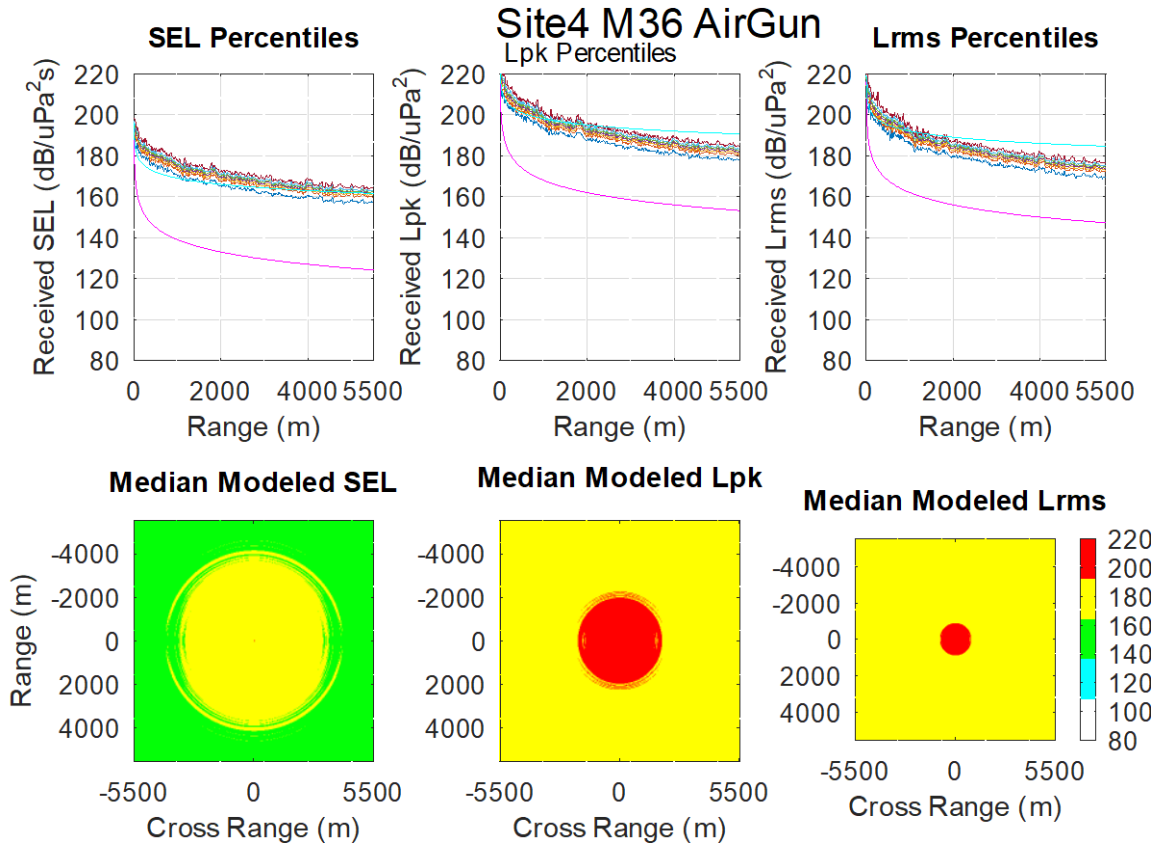


Figure 5-214. Mini GI Airgun Mode 36 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.36.5 Site 5 – Sandy Silt, 100-m Depth

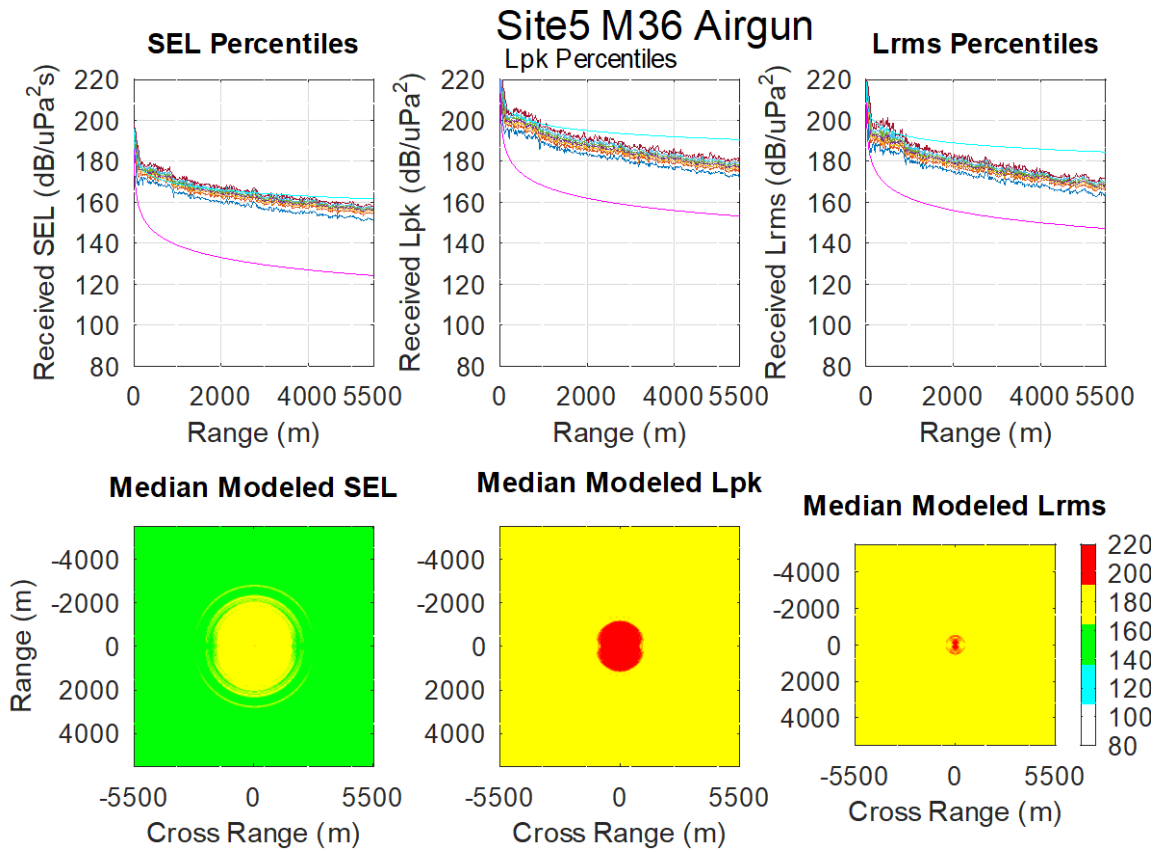


Figure 5-215. Mini GI Airgun Mode 36 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.37 Sercel Mini GI (30/30), Single Airgun, 15-inch³ Inserts, 8-second Shot Rate (Mode 37)

The Mini GI Airgun is a small LF seismic source developed to reduce or suppress bubble oscillations common with traditional seismic airguns. Measured source levels are shown in **Table 5-37**.

Table 5-37. NUWC tank measurements of Mini GI Airgun (Mode 37)

Source Settings				Source Level			
Power Level (J)	Pressure (MPa)	Pressure (psi)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
1	15.5	2,250	3.0	233	228	222	199

μ Pa = micropascal; dB = decibel; J = joule; m = meter; MPa = megapascal; NUWC = Naval Undersea Warfare Center; psi = pounds of force per square inch; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-216**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-37**. Modeling results for each site are shown in **Figures 5-217 to 5-221**.

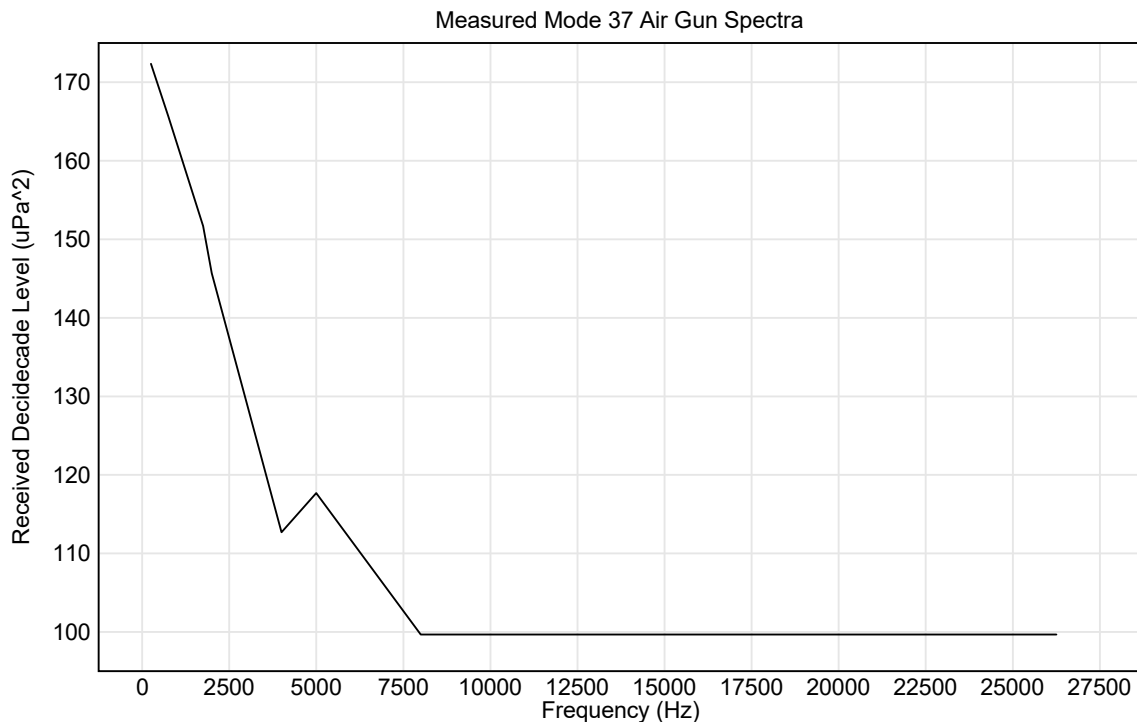


Figure 5-216. Mini GI Airgun Mode 37 measured spectra at buoy position D

μ Pa = micropascal; Hz = hertz.

5.37.1 Site 1 – Mud, 10-m Depth

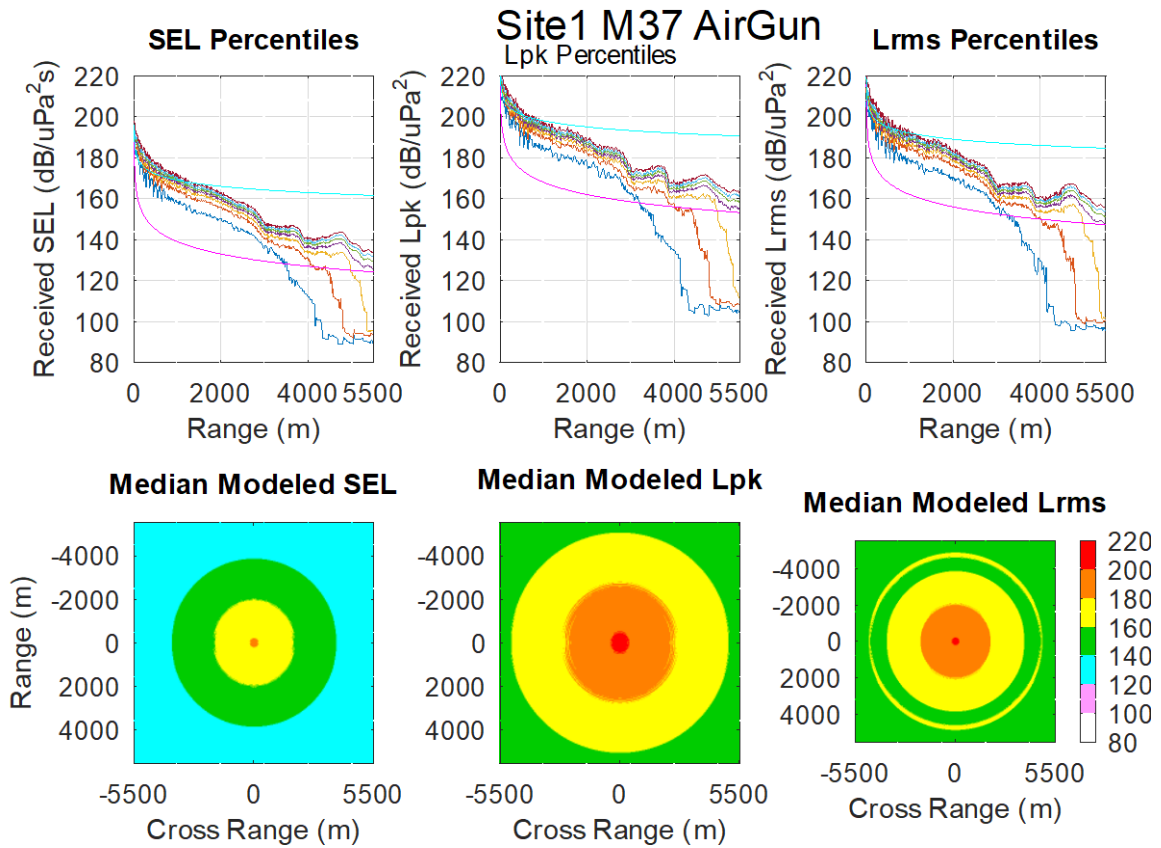


Figure 5-217. Mini GI Airgun Mode 37 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.37.2 Site 2 – Sand, 10-m Depth

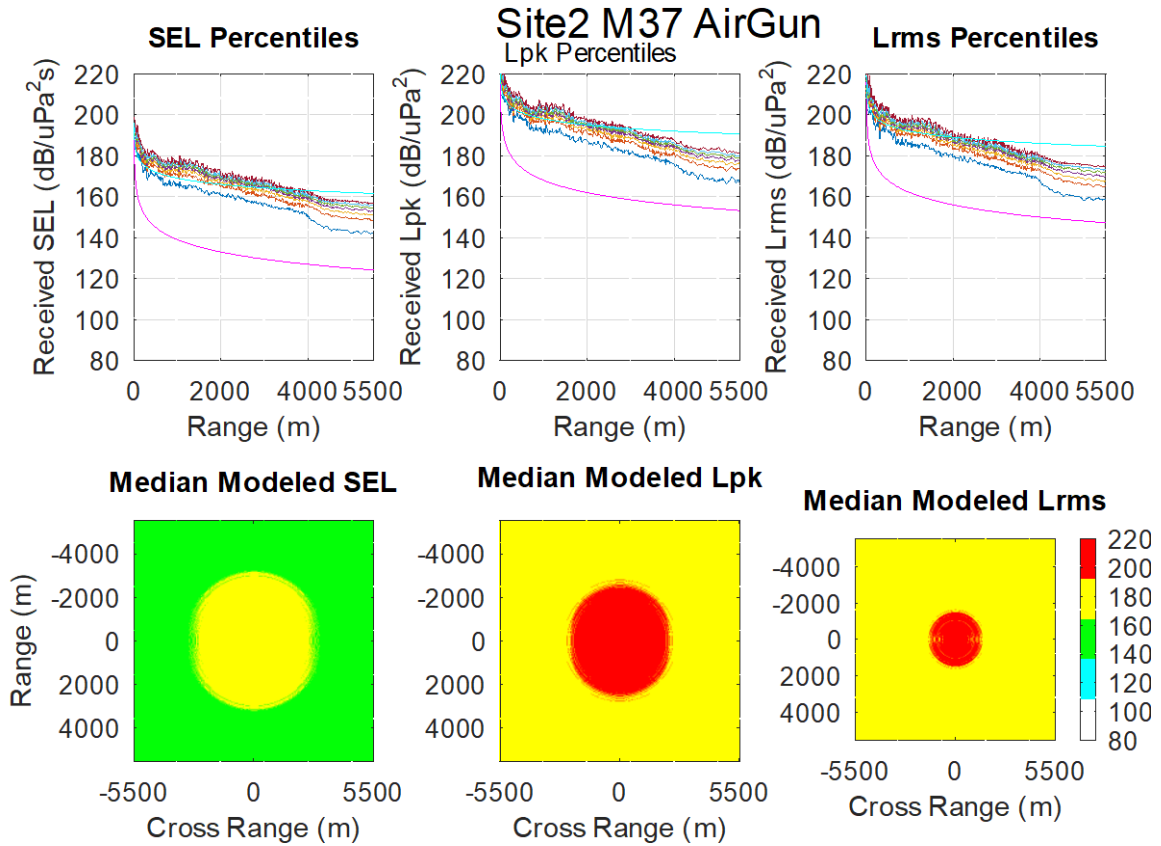


Figure 5-218. Mini GI Airgun Mode 37 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.37.3 Site 3 – Mud, 30-m Depth

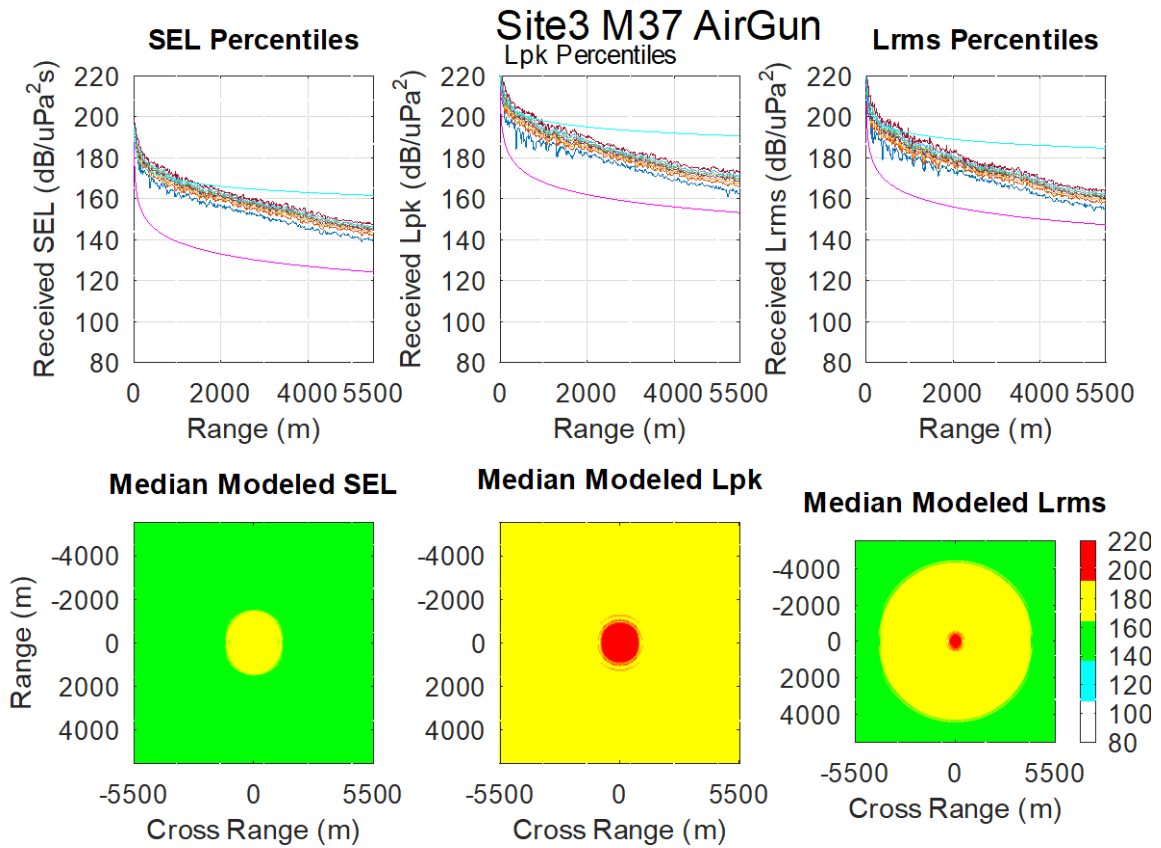


Figure 5-219. Mini GI Airgun Mode 37 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.37.4 Site 4 – Sand, 30-m Depth

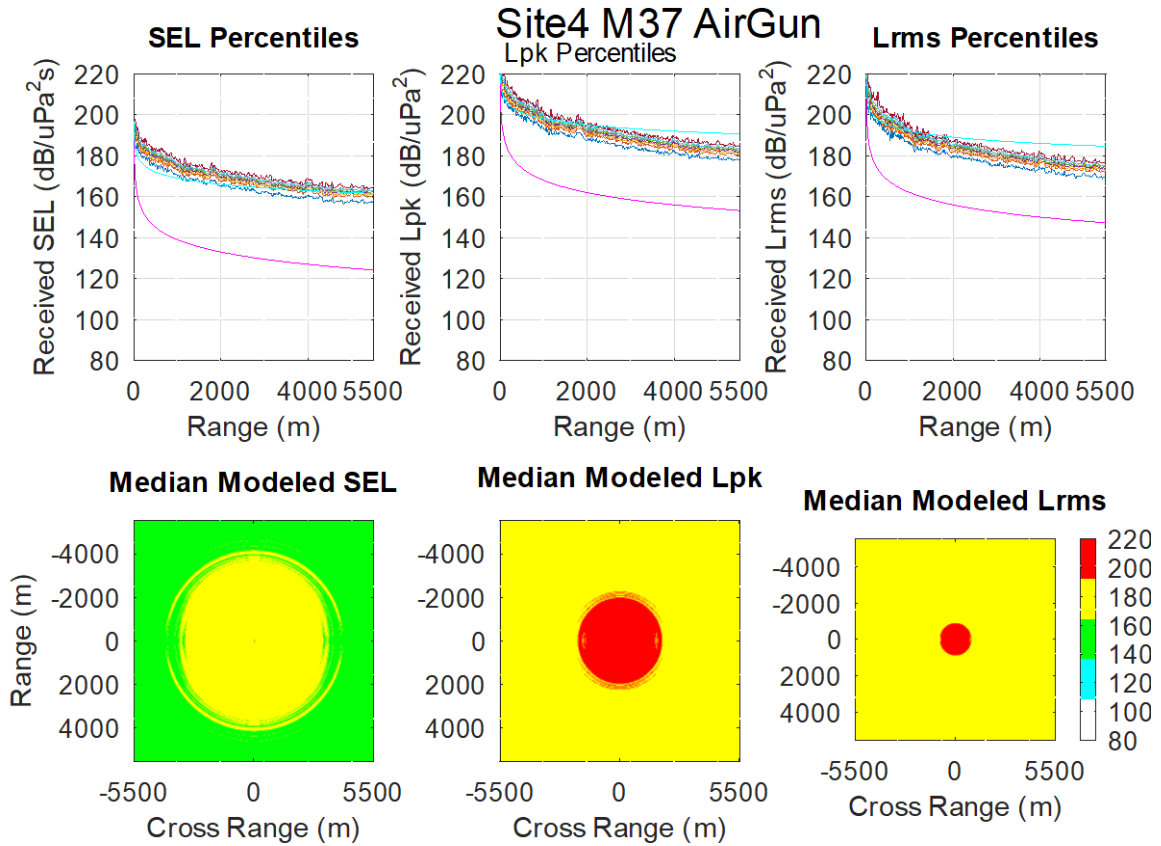


Figure 5-220. Mini GI Airgun Mode 37 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.37.5 Site 5 – Sandy Silt, 100-m Depth

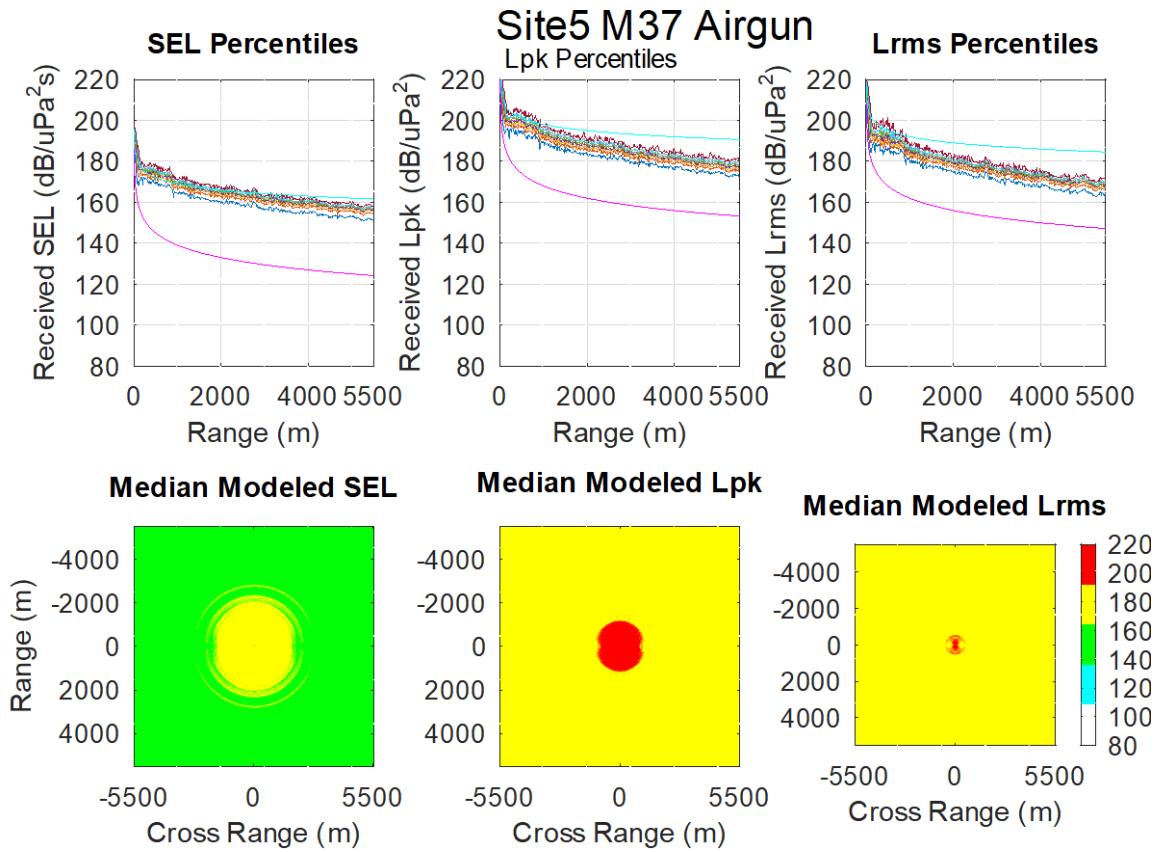


Figure 5-221. Mini GI Airgun Mode 37 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.38 Sercel Mini GI (30/30), Single Airgun #1, Full 30/30, No Insert, 24-second Shot Rate (Mode 38)

The Mini GI Airgun is a small LF seismic source developed to reduce or suppress bubble oscillations common with traditional seismic airguns. Measured source levels are shown in **Table 5-38**.

Table 5-38. NUWC tank measurements of Mini GI Airgun (Mode 38)

Source Settings				Source Level			
Power Level (J)	Pressure (MPa)	Pressure (psi)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
1	15.5	2,250	3.0	233	228	222	199

μ Pa = micropascal; dB = decibel; J = joule; m = meter; MPa = megapascal; NUWC = Naval Undersea Warfare Center; psi = pounds of force per square inch; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level. From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-222**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-38**. Modeling results for each site are shown in **Figures 5-223 to 5-227**.

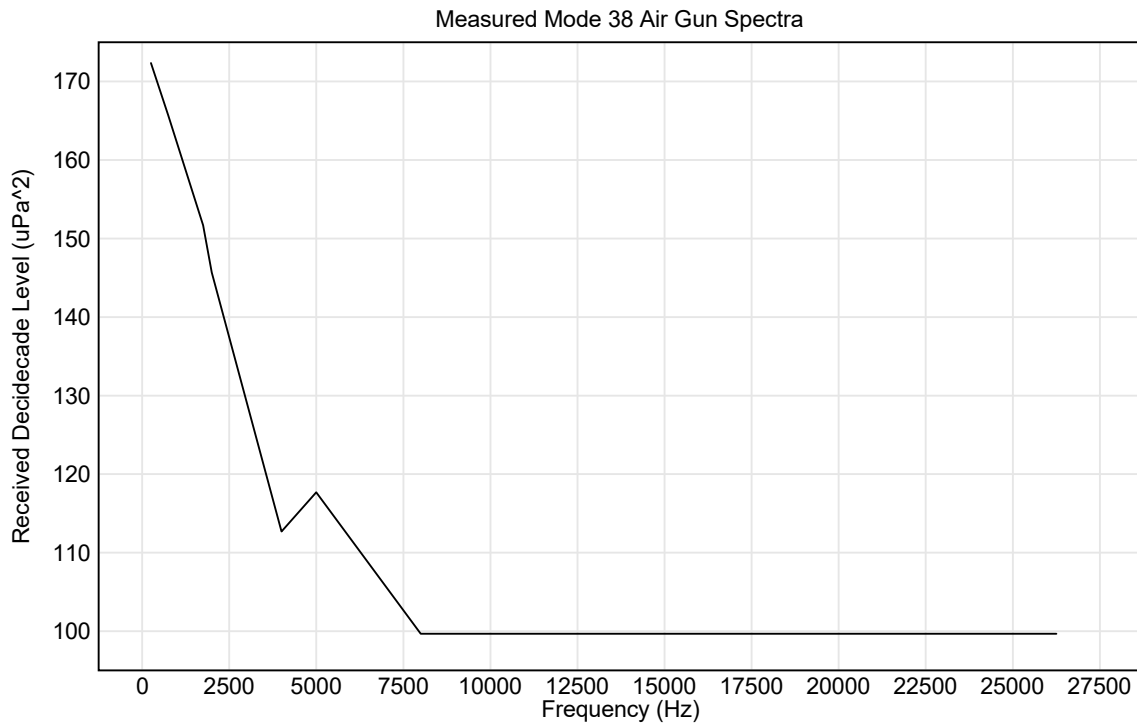


Figure 5-222. Mini GI Airgun Mode 38 measured spectra at buoy position D
 μ Pa = micropascal; Hz = hertz.

5.38.1 Site 1 – Mud, 10-m Depth

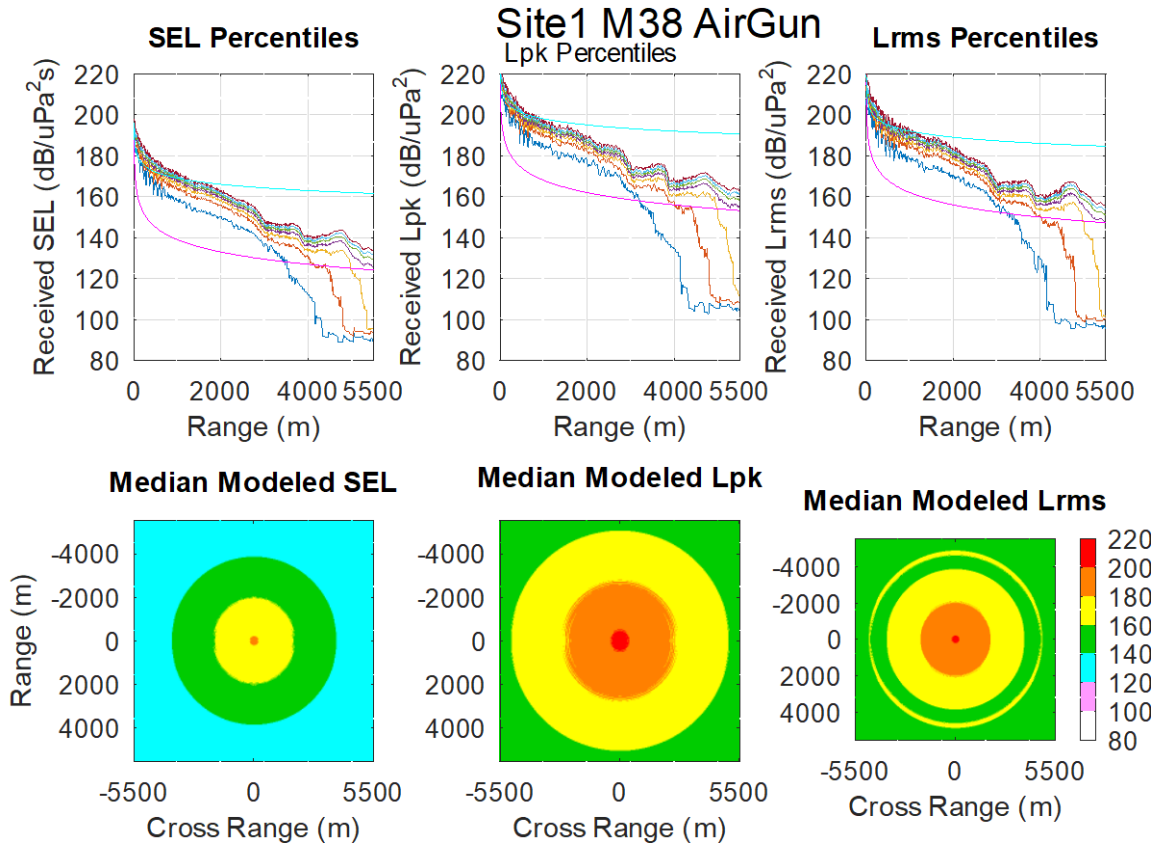


Figure 5-223. Mini GI Airgun Mode 38 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.38.2 Site 2 – Sand, 10-m Depth

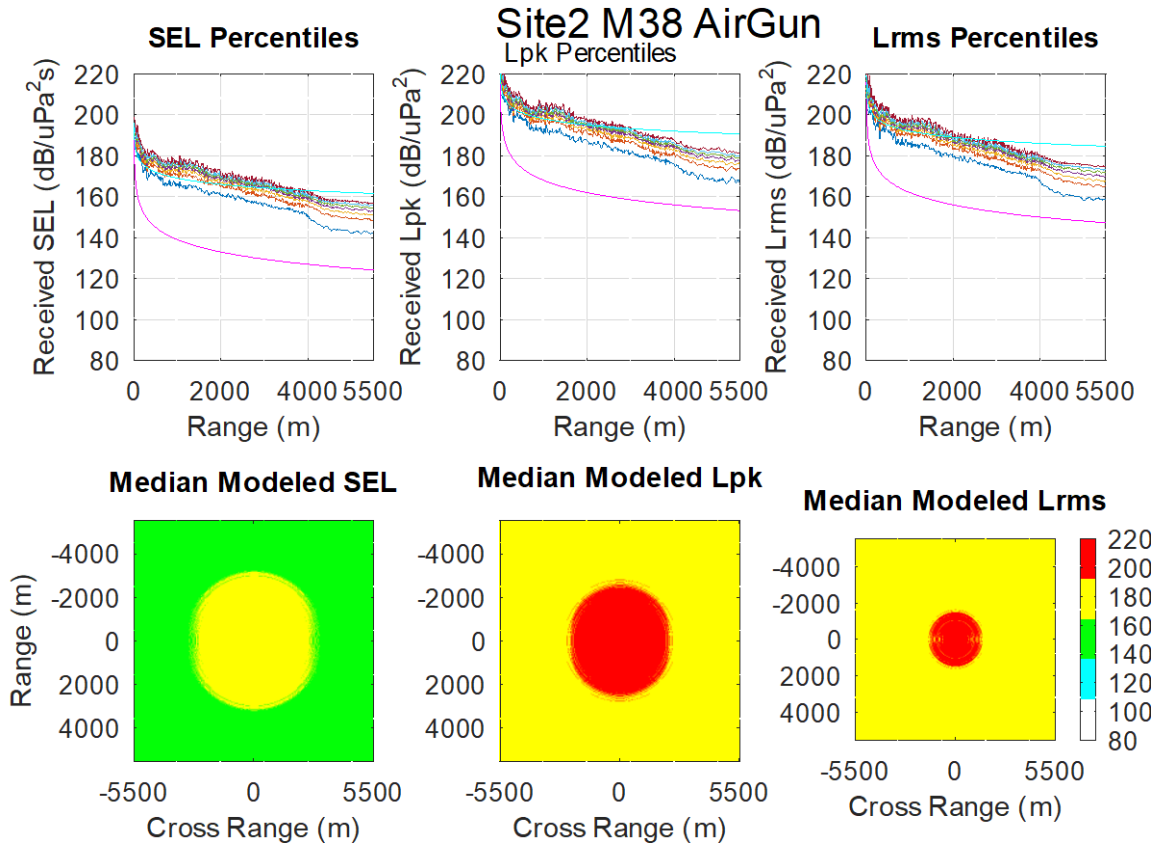


Figure 5-224. Mini GI Airgun Mode 38 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.38.3 Site 3 – Mud, 30-m Depth

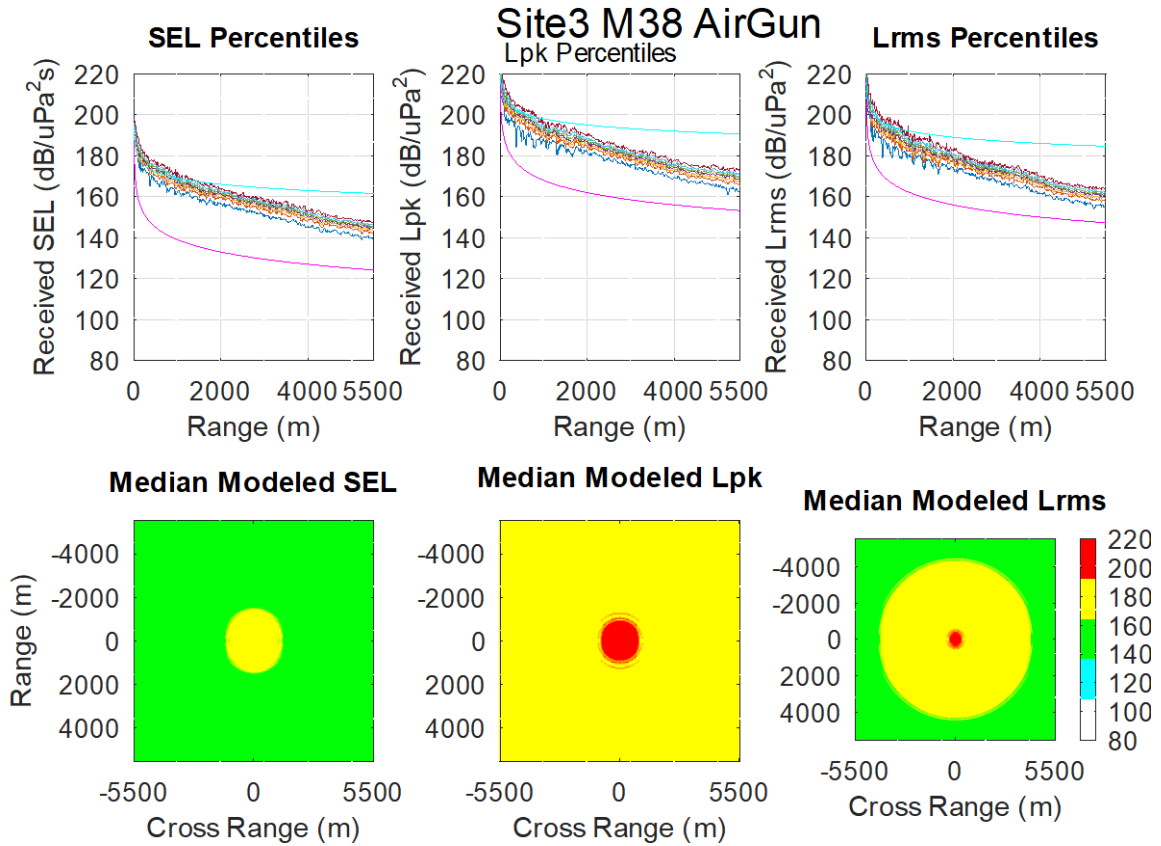


Figure 5-225. Mini GI Airgun Mode 38 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.38.4 Site 4 – Sand, 30-m Depth

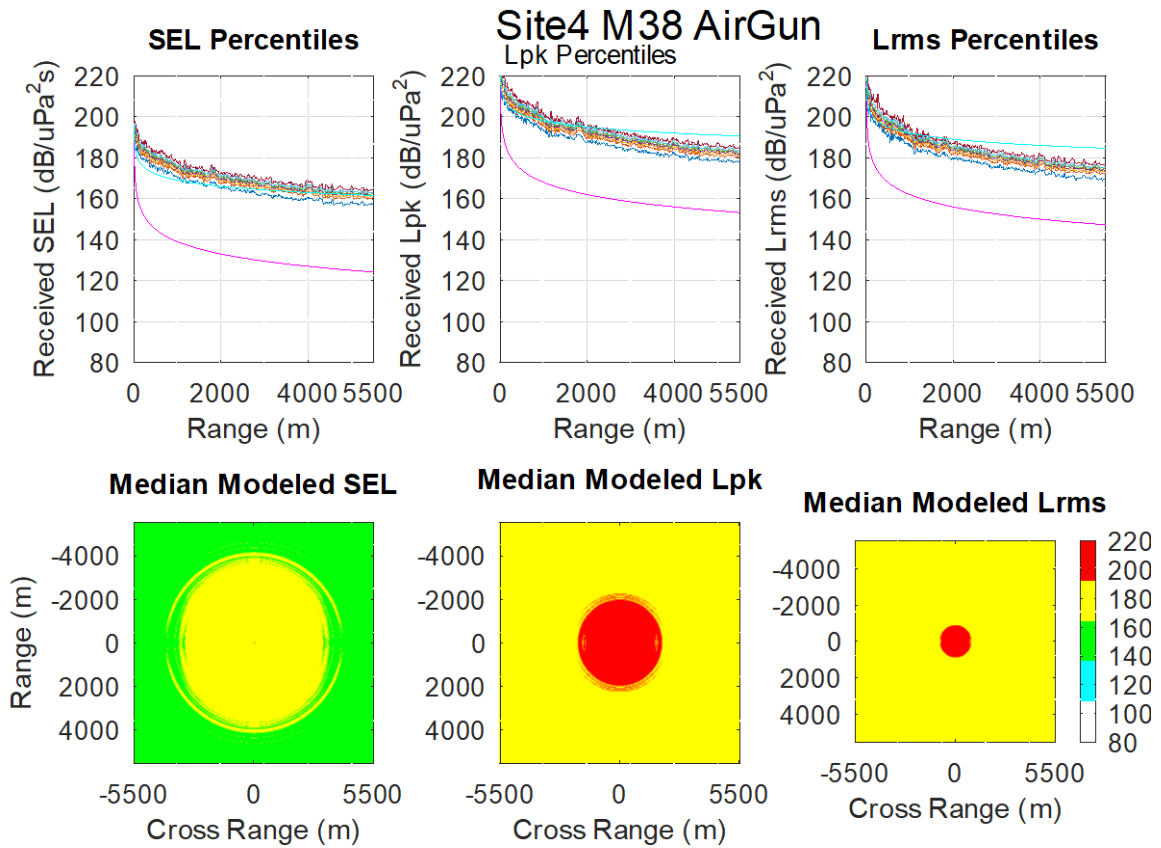


Figure 5-226. Mini GI Airgun Mode 38 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.38.5 Site 5 – Sandy Silt, 100-m Depth

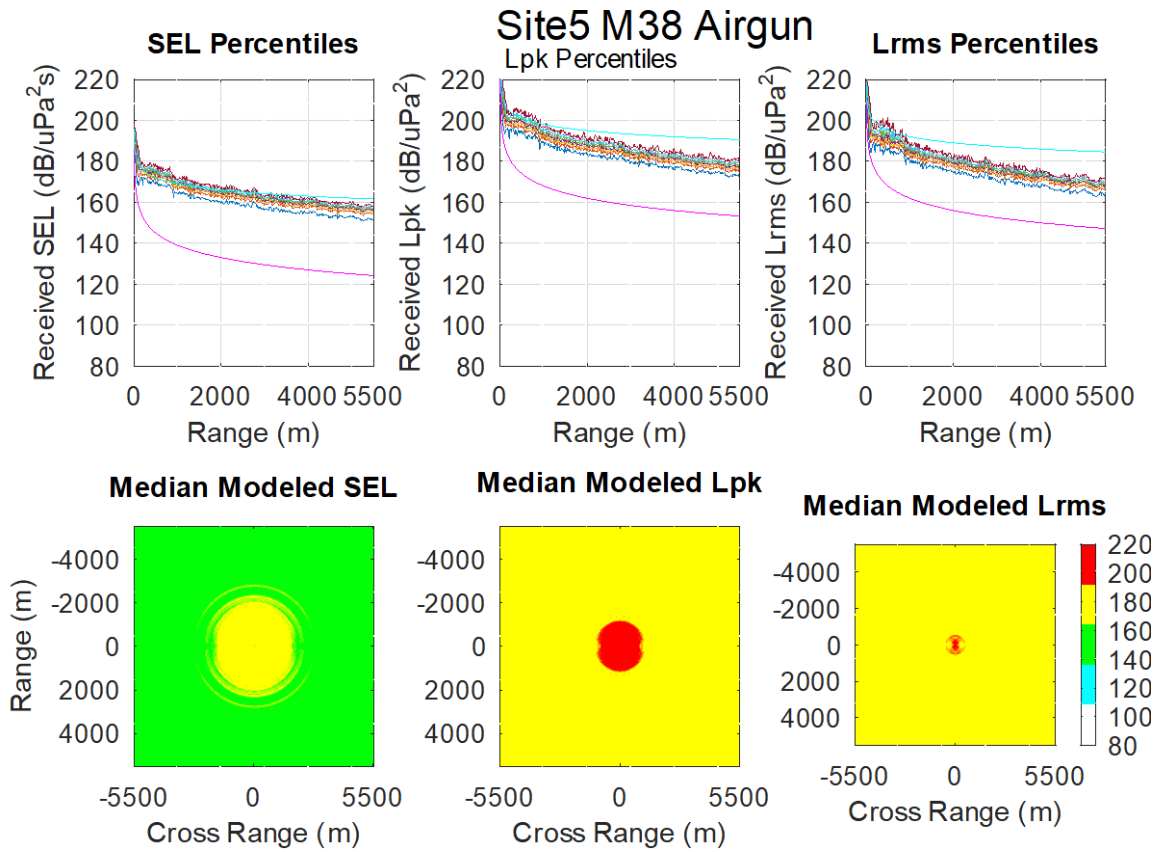


Figure 5-227. Mini GI Airgun Mode 38 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.39 Applied Acoustics Delta Sparker, 2.4 kJ, Low Power (Mode 39)

The Applied Acoustics Delta Sparker is a high-capacity LF source employing six electrodes arranged as three pairs along the length of the 2.5-m long tow frame. Measured source levels are shown in **Table 5-39**.

Table 5-39. NUWC tank measurements of Delta Sparker (Mode 39)

Source Settings		Source Level			
Power Level (J)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
2,400	1	224	221	205	185

μ Pa = micropascal; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decade band energy level at the CPA (buoy position D) is shown in **Figure 5-228**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-39**. Modeling results for each site are shown in **Figures 5-229 to 5-233**.

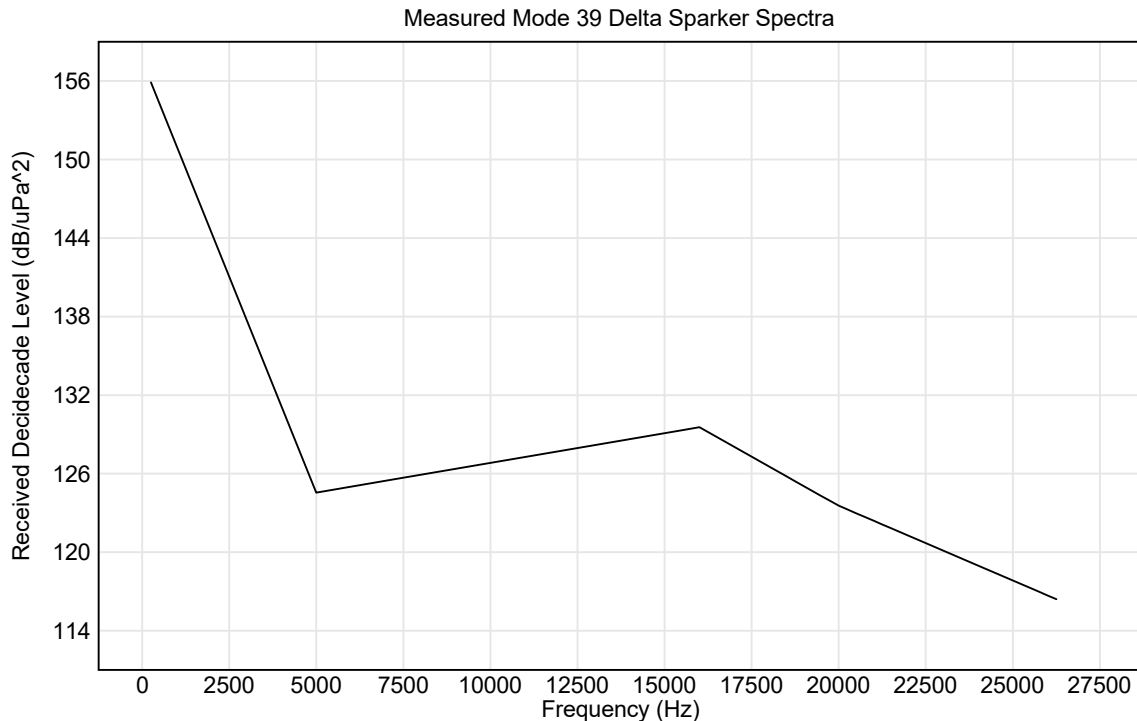


Figure 5-228. Delta Sparker Mode 39 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz.

5.39.1 Site 1 – Mud, 10-m Depth

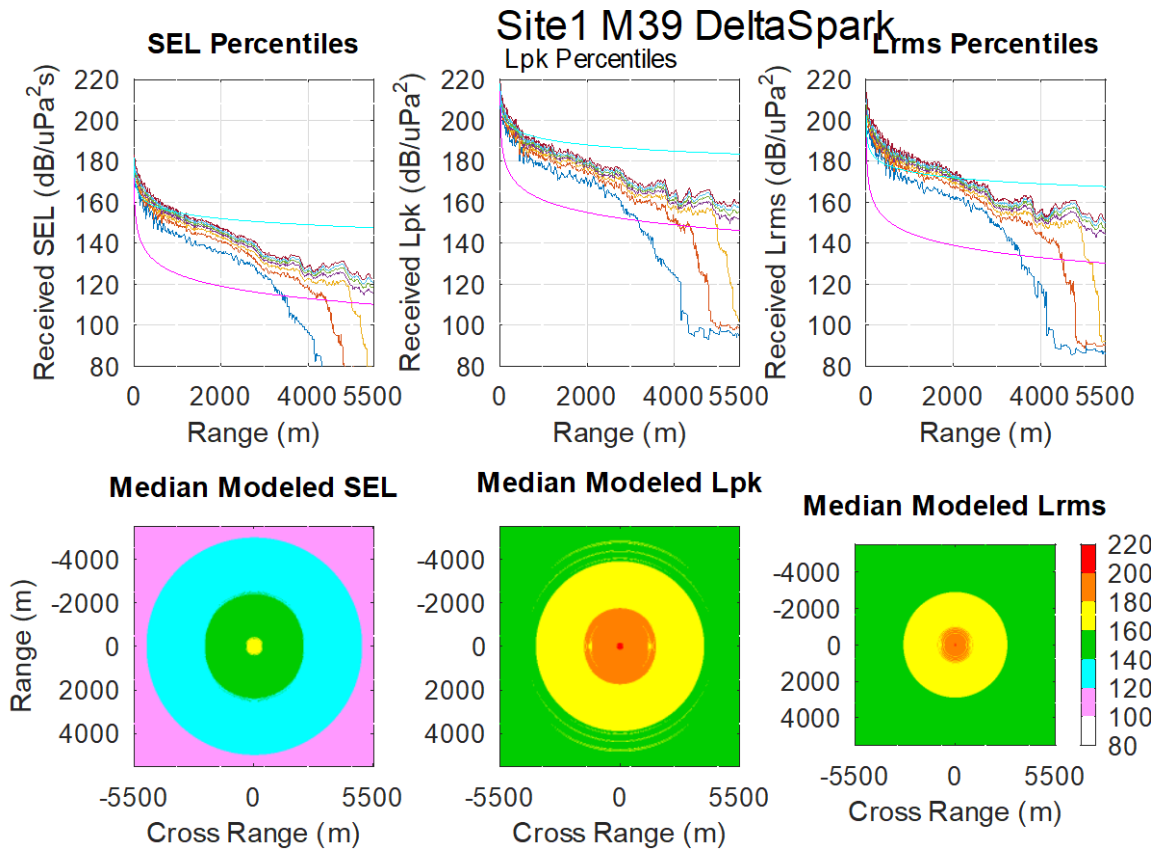


Figure 5-229. Delta Sparker Mode 39 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.39.2 Site 2 – Sand, 10-m Depth

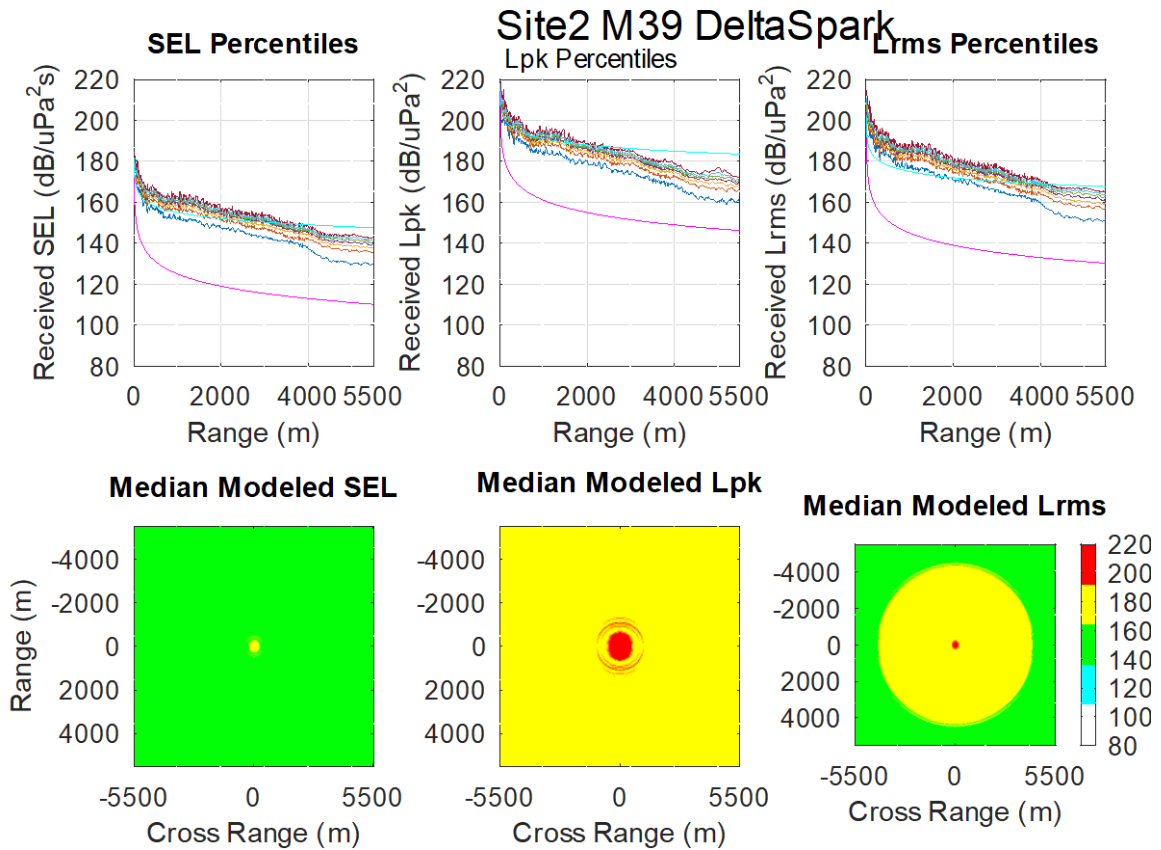


Figure 5-230. Delta Sparker Mode 39 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.39.3 Site 3 – Mud, 30-m Depth

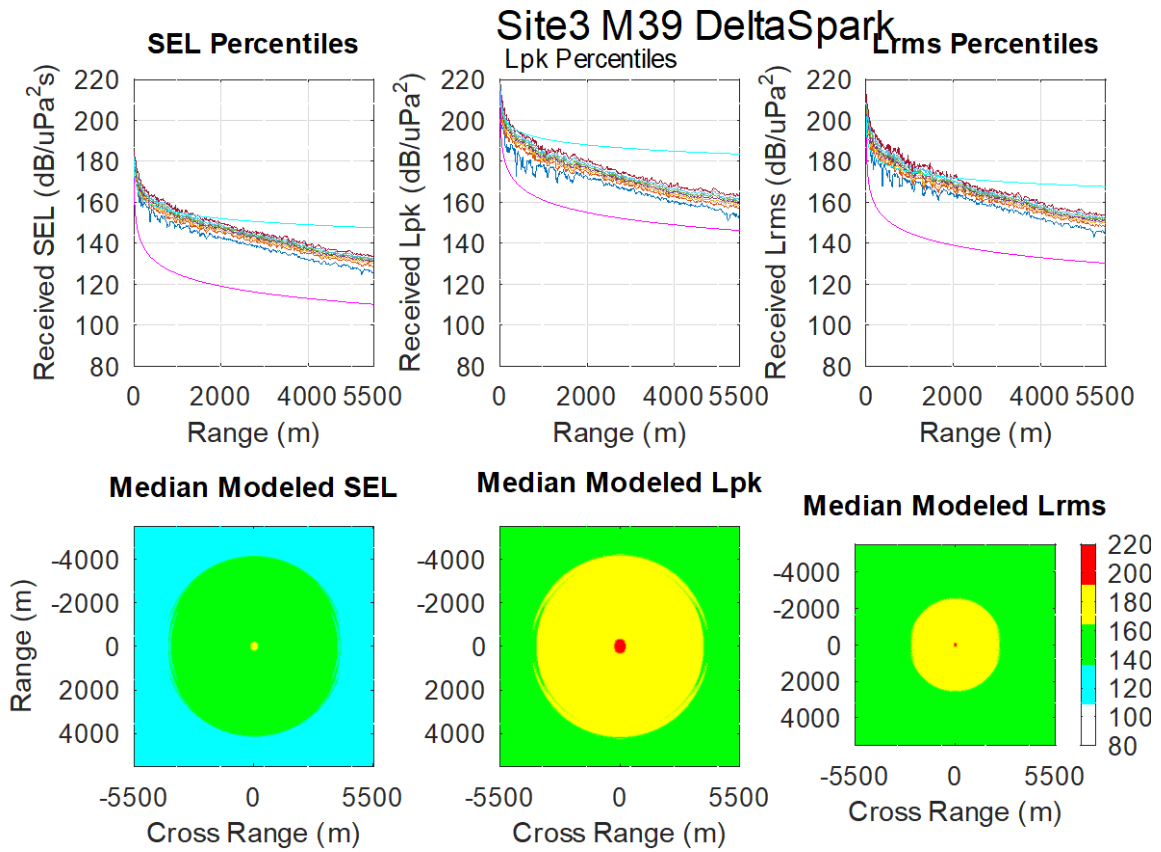


Figure 5-231. Delta Sparker Mode 39 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.39.4 Site 4 – Sand, 30-m Depth

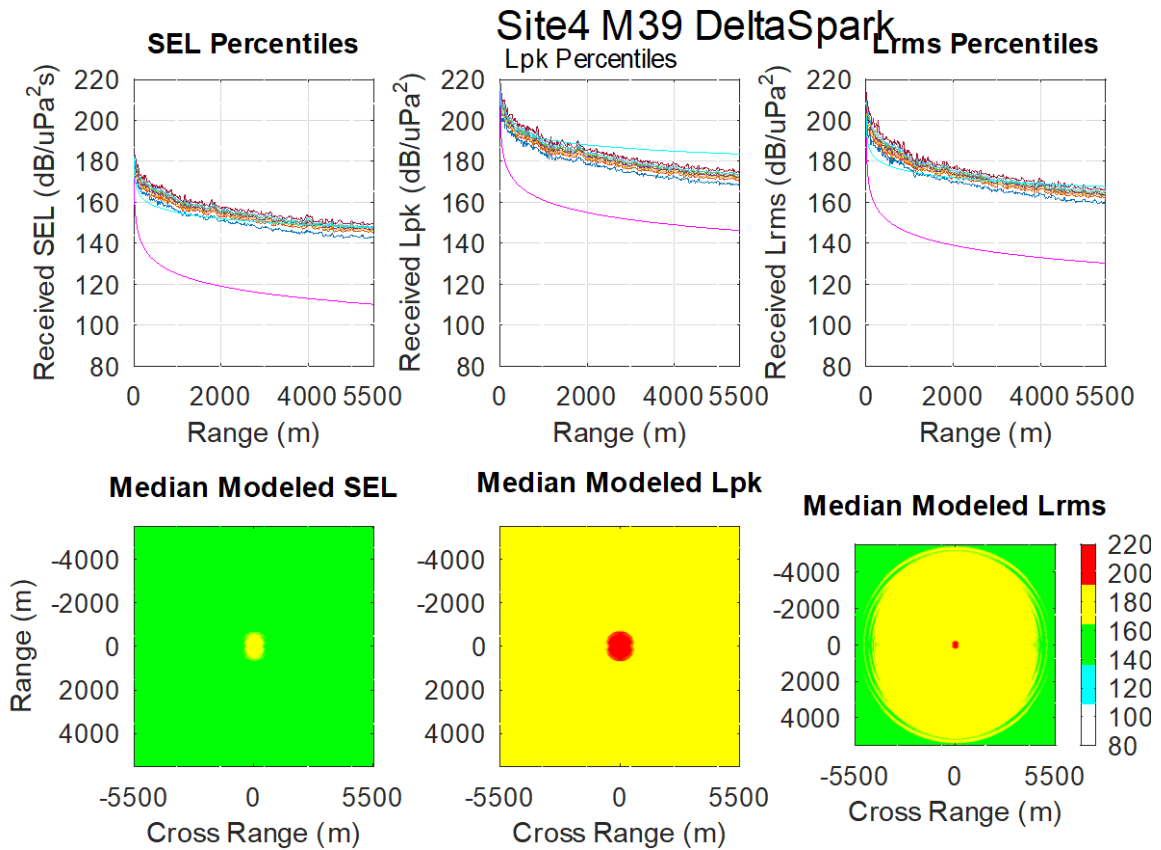


Figure 5-232. Delta Sparker Mode 39 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.39.5 Site 5 – Sandy Silt, 100-m Depth

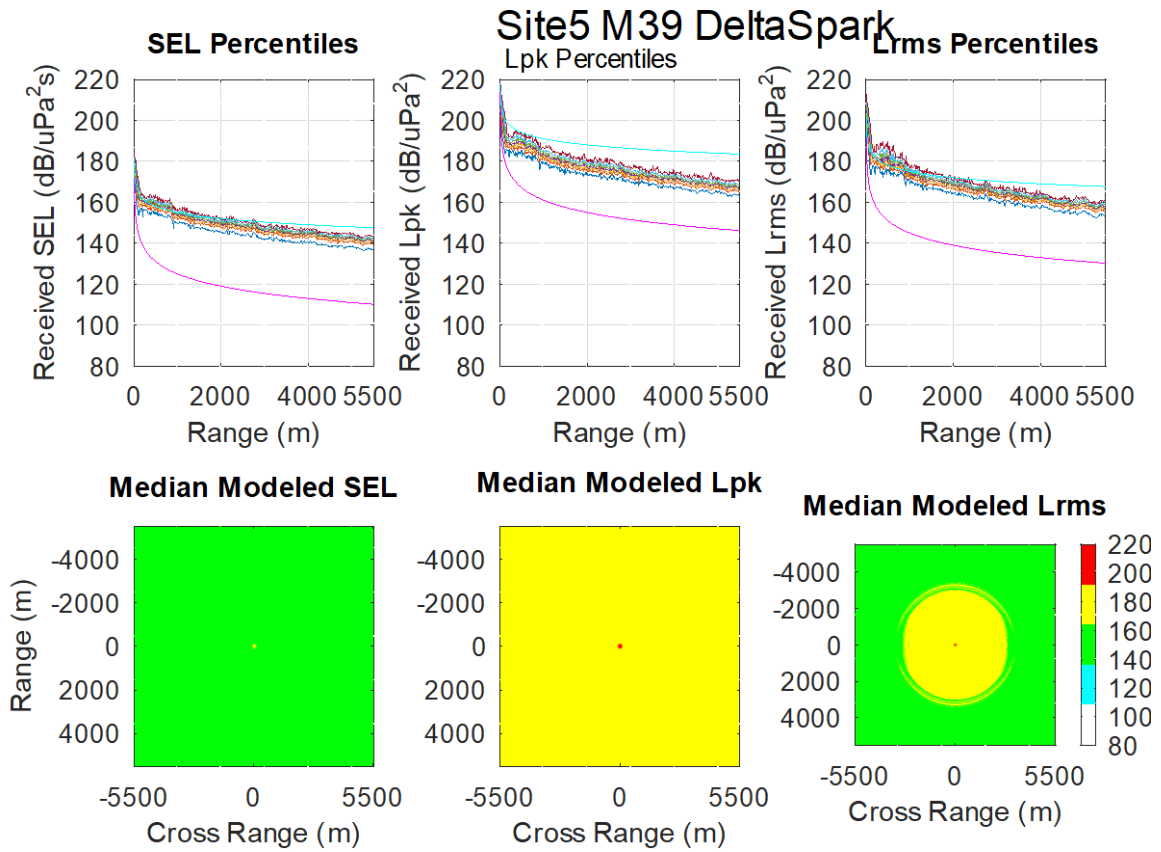


Figure 5-233. Delta Sparker Mode 39 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.40 Applied Acoustics Delta Sparker, 1.5 kJ, Low Power (Mode 40)

The Applied Acoustics Delta Sparker is a high-capacity LF source employing six electrodes arranged as three pairs along the length of the 2.5-m long tow frame. Measured source levels are shown in **Table 5-40**.

Table 5-40. NUWC tank measurements of Delta Sparker (Mode 40)

Source Settings		Source Level			
Power Level (J)	Depth (m)	Peak-to-Peak (dB re 1 μ Pa m)	Peak (dB re 1 μ Pa m)	rms (dB re 1 μ Pa m)	SEL (dB re 1 μ Pa ² m ² s)
1,500	1	223	220	204	183

μ Pa = micropascal; dB = decibel; J = joule; m = meter; NUWC = Naval Undersea Warfare Center; re = with reference to; rms = root-mean-square; s = second; SEL = sound exposure level.
From: Crocker and Fratantonio, 2016.

The measured decidecade band energy level at the CPA (buoy position D) is shown in **Figure 5-234**. This frequency weighting was applied to the propagation model to build the modeled time series. The modeled source level (after frequency weighting) was normalized to match the measured levels in **Table 5-40**. Modeling results for each site are shown in **Figures 5-235 to 5-239**.

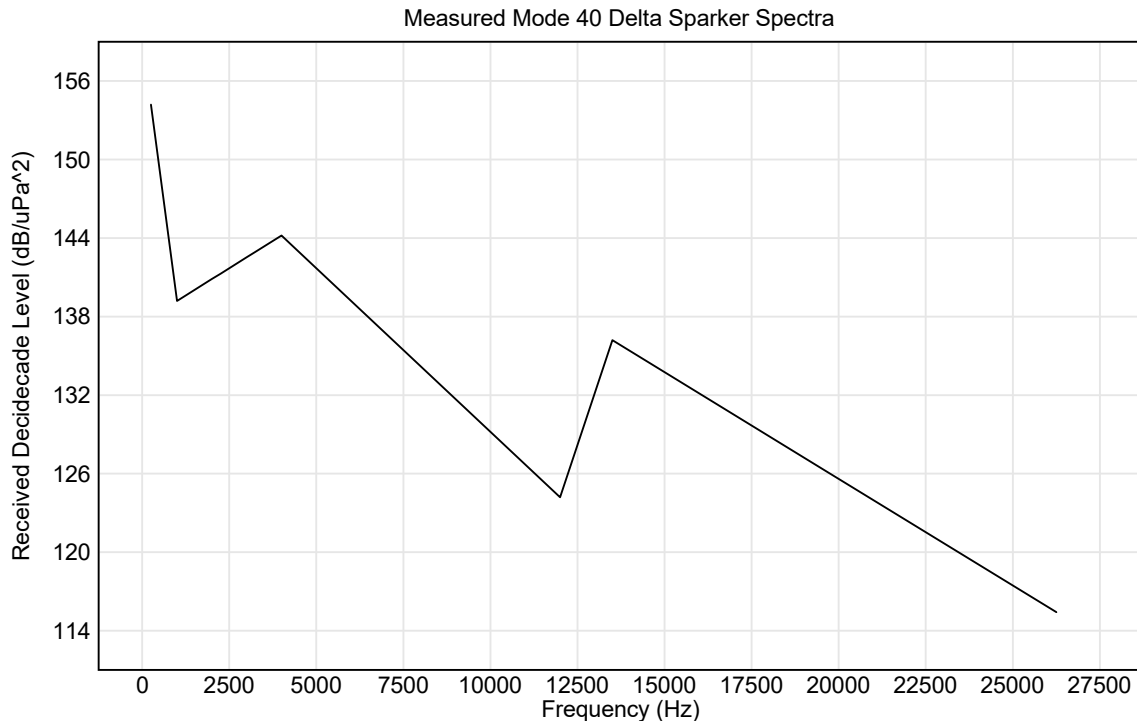


Figure 5-234. Delta Sparker Mode 40 measured spectra at buoy position D

μ Pa = micropascal; dB = decibel; Hz = hertz.

5.40.1 Site 1 – Mud, 10-m Depth

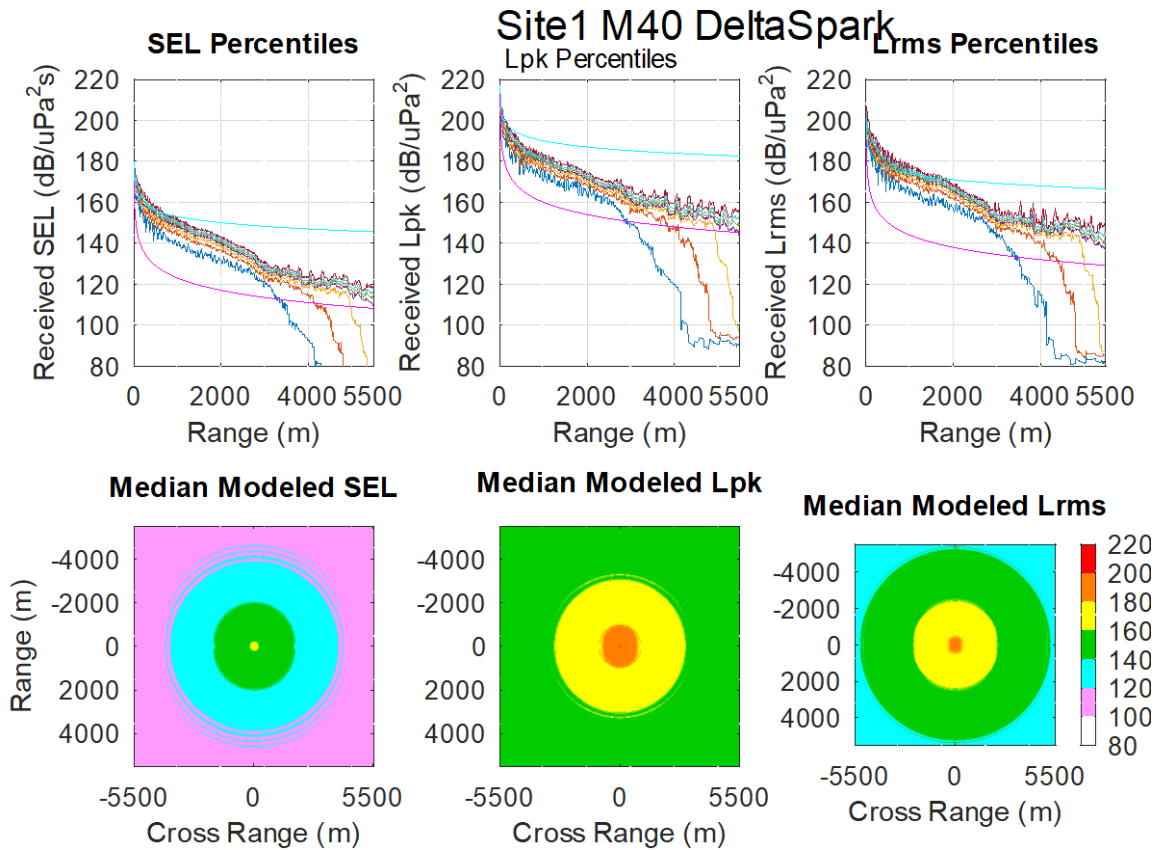


Figure 5-235. Delta Sparker Mode 40 Site 1 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.40.2 Site 2 – Sand, 10-m Depth

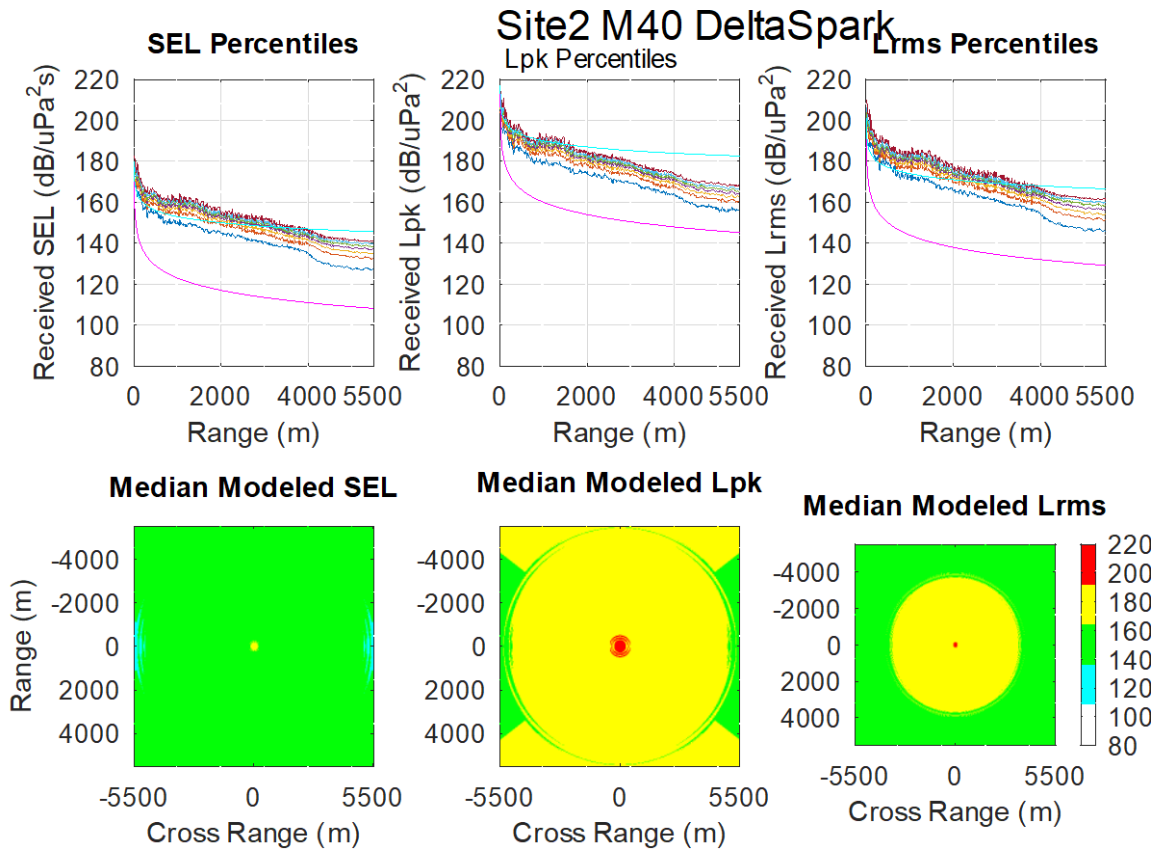


Figure 5-236. Delta Sparker Mode 40 Site 2 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.40.3 Site 3 – Mud, 30-m Depth

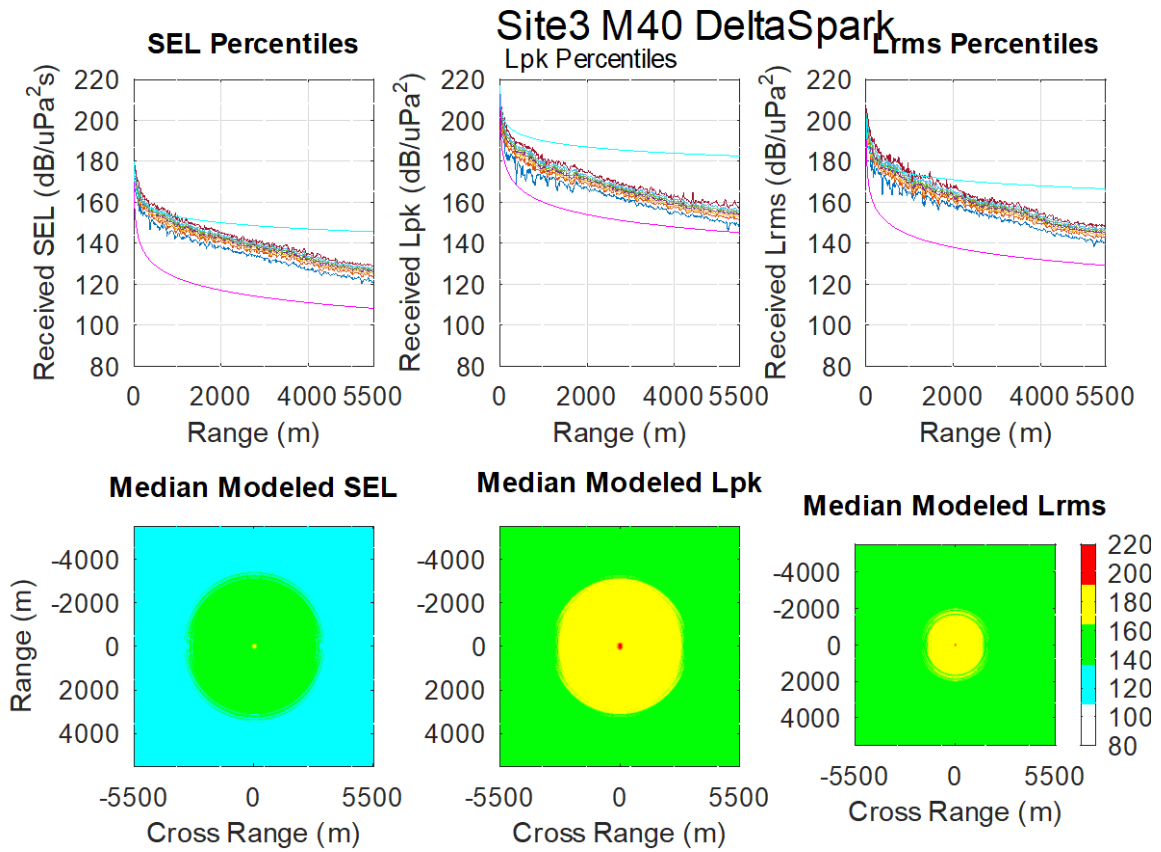


Figure 5-237. Delta Sparker Mode 40 Site 3 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.40.4 Site 4 – Sand, 30-m Depth

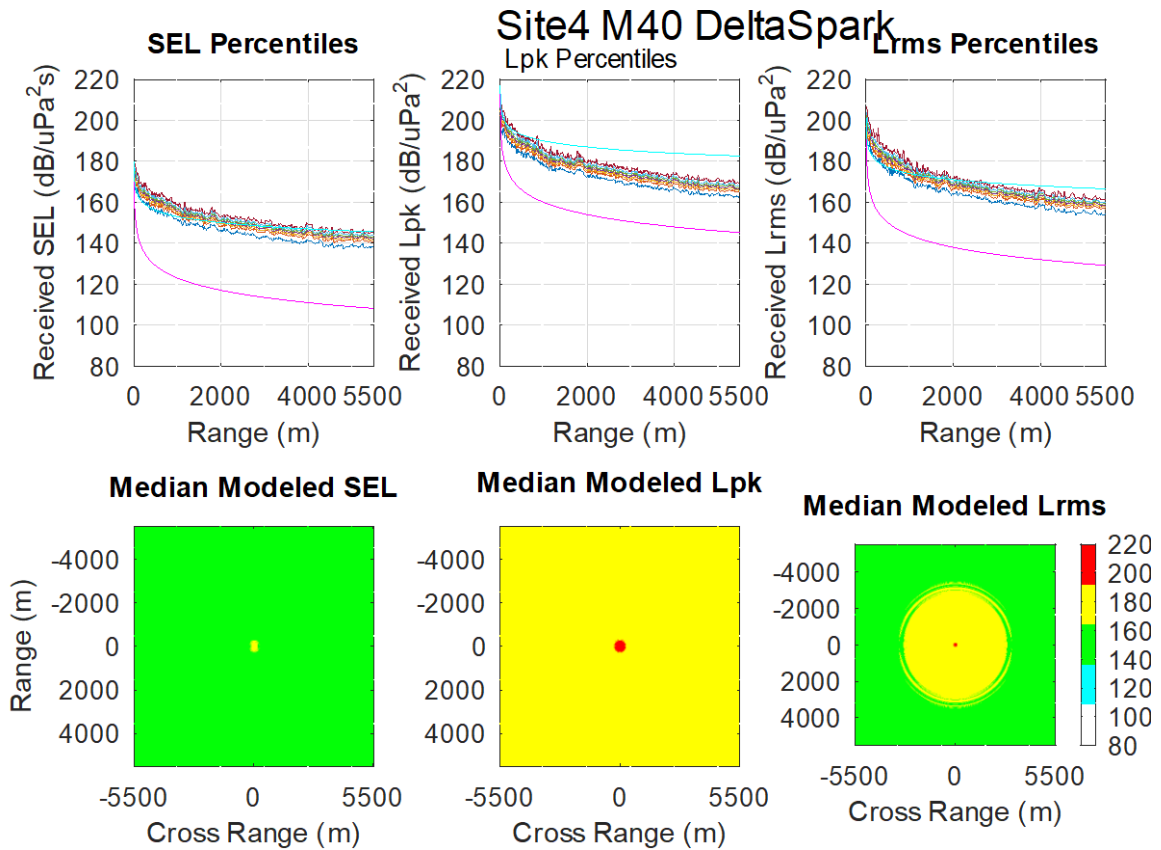


Figure 5-238. Delta Sparker Mode 40 Site 4 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

5.40.5 Site 5 – Sandy Silt, 100-m Depth

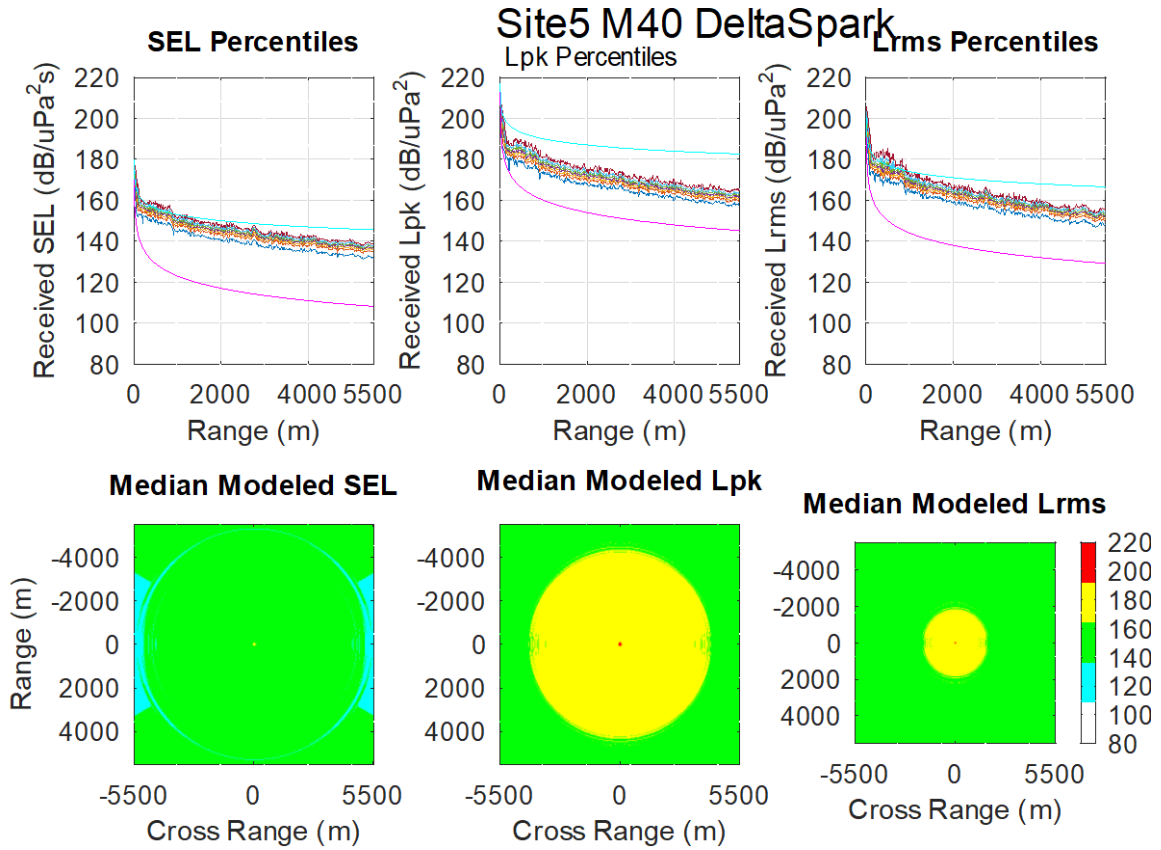


Figure 5-239. Delta Sparker Mode 40 Site 5 modeling results

Top left: SEL percentiles; Top middle: L_{pk} percentiles; Top right: L_{rms} percentiles. Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Bottom left: SEL plan view; Bottom middle: L_{pk} plan view; Bottom right: L_{rms} plan view. μPa = micropascal; dB = decibel; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

6 Conclusions

In conclusion, the data in this report need to be carefully interpreted given the layers of complexity involved in the collection, troubleshooting, and modeling phases. This report is intended to be transparent to both the troubleshooting solutions employed in processing *in situ* data and the presence of noise in the data when compared to models. Uncertainty was incorporated into the models as much as possible to reflect realities like environmental conditions constantly changing in the ocean and positions of receivers changing with the current strength. With these uncertainties and troubleshooting methods in mind, the data and modeling reported here apply only to these five sites during summer conditions in calm seas. Extrapolation to other sites in different seasons and under different weather conditions should only be performed in collaboration with an underwater acoustician to incorporate the influence of environmental parameters and how the variety of signals could most likely propagate in said environments.

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Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical Surveys: Acoustic Modeling Effort

Appendix A Calibration Report

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A.1 Appendix A: Low-Frequency Results

A.1.1 Site 1, Deployment 1

Mini Sparker Mode 28, Run 4, Buoys 5, 6, 8, and 9 (Figures A.1-1 and A.1-2).

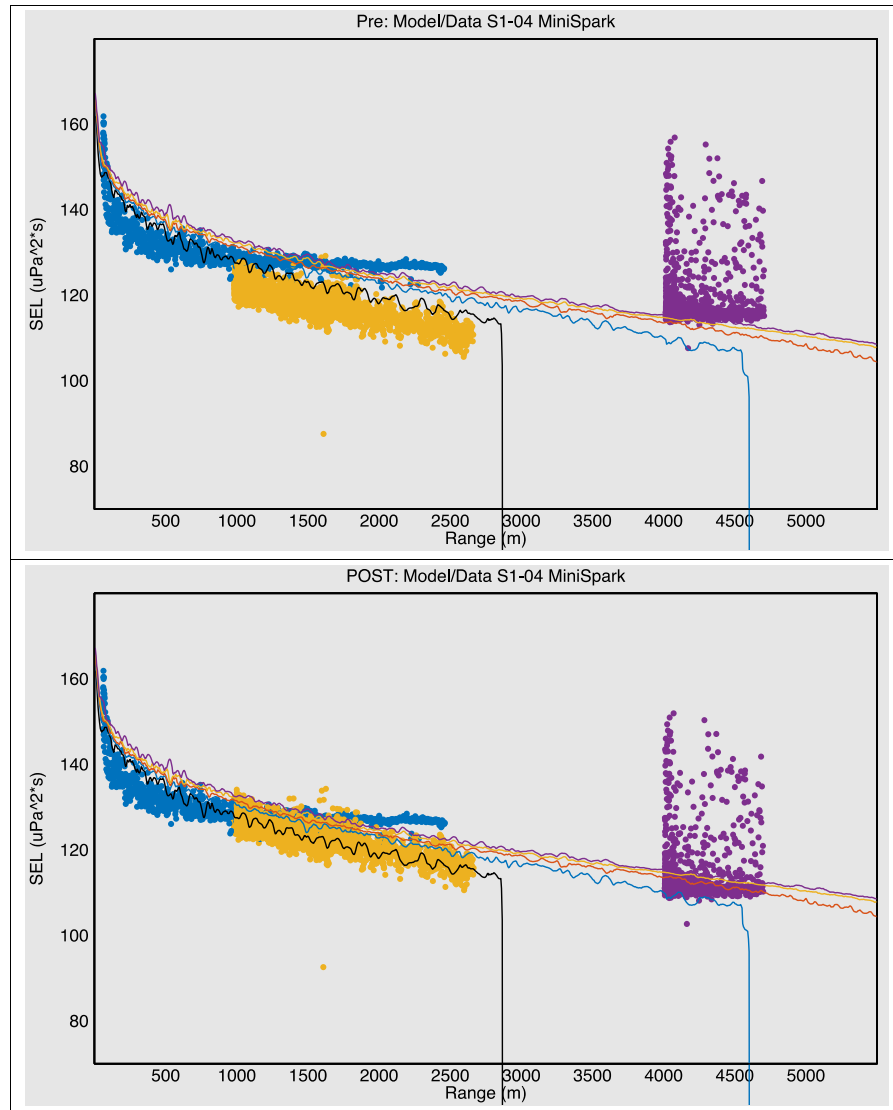


Figure A.1-1. Modeled (lines) versus measured (dots) data for Mini Sparker, Mode 28, at Site 1, Deployment 1, Run 4.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th purple; 75th yellow; 50th red; 25th blue; 5th black). The dots are measured SEL versus range for four buoys (Buoy 5 and 8, yellow; Buoy 6, blue; Buoy 9, purple). Top: pre-adjusted data; Bottom: adjusted data (dots).

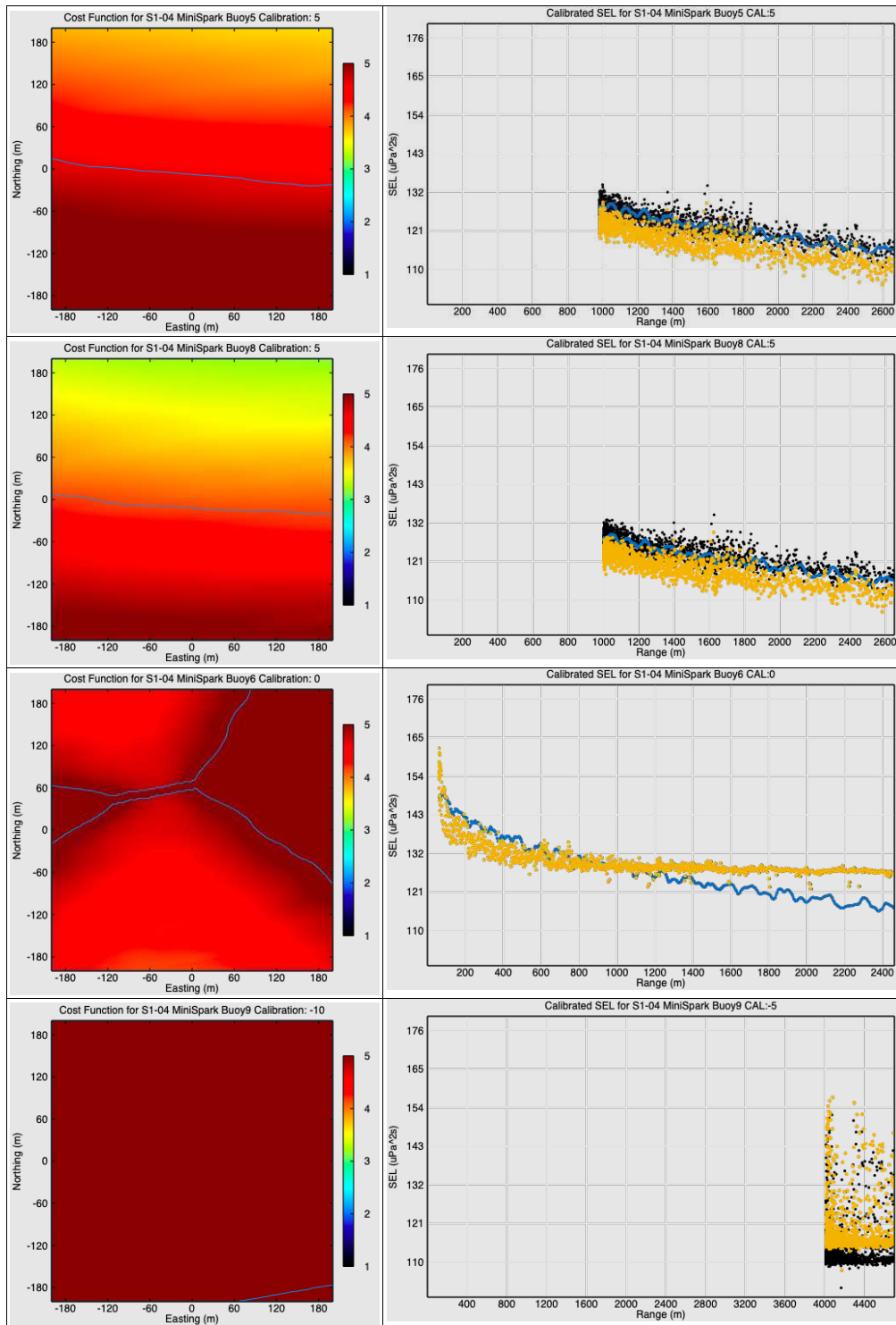


Figure A.1-2. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 28, at Site 1, Deployment 1, Run 4.

Left: Cost functions for the buoy locations (top to bottom: Buoys 5, 8, 6, and 9). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.2 Site 2, Deployment 1

Mini Sparker Mode 28, Run 6, Buoys 6 and 11 (Figures A.1-3 and A.1-4).

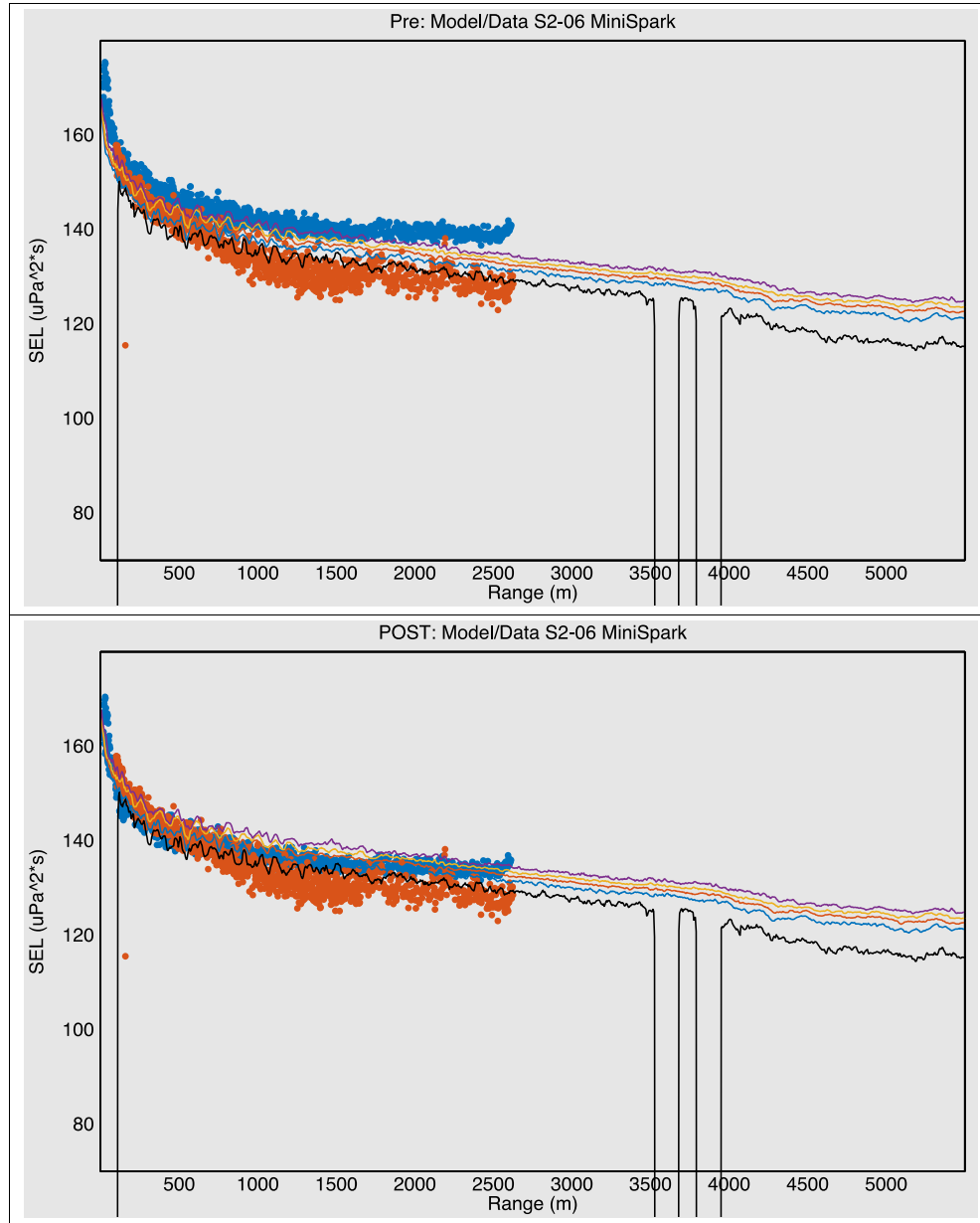


Figure A.1-3. Modeled (lines) versus measured (dots) data for Mini Sparker, Mode 28, at Site 2, Deployment 1, Run 6.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for two buoys (Buoy 6, blue; Buoy 11, red). Top: pre-adjusted data; Bottom: adjusted data (dots).

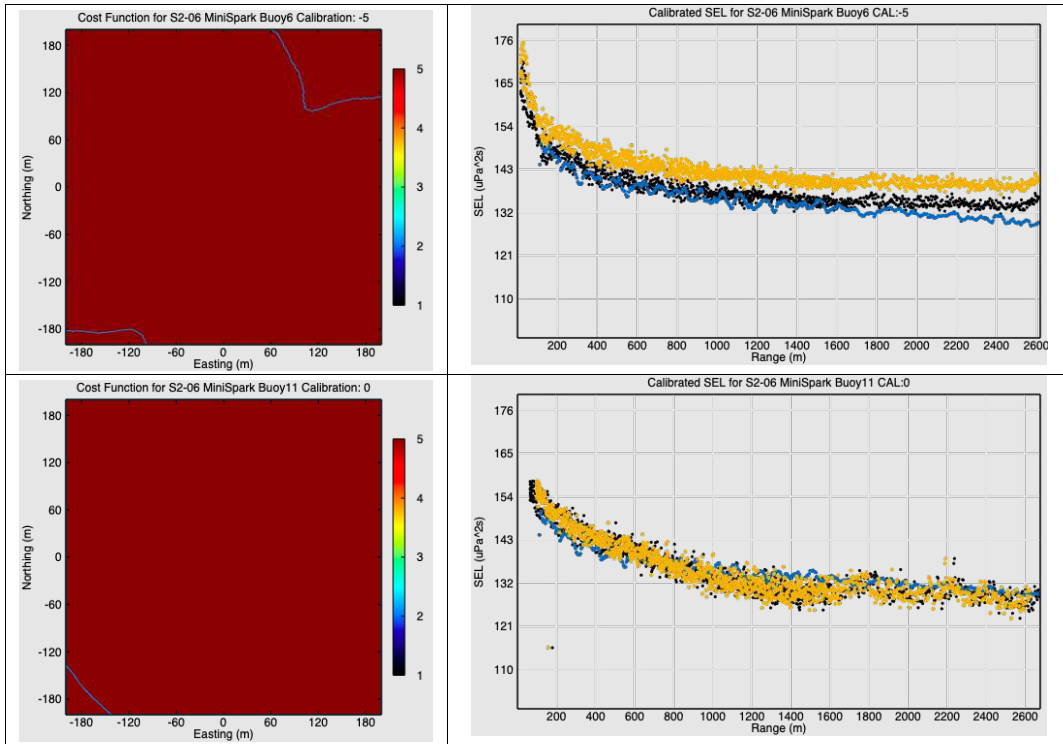


Figure A.1-4. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 28, at Site 2, Deployment 1, Run 6.

Left: Cost functions for the buoy locations (top: Buoy 6; bottom: Buoy 11). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.3 Site 3, Deployment 1

252 S-Boom, Mode 26, Run 6, Buoys 5 and 11 (Figures A.1-5 and A.1-6).

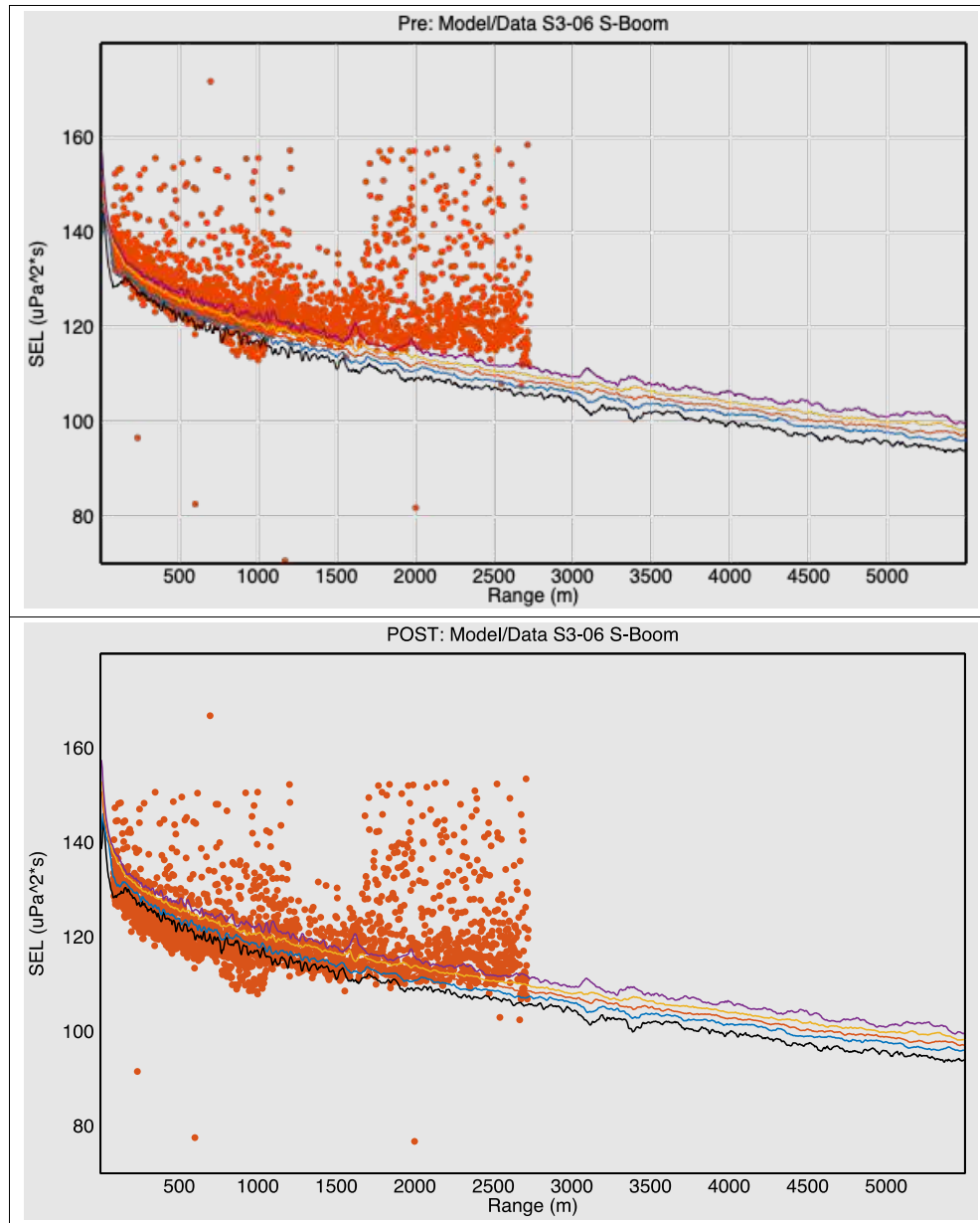


Figure A.1-5. Modeled (lines) versus measured (dots) data for 252 S-Boom, Mode 26, at Site 3, Deployment 1, Run 6.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for two buoys (Buoy 5, red; and; Buoy 12, red). Buoys 7 and 8 were deployed but had bad data. Top: pre-adjusted data; Bottom: adjusted data (dots).

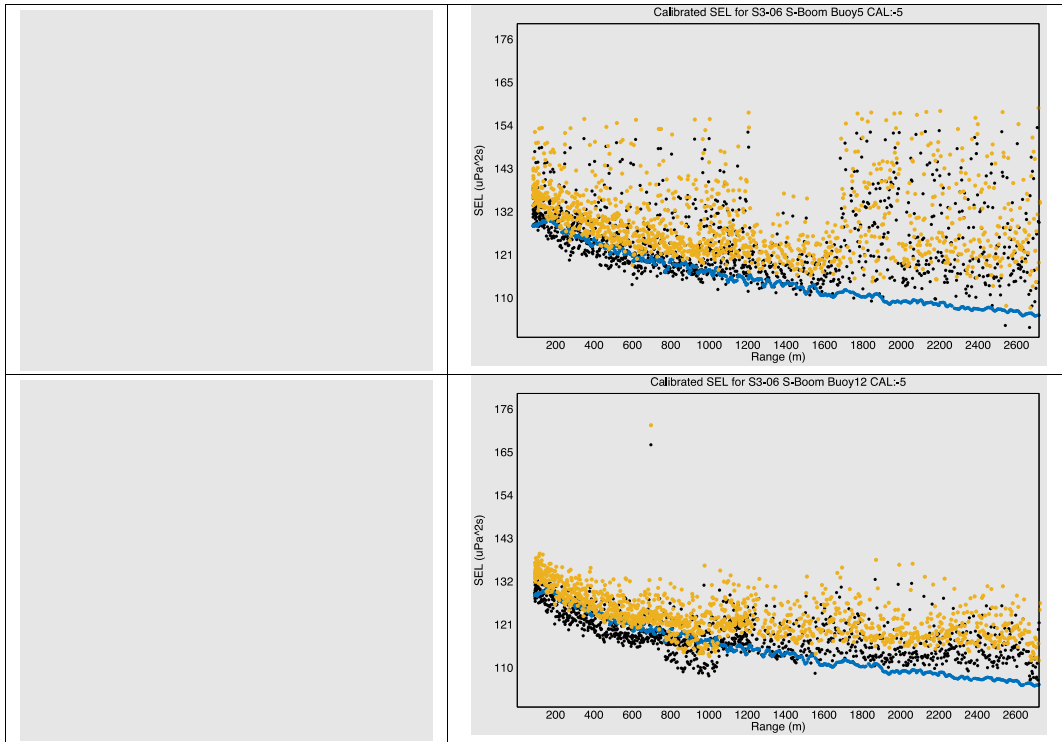


Figure A.1-6. Cost functions of buoy locations and SEL comparisons for 252 S-Boom, Mode 26, at Site 3, Deployment 1, Run 6.

Left: Cost functions for the buoy locations (top: Buoy 5; bottom: Buoy 12). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.4 Site 4, Deployment 1

252 S-Boom, Mode 26, Run 6, Buoys 6 and 8 (Figures A.1-7 and A.1-8).

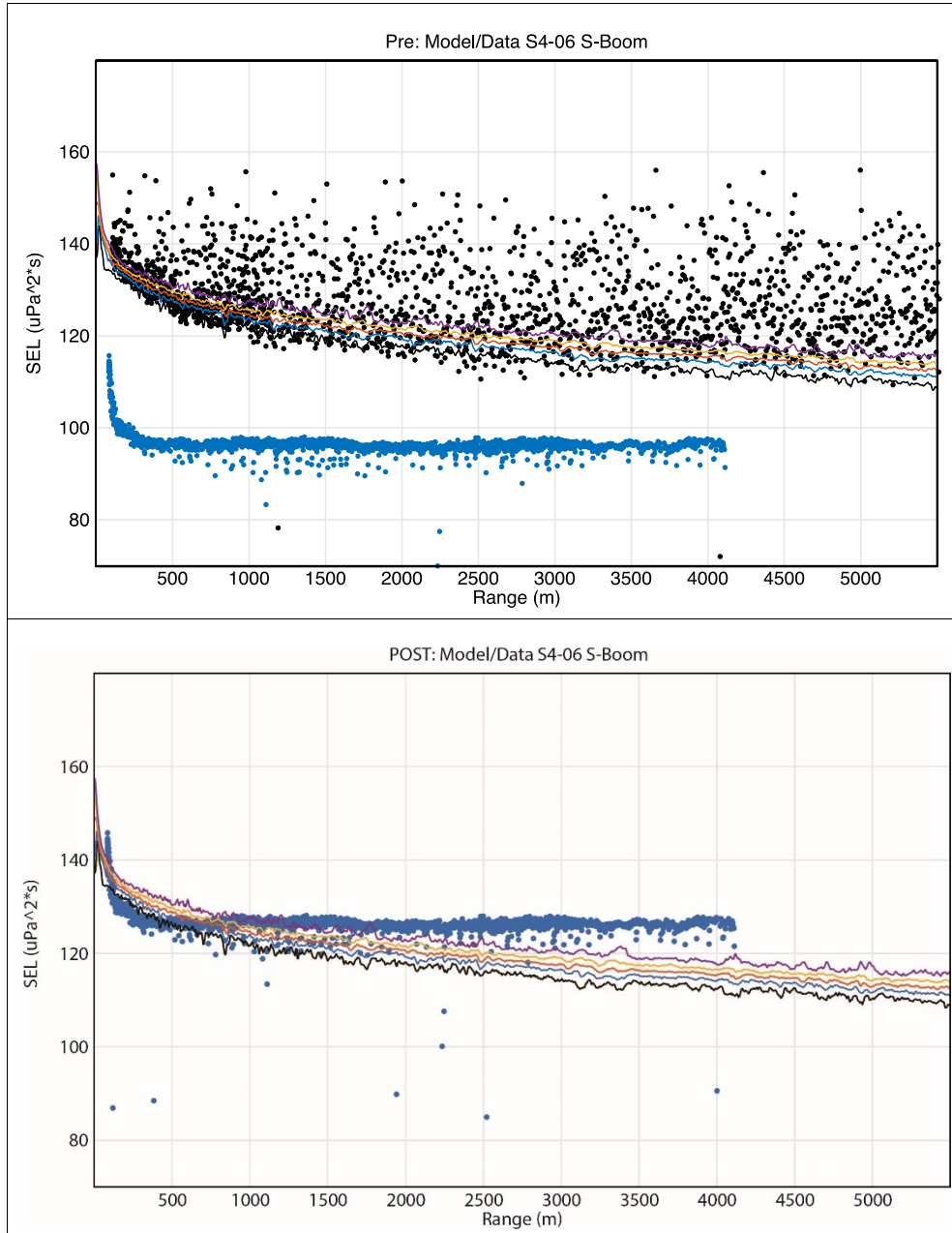


Figure A.1-7. Modeled (lines) versus measured (dots) data for 252 S-Boom, Mode 26, at Site 4, Deployment 1, Run 6.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for two buoys (Buoy 6, blue; Buoy 8, black). Buoy 6 navigation data were too poor quality for a cost function, so they are not included in the rest of the example and the adjusted data plot is not presented. Top: pre-adjusted data; Bottom: adjusted data (dots).

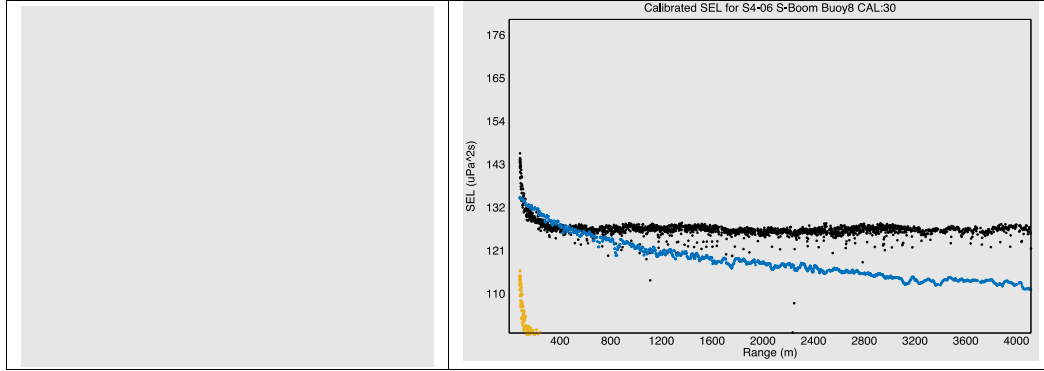


Figure A.1-8. Cost function of buoy location and SEL comparisons for 252 S-Boom, Mode 26, at Site 4, Deployment 1, Run 6.

Left: Cost function for the buoy location (Buoy 8). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.5 Site 5, Deployment 1

Delta Sparker, Mode 39, Run 1, Buoys 5, 6, 8, 9, and 12 (Figures A.1-9 and A.1-10).

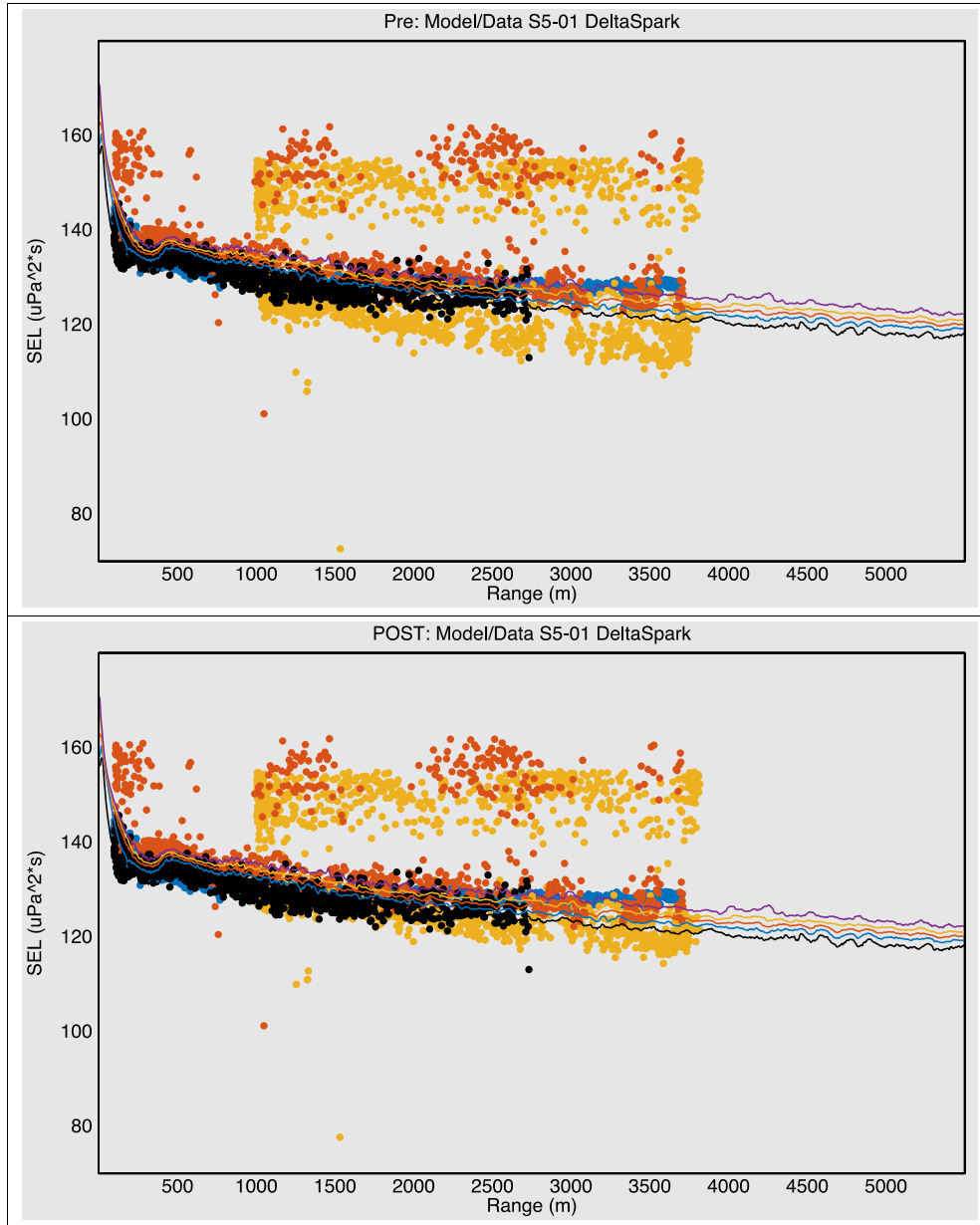


Figure A.1-9. Modeled (lines) versus measured (dots) data for Delta Sparker, Mode 39, at Site 5, Deployment 1, Run 1.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for five buoys (Buoy 5, red; Buoy 6, blue; Buoys 8 and 9, yellow; Buoy 12, black). The double stack of dots indicates bad data that were not used in the model-data comparison. Top: pre-adjusted data; Bottom: adjusted data (dots).

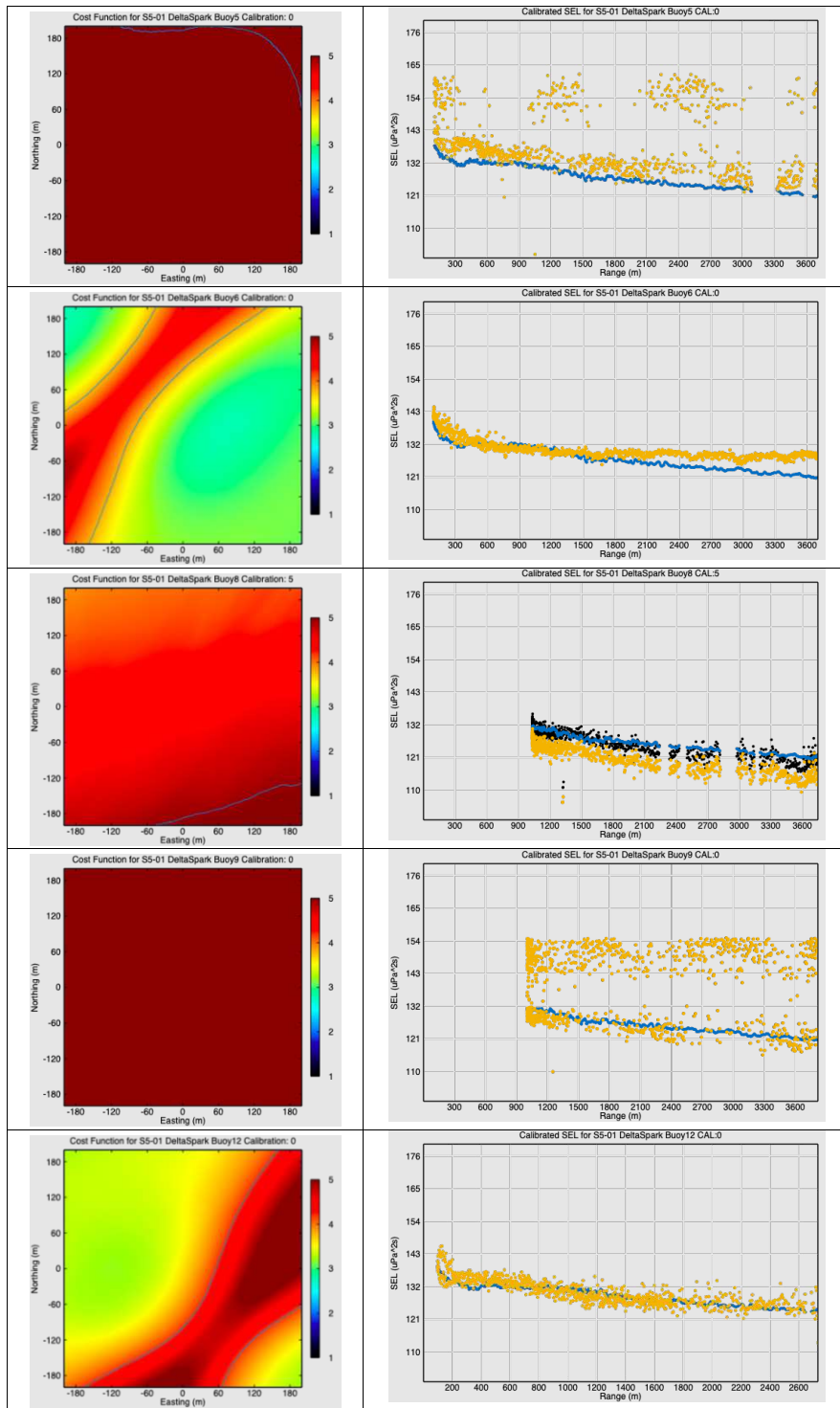


Figure A.1-10. Cost functions of buoy locations and SEL comparisons for Delta Sparker, Mode 39, at Site 5, Deployment 1, Run 1.

Left: Cost functions for the buoy locations (top to bottom: Buoys 5, 6, 8, 9, and 12). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.6 Site 2, Deployment 2

Mini Sparker Mode 29, Run 34, Buoys 5, 9, 10, and 11 (Figures A.1-11 and A.1-12).

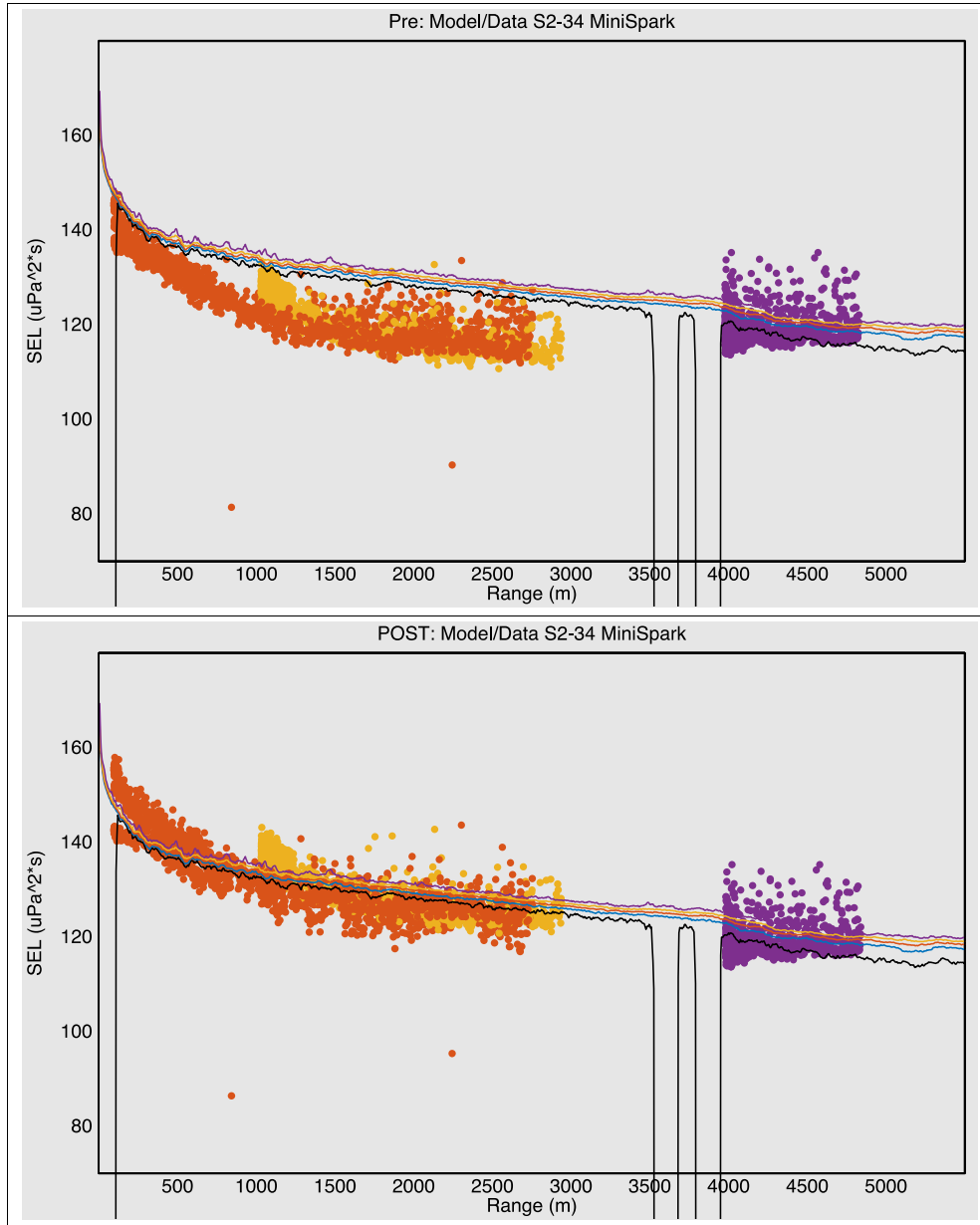


Figure A.1-11. Modeled (lines) versus measured (dots) data for Mini Sparker, Mode 29, at Site 2, Deployment 2, Run 34.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for four buoys (Buoy 5, red; Buoy 9, purple; Buoy 10, yellow; and Buoy 11, red). Top: pre-adjusted data; Bottom: adjusted data (dots).

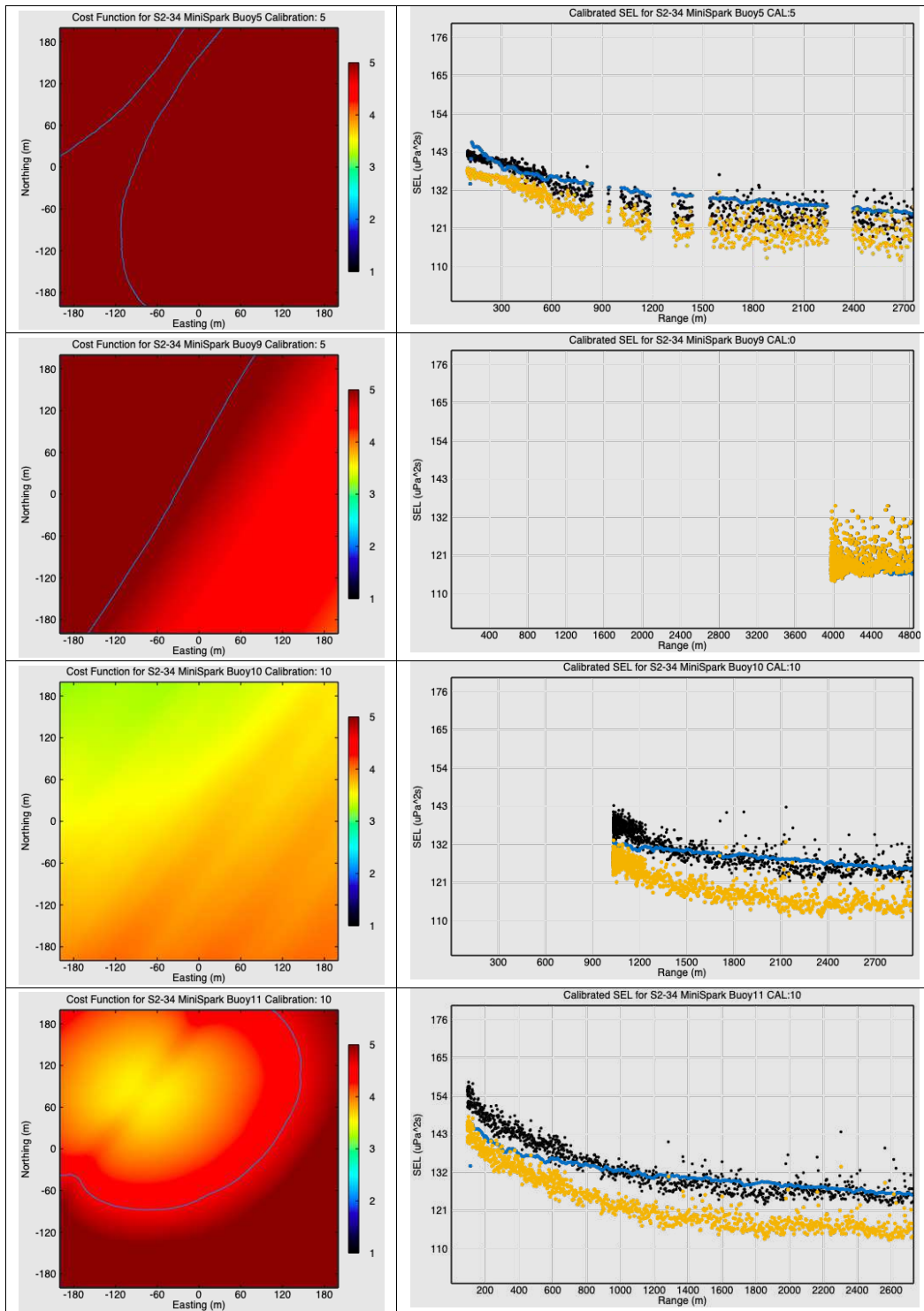


Figure A.1-12. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 29, at Site 2, Deployment 2, Run 34.

Left: Cost functions for the buoy locations (top to bottom: Buoys 5, 9, 10, and 11). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.7 Site 3, Deployment 2

Mini Sparker Mode 29, Run 11, Buoys 5, 6, and 12 (Figures A.1-13 and A.1-14).

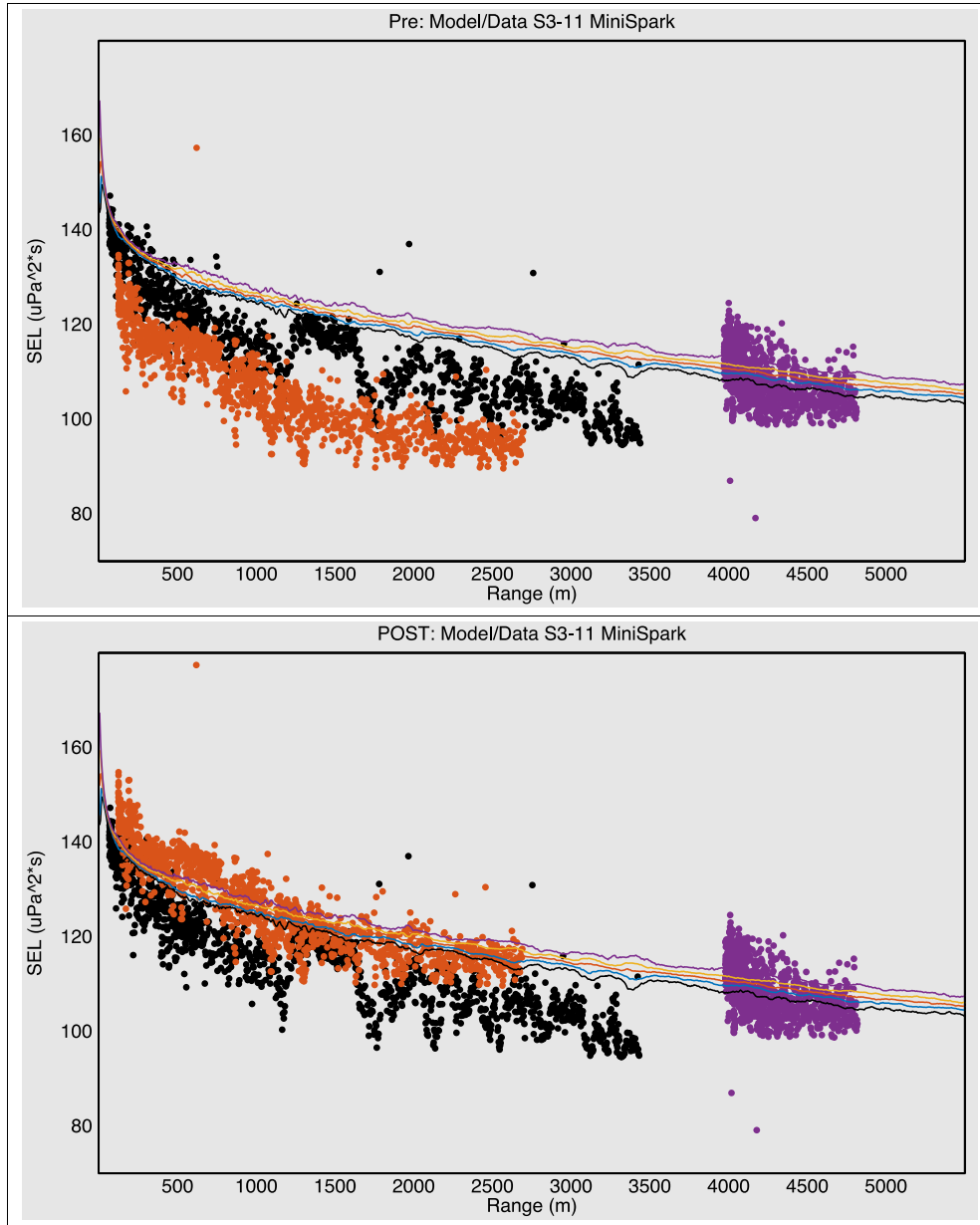


Figure A.1-13. Modeled (lines) versus measured (dots) data for Mini Sparker, Mode 29, at Site 3, Deployment 2, Run 11.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th. purple; 75th. yellow; 50th. red; 25th. blue; 5th. black). The dots are measured SEL versus range for three buoys (Buoy 5, black; Buoy 6, purple; Buoy 12, red). Top: pre-adjusted data; Bottom: adjusted data (dots).

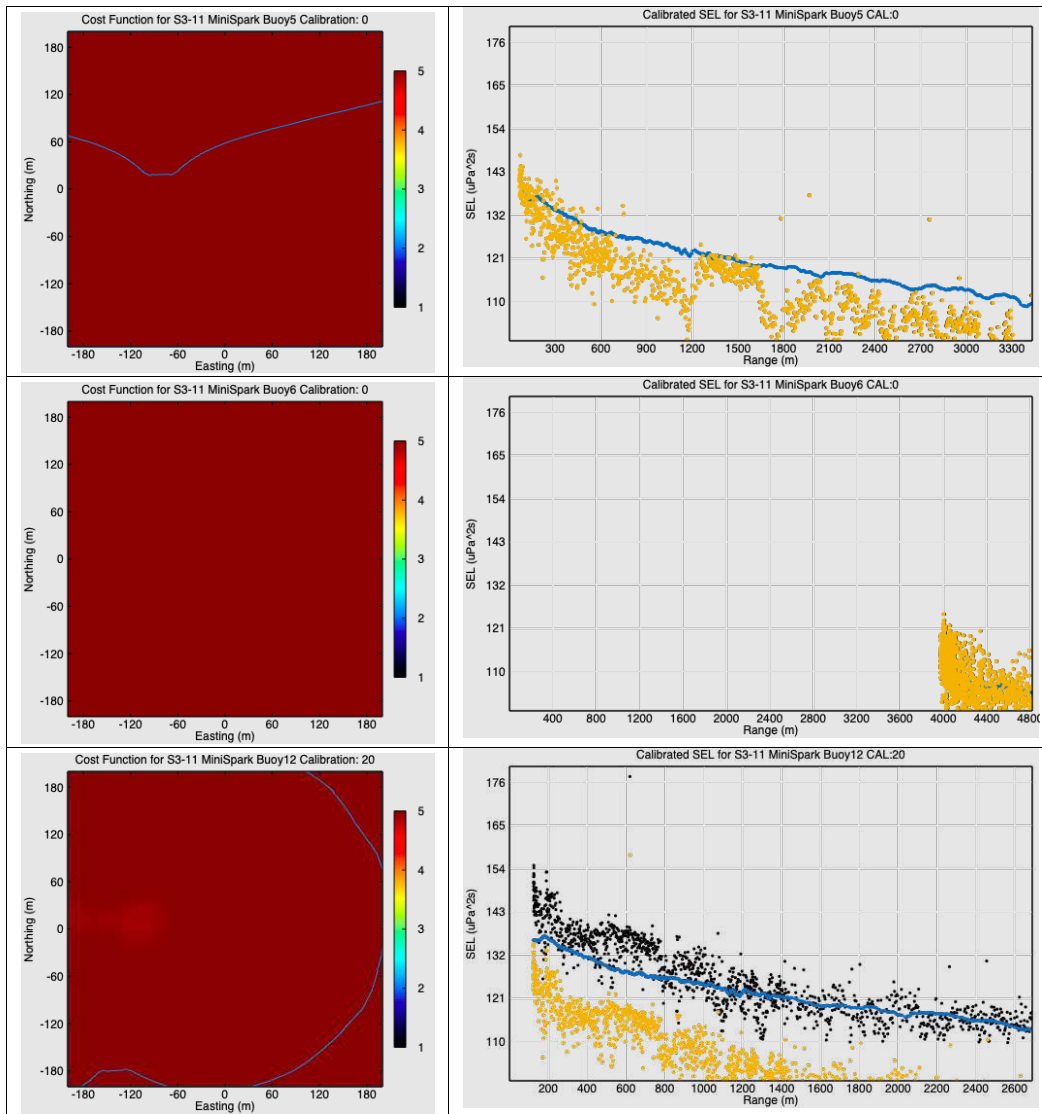


Figure A.1-14. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 29, at Site 3, Deployment 2, Run 11.

Left: Cost functions for the buoy locations (top to bottom: Buoys 5, 6, and 12). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.8 Site 4, Deployment 2

No run from Deployment 2 at Site 4 had viable data for calculating adjustment factors.

A.1.9 Site 5, Deployment 2

Mini Sparker Mode 28, Run 19, Buoys 6, 8, 9, 10, 11, and 12 (Figures A.1-15 and A.1-16).

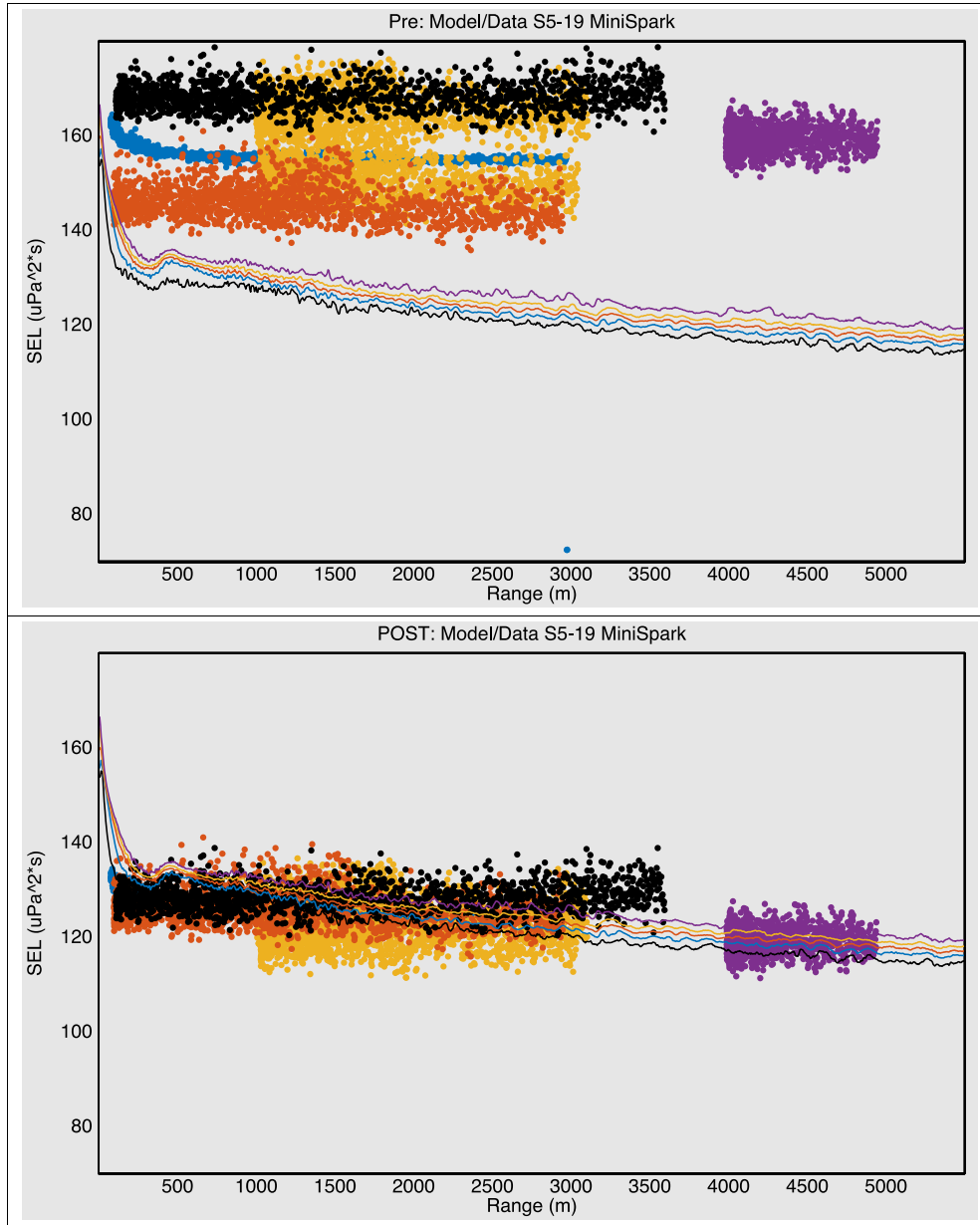


Figure A.1-15. Modeled (lines) versus measured (dots) data for Mini Sparker, Mode 28, at Site 5, Deployment 2, Run 19.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th. purple; 75th. yellow; 50th. red; 25th. blue; 5th. black). The dots are measured SEL versus range for six buoys (Buoy 6, blue; Buoys 8 and 9, yellow; Buoy 10, purple; Buoy 11, red; Buoy 12, black). Top: pre-adjusted data; Bottom: adjusted data (dots).

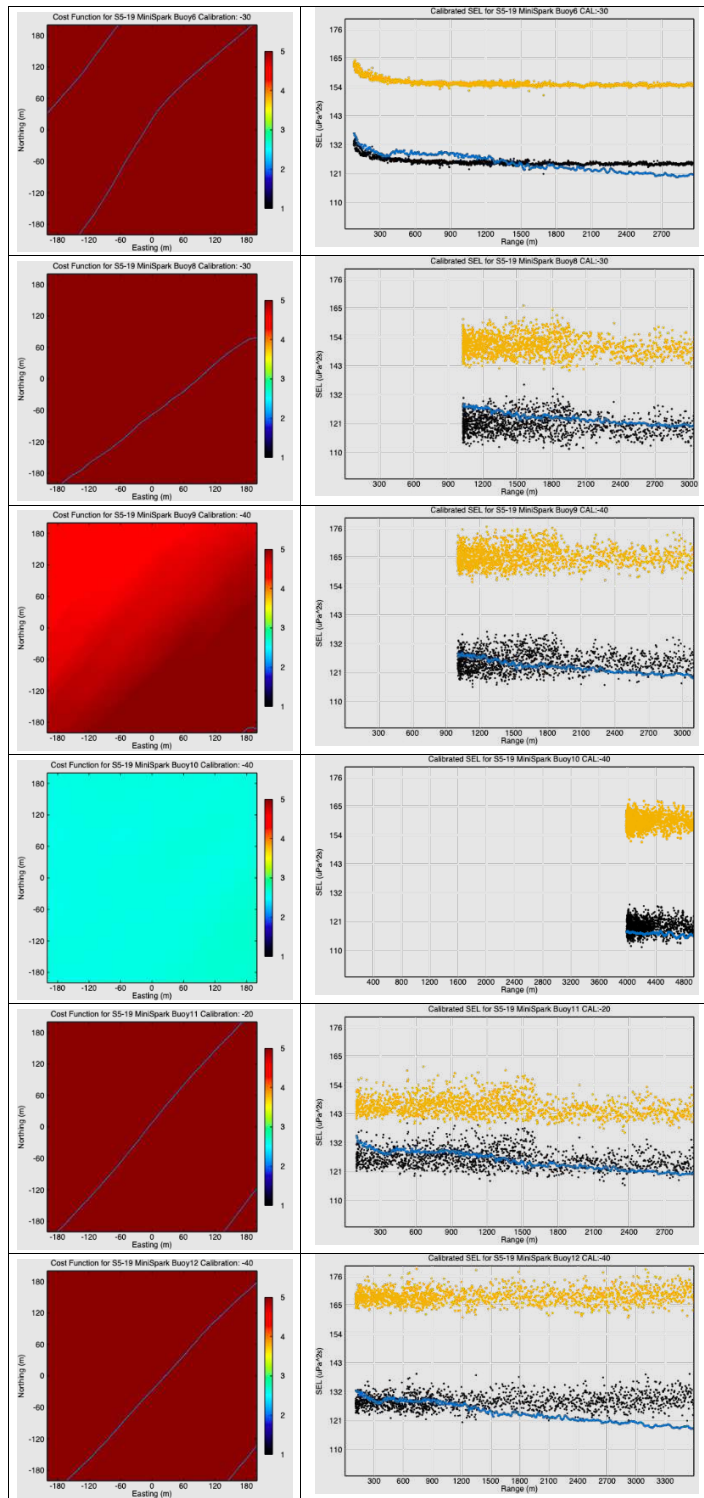


Figure A.1-16. Cost functions of buoy locations and SEL comparisons for Mini Sparker, Mode 28, at Site 5, Deployment 2, Run 19.

Left: Cost functions for the buoy locations (top to bottom: Buoys 6, 8, 9, 10, 11, and 12). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.10 Site 3, Deployment 3

The low-frequency source at Site 3 for Deployment 2 is shown in Section 2.1 of the main report.

A.1.11 Site 4, Deployment 3

Bubble Gun Mode 33, Run 28, Buoys 5 and 12 (Figures A.1-17 and A.1-18).

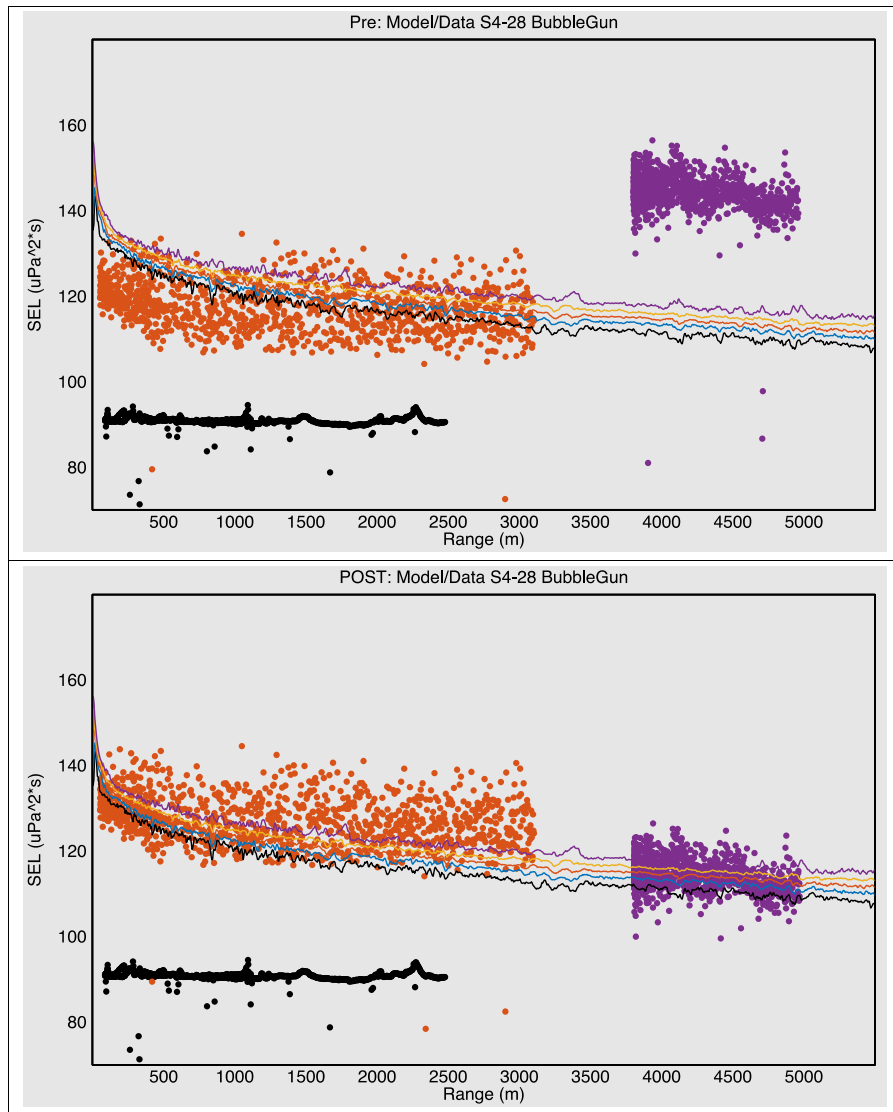


Figure A.1-17. Modeled (lines) versus measured (dots) data for Bubble Gun, Mode 33, at Site 4, Deployment 3, Run 28.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for three buoys (Buoy 5, purple; Buoy 7, black; Buoy 12, red). Top: pre-adjusted data; Bottom: adjusted data (dots). Buoy 7 (black) only had bad data, so while plotted, the data were not adjusted.

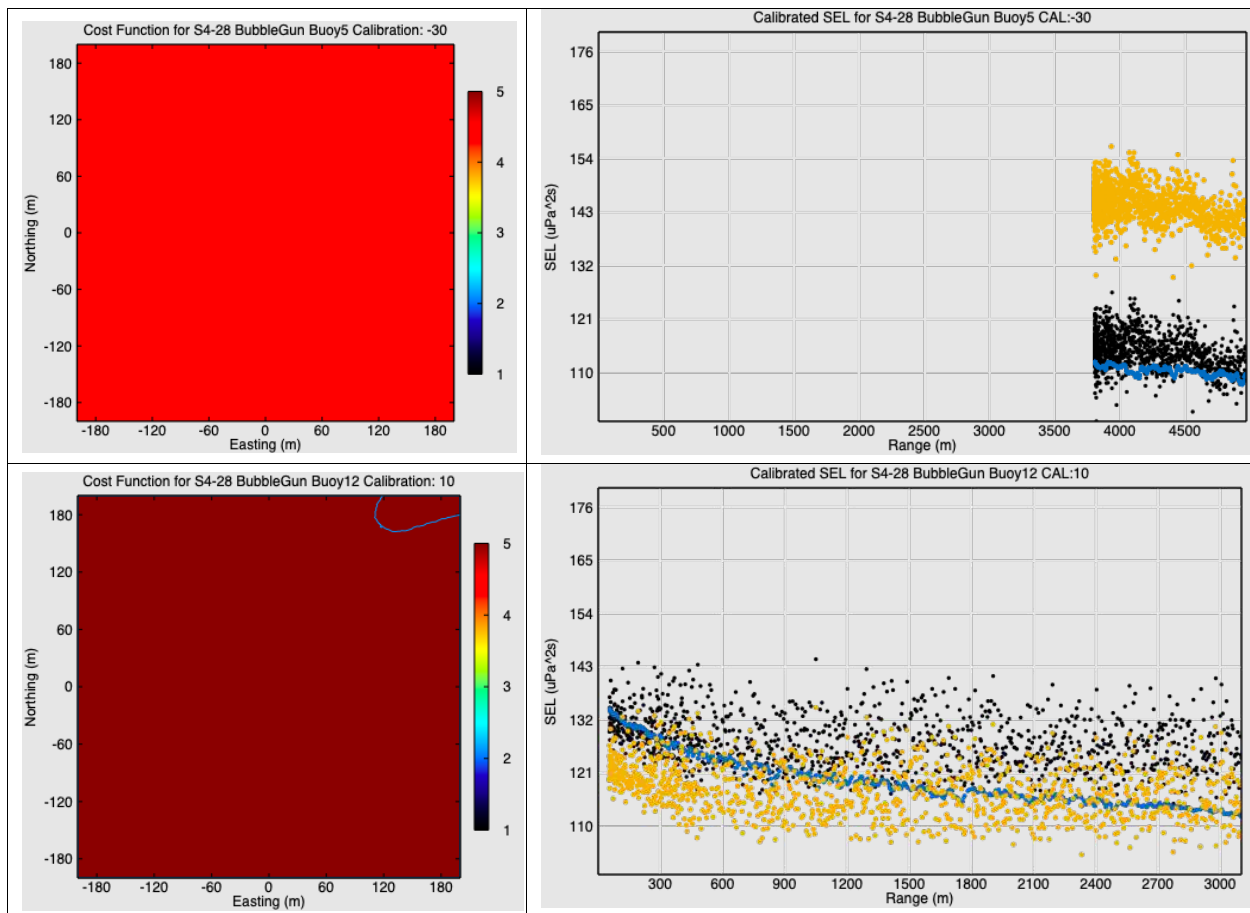


Figure A.1-18. Cost functions of buoy locations and SEL comparisons for Bubble Gun, Mode 33, at Site 4, Deployment 3, Run 28.

Left: Cost functions for the buoy locations (top: Buoy 5; bottom: Buoy 12). Right: Sound exposure level (SEL) versus range compared to the model (blue line), pre-adjusted data (yellow), and adjusted data (black).

A.1.12 Site 5, Deployment 3

No low-frequency source occurred during Deployment 3 at Site 5.

A.1.13 Low-Frequency Results Table

Table A.1-1. Adjustment factors for all low-frequency sources.

Source	Mode	Site	Deployment	Run	frequency	Channel	Buoy Position															
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1
252 S-Boom	26	1	1	3	LF	na	6	-10 dB	na	--	na	--	na	--	na	--	5	10 dB	8	10 dB	9	-20 dB
252 S-Boom	26	1	1	3	LF	na	6	200 S	na	--	na	--	na	--	na	--	5	70 N	8	200 N	9	200 N
252 S-Boom	26	1	1	3	LF	na	6	200 E	na	--	na	--	na	--	na	--	5	200 W	8	200 W	9	200 W
252 S-Boom	26	1	1	3	LF	na	6	10.59	na	--	na	--	na	--	na	--	5	3.32	8	2.98	9	5.16
252 S-Boom	26	1	1	3	LF	na	6	>400m	na	--	na	--	na	--	na	--	5	>400 m	8	>380 m	9	>400 m
Mini Sparker	28	1	1	4	LF	na	6	0 dB	na	--	na	--	na	--	na	--	5	5 dB	8	5 dB	9	-5 dB
Mini Sparker	28	1	1	4	LF	na	6	200 S	na	--	na	--	na	--	na	--	5	200 N	8	200 N	9	192 S
Mini Sparker	28	1	1	4	LF	na	6	58 W	na	--	na	--	na	--	na	--	5	196 E	8	200 E	9	200W
Mini Sparker	28	1	1	4	LF	na	6	4.16	na	--	na	--	na	--	na	--	5	3.65	8	3.17	9	7.57
Mini Sparker	28	1	1	4	LF	na	6	>260 m	na	--	na	--	na	--	na	--	5	>200 m	8	>200 m	9	>400 m
Mini Sparker	29	1	1	5	LF	na	6	0 dB	na	--	na	--	na	--	na	--	5	bad	8	30 dB	9	-10 dB
Mini Sparker	29	1	1	5	LF	na	6	50 N	na	--	na	--	na	--	na	--	5	bad	8	200 S	9	200 S
Mini Sparker	29	1	1	5	LF	na	6	64 W	na	--	na	--	na	--	na	--	5	bad	8	36 W	9	36 W
Mini Sparker	29	1	1	5	LF	na	6	12.55	na	--	na	--	na	--	na	--	5	bad	8	2.52	9	13.98
Mini Sparker	29	1	1	5	LF	na	6	>400 m	na	--	na	--	na	--	na	--	5	bad	8	>210 m	9	>380 m
Bubble Gun	33	1	1	13	LF	na	6	bad	na	--	na	--	na	--	na	--	5	10 dB	8	bad	9	no data
Bubble Gun	33	1	1	13	LF	na	6	bad	na	--	na	--	na	--	na	--	5	200 N	8	bad	9	no data
Bubble Gun	33	1	1	13	LF	na	6	bad	na	--	na	--	na	--	na	--	5	196 W	8	bad	9	no data
Bubble Gun	33	1	1	13	LF	na	6	bad	na	--	na	--	na	--	na	--	5	5.25	8	bad	9	no data
Bubble Gun	33	1	1	13	LF	na	6	bad	na	--	na	--	na	--	na	--	5	>170 m	8	bad	9	no data
252 S-Boom	26	2	1	4	LF	0	6	0 dB	na	--	na	--	na	--	na	--	na	--	na	--	F	bad
253 S-Boom	26	2	1	4	LF	0	6	48 N	na	--	na	--	na	--	na	--	na	--	na	--	F	bad
254 S-Boom	26	2	1	4	LF	0	6	156 W	na	--	na	--	na	--	na	--	na	--	na	--	F	bad
255 S-Boom	26	2	1	4	LF	0	6	4.96	na	--	na	--	na	--	na	--	na	--	na	--	F	bad
256 S-Boom	26	2	1	4	LF	0	6	>400 m	na	--	na	--	na	--	na	--	na	--	na	--	F	bad
257 S-Boom	27	2	1	5	LF	0	6	0 dB	na	--	na	--	11	15 dB	na	--	na	--	na	--	na	--
258 S-Boom	27	2	1	5	LF	0	6	200 S	na	--	na	--	11	54 S	na	--	na	--	na	--	na	--
259 S-Boom	27	2	1	5	LF	0	6	200 E	na	--	na	--	11	178 E	na	--	na	--	na	--	na	--
260 S-Boom	27	2	1	5	LF	0	6	4.42	na	--	na	--	11	3	na	--	na	--	na	--	na	--
261 S-Boom	27	2	1	5	LF	0	6	>200 m	na	--	na	--	11	>200 m	na	--	na	--	na	--	na	--
Mini Sparker	28	2	1	6	LF	0	6	-5 dB	na	--	na	--	11	0 dB	na	--	na	--	na	--	9	bad
Mini Sparker	28	2	1	6	LF	0	6	0 N	na	--	na	--	11	110 N	na	--	na	--	na	--	9	bad
Mini Sparker	28	2	1	6	LF	0	6	22 E	na	--	na	--	11	140 W	na	--	na	--	na	--	9	bad
Mini Sparker	28	2	1	6	LF	0	6	5.70	na	--	na	--	11	5.10	na	--	na	--	na	--	9	bad
Mini Sparker	28	2	1	6	LF	0	6	>260 m	na	--	na	--	11	>400 m	na	--	na	--	na	--	9	bad
Mini Sparker	29	2	1	7	LF	0	6	10 dB	na	--	na	--	11	no data	na	--	na	--	na	--	9	bad
Mini Sparker	29	2	1	7	LF	0	6	14 N	na	--	na	--	11	no data	na	--	na	--	na	--	9	bad
Mini Sparker	29	2	1	7	LF	0	6	42 E	na	--	na	--	11	no data	na	--	na	--	na	--	9	bad
Mini Sparker	29	2	1	7	LF	0	6	2.68	na	--	na	--	11	no data	na	--	na	--	na	--	9	bad
Mini Sparker	29	2	1	7	LF	0	6	>100 m	na	--	na	--	11	no data	na	--	na	--	na	--	9	bad
AA251	30	2	1	26	LF	na	6	30 dB	na	--	na	--	11	45 dB	na	--	na	--	na	--	9	10 dB
AA251	30	2	1	26	LF	na	6	24 N	na	--	na	--	11	20 S	na	--	na	--	na	--	9	200 S
AA251	30	2	1	26	LF	na	6	16 W	na	--	na	--	11	62 W	na	--	na	--	na	--	9	200 E
AA251	30	2	1	26	LF	na	6	7.76	na	--	na	--	11	2.66	na	--	na	--	na	--	9	3.43
AA251	30	2	1	26	LF	na	6	>400 m	na	--	na	--	11	>120 m	na	--	na	--	na	--	9	>200 m
AA251	31	2	1	27	LF	na	6	30 dB	na	--	na	--	11	45 dB	na	--	na	--	na	--	9	10 dB
AA251	31	2	1	27	LF	na	6	108 N	na	--	na	--	11	26 S	na	--	na	--	na	--	9	200 S
AA251	31	2	1	27	LF	na	6	200 W	na	--	na	--	11	32 W	na	--	na	--	na	--	9	200 E

Table A.1-1. (Continued).

Source	Mode	Site	Deployment	Run	frequency	Channel	Buoy Position															
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1
AA251	31	2	1	27	LF	na	6	8.16	na	--	na	--	11	2.51	na	--	na	--	na	--	9	5.18
AA251	31	2	1	27	LF	na	6	>400m	na	--	na	--	11	>150 m	na	--	na	--	na	--	9	>400 m
Bubble Gun	32	2	1	26	LF	na	6	0 dB	na	--	na	--	11	10 dB	na	--	na	--	na	--	9	bad
Bubble Gun	32	2	1	26	LF	na	6	144 N	na	--	na	--	11	188 S	na	--	na	--	na	--	9	bad
Bubble Gun	32	2	1	26	LF	na	6	200 W	na	--	na	--	11	200 E	na	--	na	--	na	--	9	bad
Bubble Gun	32	2	1	26	LF	na	6	5.78	na	--	na	--	11	5.40	na	--	na	--	na	--	9	bad
Bubble Gun	32	2	1	26	LF	na	6	>400 m	na	--	na	--	11	>400m	na	--	na	--	na	--	9	bad
Bubble Gun	33	2	1	27	LF	na	6	-10 dB	na	--	na	--	11	10 dB	na	--	na	--	na	--	9	-20 dB
Bubble Gun	33	2	1	27	LF	na	6	200 N	na	--	na	--	11	200 S	na	--	na	--	na	--	9	200 S
Bubble Gun	33	2	1	27	LF	na	6	200 W	na	--	na	--	11	200 E	na	--	na	--	na	--	9	200 E
Bubble Gun	33	2	1	27	LF	na	6	5.62	na	--	na	--	11	5.48	na	--	na	--	na	--	9	5.07
Bubble Gun	33	2	1	27	LF	na	6	>400 m	na	--	na	--	11	>400 m	na	--	na	--	na	--	9	>400 m
252 S-Boom	26	3	1	6	LF	na	8	bad	na	--	na	--	5	-5 dB	12	-5 dB	7	bad	na	--	na	--
252 S-Boom	26	3	1	6	LF	na	8	bad	na	--	na	--	5	66 S	12	176 S	7	bad	na	--	na	--
252 S-Boom	26	3	1	6	LF	na	8	bad	na	--	na	--	5	14 E	12	200 E	7	bad	na	--	na	--
252 S-Boom	26	3	1	6	LF	na	8	bad	na	--	na	--	5	11.69	12	5.72	7	bad	na	--	na	--
252 S-Boom	26	3	1	6	LF	na	8	bad	na	--	na	--	5	>400 m	12	>400 m	7	bad	na	--	na	--
252 S-Boom	27	3	1	7	LF	na	8	bad	na	--	na	--	5	-10 dB	12	-10 dB	7	bad	na	--	na	--
252 S-Boom	27	3	1	7	LF	na	8	bad	na	--	na	--	5	194 S	12	94 S	7	bad	na	--	na	--
252 S-Boom	27	3	1	7	LF	na	8	bad	na	--	na	--	5	92 W	12	138 E	7	bad	na	--	na	--
252 S-Boom	27	3	1	7	LF	na	8	bad	na	--	na	--	5	10.32	12	5.05	7	bad	na	--	na	--
252 S-Boom	27	3	1	7	LF	na	8	bad	na	--	na	--	5	>400 m	12	>400 m	7	bad	na	--	na	--
252 S-Boom	26	5	1	8	LF	na	6	-15 dB	12	-5 dB	na	--	na	--	na	--	9	0 dB	8	0 dB	10	-10 dB
252 S-Boom	26	5	1	8	LF	na	6	44 S	12	60 S	na	--	na	--	na	--	9	178 S	8	200 N	10	200 S
252 S-Boom	26	5	1	8	LF	na	6	32 E	12	200 W	na	--	na	--	na	--	9	200 E	8	200 W	10	200 E
252 S-Boom	26	5	1	8	LF	na	6	4.55	12	4.24	na	--	na	--	na	--	9	5.42	8	2.7	10	7.03
252 S-Boom	26	5	1	8	LF	na	6	>120 m	12	>260 m	na	--	na	--	na	--	9	>400 m	8	>400 m	10	>400 m
252 S-Boom	27	5	1	9	LF	na	6	-30 dB	12	-15 dB	na	--	11	-40 dB	na	--	9	-10 dB	8	-10 dB	10	-15 dB
252 S-Boom	27	5	1	9	LF	na	6	32 S	12	58 S	na	--	11	200 N	na	--	9	200 N	8	200 N	10	46 N
252 S-Boom	27	5	1	9	LF	na	6	186 E	12	200 W	na	--	11	112 W	na	--	9	200 W	8	198 W	10	198 W
252 S-Boom	27	5	1	9	LF	na	6	4.66	12	4.2	na	--	11	5.46	na	--	9	3.53	8	2.81	10	3.27
252 S-Boom	27	5	1	9	LF	na	6	>320 m	12	>120 m	na	--	11	>400 m	na	--	9	>320 m	8	>260 m	10	>400 m
Delta Sparker	39	5	1	1	LF	na	6	0 dB	12	0 dB	na	--	5	0 dB	na	--	9	0 dB	8	5 dB	10	no data
Delta Sparker	39	5	1	1	LF	na	6	2 S	12	2 N	na	--	5	182 S	na	--	9	200 S	8	200 N	10	no data
Delta Sparker	39	5	1	1	LF	na	6	76 E	12	126 W	na	--	5	76 E	na	--	9	166 W	8	194 W	10	no data
Delta Sparker	39	5	1	1	LF	na	6	2.80	12	3.20	na	--	5	12.82	na	--	9	16.00	8	3.94	10	no data
Delta Sparker	39	5	1	1	LF	na	6	>120 m	12	>120 m	na	--	5	>400 m	na	--	9	>400 m	8	>400 m	10	no data
Mini Sparker	28	5	1	3	LF	na	6	-30 dB	12	-10 dB	na	--	5	-40 dB	na	--	9	-40 dB	8	-10 dB	10	-50 dB
Mini Sparker	28	5	1	3	LF	na	6	104 S	12	44 S	na	--	5	10 N	na	--	9	200 N	8	200 N	10	198 N
Mini Sparker	28	5	1	3	LF	na	6	200 E	12	124 W	na	--	5	194 E	na	--	9	200 W	8	200 W	10	190 W
Mini Sparker	28	5	1	3	LF	na	6	1.30	12	2.31	na	--	5	9.63	na	--	9	24.56	8	2.90	10	13.5
Mini Sparker	28	5	1	3	LF	na	6	>120 m	12	>150 m	na	--	5	>400 m	na	--	9	>400 m	8	>120 m	10	>400 m
Mini Sparker	29	5	1	4	LF	na	6	-20 dB	12	bad	na	--	5	no data	na	--	9	-5 dB	8	0 dB	10	no data
Mini Sparker	29	5	1	4	LF	na	6	18 N	12	bad	na	--	5	no data	na	--	9	20 N	8	52 S	10	no data
Mini Sparker	29	5	1	4	LF	na	6	198 E	12	bad	na	--	5	no data	na	--	9	200 E	8	182 E	10	no data
Mini Sparker	29	5	1	4	LF	na	6	4.72	12	bad	na	--	5	no data	na	--	9	7.52	8	1.95	10	no data
Mini Sparker	29	5	1	4	LF	na	6	>180 m	12	bad	na	--	5	no data	na	--	9	>400 m	8	>400 m	10	no data
Mini Sparker	29	5	1	5	LF	na	6	-20 dB	12	0 dB	na	--	5	no data	na	--	9	5 dB	8	5dB	10	no data
Mini Sparker	29	5	1	5	LF	na	6	138 S	12	180 N	na	--	5	no data	na	--	9	200 S	8	200 W	10	no data

Table A.1-1. (Continued).

Source	Mode	Site	Deployment	Run	frequency	Channel	Buoy Position															
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1
Mini Sparker	29	5	1	5	LF	na	6	200 E	12	200 W	na	--	5	no data	na	--	9	140 E	8	200 N	10	no data
Mini Sparker	29	5	1	5	LF	na	6	6.72	12	3.39	na	--	5	no data	na	--	9	10.61	8	2.55	10	no data
Mini Sparker	29	5	1	5	LF	na	6	>400 m	12	>180 m	na	--	5	no data	na	--	9	>400 m	8	>400 m	10	no data
252 S-Boom	26	2	2	31	LF	na	na	--	na	--	na	--	5	-5	11	0	10	bad	na	--	9	-10 dB
253 S-Boom	26	2	2	31	LF	na	na	--	na	--	na	--	5	200 S	11	200 S	10	bad	na	--	9	200 S
254 S-Boom	26	2	2	31	LF	na	na	--	na	--	na	--	5	198 E	11	128 E	10	bad	na	--	9	200 E
255 S-Boom	26	2	2	31	LF	na	na	--	na	--	na	--	5	3.96	11	3.39	10	bad	na	--	9	2.68
256 S-Boom	26	2	2	31	LF	na	na	--	na	--	na	--	5	>320 m	11	>260m	10	bad	na	--	9	>200 m
257 S-Boom	27	2	2	32	LF	na	na	--	na	--	na	--	5	-5	11	10	10	bad	na	--	9	bad
258 S-Boom	27	2	2	32	LF	na	na	--	na	--	na	--	5	200 S	11	200 S	10	bad	na	--	9	bad
259 S-Boom	27	2	2	32	LF	na	na	--	na	--	na	--	5	26 W	11	52 W	10	bad	na	--	9	bad
260 S-Boom	27	2	2	32	LF	na	na	--	na	--	na	--	5	6.19	11	6.87	10	bad	na	--	9	bad
261 S-Boom	27	2	2	32	LF	na	na	--	na	--	na	--	5	>400 m	11	>400m	10	bad	na	--	9	bad
Mini Sparker	28	2	2	33	LF	na	na	--	na	--	na	--	5	10 dB	11	15 dB	10	20 dB	na	--	9	20 dB
Mini Sparker	28	2	2	33	LF	na	na	--	na	--	na	--	5	6 S	11	8 S	10	190 N	na	--	9	200 S
Mini Sparker	28	2	2	33	LF	na	na	--	na	--	na	--	5	140 E	11	200 E	10	200 E	na	--	9	200 E
Mini Sparker	28	2	2	33	LF	na	na	--	na	--	na	--	5	2.87	11	7.47	10	3.71	na	--	9	5.25
Mini Sparker	28	2	2	33	LF	na	na	--	na	--	na	--	5	>180m	11	>400m	10	>400 m	na	--	9	>400m
Mini Sparker	29	2	2	34	LF	na	na	--	na	--	na	--	5	5 dB	11	10 dB	10	20dB	na	--	9	10 dB
Mini Sparker	29	2	2	34	LF	na	na	--	na	--	na	--	5	54 N	11	90 N	10	200 N	na	--	9	200 S
Mini Sparker	29	2	2	34	LF	na	na	--	na	--	na	--	5	200 E	11	100 W	10	198 W	na	--	9	200 E
Mini Sparker	29	2	2	34	LF	na	na	--	na	--	na	--	5	5.12	11	3.58	10	3.20	na	--	9	3.20
Mini Sparker	29	2	2	34	LF	na	na	--	na	--	na	--	5	>400 m	11	>150 m	10	>400 m	na	--	9	>400 m
Mini Sparker	28	3	2	10	LF	na	na	--	5	-10 dB	na	--	12	no data	na	--	na	--	na	--	6	-30 dB
Mini Sparker	28	3	2	10	LF	na	na	--	5	200 N	na	--	12	no data	na	--	na	--	na	--	6	200 S
Mini Sparker	28	3	2	10	LF	na	na	--	5	194 W	na	--	12	no data	na	--	na	--	na	--	6	200 W
Mini Sparker	28	3	2	10	LF	na	na	--	5	13.54	na	--	12	no data	na	--	na	--	na	--	6	8.35
Mini Sparker	28	3	2	10	LF	na	na	--	5	>400 m	na	--	12	no data	na	--	na	--	na	--	6	>400m
Mini Sparker	29	3	2	11	LF	na	na	--	5	0 dB	na	--	12	20 dB	na	--	na	--	na	--	6	0 dB
Mini Sparker	29	3	2	11	LF	na	na	--	5	200 S	na	--	12	12 N	na	--	na	--	na	--	6	200 N
Mini Sparker	29	3	2	11	LF	na	na	--	5	200 E	na	--	12	114 W	na	--	na	--	na	--	6	176 E
Mini Sparker	29	3	2	11	LF	na	na	--	5	9.83	na	--	12	4.91	na	--	na	--	na	--	6	5.12
Mini Sparker	29	3	2	11	LF	na	na	--	5	>400 m	na	--	12	>320 m	na	--	na	--	na	--	6	>400 m
252 S-Boom	26	5	2	24	LF	na	6	0 dB	12	5 dB	na	--	11	10 dB	na	--	8	10 dB	9	10 dB	10	10 dB
252 S-Boom	26	5	2	24	LF	na	6	200 S	12	54 N	na	--	11	82 N	na	--	8	198 S	9	200 S	10	200 S
252 S-Boom	26	5	2	24	LF	na	6	6 W	12	4 E	na	--	11	2 E	na	--	8	174 W	9	200 E	10	200 E
252 S-Boom	26	5	2	24	LF	na	6	4.48	12	3.14	na	--	11	2.96	na	--	8	2.03	9	9.11	10	22.42
252 S-Boom	26	5	2	24	LF	na	6	>150 m	12	>320 m	na	--	11	>100 m	na	--	8	>400 m	9	>400 m	10	>400m
252 S-Boom	27	5	2	25	LF	na	6	-10 dB	12	-10 dB	na	--	11	-5 dB	na	--	8	-5 dB	9	0 dB	10	-5 dB
252 S-Boom	27	5	2	25	LF	na	6	32 S	12	98 S	na	--	11	54 N	na	--	8	68 S	9	200 S	10	200 S
252 S-Boom	27	5	2	25	LF	na	6	30 E	12	200 W	na	--	11	4 E	na	--	8	200 W	9	198 E	10	200 E
252 S-Boom	27	5	2	25	LF	na	6	3.12	12	4.76	na	--	11	4.23	na	--	8	3.63	9	16.12	10	24.71
252 S-Boom	27	5	2	25	LF	na	6	>100 m	12	>180 m	na	--	11	>180 m	na	--	8	>400 m	9	>400 m	10	>400m
Mini Sparker	28	5	2	19	LF	na	6	-30 dB	12	-40 dB	na	--	11	-20 dB	na	--	8	-30 dB	9	-40 dB	10	-40 dB
Mini Sparker	28	5	2	19	LF	na	6	200 S	12	200 N	na	--	11	194 N	na	--	8	200 N	9	200 N	10	68 N
Mini Sparker	28	5	2	19	LF	na	6	198 E	12	120 W	na	--	11	120 W	na	--	8	200 W	9	200 W	10	200 W
Mini Sparker	28	5	2	19	LF	na	6	5.17	12	6.06	na	--	11	5.18	na	--	8	6.59	9	4.37	10	2.57
Mini Sparker	28	5	2	19	LF	na	6	>400 m	12	>400 m	na	--	11	>400 m	na	--	8	>400 m	9	>400 m	10	>400 m
AirGun	34	5	2	14	LF	na	6	bad	12	30 dB	na	--	11	30 dB	na	--	8	30 dB	9	40 dB	10	bad

Table A.1-1. (Continued).

Source	Mode	Site	Deployment	Run	frequency	Channel	Buoy Position															
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1
AirGun	34	5	2	14	LF	na	6	bad	12	200 N	na	--	11	200 N	na	--	8	56 N	9	152 S	10	bad
AirGun	34	5	2	14	LF	na	6	bad	12	50 E	na	--	11	52 W	na	--	8	200 W	9	172 W	10	bad
AirGun	34	5	2	14	LF	na	6	bad	12	3.56	na	--	11	5.41	na	--	8	2.99	9	13.35	10	bad
AirGun	34	5	2	14	LF	na	6	bad	12	>320 m	na	--	11	>400 m	na	--	8	>400 m	9	>400 m	10	bad
AirGun	38	5	2	28	LF	na	6	-5 dB	12	-5 dB	na	--	11	no data	na	--	8	bad	9	-5 dB	10	bad
AirGun	38	5	2	28	LF	na	6	70 N	12	200 N	na	--	11	no data	na	--	8	bad	9	194 N	10	bad
AirGun	38	5	2	28	LF	na	6	200 W	12	98 W	na	--	11	no data	na	--	8	bad	9	200 W	10	bad
AirGun	38	5	2	28	LF	na	6	9.11	12	1.27	na	--	11	no data	na	--	8	bad	9	1.03	10	bad
AirGun	38	5	2	28	LF	na	6	>400m	12	>60m	na	--	11	no data	na	--	8	bad	9	>120 m	10	bad
AirGun	34	5	2	29	LF	na	6	bad	12	20 dB	na	--	11	no data	na	--	8	30 dB	9	20 dB	10	bad
AirGun	34	5	2	29	LF	na	6	bad	12	190 N	na	--	11	no data	na	--	8	76 S	9	196 S	10	bad
AirGun	34	5	2	29	LF	na	6	bad	12	24 E	na	--	11	no data	na	--	8	200 W	9	2 E	10	bad
AirGun	34	5	2	29	LF	na	6	bad	12	4.38	na	--	11	no data	na	--	8	3.11	9	15.89	10	bad
AirGun	34	5	2	29	LF	na	6	bad	12	>150 m	na	--	11	no data	n0	--	8	>400 m	9	>400 m	10	bad
AirGun	34	5	2	30	LF	na	6	0 dB	12	20 dB	na	--	11	no data	na	--	8	0 dB	9	-10 dB	10	bad
AirGun	34	5	2	30	LF	na	6	68 S	12	24 N	na	--	11	no data	na	--	8	198 S	9	200 S	10	bad
AirGun	34	5	2	30	LF	na	6	4 W	12	200 E	na	--	11	no data	na	--	8	198 E	9	200 W	10	bad
AirGun	34	5	2	30	LF	na	6	10.48	12	4.4	na	--	11	no data	na	--	8	3.45	9	4.11	10	bad
AirGun	34	5	2	30	LF	na	6	>400 m	12	>260 m	na	--	11	no data	na	--	8	>400 m	9	>400 m	10	bad
AirGun	35	5	2	15	LF	na	6	0 dB	12	0 dB	na	--	11	0 dB	na	--	8	5 dB	9	0 dB	10	0 dB
AirGun	35	5	2	15	LF	na	6	78 N	12	48 S	na	--	11	198 N	na	--	8	200 N	9	198 S	10	188 N
AirGun	35	5	2	15	LF	na	6	200 E	12	198 W	na	--	11	94 W	na	--	8	200 W	9	200 W	10	38 W
AirGun	35	5	2	15	LF	na	6	10.30	12	3.85	na	--	11	7.66	na	--	8	2.85	9	6.56	10	8.89
AirGun	35	5	2	15	LF	na	6	>400 m	12	>150m	na	--	11	>400 m	na	--	8	>260 m	9	>400 m	10	>400 m
AirGun	36	5	2	16	LF	na	6	5 dB	12	5 dB	na	--	11	5 dB	na	--	8	5 dB	9	5 dB	10	bad
AirGun	36	5	2	16	LF	na	6	6 S	12	194 N	na	--	11	198 N	na	--	8	200 N	9	58 S	10	bad
AirGun	36	5	2	16	LF	na	6	36 W	12	196 W	na	--	11	142 W	na	--	8	200 W	9	56 W	10	bad
AirGun	36	5	2	16	LF	na	6	8.54	12	2.29	na	--	11	4.03	na	--	8	3.93	9	4.74	10	bad
AirGun	36	5	2	16	LF	na	6	>400 m	12	>400m	na	--	11	>250 m	na	--	8	>320 m	9	>400 m	10	bad
AirGun	34	5	2	17	LF	na	6	0 dB	12	0 dB	na	--	11	0 dB	na	--	8	0 dB	9	10 dB	10	bad
AirGun	34	5	2	17	LF	na	6	26 S	12	110 S	na	--	11	192 N	na	--	8	200 N	9	136 S	10	bad
AirGun	34	5	2	17	LF	na	6	34 E	12	168 W	na	--	11	194 W	na	--	8	200 W	9	6 W	10	bad
AirGun	34	5	2	17	LF	na	6	9.01	12	1.54	na	--	11	4.33	na	--	8	3.49	9	4.62	10	bad
AirGun	34	5	2	17	LF	na	6	>400 m	12	>320 m	na	--	11	>320 m	na	--	8	>320 m	9	>400 m	10	bad
AirGun	37	5	2	18	LF	na	6	5 dB	12	5 dB	na	--	11	no data	na	--	8	5 dB	9	5 dB	10	bad
AirGun	37	5	2	18	LF	na	6	102 N	12	6 N	na	--	11	no data	na	--	8	200 N	9	188 S	10	bad
AirGun	37	5	2	18	LF	na	6	158 E	12	22 E	na	--	11	no data	na	--	8	200 W	9	146 E	10	bad
AirGun	37	5	2	18	LF	na	6	8.26	12	1.49	na	--	11	no data	na	--	8	2.89	9	7.10	10	bad
AirGun	37	5	2	18	LF	na	6	>400 m	12	>100m	na	--	11	no data	na	--	8	>300 m	9	>400 m	10	bad
Mini Sparker	28	3	3	30	LF	na	6	-10	12	-10	na	--	11	0	na	--	8	-5	10	-5	9	-20
Mini Sparker	28	3	3	30	LF	na	6	62 N	12	68 S	na	--	11	122 N	na	--	8	200 N	10	200 N	9	200 N
Mini Sparker	28	3	3	30	LF	na	6	0 W	12	200 E	na	--	11	78 E	na	--	8	200 E	10	200 E	9	200 E
Mini Sparker	28	3	3	30	LF	na	6	1.86	12	4.01	na	--	11	2.88	na	--	8	2.90	10	3.88	9	4.91
Mini Sparker	28	3	3	30	LF	na	6	>30 m	12	>260 m	na	--	11	>230 m	na	--	8	>300 m	10	>280 m	9	>400 m
252 S-Boom	26	3	3	29	LF	na	6	bad	12	bad	na	--	11	10 dB	na	--	8	20 dB	10	20 dB	9	bad
252 S-Boom	26	3	3	29	LF	na	6	bad	12	bad	na	--	11	200 N	na	--	8	200 S	10	104 S	9	bad
252 S-Boom	26	3	3	29	LF	na	6	bad	12	bad	na	--	11	200 E	na	--	8	200 W	10	94 E	9	bad
252 S-Boom	26	3	3	29	LF	na	6	bad	12	bad	na	--	11	9.84	na	--	8	6.78	10	6.11	9	bad
252 S-Boom	26	3	3	29	LF	na	6	bad	12	bad	na	--	11	>400 m	na	--	8	>400 m	10	>400 m	9	bad

Table A.1-1. (Continued).

Source	Mode	Site	Deployment	Run	frequency	Channel	Buoy Position															
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1
252 S-Boom	27	3	3	28	LF	na	6	bad	12	5 dB	na	--	11	10 dB	na	--	8	0 dB	10	0 dB	9	bad
252 S-Boom	27	3	3	28	LF	na	6	bad	12	200 N	na	--	11	200 S	na	--	8	200 S	10	200 S	9	bad
252 S-Boom	27	3	3	28	LF	na	6	bad	12	86 E	na	--	11	152 E	na	--	8	200 E	10	146 E	9	bad
252 S-Boom	27	3	3	28	LF	na	6	bad	12	6.51	na	--	11	8.19	na	--	8	6.1	10	6.72	9	bad
252 S-Boom	27	3	3	28	LF	na	6	bad	12	>400 m	na	--	11	>400 m	na	--	8	>400 m	10	>400 m	9	bad
252 S-Boom	26	4	1	6	LF	na	8	30 dB	6	0 dB	na	--	na	--	na	--	9	bad	na	--	na	--
252 S-Boom	26	4	1	6	LF	na	8	104 N	6	bad	na	--	na	--	na	--	9	bad	na	--	na	--
252 S-Boom	26	4	1	6	LF	na	8	68 W	6	bad	na	--	na	--	na	--	9	bad	na	--	na	--
252 S-Boom	26	4	1	6	LF	na	8	6.4	6	bad	na	--	na	--	na	--	9	bad	na	--	na	--
252 S-Boom	26	4	1	6	LF	na	8	>400 m	6	bad	na	--	na	--	na	--	9	bad	na	--	na	--
252 S-Boom	26	4	3	21	LF	na	8	bad	7	-40 dB	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	26	4	3	21	LF	na	8	bad	7	bad	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	26	4	3	21	LF	na	8	bad	7	bad	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	26	4	3	21	LF	na	8	bad	7	bad	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	26	4	3	21	LF	na	8	bad	7	bad	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	27	4	3	22	LF	na	8	40 dB	7	-60 dB	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	27	4	3	22	LF	na	8	bad	7	bad	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	27	4	3	22	LF	na	8	bad	7	bad	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	27	4	3	22	LF	na	8	bad	7	bad	na	--	12	bad	na	--	na	--	na	--	5	bad
252 S-Boom	27	4	3	22	LF	na	8	bad	7	bad	na	--	12	bad	na	--	na	--	na	--	5	bad
Mini Sparker	29	4	3	25	LF	na	na	--	7	bad	na	--	12	0 dB	na	--	na	--	na	--	9	-10 dB
Mini Sparker	29	4	3	25	LF	na	na	--	7	bad	na	--	12	118 N	na	--	na	--	na	--	9	200 N
Mini Sparker	29	4	3	25	LF	na	na	--	7	bad	na	--	12	94 W	na	--	na	--	na	--	9	200 W
Mini Sparker	29	4	3	25	LF	na	na	--	7	bad	na	--	12	3.49	na	--	na	--	na	--	9	7.49
Mini Sparker	29	4	3	25	LF	na	na	--	7	bad	na	--	12	>180 m	na	--	na	--	na	--	9	>400 m
Mini Sparker	28	4	3	26	LF	na	na	--	7	bad	na	--	12	0 dB	na	--	na	--	na	--	9	bad
Mini Sparker	28	4	3	26	LF	na	na	--	7	bad	na	--	12	118 N	na	--	na	--	na	--	9	bad
Mini Sparker	28	4	3	26	LF	na	na	--	7	bad	na	--	12	94 W	na	--	na	--	na	--	9	bad
Mini Sparker	28	4	3	26	LF	na	na	--	7	bad	na	--	12	3.49	na	--	na	--	na	--	9	bad
Mini Sparker	28	4	3	26	LF	na	na	--	7	bad	na	--	12	>150 m	na	--	na	--	na	--	9	bad
Bubble Gun	33	4	3	28	LF	na	na	--	7	bad	na	--	12	10 dB	na	--	na	--	na	--	5	bad
Bubble Gun	33	4	3	28	LF	na	na	--	7	bad	na	--	12	200 S	na	--	na	--	na	--	5	bad
Bubble Gun	33	4	3	28	LF	na	na	--	7	bad	na	--	12	98 W	na	--	na	--	na	--	5	bad
Bubble Gun	33	4	3	28	LF	na	na	--	7	bad	na	--	12	7.52	na	--	na	--	na	--	5	bad
Bubble Gun	33	4	3	28	LF	na	na	--	7	bad	na	--	12	>400 m	na	--	na	--	na	--	5	bad

-- = no information; bad = data quality too poor to ascertain an adjustment factor; dB = decibel; E = east; HRG = high-resolution geophysical; LF = low-frequency; m = meter; na = not applicable; no data = buoy did not function; N = North; S = south; W = west.

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A.2 Appendix A: Mid-Frequency Results

A.2.1 Site 1, Deployment 1

Knudsen 3260, Mode 24, Run 2, Buoys 5, 6, and 8. Buoy 9 had bad data (*Figure A.2-1*).

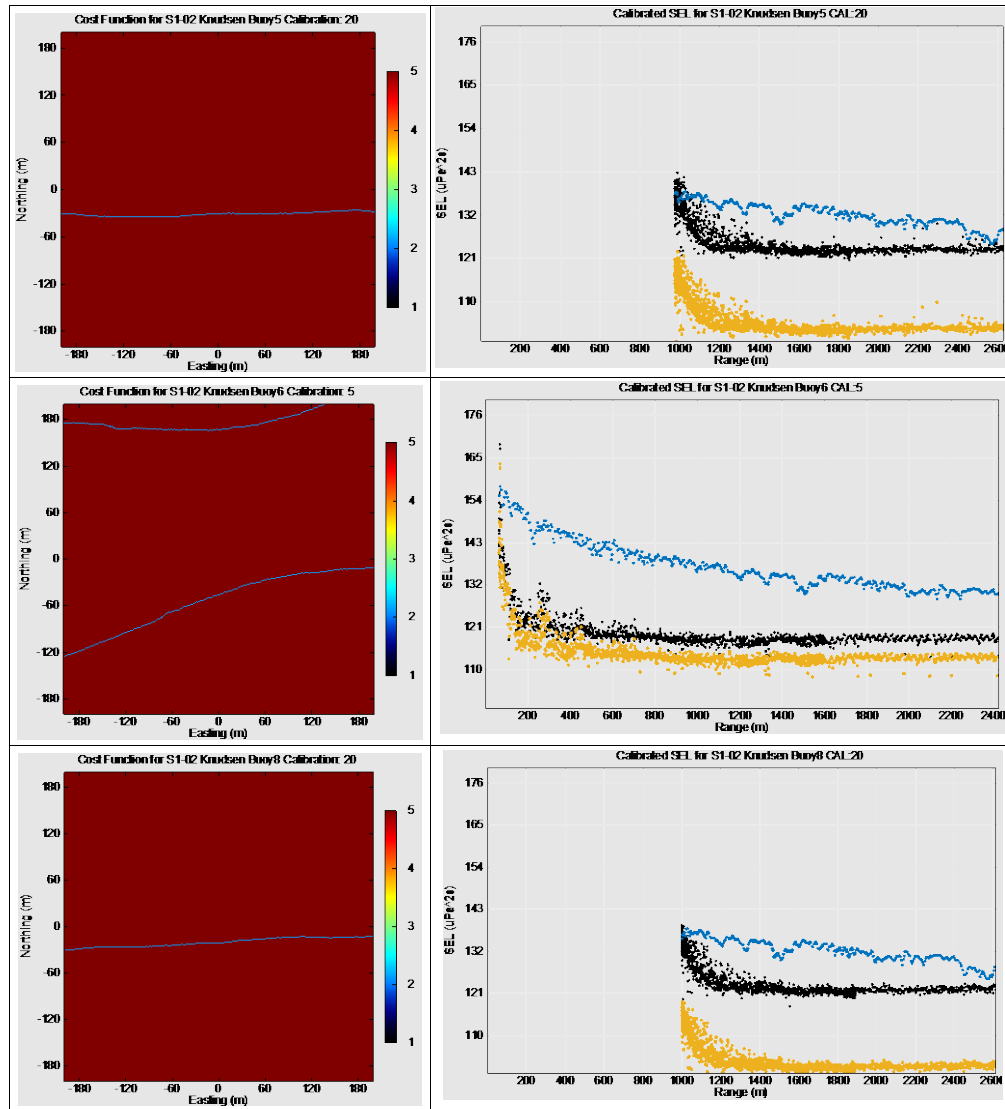


Figure A.2-1. Cost functions of buoy locations and SEL comparisons for Knudsen 3260, Mode 24, at Site 1, Deployment 1, Run 2.

Left: Cost functions for the buoy locations (top to bottom: Buoys 5, 6, and 8). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

A.2.2 Site 2, Deployment 1

Knudsen 3260, Mode 23, Run 1, Buoys 6 and 11. Buoy 9 had bad data (Figure A.2-2).

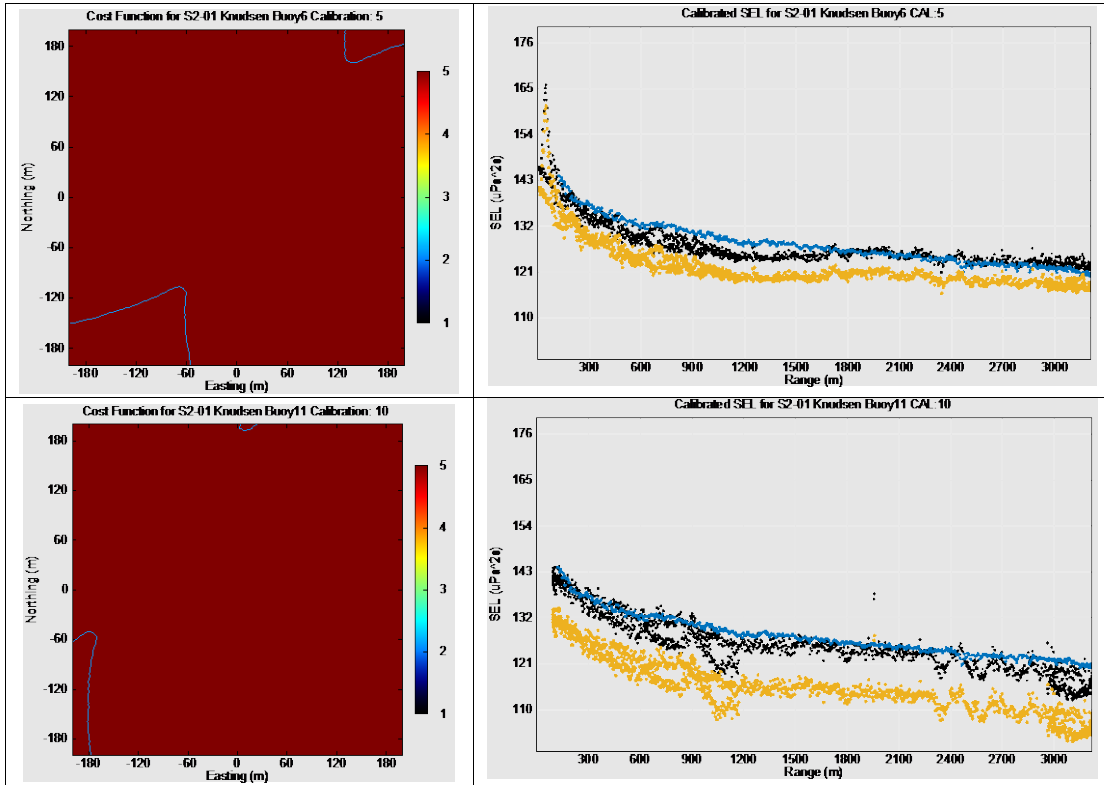


Figure A.2-2. Cost functions of buoy locations and SEL comparisons for Knudsen 3260, Mode 23, at Site 2, Deployment 1, Run 1.

Left: Cost functions for the buoy locations (top: Buoy 6; bottom: Buoy 11). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

A.2.3 Site 3, Deployment 1

Knudsen 3260, Mode 25, Run 7, Buoys 5 and 12. Buoys 7 and 8 had bad data (*Figure A.2-3*).

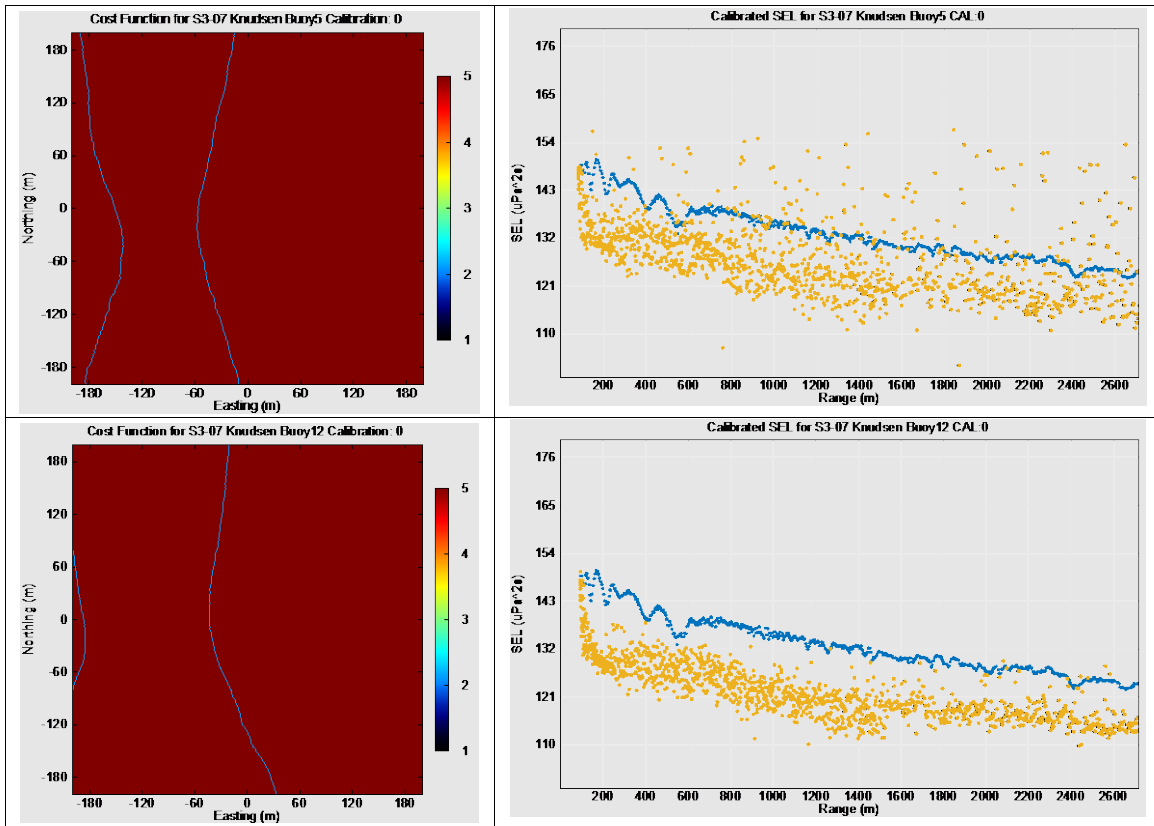


Figure A.2-3. Cost functions of buoy locations and SEL comparisons for Knudsen 3260, Mode 25, at Site 3, Deployment 1, Run 7.

Left: Cost functions for the buoy locations (top: Buoy 5; bottom: Buoy 12). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

A.2.4 Site 4, Deployment 1

ET512, Mode 20, Run 1, Buoys 5 (Hydrophone 2), 6 (Hydrophone 1), 7 (Hydrophones 1 and 2), 9 (Hydrophone 2), and 11. Buoy 8 had bad data (**Figure A.2-4**).

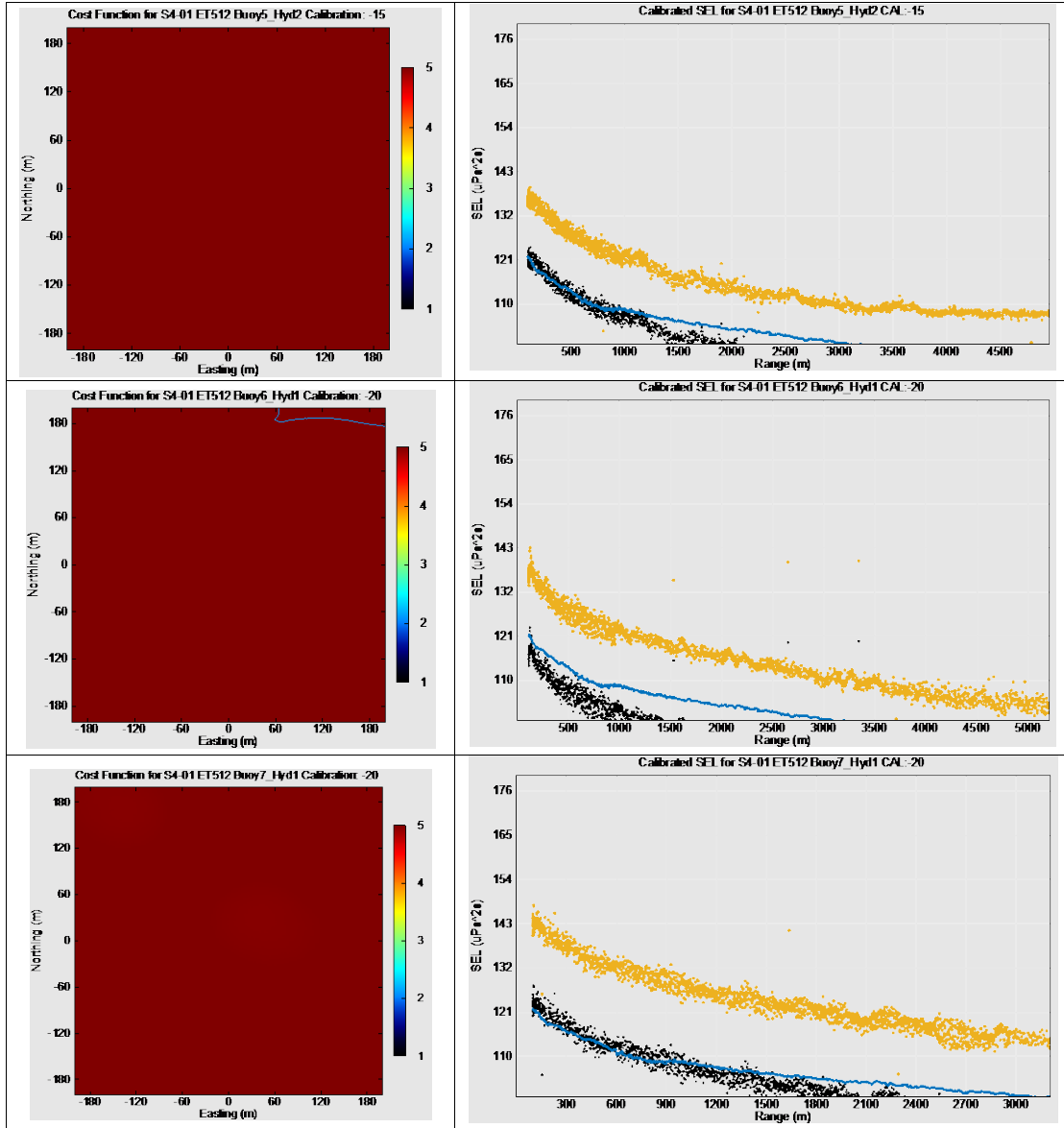


Figure A.2-4. Cost functions of buoy locations and SEL comparisons for ET512, Mode 20, at Site 4, Deployment 1, Run 1.

Left: Cost function for the buoy locations (Buoys 5_Hyd2, 6_Hyd1, 7_Hyd1, 7_Hyd2, 9_Hyd2, and 11). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

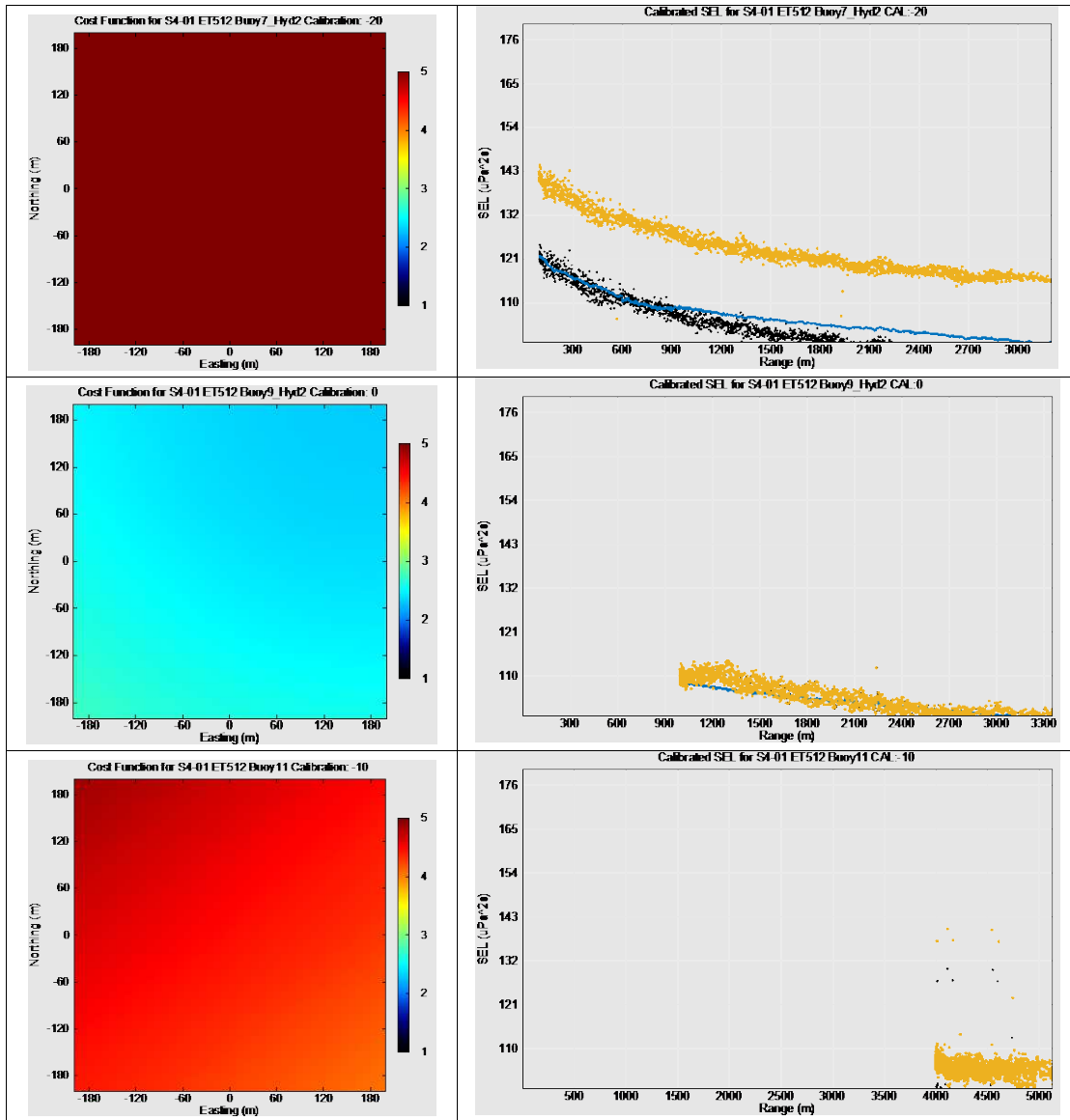


Figure A.2-4 (Continued). Cost functions of buoy locations and SEL comparisons for ET512, Mode 20, at Site 4, Deployment 1, Run 1.

Left: Cost function for the buoy locations (top to bottom: Buoy 5 Hydrophone 2, Buoy 6 Hydrophone 1, Buoy 7 Hydrophone 1, Buoy 7 Hydrophone 2, Buoy 9 Hydrophone 2, and Buoy 11). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

A.2.5 Site 5, Deployment 1

ET512, Mode 21, Run 4, Buoys 8 and 9. Buoys 6 and 12 had bad data (**Figure A.2-5**).

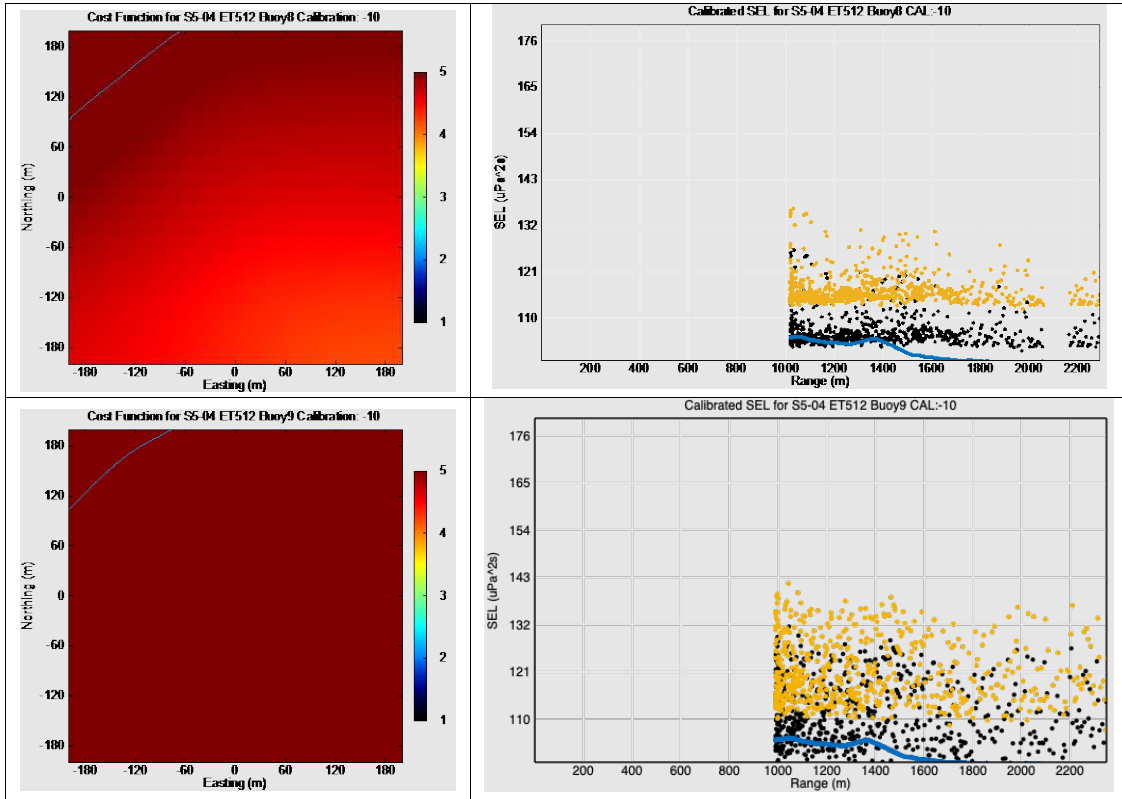


Figure A.2-5. Cost functions of buoy locations and SEL comparisons for ET512, Mode 21, at Site 5, Deployment 1, Run 4.

Left: Cost functions for the buoy locations (top: Buoy 8; bottom: Buoy 9). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

A.2.6 Site 2, Deployment 2

SBP424, Mode 19, Run 34, Buoys 5 and 11. Buoy 9 had bad data (**Figure A.2-6**).

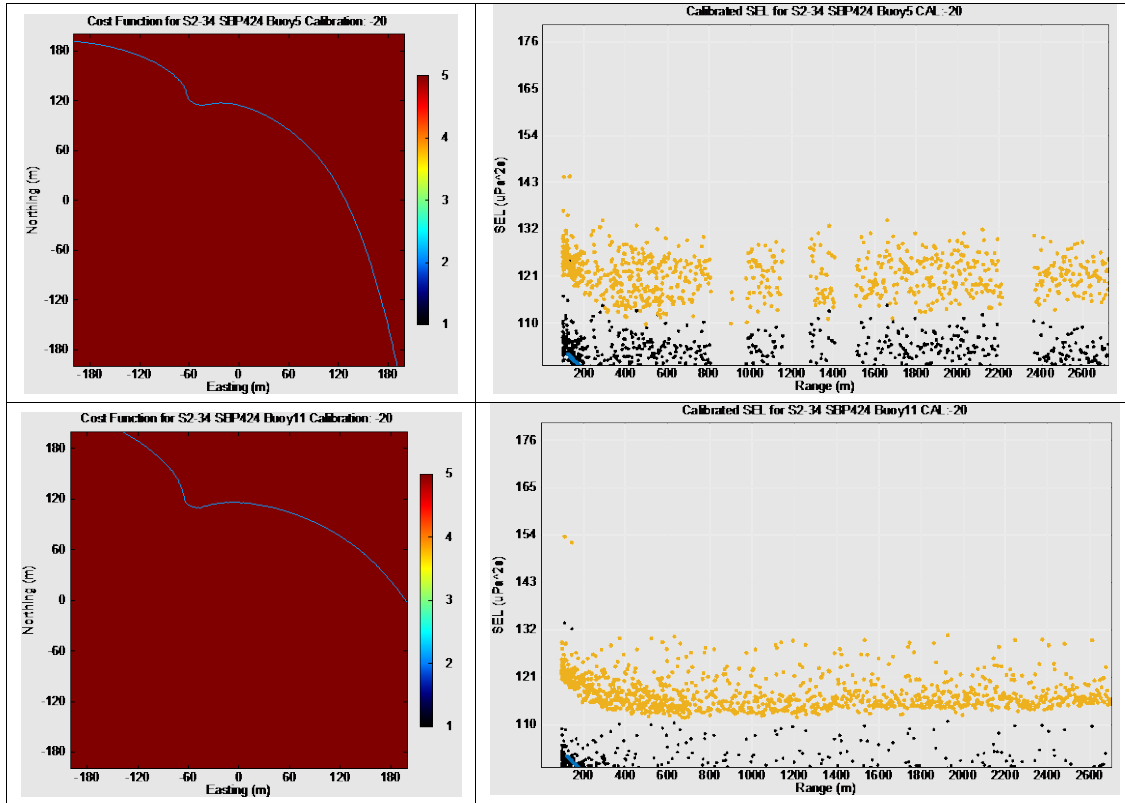


Figure A.2-6. Cost functions of buoy locations and SEL comparisons for SBP424, Mode 19, at Site 2, Deployment 2, Run 34.

Left: Cost functions for the buoy locations (top: Buoy 5; bottom: Buoy 11). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

A.2.7 Site 3, Deployment 2

SBP424, Mode 17, Run 11, Buoys 5, 6, and 12 (Figure A.2-7).

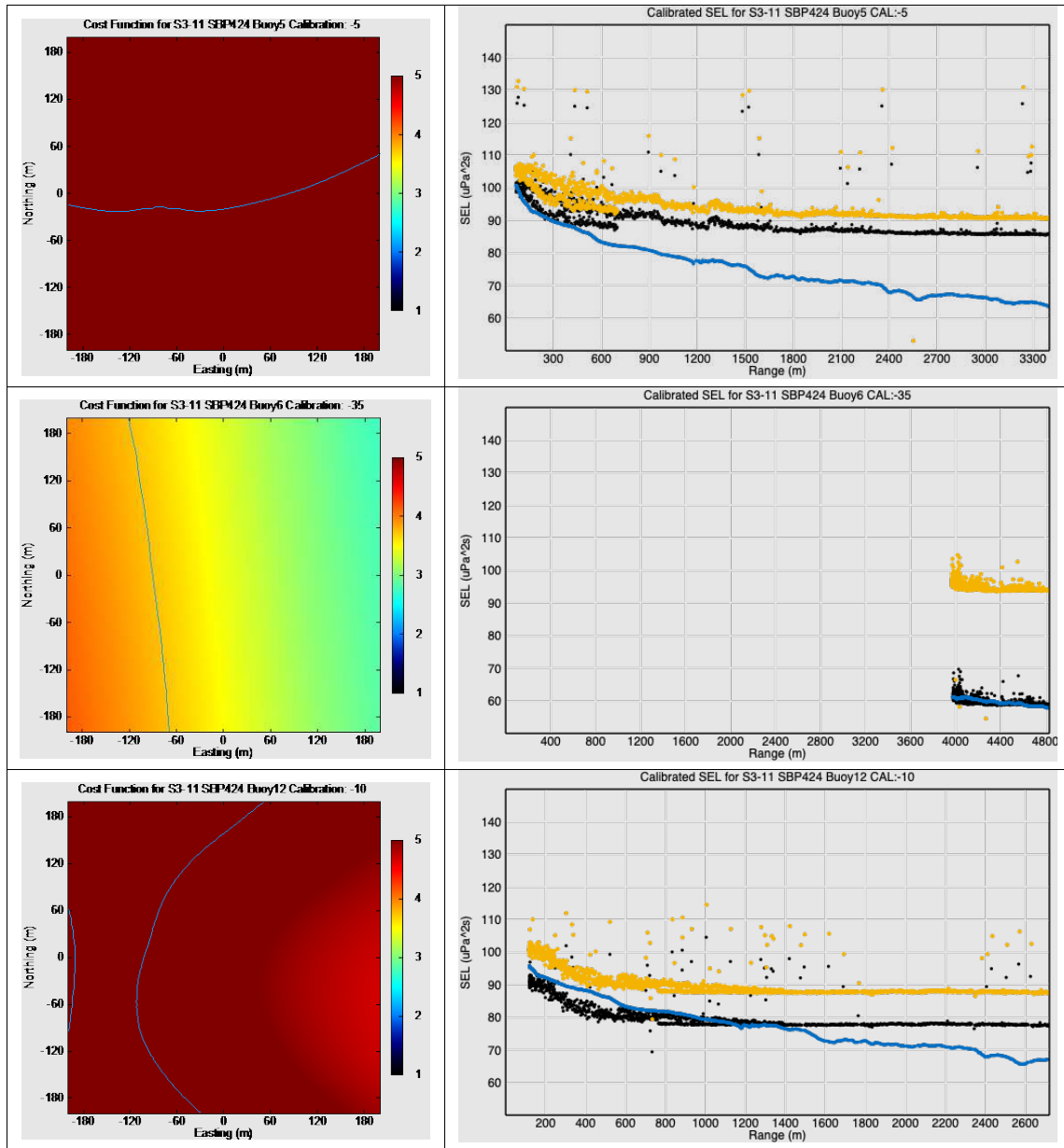


Figure A.2-7. Cost functions of buoy locations and SEL comparisons for SBP424, Mode 17, at Site 3, Deployment 2, Run 11.

Left: Cost functions for the buoy locations (top to bottom: Buoys 5, 6, and 12). Right: Sound exposure level (SEL) versus time of the adjusted data (black) compared to the model (blue) where the closest point of approach is the peak.

A.2.8 Site 4, Deployment 2

SBP424, Mode 16, Runs 10 and 11, Buoy 9 (Figure A.2-8).

Cost functions were not possible to generate with bad navigation data files; therefore, a plot of the percentiles compared with pre-adjusted data are shown for two runs, buoy 9 for run 10 and buoy 9, hydrophone 2 for run 11. Without cost functions, adjustment factors cannot be calculated or applied with the position optimization; thus, an adjusted plot is not available. Any adjustment factors are only able to be determined by visual comparison between the percentiles and the plotted pre-adjusted data.

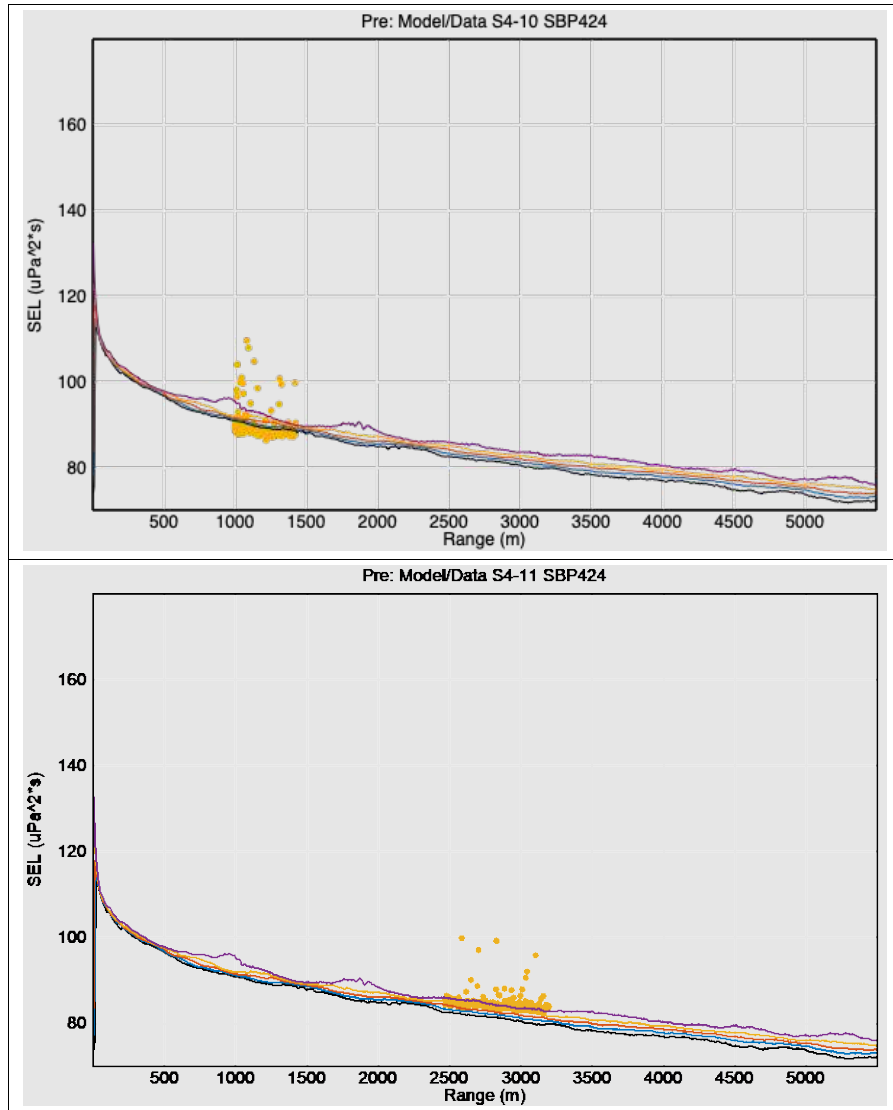


Figure A.2-8. Modeled (lines) versus measured (dots) data for SBP424, Mode 16, at Site 4, Deployment 2, Runs 10 and 11.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for Buoy 9 during run 10 (top) and Buoy 9, hydrophone 2 during run 11 (bottom).

A.2.9 Site 5, Deployment 2

ET512, Mode 20, Run 19, Buoys 6, 8, 9, 10, 11, and 12 (**Figure A.2-9**).

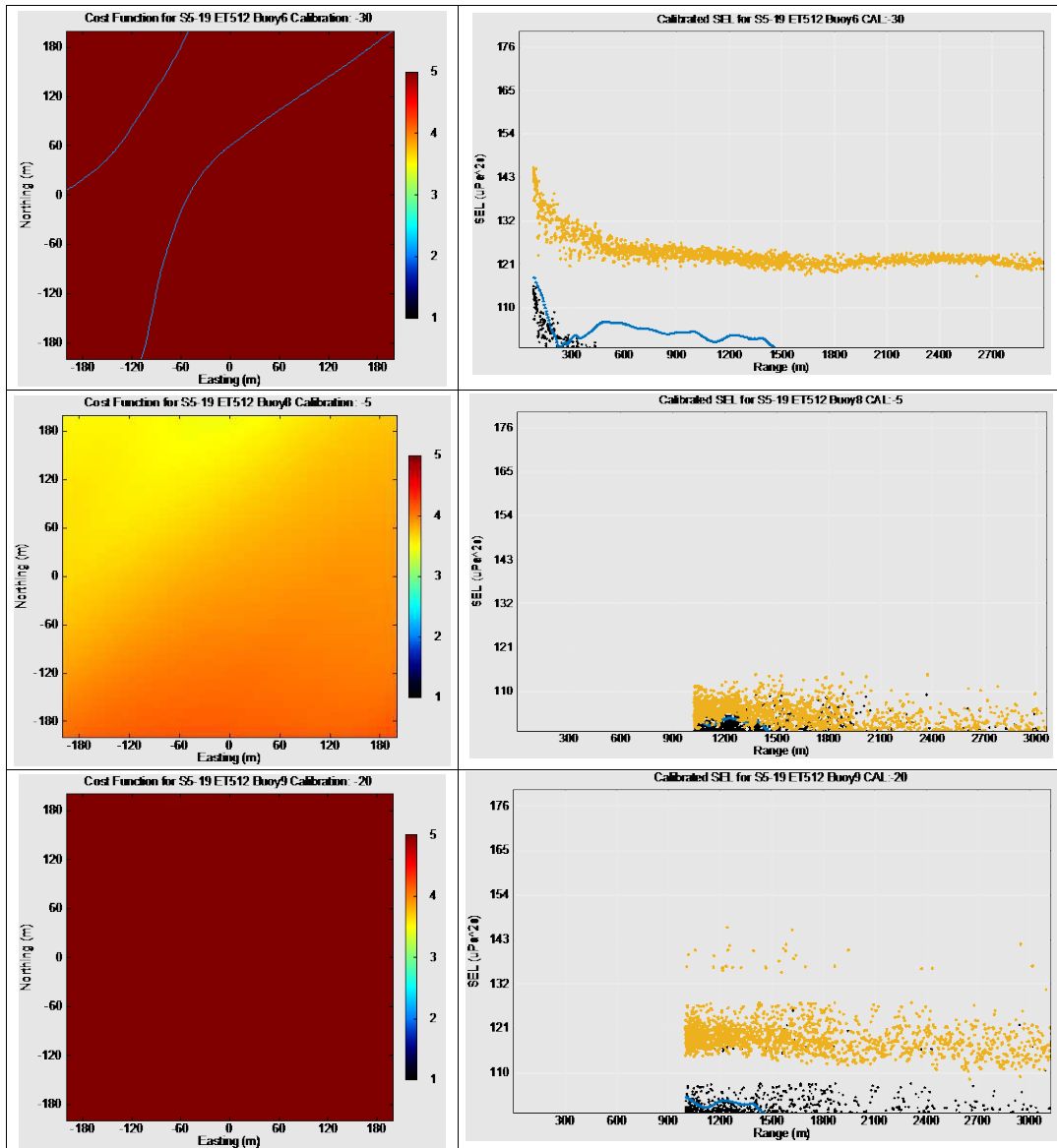


Figure A.2-9. Cost functions of buoy locations and SEL comparisons for ET512, Mode 20, at Site 5, Deployment 2, Run 19.

Left: Cost functions for the buoy locations (top to bottom: Buoys 6, 8, 9, 10, 11, and 12). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

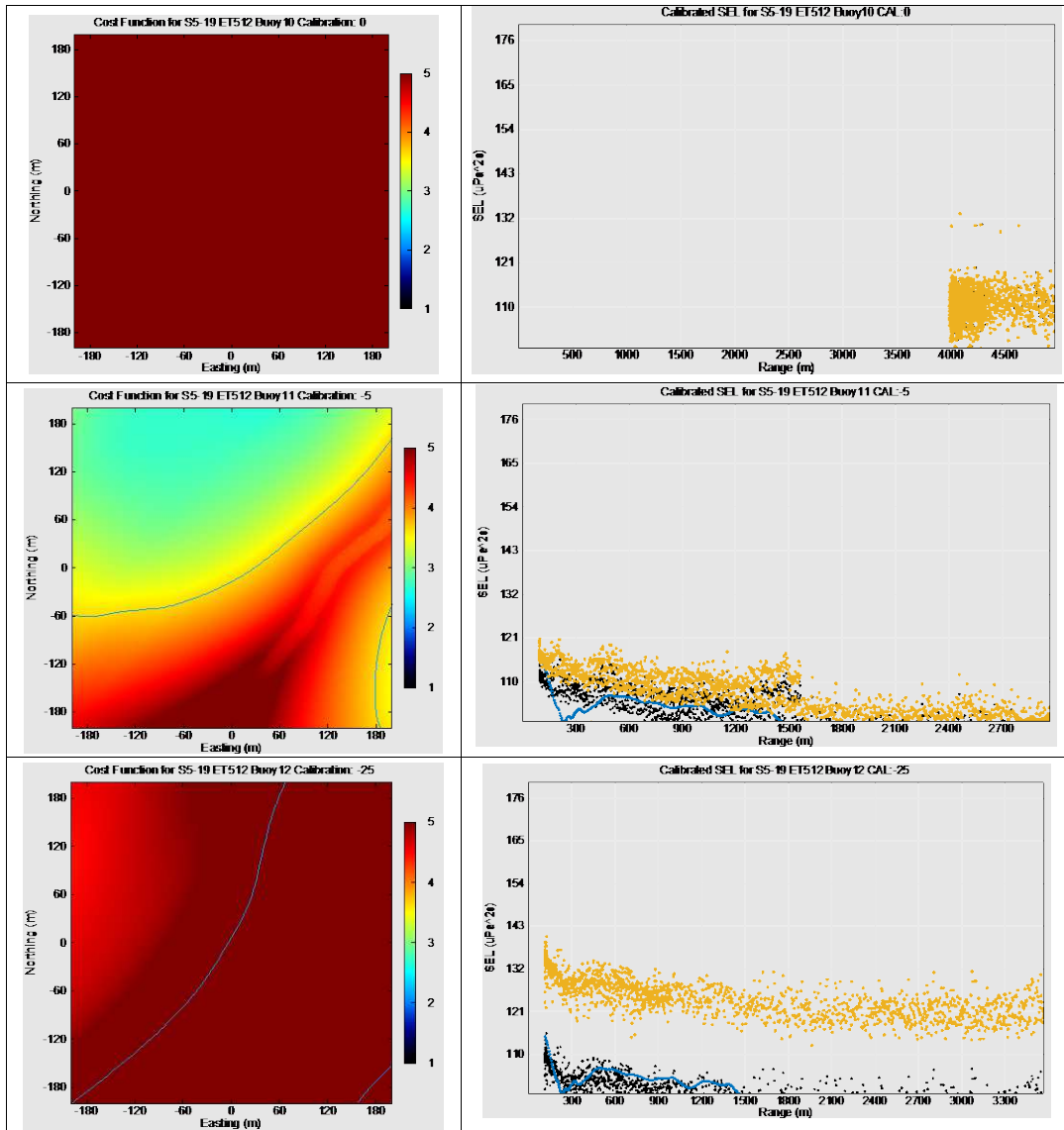


Figure A.2-10 (Continued). Cost functions of buoy locations and SEL comparisons for ET512, Mode 20, at Site 5, Deployment 2, Run 19.

Left: Cost functions for the buoy locations (top to bottom: Buoys 6, 8, 9, 10, 11, and 12). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

A.2.10 Site 3, Deployment 3

SBP424, Mode 18, Run 31, Buoys 6, 11, and 12. Buoys 8, 9, and 10 had bad data (Figure A.2-10).

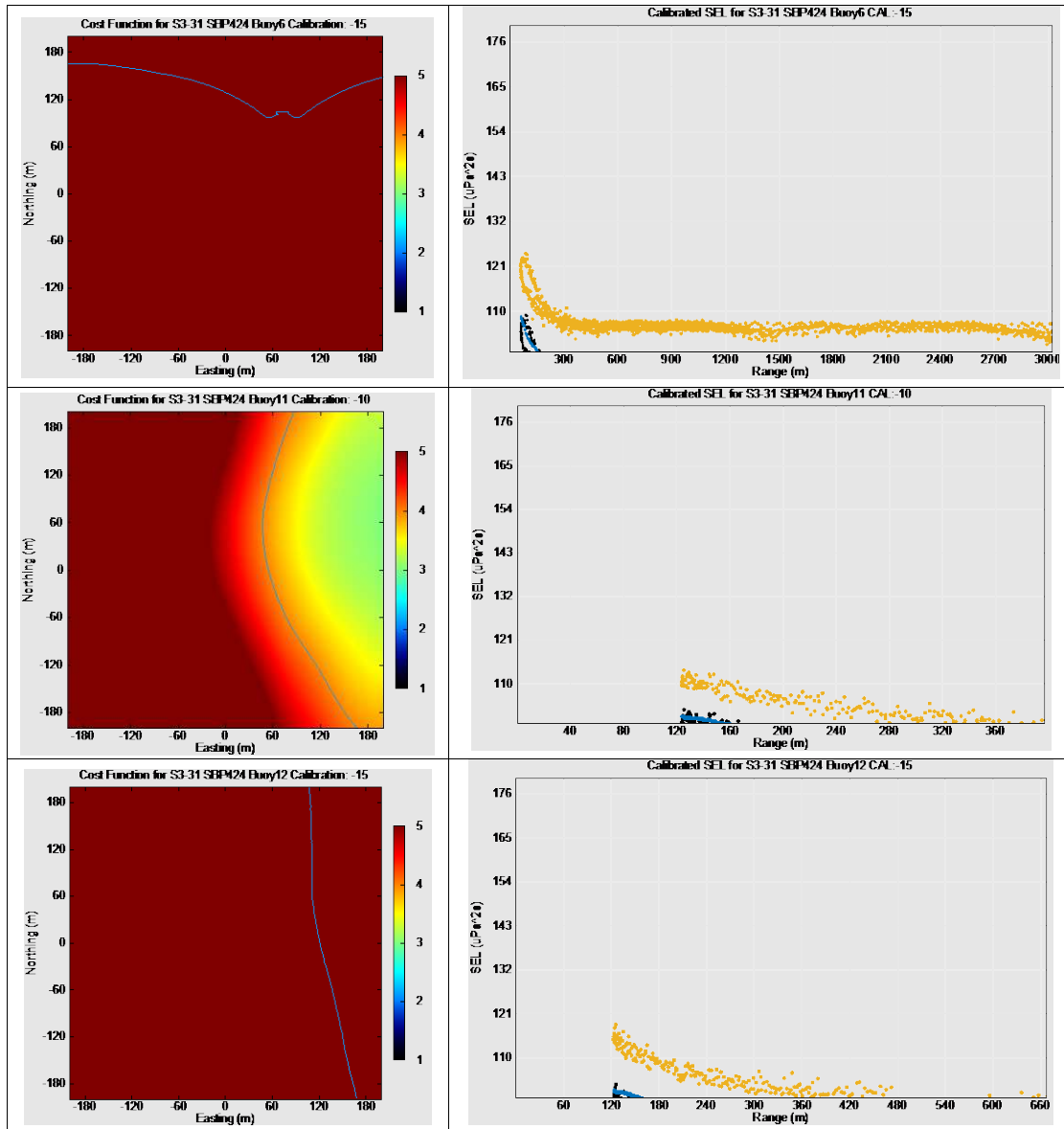


Figure A.2-11. SEL comparisons for SBP424, Mode 18, at Site 3, Deployment 3, Run 31. Left: Cost functions for the buoy locations (top to bottom: Buoys 6, 11, and 12). Right: Sound exposure level (SEL) versus range compared to the model (blue), pre-adjusted data (yellow), and adjusted data (black).

A.2.11 Site 4, Deployment 3

SBP424, Mode 19, Run 27, Buoys 5 and 12. Buoy 7 had bad data (Figure 2.2.-11).

Cost functions were not possible to generate with bad navigation data files at Site 4 during deployment 3; therefore, plots comparing percentiles and pre-adjusted data are shown. Buoy 7 data were bad. Data from Buoys 5 and 12 at the closest point of approach were shifted by -20 dB relative to the percentile range. Because no GPS data were available, position optimization could not be performed.

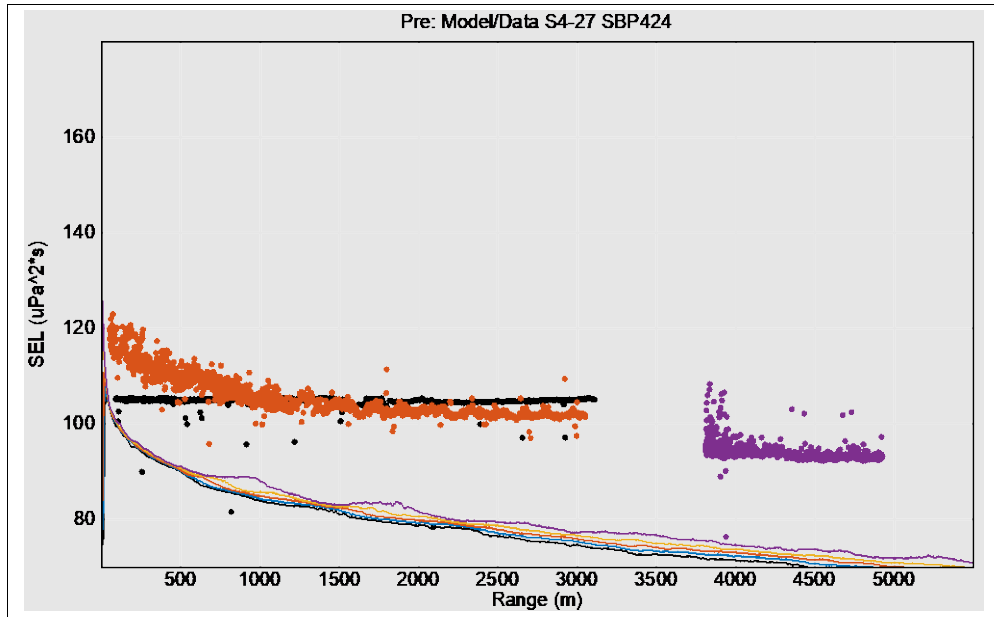


Figure A.2-12. Modeled (lines) versus measured (dots) data for SBP424, Mode 19, at Site 4, Deployment 3, Run 27.

The five percentile lines of the modeled sound exposure level (SEL) illustrate the potential environmental error (95th, purple; 75th, yellow; 50th, red; 25th, blue; 5th, black). The dots are measured SEL versus range for Buoys 5 (red), 12 (purple), and 7 (black; bad data).

A.2.12 Site 5, Deployment 3

No mid-frequency source occurred during Deployment 3 at Site 5.

A.2.13 Mid-Frequency Results Table

Table A-2.1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position										C						
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2		Buoy#	E1	Buoy#	E2	Buoy#	F1
ET424 3100P	16	2	1	4	MF	0	6	192 S	--	--	--	--	11	4 S	--	--	--	--	--	--	--	--	--
ET424 3100P	16	2	1	4	MF	0	6	200 W	--	--	--	--	11	200 E	--	--	--	--	--	--	--	--	--
ET424 3100P	16	2	1	4	MF	0	6	>400 m	--	--	--	--	11	>220 m	--	--	--	--	--	--	--	--	--
ET424 3100P	16	2	1	4	MF	0	6	13.83 dB RMSE	--	--	--	--	11	2.57 dB RMSE	--	--	--	--	--	--	--	--	--
ET424 3100P	17	2	1	5	MF	0	6	-5 dB	--	--	--	--	11	5 dB	--	--	--	--	--	--	--	--	--
ET424 3100P	17	2	1	5	MF	0	6	200 S	--	--	--	--	11	200 S	--	--	--	--	--	--	--	--	--
ET424 3100P	17	2	1	5	MF	0	6	200 W	--	--	--	--	11	96 W	--	--	--	--	--	--	--	--	--
ET424 3100P	17	2	1	5	MF	0	6	>400 m	--	--	--	--	11	>400 m	--	--	--	--	--	--	--	--	--
ET424 3100P	17	2	1	5	MF	0	6	15.25 dB RMSE	--	--	--	--	11	8.82 dB RMSE	--	--	--	--	--	--	--	--	--
ET3200XS	18	2	1	6	MF	0	6	-20 dB	--	--	--	--	11	-20 dB	--	--	--	--	--	--	--	--	--
ET3200XS	18	2	1	6	MF	0	6	8 S	--	--	--	--	11	86 N	--	--	--	--	--	--	--	--	--
ET3200XS	18	2	1	6	MF	0	6	36 E	--	--	--	--	11	200 E	--	--	--	--	--	--	--	--	--
ET3200XS	18	2	1	6	MF	0	6	>400 m	--	--	--	--	11	>400 m	--	--	--	--	--	--	--	--	--
ET3200XS	18	2	1	6	MF	0	6	7.23 dB RMSE	--	--	--	--	11	4.92 dB RMSE	--	--	--	--	--	--	--	--	--
ET3200XS	19	2	1	7	MF	0	6	-30 dB	--	--	--	--	11	-20 dB	--	--	--	--	--	--	--	--	--
ET3200XS	19	2	1	7	MF	0	6	200 S	--	--	--	--	11	200 S	--	--	--	--	--	--	--	--	--
ET3200XS	19	2	1	7	MF	0	6	200 W	--	--	--	--	11	14 W	--	--	--	--	--	--	--	--	--
ET3200XS	19	2	1	7	MF	0	6	>400 m	--	--	--	--	11	>400 m	--	--	--	--	--	--	--	--	--
ET3200XS	19	2	1	7	MF	0	6	13.88 dB RMSE	--	--	--	--	11	7.66 dB RMSE	--	--	--	--	--	--	--	--	--
ET512i	20	2	1	1	MF	0	6	bad	--	--	--	--	11	0 dB	--	--	--	--	--	9	bad	--	--
ET512i	20	2	1	1	MF	0	6	bad	--	--	--	--	11	74 S	--	--	--	--	--	9	bad	--	--
ET512i	20	2	1	1	MF	0	6	bad	--	--	--	--	11	200 E	--	--	--	--	--	9	bad	--	--
ET512i	20	2	1	1	MF	0	6	bad	--	--	--	--	11	>400 m	--	--	--	--	--	9	bad	--	--
ET512i	20	2	1	1	MF	0	6	bad	--	--	--	--	11	5.84 dB RMSE	--	--	--	--	--	9	bad	--	--
ET512i	21	2	1	2	MF	0	6	0 dB	--	--	--	--	11	0 dB	--	--	--	--	--	--	--	--	--
ET512i	21	2	1	2	MF	0	6	10 N	--	--	--	--	11	158 N	--	--	--	--	--	--	--	--	--
ET512i	21	2	1	2	MF	0	6	24 E	--	--	--	--	11	148 E	--	--	--	--	--	--	--	--	--
ET512i	21	2	1	2	MF	0	6	>100 m	--	--	--	--	11	>400 m	--	--	--	--	--	--	--	--	--
ET512i	21	2	1	2	MF	0	6	3.97 dB RMSE	--	--	--	--	11	5.81 dB RMSE	--	--	--	--	--	--	--	--	--
ET512i	22	2	1	3	MF	0	6	-5 dB	--	--	--	--	11	-5 dB	--	--	--	--	--	9	bad	--	--
ET512i	22	2	1	3	MF	0	6	2 N	--	--	--	--	11	162 S	--	--	--	--	--	9	bad	--	--
ET512i	22	2	1	3	MF	0	6	18 E	--	--	--	--	11	10 E	--	--	--	--	--	9	bad	--	--
ET512i	22	2	1	3	MF	0	6	>400 m	--	--	--	--	11	>200 m	--	--	--	--	--	9	bad	--	--
ET512i	22	2	1	3	MF	0	6	9.31 dB RMSE	--	--	--	--	11	3.39 dB RMSE	--	--	--	--	--	9	bad	--	--
Knudsen3260	23	2	1	1	MF	0	6	5 dB	--	--	--	--	11	10 dB	--	--	--	--	--	9	bad	--	--
Knudsen3260	23	2	1	1	MF	0	6	134 N	--	--	--	--	11	110 S	--	--	--	--	--	9	bad	--	--
Knudsen3260	23	2	1	1	MF	0	6	146 W	--	--	--	--	11	200 E	--	--	--	--	--	9	bad	--	--
Knudsen3260	23	2	1	1	MF	0	6	>400 m	--	--	--	--	11	>400 m	--	--	--	--	--	9	bad	--	--

Table A-2.1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
Knudsen3260	23	2	1	1	MF	0	6	6.04 dB RMSE	--	--	--	--	11	6.44 dB RMSE	--	--	--	--	--	--	9	bad	--	--
Knudsen3260	24	2	1	2	MF	0	6	10 dB	--	--	--	--	11	20 dB	--	--	--	--	--	--	--	--	--	--
Knudsen3260	24	2	1	2	MF	0	6	200 N	--	--	--	--	11	52 N	--	--	--	--	--	--	--	--	--	--
Knudsen3260	24	2	1	2	MF	0	6	194 W	--	--	--	--	11	200 E	--	--	--	--	--	--	--	--	--	--
Knudsen3260	24	2	1	2	MF	0	6	>400 m	--	--	--	--	11	>400 m	--	--	--	--	--	--	--	--	--	--
Knudsen3260	24	2	1	2	MF	0	6	10.38 dB RMSE	--	--	--	--	11	7.68 dB RMSE	--	--	--	--	--	--	--	--	--	--
Knudsen3260	25	2	1	3	MF	0	6	5 dB	--	--	--	--	11	bad	--	--	--	--	--	--	9	bad	--	--
Knudsen3260	25	2	1	3	MF	0	6	188 N	--	--	--	--	11	bad	--	--	--	--	--	--	9	bad	--	--
Knudsen3260	25	2	1	3	MF	0	6	200 W	--	--	--	--	11	bad	--	--	--	--	--	--	9	bad	--	--
Knudsen3260	25	2	1	3	MF	0	6	>400 m	--	--	--	--	11	bad	--	--	--	--	--	--	9	bad	--	--
Knudsen3260	25	2	1	3	MF	0	6	8.11 dB RMSE	--	--	--	--	11	bad	--	--	--	--	--	--	9	bad	--	--
ET512i	20	3	1	1	MF	0	--	--	--	--	--	--	5	-15 dB	12	-15 dB	7	bad	--	--	--	--	--	--
ET512i	20	3	1	1	MF	0	--	--	--	--	--	--	5	52 S	12	28 S	7	bad	--	--	--	--	--	--
ET512i	20	3	1	1	MF	0	--	--	--	--	--	--	5	150 E	12	200 E	7	bad	--	--	--	--	--	--
ET512i	20	3	1	1	MF	0	--	--	--	--	--	--	5	>400 m	12	>260 m	7	bad	--	--	--	--	--	--
ET512i	20	3	1	1	MF	0	--	--	--	--	--	--	5	5.06 dB RMSE	12	3.94 dB RMSE	7	bad	--	--	--	--	--	--
ET512i	21	3	1	2	MF	0	--	--	--	--	--	--	5	-15 dB	12	-15 dB	7	bad	--	--	--	--	--	--
ET512i	21	3	1	2	MF	0	--	--	--	--	--	--	5	198 N	12	200 N	7	bad	--	--	--	--	--	--
ET512i	21	3	1	2	MF	0	--	--	--	--	--	--	5	200 E	12	200 E	7	bad	--	--	--	--	--	--
ET512i	21	3	1	2	MF	0	--	--	--	--	--	--	5	>400 m	12	>400 m	7	bad	--	--	--	--	--	--
ET512i	21	3	1	2	MF	0	--	--	--	--	--	--	5	10.07 dB RMSE	12	9.23 dB RMSE	7	bad	--	--	--	--	--	--
ET512i	22	3	1	1	MF	0	--	--	--	--	--	--	5	-15 dB	12	-15 dB	7	bad	--	--	--	--	--	--
ET512i	22	3	1	1	MF	0	--	--	--	--	--	--	5	58 N	12	42 S	7	bad	--	--	--	--	--	--
ET512i	22	3	1	1	MF	0	--	--	--	--	--	--	5	200 E	12	200 E	7	bad	--	--	--	--	--	--
ET512i	22	3	1	1	MF	0	--	--	--	--	--	--	5	>400 m	12	>400 m	7	bad	--	--	--	--	--	--
ET512i	22	3	1	1	MF	0	--	--	--	--	--	--	5	7.96 dB RMSE	12	4.95 dB RMSE	7	bad	--	--	--	--	--	--
Knudsen3260	23	3	1	6	MF	0	--	--	--	--	--	--	5	0 dB	12	0 dB	7	bad	--	--	--	--	--	--
Knudsen3260	23	3	1	6	MF	0	--	--	--	--	--	--	5	154 N	12	194 N	7	bad	--	--	--	--	--	--
Knudsen3260	23	3	1	6	MF	0	--	--	--	--	--	--	5	200 E	12	200 E	7	bad	--	--	--	--	--	--
Knudsen3260	23	3	1	6	MF	0	--	--	--	--	--	--	5	>400 m	12	>400 m	7	bad	--	--	--	--	--	--
Knudsen3260	23	3	1	6	MF	0	--	--	--	--	--	--	5	13.02 dB RMSE	12	11.67 dB RMSE	7	bad	--	--	--	--	--	--
Knudsen3260	25	3	1	7	MF	0	8	bad	--	--	--	--	5	0 dB	12	0 dB	7	bad	--	--	--	--	--	--
Knudsen3260	25	3	1	7	MF	0	8	bad	--	--	--	--	5	172 N	12	198 N	7	bad	--	--	--	--	--	--
Knudsen3260	25	3	1	7	MF	0	8	bad	--	--	--	--	5	200 E	12	200 E	7	bad	--	--	--	--	--	--
Knudsen3260	25	3	1	7	MF	0	8	bad	--	--	--	--	5	>400 m	12	>400 m	7	bad	--	--	--	--	--	--
Knudsen3260	25	3	1	7	MF	0	8	bad	--	--	--	--	5	13.02 dB RMSE	12	16.32 dB RMSE	7	bad	--	--	--	--	--	--
ET512i	20	4	1	1	MF	0	8_Hyd2	bad	6_Hyd1	-20 dB	--	--	7_Hyd1	-20 dB	7_Hyd2	-20 dB	9_Hyd2	0 dB	--	--	11	-10 dB	5_hyd2	-15 dB
ET512i	20	4	1	1	MF	0	8_Hyd2	bad	6_Hyd1	58 N	--	--	7_Hyd1	32 N	7_Hyd2	148 S	9_Hyd2	194 N	--	--	11	200 S	5_hyd2	58 N
ET512i	20	4	1	1	MF	0	8_Hyd2	bad	6_Hyd1	200 E	--	--	7_Hyd1	42 E	7_Hyd2	142 E	9_Hyd2	196 E	--	--	11	200 E	5_hyd2	200 E
ET512i	20	4	1	1	MF	0	8_Hyd2	bad	6_Hyd1	>400 m	--	--	7_Hyd1	>400 m	7_Hyd2	>400 m	9_Hyd2	>400 m	--	--	11	>400 m	5_hyd2	>400 m

Table A-2.1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
ET512i	20	4	1	1	MF	0	8_Hyd2	bad	6_Hyd1	6.21 dB RMSE	--	--	7_Hyd1	4.97 dB RMSE	7_Hyd2	5.56 dB RMSE	9_Hyd2	2.3 dB RMSE	--	--	11	4.05 dB RMSE	5_hyd2	6.21 dB RMSE
ET512i	21	4	1	2	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	-15 dB	7_Hyd2	-15 dB	9_Hyd2	5 dB	--	--	11	0 dB	5_hyd2	-10 dB
ET512i	21	4	1	2	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	82 S	7_Hyd2	160 S	9_Hyd2	200 S	--	--	11	200 S	5_hyd2	56 N
ET512i	21	4	1	2	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	26 E	7_Hyd2	200 E	9_Hyd2	200 E	--	--	11	200 E	5_hyd2	200 E
ET512i	21	4	1	2	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	>400 m	7_Hyd2	>400 m	9_Hyd2	>400 m	--	--	11	>400 m	5_hyd2	>400 m
ET512i	21	4	1	2	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	6.36 dB RMSE	7_Hyd2	6.25 dB RMSE	9_Hyd2	2.64 dB RMSE	--	--	11	2.39 dB RMSE	5_hyd2	5.82 dB RMSE
ET512i	22	4	1	3	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	-20 dB	7_Hyd2	-20 dB	9_Hyd2	0 dB	--	--	11	-5 dB	5_hyd2	-15 dB
ET512i	22	4	1	3	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	84 S	7_Hyd2	194 S	9_Hyd2	184 N	--	--	11	56 S	5_hyd2	2 S
ET512i	22	4	1	3	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	114 E	7_Hyd2	200 E	9_Hyd2	90 W	--	--	11	200 W	5_hyd2	200 E
ET512i	22	4	1	3	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	>400 m	7_Hyd2	>260 m	9_Hyd2	>400 m	--	--	11	>400 m	5_hyd2	>400 m
ET512i	22	4	1	3	MF	0	8_Hyd2	bad	--	--	--	--	7_Hyd1	5.18 dB RMSE	7_Hyd2	3.53 dB RMSE	9_Hyd2	4.51 dB RMSE	--	--	11	4.41 dB RMSE	5_hyd2	4.51 dB RMSE
Knudsen3260	23	4	1	6	MF	0	8	30 dB	6	bad	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
Knudsen3260	23	4	1	6	MF	0	8	200 N	6	bad	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
Knudsen3260	23	4	1	6	MF	0	8	200 W	6	bad	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
Knudsen3260	23	4	1	6	MF	0	8	>400 m	6	bad	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
Knudsen3260	23	4	1	6	MF	0	8	15.69 dB RMSE	6	bad	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET512i	20	5	1	3	MF	0	6	-40 dB	12	-20 dB	--	--	5	-30 dB	--	--	8	-20 dB	9	-30 dB	10	-15 dB	--	--
ET512i	20	5	1	3	MF	0	6	102 S	12	30 S	--	--	5	200 S	--	--	8	200 N	9	200 S	10	200 S	--	--
ET512i	20	5	1	3	MF	0	6	200 E	12	70 W	--	--	5	200 W	--	--	8	4 E	9	46 E	10	200 W	--	--
ET512i	20	5	1	3	MF	0	6	>230 m	12	>120 m	--	--	5	>400 m	--	--	8	>400 m	9	>400 m	10	>400 m	--	--
ET512i	20	5	1	3	MF	0	6	3.64 dB RMSE	12	3.19 dB RMSE	--	--	5	19.53 dB RMSE	--	--	8	5.29 dB RMSE	9	25.55 dB RMSE	10	37.76 dB RMSE	--	--
ET512i	21	5	1	4	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	-10 dB	9	-10 dB	--	--	--	--
ET512i	21	5	1	4	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	200 S	9	200 S	--	--	--	--
ET512i	21	5	1	4	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	200 E	9	200 E	--	--	--	--
ET512i	21	5	1	4	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	>320 m	9	>400 m	--	--	--	--
ET512i	21	5	1	4	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	4.21 dB RMSE	9	16.86 dB RMSE	--	--	--	--
ET512i	22	5	1	5	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	-20 dB	--	--	--	--	--	--
ET512i	22	5	1	5	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	200 N	--	--	--	--	--	--
ET512i	22	5	1	5	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	114 W	--	--	--	--	--	--
ET512i	22	5	1	5	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	>400 m	--	--	--	--	--	--
ET512i	22	5	1	5	MF	0	6	bad	12	bad	--	--	--	--	--	--	8	4.04 dB RMSE	--	--	--	--	--	--
Knudsen3260	23	5	1	10	MF	0	6	-20 dB	12	-5 dB	--	--	5	bad	11	bad	8	10 dB	9	10 dB	10	5 dB	--	--
Knudsen3260	23	5	1	10	MF	0	6	198 S	12	200 N	--	--	5	bad	11	bad	8	200 N	9	200 N	10	196 S	--	--
Knudsen3260	23	5	1	10	MF	0	6	200 E	12	200 W	--	--	5	bad	11	bad	8	200 W	9	200 W	10	200 E	--	--
Knudsen3260	23	5	1	10	MF	0	6	>400 m	12	>400 m	--	--	5	bad	11	bad	8	>400 m	9	>400 m	10	>400 m	--	--
Knudsen3260	23	5	1	10	MF	0	6	11.2 dB RMSE	12	15.56 dB RMSE	--	--	5	bad	11	bad	8	6.63 dB RMSE	9	7.84 dB RMSE	10	3.94 dB RMSE	--	--
Knudsen3260	23	5	1	11	MF	0	6	-10 dB	12	-10 dB	--	--	5	bad	11	bad	8	10 dB	9	10 dB	10	-10 dB	--	--
Knudsen3260	23	5	1	11	MF	0	6	198 S	12	198 S	--	--	5	bad	11	bad	8	200 N	9	154N	10	200 N	--	--

Table A-2.1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
Knudsen3260	23	5	1	11	MF	0	6	200 E	12	200 E	--	--	5	bad	11	bad	8	200 W	9	200 W	10	200 W	--	--
Knudsen3260	23	5	1	11	MF	0	6	>400 m	12	>400 m	--	--	5	bad	11	bad	8	>400 m	9	>400 m	10	>400 m	--	--
Knudsen3260	23	5	1	11	MF	0	6	9.11 dB RMSE	12	19.24 dB RMSE	--	--	5	bad	11	bad	8	3.49 dB RMSE	9	7.66 dB RMSE	10	8.78 dB RMSE	--	--
ET424 3100P	16	2	2	31	MF	0	--	--	--	--	--	--	5	bad	11	bad	10	bad	--	--	9	bad	--	--
ET424 3100P	16	2	2	31	MF	0	--	--	--	--	--	--	5	bad	11	bad	10	bad	--	--	9	bad	--	--
ET424 3100P	16	2	2	31	MF	0	--	--	--	--	--	--	5	bad	11	bad	10	bad	--	--	9	bad	--	--
ET424 3100P	16	2	2	31	MF	0	--	--	--	--	--	--	5	bad	11	bad	10	bad	--	--	9	bad	--	--
ET424 3100P	17	2	2	32	MF	0	--	--	--	--	--	--	5	0 dB	11	5 dB	10	bad	--	--	9	bad	--	--
ET424 3100P	17	2	2	32	MF	0	--	--	--	--	--	--	5	200 S	11	200 S	10	bad	--	--	9	bad	--	--
ET424 3100P	17	2	2	32	MF	0	--	--	--	--	--	--	5	200 E	11	162 W	10	bad	--	--	9	bad	--	--
ET424 3100P	17	2	2	32	MF	0	--	--	--	--	--	--	5	>400 m	11	>400 m	10	bad	--	--	9	bad	--	--
ET424 3100P	17	2	2	32	MF	0	--	--	--	--	--	--	5	6.08 dB RMSE	11	10.84 dB RMSE	10	bad	--	--	9	bad	--	--
ET3200XS	18	2	2	33	MF	0	--	--	--	--	--	--	5	-20 dB	11	-20 dB	10	-30 dB	--	--	9	-35 dB	--	--
ET3200XS	18	2	2	33	MF	0	--	--	--	--	--	--	5	56 S	11	52 S	10	86 N	--	--	9	50 N	--	--
ET3200XS	18	2	2	33	MF	0	--	--	--	--	--	--	5	44 W	11	170 E	10	200 E	--	--	9	18 W	--	--
ET3200XS	18	2	2	33	MF	0	--	--	--	--	--	--	5	>400 m	11	>400 m	10	>400 m	--	--	9	>400 m	--	--
ET3200XS	18	2	2	33	MF	0	--	--	--	--	--	--	5	11.36 dB RMSE	11	5.34 dB RMSE	10	3.33 dB RMSE	--	--	9	2.87 dB RMSE	--	--
ET3200XS	19	2	2	34	MF	0	--	--	--	--	--	--	5	-20 dB	11	-20 dB			--	--	9	bad	--	--
ET3200XS	19	2	2	34	MF	0	--	--	--	--	--	--	5	200 S	11	200 S			--	--	9	bad	--	--
ET3200XS	19	2	2	34	MF	0	--	--	--	--	--	--	5	200 W	11	148 W			--	--	9	bad	--	--
ET3200XS	19	2	2	34	MF	0	--	--	--	--	--	--	5	>400 m	11	>400 m			--	--	9	bad	--	--
ET3200XS	19	2	2	34	MF	0	--	--	--	--	--	--	5	9.29 dB RMSE	11	12.9 dB RMSE			--	--	9	bad	--	--
ET512i	20	2	2	29	MF	0	--	--	--	--	--	--	5	5 dB	11	5 dB	10	10 dB	--	--	9	5 dB	--	--
ET512i	20	2	2	29	MF	0	--	--	--	--	--	--	5	200 S	11	200 S	10	200 S	--	--	9	200 N	--	--
ET512i	20	2	2	29	MF	0	--	--	--	--	--	--	5	178 E	11	200 W	10	200 E	--	--	9	200 W	--	--
ET512i	20	2	2	29	MF	0	--	--	--	--	--	--	5	>400 m	11	>320 m	10	>400 m	--	--	9	>400 m	--	--
ET512i	20	2	2	29	MF	0	--	--	--	--	--	--	5	4.66 dB RMSE	11	3.89 dB RMSE	10	5.75 dB RMSE	--	--	9	5.01 dB RMSE	--	--
ET512i	21	2	2	30	MF	0	--	--	--	--	--	--	5	0 dB	11	5 dB	10	10 dB	--	--	9	-5 dB	--	--
ET512i	21	2	2	30	MF	0	--	--	--	--	--	--	5	60 N	11	22 N	10	200 N	--	--	9	200 N	--	--
ET512i	21	2	2	30	MF	0	--	--	--	--	--	--	5	198 E	11	32 E	10	106 E	--	--	9	200 W	--	--
ET512i	21	2	2	30	MF	0	--	--	--	--	--	--	5	>400 m	11	>200 m	10	>400 m	--	--	9	>400 m	--	--
ET512i	21	2	2	30	MF	0	--	--	--	--	--	--	5	7.61 dB RMSE	11	4.46 dB RMSE	10	2 dB RMSE	--	--	9	4.93 dB RMSE	--	--
Knudsen3260	23	2	2	29	MF	0	--	--	--	--	--	--	5	15 dB	11	15 dB	10	15 dB	--	--	9	15 dB	--	--
Knudsen3261	23	2	2	29	MF	0	--	--	--	--	--	--	5	114 S	11	200 S	10	200 S	--	--	9	200 S	--	--
Knudsen3262	23	2	2	29	MF	0	--	--	--	--	--	--	5	200 W	11	200 W	10	198 E	--	--	9	200 E	--	--
Knudsen3263	23	2	2	29	MF	0	--	--	--	--	--	--	5	>400 m	11	>400 m	10	>400 m	--	--	9	>400 m	--	--
Knudsen3264	23	2	2	29	MF	0	--	--	--	--	--	--	5	4.11 dB RMSE	11	5.67 dB RMSE	10	7.42 dB RMSE	--	--	9	6.8 dB RMSE	--	--
Knudsen3265	24	2	2	30	MF	0	--	--	--	--	--	--	5	20 dB	11	20 dB	10	15 dB	--	--	9	0 dB	--	--
Knudsen3266	24	2	2	30	MF	0	--	--	--	--	--	--	5	18 N	11	38 N	10	198 N	--	--	9	200 S	--	--
Knudsen3267	24	2	2	30	MF	0	--	--	--	--	--	--	5	200 E	11	200 E	10	200 W	--	--	9	200 E	--	--

Table A-2.1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
Knudsen3268	24	2	2	30	MF	0	--	--	--	--	--	--	5	>400 m	11	>400 m	10	>400 m	--	--	9	>400 m	--	--
Knudsen3269	24	2	2	30	MF	0	--	--	--	--	--	--	5	6.39 dB RMSE	11	8.27 dB RMSE	10	14.59 dB RMSE	--	--	9	6.99 dB RMSE	--	--
ET424 3100P	16	3	2	10	MF	0	--	--	5	-15 dB	--	--	--	--	--	--	--	--	--	--	6	-35 dB	--	--
ET424 3100P	16	3	2	10	MF	0	--	--	5	200 N	--	--	--	--	--	--	--	--	--	--	6	200 S	--	--
ET424 3100P	16	3	2	10	MF	0	--	--	5	98 E	--	--	--	--	--	--	--	--	--	--	6	200 W	--	--
ET424 3100P	16	3	2	10	MF	0	--	--	5	>400 m	--	--	--	--	--	--	--	--	--	--	6	>400 m	--	--
ET424 3100P	16	3	2	10	MF	0	--	--	5	10.22 dB RMSE	--	--	--	--	--	--	--	--	--	--	6	6.12 dB RMSE	--	--
ET424 3100P	17	3	2	11	MF	0	--	--	5	-5 dB	--	--	12	-10 dB	--	--	--	--	--	--	6	-35 dB	--	--
ET424 3100P	17	3	2	11	MF	0	--	--	5	200 N	--	--	12	50 S	--	--	--	--	--	--	6	200 N	--	--
ET424 3100P	17	3	2	11	MF	0	--	--	5	20 W	--	--	12	20 E	--	--	--	--	--	--	6	200 E	--	--
ET424 3100P	17	3	2	11	MF	0	--	--	5	>400 m	--	--	12	>360 m	--	--	--	--	--	--	6	>260 m	--	--
ET424 3100P	17	3	2	11	MF	0	--	--	5	11.86 dB RMSE	--	--	12	4.67 dB RMSE	--	--	--	--	--	--	6	2.74 dB RMSE	--	--
ET3200XS	18	3	2	12	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET3200XS	18	3	2	12	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET3200XS	18	3	2	12	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET3200XS	18	3	2	12	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET3200XS	18	3	2	12	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET3200XS	19	3	2	13	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET3200XS	19	3	2	13	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET3200XS	19	3	2	13	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET3200XS	19	3	2	13	MF	0	--	--	5	bad	--	--	12	bad	--	--	--	--	--	--	6	bad	--	--
ET424 3100P	16	4	2	10	MF	0	--	--	6	0 dB	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	10	MF	0	--	--	6	bad nav	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	10	MF	0	--	--	6	bad nav	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	10	MF	0	--	--	6	bad nav	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	10	MF	0	--	--	6	bad nav	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	11	MF	0	--	--	6	0 dB	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	11	MF	0	--	--	6	bad nav	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	11	MF	0	--	--	6	bad nav	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	11	MF	0	--	--	6	bad nav	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	16	4	2	11	MF	0	--	--	6	bad nav	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET424 3100P	17	4	2	12	MF	0	--	--	--	--	--	--	--	--	--	--	9	-20 dB	--	--	--	--	--	--
ET424 3100P	17	4	2	12	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad nav	--	--	--	--	--	--
ET424 3100P	17	4	2	12	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad nav	--	--	--	--	--	--
ET424 3100P	17	4	2	12	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad nav	--	--	--	--	--	--
ET424 3100P	17	4	2	12	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad nav	--	--	--	--	--	--
ET3200XS	18	4	2	14	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET3200XS	18	4	2	14	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET3200XS	18	4	2	14	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET3200XS	18	4	2	14	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET3200XS	18	4	2	14	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad	--	--	--	--	--	--
ET3200XS	19	4	2	13	MF	0	--	--	--	--	--	--	--	--	--	--	9	-40 dB	--	--	--	--	--	--
ET3200XS	19	4	2	13	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad nav	--	--	--	--	--	--
ET3200XS	19	4	2	13	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad nav	--	--	--	--	--	--
ET3200XS	19	4	2	13	MF	0	--	--	--	--	--	--	--	--	--	--	9	bad nav	--	--	--	--	--	--

Table A-2.1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
ET3200XS	19	4	2	13	MF	0	--	--	--	--	--	--	--	--	--	9	bad nav	--	--	--	--	--	--	
ET512i	20	5	2	29	MF	0	6	-30 dB	12	-25 dB	--	--	11	-5 dB	--	--	8	-5 dB	9	-20 dB	10	0 dB	--	--
ET512i	20	5	2	29	MF	0	6	200 S	12	104 N	--	--	11	200 N	--	--	8	200 N	9	200 S	10	8 N	--	--
ET512i	20	5	2	29	MF	0	6	200 E	12	200 W	--	--	11	26 E	--	--	8	22 W	9	54 W	10	200 W	--	--
ET512i	20	5	2	29	MF	0	6	>400 m	12	>200 m	--	--	11	>200 m	--	--	8	>400 m	9	>400 m	10	>400 m	--	--
ET512i	20	5	2	29	MF	0	6	9.67 dB RMSE	12	4.45 dB RMSE	--	--	11	2.65 dB RMSE	--	--	8	3.45 dB RMSE	9	4.98 dB RMSE	10	17.53 dB RMSE	--	--
ET424 3100P	16	3	3	30	MF	0	6	bad	12	-10 dB	--	--	11	-5 dB	--	--	8	bad	10	bad	9	-40 dB	--	--
ET424 3100P	16	3	3	30	MF	0	6	bad	12	200 N	--	--	11	30 N	--	--	8	bad	10	bad	9	200 N	--	--
ET424 3100P	16	3	3	30	MF	0	6	bad	12	200 E	--	--	11	122 E	--	--	8	bad	10	bad	9	200 E	--	--
ET424 3100P	16	3	3	30	MF	0	6	bad	12	>400 m	--	--	11	>120 m	--	--	8	bad	10	bad	9	>360 m	--	--
ET424 3100P	16	3	3	30	MF	0	6	bad	12	8.34 dB RMSE	--	--	11	4.69 dB RMSE	--	--	8	bad	10	bad	9	3.38 dB RMSE	--	--
ET3200XS	18	3	3	31	MF	0	6	-15 dB	12	-15 dB	--	--	11	-10 dB	--	--	8	bad	10	bad	9	bad	--	--
ET3200XS	18	3	3	31	MF	0	6	200 S	12	200 N	--	--	11	60 N	--	--	8	bad	10	bad	9	bad	--	--
ET3200XS	18	3	3	31	MF	0	6	200 W	12	200 E	--	--	11	200 E	--	--	8	bad	10	bad	9	bad	--	--
ET3200XS	18	3	3	31	MF	0	6	>400 m	12	>400 m	--	--	11	>150 m	--	--	8	bad	10	bad	9	bad	--	--
ET3200XS	18	3	3	31	MF	0	6	7.08 dB RMSE	12	5.78 dB RMSE	--	--	11	2.99 dB RMSE	--	--	8	bad	10	bad	9	bad	--	--
ET512i	20	3	3	21	MF	0	6	-20 dB	12	-15 dB	--	--	11	-10 dB	--	--	8	0 dB	10	-5 dB	9	0 dB	--	--
ET512i	20	3	3	21	MF	0	6	38 N	12	200 S	--	--	11	200 N	--	--	8	68 N	10	200 N	9	200 S	--	--
ET512i	20	3	3	21	MF	0	6	200 W	12	200 E	--	--	11	200 E	--	--	8	22 E	10	200 E	9	48 E	--	--
ET512i	20	3	3	21	MF	0	6	>400 m	12	>400 m	--	--	11	>400 m	--	--	8	>400 m	10	>260 m	9	>400 m	--	--
ET512i	20	3	3	21	MF	0	6	5.17 dB RMSE	12	7.29 dB RMSE	--	--	11	8.43 dB RMSE	--	--	8	1.64 dB RMSE	10	3.99 dB RMSE	9	2.35 dB RMSE	--	--
ET512i	21	3	3	22	MF	0	6	-15 dB	12	-10 dB	--	--	11	-5 dB	--	--	8	bad	10	5 dB	9	bad	--	--
ET512i	21	3	3	22	MF	0	6	116 S	12	200 S	--	--	11	196 N	--	--	8	bad	10	200 S	9	bad	--	--
ET512i	21	3	3	22	MF	0	6	200 W	12	200 E	--	--	11	200 E	--	--	8	bad	10	200 E	9	bad	--	--
ET512i	21	3	3	22	MF	0	6	>400 m	12	>400 m	--	--	11	>400 m	--	--	8	bad	10	>350 m	9	bad	--	--
ET512i	21	3	3	22	MF	0	6	5.12 dB RMSE	12	10.79 dB RMSE	--	--	11	7.79 dB RMSE	--	--	8	bad	10	1.57 dB RMSE	9	bad	--	--
ET512i	22	3	3	23	MF	0	6	-20 dB	12	-10 dB	--	--	11	-10 dB	--	--	8	bad	10	-5 dB	--	--	--	--
ET512i	22	3	3	23	MF	0	6	200 S	12	200 N	--	--	11	86 N	--	--	8	bad	10	60 N	--	--	--	--
ET512i	22	3	3	23	MF	0	6	14 E	12	92 E	--	--	11	200 E	--	--	8	bad	10	120 W	--	--	--	--
ET512i	22	3	3	23	MF	0	6	>400 m	12	>400 m	--	--	11	>260 m	--	--	8	bad	10	>400 m	--	--	--	--
ET512i	22	3	3	23	MF	0	6	17.07 dB RMSE	12	6.42 dB RMSE	--	--	11	3.43 dB RMSE	--	--	8	bad	10	4.58 dB RMSE	--	--	--	--
Knudsen3260	23	3	3	27	MF	0	6	20 dB	12	20 dB	--	--	11	30 dB	--	--	8	20 dB	10	15 dB	9	-5 dB	--	--
Knudsen3260	23	3	3	27	MF	0	6	200 N	12	200 S	--	--	11	170 S	--	--	8	200 S	10	200 S	9	200 S	--	--
Knudsen3260	23	3	3	27	MF	0	6	200 W	12	200 E	--	--	11	156 E	--	--	8	200 E	10	200 E	9	200 E	--	--
Knudsen3260	23	3	3	27	MF	0	6	>150 m	12	>400 m	--	--	11	>230 m	--	--	8	>400 m	10	>400 m	9	>400 m	--	--
Knudsen3260	23	3	3	27	MF	0	6	3.19 dB RMSE	12	6 dB RMSE	--	--	11	2.74 dB RMSE	--	--	8	12.49 dB RMSE	10	17.9 dB RMSE	9	26.64 dB RMSE	--	--
Knudsen3260	25	3	3	28	MF	0	6	0 dB	12	10 dB	--	--	11	20 dB	--	--	8	15 dB	10	15 dB	9	bad	--	--
Knudsen3260	25	3	3	28	MF	0	6	200 N	12	200 S	--	--	11	200 N	--	--	8	200 N	10	200 S	9	bad	--	--
Knudsen3260	25	3	3	28	MF	0	6	200 W	12	200 E	--	--	11	200 E	--	--	8	200 E	10	200 E	9	bad	--	--
Knudsen3260	25	3	3	28	MF	0	6	>400 m	12	>400 m	--	--	11	>400 m	--	--	8	>400 m	10	>400 m	9	bad	--	--
Knudsen3260	25	3	3	28	MF	0	6	11.66 dB RMSE	12	13.7 dB RMSE	--	--	11	6.94 dB RMSE	--	--	8	14.08 dB RMSE	10	13.7 dB RMSE	9	bad	--	--
ET424 3100P	16	4	3	25	MF	0	--	--	--	--	--	--	12	0 dB	--	--	--	--	--	5	-20 dB	--	--	

Table A-2.1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
ET424 3100P	16	4	3	25	MF	0	--	--	--	--	--	--	12	bad nav	--	--	--	--	--	--	5	bad nav	--	--
ET424 3100P	16	4	3	25	MF	0	--	--	--	--	--	--	12	bad nav	--	--	--	--	--	--	5	bad nav	--	--
ET424 3100P	16	4	3	25	MF	0	--	--	--	--	--	--	12	bad nav	--	--	--	--	--	--	5	bad nav	--	--
ET424 3100P	16	4	3	25	MF	0	--	--	--	--	--	--	12	bad nav	--	--	--	--	--	--	5	bad nav	--	--
ET424 3100P	17	4	3	26	MF	0	--	--	7	bad	--	--	12	-10 dB	--	--	--	--	--	--	5	-20 dB	--	--
ET424 3100P	17	4	3	26	MF	0	--	--	7	bad	--	--	12	198 S	--	--	--	--	--	--	5	188 N	--	--
ET424 3100P	17	4	3	26	MF	0	--	--	7	bad	--	--	12	124 W	--	--	--	--	--	--	5	200 W	--	--
ET424 3100P	17	4	3	26	MF	0	--	--	7	bad	--	--	12	>400 m	--	--	--	--	--	--	5	>400 m	--	--
ET424 3100P	17	4	3	26	MF	0	--	--	7	bad	--	--	12	6.51 dB RMSE	--	--	--	--	--	--	5	8.99 dB RMSE	--	--
ET3200XS	18	4	3	27	MF	0	--	--	7	bad	--	--	12	-20 dB	--	--	--	--	--	--	5	bad	--	--
ET3200XS	18	4	3	27	MF	0	--	--	7	bad	--	--	12	200 S	--	--	--	--	--	--	5	bad	--	--
ET3200XS	18	4	3	27	MF	0	--	--	7	bad	--	--	12	200 W	--	--	--	--	--	--	5	bad	--	--
ET3200XS	18	4	3	27	MF	0	--	--	7	bad	--	--	12	>400 m	--	--	--	--	--	--	5	bad	--	--
ET3200XS	18	4	3	27	MF	0	--	--	7	bad	--	--	12	11.13 dB RMSE	--	--	--	--	--	--	5	bad	--	--
ET3200XS	19	4	3	28	MF	0	--	--	7	bad	--	--	12	-20 dB	--	--	--	--	--	--	5	-20 dB	--	--
ET3200XS	19	4	3	28	MF	0	--	--	7	bad	--	--	12	bad nav	--	--	--	--	--	--	5	bad nav	--	--
ET3200XS	19	4	3	28	MF	0	--	--	7	bad	--	--	12	bad nav	--	--	--	--	--	--	5	bad nav	--	--
ET3200XS	19	4	3	28	MF	0	--	--	7	bad	--	--	12	bad nav	--	--	--	--	--	--	5	bad nav	--	--
ET3200XS	19	4	3	28	MF	0	--	--	7	bad	--	--	12	bad nav	--	--	--	--	--	--	5	bad nav	--	--
Knudsen3260	23	4	3	21	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	23	4	3	21	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	23	4	3	21	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	23	4	3	21	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	23	4	3	21	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	25	4	3	22	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	25	4	3	22	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	25	4	3	22	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	25	4	3	22	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--
Knudsen3260	25	4	3	22	MF	0	8	bad	7	bad	--	--	12	bad	--	--	--	--	--	--	5	bad	--	--

-- = no information; bad = data quality too poor to ascertain an adjustment factor; dB = decibel; E = east; HRG = high-resolution geophysical; m = meter; MF = mid-frequency; na = not applicable; no data = buoy did not function; N = North; S = south; W = west.

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A.3 Appendix A: High-Frequency Results

A.3.1 Site 1, Deployment 1

Klein 3000, Mode 6, Run 12, Buoys 5 and 6 (Figure A.3-1).

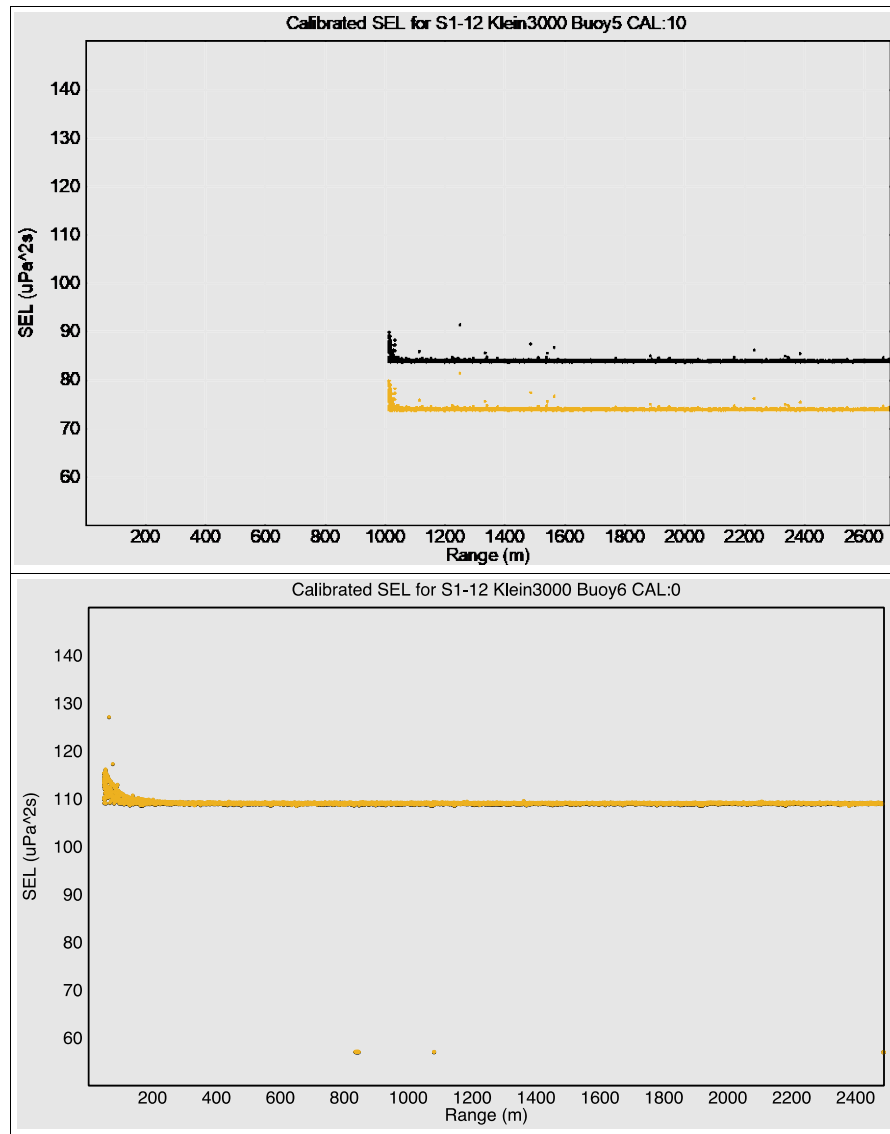


Figure A.3-1. SEL comparisons for Klein 3000, Mode 6, at Site 1, Deployment 1, Run 12. Sound exposure level (SEL) versus range (top: Buoy 5; bottom: Buoy 6). Pre-adjusted data (yellow) and adjusted data (black).

A.3.2 Site 2, Deployment 1

Reson 7125, Mode 1, Run 12, Buoys 6 and 11 (Figure A.3-2).

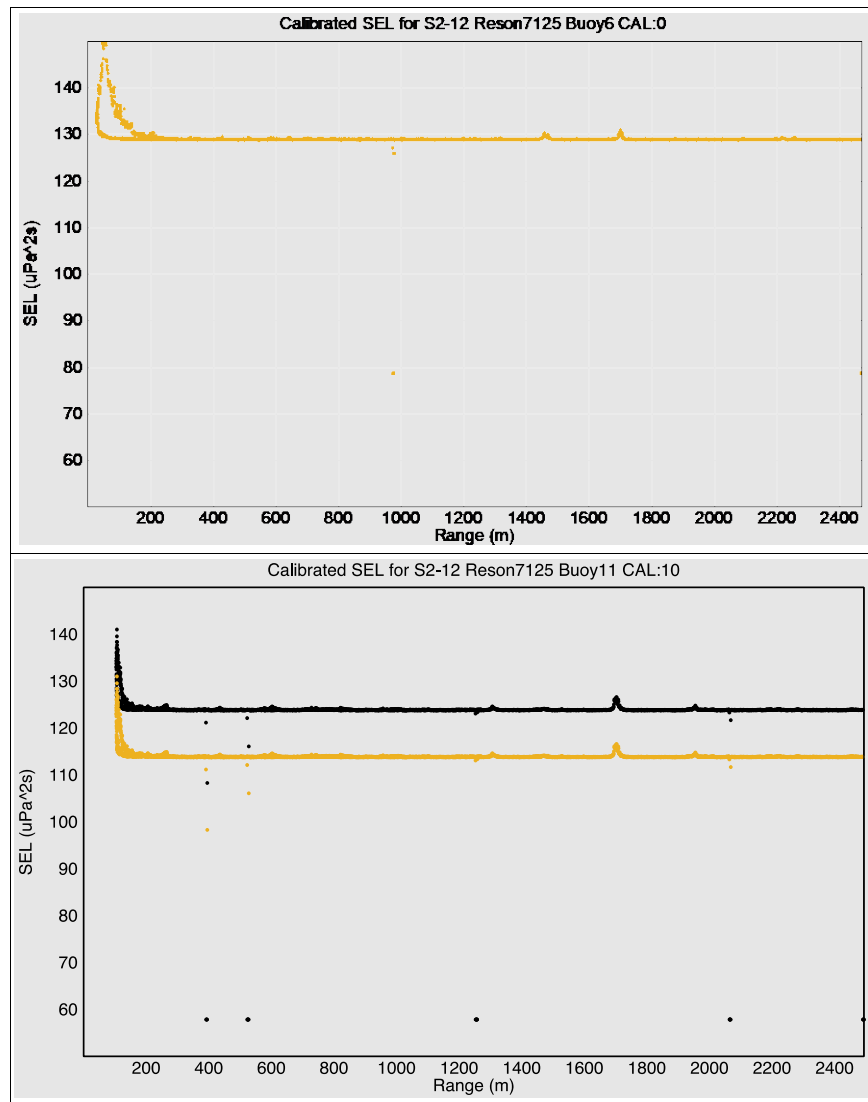


Figure A.3-2. SEL comparisons for Reson 7125, Mode 1, at Site 2, Deployment 1, Run 12. Sound exposure level (SEL) versus range (top: Buoy 6; bottom: Buoy 11). Pre-adjusted data (yellow) and adjusted data (black).

A.3.3 Site 3, Deployment 1

EK60, Mode 14, Run 2, Buoys 5 and 12 (Figure A.3-3).

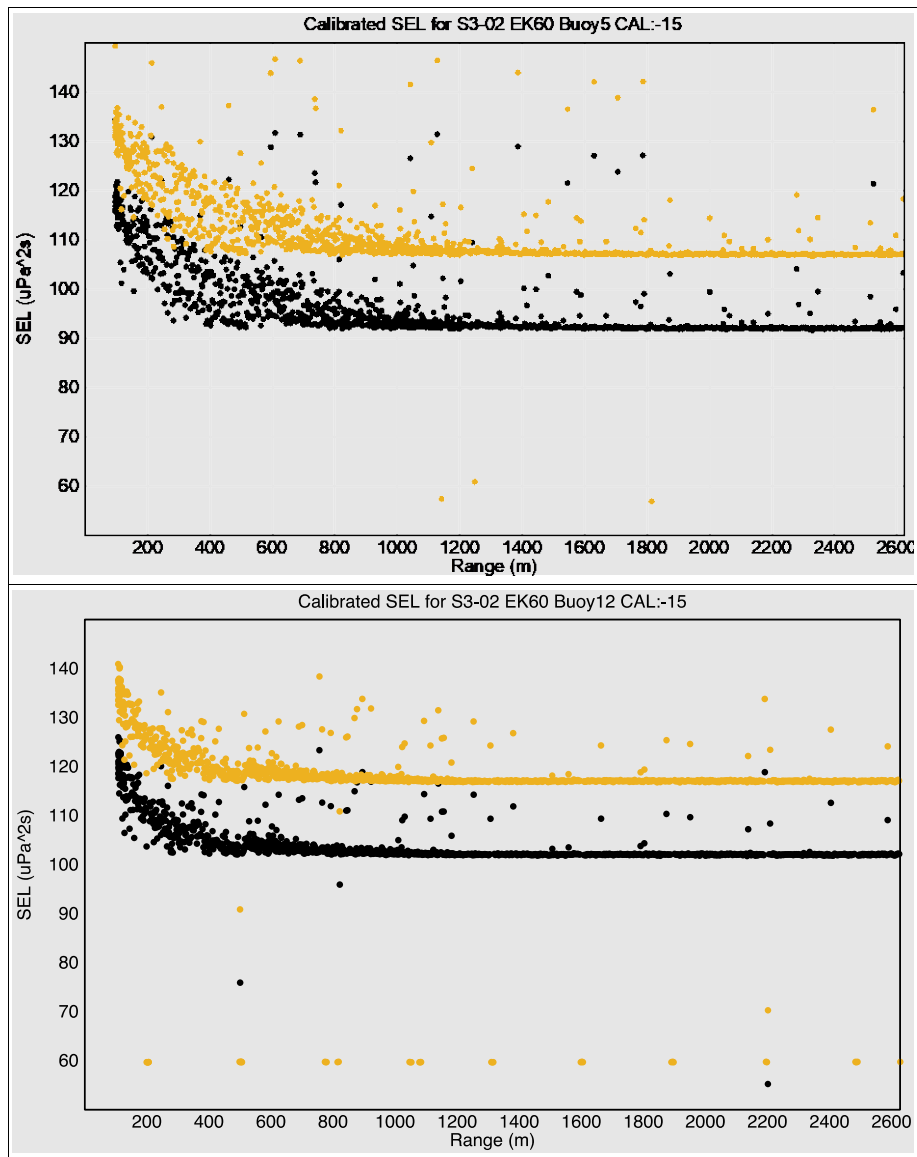


Figure A.3-3. SEL comparisons for EK60, Mode 14, at Site 3, Deployment 1, Run 2.

Sound exposure level (SEL) versus range (top: Buoy 5; bottom: Buoy 12). Pre-adjusted data (yellow) and adjusted data (black).

A.3.4 Site 4, Deployment 1

EK60, Mode 15, Run 3, Buoys 5, 7 (both hydrophones), 9, and 11 (Figure A.3-4).

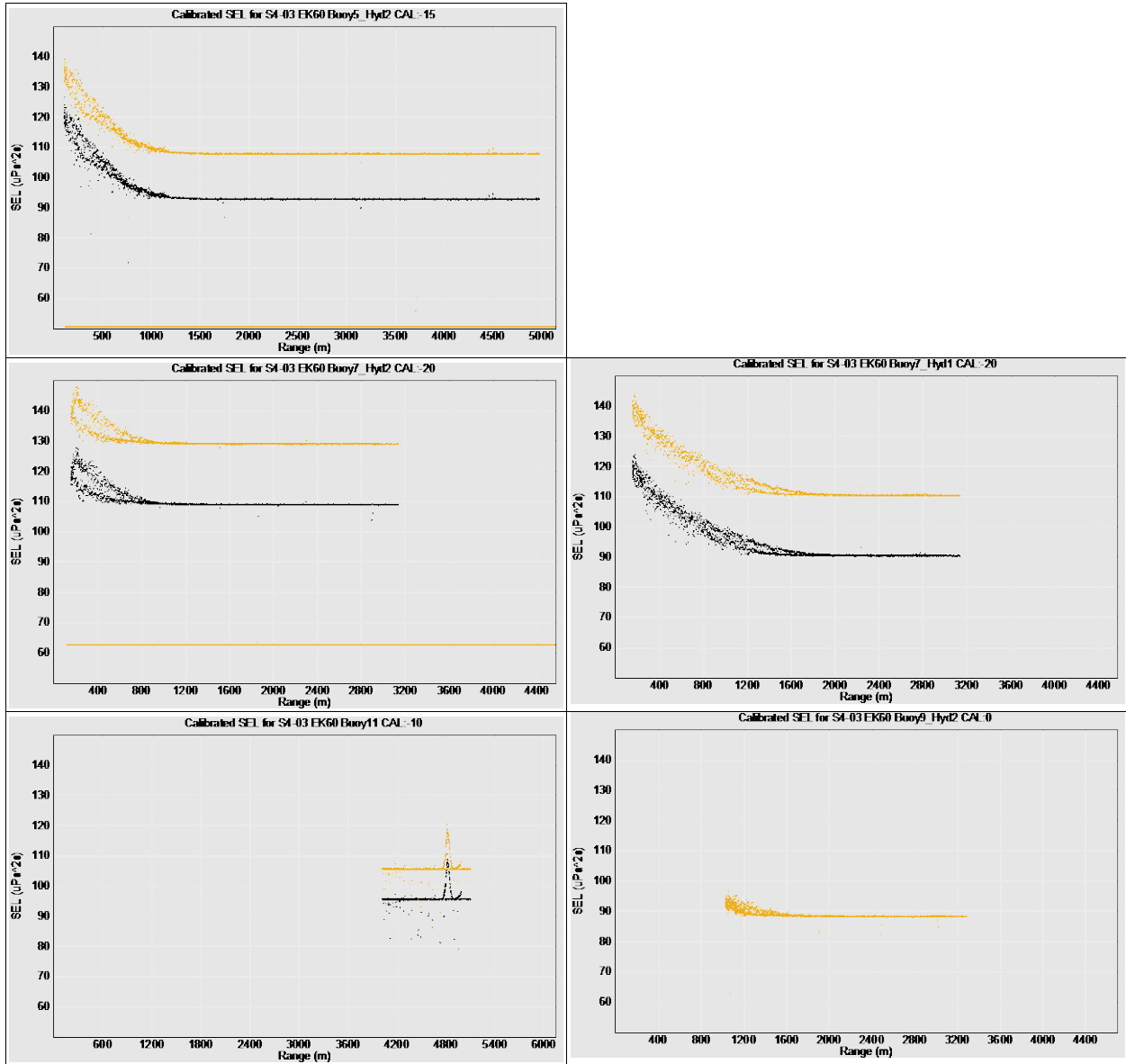


Figure A.3-4. SEL comparisons for EK60, Mode 15, at Site 4, Deployment 1, Run 3.

Sound exposure level (SEL) versus range. Top to bottom: Buoy 5 hydrophone 2; Buoy 7 hydrophone 2 (left), hydrophone 1 (right); Buoy 11 hydrophone 2 (left); and Buoy 9 hydrophone 2 (right). Pre-adjusted data (yellow) and adjusted data (black).

A.3.5 Site 5, Deployment 1

Reason 7111, Mode 3, Run 6, Buoys 6, 11, and 12 (Figure A.3-5).

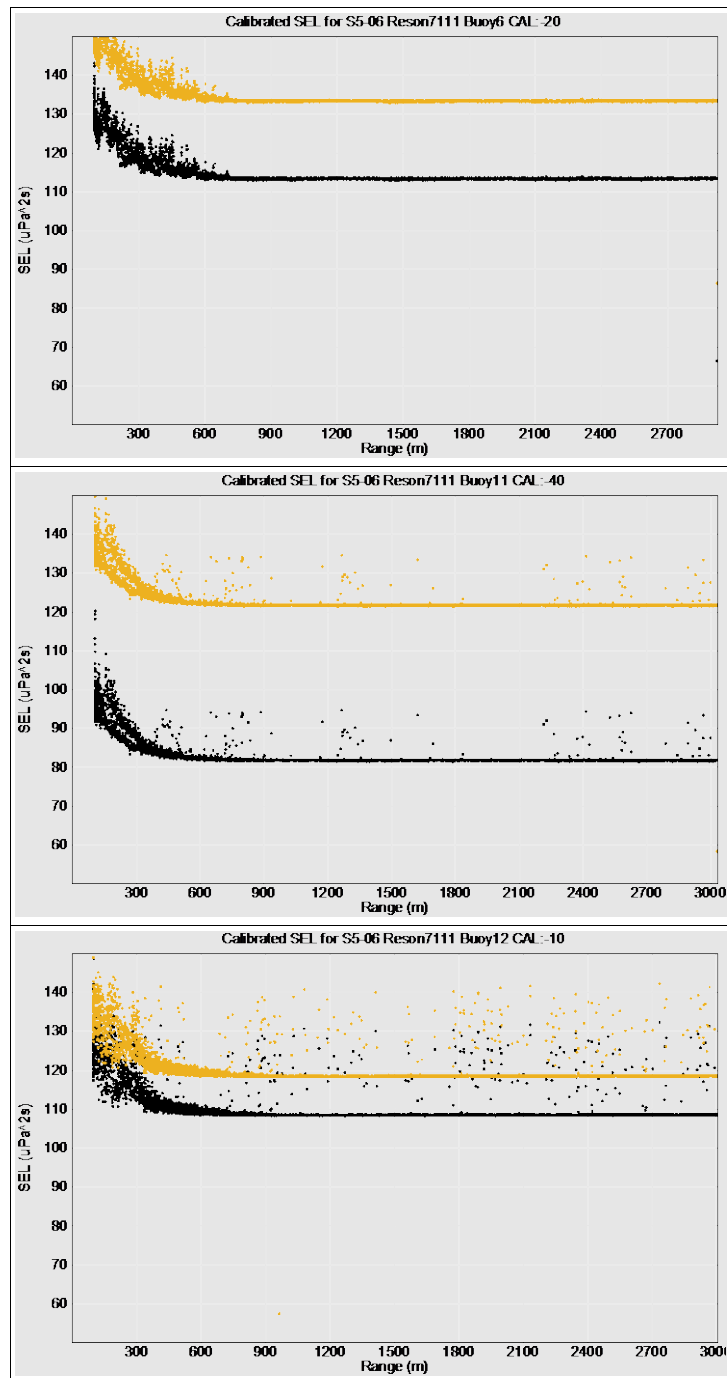


Figure A.3-5. SEL comparisons for Reson 7111, Mode 3, at Site 5, Deployment 1, Run 6. Sound exposure level (SEL) versus range (top to bottom: Buoys 6, 11, and 12). Pre-adjusted data (yellow) and adjusted data (black).

A.3.6 Site 2, Deployment 2

Klein 3000, Mode 5, Run 40, Buoys 5 and 11 (Figure A.3-6).

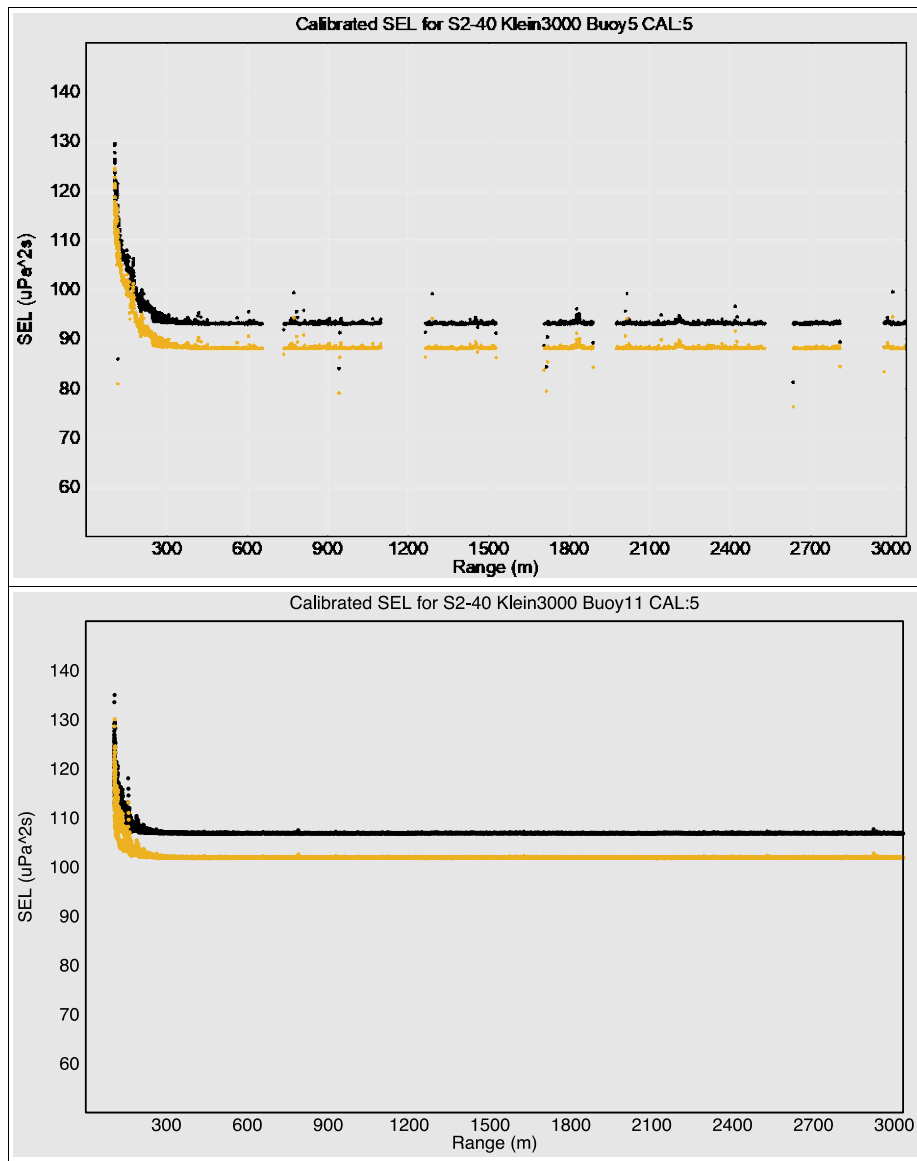


Figure A.3-6. SEL comparisons for Klein 3000, Mode 5, at Site 2, Deployment 2, Run 40. Sound exposure level (SEL) versus range (top: Buoy 5; bottom: Buoy 11). Pre-adjusted data (yellow) and adjusted data (black).

A.3.7 Site 3, Deployment 2

Klein 3000, Mode 5, Run 18, Buoys 5, 6, and 12 (Figure A.3-7).

During Deployment 2 at Site 3, no low- or mid-frequency sources had good data to provide adjustment factors to the high-frequency sources that did have good data. Therefore, the figures below show only the unadjusted data, which will be adjusted, if needed, in the model-data comparison section.

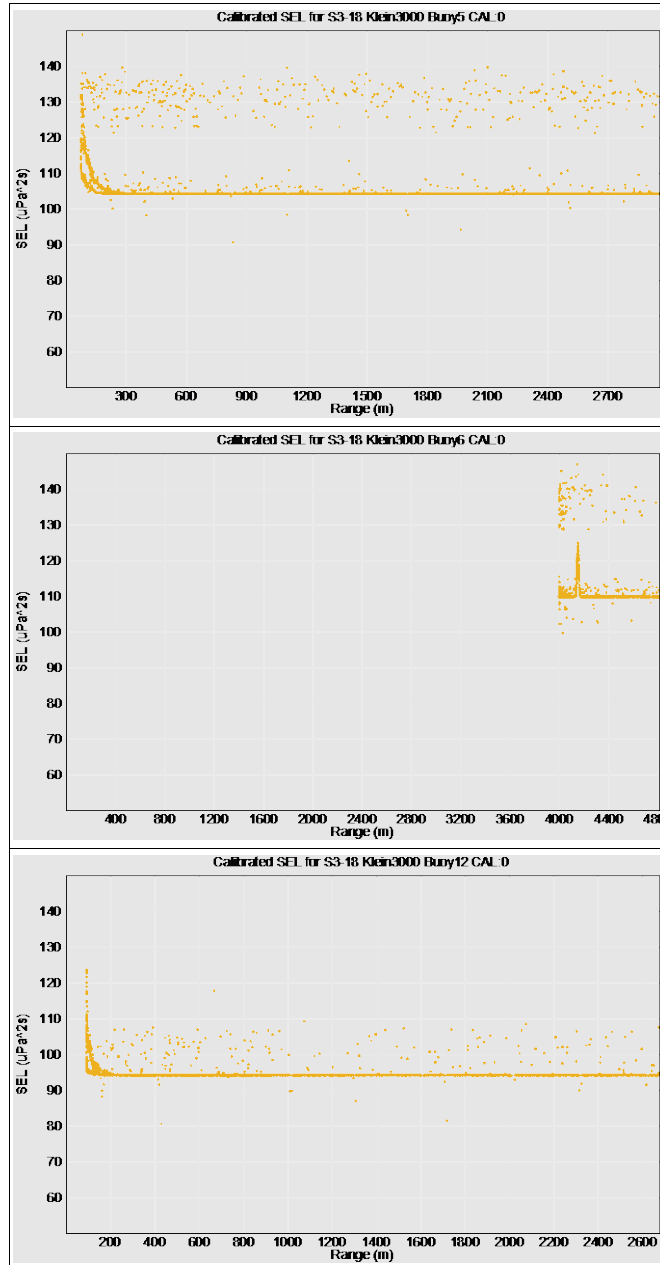


Figure A.3-7. SEL original data for Klein 3000, Mode 5, at Site 3, Deployment 2, Run 18. Sound exposure level (SEL) versus range (top to bottom: Buoys 5, 6, and 12). Pre-adjusted data (yellow) and adjusted data (black).

A.3.8 Site 4, Deployment 2

No buoy during the high-frequency source runs recorded good data.

A.3.9 Site 5, Deployment 2

EK60, Mode 13, Run 24, Buoys 6, 11, and 12 (Figure A.3-8).

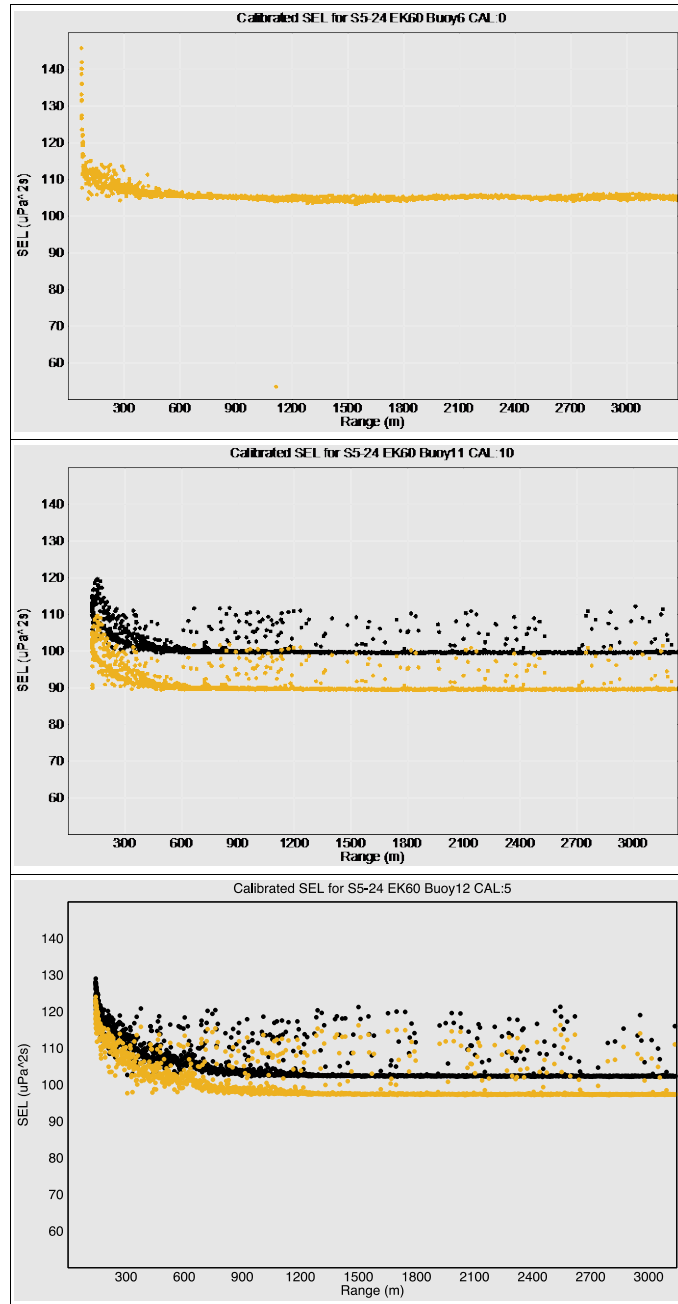


Figure A.3-8. SEL comparisons for EK60, Mode 13, at Site 5, Deployment 2, Run 24. Sound exposure level (SEL) versus range (top to bottom: Buoys 6, 11, and 12). Pre-adjusted data (yellow) and adjusted data (black).

A.3.10 Site 3, Deployment 3

SwathPlus, Mode 12, Run 33, Buoys 6, 11, and 12 (Figure A.3-9).

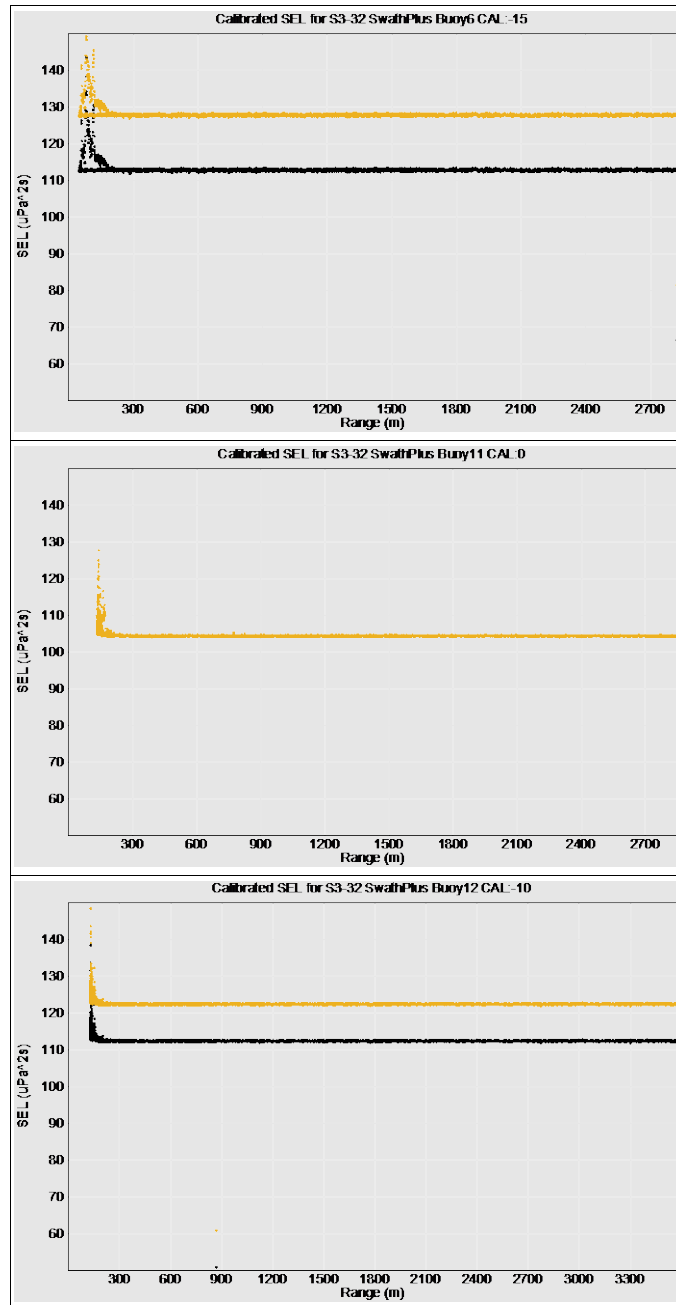


Figure A.3-9. SEL comparisons for SwathPlus, Mode 12, at Site 3, Deployment 3, Run 33. Sound exposure level (SEL) versus range (top to bottom: Buoys 6, 11, and 12). Pre-adjusted data (yellow) and adjusted data (black).

A.3.11 Site 4, Deployment 3

Reson7125, Mode 1, Run 31, Buoys 5 and 12 (Figure A.3-10).

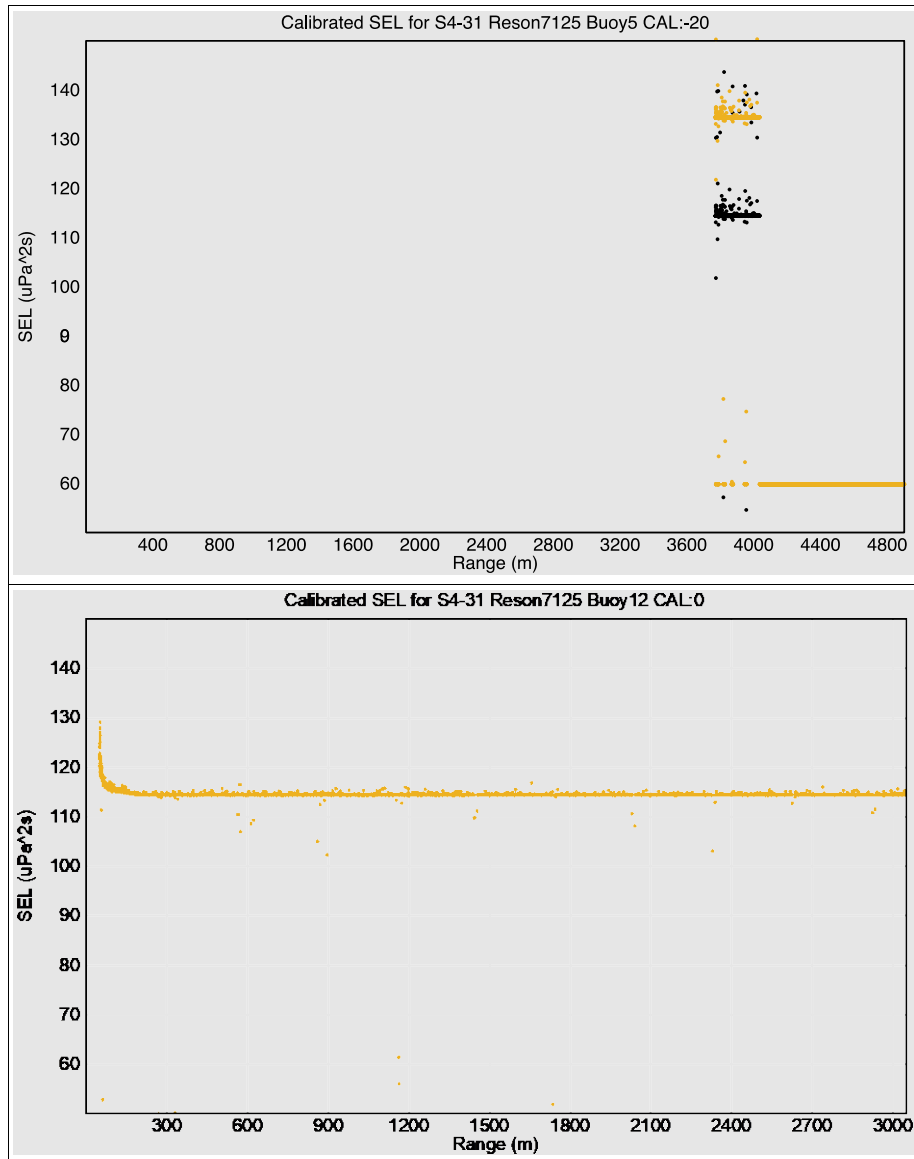


Figure A.3-10. SEL comparisons for Reson7125, Mode 1, at Site 4, Deployment 3, Run 31. Sound exposure level (SEL) versus range, (top: Buoy 5; bottom: Buoy 12). Pre-adjusted data (yellow) and adjusted data (black).

A.3.12 Site 5, Deployment 3

No sources were operated at Site 5 during Deployment 3.

A.3.13 High-Frequency Results Table

Table A.3-1. Adjustment factors for all high-frequency sources.

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
Reson 7125	1	1	1	8	HF	0	6	0 dB	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Reson 7125	1	1	1	8	HF	0	6	153 S	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Reson 7125	1	1	1	8	HF	0	6	83 E	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Reson 7125	2	1	1	9	HF	0	6	Bad	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Reson 7125	2	1	1	9	HF	0	6	Bad	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Reson 7125	2	1	1	9	HF	0	6	Bad	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Klein 3000	5	1	1	11	HF	0	6	0 dB	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Klein 3000	5	1	1	11	HF	0	6	153 S	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Klein 3000	5	1	1	11	HF	0	6	83 E	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Klein 3000	6	1	1	12	HF	0	6	0 dB	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Klein 3000	6	1	1	12	HF	0	6	153 S	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Klein 3000	6	1	1	12	HF	0	6	83 E	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Edgetech 4200	7	1	1	6	HF	0	6	0 dB	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Edgetech 4200	7	1	1	6	HF	0	6	153 S	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Edgetech 4200	7	1	1	6	HF	0	6	83 E	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Edgetech 4200	8	1	1	7	HF	0	6	0 dB	--	--	--	--	--	--	--	--	5	Bad	8	Bad	9	-10 dB	--	--
Edgetech 4200	8	1	1	7	HF	0	6	153 S	--	--	--	--	--	--	--	--	5	Bad	8	Bad	9	75 S	--	--
Edgetech 4200	8	1	1	7	HF	0	6	83 E	--	--	--	--	--	--	--	--	5	Bad	8	Bad	9	94 W	--	--
SwathPlus	9	1	1	10	HF	0	6	0 dB	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
SwathPlus	9	1	1	10	HF	0	6	153 S	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
SwathPlus	9	1	1	10	HF	0	6	83 E	--	--	--	--	--	--	--	--	5	Bad	8	Bad	--	--	--	--
Reson 7125	1	2	1	12	HF	0	6	0 dB	--	--	--	--	--	--	11	10 dB	--	--	--	--	9	Bad	--	--
Reson 7125	1	2	1	12	HF	0	6	81 N	--	--	--	--	--	--	11	50 S	--	--	--	--	9	Bad	--	--
Reson 7125	1	2	1	12	HF	0	6	83 W	--	--	--	--	--	--	11	101 E	--	--	--	--	9	Bad	--	--
Reson 7125	2	2	1	13	HF	0	6	Bad	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
Reson 7125	2	2	1	13	HF	0	6	Bad	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
Reson 7125	2	2	1	13	HF	0	6	Bad	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
Klein 3000	5	2	1	14	HF	0	6	0 dB	--	--	--	--	--	--	11	10 dB	--	--	--	--	9	Bad	--	--
Klein 3000	5	2	1	14	HF	0	6	81 N	--	--	--	--	--	--	11	50 S	--	--	--	--	9	Bad	--	--
Klein 3000	5	2	1	14	HF	0	6	83 W	--	--	--	--	--	--	11	101 E	--	--	--	--	9	Bad	--	--
Klein 3000	6	2	1	15	HF	0	6	0 dB	--	--	--	--	--	--	11	10 dB	--	--	--	--	9	Bad	--	--
Klein 3000	6	2	1	15	HF	0	6	81 N	--	--	--	--	--	--	11	50 S	--	--	--	--	9	Bad	--	--
Klein 3000	6	2	1	15	HF	0	6	83 W	--	--	--	--	--	--	11	101 E	--	--	--	--	9	Bad	--	--
Edgetech 4200	7	2	1	8	HF	0	6	Bad	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
Edgetech 4200	7	2	1	8	HF	0	6	Bad	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
Edgetech 4200	7	2	1	8	HF	0	6	Bad	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
Edgetech 4200	8	2	1	9	HF	0	6	0 dB	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
Edgetech 4200	8	2	1	9	HF	0	6	81 N	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
Edgetech 4200	8	2	1	9	HF	0	6	83 W	--	--	--	--	--	--	11	Bad	--	--	--	--	9	Bad	--	--
SwathPlus	9	2	1	10	HF	0	6	0 dB	--	--	--	--	--	--	11	10 dB	--	--	--	--	9	Bad	--	--
SwathPlus	9	2	1	10	HF	0	6	81 N	--	--	--	--	--	--	11	50 S	--	--	--	--	9	Bad	--	--
SwathPlus	9	2	1	10	HF	0	6	83 W	--	--	--	--	--	--	11	101 E	--	--	--	--	9	Bad	--	--
SwathPlus	11	2	1	12	HF	0	6	0 dB	--	--	--	--	--	--	11	10 dB	--	--	--	--	9	Bad	--	--
SwathPlus	11	2	1	12	HF	0	6	81 N	--	--	--	--	--	--	11	50 S	--	--	--	--	9	Bad	--	--
SwathPlus	11	2	1	12	HF	0	6	83 W	--	--	--	--	--	--	11	101 E	--	--	--	--	9	Bad	--	--
Edgetech 4200	7	3	1	?	HF	0	8	Bad	--	--	--	--	5	Bad	12	Bad	7	Bad	--	--	--	--	--	--
Edgetech 4200	7	3	1	?	HF	0	8	Bad	--	--	--	--	5	Bad	12	Bad	7	Bad	--	--	--	--	--	--
Edgetech 4200	7	3	1	?	HF	0	8	Bad	--	--	--	--	5	Bad	12	Bad	7	Bad	--	--	--	--	--	--
Edgetech 4200	8	3	1	?	HF	0	8	Bad	--	--	--	--	5	Bad	12	Bad	7	Bad	--	--	--	--	--	--

Table A.3-1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
Edgetech 4200	8	3	1	?	HF	0	8	Bad	--	--	--	--	5	Bad	12	Bad	7	Bad	--	--	--	--	--	
Edgetech 4200	8	3	1	?	HF	0	8	Bad	--	--	--	--	5	Bad	12	Bad	7	Bad	--	--	--	--	--	
SwathPlus	10/11	3	1	4	HF	0	8	Bad	--	--	--	--	5	-10 dB	12	Bad	7	Bad	--	--	--	--	--	
SwathPlus	10/11	3	1	4	HF	0	8	Bad	--	--	--	--	5	52 S	12	Bad	7	Bad	--	--	--	--	--	
SwathPlus	10/11	3	1	4	HF	0	8	Bad	--	--	--	--	5	119 E	12	Bad	7	Bad	--	--	--	--	--	
SwathPlus	12	3	1	5	HF	0	8	Bad	--	--	--	--	5	-10 dB	12	-10 dB	7	Bad	--	--	--	--	--	
SwathPlus	12	3	1	5	HF	0	8	Bad	--	--	--	--	5	52 S	12	52 S	7	Bad	--	--	--	--	--	
SwathPlus	12	3	1	5	HF	0	8	Bad	--	--	--	--	5	119 E	12	119 E	7	Bad	--	--	--	--	--	
EK60	13	3	1	1	HF	0	8	Bad	--	--	--	--	5	-15 dB	12	-15 dB	7	Bad	--	--	--	--	--	
EK60	13	3	1	1	HF	0	8	Bad	--	--	--	--	5	52 S	12	52 S	7	Bad	--	--	--	--	--	
EK60	13	3	1	1	HF	0	8	Bad	--	--	--	--	5	119 E	12	119 E	7	Bad	--	--	--	--	--	
EK60	14	3	1	3?	HF	0	8	Bad	--	--	--	--	5	-15 dB	12	-15 dB	7	Bad	--	--	--	--	--	
EK60	14	3	1	3?	HF	0	8	Bad	--	--	--	--	5	52 S	12	52 S	7	Bad	--	--	--	--	--	
EK60	14	3	1	3?	HF	0	8	Bad	--	--	--	--	5	119 E	12	119 E	7	Bad	--	--	--	--	--	
EK60	15	3	1	2?	HF	0	8	0 dB	--	--	--	--	5	-15 dB	12	-15 dB	7	Bad	--	--	--	--	--	
EK60	15	3	1	2?	HF	0	8	No ref.	--	--	--	--	5	52 S	12	52 S	7	Bad	--	--	--	--	--	
EK60	15	3	1	2?	HF	0	8	No ref.	--	--	--	--	5	119 E	12	119 E	7	Bad	--	--	--	--	--	
Reson 7111	3	4	1	4	HF	0	8	Bad	6	-20 dB	--	--	7_H	Bad	7_L	Bad	9	Bad	--	--	11	Bad	5	-15 dB
Reson 7111	3	4	1	4	HF	0	8	Bad	6	58 N	--	--	7_H	Bad	7_L	Bad	9	Bad	--	--	11	Bad	5	37 N
Reson 7111	3	4	1	4	HF	0	8	Bad	6	200 E	--	--	7_H	Bad	7_L	Bad	9	Bad	--	--	11	Bad	5	200 E
Reson 7111	4	4	1	5	HF	0	8	Bad	6	-20 dB	--	--	7_H	-20 dB	7_L	-20 dB	9	Bad	--	--	11	Bad	5	-15 dB
Reson 7111	4	4	1	5	HF	0	8	Bad	6	58 N	--	--	7_H	127 S	7_L	106 S	9	Bad	--	--	11	Bad	5	37 N
Reson 7111	4	4	1	5	HF	0	8	Bad	6	200 E	--	--	7_H	105 E	7_L	121 E	9	Bad	--	--	11	Bad	5	200 E
EK60	13	4	1	1	HF	0	8	Bad	6	-20 dB	--	--	7_H	-20 dB	7_L	-20 dB	9	0 dB	--	--	11	Bad	5	-15 dB
EK60	13	4	1	1	HF	0	8	Bad	6	58 N	--	--	7_H	127 S	7_L	106 S	9	59 N	--	--	11	Bad	5	37 N
EK60	13	4	1	1	HF	0	8	Bad	6	200 E	--	--	7_H	105 E	7_L	121 E	9	102 E	--	--	11	Bad	5	200 E
EK60	14	4	1	2?	HF	0	8	Bad	6	Bad	--	--	7_H	-20 dB	7_L	-20 dB	9	0 dB	--	--	11	Bad	5	-15 dB
EK60	14	4	1	2?	HF	0	8	Bad	6	Bad	--	--	7_H	127 S	7_L	106 S	9	59 N	--	--	11	Bad	5	37 N
EK60	14	4	1	2?	HF	0	8	Bad	6	Bad	--	--	7_H	105 E	7_L	121 E	9	102 E	--	--	11	Bad	5	200 E
EK60	15	4	1	3?	HF	0	8	Bad	6	Bad	--	--	7_H	-20 dB	7_L	-20 dB	9	0 dB	--	--	11	-10 dB	5	-15 dB
EK60	15	4	1	3?	HF	0	8	Bad	6	Bad	--	--	7_H	127 S	7_L	106 S	9	59 N	--	--	11	128 S	5	37 N
EK60	15	4	1	3?	HF	0	8	Bad	6	Bad	--	--	7_H	105 E	7_L	121 E	9	102 E	--	--	11	0 E	5	200 E
Reson 7125	1	5	1	12	HF	0	6	Bad	12	-10 dB	--	--	11	-40 dB	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7125	1	5	1	12	HF	0	6	Bad	12	10 N	--	--	11	10 N	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7125	1	5	1	12	HF	0	6	Bad	12	168 W	--	--	11	88 E	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7125	2	5	1	13	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7125	2	5	1	13	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7111	3	5	1	6	HF	0	6	-20 dB	12	-10 dB	--	--	11	-40 dB	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7111	3	5	1	6	HF	0	6	83 S	12	10 N	--	--	11	10 N	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7111	3	5	1	6	HF	0	6	161 E	12	168 W	--	--	11	88 E	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7111	4	5	1	7	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7111	4	5	1	7	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	9	Bad	8	Bad	10	Bad	--	--
Reson 7111	4	5	1	7	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	9	Bad	8	Bad	10	Bad	--	--
EK60	13	5	1	8	HF	0	6	-20 dB	12	-10 dB	--	--	11	Bad	--	--	9	0 dB	8	-10 dB	10	-15 dB	--	--
EK60	13	5	1	8	HF	0	6	83 S	12	10 N	--	--	11	Bad	--	--	9	71 N	8	71 N	10	39 S	--	--
EK60	13	5	1	8	HF	0	6	161 E	12	168 W	--	--	11	Bad	--	--	9	65 W	8	65 W	10	97 W	--	--
EK60	15	5	1	9	HF	0	6	-20 dB	12	-10 dB	--	--	11	Bad	--	--	9	0 dB	8	-10 dB	10	Bad	--	--
EK60	15	5	1	9	HF	0	6	83 S	12	10 N	--	--	11	Bad	--	--	9	71 N	8	71 N	10	Bad	--	--
EK60	15	5	1	9	HF	0	6	161 E	12	168 W	--	--	11	Bad	--	--	9	65 W	8	65 W	10	Bad	--	--
Reson 7125	1	2	2	38	HF	0	--	--	--	--	--	--	5	Bad	11	Bad	10	Bad	--	--	9	Bad	--	--

Table A.3-1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
Reson 7125	1	2	2	38	HF	0	--	--	--	--	--	--	5	Bad	11	Bad	10	Bad	--	--	9	Bad	--	--
Reson 7125	1	2	2	38	HF	0	--	--	--	--	--	--	5	Bad	11	Bad	10	Bad	--	--	9	Bad	--	--
Reson 7125	2	2	2	39	HF	0	--	--	--	--	--	--	5	Bad	11	Bad	10	Bad	--	--	9	Bad	--	--
Reson 7125	2	2	2	39	HF	0	--	--	--	--	--	--	5	Bad	11	Bad	10	Bad	--	--	9	Bad	--	--
Reson 7125	2	2	2	39	HF	0	--	--	--	--	--	--	5	Bad	11	Bad	10	Bad	--	--	9	Bad	--	--
Klein 3000	5	2	2	40	HF	0	--	--	--	--	--	--	5	5 dB	11	5 dB	10	Bad	--	--	9	Bad	--	--
Klein 3000	5	2	2	40	HF	0	--	--	--	--	--	--	5	69 S	11	69 S	10	Bad	--	--	9	Bad	--	--
Klein 3000	5	2	2	40	HF	0	--	--	--	--	--	--	5	57 E	11	57 E	10	Bad	--	--	9	Bad	--	--
Klein 3000	6	2	2	41	HF	0	--	--	--	--	--	--	5	5 dB	11	5 dB	10	Bad	--	--	9	Bad	--	--
Klein 3000	6	2	2	41	HF	0	--	--	--	--	--	--	5	69 S	11	69 S	10	Bad	--	--	9	Bad	--	--
Klein 3000	6	2	2	41	HF	0	--	--	--	--	--	--	5	57 E	11	57 E	10	Bad	--	--	9	Bad	--	--
Edgetech 4200	7	2	2	35	HF	0	--	--	--	--	--	--	5	5 dB	11	Bad	10	Bad	--	--	9	Bad	--	--
Edgetech 4200	7	2	2	35	HF	0	--	--	--	--	--	--	5	69 S	11	Bad	10	Bad	--	--	9	Bad	--	--
Edgetech 4200	7	2	2	35	HF	0	--	--	--	--	--	--	5	57 E	11	Bad	10	Bad	--	--	9	Bad	--	--
Edgetech 4200	8	2	2	36	HF	0	--	--	--	--	--	--	5	5 dB	11	Bad	10	Bad	--	--	9	Bad	--	--
Edgetech 4200	8	2	2	36	HF	0	--	--	--	--	--	--	5	69 S	11	Bad	10	Bad	--	--	9	Bad	--	--
Edgetech 4200	8	2	2	36	HF	0	--	--	--	--	--	--	5	57 E	11	Bad	10	Bad	--	--	9	Bad	--	--
SwathPlus	10	2	2	37	HF	0	--	--	--	--	--	--	5	Bad	11	5 dB	10	Bad	--	--	9	Bad	--	--
SwathPlus	10	2	2	37	HF	0	--	--	--	--	--	--	5	Bad	11	69 S	10	Bad	--	--	9	Bad	--	--
SwathPlus	10	2	2	37	HF	0	--	--	--	--	--	--	5	Bad	11	57 E	10	Bad	--	--	9	Bad	--	--
Reson 7125	1	3	2	17	HF	0	--	--	5	Pending	--	--	12	Pending	--	--	--	--	--	--	6	Bad	--	--
Reson 7125	1	3	2	17	HF	0	--	--	5	0 N	--	--	12	12 N	--	--	--	--	--	--	6	Bad	--	--
Reson 7125	1	3	2	17	HF	0	--	--	5	3 W	--	--	12	114 W	--	--	--	--	--	--	6	Bad	--	--
Reson 7125	2	3	2	16	HF	0	--	--	5	Bad	--	--	12	Bad	--	--	--	--	--	--	6	Bad	--	--
Reson 7125	2	3	2	16	HF	0	--	--	5	Bad	--	--	12	Bad	--	--	--	--	--	--	6	Bad	--	--
Reson 7125	2	3	2	16	HF	0	--	--	5	Bad	--	--	12	Bad	--	--	--	--	--	--	6	Bad	--	--
Reson 7111	3	3	2	14	HF	0	--	--	5	Bad	--	--	12	Pending	--	--	--	--	--	--	6	Bad	--	--
Reson 7111	3	3	2	14	HF	0	--	--	5	Bad	--	--	12	12 N	--	--	--	--	--	--	6	Bad	--	--
Reson 7111	3	3	2	14	HF	0	--	--	5	Bad	--	--	12	114 W	--	--	--	--	--	--	6	Bad	--	--
Reson 7111	4	3	2	15	HF	0	--	--	5	Bad	--	--	12	Bad	--	--	--	--	--	--	6	Bad	--	--
Reson 7111	4	3	2	15	HF	0	--	--	5	Bad	--	--	12	Bad	--	--	--	--	--	--	6	Bad	--	--
Reson 7111	4	3	2	15	HF	0	--	--	5	Bad	--	--	12	Bad	--	--	--	--	--	--	6	Bad	--	--
Klein 3000	5	3	2	18	HF	0	--	--	5	Pending	--	--	12	Pending	--	--	--	--	--	--	6	Pending	--	--
Klein 3000	5	3	2	18	HF	0	--	--	5	0 N	--	--	12	12 N	--	--	--	--	--	--	6	0 N	--	--
Klein 3000	5	3	2	18	HF	0	--	--	5	3 W	--	--	12	114 W	--	--	--	--	--	--	6	12 W	--	--
Klein 3000	6	3	2	19	HF	0	--	--	5	Pending	--	--	12	Pending	--	--	--	--	--	--	6	Pending	--	--
Klein 3000	6	3	2	19	HF	0	--	--	5	0 N	--	--	12	12 N	--	--	--	--	--	--	6	0 N	--	--
Klein 3000	6	3	2	19	HF	0	--	--	5	3 W	--	--	12	114 W	--	--	--	--	--	--	6	12 W	--	--
Reson 7125	1	4	2	17	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
Reson 7125	1	4	2	17	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
Reson 7125	1	4	2	17	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
Reson 7125	2	4	2	18	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
Reson 7125	2	4	2	18	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
Reson 7125	2	4	2	18	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
EdgeTech4200	7	4	2	8	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
EdgeTech4200	7	4	2	8	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
EdgeTech4200	7	4	2	8	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
EdgeTech4200	8	4	2	9	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
EdgeTech4200	8	4	2	9	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
EdgeTech4200	8	4	2	9	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
SwathPlus	10	4	2	15	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	

Table A.3-1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
SwathPlus	10	4	2	15	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
SwathPlus	10	4	2	15	HF	0	--	--	--	--	--	--	--	--	--	--	9	Bad	--	--	--	--	--	
Reson 7125	1	5	2	12	HF	0	6	0 dB	12	5 dB	--	--	11	10 dB	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7125	1	5	2	12	HF	0	6	48 S	12	84 N	--	--	11	164 N	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7125	1	5	2	12	HF	0	6	57 E	12	62 W	--	--	11	90 W	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7125	2	5	2	13	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7125	2	5	2	13	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7125	2	5	2	13	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7111	3	5	2	6	HF	0	6	0 dB	12	5 dB	--	--	11	10 dB	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7111	3	5	2	6	HF	0	6	48 S	12	84 N	--	--	11	164 N	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7111	3	5	2	6	HF	0	6	57 E	12	62 W	--	--	11	90 W	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7111	4	5	2	7	HF	0	6	0 dB	12	5 dB	--	--	11	10 dB	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7111	4	5	2	7	HF	0	6	48 S	12	84 N	--	--	11	164 N	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7111	4	5	2	7	HF	0	6	57 E	12	62 W	--	--	11	90 W	--	--	8	Bad	9	Bad	10	Bad	--	--
EK60	13	5	2	8	HF	0	6	0 dB	12	5 dB	--	--	11	10 dB	--	--	8	Bad	9	Bad	10	Bad	--	--
EK60	13	5	2	8	HF	0	6	48 S	12	84 N	--	--	11	164 N	--	--	8	Bad	9	Bad	10	Bad	--	--
EK60	13	5	2	8	HF	0	6	57 E	12	62 W	--	--	11	90 W	--	--	8	Bad	9	Bad	10	Bad	--	--
EK60	15	5	2	9	HF	0	6	0 dB	12	5 dB	--	--	11	10 dB	--	--	8	Bad	9	Bad	10	Bad	--	--
EK60	15	5	2	9	HF	0	6	48 S	12	84 N	--	--	11	164 N	--	--	8	Bad	9	Bad	10	Bad	--	--
EK60	15	5	2	9	HF	0	6	57 E	12	62 W	--	--	11	90 W	--	--	8	Bad	9	Bad	10	Bad	--	--
Reson 7125	1	3	3	34	HF	0	6	-15 dB	12	-10	--	--	11	0 dB	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7125	1	3	3	34	HF	0	6	6 N	12	7 N	--	--	11	41 N	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7125	1	3	3	34	HF	0	6	123 W	12	162 E	--	--	11	161 E	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7125	2	3	3	35	HF	0	6	-15 dB	12	-10	--	--	11	0 dB	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7125	2	3	3	35	HF	0	6	6 N	12	7 N	--	--	11	41 N	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7125	2	3	3	35	HF	0	6	123 W	12	162 E	--	--	11	161 E	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7111	3	3	3	24	HF	0	6	-15 dB	12	-10	--	--	11	0 dB	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7111	3	3	3	24	HF	0	6	6 N	12	7 N	--	--	11	41 N	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7111	3	3	3	24	HF	0	6	123 W	12	162 E	--	--	11	161 E	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7111	4	3	3	25	HF	0	6	-15 dB	12	-10	--	--	11	0 dB	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7111	4	3	3	25	HF	0	6	6 N	12	7 N	--	--	11	41 N	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7111	4	3	3	25	HF	0	6	123 W	12	162 E	--	--	11	161 E	--	--	8	Bad	10	Bad	9	Bad	--	--
Klein 3000	5	3	3	36	HF	0	6	-15 dB	12	-10	--	--	11	0 dB	--	--	8	Bad	10	Bad	9	Bad	--	--
Klein 3000	5	3	3	36	HF	0	6	6 N	12	7 N	--	--	11	41 N	--	--	8	Bad	10	Bad	9	Bad	--	--
Klein 3000	5	3	3	36	HF	0	6	123 W	12	162 E	--	--	11	161 E	--	--	8	Bad	10	Bad	9	Bad	--	--
Klein 3000	6	3	3	37	HF	0	6	-15 dB	12	-10	--	--	11	0 dB	--	--	8	Bad	10	Bad	9	Bad	--	--
Klein 3000	6	3	3	37	HF	0	6	6 N	12	7 N	--	--	11	41 N	--	--	8	Bad	10	Bad	9	Bad	--	--
Klein 3000	6	3	3	37	HF	0	6	123 W	12	162 E	--	--	11	161 E	--	--	8	Bad	10	Bad	9	Bad	--	--
EdgeTech 4200	7	3	3	29	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	10	Bad	9	Bad	--	--
EdgeTech 4200	7	3	3	29	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	10	Bad	9	Bad	--	--
EdgeTech 4200	7	3	3	29	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	10	Bad	9	Bad	--	--
EdgeTech 4200	8	3	3	29	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	10	Bad	9	Bad	--	--
EdgeTech 4200	8	3	3	29	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	10	Bad	9	Bad	--	--
EdgeTech 4200	8	3	3	29	HF	0	6	Bad	12	Bad	--	--	11	Bad	--	--	8	Bad	10	Bad	9	Bad	--	--
SwathPlus	10	3	3	32	HF	0	6	-15 dB	12	-10	--	--	11	0 dB	--	--	8	Bad	10	Bad	9	Bad	--	--
SwathPlus	10	3	3	32	HF	0	6	6 N	12	7 N	--	--	11	41 N	--	--	8	Bad	10	Bad	9	Bad	--	--
SwathPlus	10	3	3	32	HF	0	6	123 W	12	162 E	--	--	11	161 E	--	--	8	Bad	10	Bad	9	Bad	--	--
SwathPlus	12	3	3	33	HF		6	-15 dB	12	-10	--	--	11	0 dB	--	--	8	Bad	10	Bad	9	Bad	--	--
SwathPlus	12	3	3	33	HF		6	6 N	12	7 N	--	--	11	41 N	--	--	8	Bad	10	Bad	9	Bad	--	--
SwathPlus	12	3	3	33	HF		6	123 W	12	162 E	--	--	11	161 E	--	--	8	Bad	10	Bad	9	Bad	--	--
Reson 7125	1	4	3	31	HF		8	Bad	7	Bad	--	--	12	0 dB	--	--	--	--	--	--	5	-20 dB	--	--

Table A.3-1. (Continued).

Source	Mode	Site	Deployment	Run	Frequency	Channel	Buoy Position																	
							Buoy#	D	Buoy#	A1	Buoy#	A2	Buoy#	B1	Buoy#	B2	Buoy#	E1	Buoy#	E2	Buoy#	F1	Buoy#	C
Reson 7125	1	4	3	31	HF		8	Bad	7	Bad	--	--	12	12 N	--	--	--	--	--	--	5	200 N	--	--
Reson 7125	1	4	3	31	HF		8	Bad	7	Bad	--	--	12	95 W	--	--	--	--	--	--	5	200 W	--	--
Reson 7125	2	4	3	32	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
Reson 7125	2	4	3	32	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
Reson 7125	2	4	3	32	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
EdgeTech 4200	7	4	3	24	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
EdgeTech 4200	7	4	3	24	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
EdgeTech 4200	7	4	3	24	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
EdgeTech 4200	7	4	3	23	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
EdgeTech 4200	7	4	3	23	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
EdgeTech 4200	7	4	3	23	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
SwathPlus	9	4	3	30	HF		8	Bad	7	Bad	--	--	12	0 dB	--	--	--	--	--	--	5	Bad	--	--
SwathPlus	9	4	3	30	HF		8	Bad	7	Bad	--	--	12	12 N	--	--	--	--	--	--	5	Bad	--	--
SwathPlus	9	4	3	30	HF		8	Bad	7	Bad	--	--	12	95 W	--	--	--	--	--	--	5	Bad	--	--
SwathPlus	10	4	3	29	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
SwathPlus	10	4	3	29	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--
SwathPlus	10	4	3	29	HF		8	Bad	7	Bad	--	--	12	Bad	--	--	--	--	--	--	5	Bad	--	--

-- = no information; bad = data quality too poor to ascertain an adjustment factor; dB = decibel; E = east; HRG = high-resolution geophysical; m = meter; MF = mid-frequency; na = not applicable; no data = buoy did not function; N = north; S = south; W = west.

A.4 Appendix A: Bibliography

Halvorsen, M.B. and K.D. Heaney. 2018. Propagation characteristics of high-resolution geophysical surveys: open water testing. U.S. Department of the Interior, Bureau of Ocean Energy Management, Sterling, VA. Prepared by CSA Ocean Sciences Inc. OCS Study BOEM 2018-052. 806 pp.

Propagation Characteristics of High-Frequency Sounds Emitted During High-Resolution Geophysical Surveys: Acoustic Modeling Effort

Appendix B Modeling Results

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Appendix B: Modeling Results

B.1 Modeled to Measured Data Comparison Results

The results of the modeled to measured data comparison for all sources and sites are shown in this appendix. The source type, settings, and modes are provided in the headers followed by site-specific results. For each plot, the modeled percentiles (5th to 95th) and spherical and cylindrical spreading loss are shown as colored lines, and the individual signal measurements are overlaid as dots. Each figure is organized as follows:

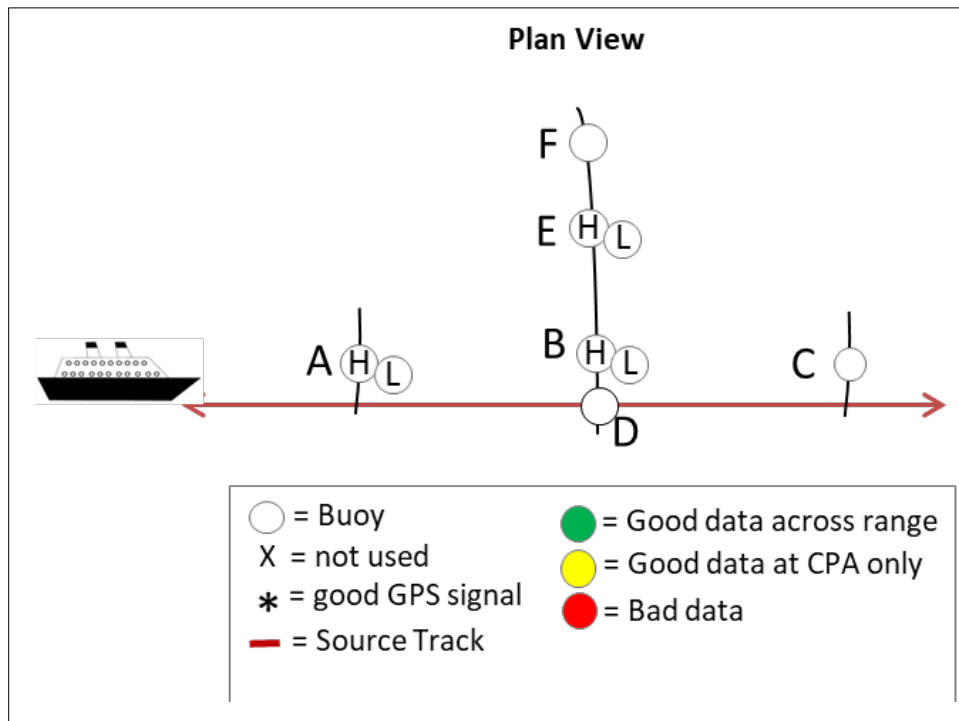
Top: L_{pk} ; Middle: SEL; Bottom: L_{rms} . Model percentiles are 5%, 20%, 35%, 50%, 65%, 80%, and 95%. Spreading losses: cylindrical (cyan) and spherical (magenta). Data points are for buoy positions D (blue), A (black), B (red), C (green), E (yellow), and F (pink).

Inset: Buoy positioning relative to source track (red line) along bottom: buoy D centered below source track, buoy A (left dot), buoy B (middle dot), buoy C (right dot), buoy E (above buoy B), and buoy F (above buoy E). Asterisks indicate good GPS data from at least one run. Buoy colors: green = acoustic data at the CPA and beyond; yellow = acoustic data at the CPA; red = no acoustic data; X = no buoy present.

μPa = micropascal; CPA = closest point of approach; dB = decibel; GPS = global positioning system; L_{pk} = peak sound pressure level; L_{rms} = root-mean-square sound pressure level; m = meter; s = second; SEL = sound exposure level.

To reduce repetition, the figure legend below is only presented here rather than following each figure.

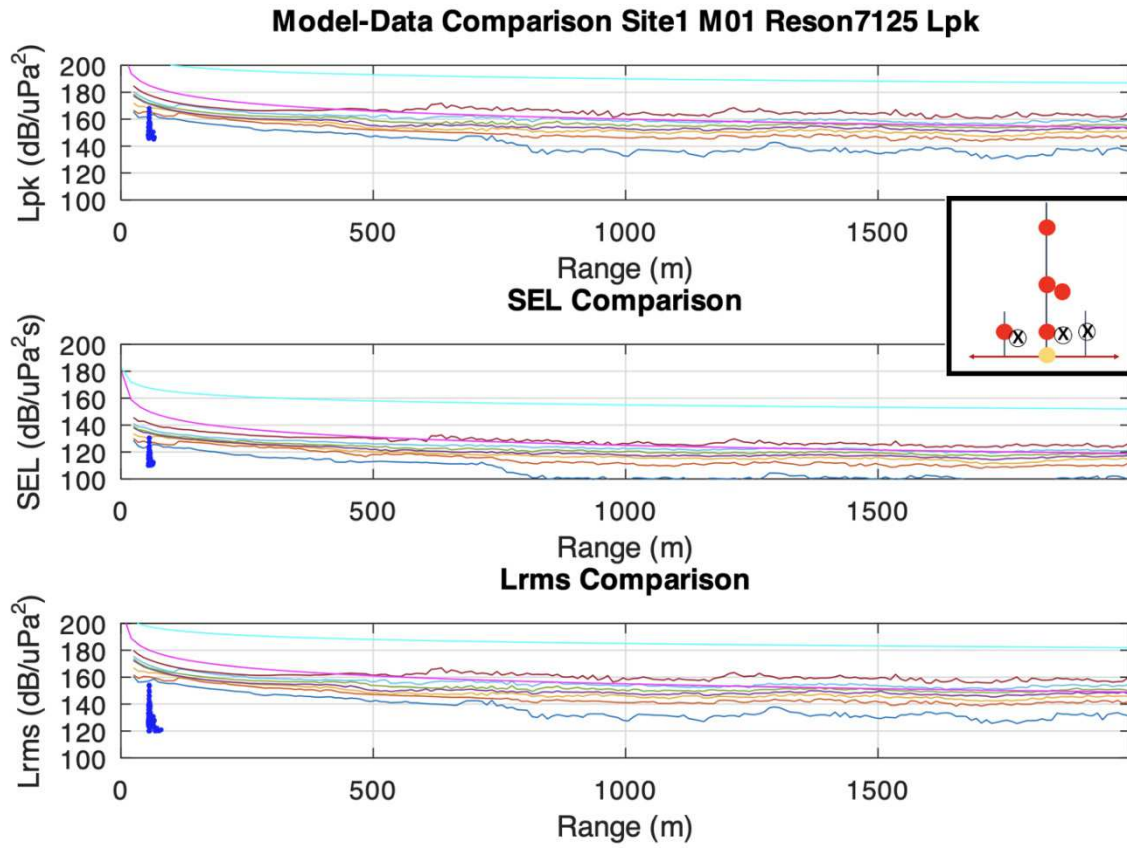
If desired, the following diagram can be printed to help interpret the inset reliability legends.



B.2 Reson 7125, 200 kHz, 220 dB, 100 Percent Power (Mode 1)

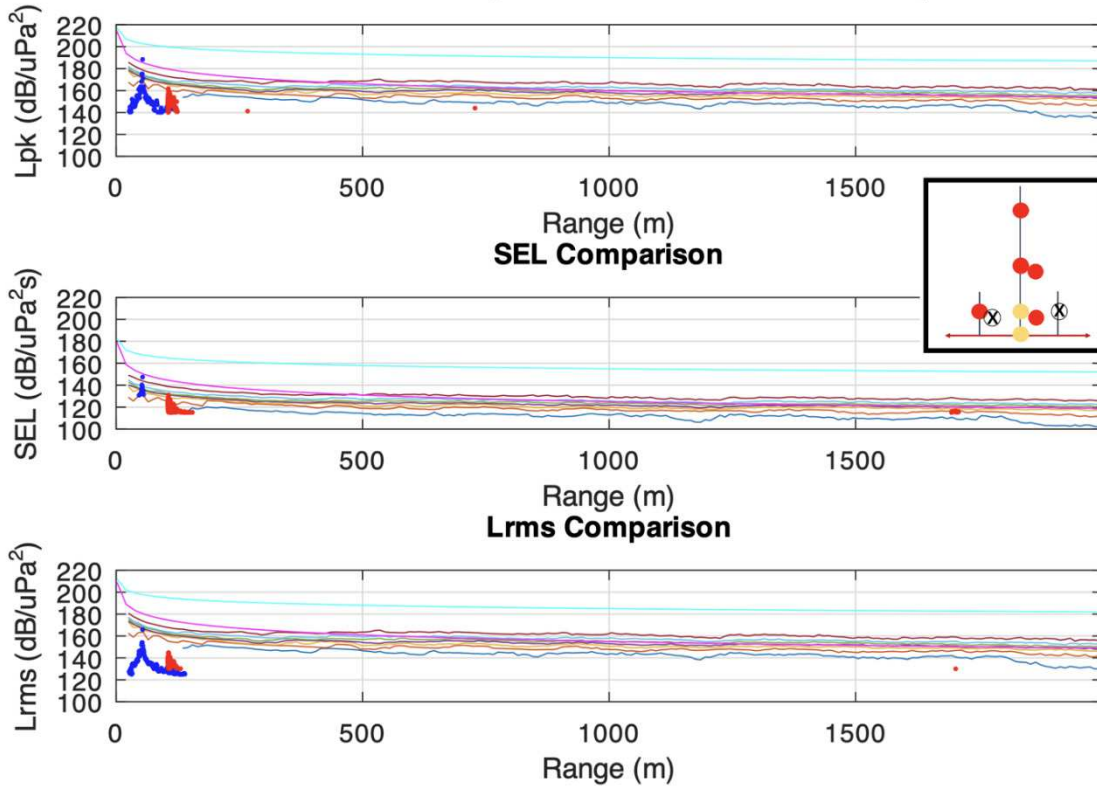
The Reson 7125 is a very high-frequency (VHF) directional source.

B.2.1 Site 1 – Mud, 10-m Depth



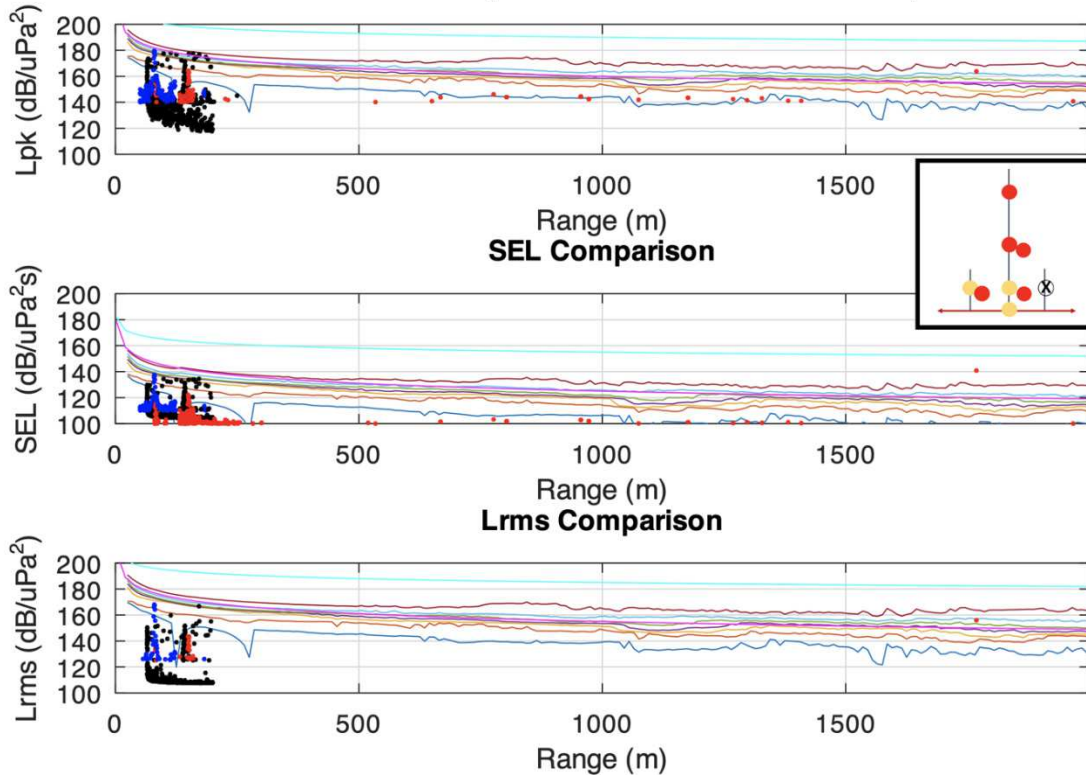
B.2.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M01 Reson7125 Lpk



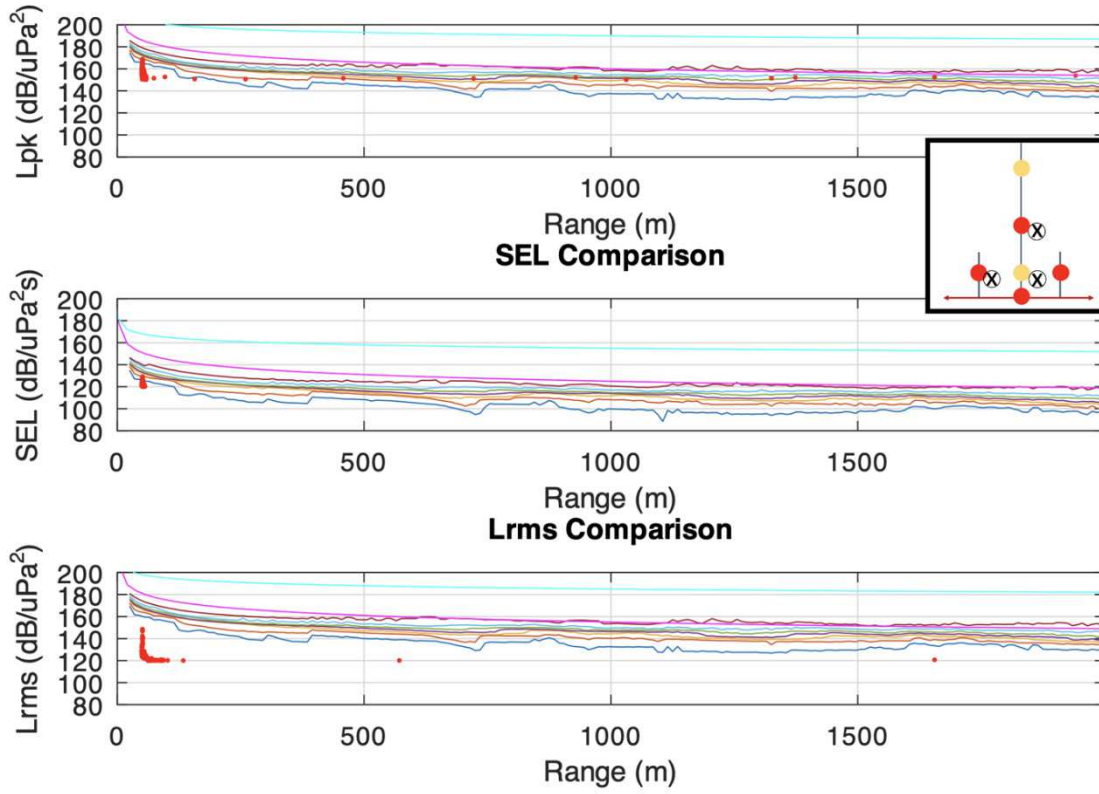
B.2.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M01 Reson7125 Lpk

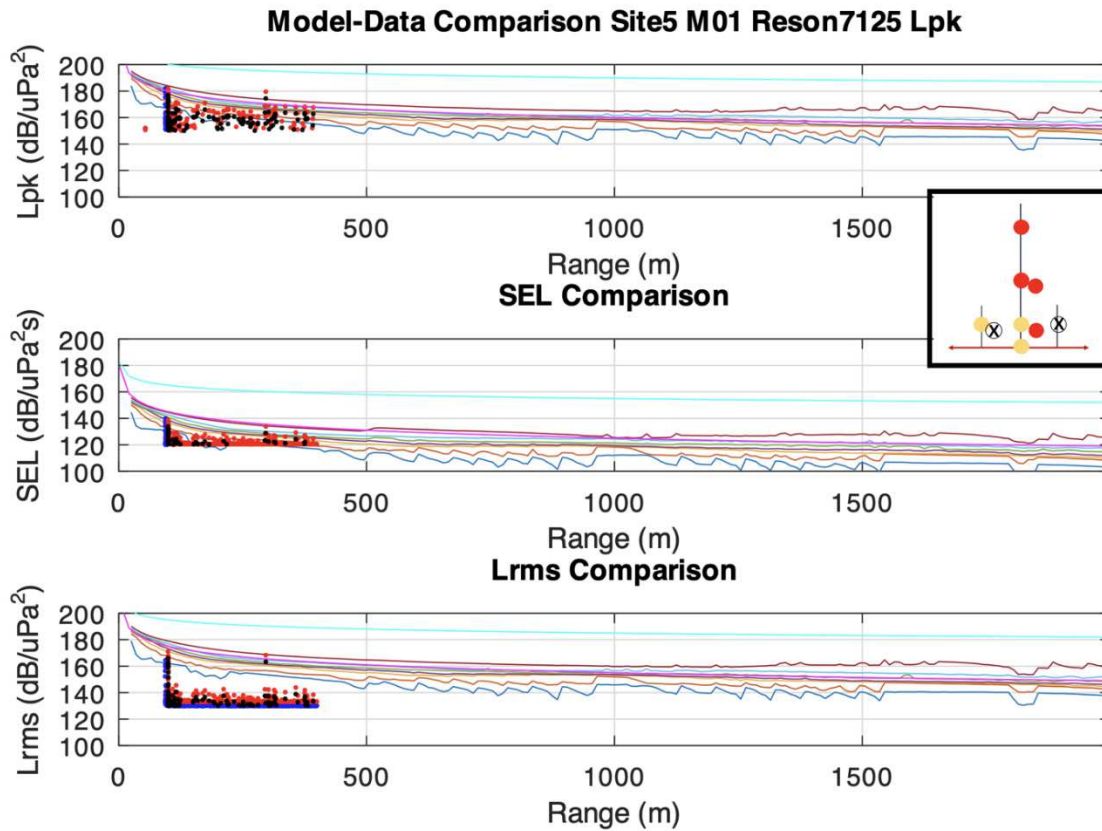


B.2.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M01 Reson7125 Lpk



B.2.5 Site 5 – Sandy Silt, 100-m Depth



B.3 Reson 7125, 200 kHz, 190 dB, 50 Percent Power (Mode 2)

The Reson 7125 is a VHF directional source.

B.3.1 Site 1 – Mud, 10-m Depth

There were no Mode 2 source tows with good data at Site 1.

B.3.2 Site 2 – Sand, 10-m Depth

There were no Mode 2 source tows with good data at Site 2.

B.3.3 Site 3 – Mud, 30-m Depth

There were no Mode 2 source tows with good data at Site 3.

B.3.4 Site 4 – Sand, 30-m Depth

There were no Mode 2 source tows with good data at Site 4.

B.3.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 2 source tows with good data at Site 5.

B.4 Reson 7111, 100 kHz, 200 dB, 0.17-ms Pulse, 1.5° (Mode 3)

The Reson 7111 is a high-frequency (HF) directional source.

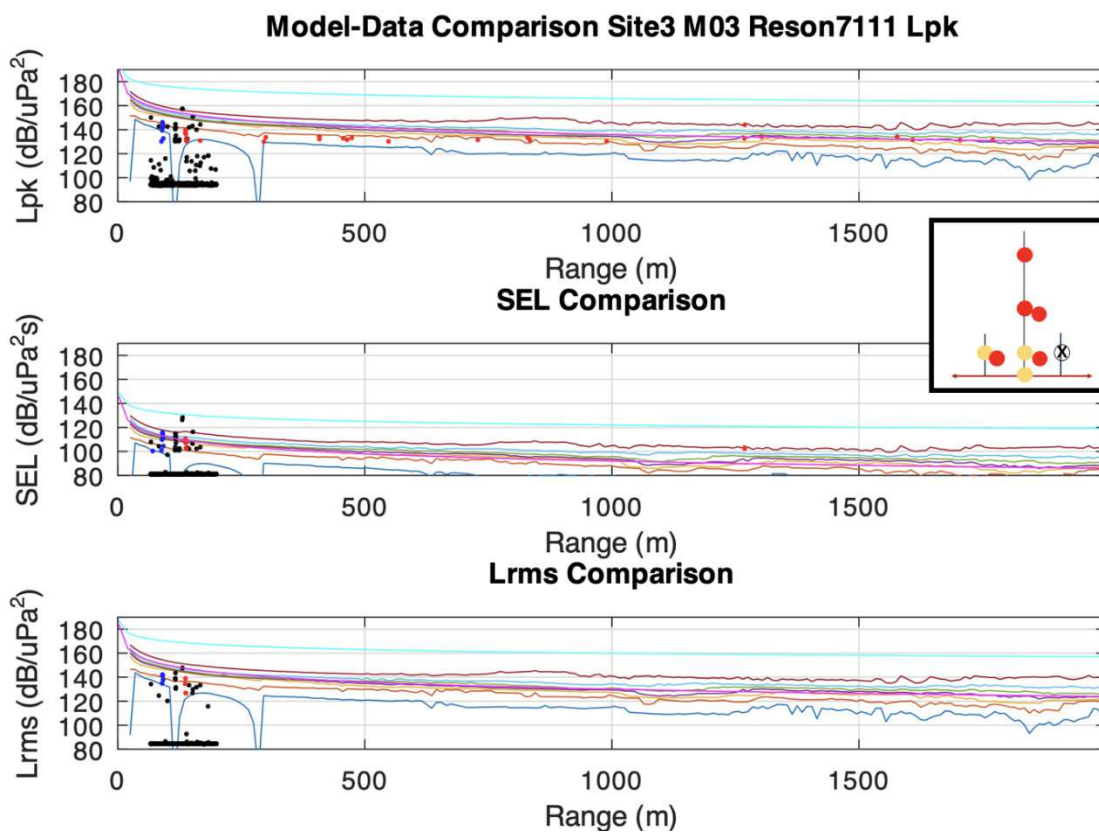
B.4.1 Site 1 – Mud, 10-m Depth

There were no Mode 3 source tows at Site 1.

B.4.2 Site 2 – Sand, 10-m Depth

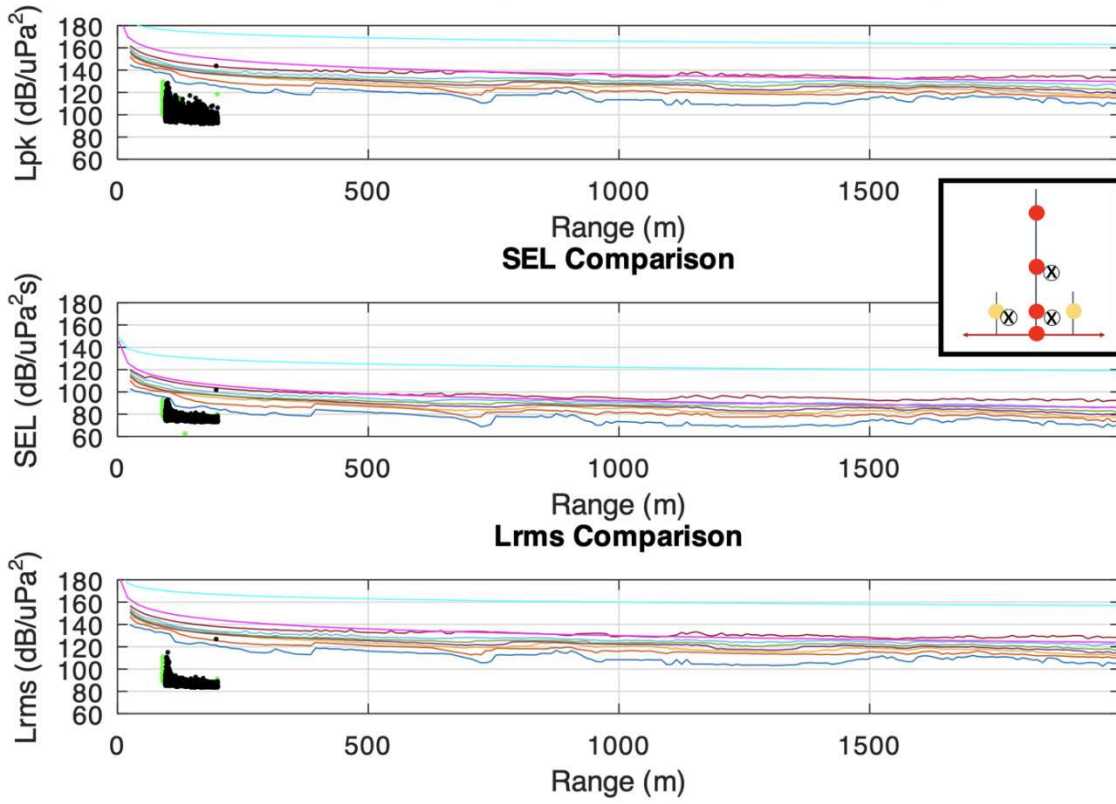
There were no Mode 3 source tows at Site 2.

B.4.3 Site 3 – Mud, 30-m Depth

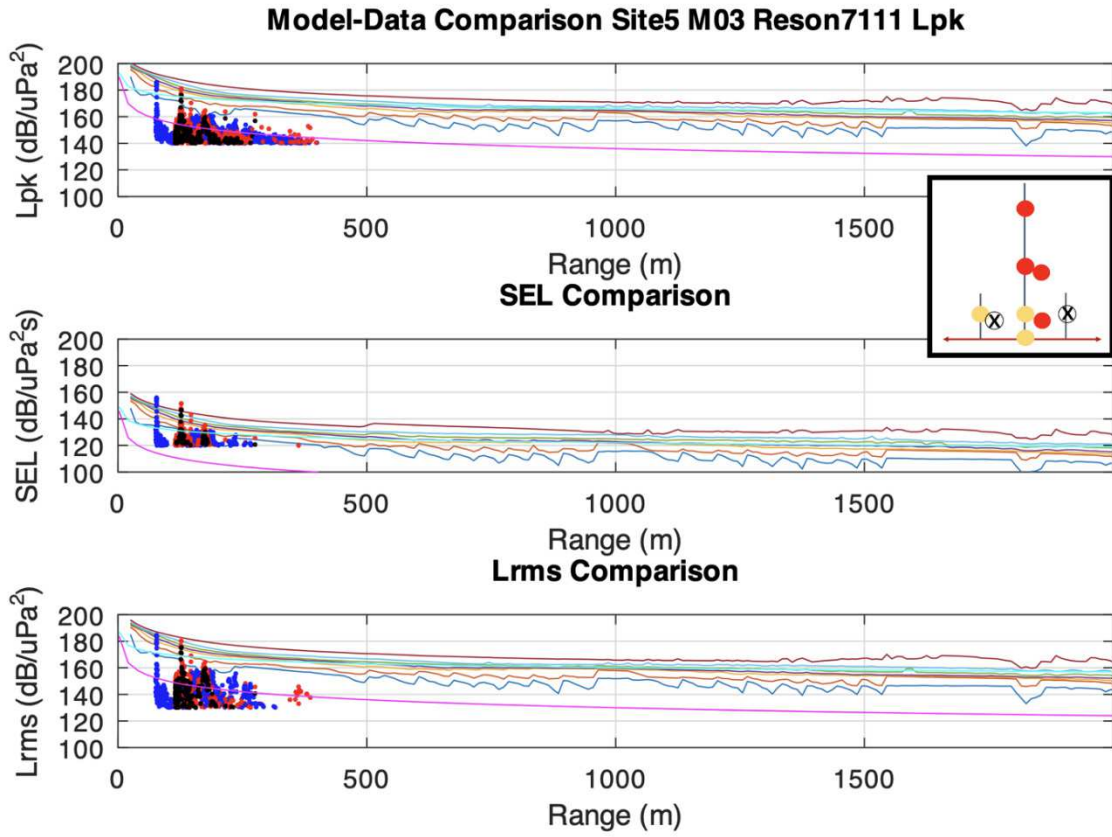


B.4.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M03 Reson7111 Lpk



B.4.5 Site 5 – Sandy Silt, 100-m Depth



B.5 Reson 7111, 100 kHz, 200 dB, 0.17-ms Pulse, 3° (Mode 4)

The Reson 7111 is an HF directional source.

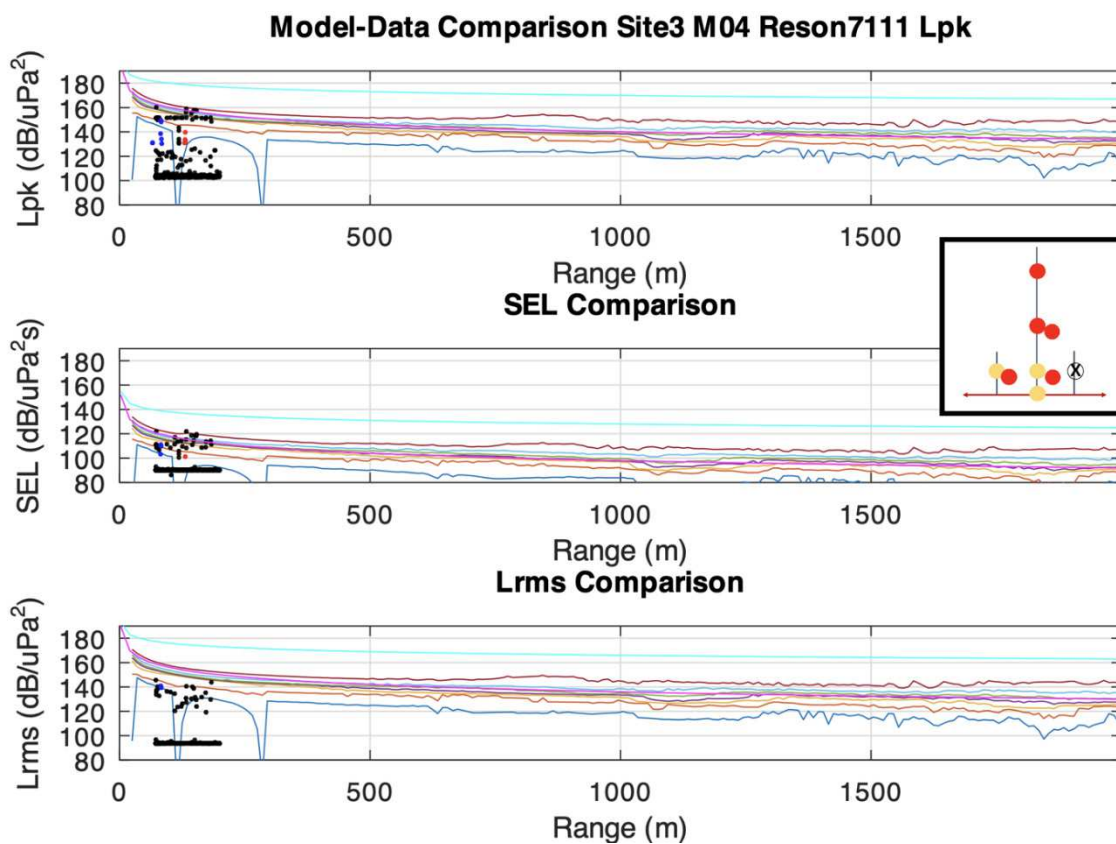
B.5.1 Site 1 – Mud, 10-m Depth

There were no Mode 4 source tows at Site 1.

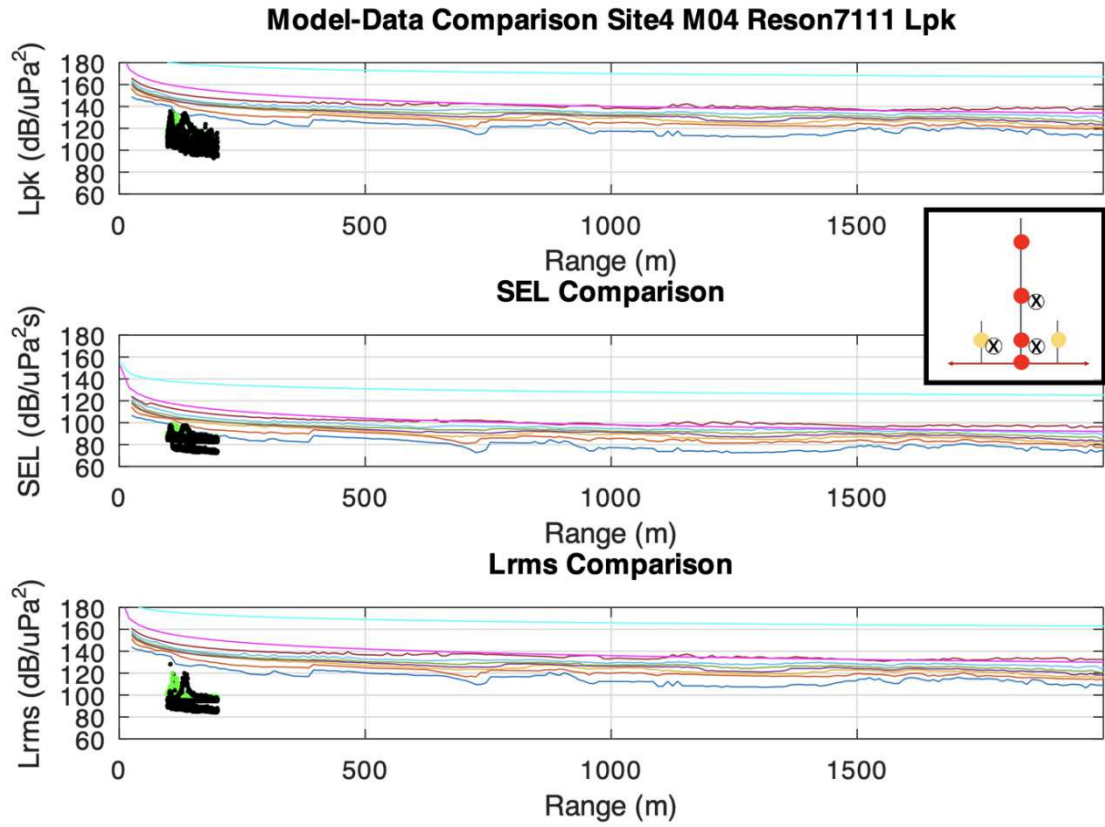
B.5.2 Site 2 – Sand, 10-m Depth

There were no Mode 4 source tows at Site 2.

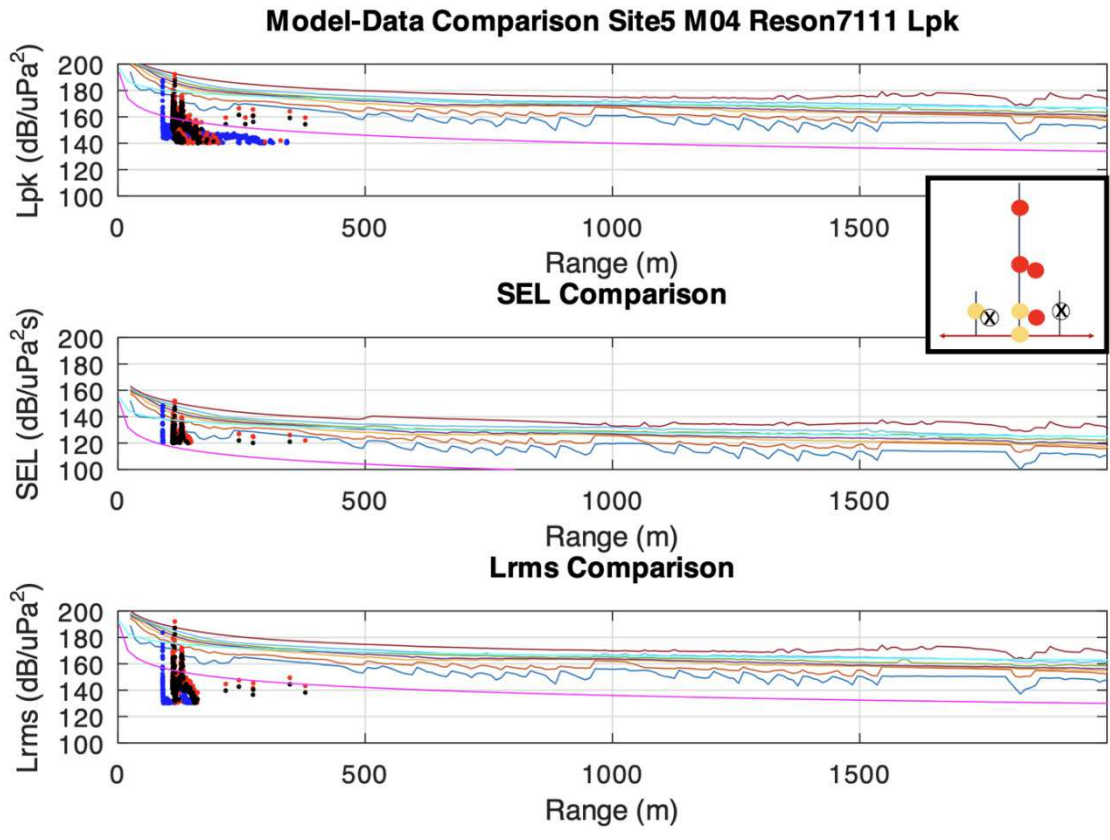
B.5.3 Site 3 – Mud, 30-m Depth



B.5.4 Site 4 – Sand, 30-m Depth



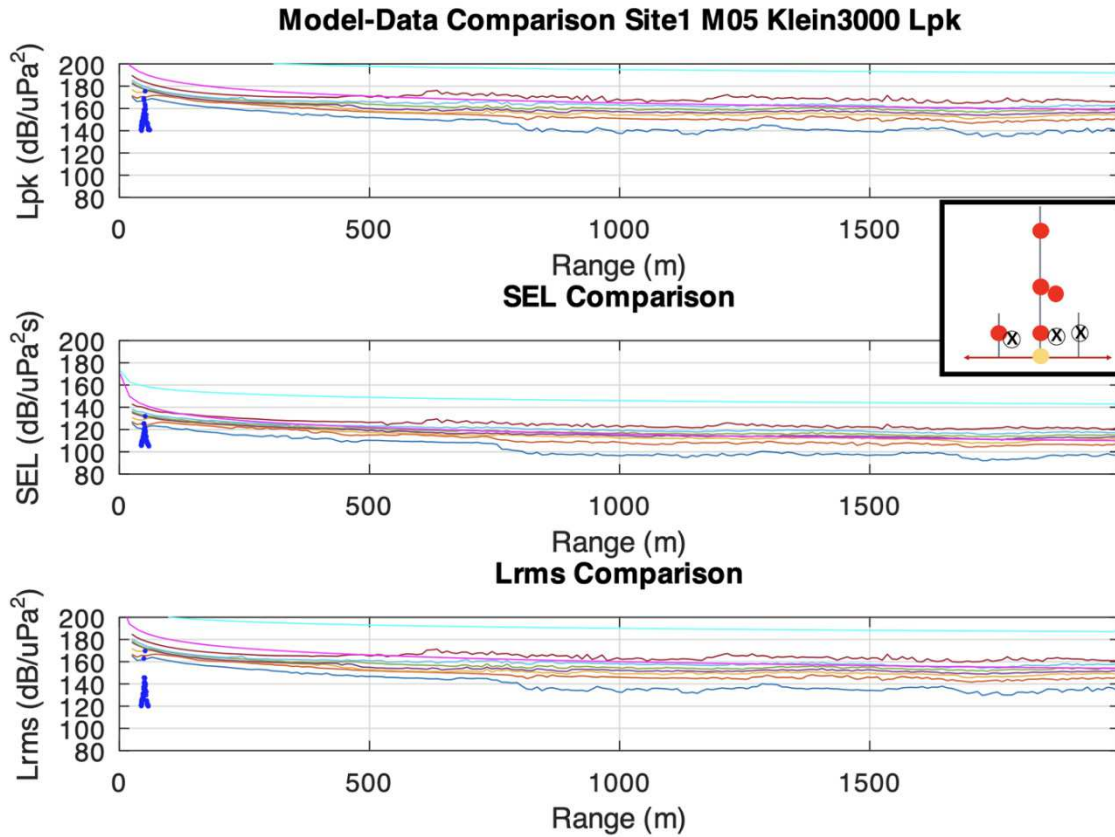
B.5.5 Site 5 – Sandy Silt, 100-m Depth



B.6 Klein 3000, 132 kHz, 50- μ s Pulse, 400-ms Ping Rate, 400-m Range (Mode 5)

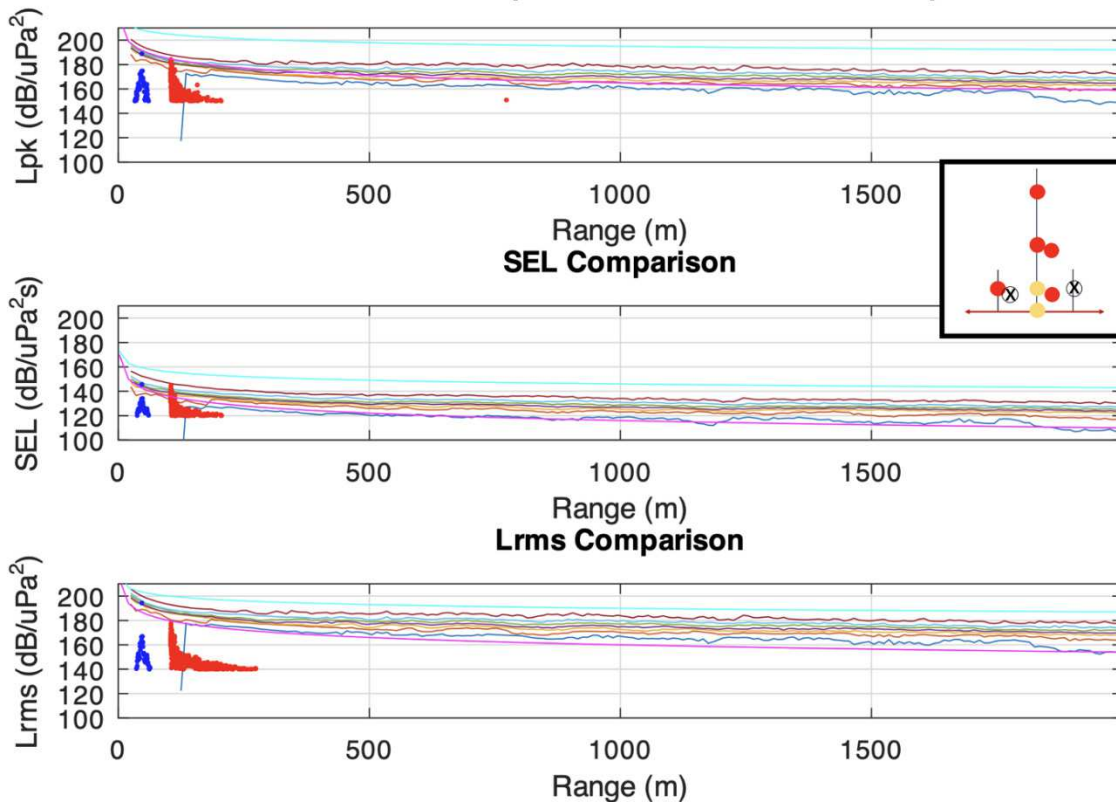
The Klein 3000 is an HF directional source.

B.6.1 Site 1 – Mud, 10-m Depth

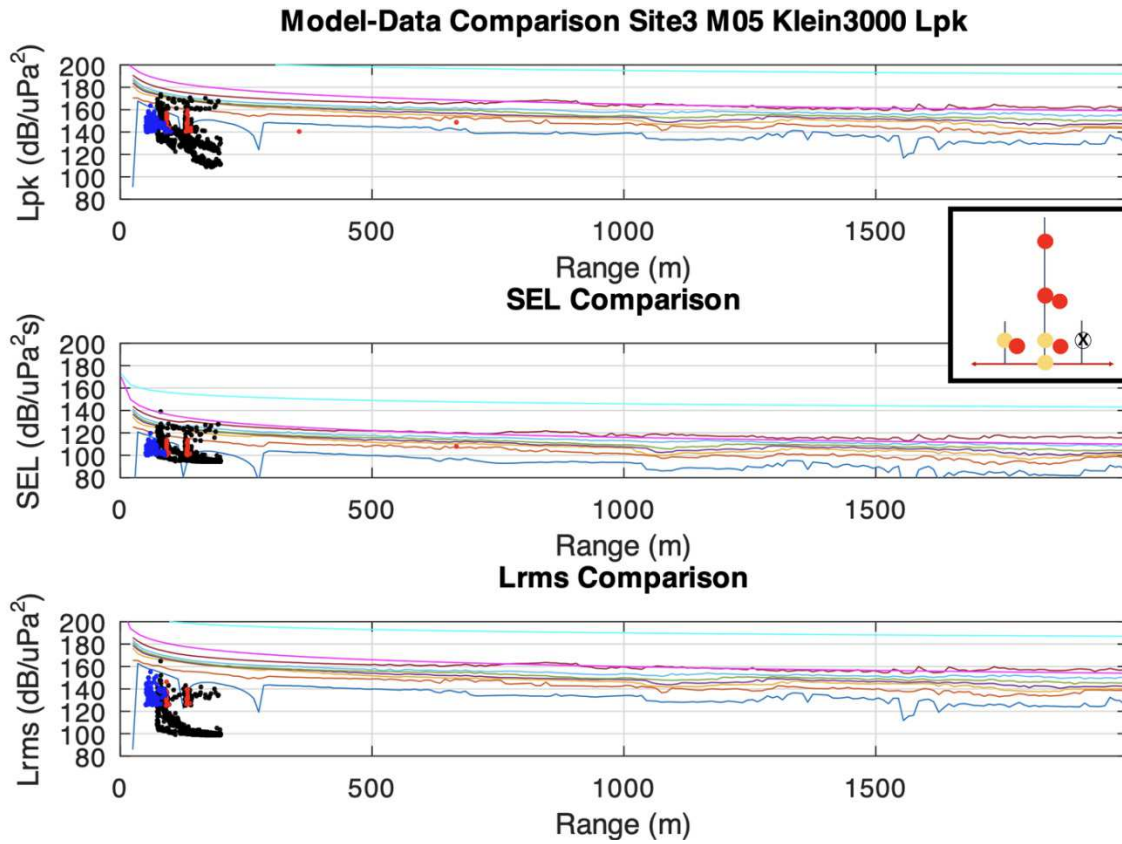


B.6.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M05 Klein3000 Lpk



B.6.3 Site 3 – Mud, 30-m Depth



B.6.4 Site 4 – Sand, 30-m Depth

There were no Mode 5 source tows with good data at Site 4.

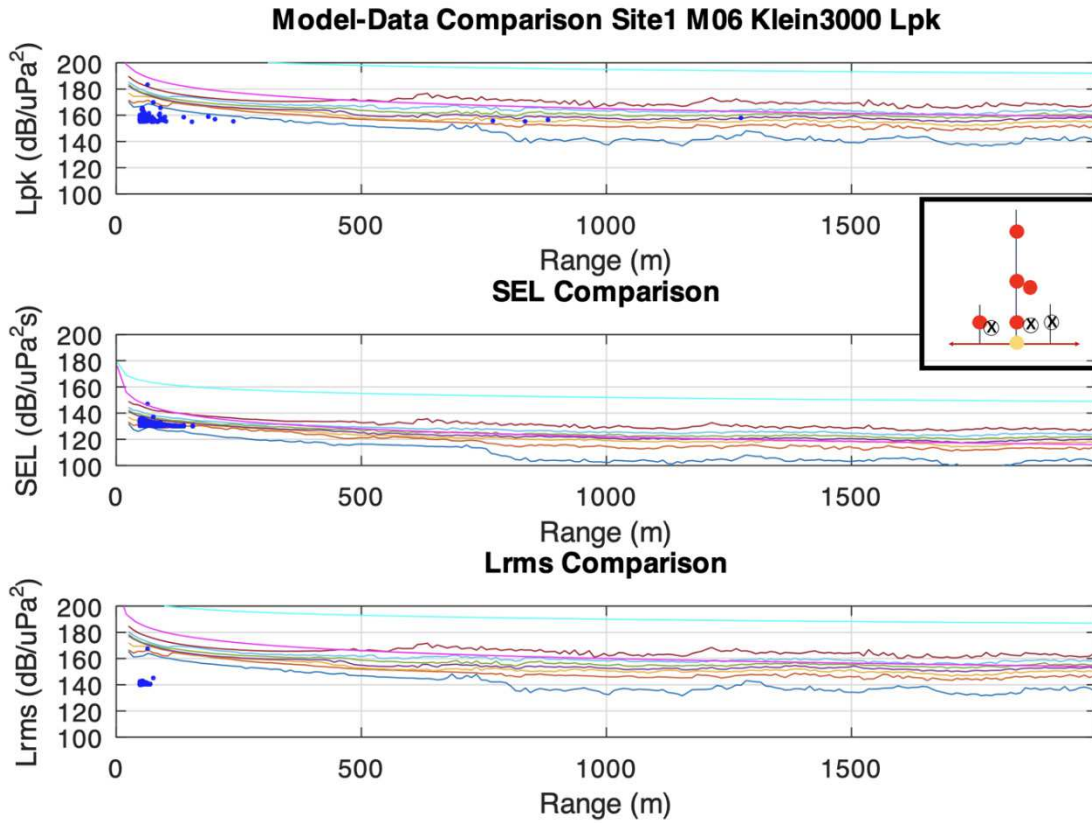
B.6.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 5 source tows with good data at Site 5.

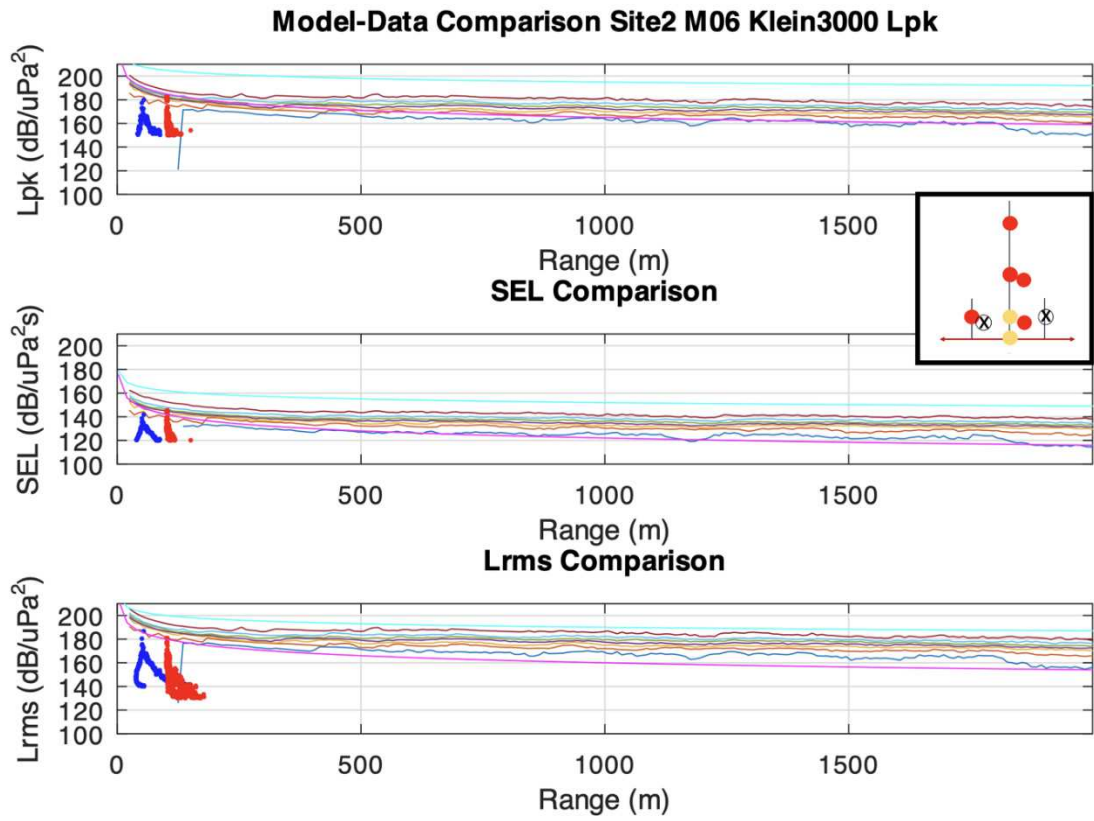
B.7 Klein 3000, 132 kHz, 200- μ s Pulse, 400-ms Ping Rate, 200-m Range (Mode 6)

The Klein 3000 is an HF directional source.

B.7.1 Site 1 – Mud, 10-m Depth

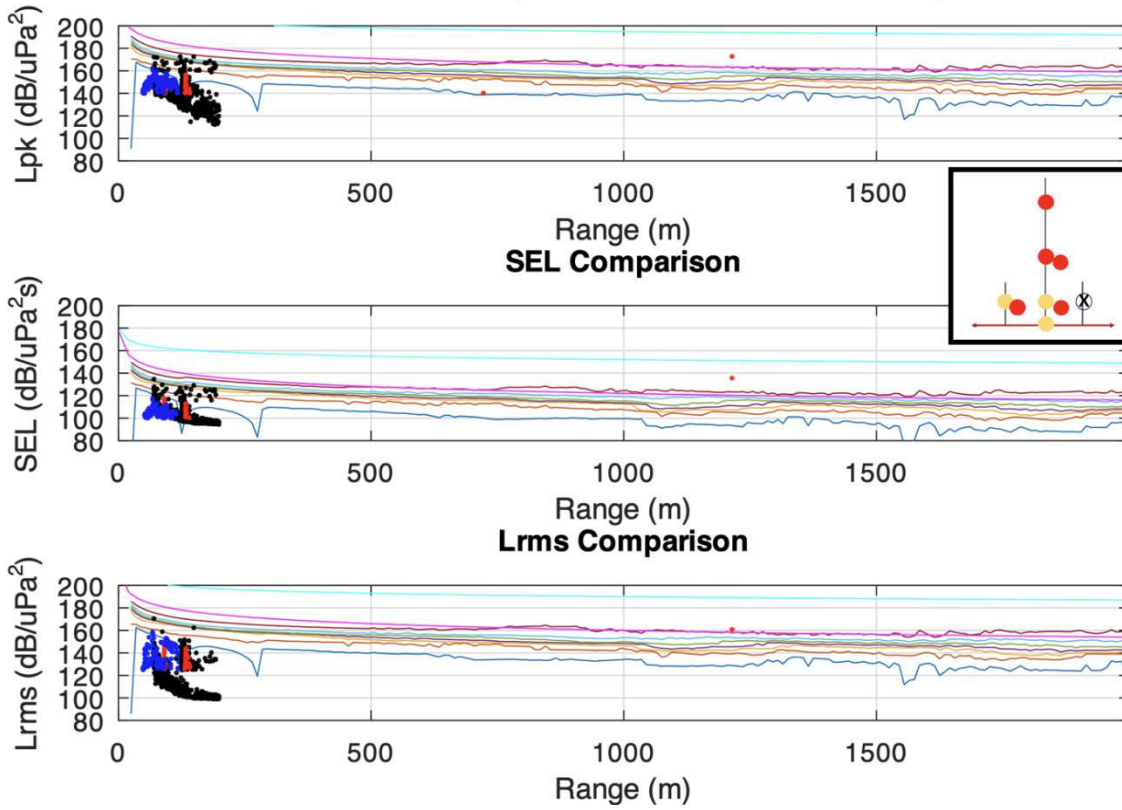


B.7.2 Site 2 – Sand, 10-m Depth



B.7.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M06 Klein3000 Lpk



B.7.4 Site 4 – Sand, 30-m Depth

There were no Mode 6 source tows at Site 4.

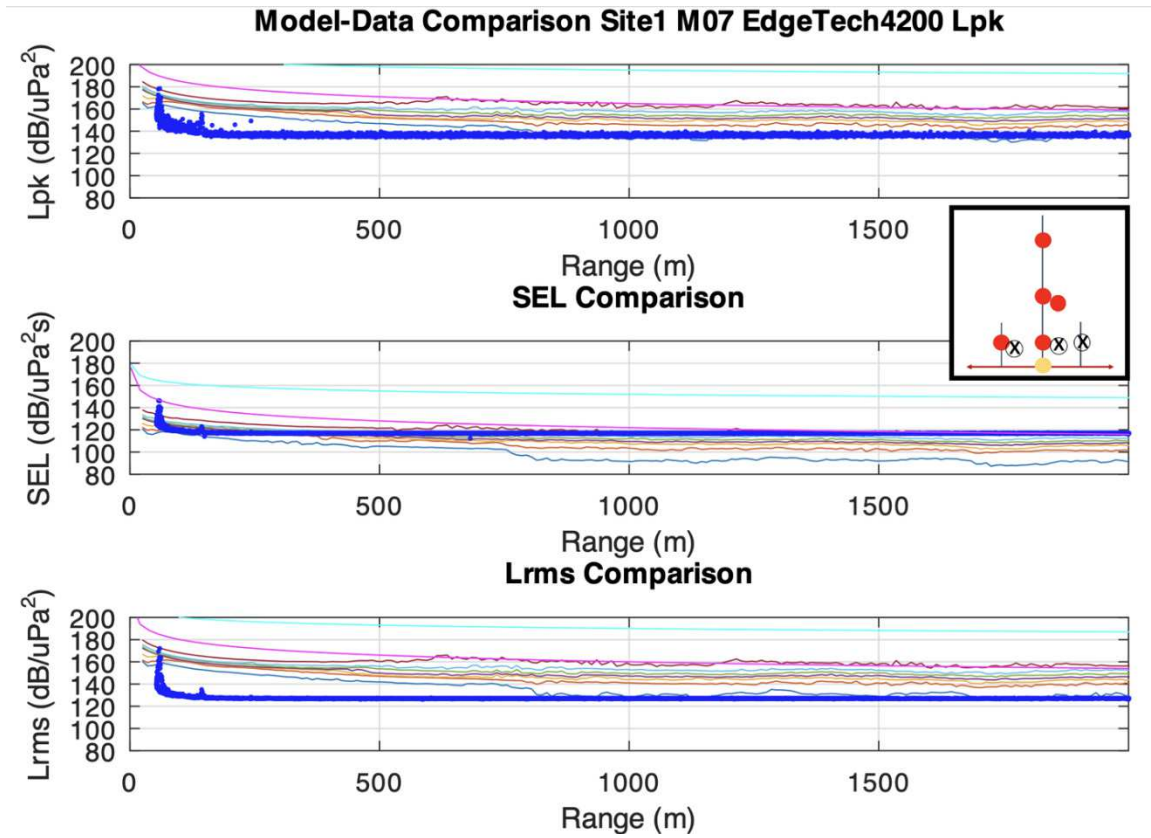
B.7.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 6 source tows at Site 5.

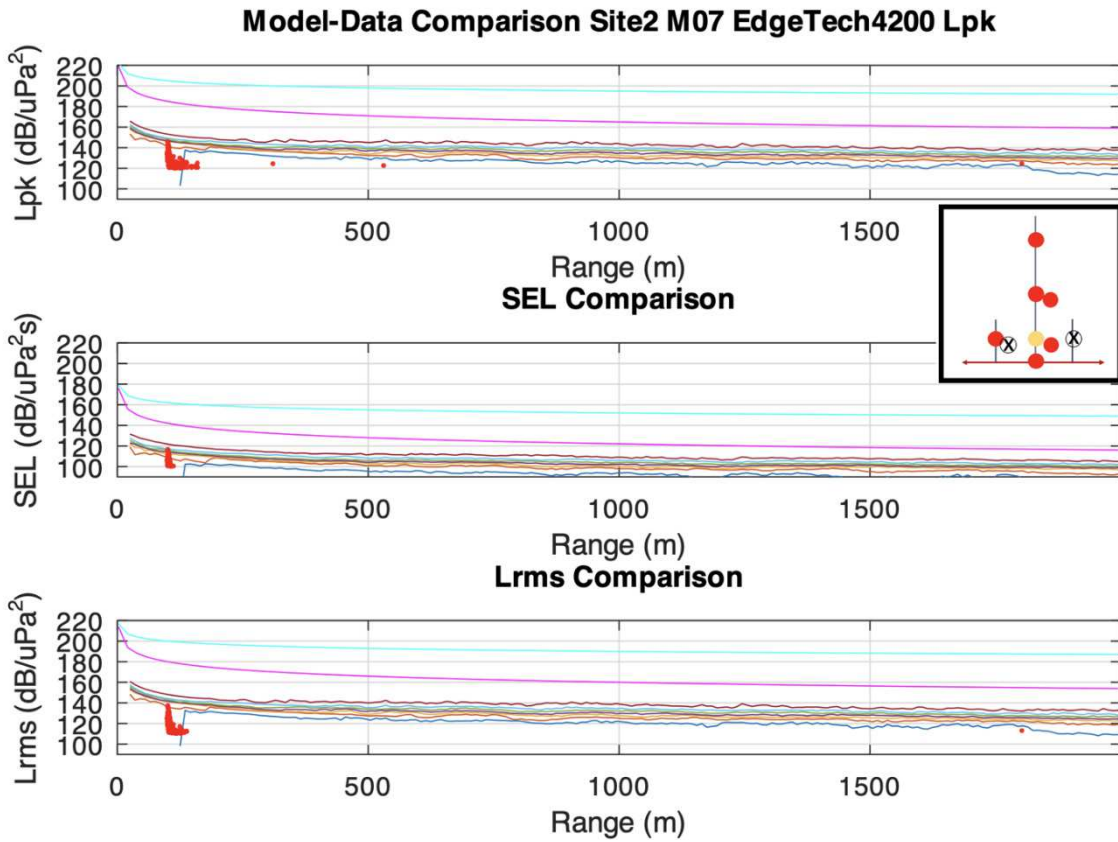
B.8 EdgeTech 4200, 100 kHz, 500-ms Ping Rate, 50-m Range (Mode 7)

The EdgeTech 4200 is an HF directional source.

B.8.1 Site 1 – Mud, 10-m Depth



B.8.2 Site 2 – Sand, 10-m Depth



B.8.3 Site 3 – Mud, 30-m Depth

There were no Mode 7 source tows with good data at Site 3.

B.8.4 Site 4 – Sand, 30-m Depth

There were no Mode 7 source tows with good data at Site 4.

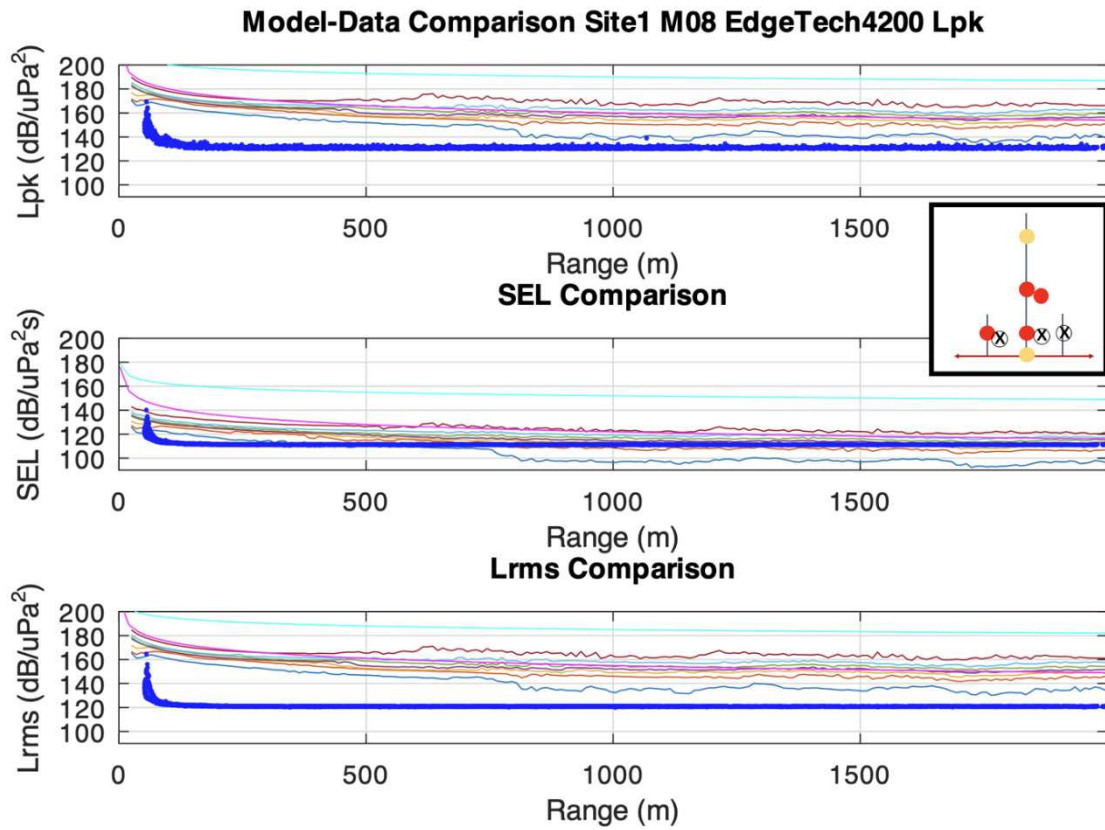
B.8.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 7 source tows at Site 5.

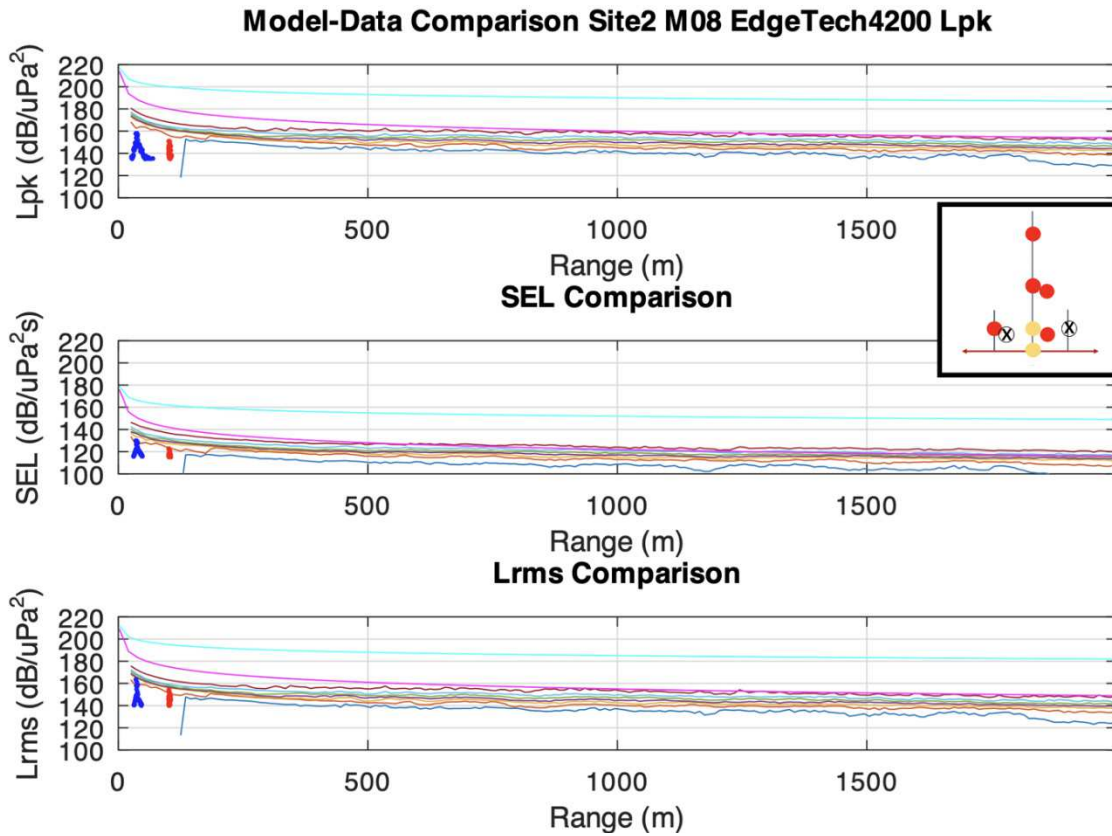
B.9 EdgeTech 4200, 100 kHz, 500-ms Ping Rate, 100-m Range (Mode 8)

The EdgeTech 4200 is an HF directional source.

B.9.1 Site 1 – Mud, 10-m Depth



B.9.2 Site 2 – Sand, 10-m Depth



B.9.3 Site 3 – Mud, 30-m Depth

There were no Mode 8 source tows with good data at Site 3.

B.9.4 Site 4 – Sand, 30-m Depth

There were no Mode 8 source tows with good data at Site 4.

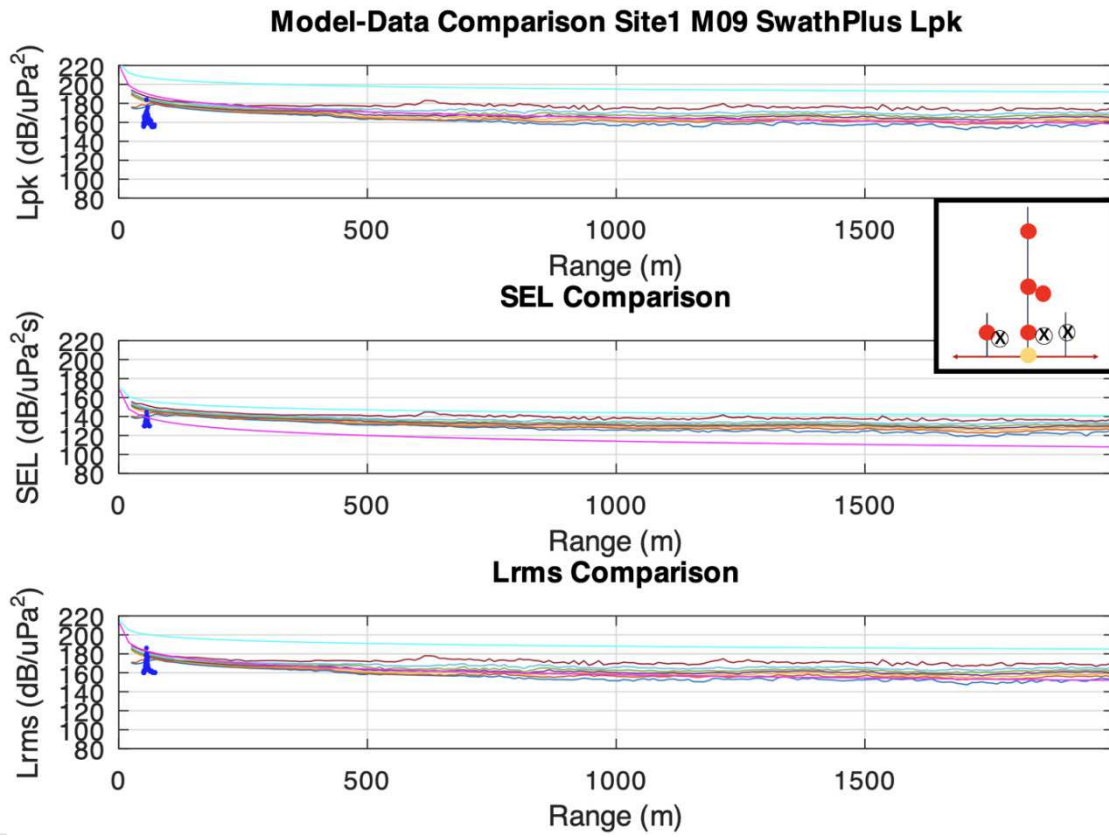
B.9.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 8 source tows at Site 5.

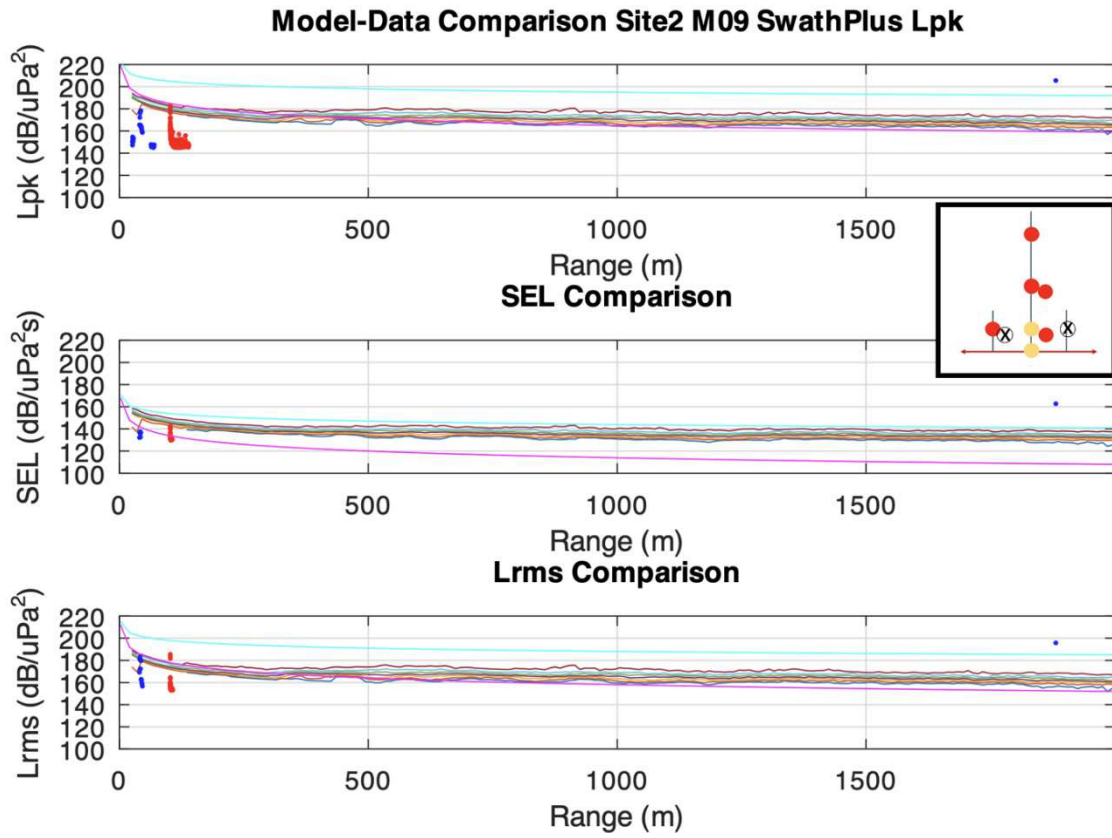
B.10 SEA SWATHPlus, 234 kHz, 100 Percent Power, 12 Cycles (Mode 9)

The SWATHPlus is a VHF directional source.

B.10.1 Site 1 – Mud, 10-m Depth



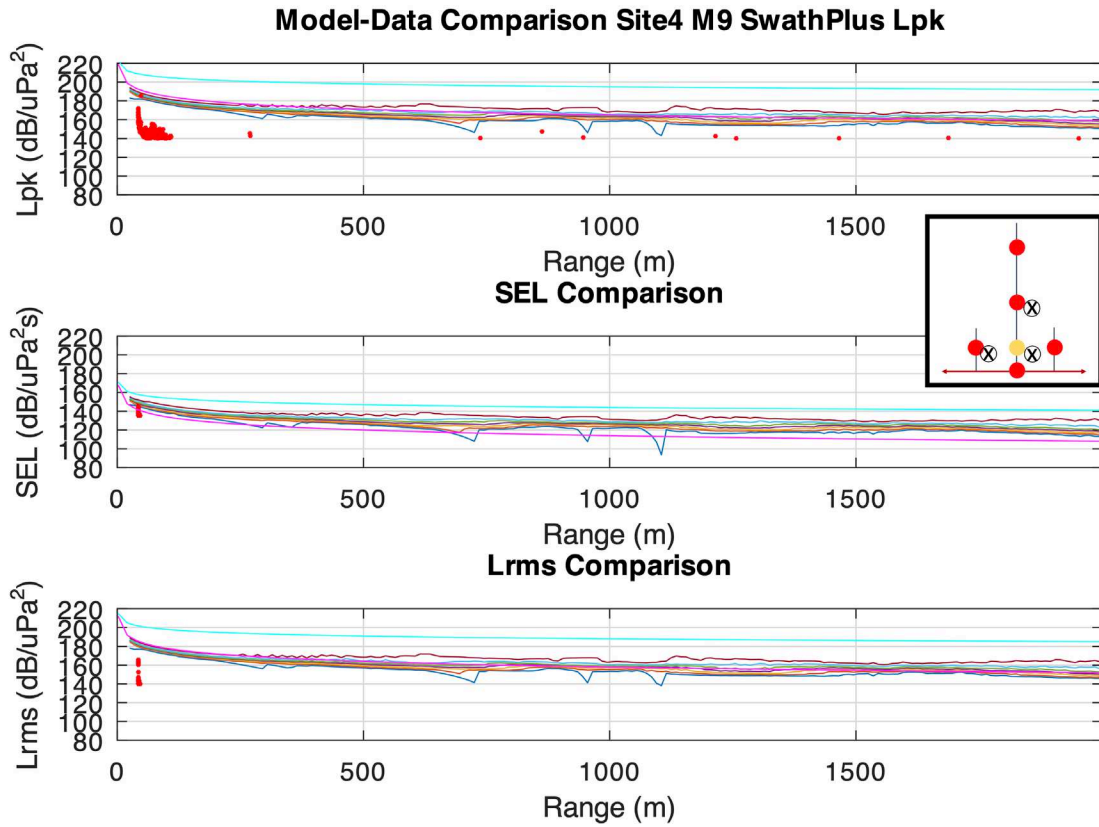
B.10.2 Site 2 – Sand, 10-m Depth



B.10.3 Site 3 – Mud, 30-m Depth

There were no Mode 9 source tows at Site 3.

B.10.4 Site 4 – Sand, 30-m Depth



B.10.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 9 source tows at Site 5.

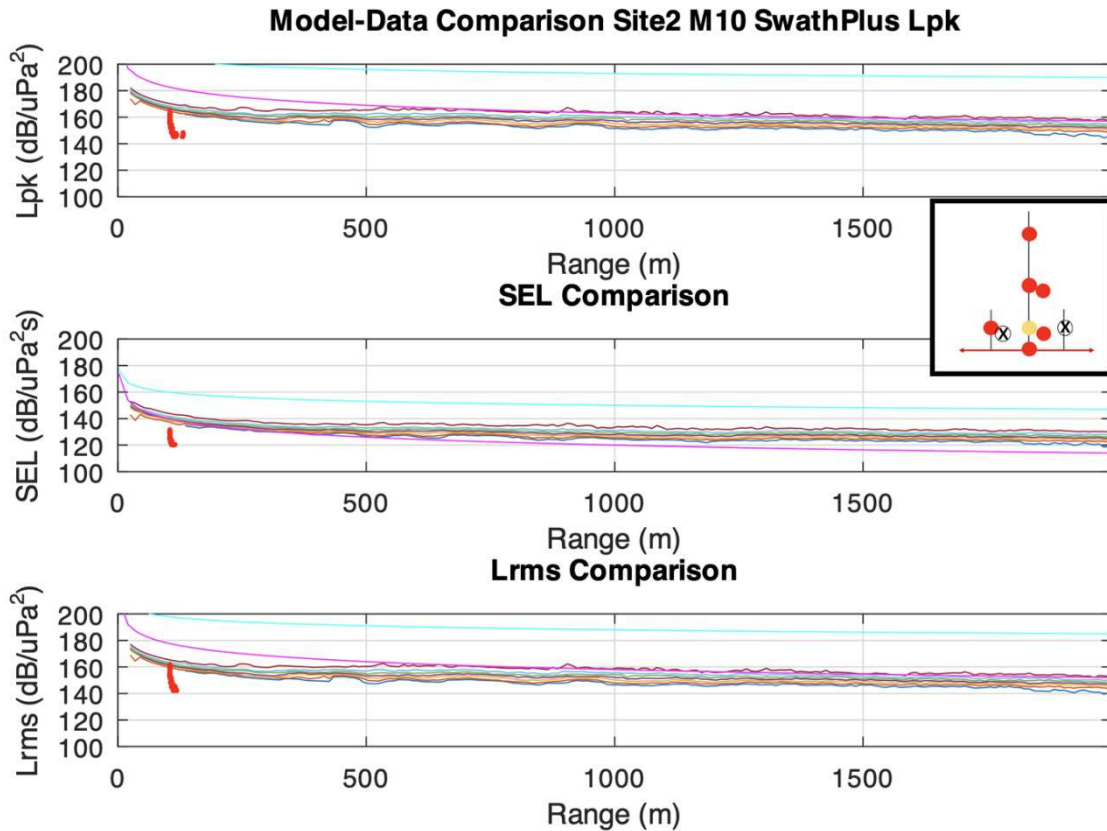
B.11 SEA SWATHPlus, 234 kHz, 100 Percent Power, 60 Cycles (Mode 10)

The SWATHPlus is a VHF directional source.

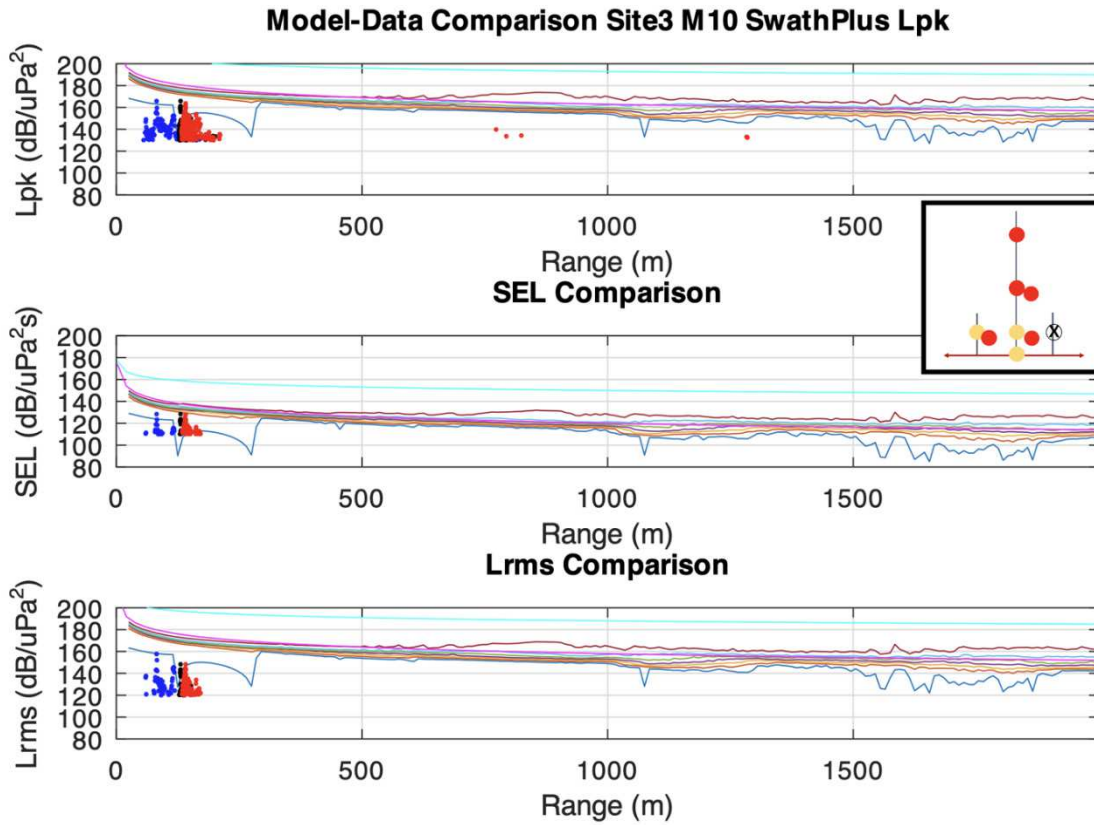
B.11.1 Site 1 – Mud, 10-m Depth

There were no Mode 10 source tows at Site 1.

B.11.2 Site 2 – Sand, 10-m Depth



B.11.3 Site 3 – Mud, 30-m Depth



B.11.4 Site 4 – Sand, 30-m Depth

There were no Mode 10 source tows with good data at Site 4.

B.11.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 10 source tows at Site 5.

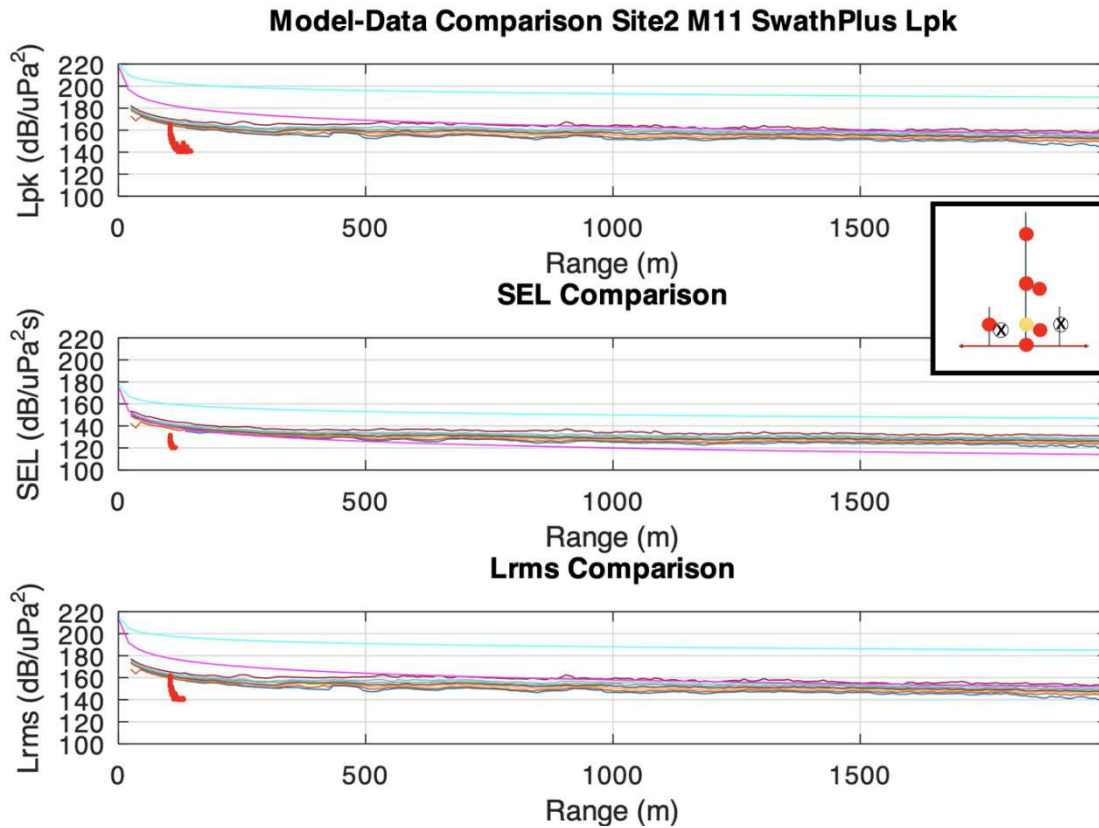
B.12 SEA SWATHPlus, 234 kHz, 100 Percent Power, 50 Cycles (Mode 11)

The SWATHPlus is a VHF directional source.

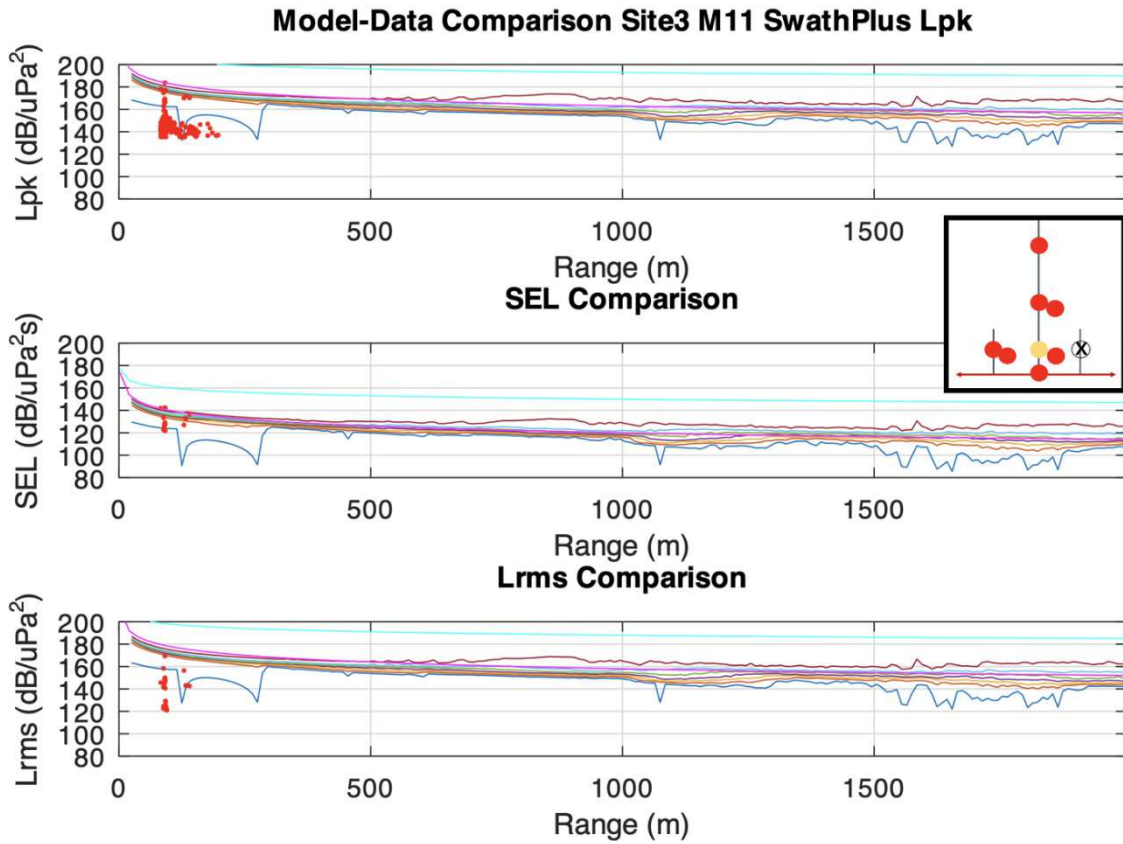
B.12.1 Site 1 – Mud, 10-m Depth

There were no Mode 11 source tows at Site 1.

B.12.2 Site 2 – Sand, 10-m Depth



B.12.3 Site 3 – Mud, 30-m Depth



B.12.4 Site 4 – Sand, 30-m Depth

There were no Mode 11 source tows at Site 4.

B.12.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 11 source tows at Site 5.

B.13 SEA SWATHPlus, 234 kHz, 100 Percent Power, 250 Cycles (Mode 12)

The SWATHPlus is a VHF directional source.

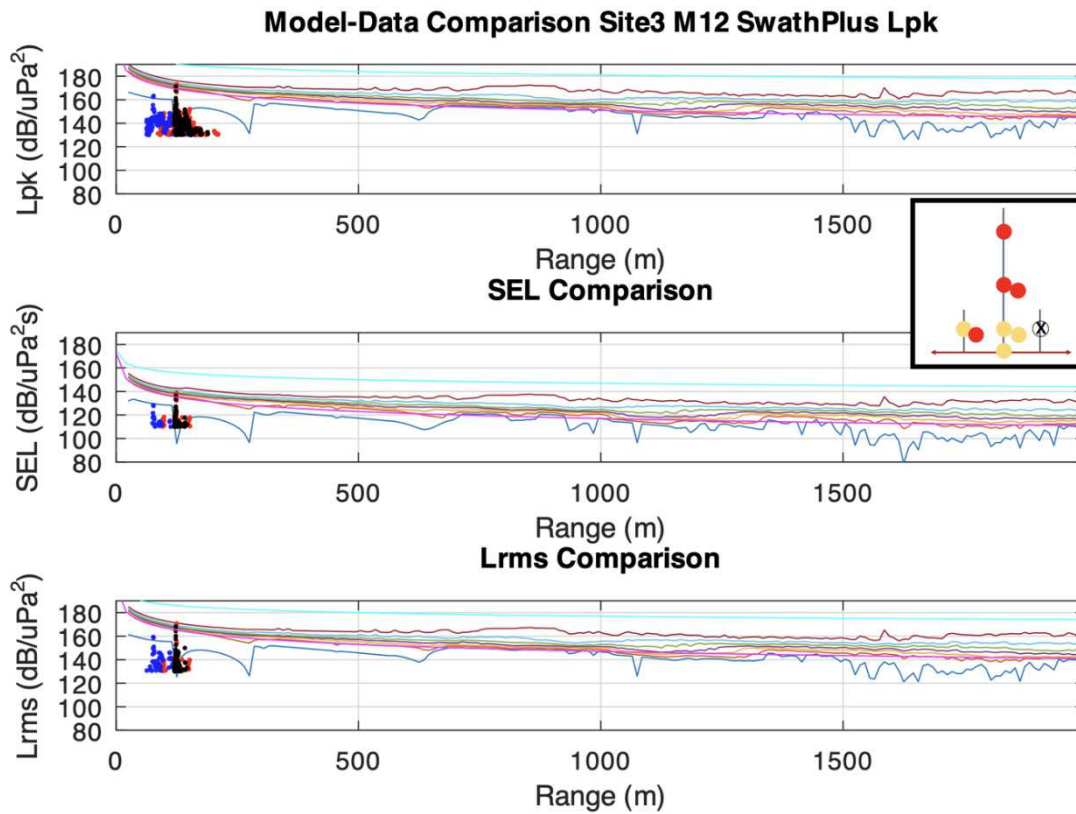
B.13.1 Site 1 – Mud, 10-m Depth

There were no Mode 12 source tows at Site 1.

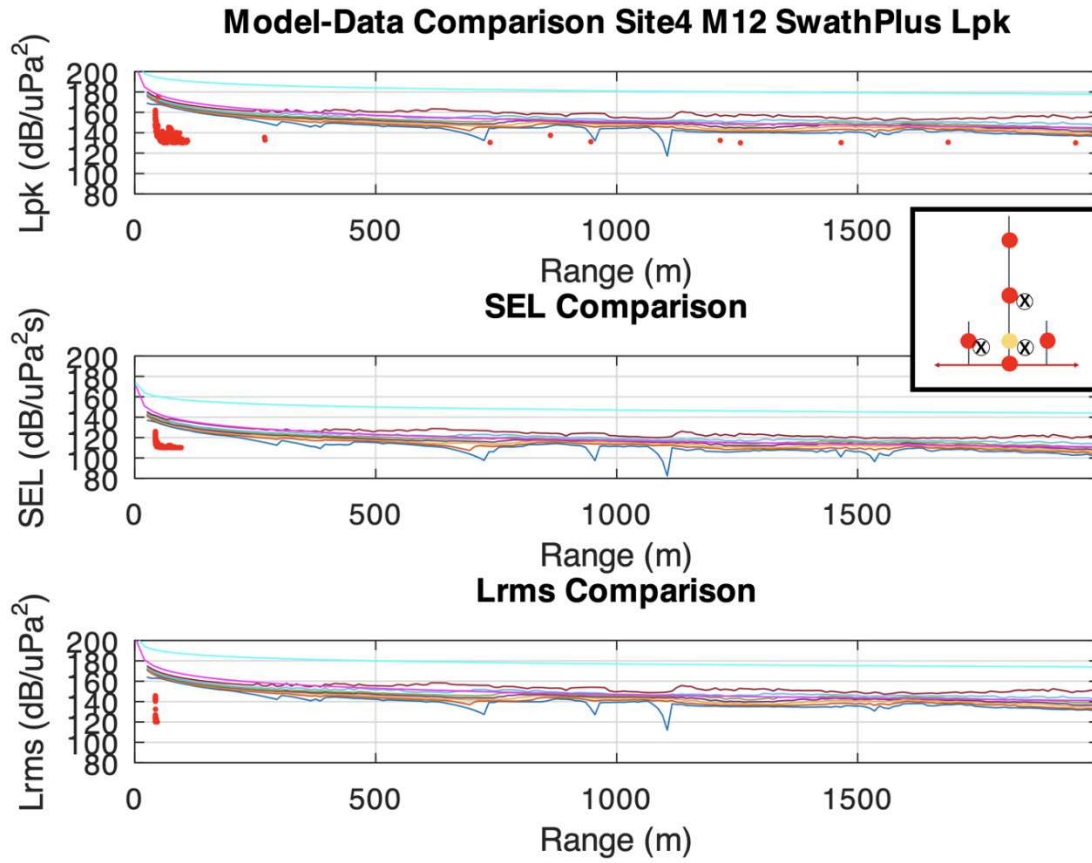
B.13.2 Site 2 – Sand, 10-m Depth

There were no Mode 12 source tows at Site 2.

B.13.3 Site 3 – Mud, 30-m Depth



B.13.4 Site 4 – Sand, 30-m Depth



B.13.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 12 source tows at Site 5.

B.14 Simrad EK60, 30 kHz, 100 Percent Power, 512- μ s Pulse (Mode 13)

The EK60 is an HF directional source.

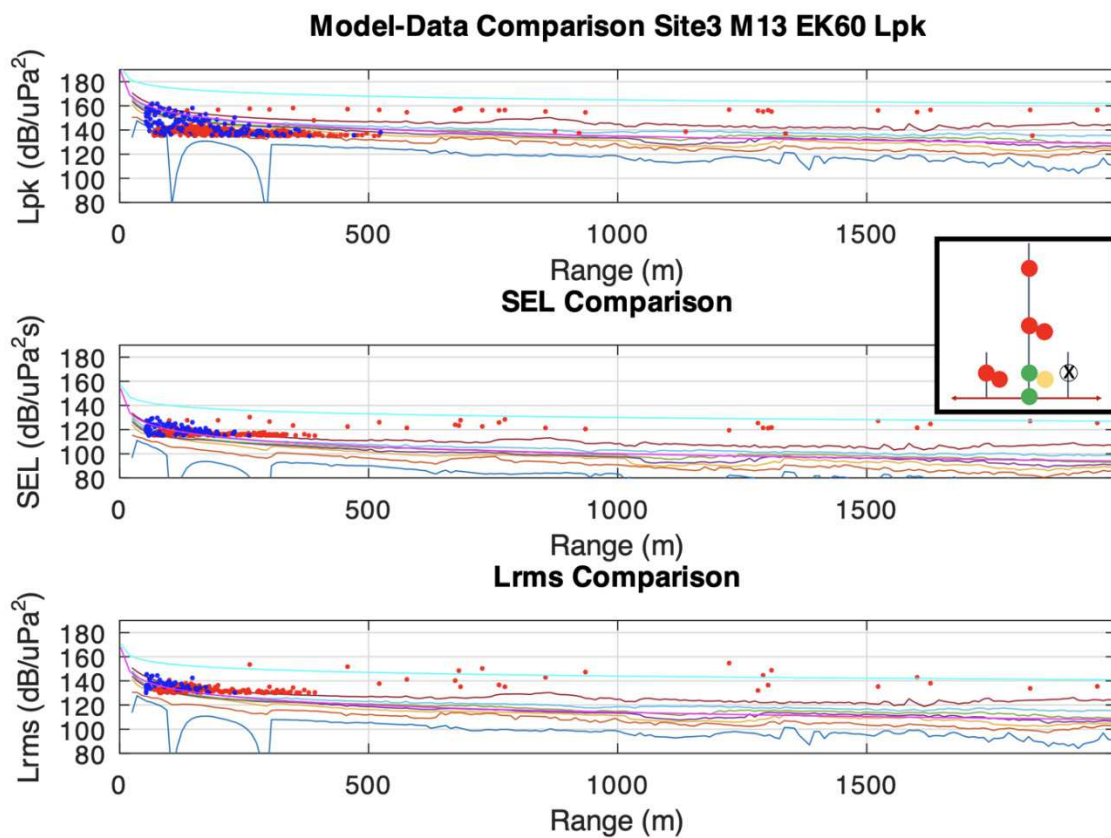
B.14.1 Site 1 – Mud, 10-m Depth

There were no Mode 13 source tows at Site 1.

B.14.2 Site 2 – Sand, 10-m Depth

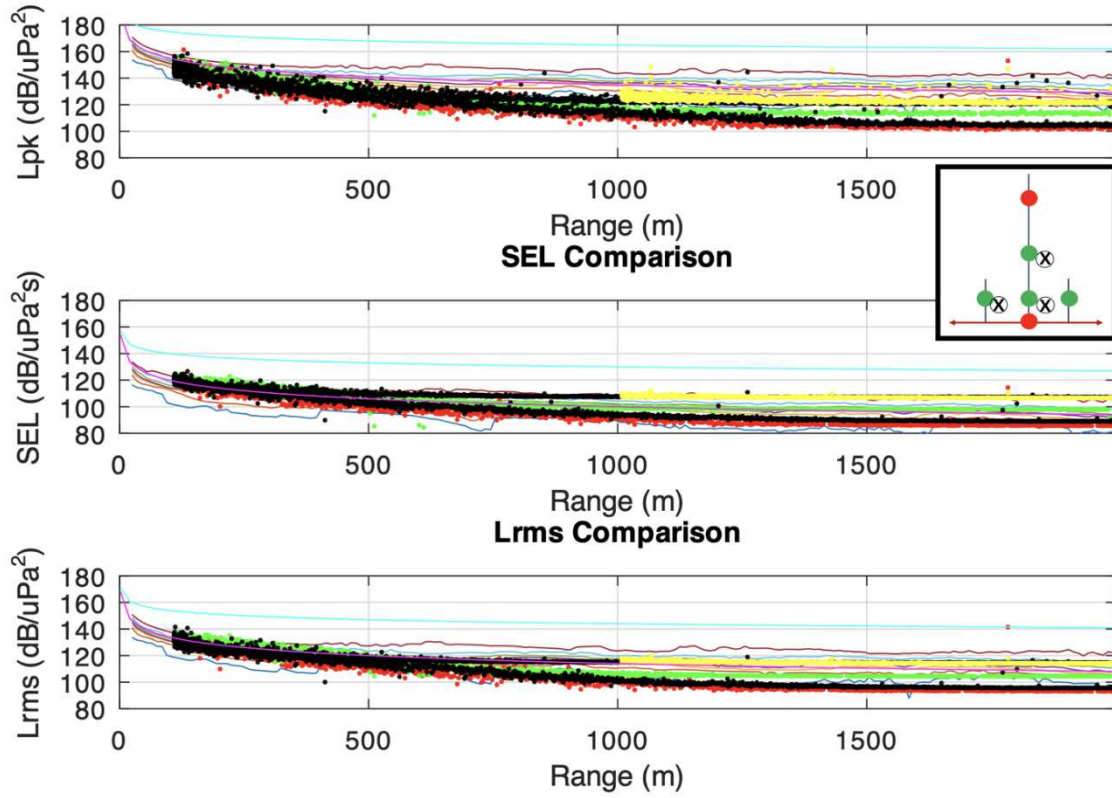
There were no Mode 13 source tows at Site 2.

B.14.3 Site 3 – Mud, 30-m Depth



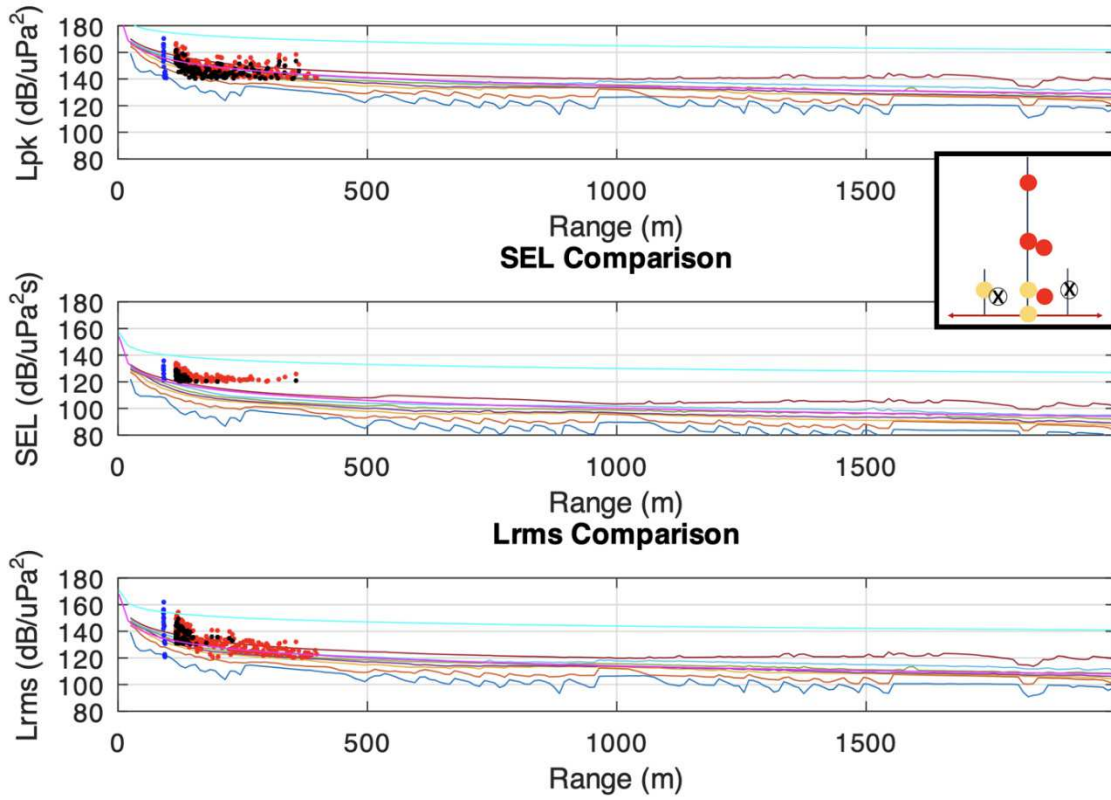
B.14.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M13 EK60 Lpk



B.14.5 Site 5 – Sandy Silt, 100-m Depth

Model-Data Comparison Site5 M13 EK60 Lpk



B.15 Simrad EK60, 38 kHz, 100 Percent Power, 1,024- μ s Pulse (Mode 14)

The EK60 is an HF directional source.

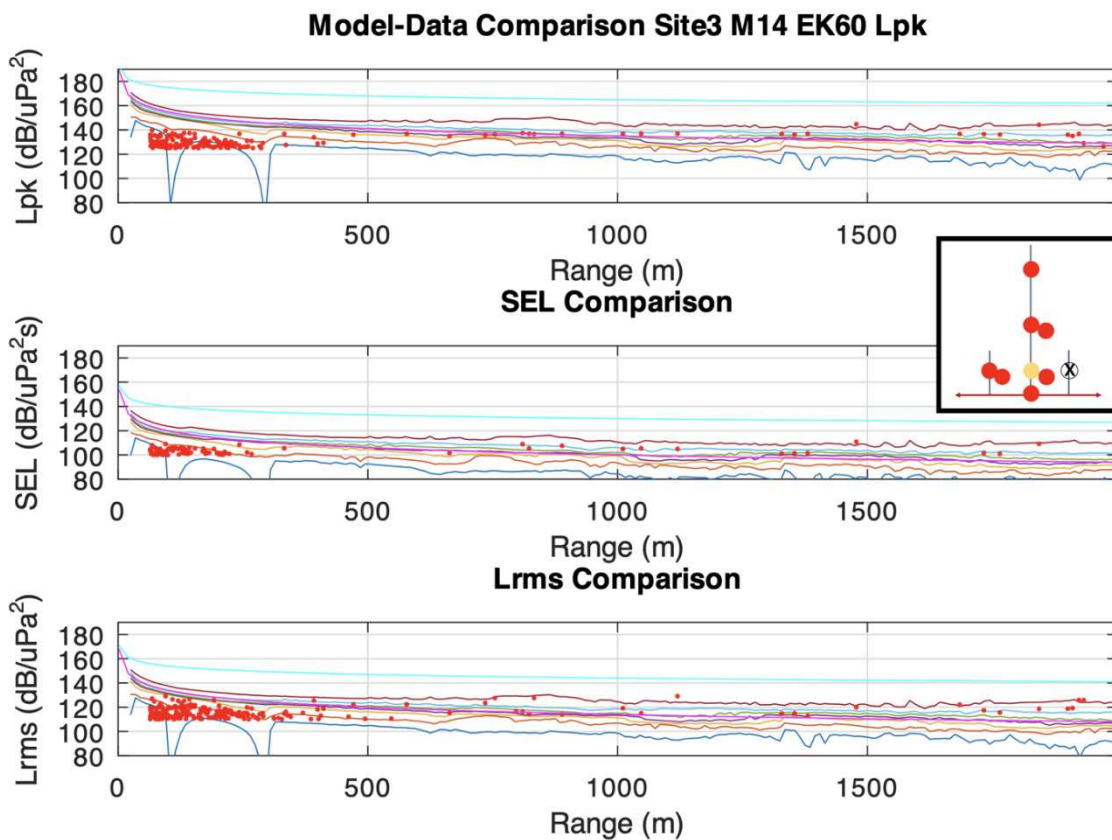
B.15.1 Site 1 – Mud, 10-m Depth

There were no Mode 14 source tows at Site 1.

B.15.2 Site 2 – Sand, 10-m Depth

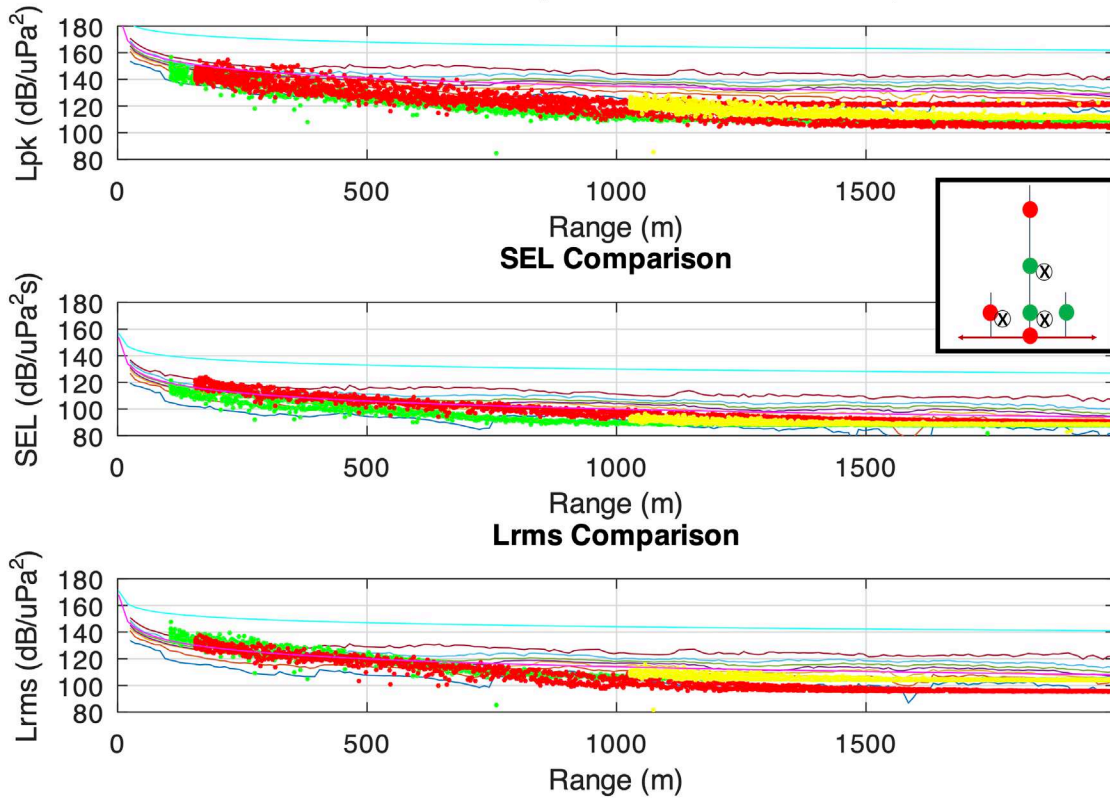
There were no Mode 14 source tows at Site 2.

B.15.3 Site 3 – Mud, 30-m Depth



B.15.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M14 EK60 Lpk



B.15.5 Site 5 – Sandy Silt, 100-m Depth

There were no Mode 14 source tows at Site 5.

B.16 Simrad EK60, 30 kHz, 50 Percent Power, 512- μ s Pulse (Mode 15)

The EK60 is an HF directional source.

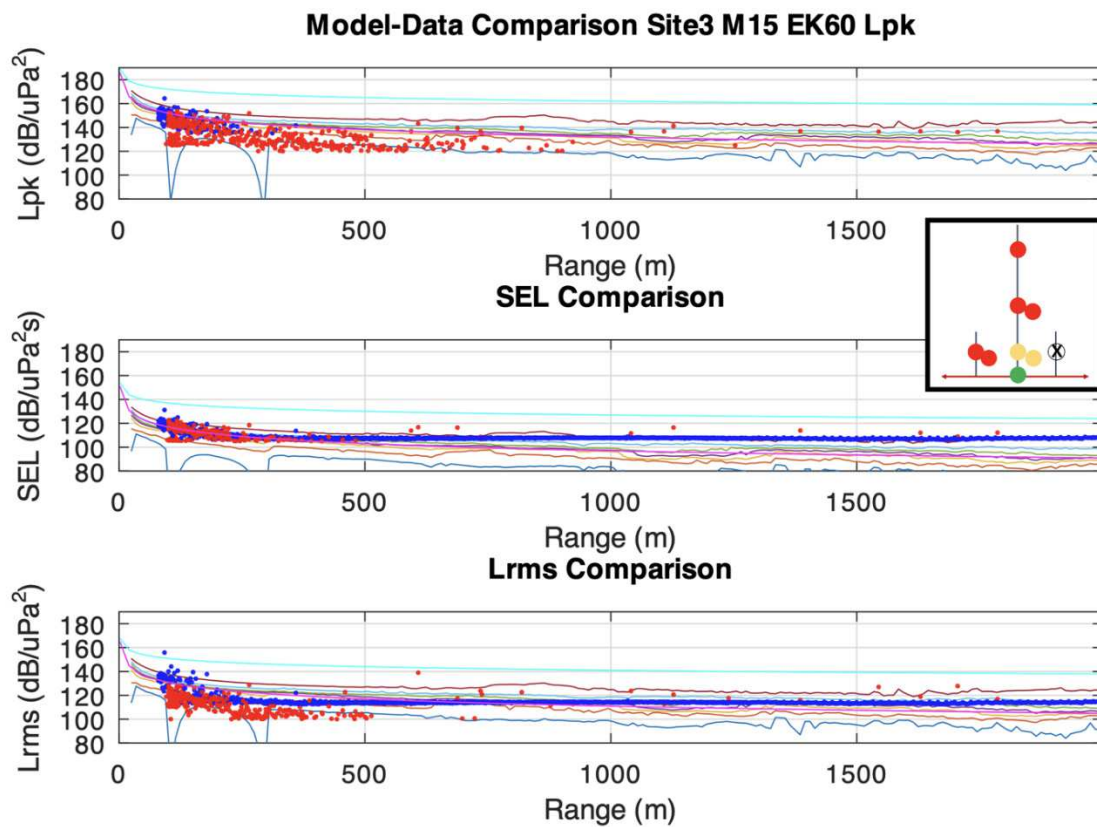
B.16.1 Site 1 – Mud, 10-m Depth

There were no Mode 15 source tows at Site 1.

B.16.2 Site 2 – Sand, 10-m Depth

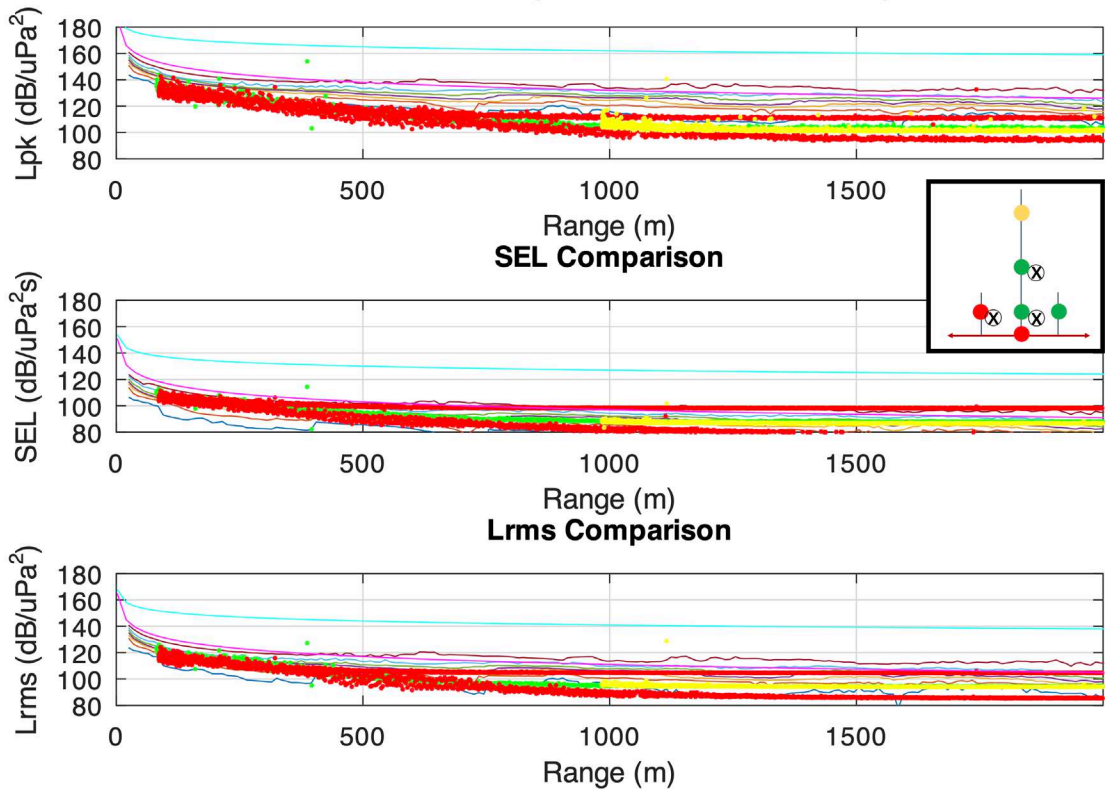
There were no Mode 15 source tows at Site 2.

B.16.3 Site 3 – Mud, 30-m Depth



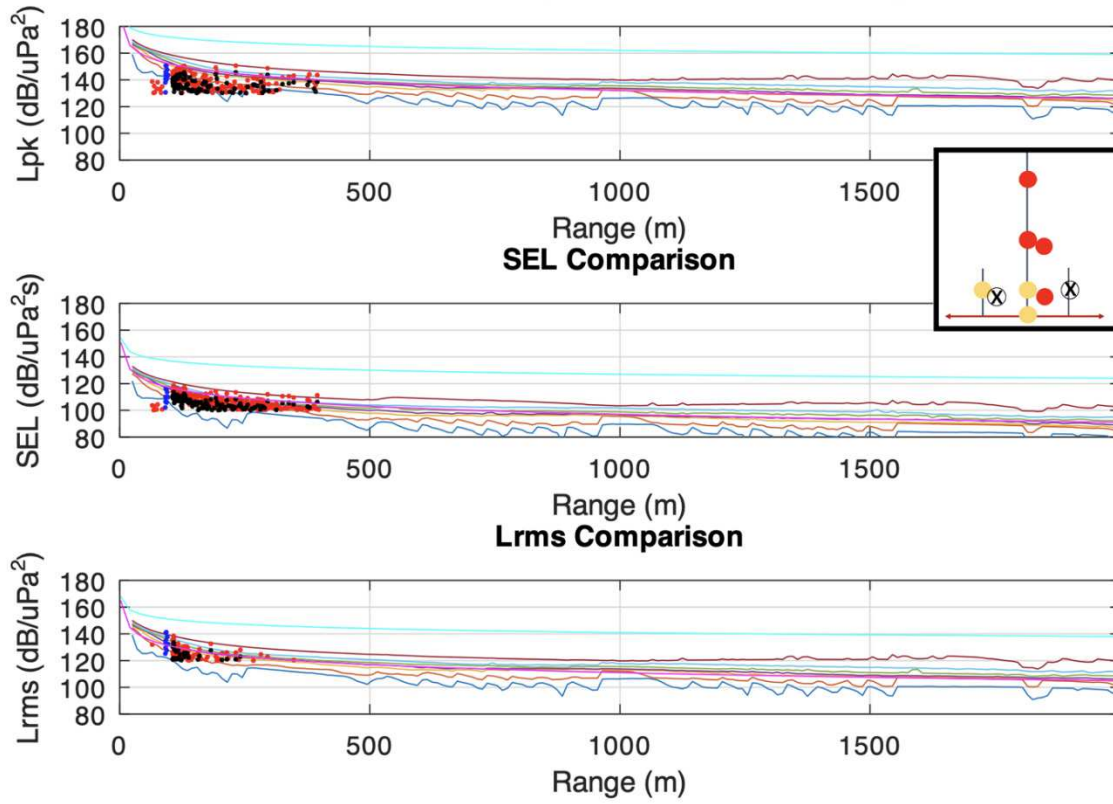
B.16.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M15 EK60 Lpk



B.16.5 Site 5 – Sandy Silt, 100-m Depth

Model-Data Comparison Site5 M15 EK60 Lpk



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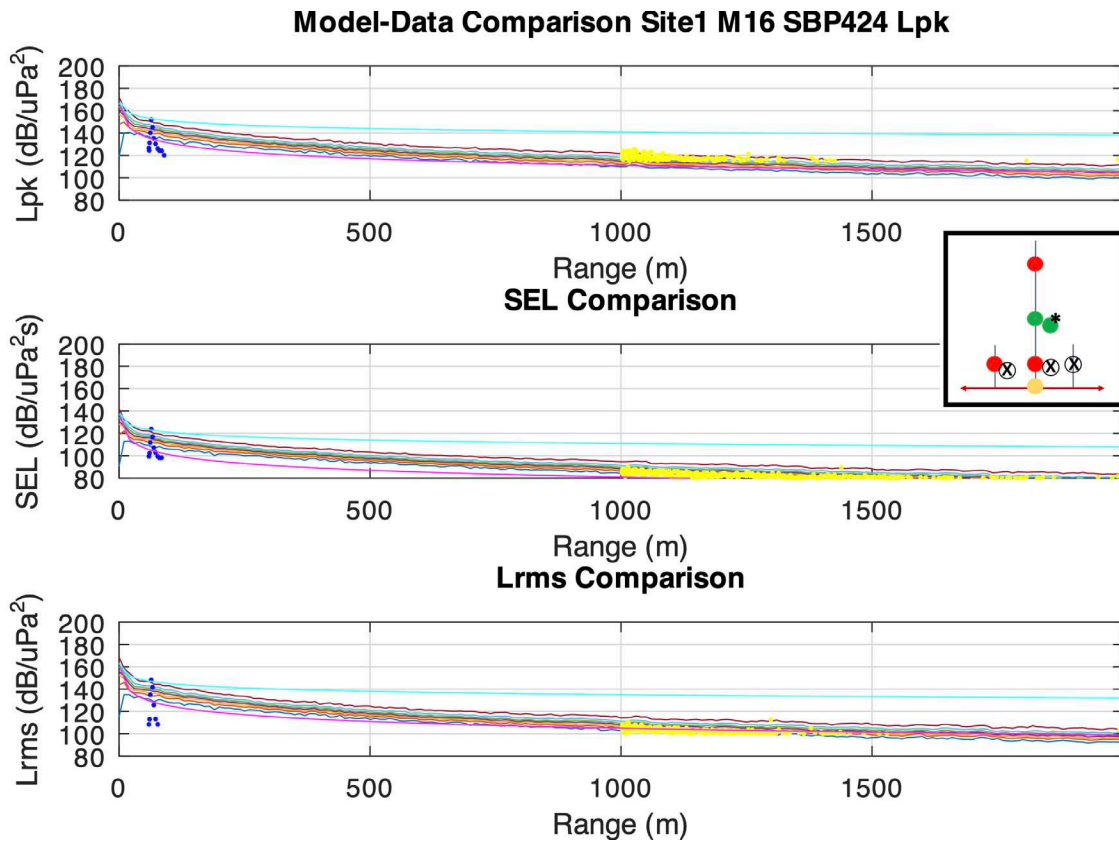
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Appendix B: Modeling Results (Mode 16 - 27)

B.17 Edgetech 424 3100P, 4 to 24 kHz, 100 Percent Power, 10-ms Pulse (Mode 16)

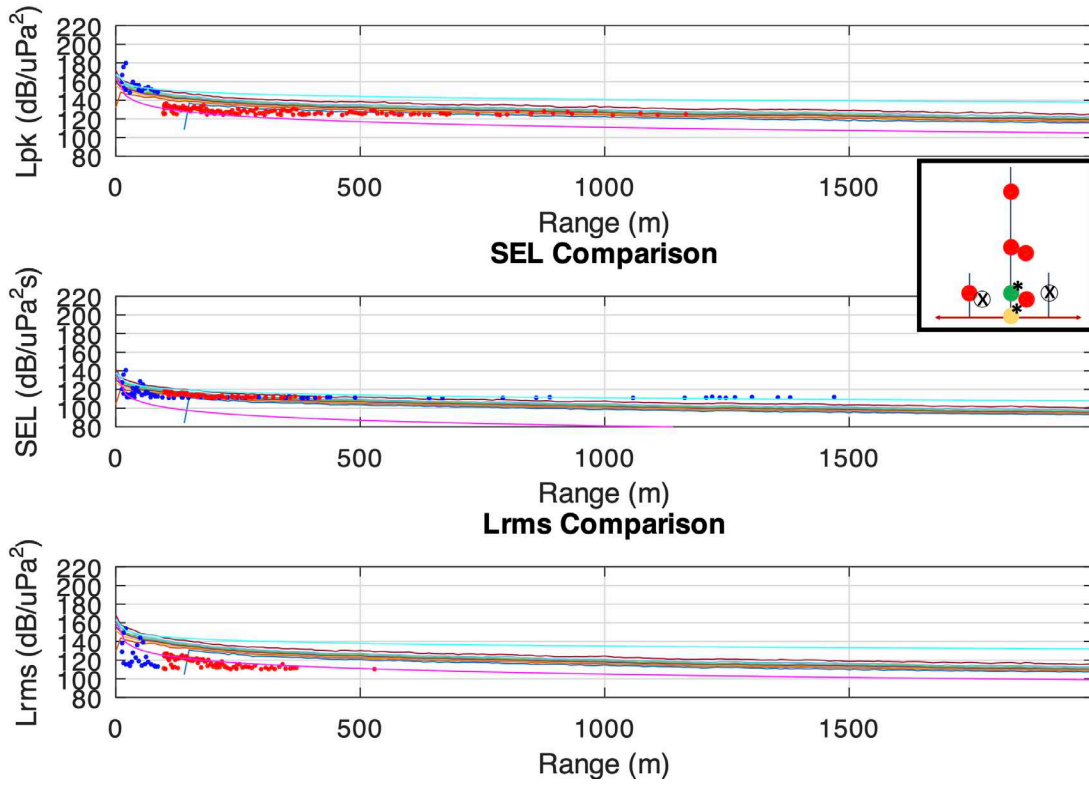
The Edgetech 424 is a mid-frequency (MF) source.

B.17.1 Site 1 – Mud, 10-m Depth



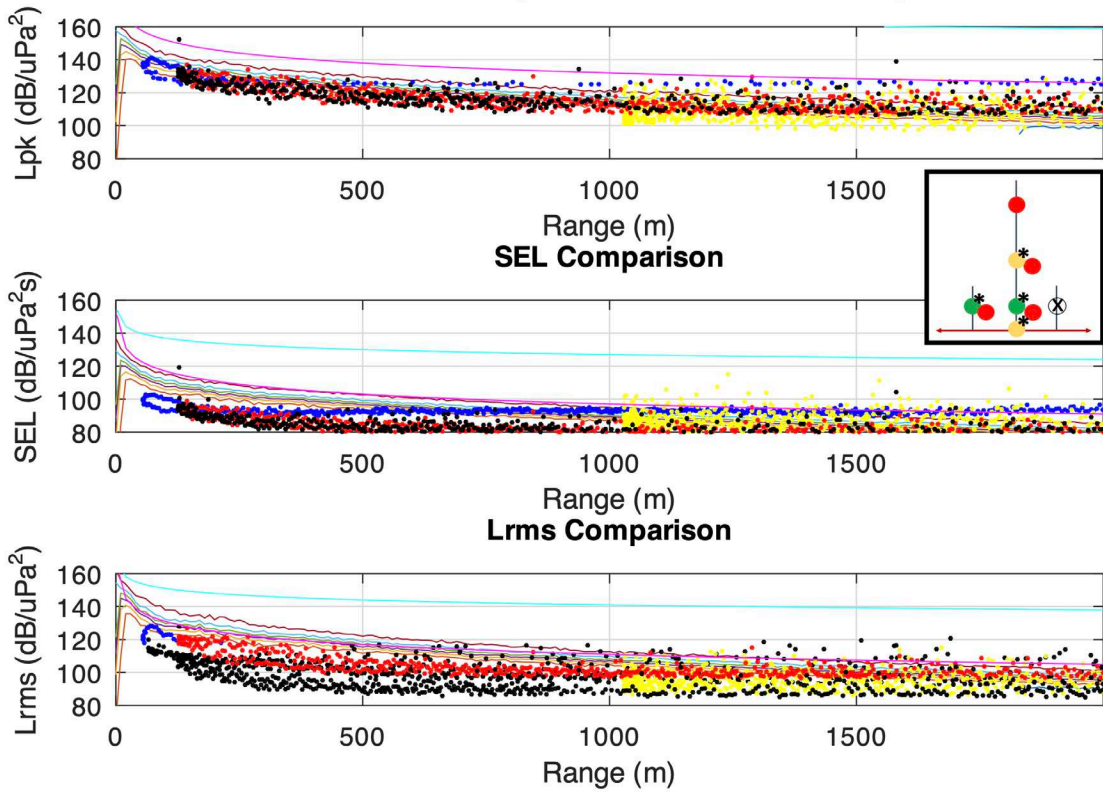
B.17.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M16 SBP424 Lpk

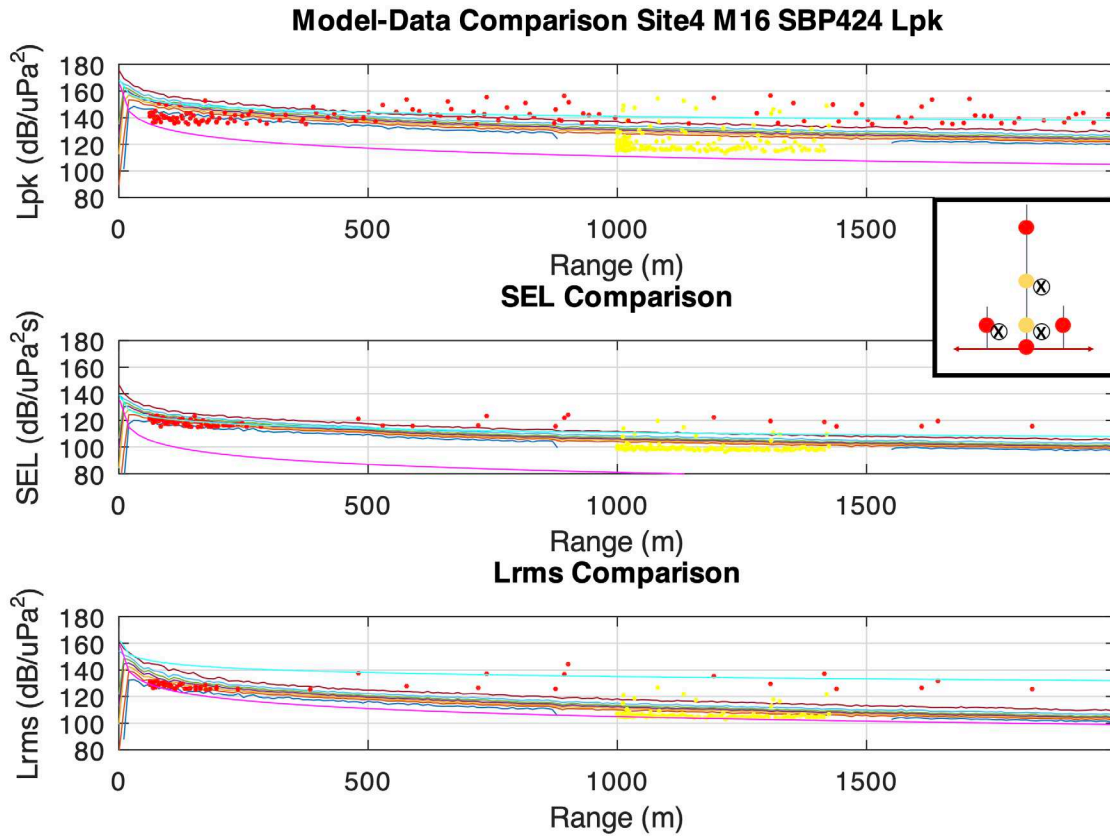


B.17.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M16 SBP424 Lpk



B.17.4 Site 4 – Sand, 30-m Depth



B.17.5 Site 5 – Sandy/Silt, 100-m Depth

There were no source tows.

B.18 Edgetech 424 3100P, 4 to 24 kHz, 100 Percent Power, 1-ms Pulse (Mode 17)

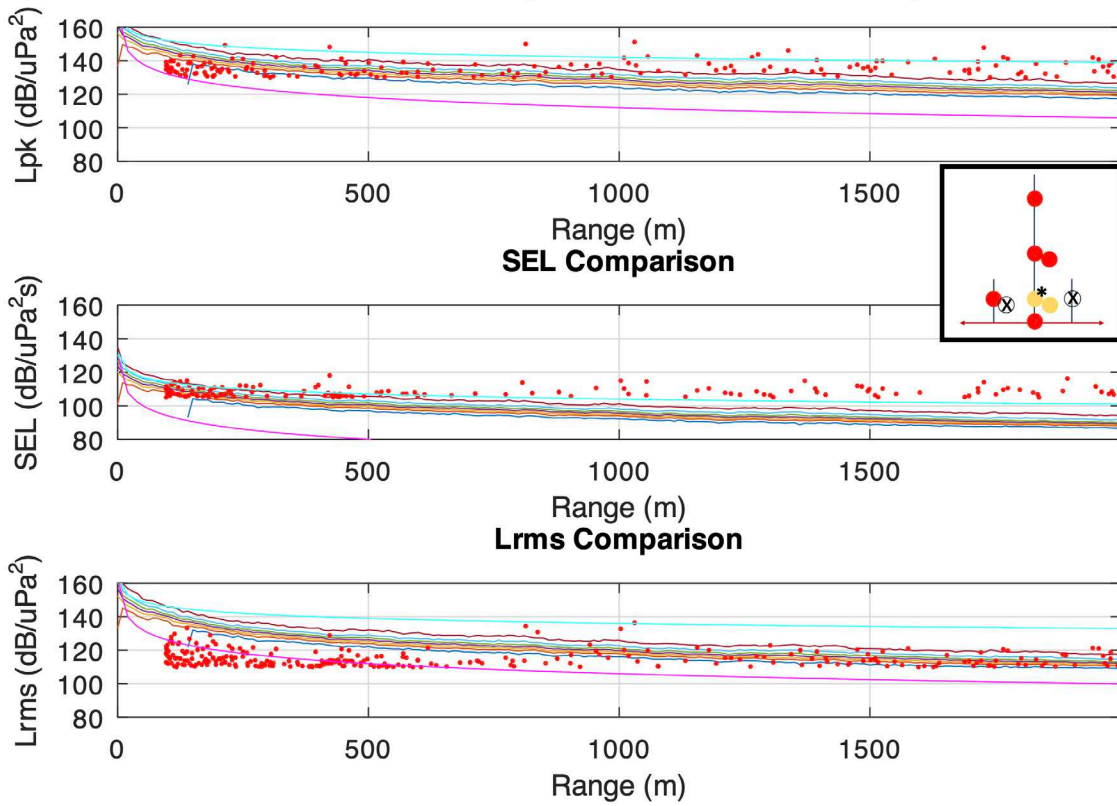
The Edgetech 424 is an MF source.

B.18.1 Site 1 – Mud, 10-m Depth

There were no source tows.

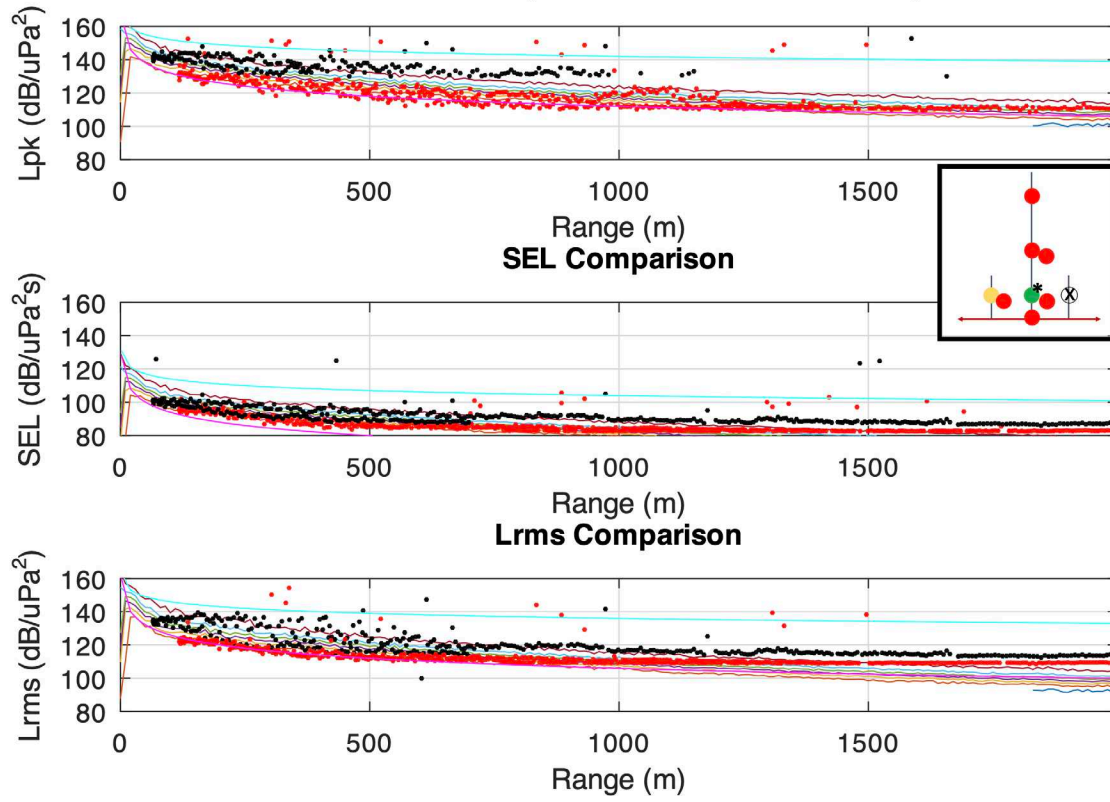
B.18.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M17 SBP424 Lpk

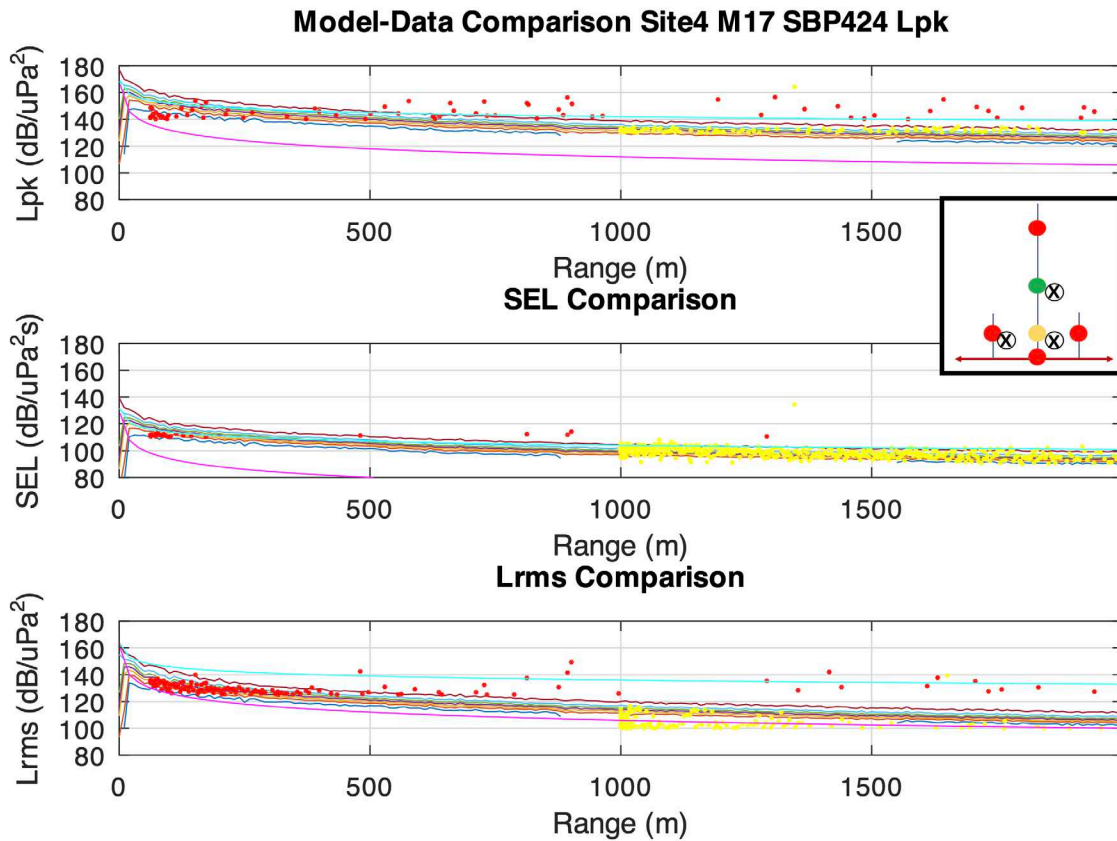


B.18.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M17 SBP424 Lpk



B.18.4 Site 4 – Sand, 30-m Depth



B.18.5 Site 5 – Sandy/Silt, 100-m Depth

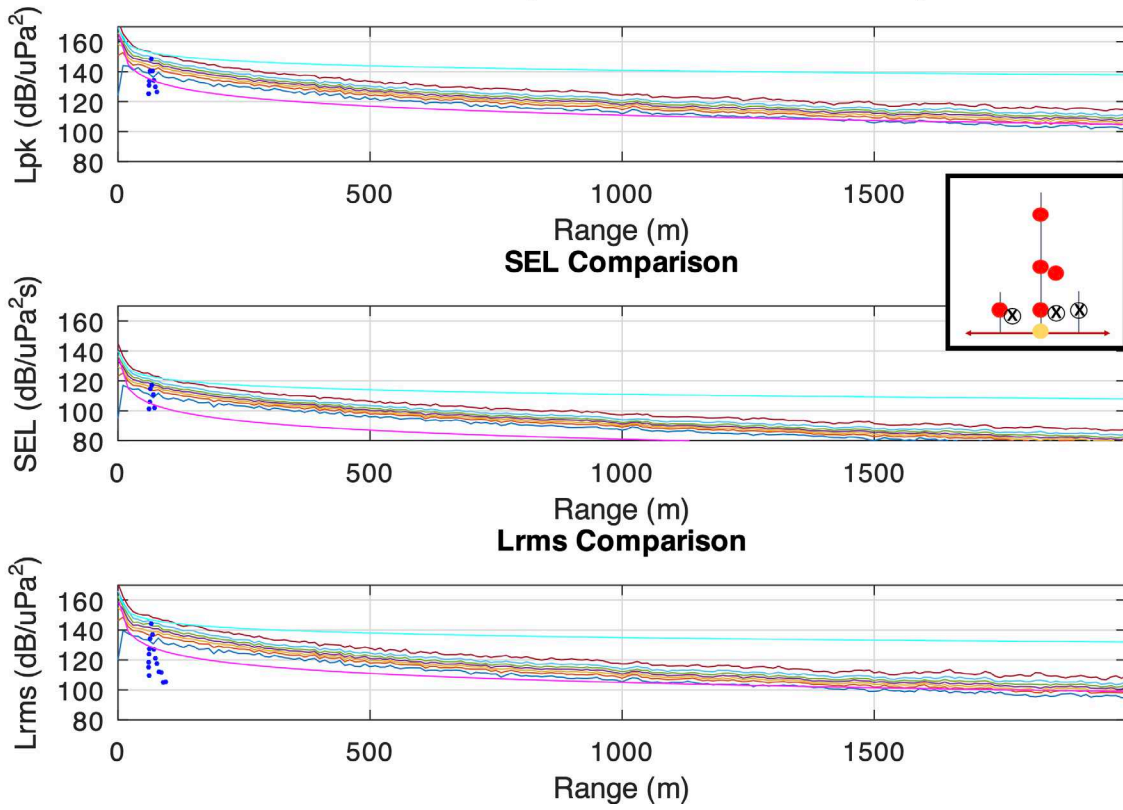
There were no source tows.

B.19 Edgetech 424 3200XS, 4 to 24 kHz, 100 Percent Power, 10-ms Pulse (Mode 18)

The Edgetech 424 is an MF source.

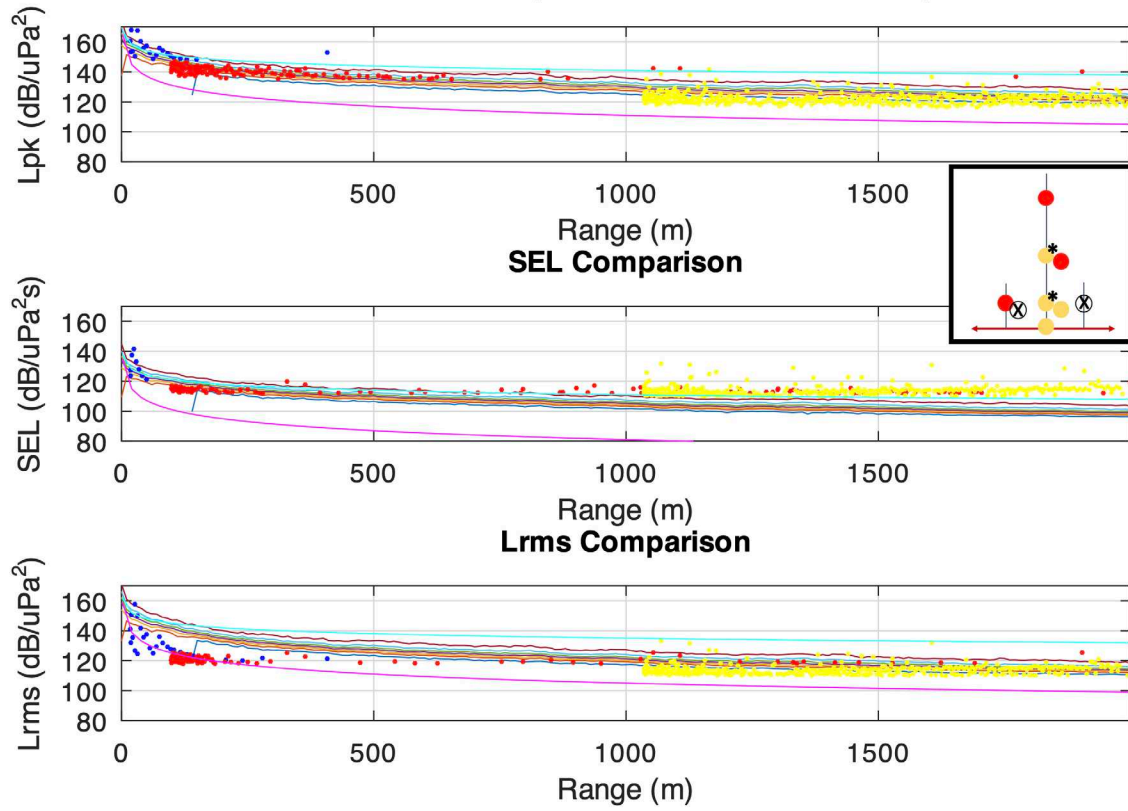
B.19.1 Site 1 – Mud, 10-m Depth

Model-Data Comparison Site1 M18 SBP424 Lpk



B.19.2 Site 2 – Sand, 10-m Depth

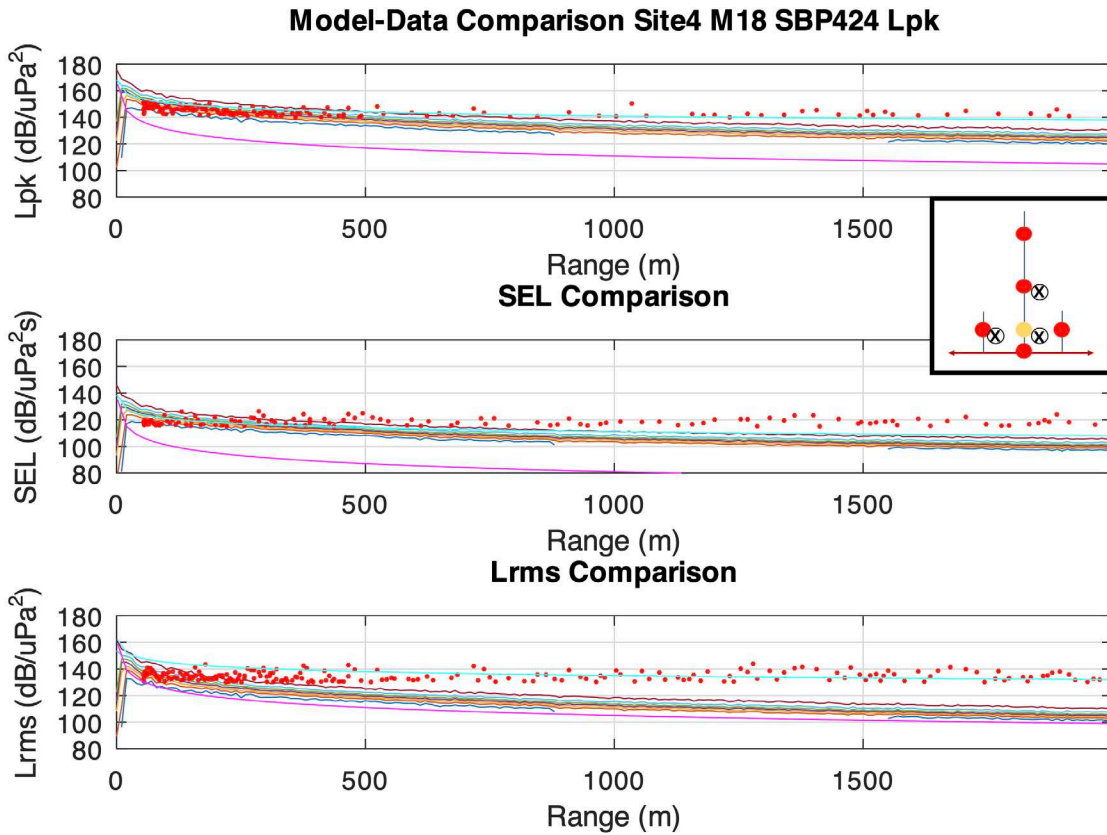
Model-Data Comparison Site2 M18 SBP424 Lpk



B.19.3 Site 3 – Mud, 30-m Depth

There were no source tows.

B.19.4 Site 4 – Sand, 30-m Depth



B.19.5 Site 5 – Sandy/Silt, 100-m Depth

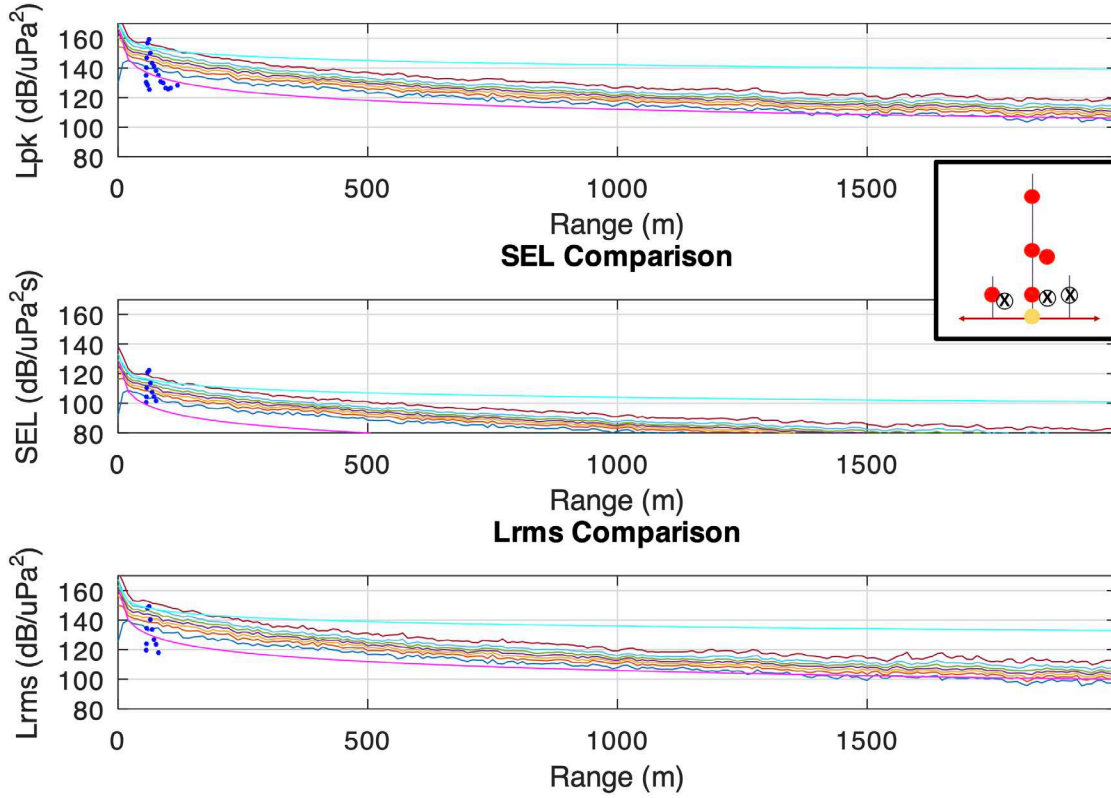
There were no source tows.

B.20 Edgetech 424 3200XS, 4 to 24 kHz, 100 Percent Power, 1-ms Pulse (Mode 19)

The Edgetech 424 is an MF source.

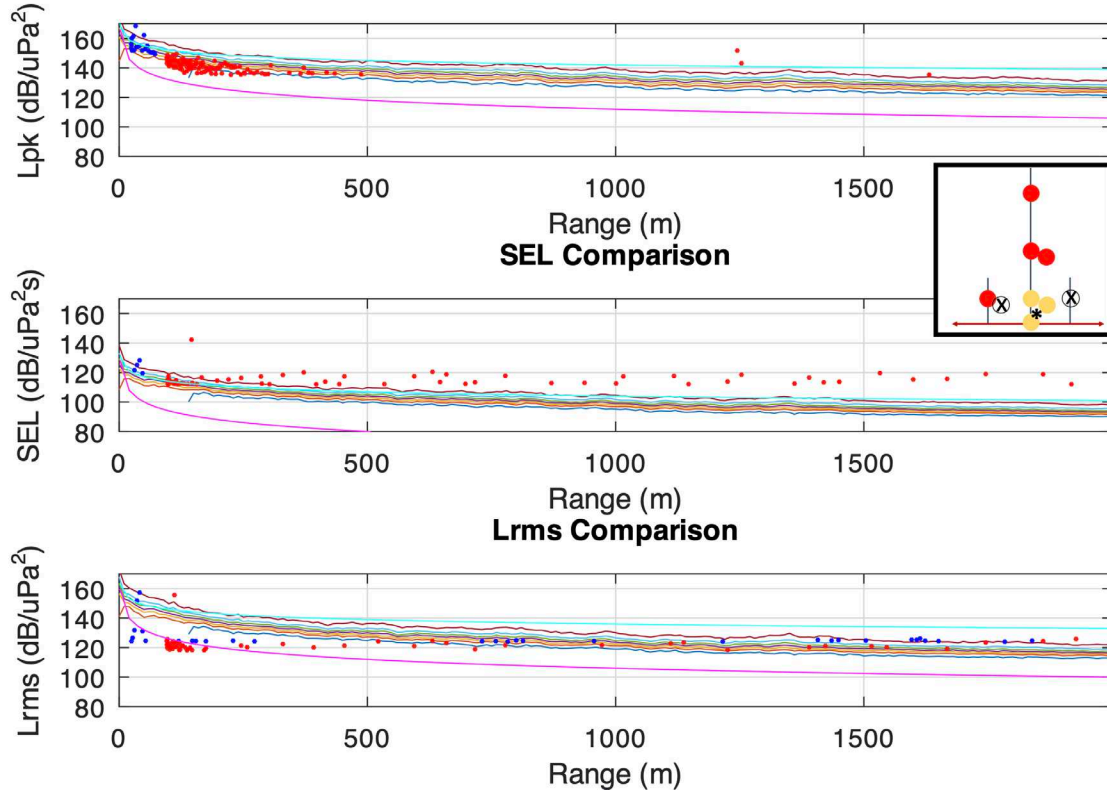
B.20.1 Site 1 – Mud, 10-m Depth

Model-Data Comparison Site1 M19 SBP424 Lpk



B.20.2 Site 2 – Sand, 10-m Depth

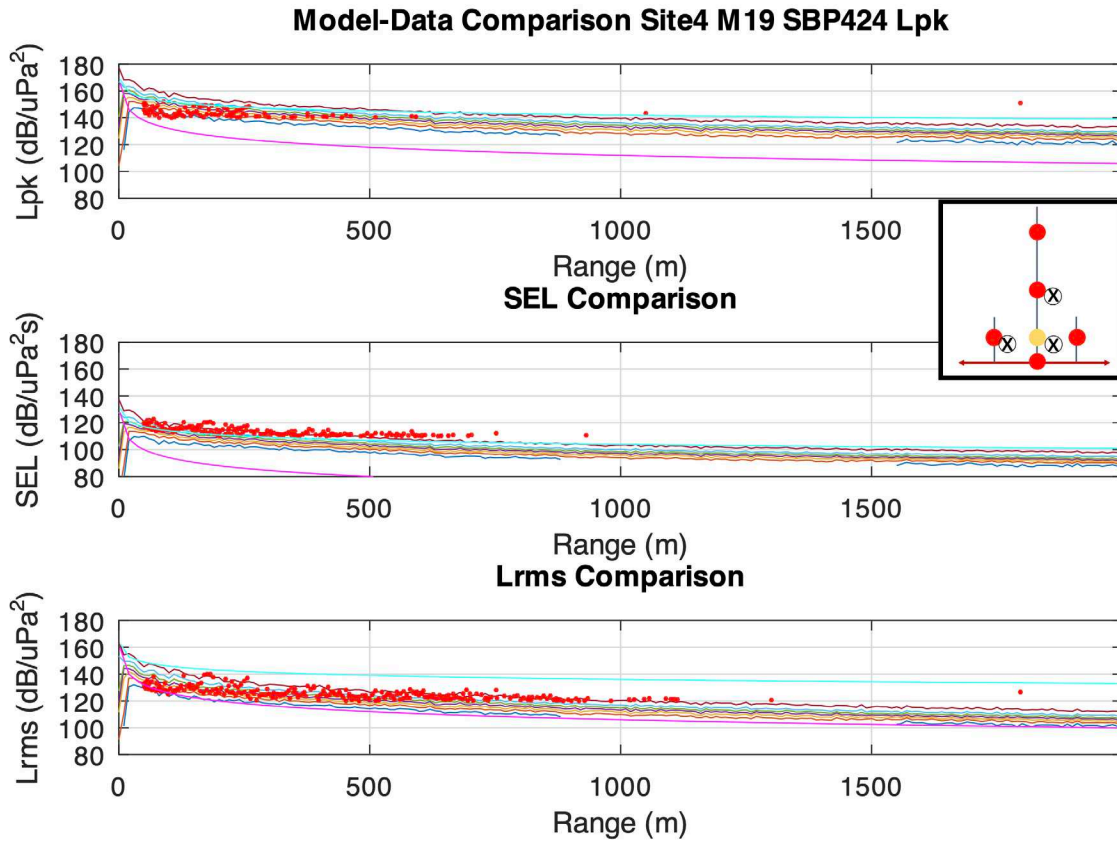
Model-Data Comparison Site2 M19 SBP424 Lpk



B.20.3 Site 3 – Mud, 30-m Depth

There were no source tows.

B.20.4 Site 4 – Sand, 30-m Depth



B.20.5 Site 5 – Sandy/Silt, 100-m Depth

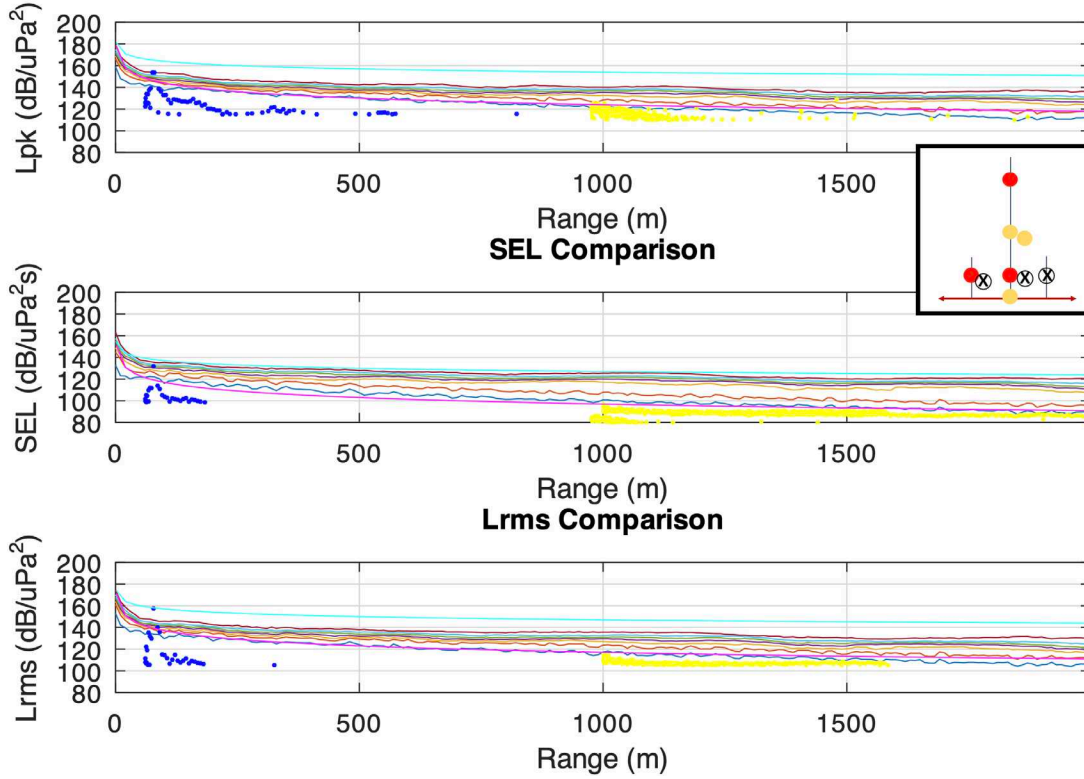
There were no source tows.

B.21 Edgetech 512i, 0.5 to 7.2 kHz, 100 Percent Power, 30-ms Pulse (Mode 20)

The Edgetech 512i is an MF source.

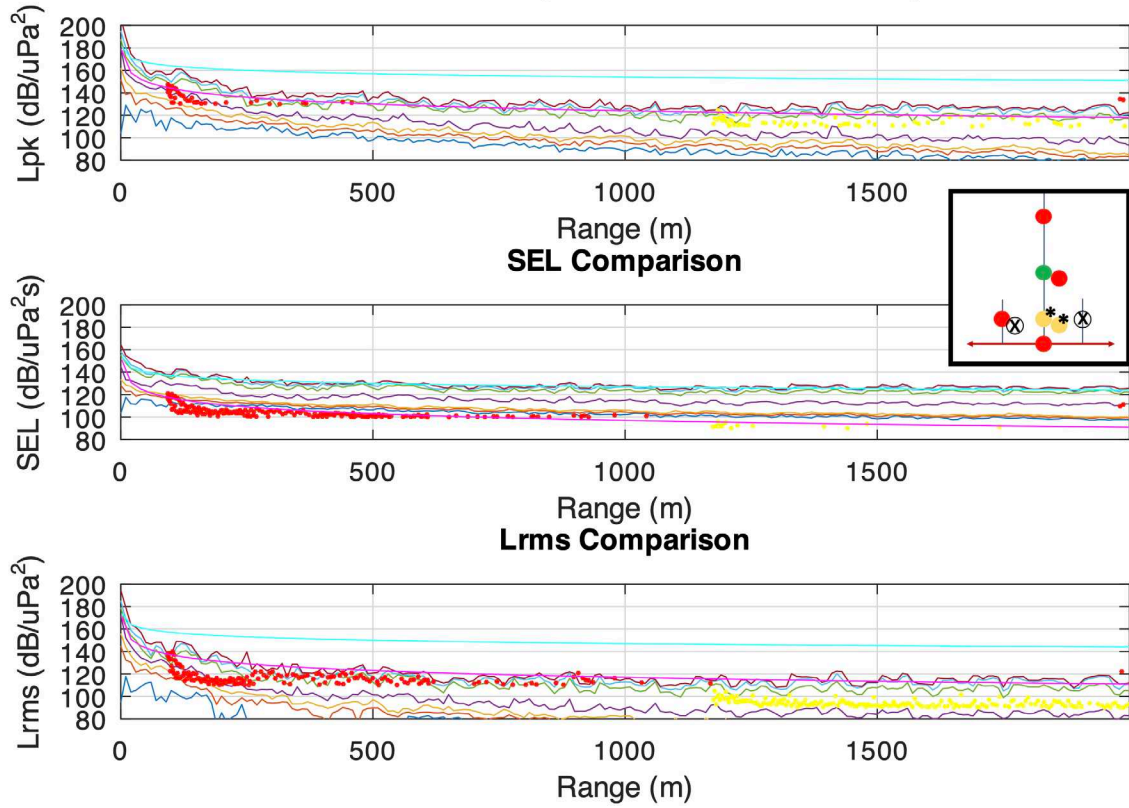
B.21.1 Site 1 – Mud, 10-m Depth

Model-Data Comparison Site1 M20 ET512 Lpk



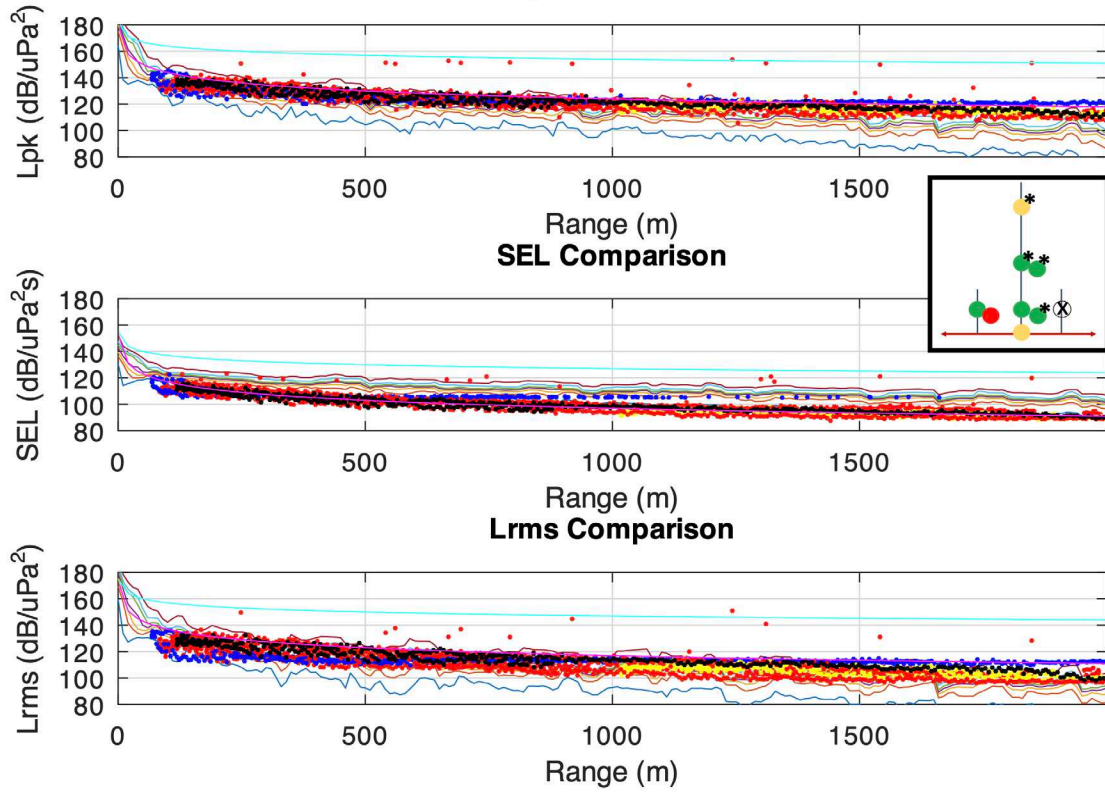
B.21.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M20 ET512 Lpk



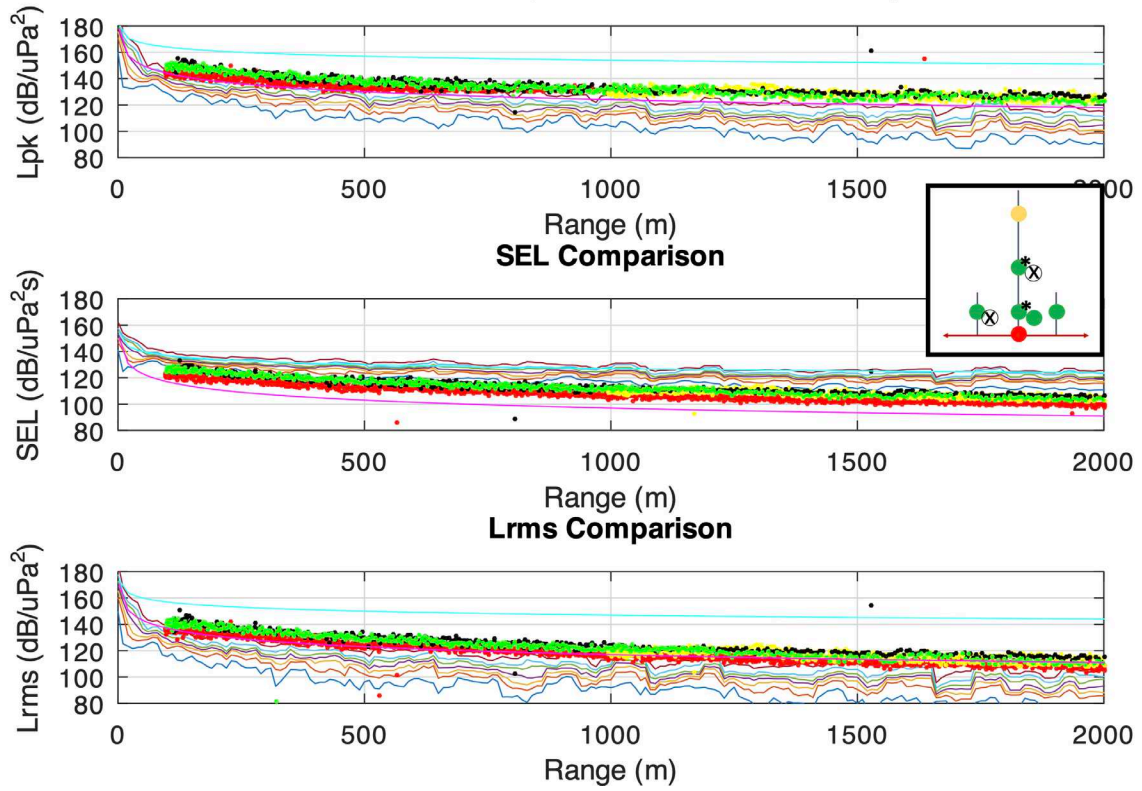
B.21.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M20 ET512 Lpk



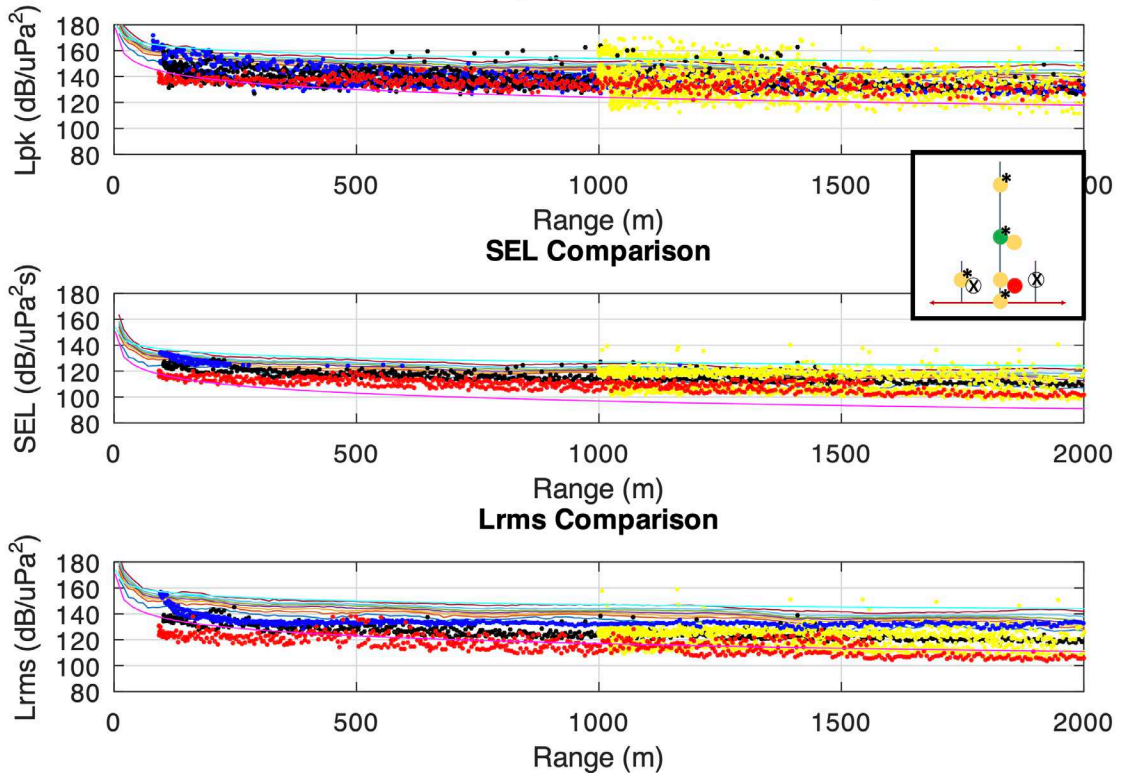
B.21.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M20 ET512 Lpk



B.21.5 Site 5 – Sandy/Silt, 100-m Depth

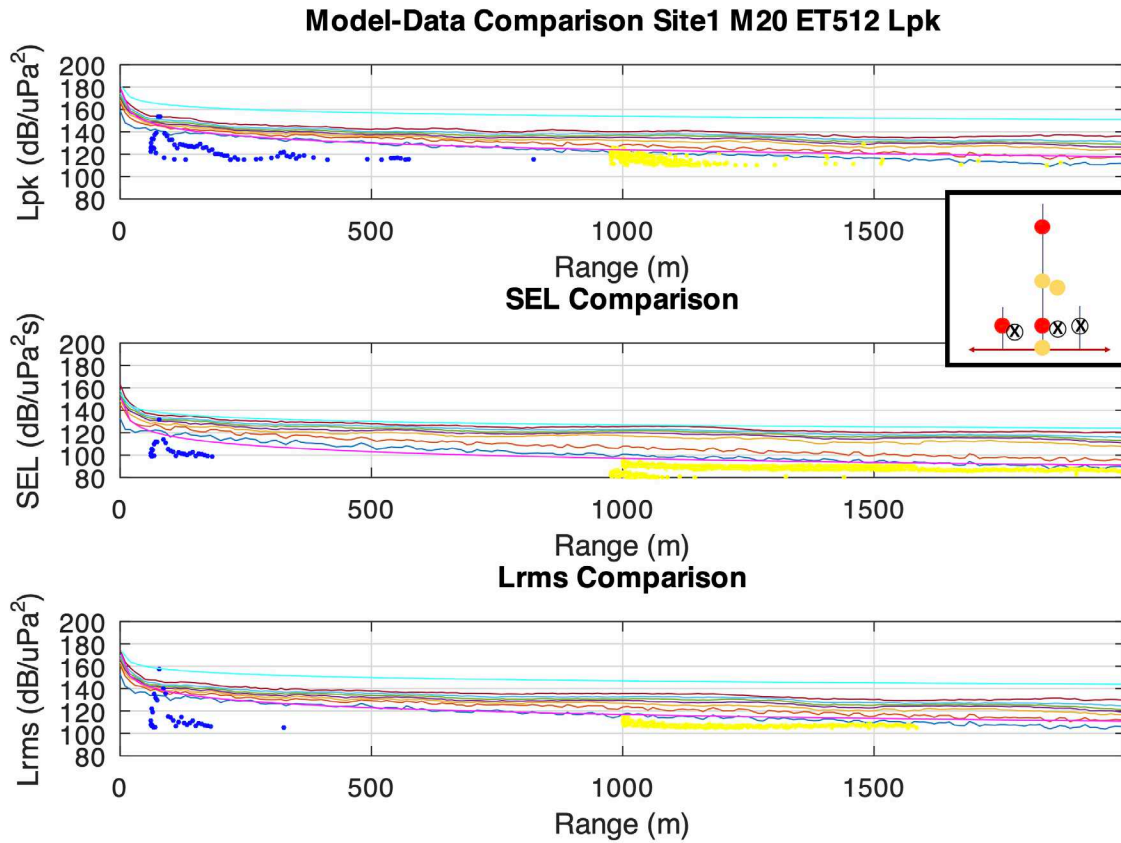
Model-Data Comparison Site5 M20 ET512 Lpk



B.22 Edgetech 512i, 2 to 12 kHz, 100 Percent Power, 20-ms Pulse (Mode 21)

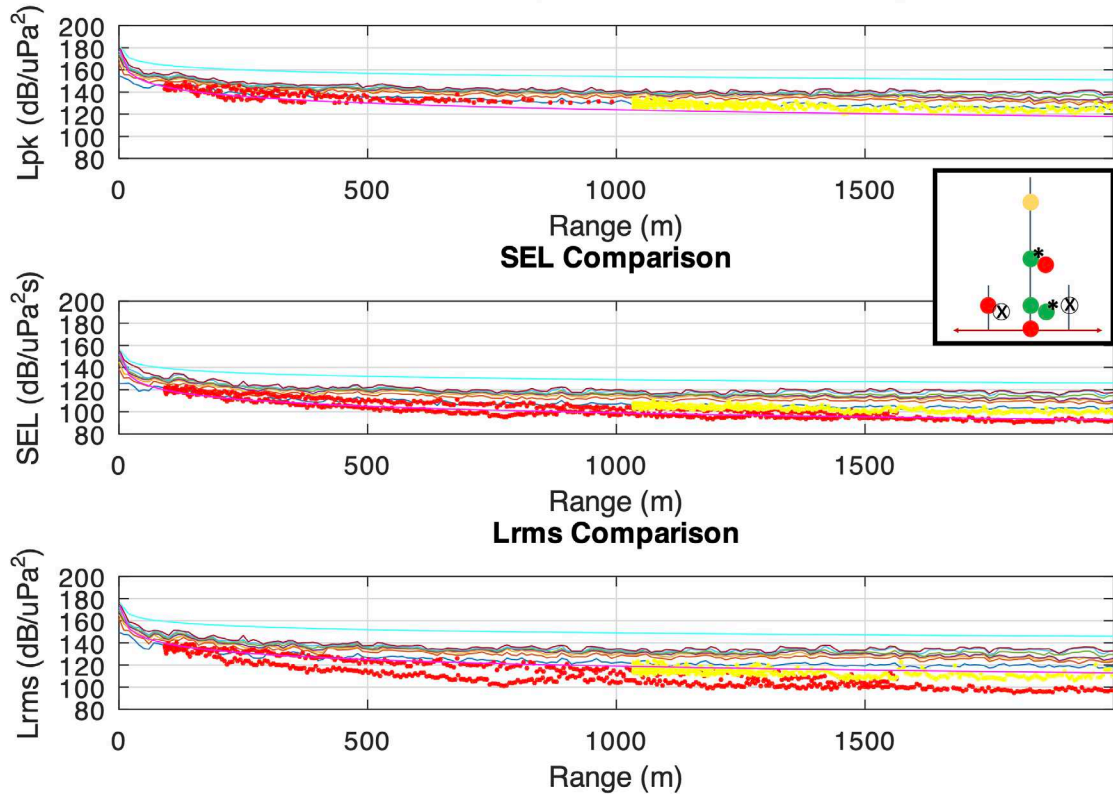
The Edgetech 512i is an MF source.

B.22.1 Site 1 – Mud, 10-m Depth



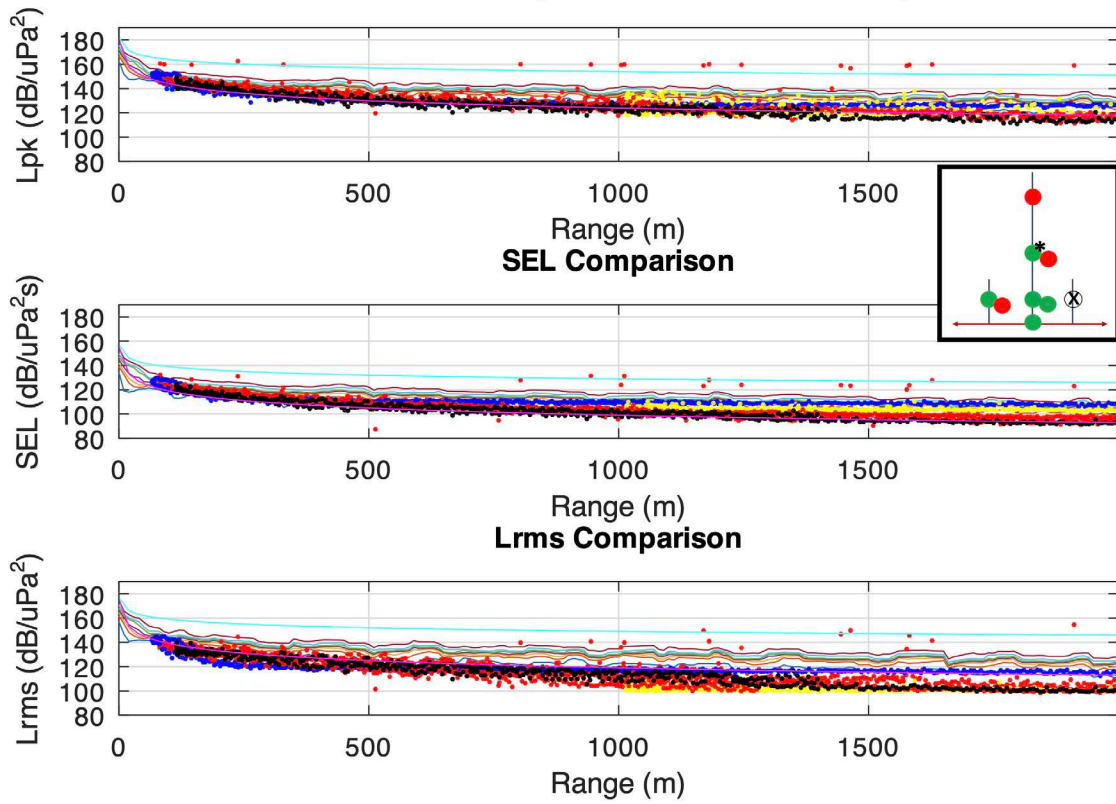
B.22.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M21 ET512 Lpk



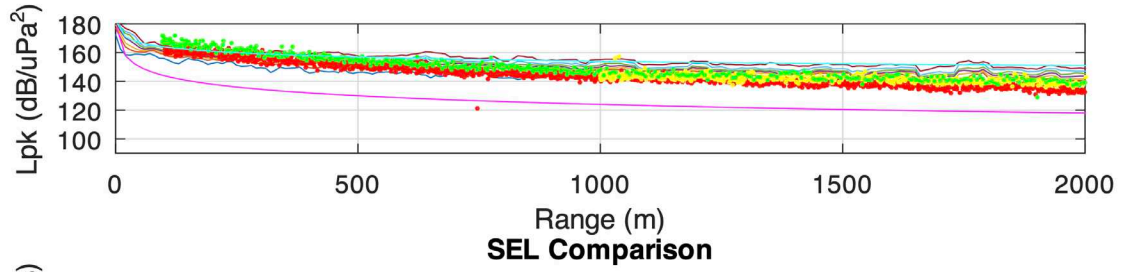
B.22.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M21 ET512 Lpk

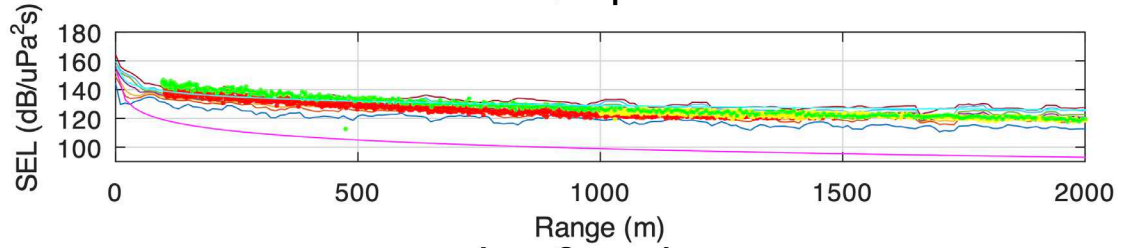


B.22.4 Site 4 – Sand, 30-m Depth

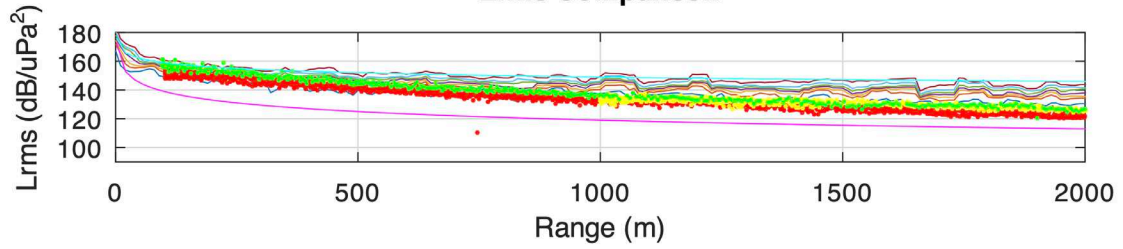
Model-Data Comparison Site4 M21 ET512 Lpk



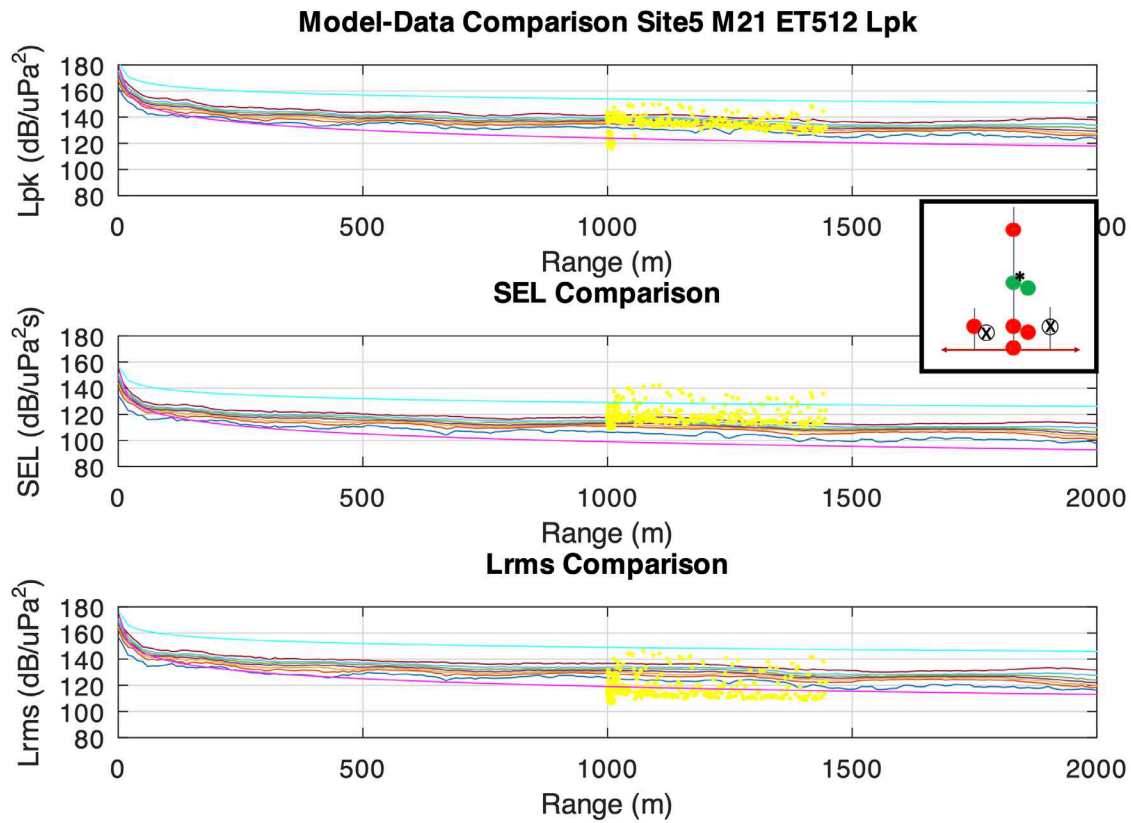
SEL Comparison



Lrms Comparison



B.22.5 Site 5 – Sandy/Silt, 100-m Depth



B.23 Edgetech 512i, 0.5 to 8 kHz, 100 Percent Power, 5-ms Pulse (Mode 22)

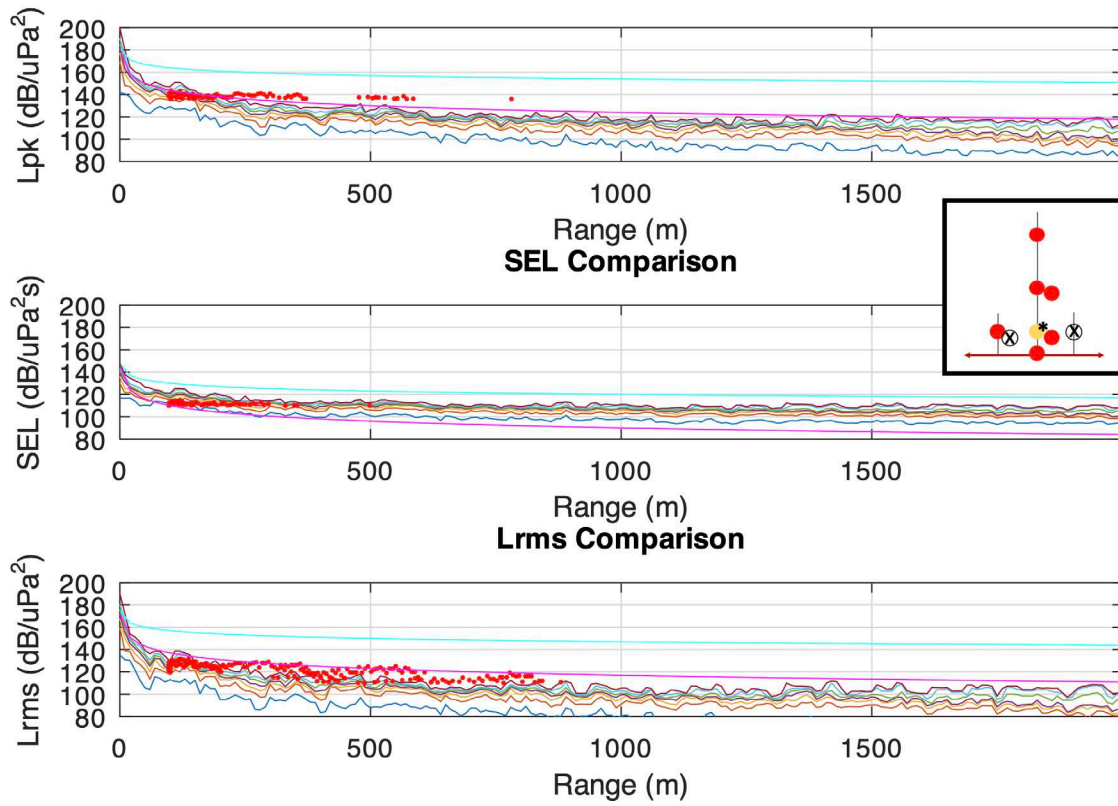
The Edgetech 512i is an MF source.

B.23.1 Site 1 – Mud, 10-m Depth

There were no source tows.

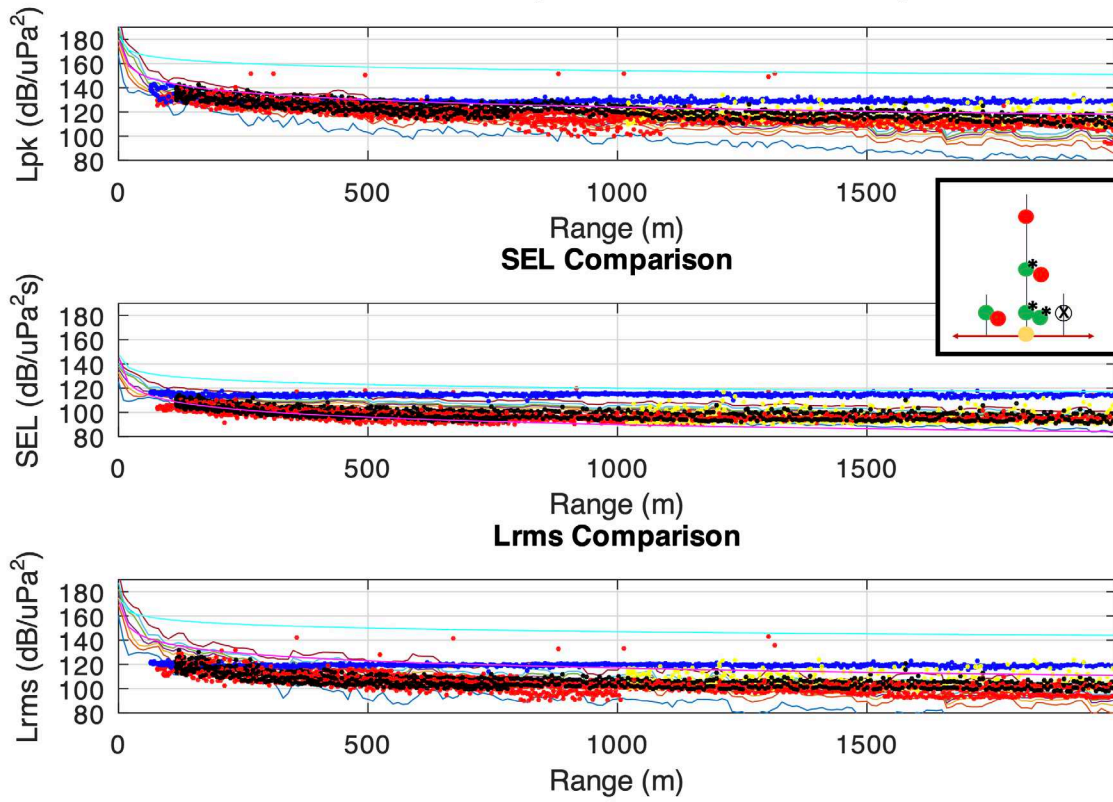
B.23.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M22 ET512 Lpk



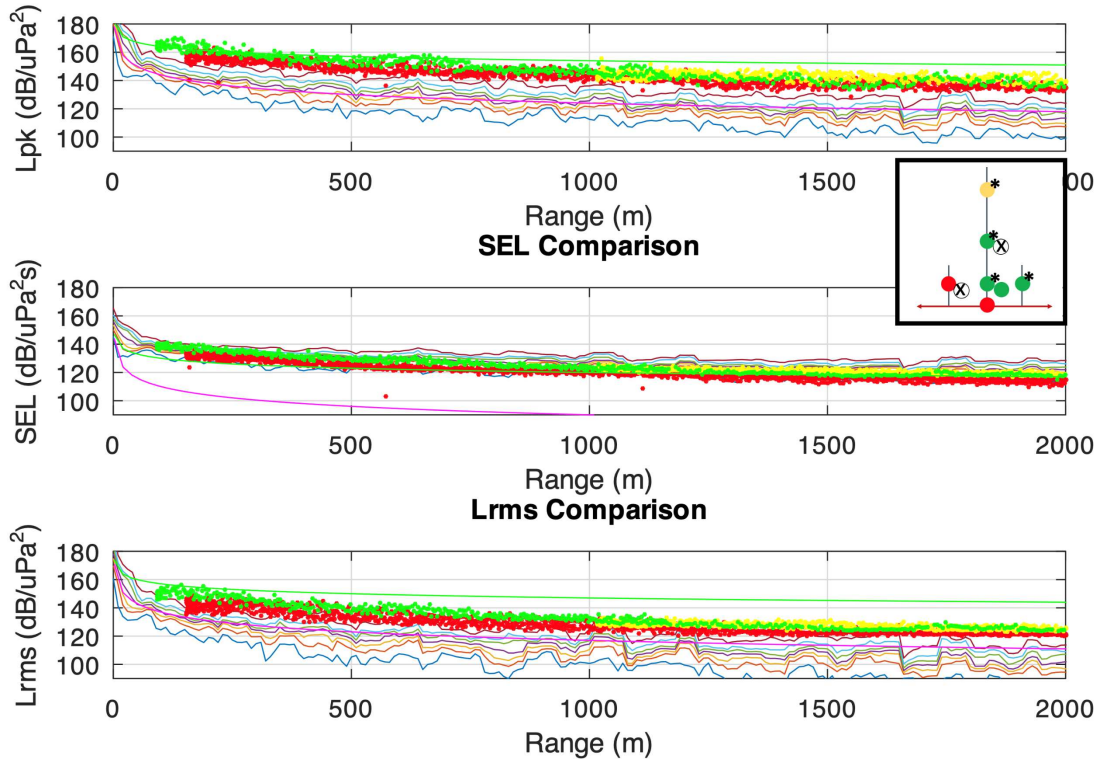
B.23.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M22 ET512 Lpk

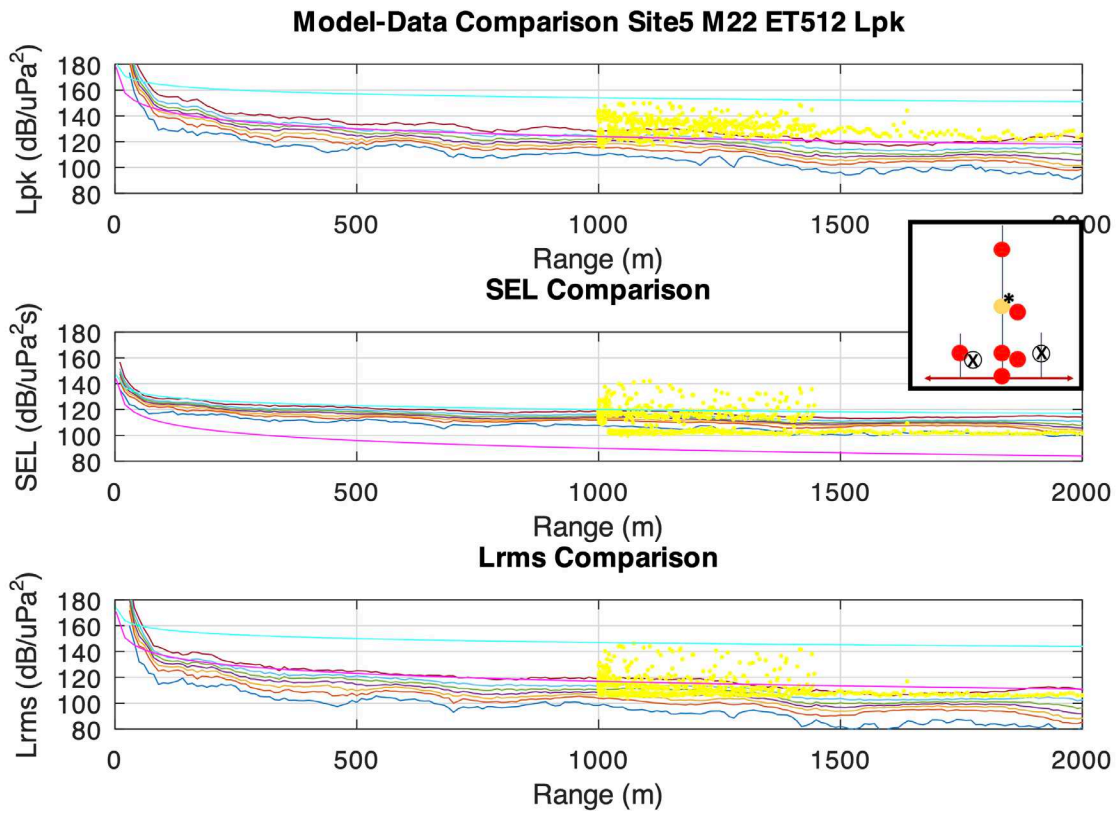


B.23.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M22 ET512 Lpk



B.23.5 Site 5 – Sandy/Silt, 100-m Depth

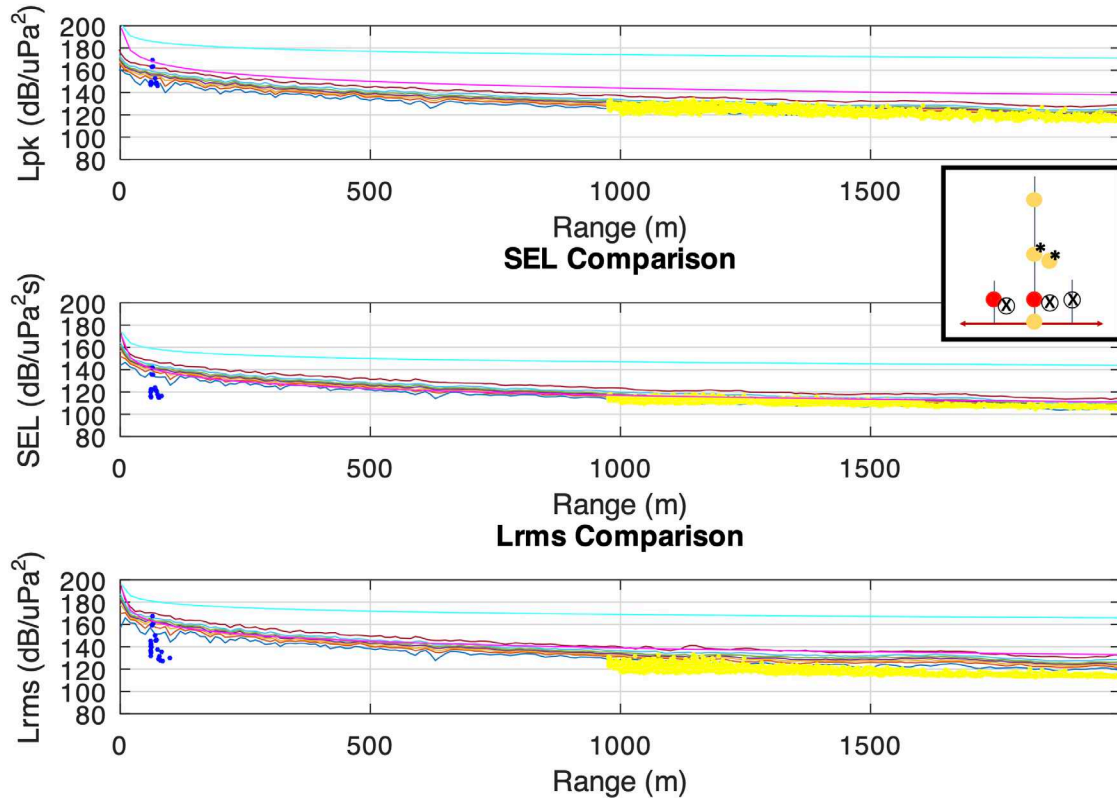


B.24 Knudsen 3260, 3.3 to 5.6 kHz, Power Level 1, 8-ms Pulse (Mode 23)

The Knudsen 3260 is an MF source.

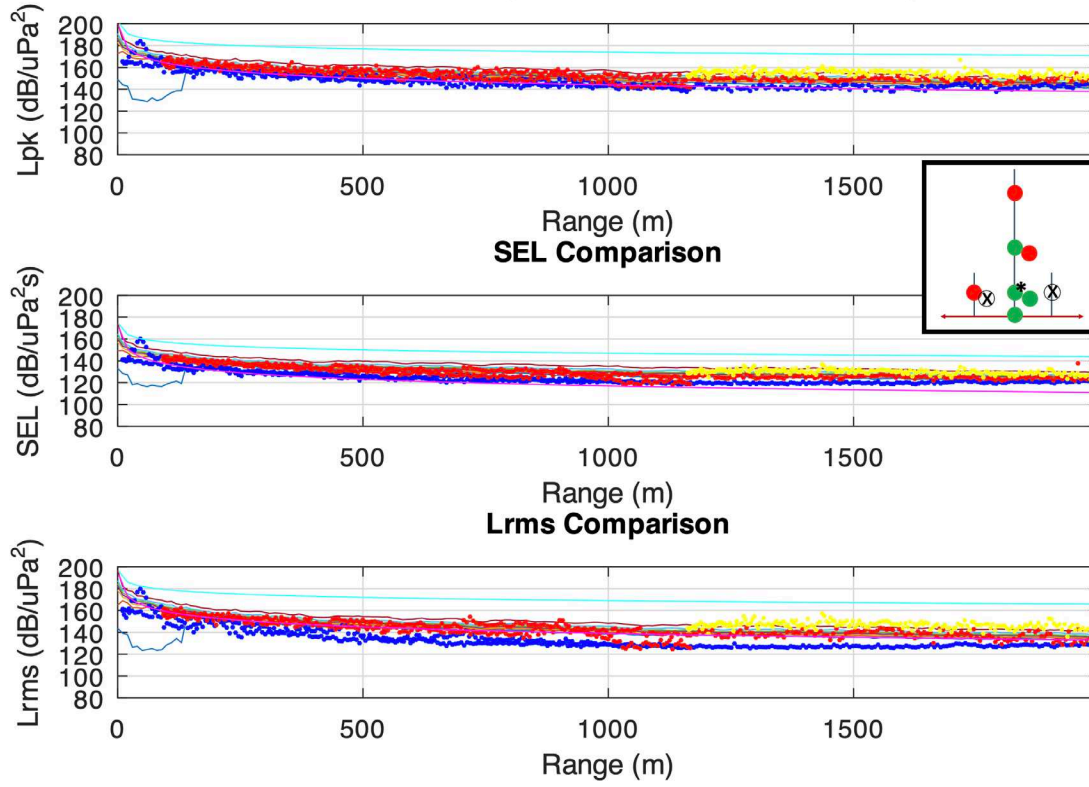
B.24.1 Site 1 – Mud, 10-m Depth

Model-Data Comparison Site1 M23 Knudsen Lpk

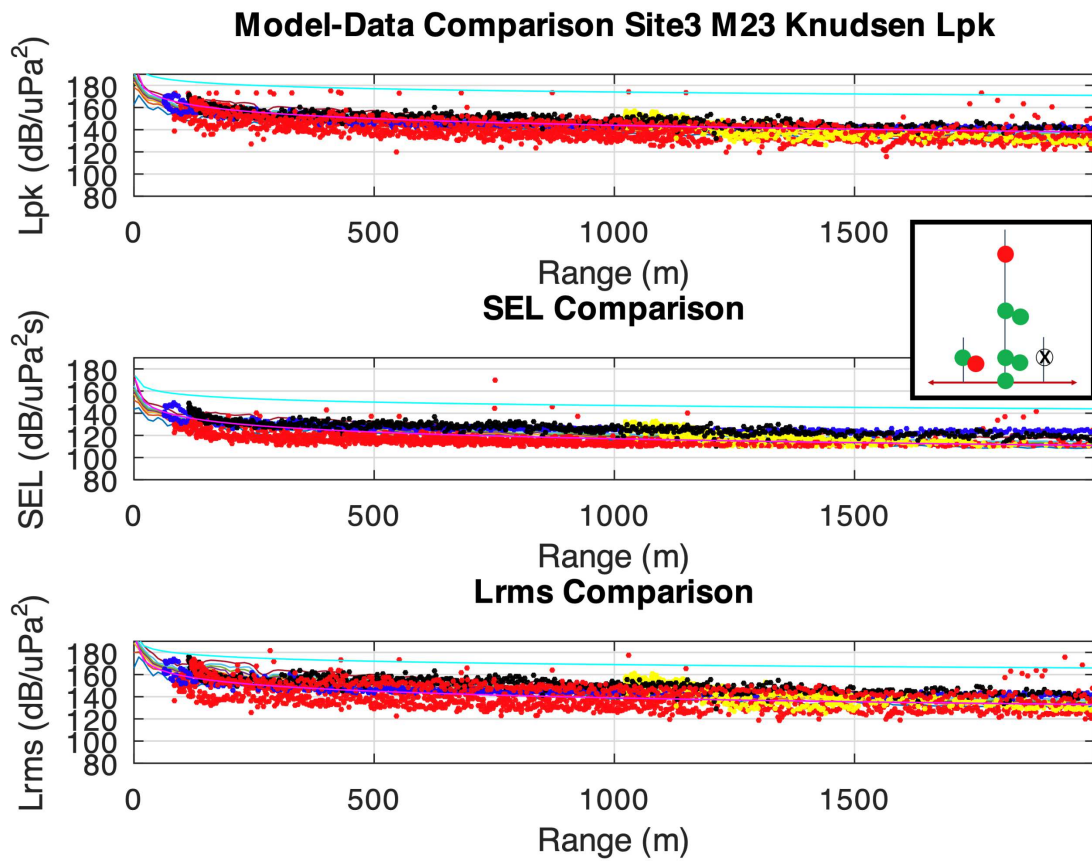


B.24.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M23 Knudsen Lpk

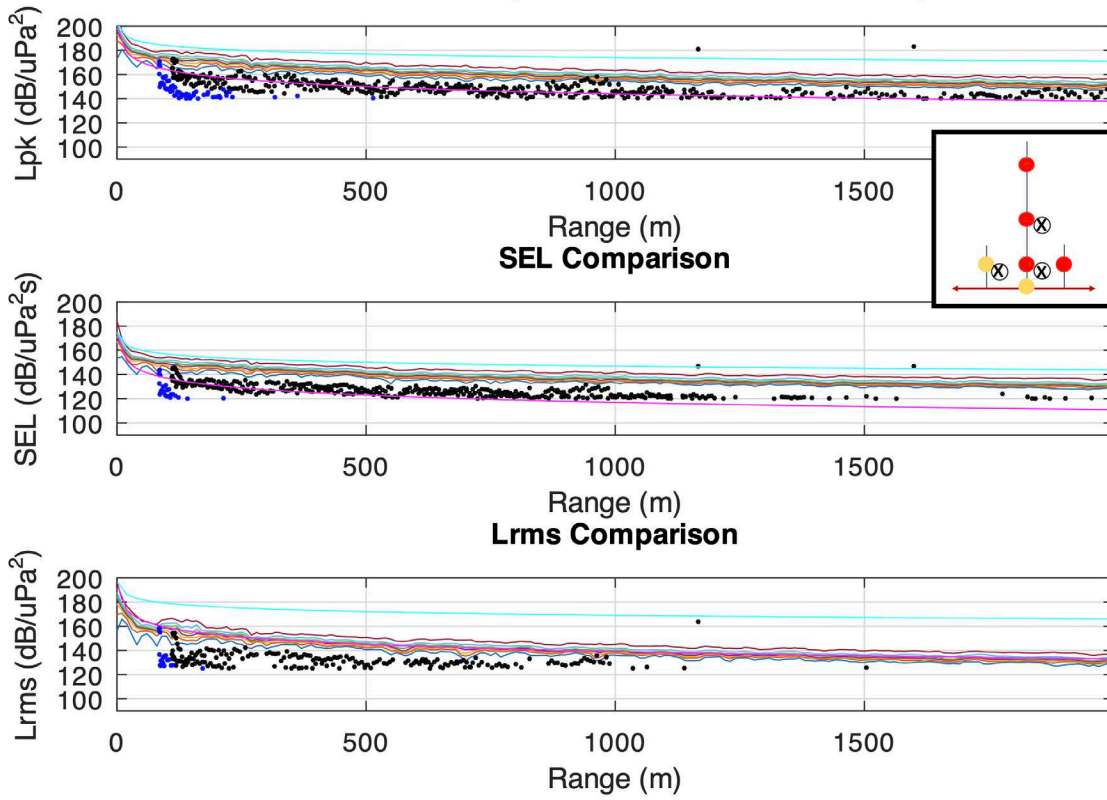


B.24.3 Site 3 – Mud, 30-m Depth

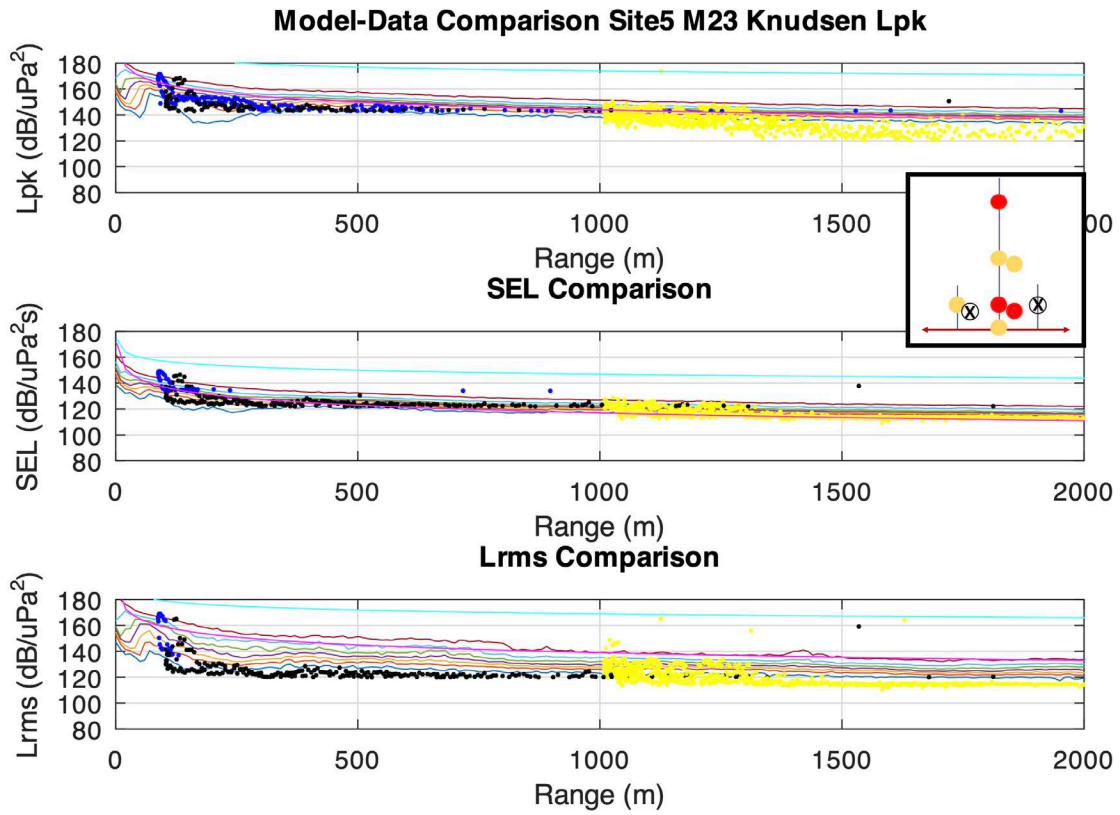


B.24.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M23 Knudsen Lpk



B.24.5 Site 5 – Sandy/Silt, 100-m Depth

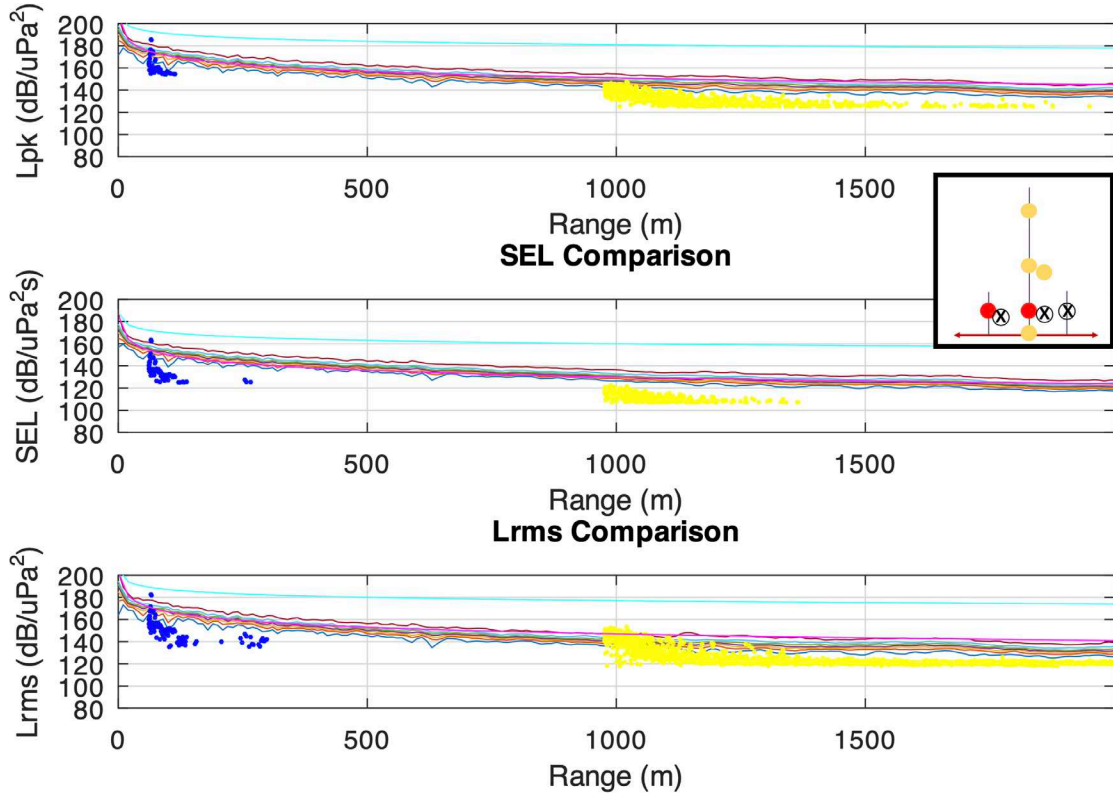


B.25 Knudsen 3260, 3.3 to 5.6 kHz, Power Level 1, 32-ms Pulse (Mode 24)

The Knudsen 3260 is an MF source.

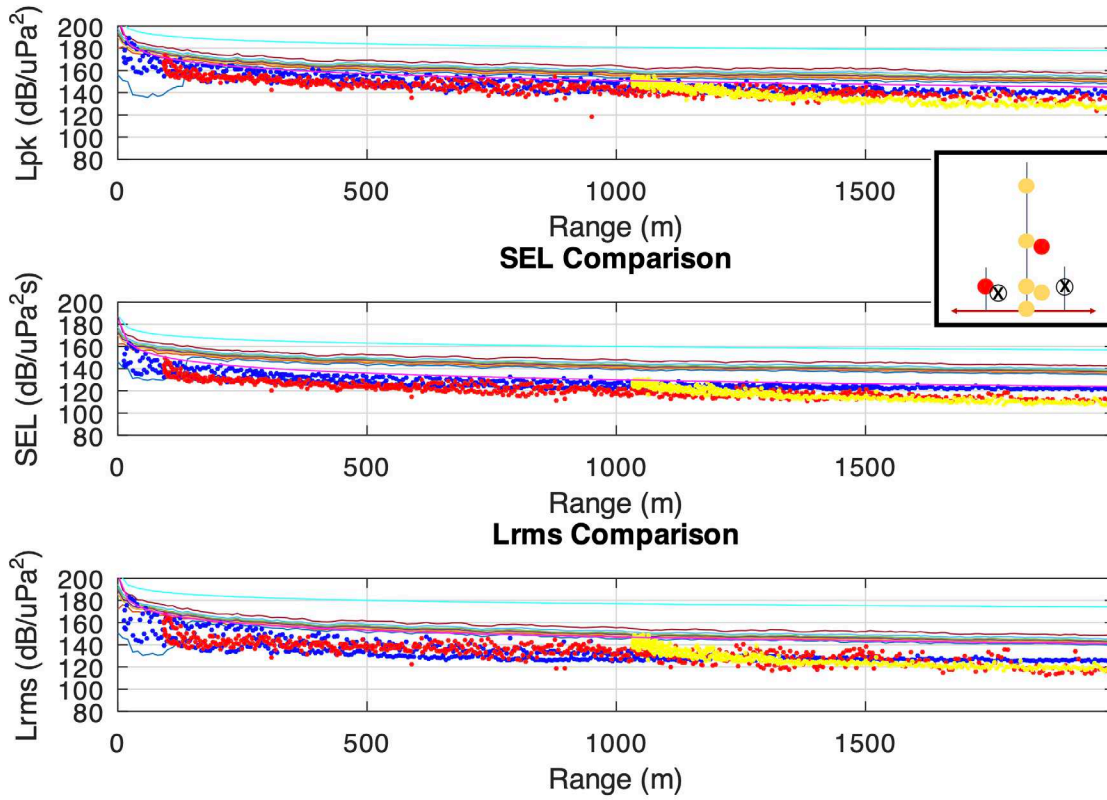
B.25.1 Site 1 – Mud, 10-m Depth

Model-Data Comparison Site1 M24 Knudsen Lpk

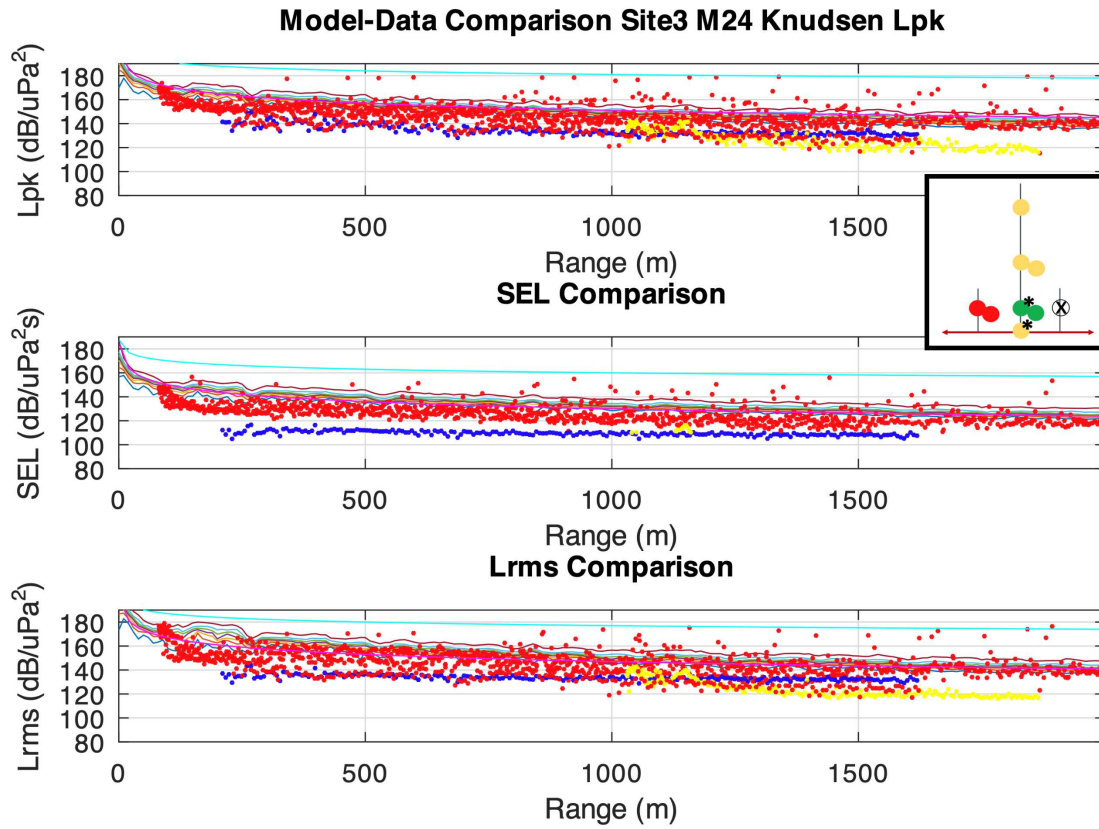


B.25.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M24 Knudsen Lpk



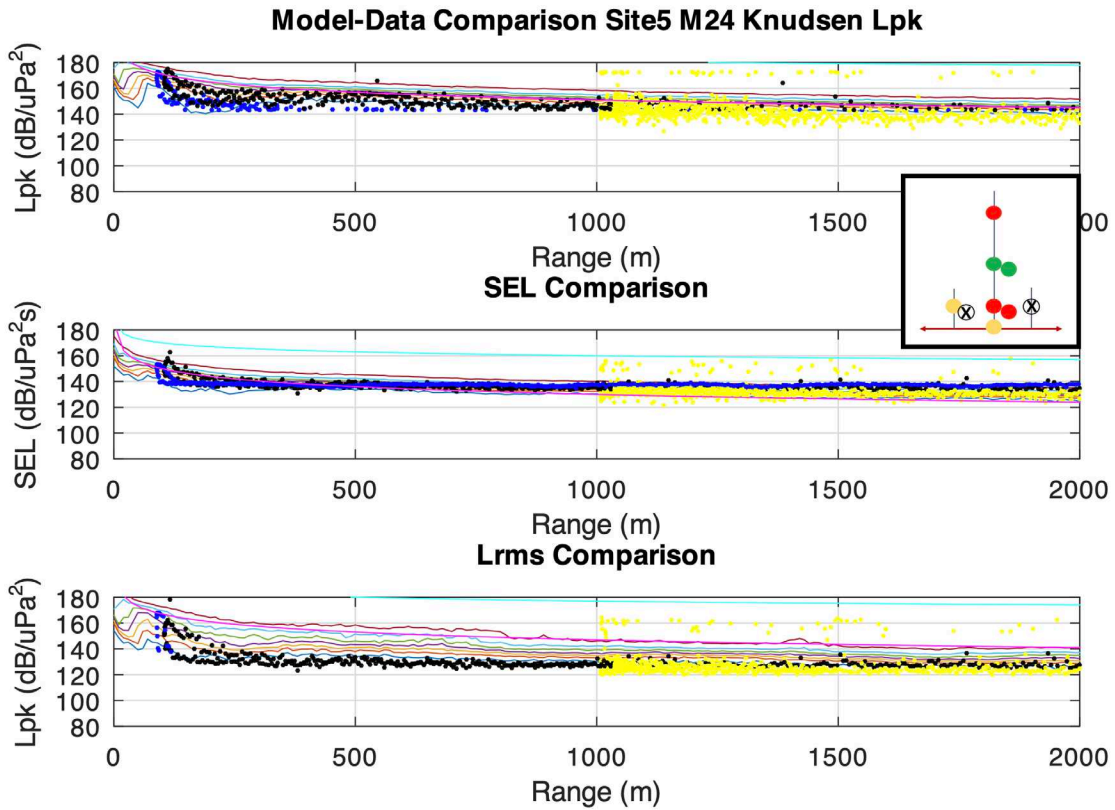
B.25.3 Site 3 – Mud, 30-m Depth



B.25.4 Site 4 – Sand, 30-m Depth

There were no source tows.

B.25.5 Site 5 – Sandy/Silt, 100-m Depth



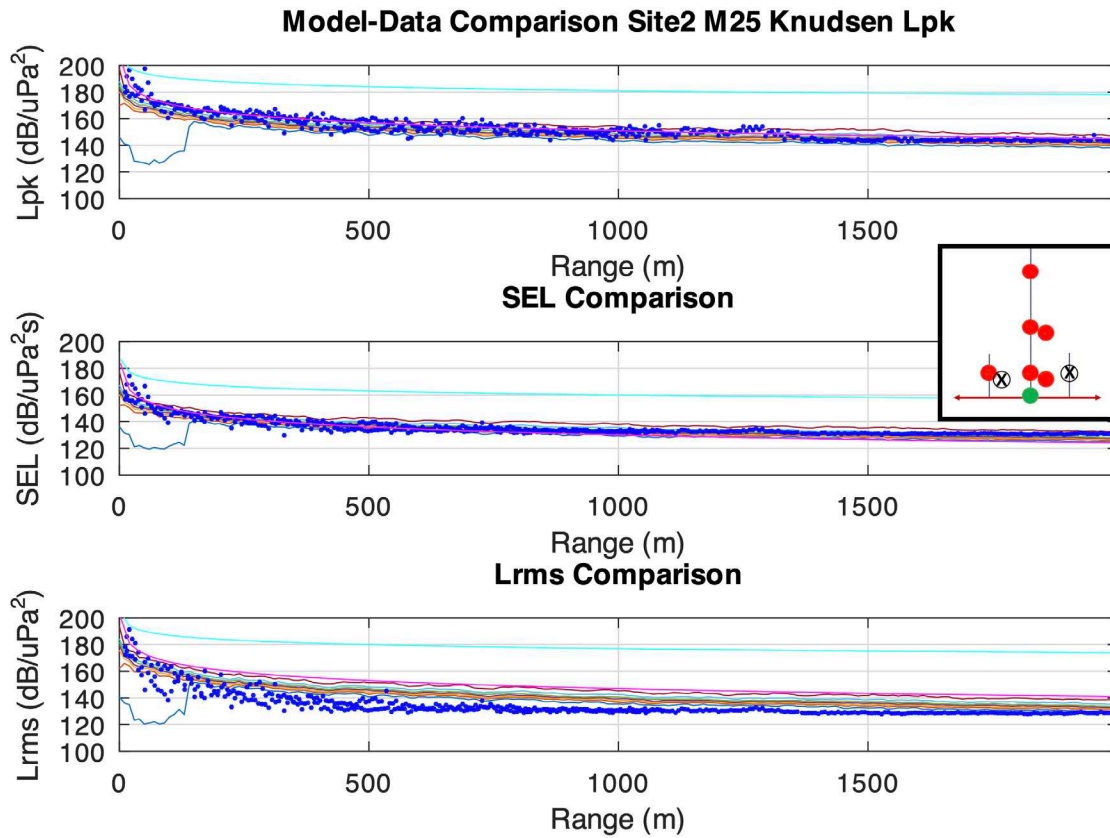
B.26 Knudsen 3260, 3.3 to 5.6 kHz, Power Level 1, 64-ms Pulse (Mode 25)

The Knudsen 3260 is an MF source.

B.26.1 Site 1 – Mud, 10-m Depth

There were no source tows.

B.26.2 Site 2 – Sand, 10-m Depth



B.26.3 Site 3 – Mud, 30-m Depth

There were no source tows.

B.26.4 Site 4 – Sand, 30-m Depth

There were no source tows.

B.26.5 Site 5 – Sandy/Silt, 100-m Depth

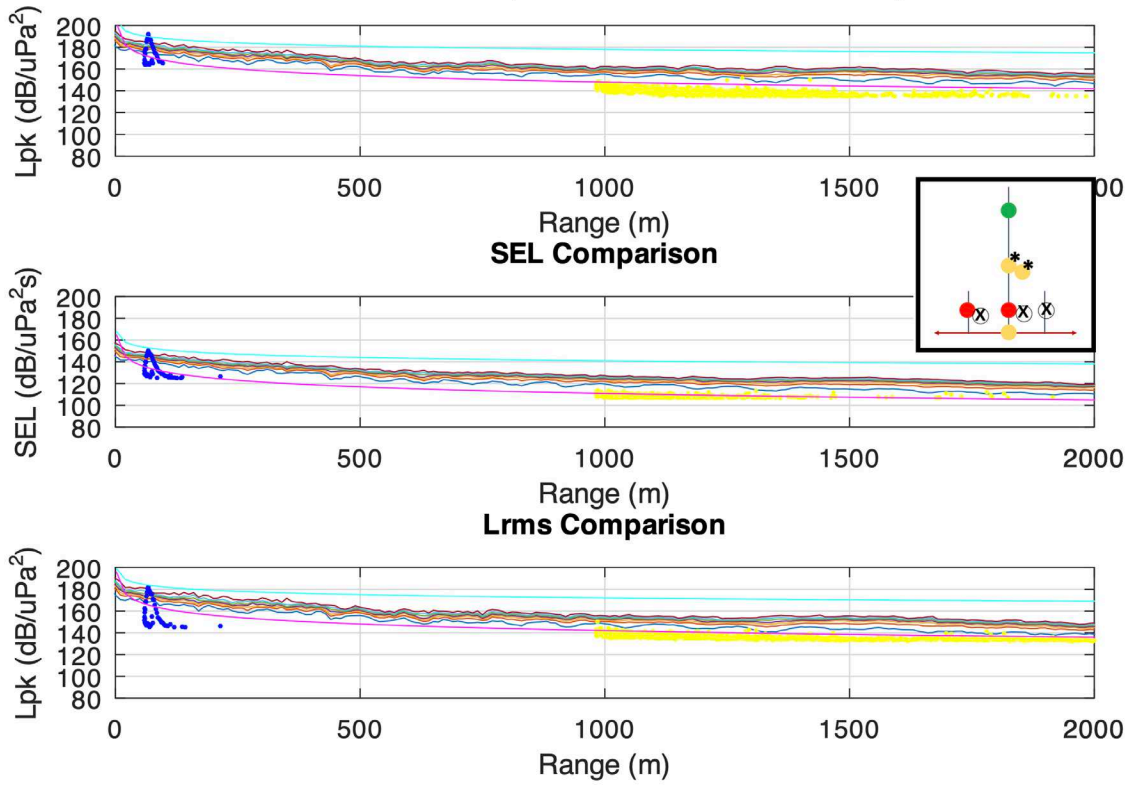
There were no source tows.

B.27 Applied Acoustics 252 S-Boom, 0.1 to 5 kHz, 1 kJ, Low Power, Three Plates (Mode 26)

The Applied Acoustics 252 S-Boom is an MF source.

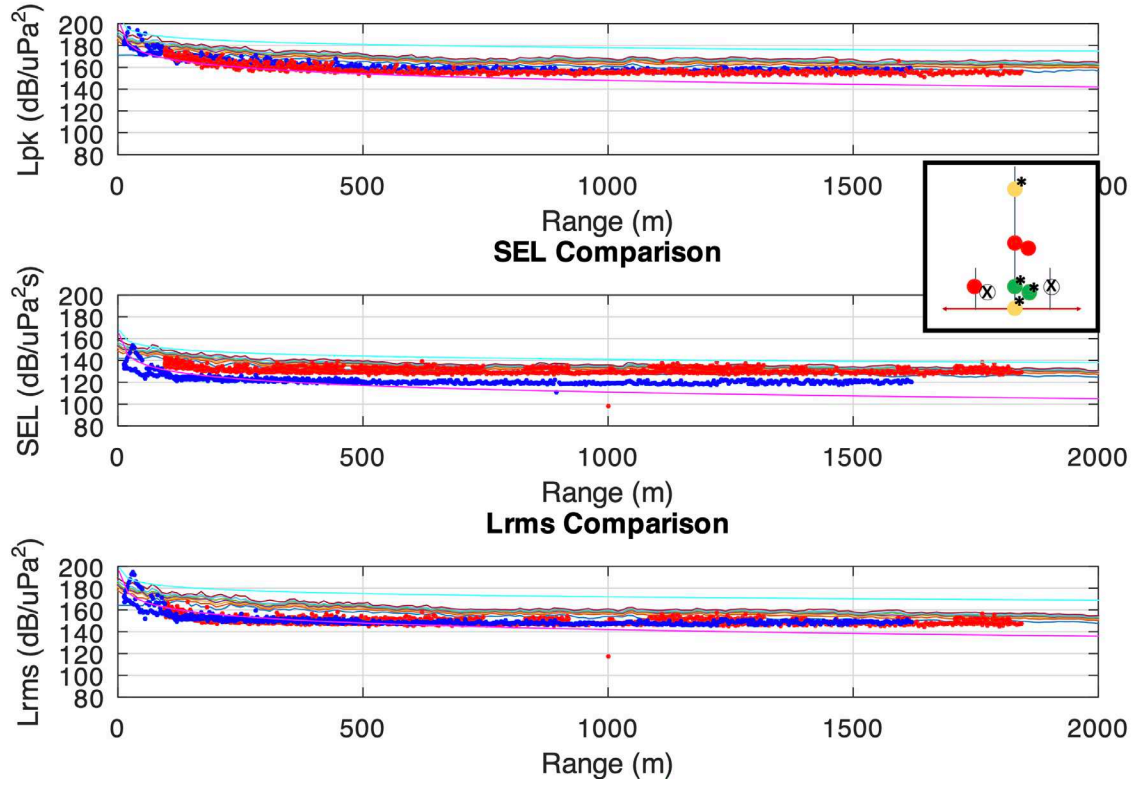
B.27.1 Site 1 – Mud, 10-m Depth

Model-Data Comparison Site1 M26 S-Boom Lpk



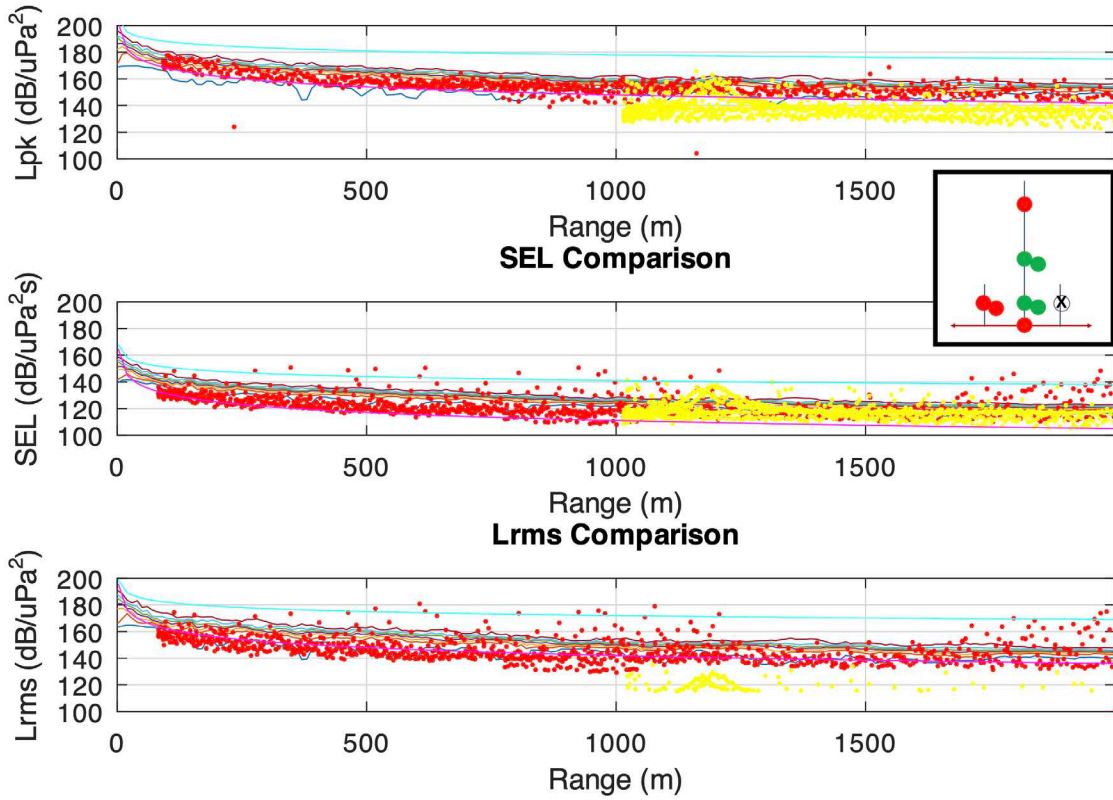
B.27.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M26 S-Boom Lpk

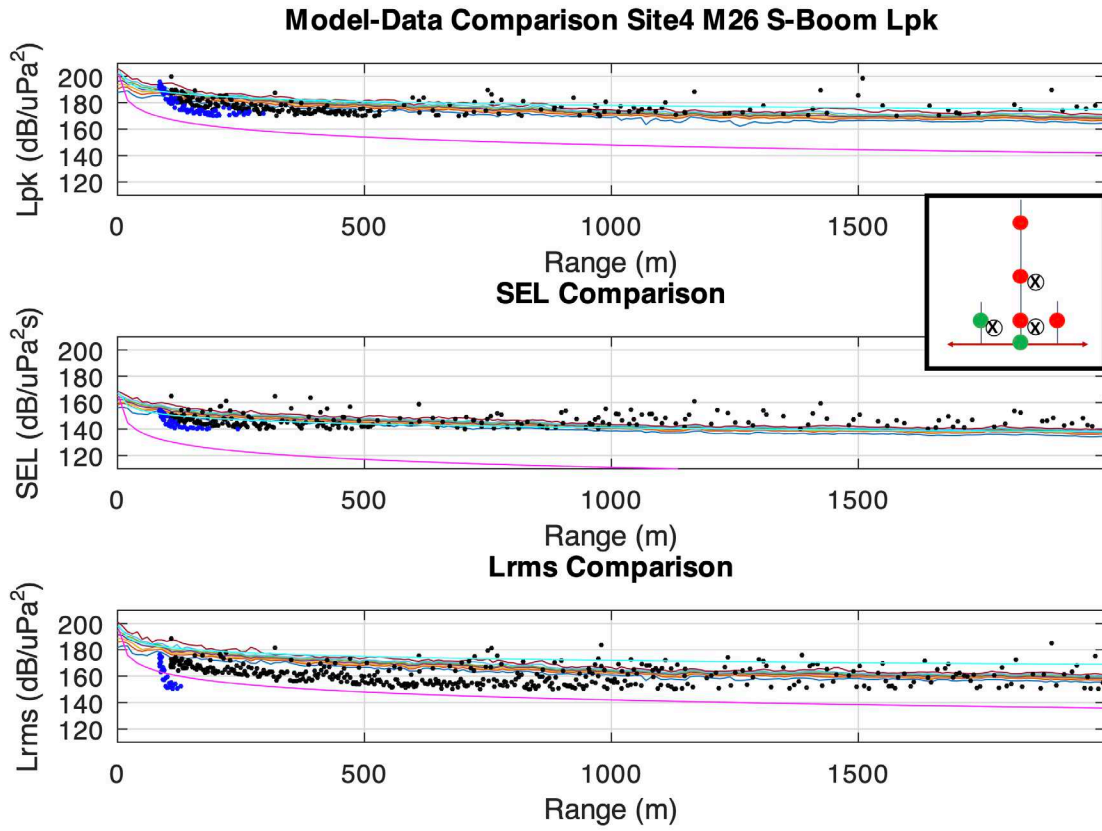


B.27.3 Site 3 – Mud, 30-m Depth

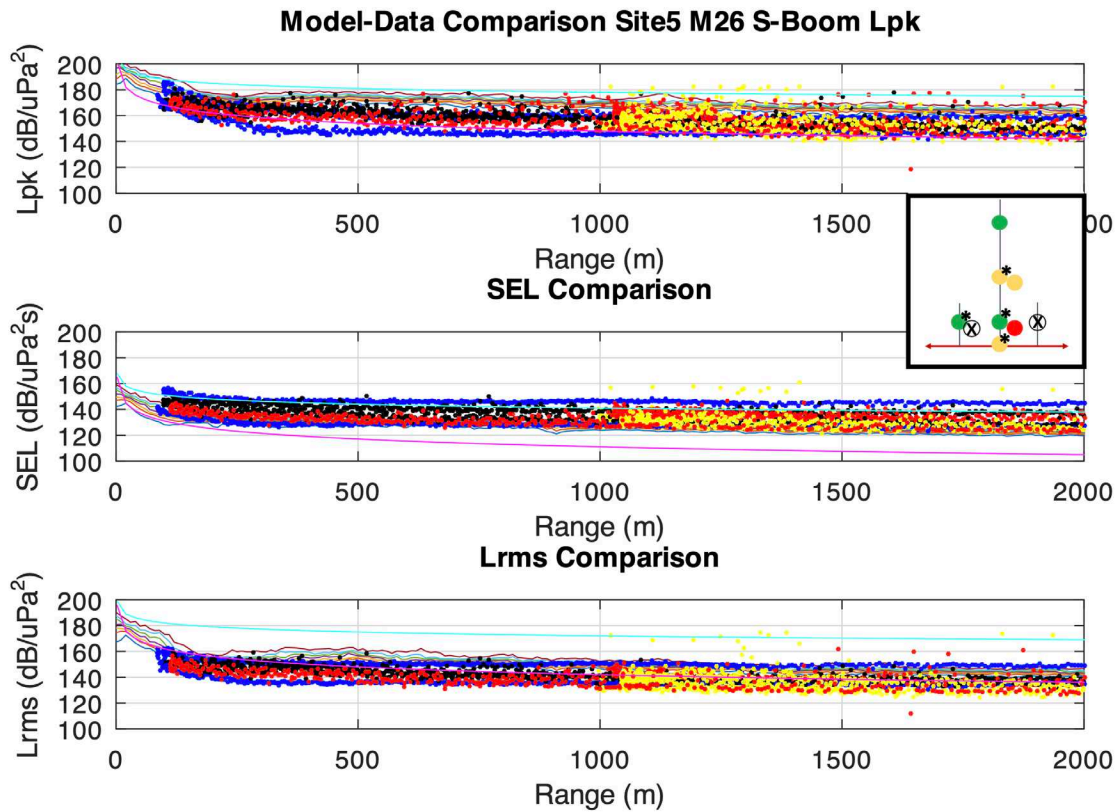
Model-Data Comparison Site3 M26 S-Boom Lpk



B.27.4 Site 4 – Sand, 30-m Depth



B.27.5 Site 5 – Sandy/Silt, 100-m Depth



B.28 Applied Acoustics 252 S-Boom, 0.1 to 5 kHz, 200 J, Low Power, Single Plate (Mode 27)

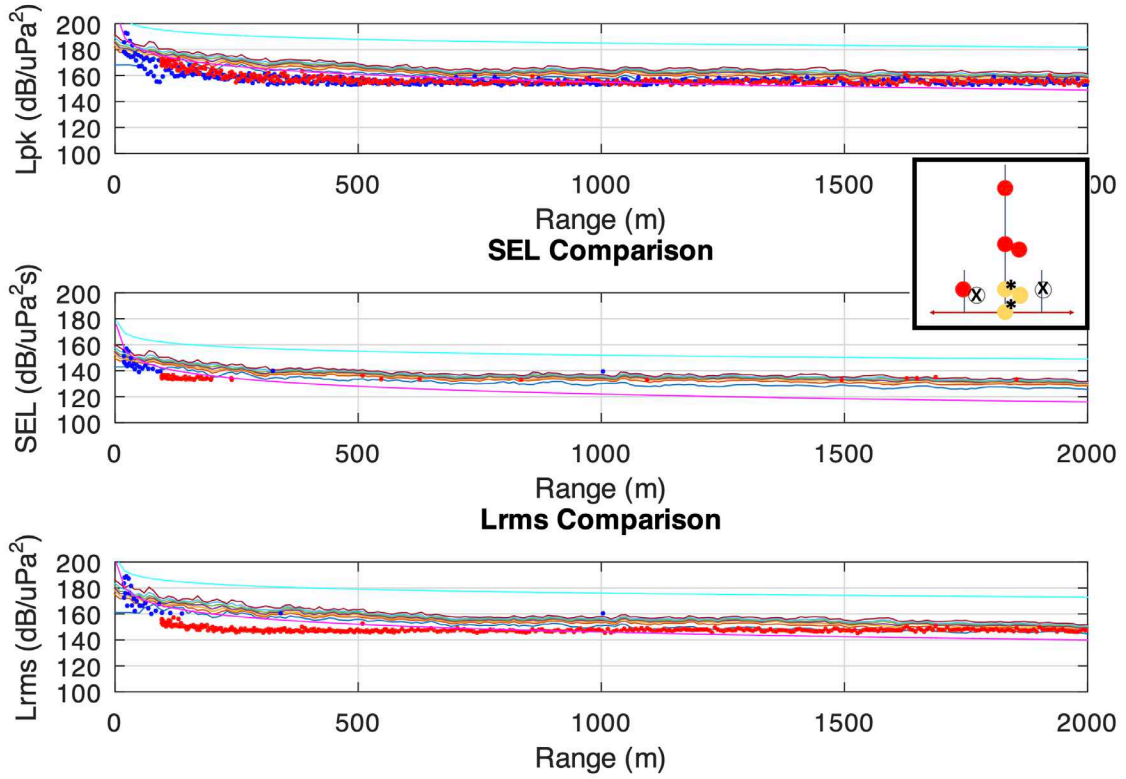
The Applied Acoustics 252 S-Boom is an MF source.

B.28.1 Site 1 – Mud, 10-m Depth

There were no source tows.

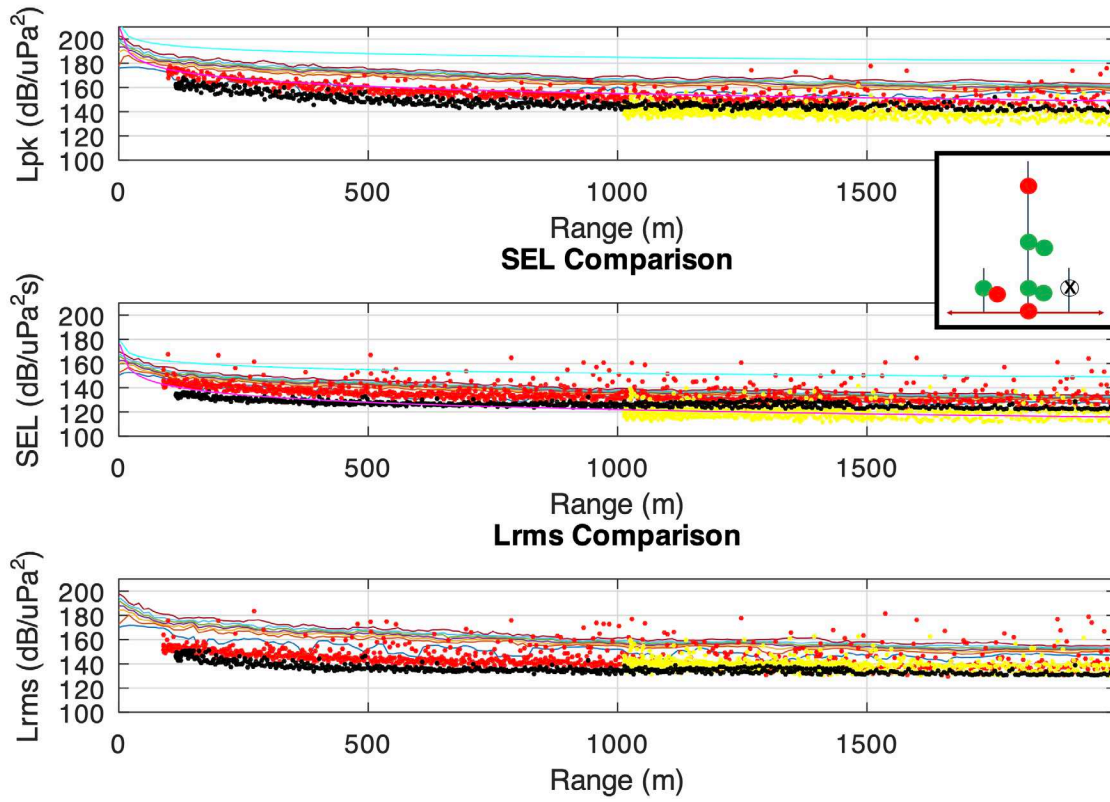
B.28.2 Site 2 – Sand, 10-m Depth

Model-Data Comparison Site2 M27 S-Boom Lpk



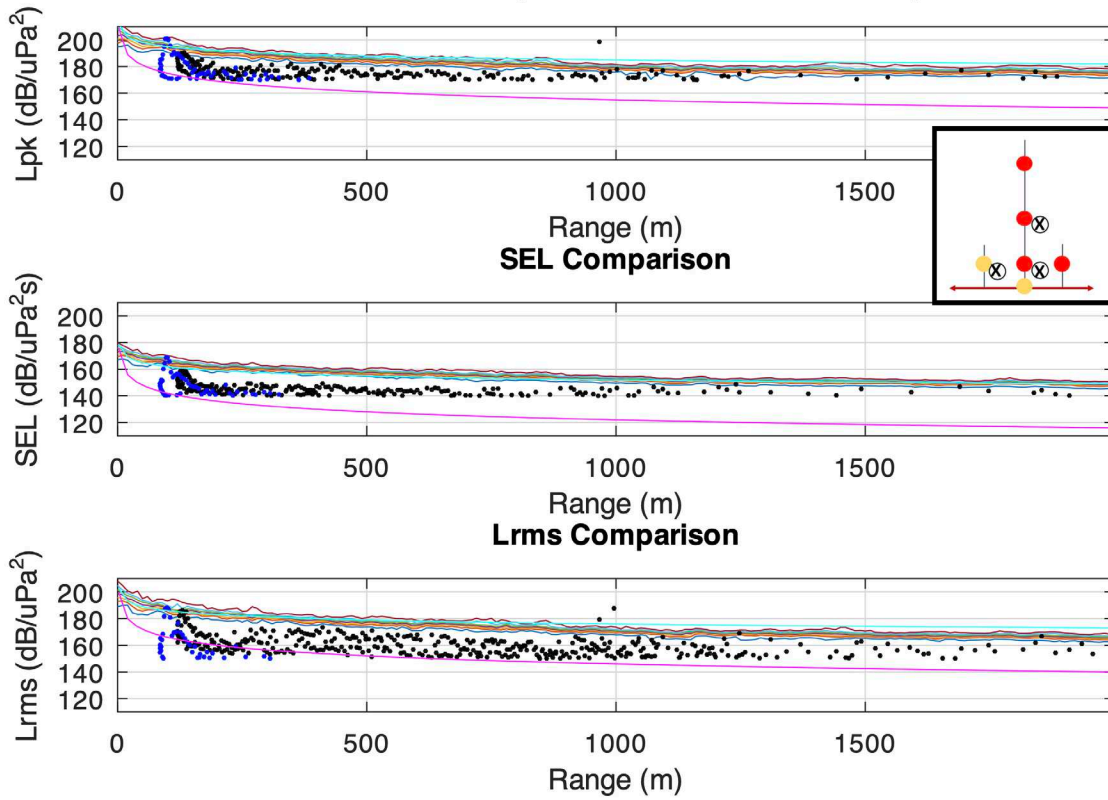
B.28.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M27 S-Boom Lpk

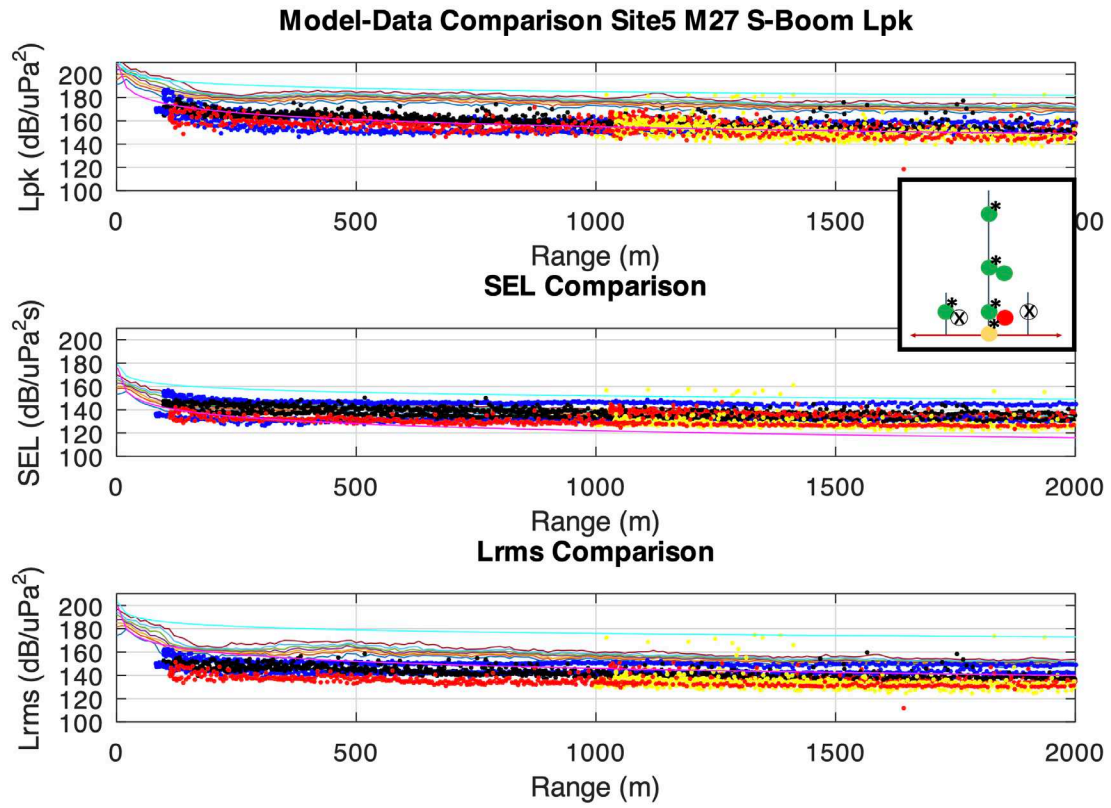


B.28.4 Site 4 – Sand, 30-m Depth

Model-Data Comparison Site4 M27 S-Boom Lpk



B.28.5 Site 5 – Sandy/Silt, 100-m Depth



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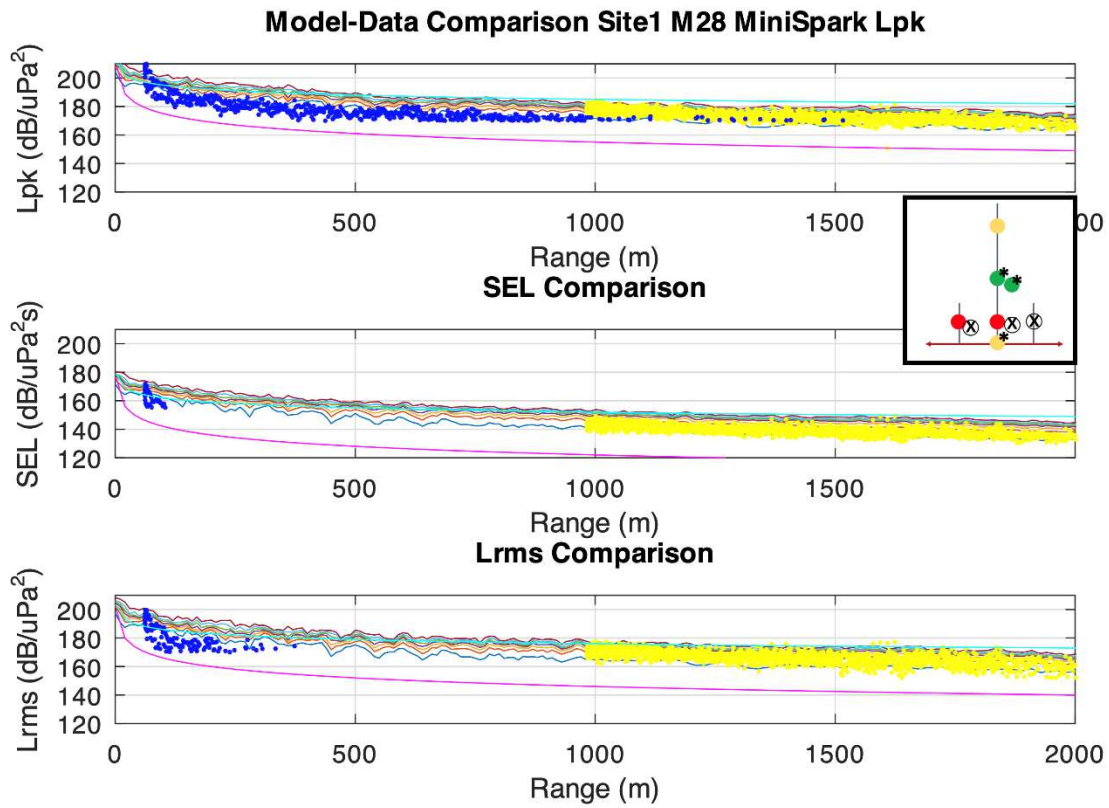
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Appendix B: Modelling Results (Mode28-40)

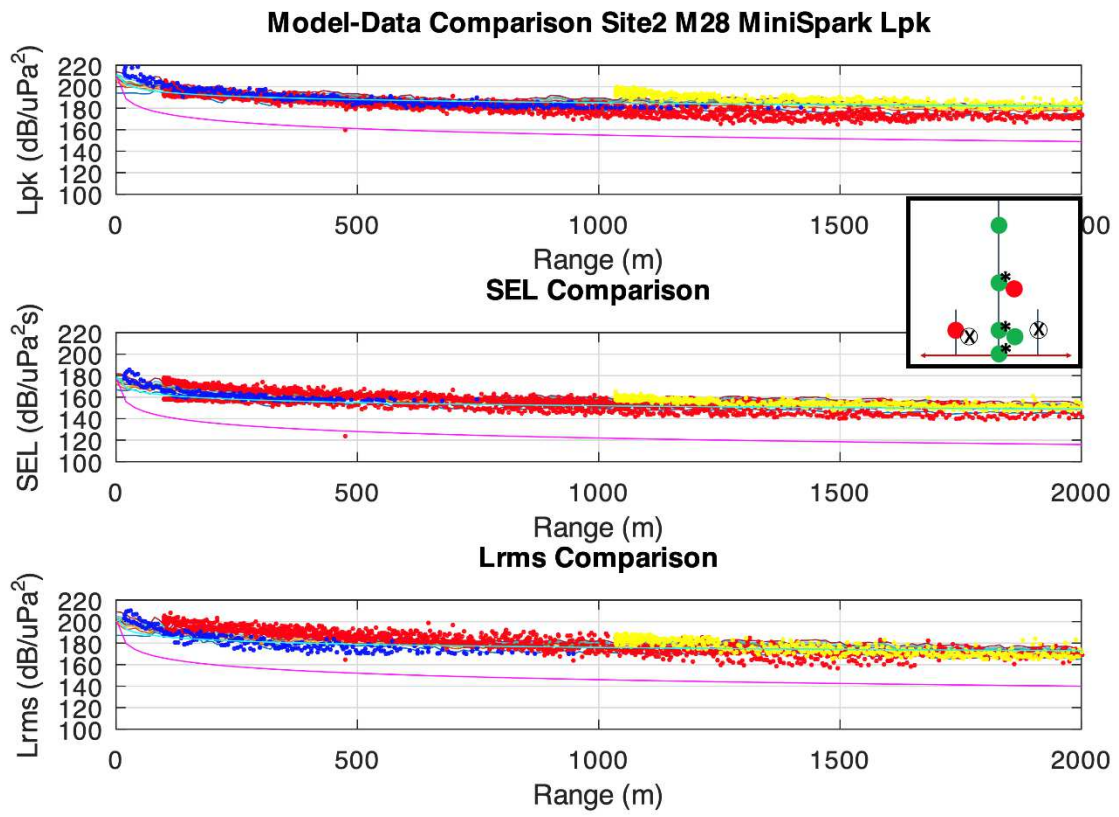
B.29 SIG 2 Mini Sparker ELC 820, 700 J, Low Power (Mode 28)

The Mini Sparker is a low frequency (LF) source.

B.29.1 Site 1 – Mud, 10-m Depth

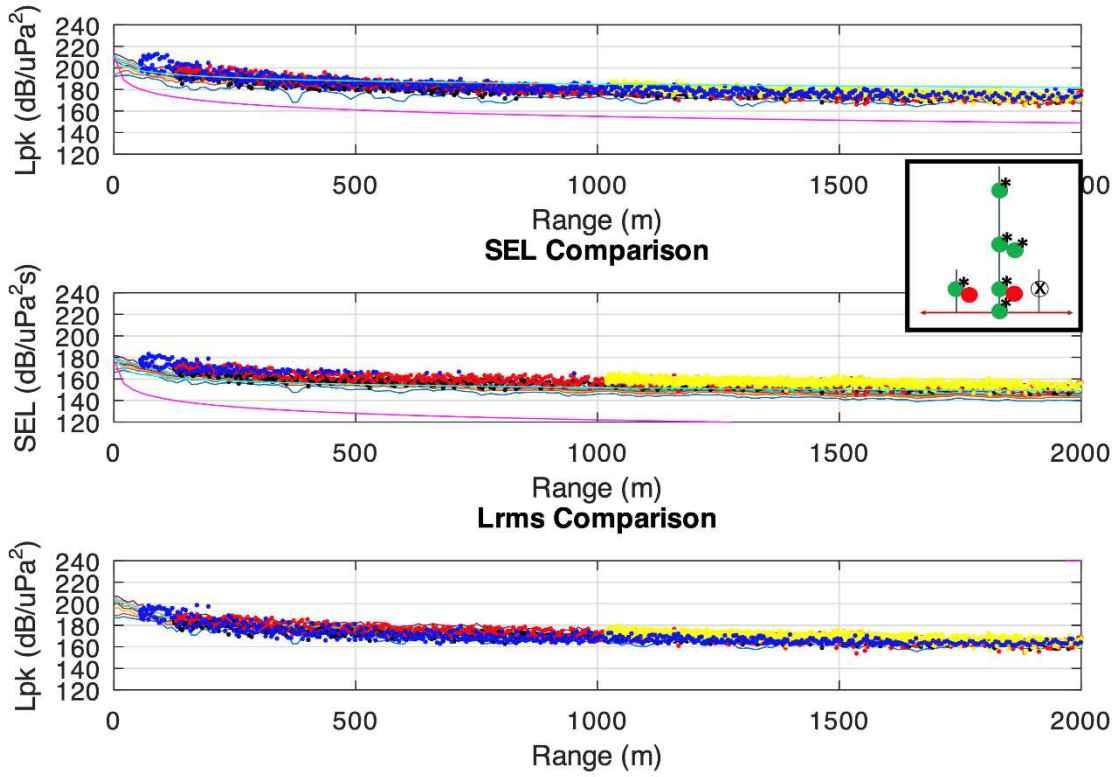


B.29.2 Site 2 – Sand, 10-m Depth

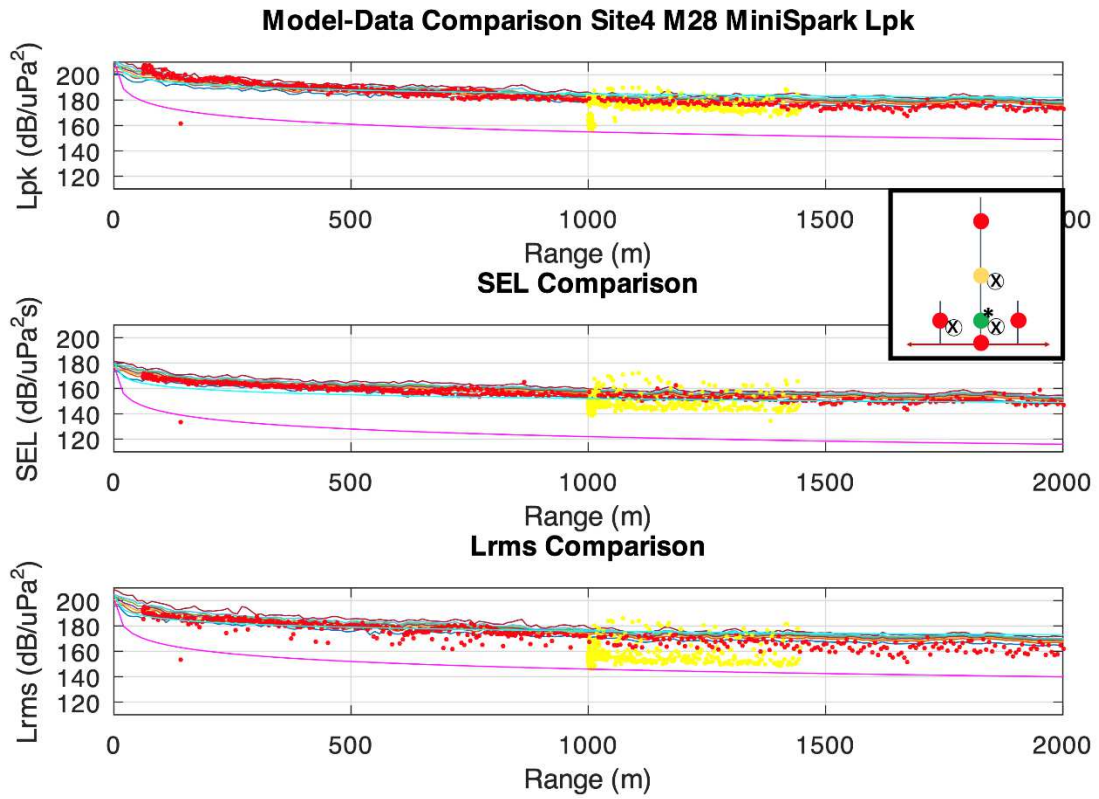


B.29.3 Site 3 – Mud, 30-m Depth

Model-Data Comparison Site3 M28 MiniSpark Lpk

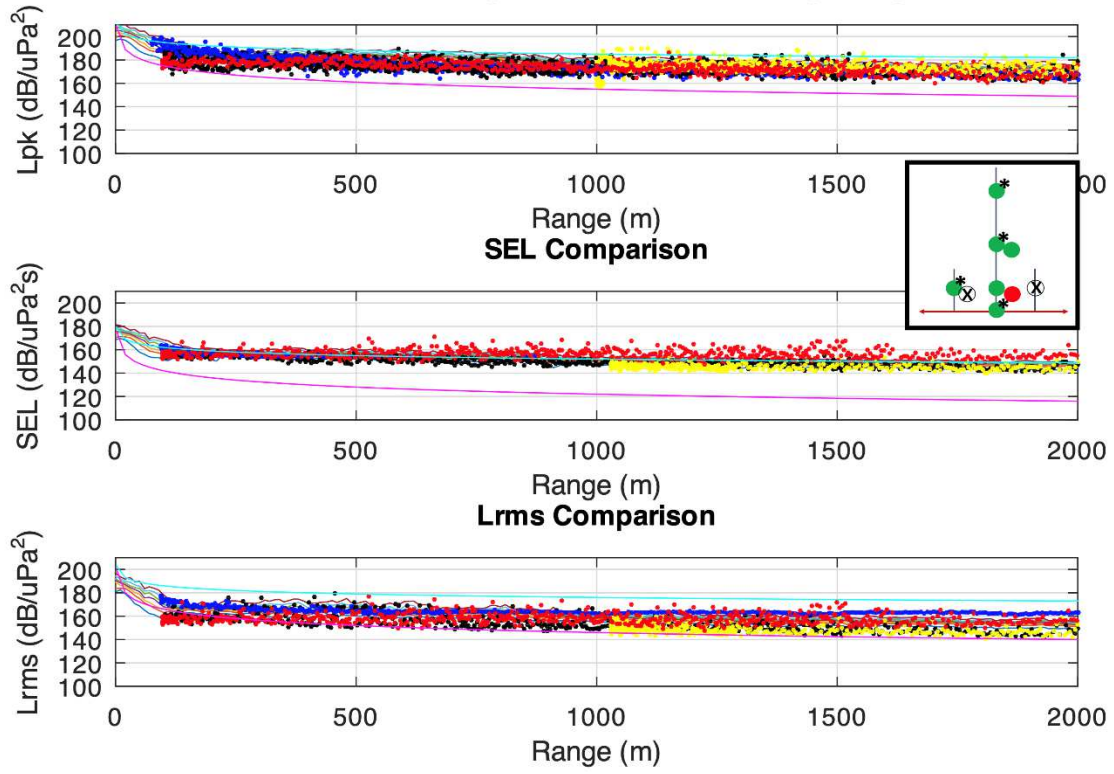


B.29.4 Site 4 – Sand, 30-m Depth



B.29.5 Site 5 – Sandy-Silt, 100-m Depth

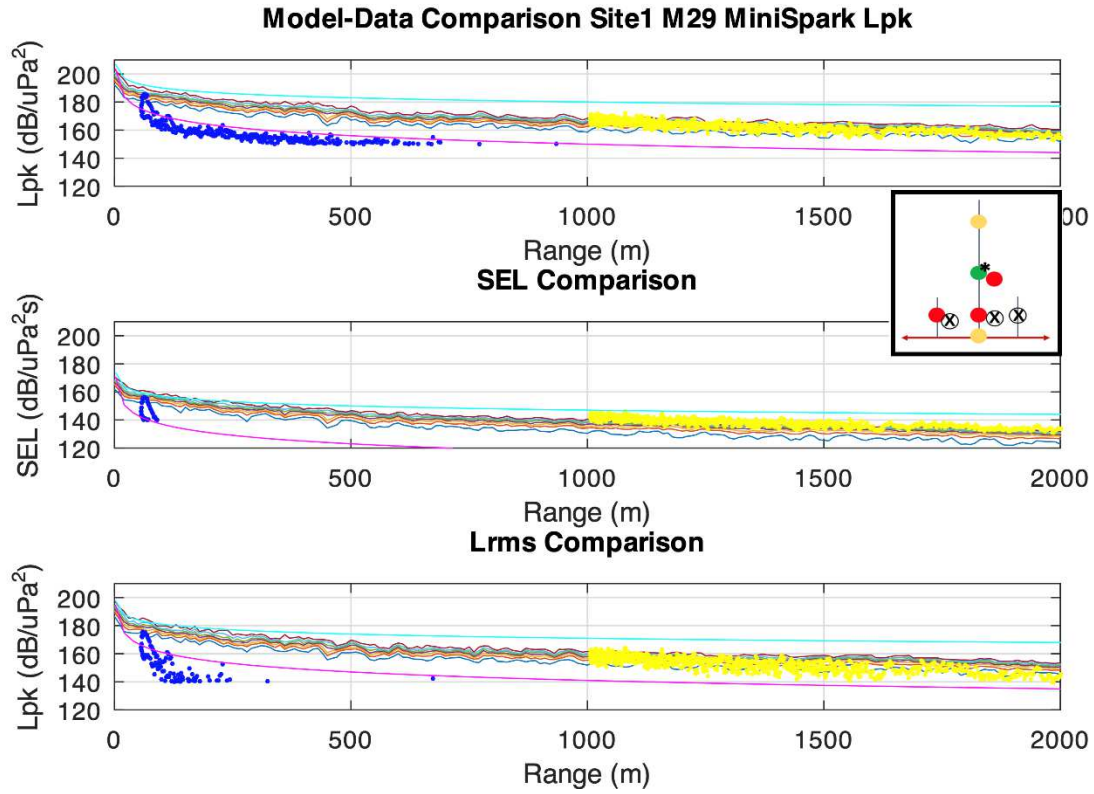
Model-Data Comparison Site5 M28 MiniSpark Lpk



B.30 SIG 2 Mini Sparker ELC 820, 500 J, High Power (Mode 29)

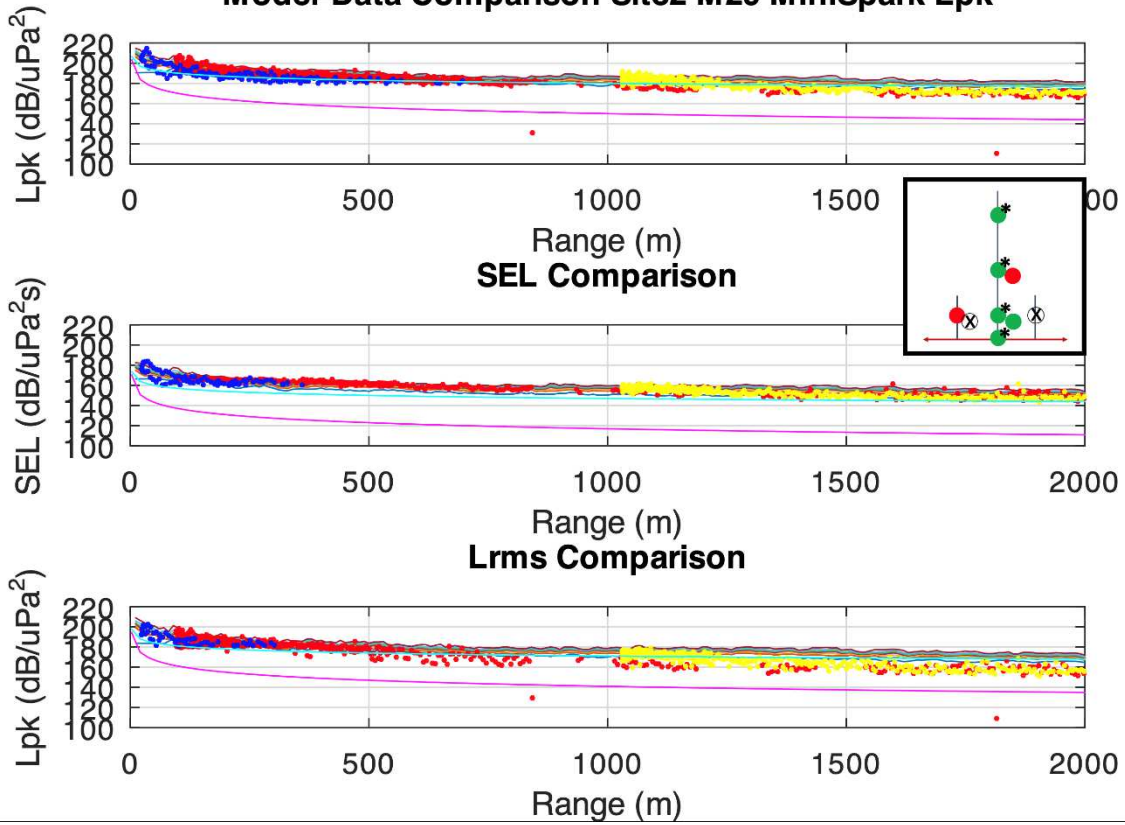
The Mini Sparker is an LF source.

B.30.1 Site 1 – Mud, 10-m Depth

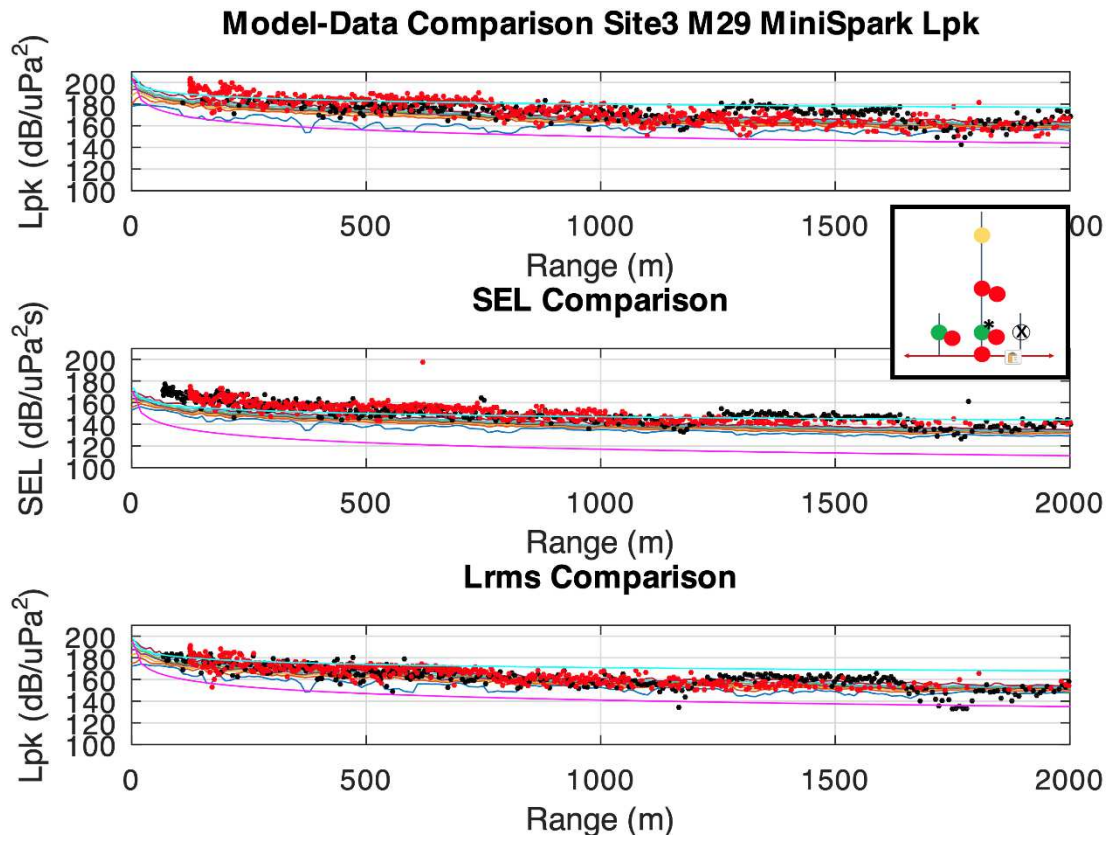


B.30.2 Site 2 – Sand, 10-m Depth

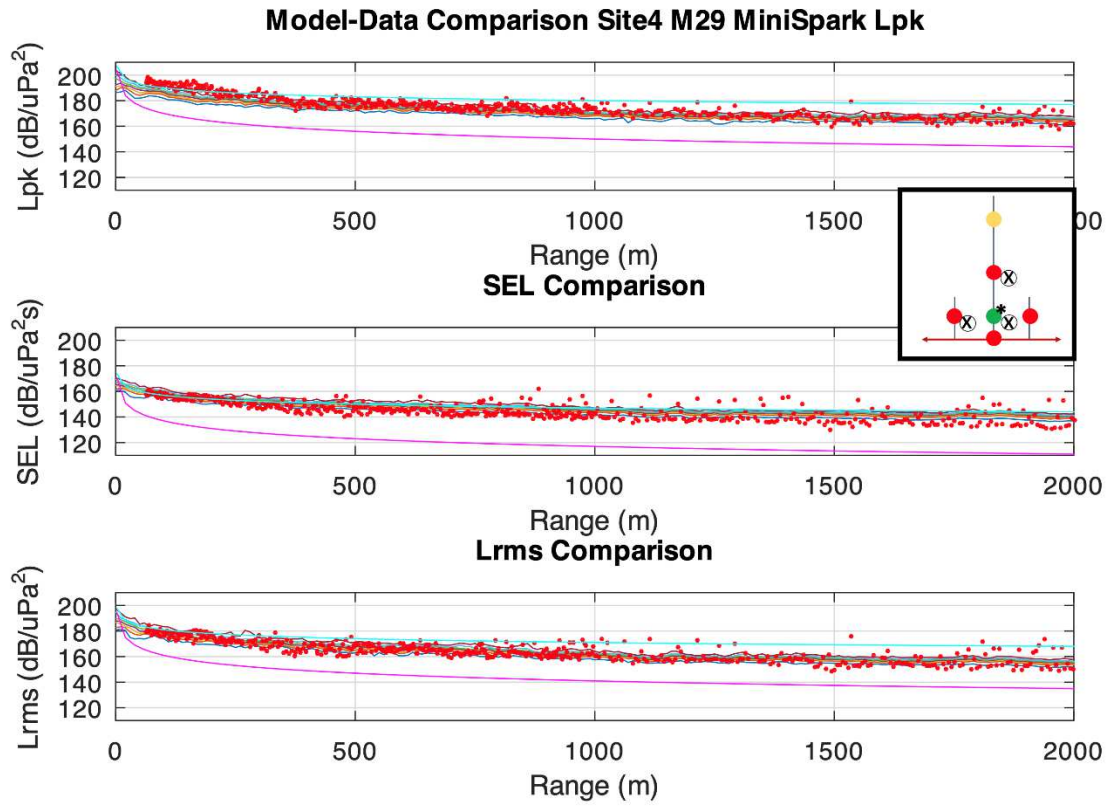
Model-Data Comparison Site2 M29 MiniSpark Lpk



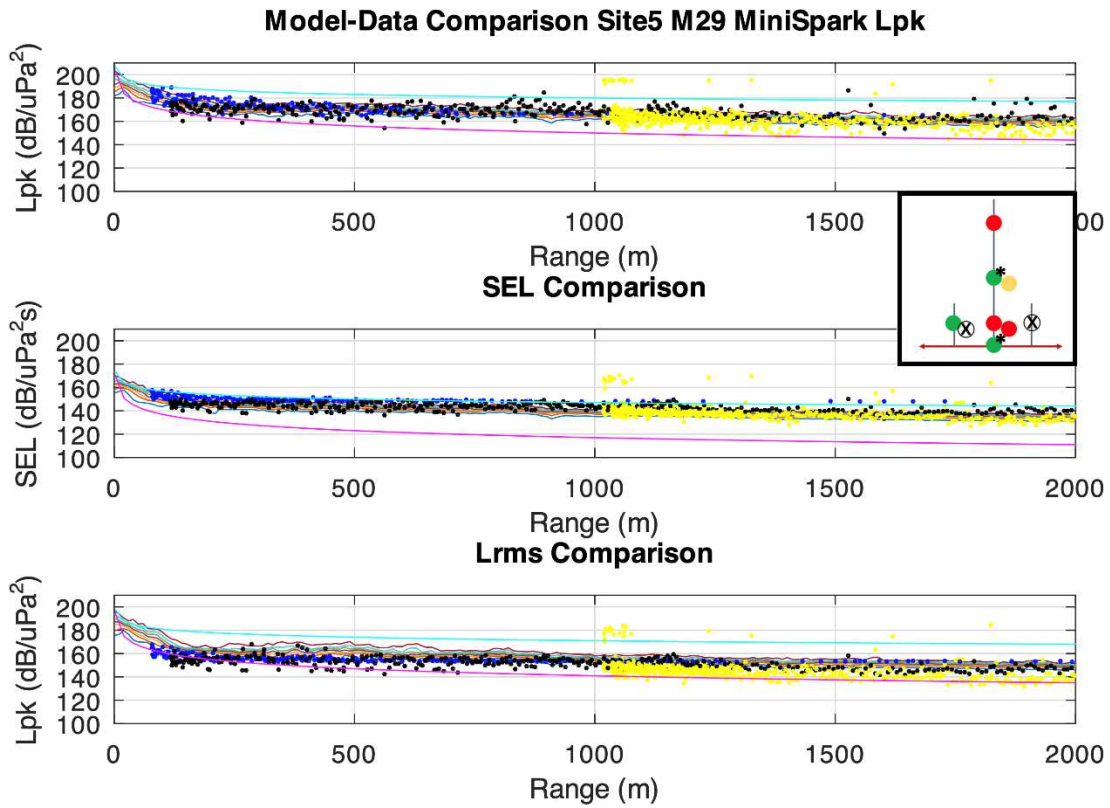
B.30.3 Site 3 – Mud, 30-m Depth



B.30.4 Site 4 – Sand, 30-m Depth



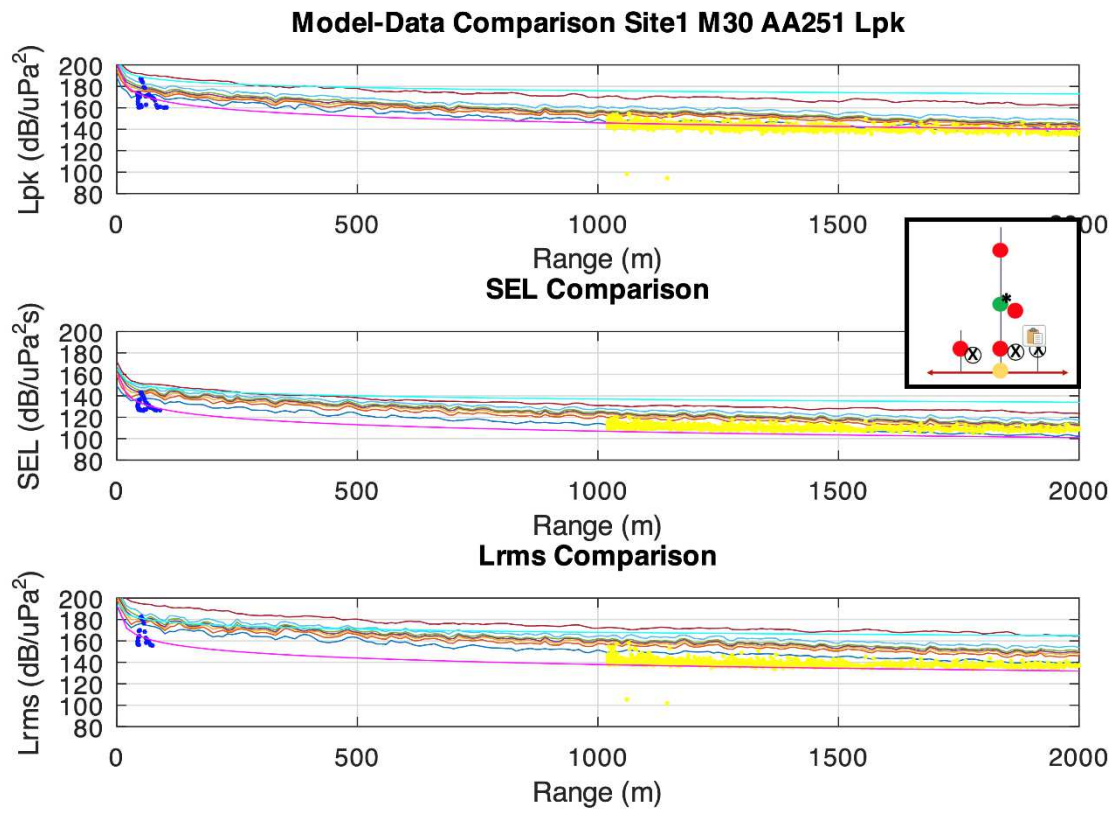
B.30.5 Site 5 – Sandy-Silt, 100-m Depth



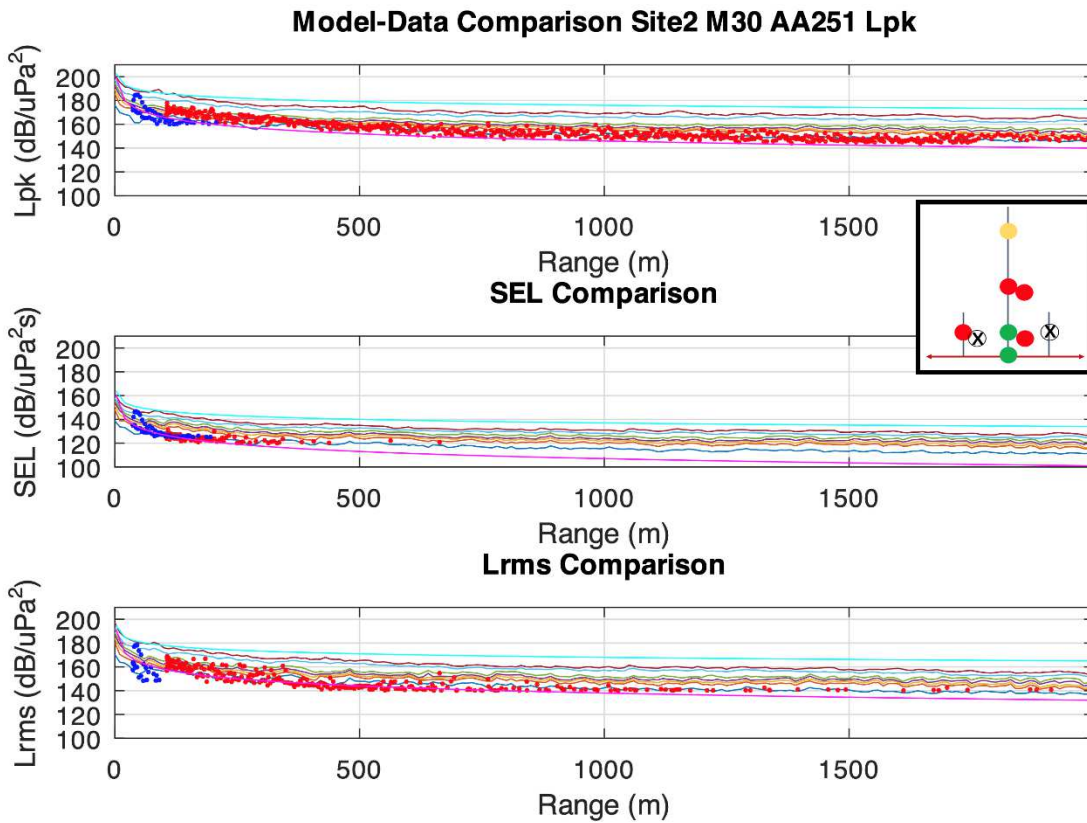
B.31 Applied Acoustics 251 Boomer, 0.1 to 5 kHz, 200 J, Lower Power, Single Plate (Mode 30)

The Applied Acoustics 251 Boomer is an MF source.

B.31.1 Site 1 – Mud, 10-m Depth



B.31.2 Site 2 – Sand, 10-m Depth



B.31.3 Site 3 – Mud, 30-m Depth

There were no source tows.

B.31.4 Site 4 – Sand, 30-m Depth

There were no source tows.

B.31.5 Site 5 – Sandy/Silt, 100-m Depth

There were no source tows.

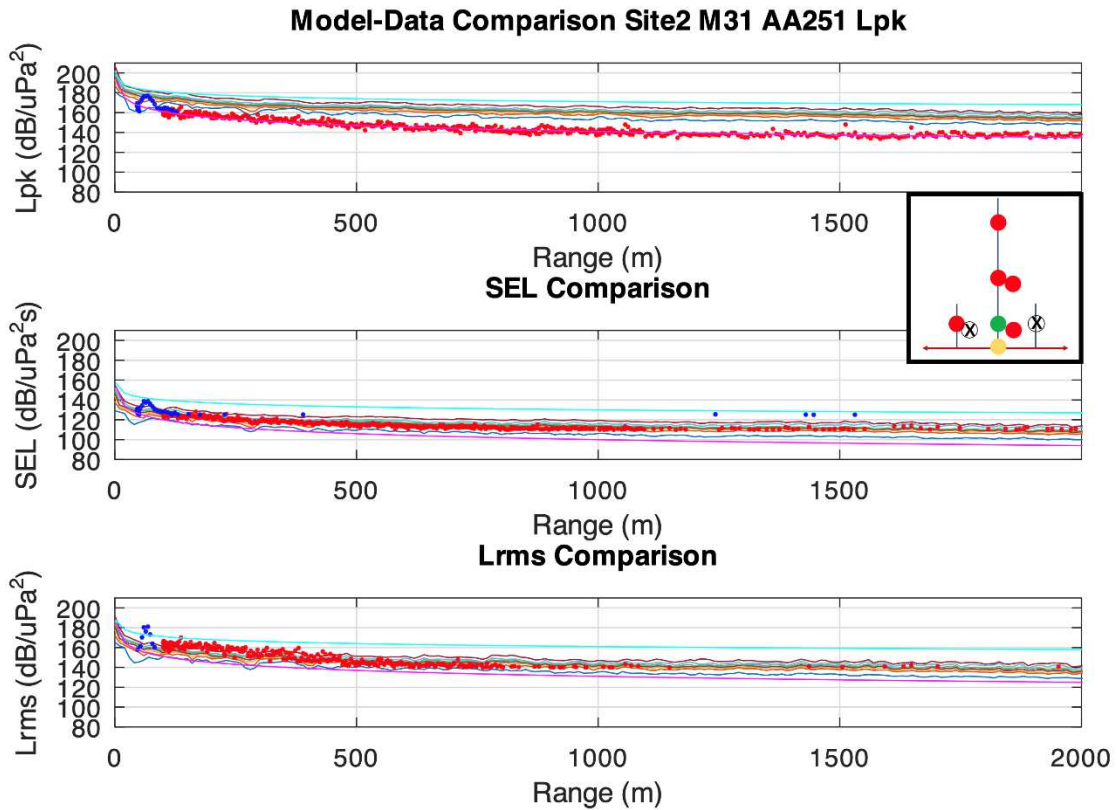
B.32 Applied Acoustics 251 Boomer, 0.1 to 5 kHz, 100 J, Lower Power, Single Plate (Mode 31)

The Applied Acoustics 251 Boomer is an MF source.

B.32.1 Site 1 – Mud, 10-m Depth

There were no source tows.

B.32.2 Site 2 – Sand, 10-m Depth



B.32.3 Site 3 – Mud, 30-m Depth

There were no source tows.

B.32.4 Site 4 – Sand, 30-m Depth

There were no source tows.

B.32.5 Site 5 – Sandy/Silt, 100-m Depth

There were no source tows.

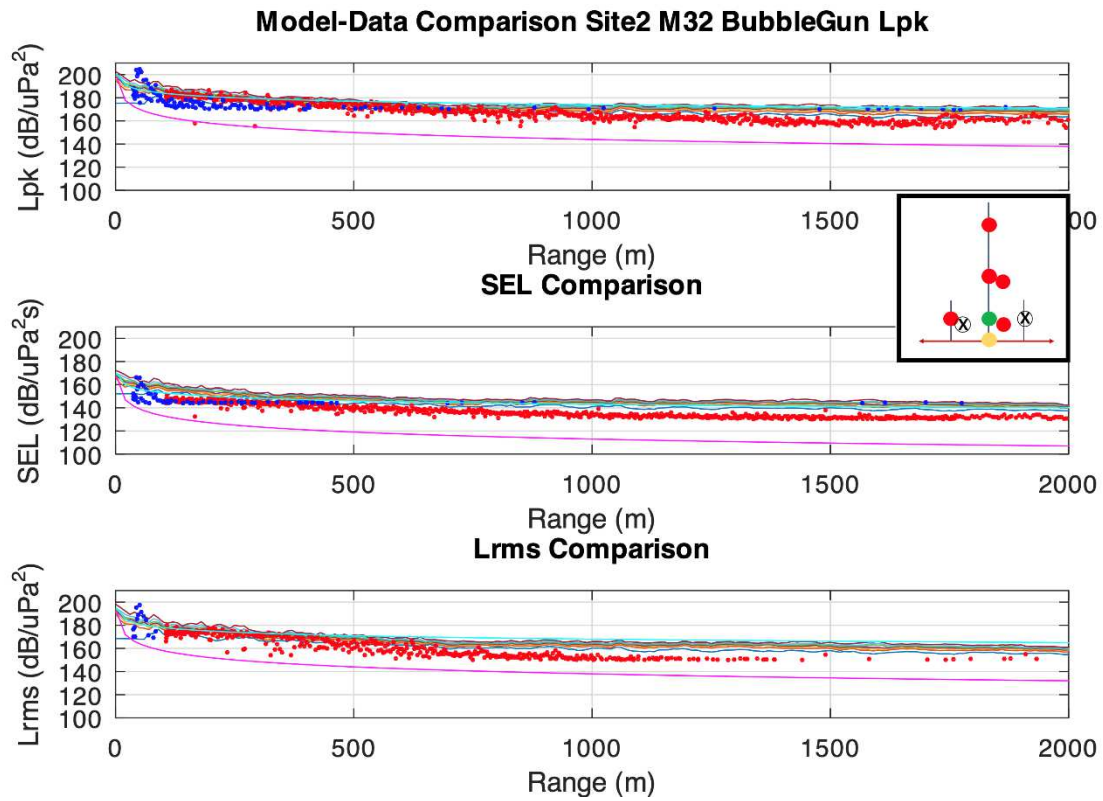
B.33 FSI Bubble Gun, 0.1–2 kHz, Dual Plate (Mode 32)

The Bubble Gun is an LF source.

B.33.1 Site 1 – Mud, 10-m Depth

There were no Mode 32 source tows.

B.33.2 Site 2 – Sand, 10-m Depth



B.33.3 Site 3 – Mud, 30-m Depth

There were no Mode 32 source tows.

B.33.4 Site 4 – Sand, 30-m Depth

There were no Mode 32 source tows.

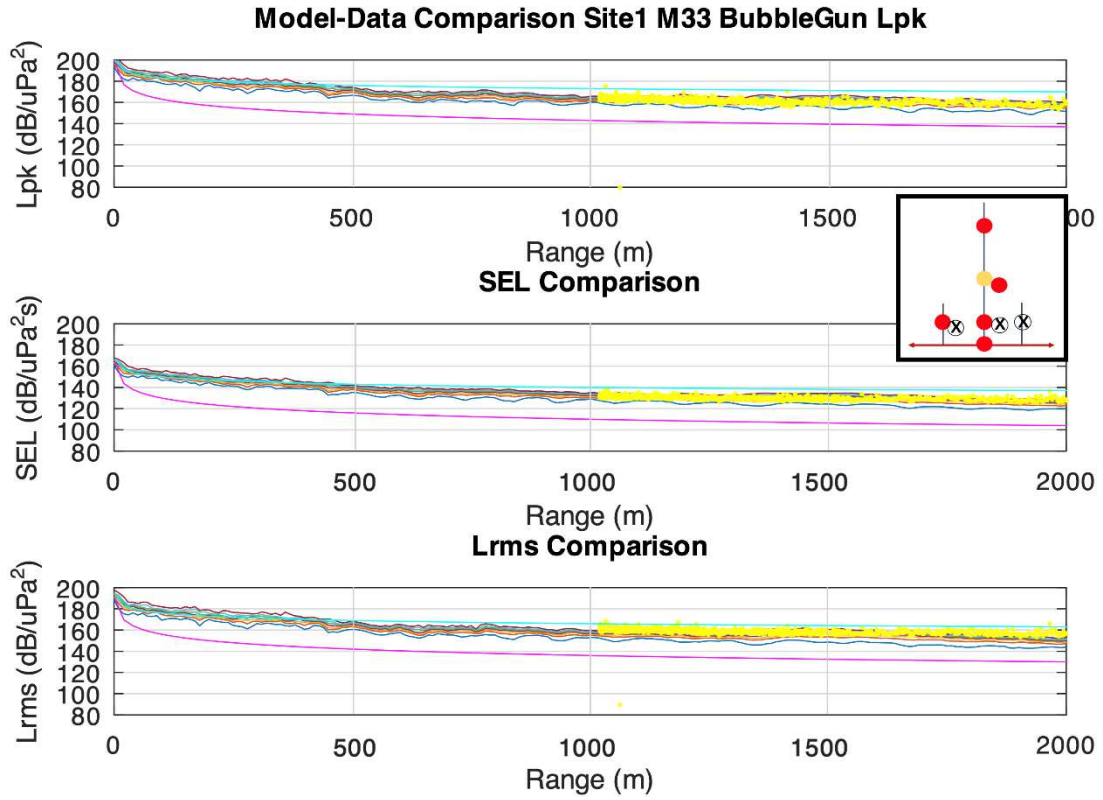
B.33.5 Site 5 – Sandy-Silt, 100-m Depth

There were no Mode 32 source tows.

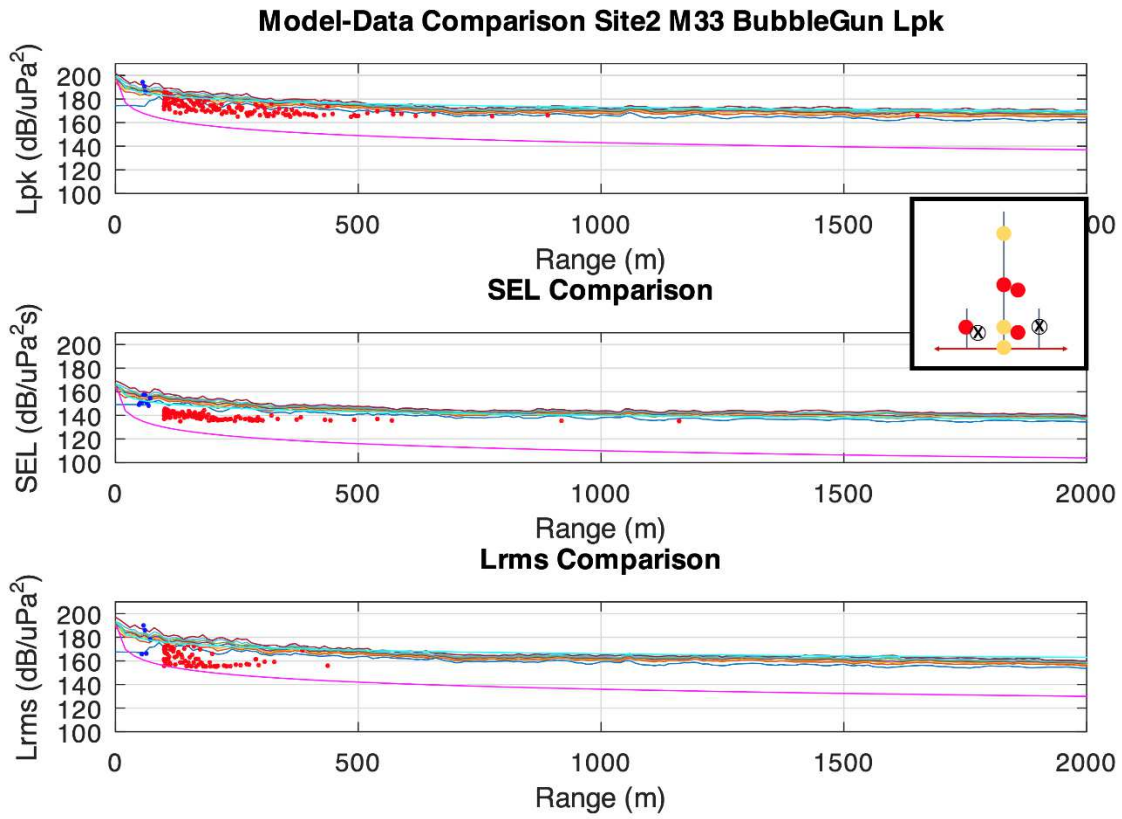
B.34 FSI Bubble Gun, 0.1–2 kHz, Single Plate (Mode 33)

The Bubble Gun is an LF source.

B.34.1 Site 1 – Mud, 10-m Depth



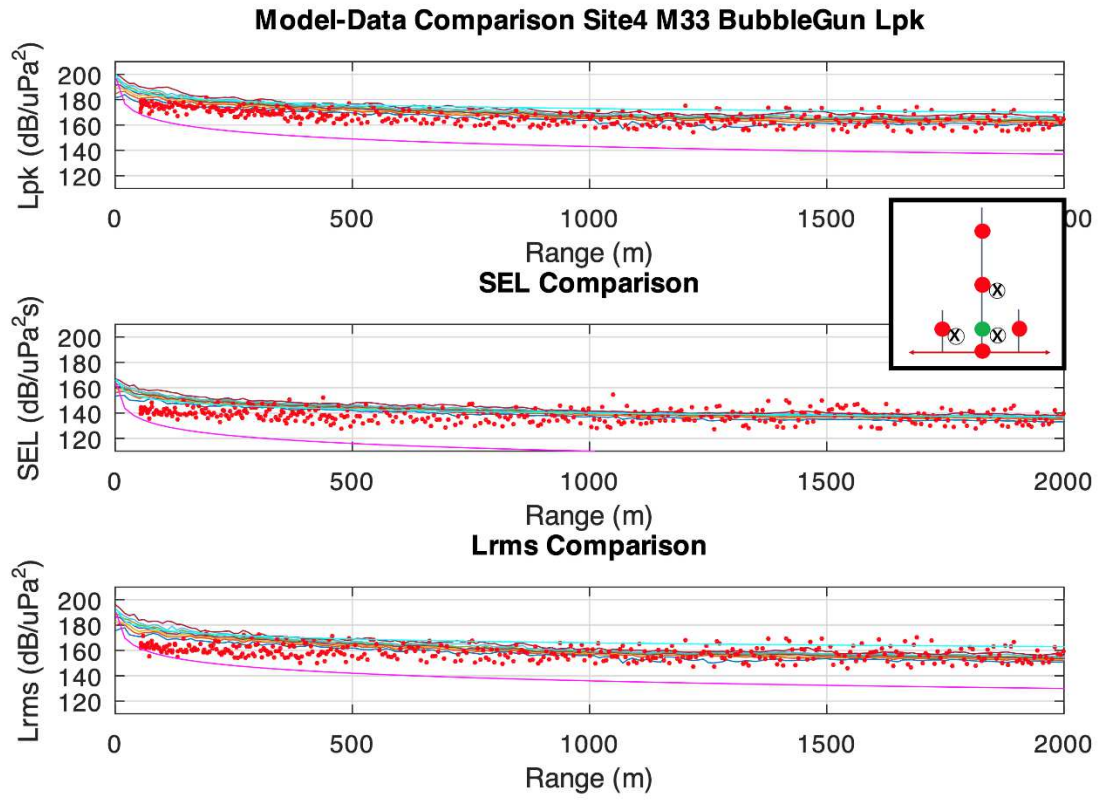
B.34.2 Site 2 – Sand, 10-m Depth



B.34.3 Site 3 – Mud, 30-m Depth

There were no Mode 33 source tows.

B.34.4 Site 4 – Sand, 30-m Depth



B.34.5 Site 5 – Sandy-Silt, 100-m Depth

There were no Mode 33 source tows.

B.35 Sercel Mini GI (30/30), Dual Airguns, No Insert, 30-, 26-, and 24-Second Shot Rates (Mode 34)

The Airgun is an LF source.

B.35.1 Site 1 – Mud, 10-m Depth

There were no Mode 34 source tows.

B.35.2 Site 2 – Sand, 10-m Depth

There were no Mode 34 source tows.

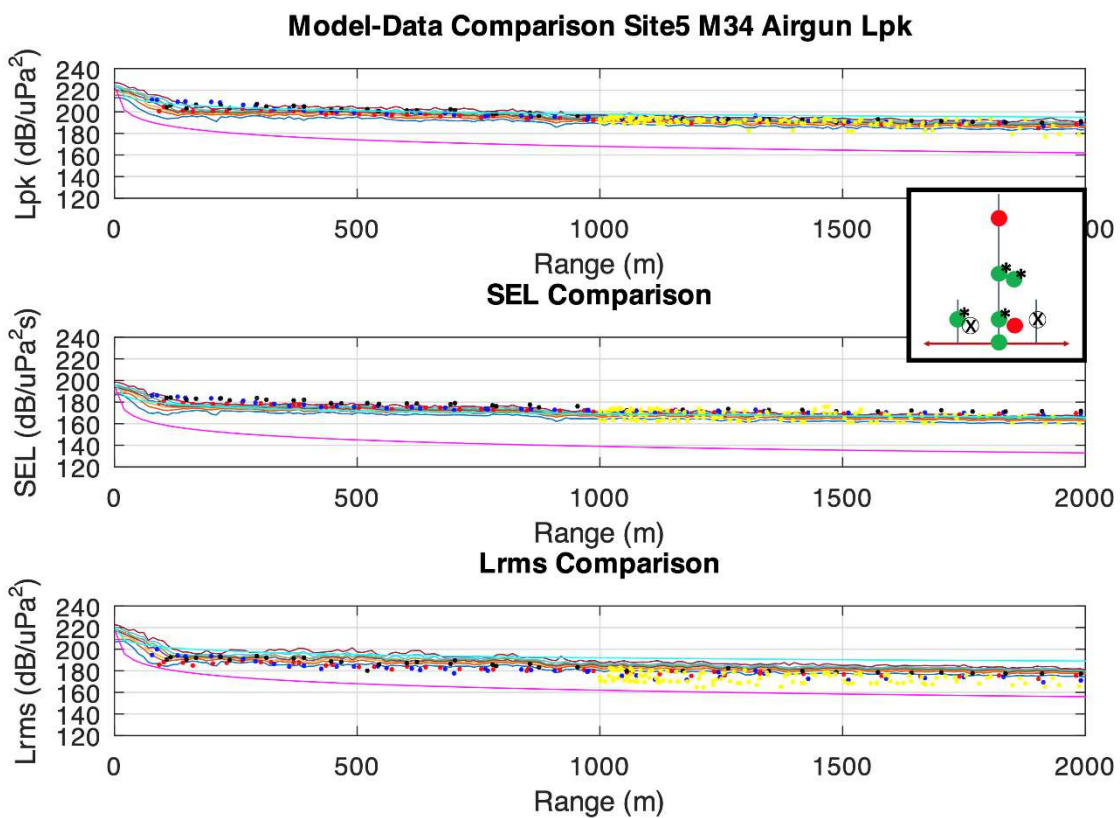
B.35.3 Site 3 – Mud, 30-m Depth

There were no Mode 34 source tows.

B.35.4 Site 4 – Sand, 30-m Depth

There were no Mode 34 source tows.

B.35.5 Site 5 – Sandy-Silt, 100-m Depth



B.36 Sercel Mini GI (30/30), Single Airgun#1, No Insert, 24-Second Shot Rate (Mode 35)

The Airgun is an LF source.

B.36.1 Site 1 – Mud, 10-m Depth

There were no Mode 35 source tows.

B.36.2 Site 2 – Sand, 10-m Depth

There were no Mode 35 source tows.

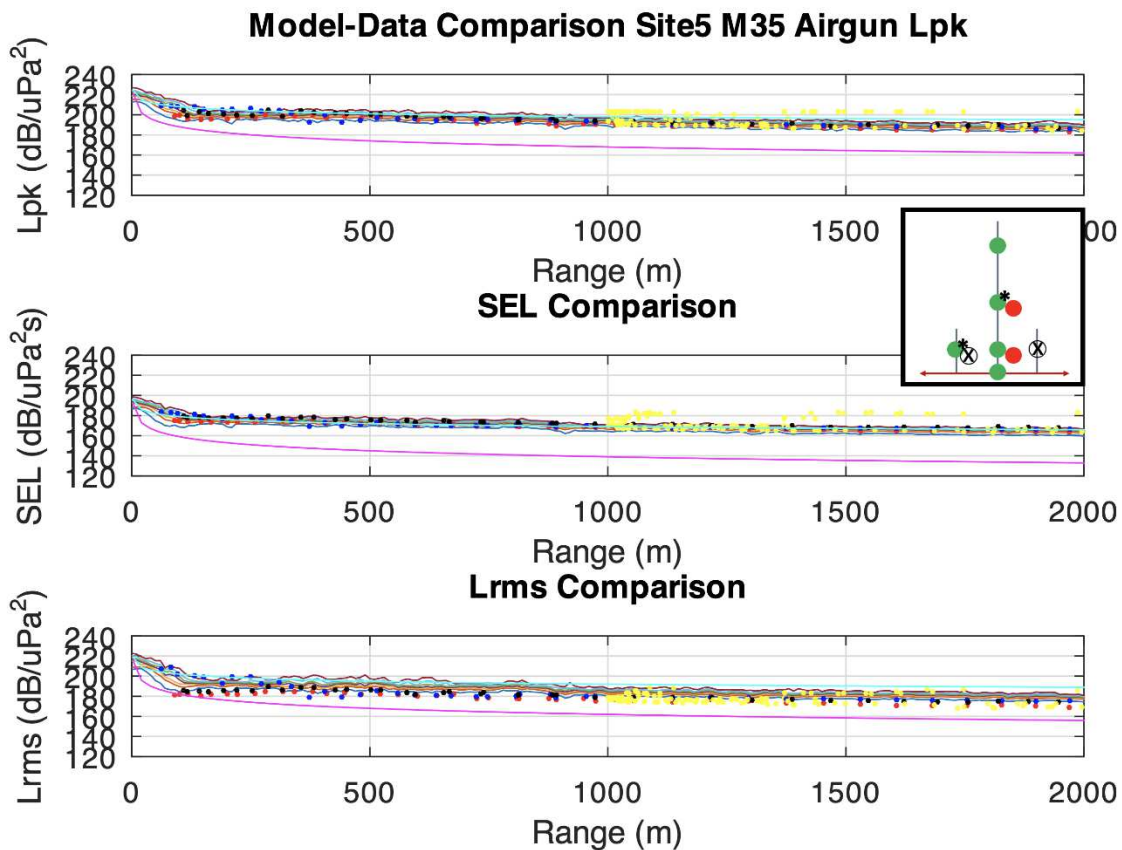
B.36.3 Site 3 – Mud, 30-m Depth

There were no Mode 35 source tows.

B.36.4 Site 4 – Sand, 30-m Depth

There were no Mode 35 source tows.

B.36.5 Site 5 – Sandy-Silt, 100-m Depth



B.37 Sercel Mini GI (30/30), Single Airgun#2, No Insert, 24-Second Shot Rate (Mode 36)

The Airgun is an LF source.

B.37.1 Site 1 – Mud, 10-m Depth

There were no Mode 36 source tows.

B.37.2 Site 2 – Sand, 10-m Depth

There were no Mode 36 source tows.

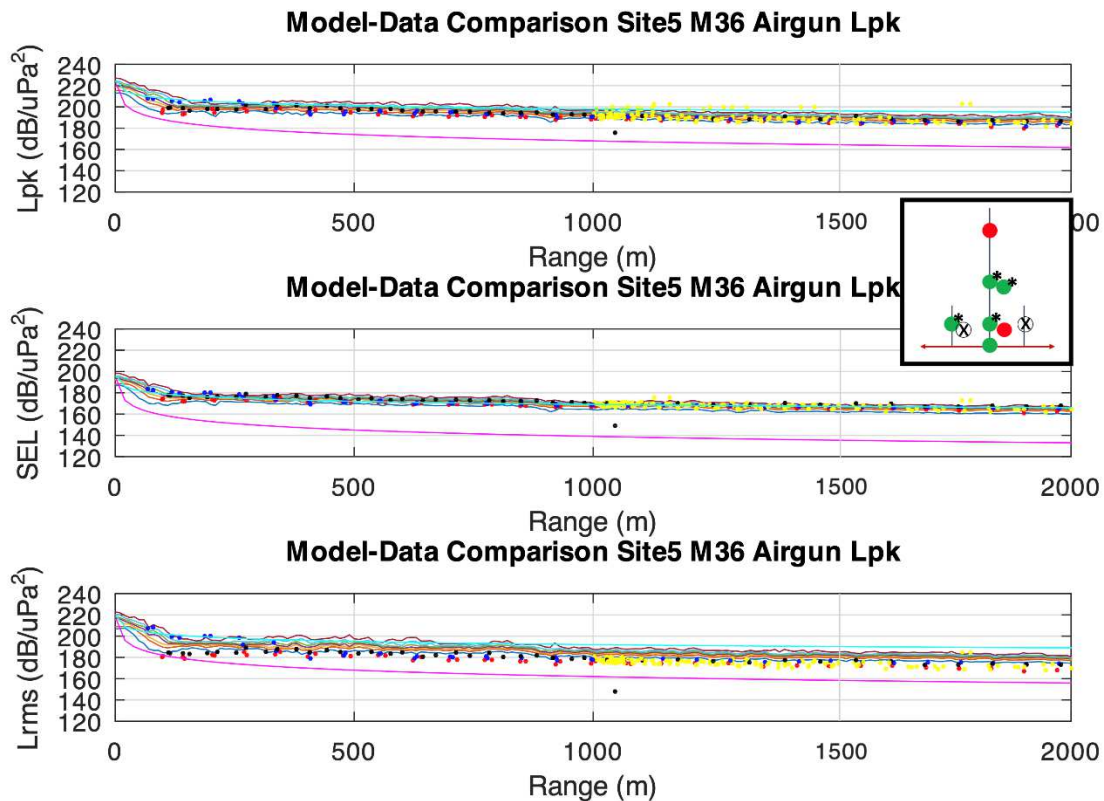
B.37.3 Site 3 – Mud, 30-m Depth

There were no Mode 36 source tows.

B.37.4 Site 4 – Sand, 30-m Depth

There were no Mode 36 source tows.

B.37.5 Site 5 – Sandy-Silt, 100-m Depth



B.38 Sercel Mini GI (30/30), Single Airgun, 15-in³ Inserts, 8-second Shot Rate (Mode 37)

The Airgun is an LF source.

B.38.1 Site 1 – Mud, 10-m Depth

There were no Mode 37 source tows.

B.38.2 Site 2 – Sand, 10-m Depth

There were no Mode 37 source tows.

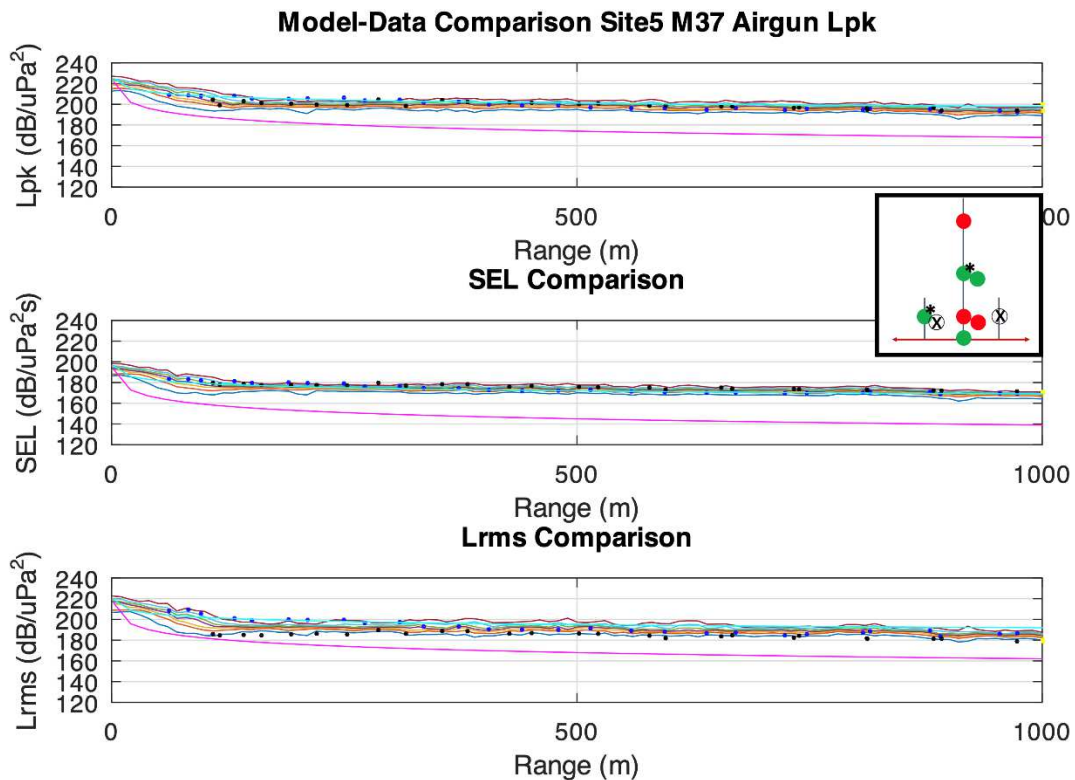
B.38.3 Site 3 – Mud, 30-m Depth

There were no Mode 37 source tows.

B.38.4 Site 4 – Sand, 30-m Depth

There were no Mode 37 source tows.

B.38.5 Site 5 – Sandy-Silt, 100-m Depth



B.39 Sercel Mini GI (30/30), Single Airgun#1, Full 30/30, No Insert, 24-Second Shot Rate (Mode 38)

The Airgun is an LF source.

B.39.1 Site 1 – Mud, 10-m Depth

There were no Mode 38 source tows.

B.39.2 Site 2 – Sand, 10-m Depth

There were no Mode 38 source tows.

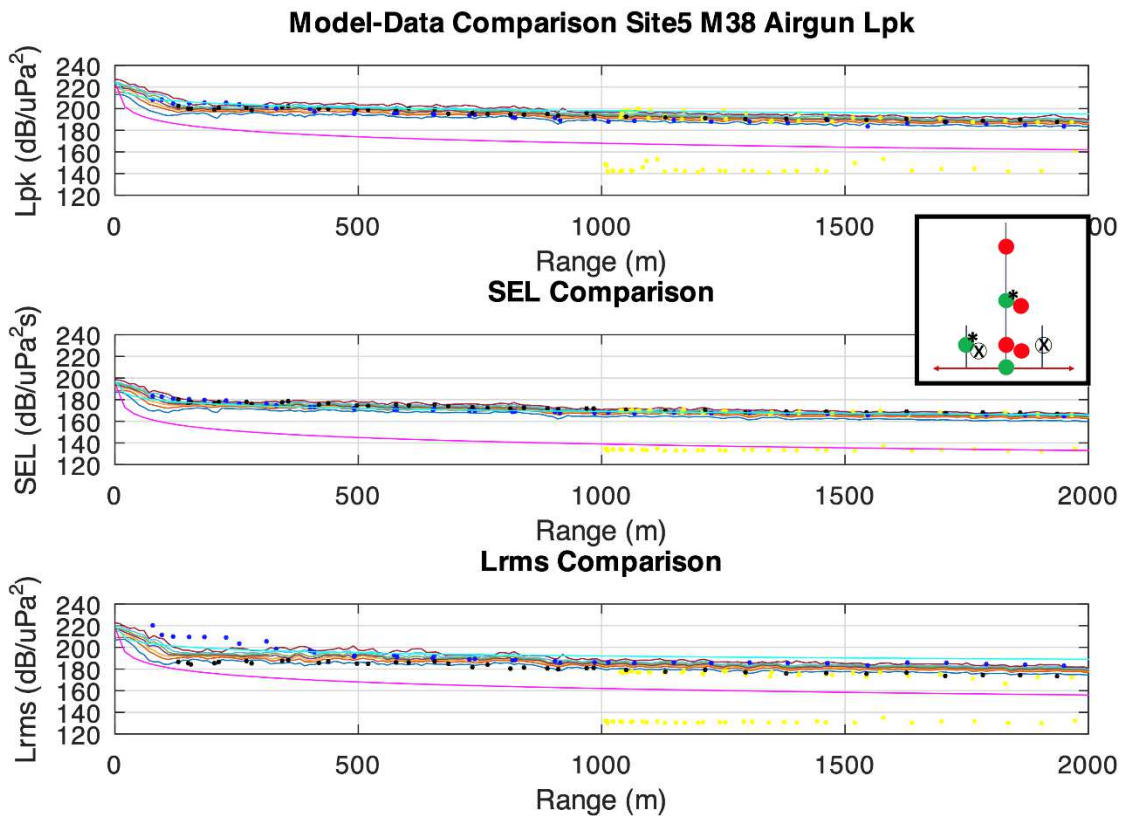
B.39.3 Site 3 – Mud, 30-m Depth

There were no Mode 38 source tows.

B.39.4 Site 4 – Sand, 30-m Depth

There were no Mode 38 source tows.

B.39.5 Site 5 – Sandy-Silt, 100-m Depth



B.40 Applied Acoustics Delta Sparker, 2.4 kJ, Low Power (Mode 39)

The Delta Sparker is an LF source.

B.40.1 Site 1 – Mud, 10-m Depth

There were no Mode 39 source tows.

B.40.2 Site 2 – Sand, 10-m Depth

There were no Mode 39 source tows.

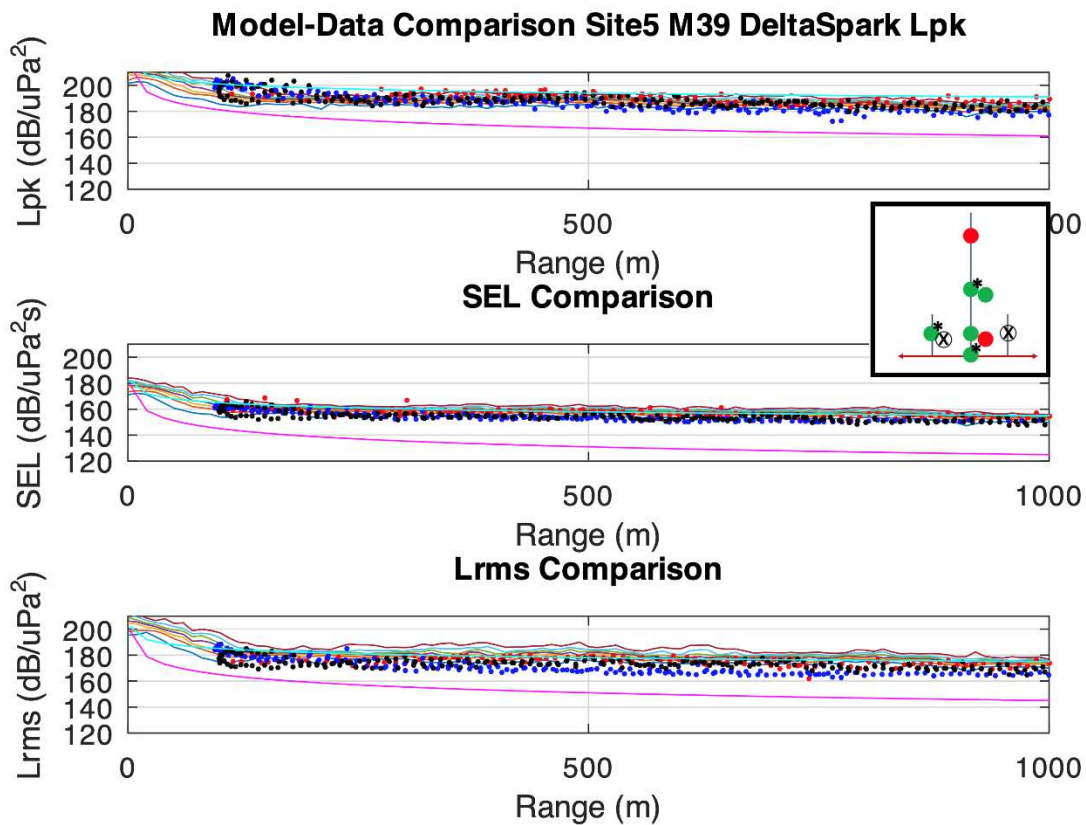
B.40.3 Site 3 – Mud, 30-m Depth

There were no Mode 39 source tows.

B.40.4 Site 4 – Sand, 30-m Depth

There were no Mode 39 source tows.

B.40.5 Site 5 – Sandy-Silt, 100-m Depth



B.41 Applied Acoustics Delta Sparker, 1.5 kJ, Low Power (Mode 40)

The Delta Sparker is an LF source.

B.41.1 Site 1 – Mud, 10-m Depth

There were no Mode 40 source tows.

B.41.2 Site 2 – Sand, 10-m Depth

There were no Mode 40 source tows.

B.41.3 Site 3 – Mud, 30-m Depth

There were no Mode 40 source tows.

B.41.4 Site 4 – Sand, 30-m Depth

There were no Mode 40 source tows.

B.41.5 Site 5 – Sandy-Silt, 100-m Depth

There were no Mode 40 source tows with good data.