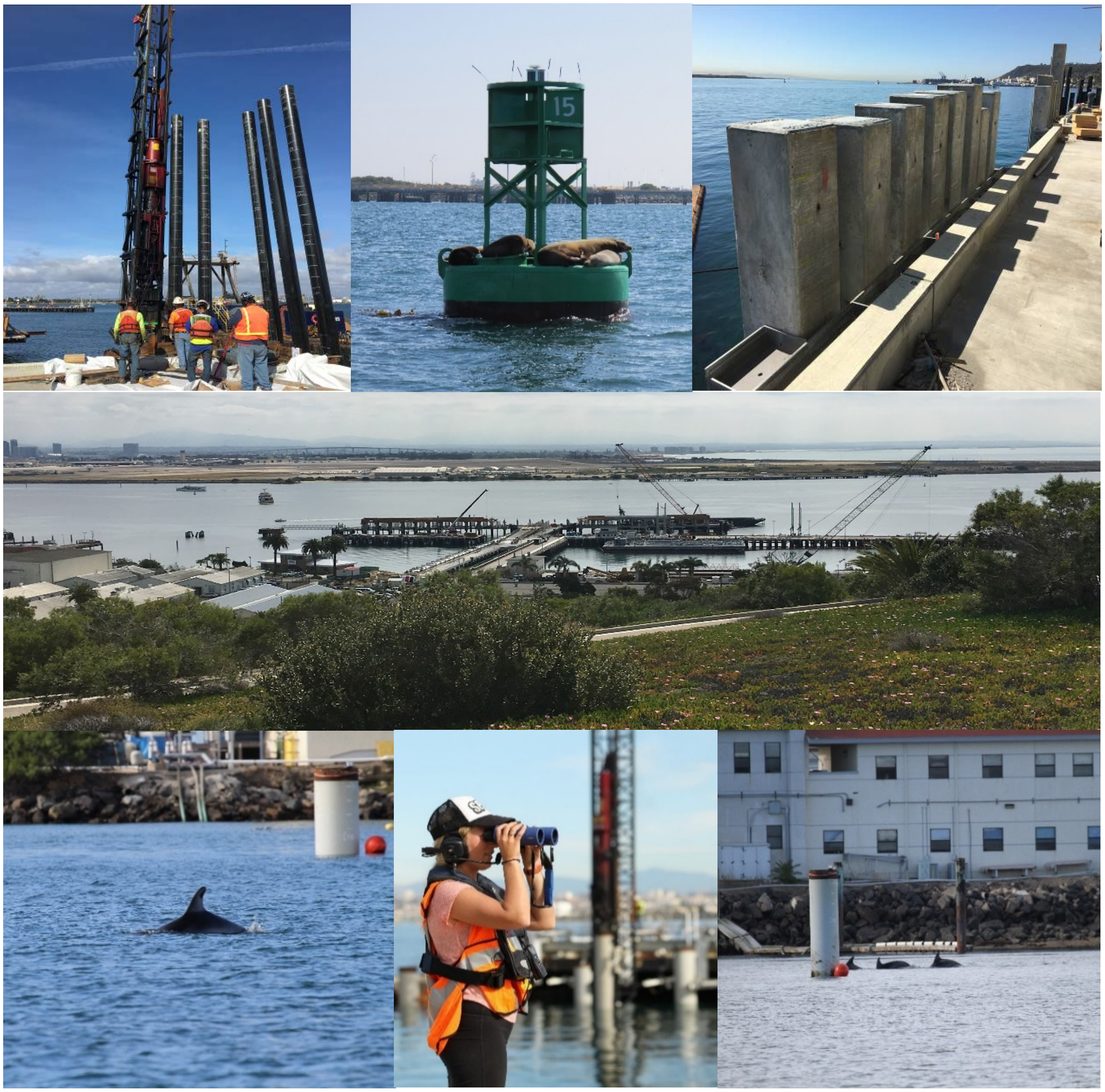
COMPENDIUM OF UNDERWATER AND AIRBORNE SOUND DATA DURING PILE INSTALLATION AND IN-WATER DEMOLITION ACTIVITIES IN SAN DIEGO BAY, CALIFORNIA



October 2020

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COMPENDIUM OF UNDERWATER AND AIRBORNE SOUND DATA DURING PILE INSTALLATION AND IN-WATER DEMOLITION ACTIVITIES IN SAN DIEGO BAY, CALIFORNIA

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Abbreviations and Acronyms

%	percent
APL-UW	Applied Physics Laboratory-University of Washington
Caltrans	California Department of Transportation
dB	decibel
ft	feet
ft^2	square feet
HDA	Harbor Drive Annex
Hz	hertz
IHA	Incidental Harassment Authorization
IPP	Indicator Pile Program
kHz	kilohertz
km	kilometers
kN	kilonewton
L	Level (represented as L_{90}, L_{50}, and L_{10})
LD	Larson Davis
LZ_{eq}	Z-weighted equivalent continuous sound level
LZF_{max}	Z-weighted, Fast (maximum) rms sound pressure level
LZF_{peak}	Level Z unweighted, Fast (peak) rms sound pressure level
m	meters
mi	miles
M1	Method 1 (High-Pressure Water Jetting)
M2	Method 2 (High-Pressure Water Jetting)
MMP	Marine Mammal Program
MMPA	Marine Mammal Protection Act
NAVFAC SW	Naval Facilities Engineering Command Southwest
Navy	U.S. Department of the Navy
NBPL	Naval Base Point Loma
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
psi	pounds per square inch
PTS	permanent threshold shift
R^2	R-squared (coefficient of determination)
re 1 µPa	referenced to 1 microPascal
re 20 µPa	referenced to 20 microPascals
re 1 μPa^2-sec	referenced to 1 microPascal squared seconds
rms	Root mean square
rms_{90}	Root mean square (90^{th} percentile)
SEL	Sound exposure level
SEL_{90}	Sound exposure level (90^{th} percentile)

SEL_{cum}	Cumulative sound exposure level
SIO/UCSD MarFac	Scripps Institution of Oceanography/University of California San Diego, Nimitz Marine Facility
SLM	Sound level meter
SPL	Sound pressure level
TL	Transmission loss
USLM	Underwater sound level meter
WSDOT	Washington State Department of Transportation
ZOI	Zone of Influence
Z-weighted	Z (=’zero’) frequency weighting for the human ear (may also be referred to as unweighted for the human ear)

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1.0 Introduction

1.1 Summary

This technical document summarizes underwater and airborne acoustic data collected during monitoring of two pier and wharf construction and demolition projects in San Diego Bay, California. This document represents the first comprehensive compilation of marine construction-related acoustic data collected for this bay. San Diego Bay is the largest naturally occurring embayment in the Southern California Bight, with approximately 11,000 acres of marine habitat. The nutrient-rich and diverse environment provides habitat for numerous marine species, including fish, sea turtles, marine mammals, and migratory and resident birds (U.S. Department of the Navy [Navy] and Port of San Diego 2013). While most of the data presented herein was collected as part of the Naval Base Point Loma (NBPL) Fuel Pier Replacement Project, this document was prepared so that it would serve as a "living" document, with data from other projects incorporated as additional acoustic data becomes available.

1.2 Background

Marine construction or demolition projects may utilize a variety of equipment, including impact and vibratory hammers, high-pressure water jets, and cutting equipment. Activities with both impulsive (e.g., impact pile driving) and continuous noise (e.g., vibratory pile driving) generate underwater noise with the potential to impact marine animals. Airborne noise has the potential to impact terrestrial species, as well as hauled-out marine mammals. Many of these species are regulated by one or more environmental laws (e.g., Endangered Species Act, Magnuson-Stevens Fisheries Conservation and Management Act, Marine Mammal Protection Act [MMPA], Migratory Bird Treaty Act). Guidance and regulatory thresholds have been developed to protect wildlife from noise associated with marine construction and other anthropogenic activities (e.g., Stadler and Woodbury 2009; Southall et al. 2007; Normandeau Associates 2012; California Department of Transportation [Caltrans] 2015; National Marine Fisheries Service [NMFS] 2016, 2018a).

Hydroacoustic and airborne data collected during past projects provide valuable empirical data regarding sound levels associated with different types of marine construction projects and activities (e.g., Caltrans 2015; Illingworth and Rodkin 2016; Washington State Department of Transportation [WSDOT] 2020). Such information allows approximation of acoustic zones of influence (ZOIs) for projects using similar construction materials and methods. However, sound levels may vary among projects due to differences in materials (e.g., pile composition, shape, or size), equipment (e.g., impact versus vibratory hammer, size of hammer, jetting, type of demolition equipment), and site-specific differences in physical features and environmental conditions. Acoustic monitoring during project implementation allows refinement of ZOI distances to regulatory thresholds based on project- and site-specific conditions.

1.3 Acoustic Terminology

This document uses specialized terminology related to underwater and airborne sound. Terminology is described below based on consideration of several references (Bradley and Stern 2008; Dahl 2020; Discovery of Sound in the Sea 2020; Ketten 2004; NMFS 2018a; Southall et al. 2007, 2019), as follows:

- Impulsive noise — noise with high peak sound pressure, short duration, fast rise-time, and broad frequency content; for example, impact pile driving.
- Non-impulsive (i.e., steady state) noise; for example, vibratory pile driving, water jetting, underwater saws.
- Sound level meter (SLM) is an instrument used to obtain acoustic measurements. The term USLM in this document refers to an underwater sound level meter.

- Sound pressure level (SPL) is the decibel (dB) value of the actual sound pressure divided by a reference sound pressure, and then taking the logarithm (base 10) of the result; i.e., 20log10(sound pressure/reference sound pressure). The reference sound pressure is 20 microPascals (µPa) for airborne sound and 1 µPa for sound in media other than air (i.e., underwater in this report).
- Frequency is the number of times per second that a sound pressure wave repeats itself. The units of sound frequency are hertz (Hz). A Hz is a measure of sound frequency equal to 1 cycle per second. A kilohertz (kHz) is one thousand cycles per second. The 'normal' human hearing range is from 20 Hz to 20 kHz. The generalized hearing range of marine mammals as a group is 7 Hz to 160 kHz.
- Peak sound pressure is the maximum absolute value pressure. Reported in units relative to the reference sound pressure (1 µPa dB for underwater sound; 20 µPa dB in air, also see LZ_{peak} below).
- The rms SPL (also referred to as the time-averaged level) is calculated by taking the square root of the average of the square of the pressure of the sound pressure waveform over the duration of the time period. For ambient and continuous noise sources (e.g., vibratory hammer) it is reported as rms. For impulsive sound sources (e.g., impact pile driving), it is the rms pressure measured over the time period that contained 90 percent (%) of the sound energy (rms_{90}). Reported in units relative to the reference sound pressure (dB re 1 µPa dB for underwater sound or 20 µPa dB in air, also see LZ_{MAX} below).
- Sound Exposure Level (SEL) is a measure of energy that takes into account both received level and duration of exposure. For a single-strike SEL, it is the dB level of the time integral of the squared-instantaneous sound pressure, normalized to a 1-second period. The cumulative SEL (SEL_{cum}) is used to describe the SEL accumulated over the duration of the activity (e.g., many pile strikes). NMFS (2018a) intends for the weighted SEL_{cum} metric to account for the accumulated exposure over the duration of the activity within a 24-hour period) for individual activities/sources; it is not intended for accumulating sound exposure from multiple activities occurring within the same area or over the same time. Both SEL and SEL_{cum} are reported in units relative to the reference sound pressure (dB microPascal squared seconds (re 1 μPa^2-sec) for underwater sound; 20 μPa^2-sec in air; also see LZ_{eq} below).
- Z-weighted (denoted by capital Z), where Z = 'zero' frequency weighting, which provides a flat frequency response across the spectrum of 10 Hz to 20 kHz ±1.5 dB. Z-weighted replaces the older 'Linear' or 'Unweighted' frequency terms as these did not define the frequency range over which the meter would be linear.
- LZ_{eq}: Z-weighted L_{eq}, where L_{eq} is the equivalent continuous sound level, and represents the total sound exposure for the period of interest or an energy average noise level for the period of interest. L_{eq} values are typically written with specification of the frequency weighting, such as Z-weighting, and also the measurement duration. LZ_{eq} normalized to 1 second is equivalent to SEL.
- LZF_{max}: Maximum Z-weighted Fast rms SPL, reported in units of dB re 20 µPa. Fast Time-Weighting (denoted by capital F): a sound level meter set to a fast setting responds to changes in sound in 0.125 seconds (125 milliseconds), which is quicker than a meter set to a slow time weighting. Reported in units relative to the reference sound pressure (dB re 1 µPa dB for underwater sound or 20 µPa dB in air.
- LZ_{peak}: Z-weighted peak SPL. Reported in units relative to the reference sound pressure (dB re 1 µPa dB for underwater sound or 20 µPa dB in air.

The primary acoustic metrics referenced in this document are summarized in Table 1.

Table 1. Summary Metrics for Acoustic Activity Measurements.

Recording Type	Acoustic Activity Type	Metrics (dB)
Hydroacoustic	Impulsive Noise	rms_{90} (Maximum) re 1 µPa Peak (Maximum) re 1 µPa SEL_{90} (Maximum) re 1 µPa^2-sec
	Continuous Noise	rms (Average) rms (Maximum)
Airborne	Impulsive and Continuous Noise	LZF_{max} (Maximum) LZ_{peak} (Maximum) LZ_{eq} (Maximum)

1.4 Document Organization

Following this Introduction, the document is organized in two major sections. Section 2.0 includes brief descriptions of projects and their acoustic data collection and analysis methods. Section 3.0 provides the results of acoustical analyses associated with the projects described in Section 2.0. The data are summarized by project, unique location, activity (e.g., pile installation or in-water demolition activities), pile type (i.e., steel, concrete, poly-concrete) and pile size. All pile installation or demolition methods, as well as underwater and/or airborne acoustic data, are provided under subsection headings organized as described above. Within each subsection, tables are provided that summarize the collected acoustic data as well as specific information pertinent to the data collection, including acoustic equipment (SLM used, deployment depth, stations monitored) and the pile installation or demolition equipment (type used, power level range, or maximum pressure). Appendix A provides expanded acoustic metrics for data summarized in Section 3.0 and Appendix B provides values pertinent to calculation of distances to permanent threshold shift (PTS) onset thresholds (Level A injury) (NMFS 2016, 2018b), as well as sound source levels that may be used to generate distances to the Level B thresholds using a simplistic spreading loss model, as applicable.

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2.0 Projects—Descriptions and Acoustic Methods

This section is organized with separate subsections for each project included in this compendium. For each project, a brief description of the construction and demolition activities and the acoustic equipment and data collection methods are provided. The acoustic data are presented in Section 3.0.

2.1 Naval Base Point Loma Fuel Pier Replacement Project

2.1.1 Project Description

The NBPL Fuel Pier Replacement Project occurred at two locations (the NBPL Fuel Pier and the NBPL Harbor Drive Annex [HDA]) in north San Diego Bay. Dredging only occurred at the NBPL Fuel Pier location; whereas, materials installation and removal activities occurred at both locations. The NBPL Fuel Pier location was approximately 3.4 kilometers (km) (2.1 miles [mi]) from the bay entrance. This project location was on the western side of the bay in a relatively unobstructed location where the bay is approximately 1 km (0.65 nautical mile)-wide and bounded by two land masses, Point Loma to the west and Naval Air Station North Island on Coronado Island to the east. The NBPL Fuel Pier project area had varying depths ranging from approximately 4.6 to 6 meters (m; 15 to 20 feet [ft]) directly around the old fuel pier, but with depths of from 12 to 18 m (40 to 60 ft) on the outside of the new fuel pier, closer to the navigation channel. Water depths in the navigation channel near this project area ranged from 15 to 18 m (50 to 60 ft). The NBPL HDA project area was approximately 6.3 km (3.9 mi) from the bay entrance, on the western side of a relatively narrow channel of approximately 250 m (820 ft). The NBPL HDA location was also near channels to the north and east, with a marina in the east channel. Water depths at the NBPL HDA project area were generally uniform, ranging from 3 to 4 m (10 to 13 ft). Due to different landform and bathymetric environments, the propagation of underwater sound differed at these project-related locations; therefore, acoustic data for these two locations are presented in separate subsections in Section 3.

The Fuel Pier Replacement Project was phased over a five-year timeline, with Phase 1 involving dredging of the turning basin to the east of the pier, the temporary relocation of the Navy's Marine Mammal Program (MMP) enclosures from their location close to the fuel pier to the NBPL HDA location, and the Incidental Harassment Authorization (IHA) Year 1 covering the Indicator Pile Program (IPP) for the Project. IHA Year 2 included the completion of the pile driving for the IPP, and installation of steel structural piles for the new fuel pier decking, as well as the installation of a temporary mooring dolphin at the south end of the old fuel pier. IHA Year 3 involved driving a portion of the new fuel pier fender pile system. IHA Year 4 included pile driving of the fender and mooring dolphin piles for the new fuel pier, including the final two IPP piles; starting the demolition of the old fuel pier; moving the MMP enclosures back to their normal location near the fuel pier; and returning the HDA docks to their original marina configuration. IHA Year 5 included the completion of demolition of the old fuel pier, including removal of the caissons, structural and fender piles, and the temporary mooring dolphin installed during Phase 2.

A total of 554 piles (including concrete, poly-concrete, and steel piles) were installed via high-pressure water jetting and impact or vibratory pile driving to support the new fuel pier and relocation of the MMP enclosures at the NBPL HDA. Throughout the course of the Project, as part of the demolition process for the old Fuel Pier, a total of 1,526 steel, concrete, and plastic piles (n=1,471) and steel-encased concrete caissons (n=55) were removed. Underwater demolition work consisted of pile or caisson removal via wire saws, pile clippers, plasma torch cutting, multiple types of high-pressure water jetting, and an underwater chainsaw. Two additional types of equipment (hydraulically actuated reciprocating saw, plasma torch) were briefly used during pile demolition, but acoustic data were not collected either because the of the very short duration of use and/or low sound level (low energy during equipment operation). The IHA monitoring reports (Naval Facilities Engineering Command Southwest [NAVFAC SW] 2014, 2015, 2016a,b, 2017a,b, 2018) provided detailed descriptions of all Project-related activities, as well as the methods of acoustic data collection. Acoustic data were collected for 265 (12.7%) of the 2,080 piles or caissons, providing a good representation of the acoustic signatures for the different types and sizes of pier structures removed or installed (Table 2). The initial intent of acoustic monitoring during IHA Year 1 was to verify the ZOIs that were based on modeling from Dahl et al. (2012), with a site-specific acoustic modeling put forth in the initial IHA application (Navy 2013). During subsequent project phases, as new pile sizes or types were removed or installed, or new techniques were used, *in situ* acoustic data were collected to verify any simplistic modeling (i.e., via practical spreading loss) used to generate ZOIs based on sound source levels for similar piles and in-water activities from other locations (Caltrans 2015; WSDOT 2005, 2007a,b, 2012).

Table 2. Summary of Recorded Piles and Caissons per Project Phase.

Pile Size	Pile Type	Number of Piles/Caissons Recorded					TOTAL
		IHA Year #1	IHA Year #2	IHA Year #3	IHA Year #4	IHA Year #5	
Pile Installation							
16-inch[1]	Round concrete	55			16		**71**
16-inch	Round poly-concrete			11			**11**
18-inch	Round steel		1				**1**
24x30	Rectangular concrete			29	5		**34**
30-inch	Round steel	2	2				**4**
36-inch	Round steel	7	33				**40**
SUBTOTAL		**73**	**36**	**40**	**21**	**0**	**170**
Pile/Caisson Removal							
16-inch[1]	Round concrete	16			8		**24**
16-inch	Square concrete				25		**25**
18-inch	Square concrete			6	11		**17**
24-inch	Square concrete				4	17	**21**
66-inch	Round caisson					1	**1**
84-inch	Round caisson				7		**7**
SUBTOTAL		**16**	**0**	**6**	**55**	**18**	**95**
TOTAL		**89**	**36**	**46**	**76**	**18**	**265**

Note: [1]Data recorded at the NBPL HDA. All other data were recorded at the NBPL Fuel Pier.

2.1.2 Methods

2.1.2.1 Acoustic Monitoring Equipment

Acoustic monitoring for installation and demolition activities began in January 2014 with the IPP and was finished in early 2018 with the completion of the demolition of the old fuel pier. Various SLMs were used to collect both hydroacoustic and airborne acoustic data associated with in-water pile driving and demolition activities (Table 3). The Larson Davis (LD; model 831) SLM was used to collect airborne and limited underwater data (i.e., diamond wire saw cutting of 66-inch round caissons). Initially, underwater sound levels associated with pile driving (impact, vibratory) were collected using the Loggerhead DSG-Ocean (Loggerhead) underwater acoustic datalogger, but the majority of data were collected using a custom-made USLM developed under the leadership of Dr. Peter Dahl at the Applied Physics Laboratory-University of Washington (APL-UW USLM; also referred to as Hydro dB USLM in the IHA monitoring reports). The Loggerhead USLM did not provide the capability for live field reporting of sound metrics, and data downloaded from the instruments were post-processed by staff at the APL-UW. The APL-UW USLM provided real-time sound metrics via a tablet-based system, as well as an output that could be easily post-processed as part of internal acoustical processing efforts. All airborne data were collected using a LD 831 SLM unit fitted with a microphone attachment and preamplifier.

Table 3. Equipment Used to Collect Acoustic Data.

Make	Model	Hydrophone/Microphone
Underwater Sound Level Meters		
Larson Davis	831	Reson TC-4033
Loggerhead	DSG-Ocean	HTI 96-min[1]
APL-UW USLM	Custom	HTI 96-min[2]
Airborne Sound Level Meters		
Larson Davis	831	PCB 377B02
Preamplifier		PCB PRM 831
Calibration (Pistonphone)		
ETMC Technologies	42AC	N/A

Note: [1]Sensivities ranged from 180 dBV/µPa to 220 dBV/µPa depending on hydrophone and respective deployment location; [2]Hydrophone sensitivity 206 dBV/µPa. N/A=Not Applicable.

2.1.2.2 Instrument Calibration

Individual hydrophones and PCB microphones were regularly calibrated, and in the case of hydrophones, calibration tones were recorded for at least thirty seconds to establish relative receiving voltage sensitivity relationships needed for post-processing of recorded data. Calibrations were made using an ETMC 42AC pistonphone equipped with custom couplers designed for a 96-min hydrophone and PCB microphone. The pistonphone generates a consistent 100 Pascal signal and calibrations were made at 163.9 dB re 1 µPa at 250 Hz for each hydrophone and 134.0 dB re 20 µPa at 250 Hz for airborne microphones each day prior to deployment. During times when both the Loggerhead and the APL-UW USLMs were used at the same locations and times, the Loggerhead USLM data logger files were intermittently compared to APL-UW USLM data recordings to conduct reference calibrations and to ensure consistent results.

2.1.2.3 Acoustic Data Collection

Underwater Acoustic Data Collection

Underwater SPLs were recorded within approximately 10 m (33 ft) of construction or demolition (i.e., source measurements) as well as at various distances from the source of the noise (far-field measurements). All source data were collected from the barges associated with the pile installation or pier demolition activities, and all far-field measurements were either from a boat at anchor, or from piers or barges near the project area. In all cases, regardless of hydrophone location, the measurements were recorded at a depth equal to half of the water depth, and the positions were logged for each individual sound recording file. During all vessel-based acoustic recordings, the vessel’s engine and depth sounder were turned off. The hydrophones were deployed so that minimal influence from the deployment process would interfere with the data collection. The monitoring reports for each year (NAVFAC SW 2014, 2015, 2016a,b, 2017a,b, 2018) provide details of any differences in acoustic data collection methodologies for each project phase.

The Loggerhead units used hydrophones with different sensitivities depending on deployment at source (10 m [33 ft]) or at far-field locations. As mentioned in the previous section, the data were downloaded from the units and sent to the APL-UW for analysis. With the transition to the APL-UW USLM, the hydroacoustic measurements were recorded using either the “impact” setting (i.e., during impact pile driving) or “vibratory” setting (i.e., vibratory pile driving, or other non-impulsive noise sources). For in-water activities using other equipment (e.g., high-pressure water jetting, pile clipping, underwater saw cutting, diamond wire saw), the data initially were recorded using both the “impact” and “vibratory” settings; however, data reported herein were from the “vibratory” setting because the sounds pressure waveforms were more similar to a non-impulsive sound source than to impulsive noise during impact pile driving; Dr. Dahl was consulted as necessary to confirm the proper instrument setting.

For the first IHA, a site-specific model was developed for Transmission loss (TL) from pile driving at a central point at the NBPL Fuel Pier project site (Navy 2013). The model was based on historical temperature-salinity data and location-dependent bathymetry. In the model, TL was the same for different sound source levels and was applied to each of the different activities to determine the point at which the applicable marine mammal acoustic thresholds were reached as a function of distance from the source. The model's predictions were intended to be conservative and were tested during pile driving for the IPP (NAVFAC SW 2014, 2015), as well as during IHA Year 2. The collected acoustic data were used to adjust the distances to the MMPA Level A (injury) and Level B (behavioral harassment) ZOIs to reflect actual field conditions, as opposed to a model. This same method was followed for each subsequent year, with new *in situ* acoustic data replacing any modeling that was performed to predict ZOIs.

<u>Airborne Acoustic Data Collection</u>

Airborne sound recordings were collected at source (15.2 m [50 ft]) as well as at various distances away (up to a maximum of 250 m [820 ft]) during pile driving activities. The airborne measurement system was positioned with a direct line of sight to the pile and mounted approximately 1.5 m (5 ft) above construction barges or pier structures. Airborne sound measurements were recorded for both vibratory and impact pile driving activities to determine airborne SPLs.

<u>Ambient Data Collection</u>

Both airborne and hydroacoustic ambient data were collected during IHA Years 2 to 3. During the recording periods, ambient data collection was conducted in a manner consistent with National Oceanic and Atmospheric Administration (NOAA) guidance for both underwater and airborne measurements (NOAA 2012), with the ambient underwater data collected over three days in the absence of construction activities and during typical construction time periods (07:00 to 16:00). Ambient underwater data were conducted using the Loggerhead USLM, to the extent possible in paired measurements at two different locations approximately 400 to 750 m (1,312 to 2,461 ft) to the south and north of the NBPL Fuel Pier project location, respectively. These hydrophone sites were chosen to minimize the potential for boat traffic to effect results, but to be within the potential project impact footprint.

During IHA Years 2 and 3, ambient airborne data collection consisted of four separate efforts during two different seasons of the construction time frame using the LD 831 SLM. Ambient airborne data were collected when no pile driving was taking place, at approximately 250 to 300 m (820 to 984 ft) from the NBPL Fuel Pier project location. The LD 831 SLM units were affixed to tripods adjusted to a height of 1.5 m (5 ft).

2.1.3 Acoustic Data Management and Analysis

Acoustic information was documented on field data forms and then transferred to Tierra Data, Inc.'s master database. Information collected at the time of the recording included: date, acoustic technician's initials, general morning/afternoon weather information (wind, waves, and air temperature), pile number, hydrophone location, hydrophone depth, water depth, start/end time of activity, and type of activity. Data records were subject to quality assurance/quality control during data entry and printed copies for each day were archived with the original field data forms. Saximeter recordings provided by the construction contractor, including the number of strikes per pile and depth of the piles also were input to the database. All raw acoustic files from the APL-UW USLM were saved as *.BIN files and converted to *.TXT files, which were imported into MS Excel where mean values were calculated for acoustic metrics and minimum and maximum values were identified. Raw files from the Loggerhead were saved as *.DSG files and post processed using Matlab software to identify maximum vibratory pile driving SPLs and duration, and to calculate reporting metrics for impact pile driving activities. The LD 831 SLM units simultaneously recorded in two file formats: one as a raw wav file and the other as a summary file archiving several acoustic metrics. The raw wav files from the LD 831 were processed using the Larson Davis Slim Utility-G3 software.

Mean and maximum (and sometimes median) metrics were reported for impact pile driving metrics (rms_{90}, peak, and SEL_{90}) and for vibratory pile driving and other non-impulsive sounds (rms). SELcum was computed for individual pile driving events based on single strike SEL_{90} and number of hammer strikes, as defined by the mean single strike SEL + 10*log10 (# hammer strikes) in dB re μPa^2-sec.

In some cases (e.g., caisson cutting, pile jetting), the SPLs at far-field distances were difficult to distinguish from ambient noise during real-time data collection and a reliable *in situ* distance to the Level B ZOI could not be determined. As a result, source levels recorded at 10 m (33 ft) and calculations based on a Practical Spreading Loss model were used to estimate the distance to the Level B ZOI. Due to the nearshore environment associated with San Diego Bay, the Practical Spreading Loss model was chosen as the best alternative to real-time data. Because the far-field measurements were also hard to distinguish from ambient noise for pile clipping activities, the Practical Spreading Loss model also was used in place of *in situ* data for these activities.

For all acoustic data, plots of the dBs relative to distance were generated and trendlines (i.e., linear or logarithmic) applied (see figures in Section 3 by pile size/type and installation or removal method). The coefficient of determination (R squared [R^2]) values were used to identify the best fit trendlines and TL values were calculated from the data. TL is considered herein to be equivalent to the terms “transmission loss” or “propagation” in the NMFS user spreadsheet (NMFS 2018b).

The TL is the accumulated decrease in acoustic intensity as an acoustic pressure wave propagates outwards from a source. The intensity of sound pressure is reduced with increasing distance due to spreading. Spreading can be categorized into two models, spherical spreading and cylindrical spreading models. The TL parameters vary with frequency, temperature, sea or atmospheric conditions, current, source and receiver depth or height, water depth, water chemistry, and bottom composition and bathymetry (in water), or landforms (in air).

The general formula for TL is:

$$TL = B * \log_{10}(R) + C * R, \text{ where}$$

B = logarithmic (predominantly spreading) loss
C = linear (scattering and absorption) loss
R = ratio of receiver distance to source reference distance (usually 1 m or 10 m)

The C term is strongly dependent on frequency, temperature, and depth, but is conservatively assumed to equal zero for pile driving. The B term has a value of 10 for cylindrical spreading and 20 for spherical spreading. A practical spreading value of 15 is often used in shallow water conditions where spreading may start out spherically but then end up cylindrically as the sound is constrained by the water surface and the bottom sediments. For the purposes of generating distances to MMPA Level A thresholds for projects in San Diego Bay, if a specific TL value is not available, a practical spreading value of 15 is considered the most applicable TL value. The TL values identified in the following sections, and in Appendix B, were calculated using actual maximum dB rms values and may be used in place of simplistic spreading loss models (e.g., spherical, cylindrical, or practical spreading loss) for projects using similar equipment, pile size/type and locations in San Diego Bay unless noted otherwise.

2.2 Nimitz Marine Facility Pier Replacement Project

2.2.1 Project Description

The University of California replaced an existing pier structure associated with the Scripps Institution of Oceanography/University of California San Diego, Nimitz Marine Facility (SIO/UCSD MarFac) on San Diego Bay. The activities entailed demolishing the existing structurally deficient wharf (10,285 square feet [ft^2]) and pier (18,250 ft^2) and constructing a new wharf and pier of approximately the same size and orientation. 24-inch-diameter octagonal concrete piles were installed to support the new wharf and pier and 18-inch square concrete fender piles were installed to provide greater energy absorption and durability than the old system.

The surrounding waters around the pier are a high use area, with boats entering or leaving the moorings and marinas behind Shelter Island to the northeast of the project location. Water depths in the area range from less than 3 m (9.8 ft) at a shoaling marker approximately 300 m (984 ft) to the east of the site, to 6.4 m (21 ft) in a narrow navigation channel adjacent to the pier that leads to the moorings and marina behind Shelter Island.

2.2.2 Methods

2.2.2.1 Acoustic Monitoring Equipment

The same APL-UW USLM and hydrophone described in Section 2.1.2.1 were used for the hydroacoustic data collection at the SIO/UCSD MarFac pier (see Table 3 for descriptions of the APL-UW USLM and hydrophone used). No airborne pile driving, or ambient data were collected as part of the SIO/UCSD MarFac pier construction.

2.2.2.2 Instrument Calibration

The same calibration methods were used as described in Section 2.1.2.2 for the APL-UW USLM hydrophone.

2.2.2.3 Acoustic Data Collection

Underwater Acoustic Data Collection

In January 2015, 18-inch square concrete piles were installed and hydroacoustic data was collected for impact pile driving on three piles (2.1% of the 140 total piles driven). The APL-UW USLM was used to collect far-field data at 40, 45, and 80 m (131, 147, and 262 ft, respectively) from a small boat (5.2 m [17 ft]). Source data was not collected due to safety concerns with being very close to pile driving activities. The hydrophone was lowered into the water to mid-depth (approximately 3 to 3.5 m [9.8 to 11.5 ft]) and data were recorded using the “impact” pile driving setting. To eliminate the potential for noise interference from pile driving at the NBPL Fuel Pier, the acoustic data collection for the SIO/UCSD MarFac pier was timed so that pile driving at the NBPL Fuel Pier was not occurring at the same time.

2.2.3 Acoustic Data Management and Analysis

The data collected as part of this acoustic measurement effort were not part of any specific monitoring project, but rather were collected on an opportunistic basis. The underwater acoustic data were recorded and logged following the same procedures identified in Section 2.1.3.

3.0 Acoustic Data

This section is organized into major subsections for each project and unique project locations identified in Section 2.0. The major subsections are further separated according to type and size of pile (or caisson) and construction equipment used. Appendix A provides expanded acoustic metrics and Appendix B provides pertinent values that may be used as input to the NMFS (2018b) optional User Spreadsheet tool to estimate distances associated with PTS onset (Level A injury) thresholds (NMFS 2016, 2018a).

3.1 Naval Base Point Loma Fuel Pier Replacement Project – Fuel Pier

3.1.1 Steel Pile Installation (Underwater and Airborne Acoustics)

3.1.1.1 18-inch Round Steel Pipe Piles (Impact Driving, Underwater Acoustics)

In March 2015, four 18-inch steel piles were temporarily installed to provide support for the southern section of the old Fuel Pier after a section was removed to allow construction of a trestle for the new Fuel Pier. Acoustic data were collected using the APL-UW USLM at source (10 to 12 m [33 to 39 ft]) for all four piles (Table 4, Figure 1). Maximum rms_{90} values ranged from 184.4 to 187.1 dB, maximum peak values ranged from 200.7 to 202.4 dB, and maximum single strike SEL_{90} values ranged from 171.1 to 174.4 dB (Table 5). Figure 2 shows an example of the APL-UW USLM data output at the source location. A TL could not be calculated for the 18-inch round steel piles because data were only recorded at source. For expanded metrics see Appendix A.1 and Appendix B.1.

Table 4. Acoustic and Pile Installation Equipment Used for 18-inch Round Steel Pipe Piles at the NBPL Fuel Pier (Impact Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (foot-pounds [ft-lbs])
APL-UW USLM	4.0	Source	D62-22 DELMAG Diesel Impact Hammer	76,956 - 153,770

Table 5. Maximum Underwater Sound Pressure Metrics for Impact Pile Driving of 18-inch Round Steel Pipe Piles at Source (10 to 12 m [33 to 39 ft]).

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 μPa)		Maximum (dB re 1 μPa²-sec)
				rms_{90}	Peak	SEL_{90}
11-Mar-15	T3	Source	10 (33)	187.0	201.7	172.6
	T1		10 (33)	184.4	200.7	171.1
	T4		12 (39)	187.1	202.4	174.4
	T2		12 (39)	186.4	201.9	173.1

Notes: All SEL_{90} values are for a single strike.

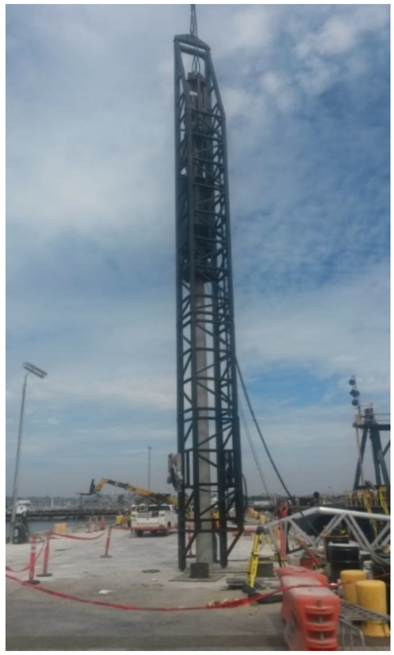

Figure 1. Installation of 18-inch Round Steel Pipe Piles Using a D62-22 Diesel Powered Impact Hammer.

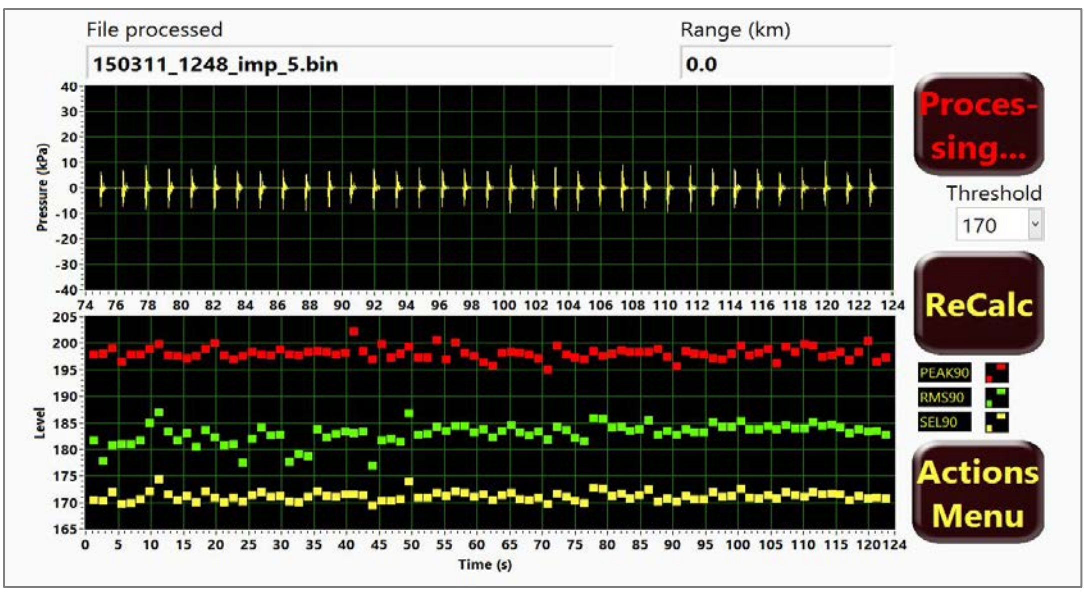

Figure 2. APL-UW USLM Acoustic Time Series Plot for Impact Pile Driving of 18-inch Round Steel Pipe Piles at Source (10 m [33 ft]).

3.1.1.2 30-inch Round Steel Pipe Structural Piles (Vibratory and Impact Driving, Underwater and Airborne Acoustics)

In May and October 2014 and then again in February and March 2017, acoustic monitoring was conducted for the installation of 30-inch steel pipe piles associated with construction of individual mooring and breasting dolphins located both north and south of the main fuel pier structure (Figure 3). All piles were initially installed by vibratory pile driving and completed via impact pile driving. Subsections below summarize hydroacoustic and airborne data recorded during the two pile driving operations.

Figure 3. Installation of 30-inch Round Steel Piles for NBPL Fuel Pier Mooring Dolphins.

Vibratory Pile Driving (Underwater Acoustics)

Underwater acoustic monitoring of 30-inch round steel pipe piles during vibratory driving was completed using two USLMs (Table 6, Figure 4). In 2014 the Loggerhead USLM was used and reported values were maximum SPLs. Data were again collected on this pile type in 2017 using the APL-UW USLM, and reported metrics included average and maximum SPLs. Data were collected both at source (10 m [33 ft]) and at far-field distances ranging from 154 to 480 m (505 to 1,575 ft). At source, average SPLs ranged from 166.0 to 169.5 dB rms and maximum SPLs ranged from 160.0 to 174.0 dB rms (Table 7). At far-field distances, average SPLs ranged from 146.0 to 149.3 dB rms and maximum SPLs ranged from 149.5 to 162.0 dB rms (Table 7). A logarithmic trendline provided a relatively strong fit to the data (R^2 of 0.747) (Figure 5). The calculated TL associated with the installation of 30-inch round steel piles was 10.1. For expanded metrics see Appendix A.1 and Appendix B.2.

Table 6. Acoustic and Pile Installation Equipment Used for 30-inch Steel Pipe Piles at the NBPL Fuel Pier (Vibratory Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (kilonewtons [kN] [tons])
Loggerhead	2.0 - 9.0	Source, Far-Field	APE Variable Moment 250 VM Vibratory Hammer/Extractor	2,389 (269)
APL-UW USLM				

Figure 4. Installation of 30-inch Steel Pipe Piles Using an APE Variable Moment 250 VM Vibratory Hammer/Extractor.

Table 7. Underwater Sound Pressure Metrics for Vibratory Pile Driving of 30-inch Round Steel Pipe Piles at Source (10 m [33 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
7-May-14	D1-DB[1]	Source	10 (33)	No Data	172.0
8-May-14	TD2-TDB[1]				168.0
24-Oct-14	TD1-TDA[1]				165.0
24-Oct-14	TD2-TDB[1]				160.0
22-Feb-17	D7-DA			166.0	172.4
	D8-DA			169.5	174.0
7-May-14	D1-DB[1]	Far-Field	154 (505)	No Data	162.0
28-Feb-17	D8-DB-B2		200 (656)	148.5	155.9
8-Mar-17	D7-DA-B1			149.3	152.8
8-May-14	TD2-TDB[1]		272 (892)	No Data	155.0
18-Mar-17	D6-PB-B2		480 (1,575)	146.0	149.5

Note: [1]Data collected using the Loggerhead, all other data were collected using the APL-UW USLM.

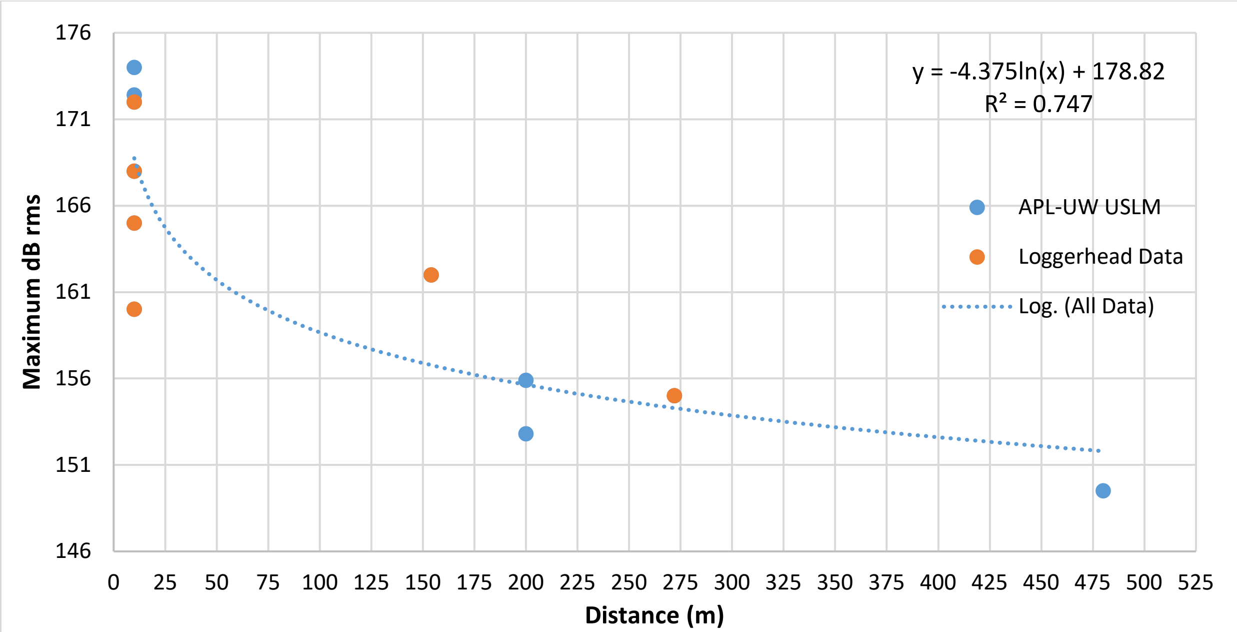

Figure 5. Maximum Underwater dB rms for Vibratory Pile Driving of 30-inch Round Steel Pipe Piles at Source (10 m [33 ft]) and Graduated Distances.

Vibratory Pile Driving (Airborne Acoustics)

In February and March 2017, airborne acoustic monitoring was conducted during the vibratory driving of 30-inch steel piles. Data were recorded using the LD 831 SLM at both source (15.2 m [50 ft]) and far-field distances ranging from 200 to 257 m (656 to 843 ft). At source, LZF_{max} values ranged from 102.4 to 106.3 dB, LZ_{peak} values ranged from 114.6 to 117.2 dB, and LZ_{eq} values ranged from 102.1 to 106.0 dB (Table 8). Far-field LZF_{max} values ranged from 86.9 to 104.4 dB, LZ_{peak} values ranged from 97.7 to 114.9 dB, and LZ_{eq} values ranged from 85.4 to 102.8 dB (Table 8). A linear trendline had a relatively strong fit to the data (R^2 value of 0.806) (Figure 6). The TL for airborne sound during 30-inch steel vibratory pile driving was 11.9. For expanded metrics see Appendix A.5.

Table 8. Maximum Airborne Sound Pressure Metrics for Vibratory Pile Driving of 30-inch Round Steel Pipe Piles at Source (15.2 m [50 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 μPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
17-Mar-17	D5-PD-B1	Source	15.2 (50)	104.8	117.0	104.2
16-Mar-17	D5-PD-B2			105.2	117.2	104.8
17-Mar-17	D5-PB-B2			104.1	116.0	103.6
18-Mar-17	D6-PB-B2			102.8	115.5	102.1
1-Mar-17	D8-DB-B1			106.3	116.6	106.0
22-Feb-17	D8-DA			102.4	114.6	102.3
	D7-DA			103.0	116.0	102.5
16-Mar-17	D5-PD-B2	Far-Field	200 (656)	97.5	103.4	94.5
15-Mar-17	D6-PD-B2			93.8	114.9	102.8
8-Mar-17	D7-DA-B1			86.9	97.7	85.4
28-Feb-17	D8-DB-B2			94.9	102.0	91.3
16-Mar-17	D6-PD-B1			92.3	99.9	89.5
17-Mar-17	D5-PB-B2		257 (843)	104.4	111.7	100.9
	D5-PD-B1			102.3	108.0	99.0

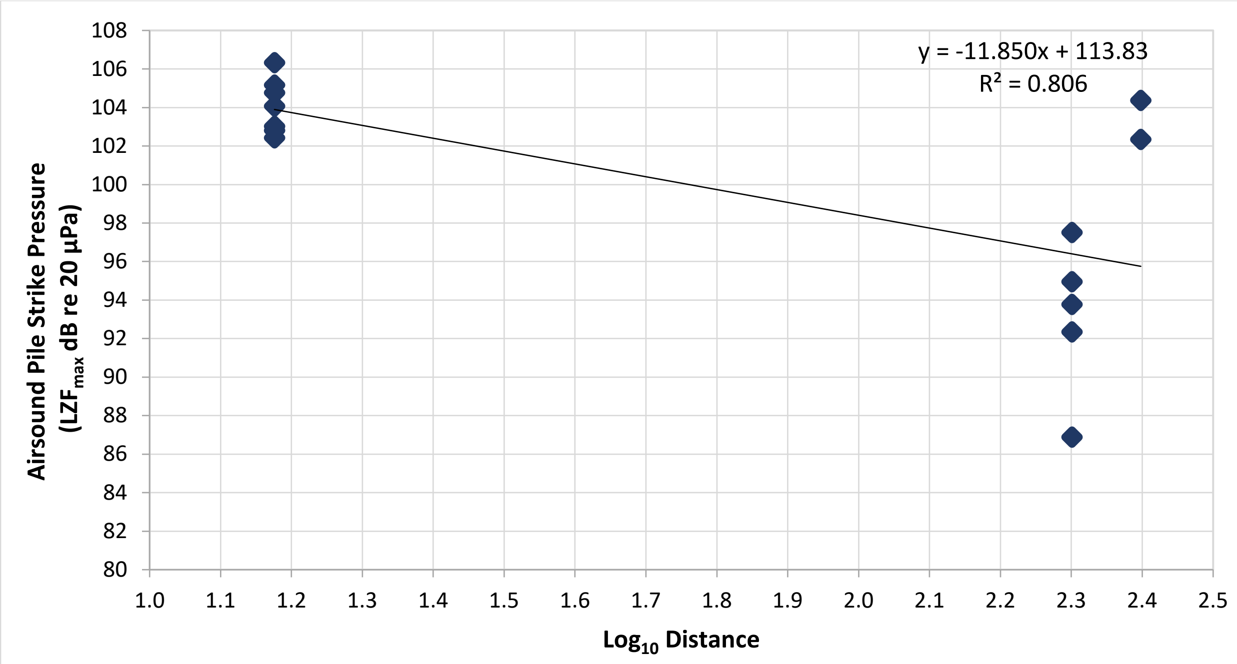

Figure 6. Maximum Airborne LZF_{max} for Vibratory Pile Driving of 30-inch Round Steel Pipe Piles at Source (15.2 m [50 ft]) and Graduated Distances.

Impact Pile Driving (Underwater Acoustics)

Underwater acoustic monitoring of impact driving of 30-inch round steel piles was completed using the Loggerhead USLM in 2014 and APL-USLM in 2017 (Table 9, Figure 7). Both source (10 m [33 ft]) and far-field data at distances ranging from 124 to 3,045 m (407 to 9,990 ft) were collected. At source, maximum rms_{90} values ranged from 192.0 to 200.6 dB, maximum peak values ranged from 206.0 to 216.4 dB, and maximum single strike SEL_{90} values ranged from 176.0 to 184.8 dB (Table 10). At far-field distances, maximum rms_{90} values ranged from 152.4 to 187.6 dB, maximum peak values ranging from 182.7 to 197.9 dB (only collected with the APL-UW USLM), and maximum SEL_{90} values ranged from 139.7 to 171.8 dB (Table 10). A logarithmic trendline provided a relatively strong fit to the data (R^2 value of 0.879) (Figure 8). The calculated TL associated with the installation of 30-inch round steel piles was 15.5. For expanded metrics see Appendix A.1 and Appendix B.1.

Table 9. Acoustic and Pile Installation Equipment Used for 30-inch Round Steel Pipe Piles at the NBPL Fuel Pier (Impact Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (ft-lbs)
Loggerhead	2.0 - 9.0	Source, Far-Field	D62-22 DELMAG Diesel Impact Hammer	76,956 - 153,770
APL-UW USLM				

Figure 7. Installation of 30-inch Steel Pipe Piles Using a D62-22 Diesel Powered Impact Hammer.

Table 10. Maximum Underwater Sound Pressure Metrics for Impact Pile Driving of 30-inch Round Steel Pipe Piles at Source (10 m [33 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 μPa) rms$_{90}$	Maximum (dB re 1 μPa) Peak	Maximum (dB re 1 μPa^2-sec) SEL$_{90}$[2]
7-May-14	D1-DB[1]	Source	10 (33)	195.5	No Data	180.0
8-May-14	TD2-TDB[1]			194.6		178.5
24-Oct-14	TD1-TDA[1]			196.0	210.0	179.0
	TD2-TDB[1]			192.0	206.0	176.0
22-Feb-17	D7-DA			198.2	213.5	182.8
	D8-DA			200.6	216.4	184.8
7-May-14	D1-DB[1]	Far-Field	124 (407)	188.0	No Data	171.8
8-Mar-17	D7-DA-B1		200 (656)	187.3	197.9	170.7
8-May-14	TD2-TDB[1]		279 (915)	184.8	No Data	169.0
18-Mar-17	D6-PB-B2		480 (1,575)	167.0	185.3	157.9
9-Mar-17	D8-DA-B1		525 (1,722)	162.7	182.7	155.4
8-May-14	TD2-TDB[1]		2,157 (7,077)	161.2	No Data	148.9
7-May-14	D1-DB[1]		2,385 (7,825)	162.6		148.1
8-May-14	TD2-TDB[1]		3,045 (9,990)	152.4		139.7

Note: [1]Data collected using the Loggerhead, all other data collected using the APL-UW USLM; [2]All SEL$_{90}$ values are for a single strike.

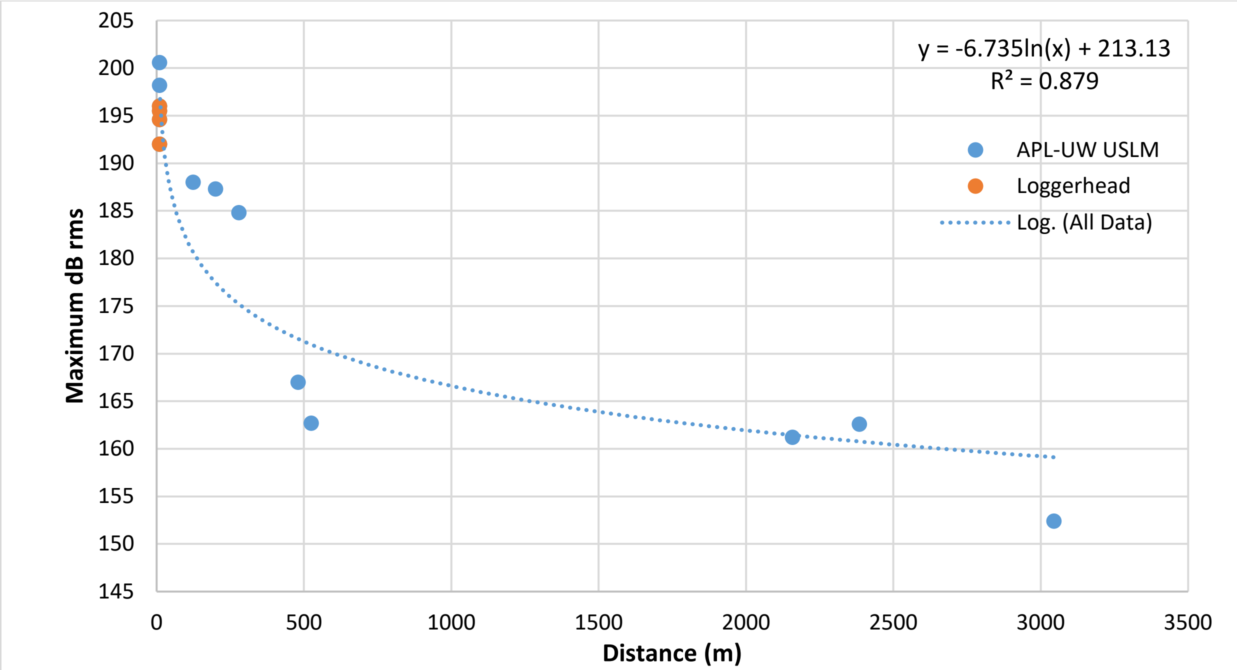

Figure 8. Maximum Underwater dB rms_{90} for Impact Pile Driving of 30-inch Round Steel Pipe Piles at Source (10 m [33 ft]) and Graduated Distances.

Impact Pile Driving (Airborne Acoustics)

In February and March 2017, airborne acoustic monitoring was conducted during the impact driving of 30-inch steel piles. Data were recorded using the LD 831 SLM, at both source (15.2 m [50 ft]) and far-field distances ranging from 200 to 257 m (656 to 843 ft). At source, LZF_{max} values ranged from 112.4 to 118.5 dB, LZ_{peak} values ranged from 129.0 to 135.7 dB, and LZ_{eq} values ranged from 105.6 to 111.5 dB (Table 11). At far-field distances, LZF_{max} values ranged from 93.1 to 107.8 dB, LZ_{peak} values ranged from 107.2 to 114.9 dB, and LZ_{eq} values ranged from 88.1 to 102.8 dB (Table 11). A linear trendline had a relatively strong fit to the data (R^2 value of 0.776) (Figure 9). The TL for airborne sound during 30-inch steel impact pile driving was 13.1. For expanded metrics see Appendix A.5.

Table 11. Maximum Airborne Sound Pressure Metrics for Impact Pile Driving of 30-inch Round Steel Pipe Piles at Source (15.2 m [50 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 µPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
17-Mar-17	D5-PD-B1	Source	15.2 (50)	118.5	135.7	111.5
1-Mar-17	D8-DB-B1			118.0	135.7	111.3
22-Feb-17	D7-DA			117.4	135.0	110.9
22-Feb-17	D8-DA			117.1	134.6	110.8
16-Mar-17	D5-PD-B2			116.9	133.4	110.6
28-Feb-17	D8-DB-B2			114.0	130.9	107.8
17-Mar-17	D5-PB-B2			113.4	129.0	107.0
18-Mar-17	D6-PB-B2			112.8	130.0	107.0
16-Mar-17	D6-PD-B1			112.4	129.8	105.6
8-Mar-17	D7-DA-B1	Far-Field	200 (656)	93.1	110.8	88.1
16-Mar-17	D5-PD-B2			99.7	107.3	97.2
	D6-PD-B1			99.1	109.1	95.8

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 µPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
18-Mar-17	D6-PB-B2	Far-Field	257 (843)	107.8	114.9	102.8
17-Mar-17	D5-PB-B2			106.7	111.9	102.4
20-Feb-17	D5-PB-B1			93.3	111.9	88.3
17-Mar-17	D5-PD-B1			99.6	107.2	93.7

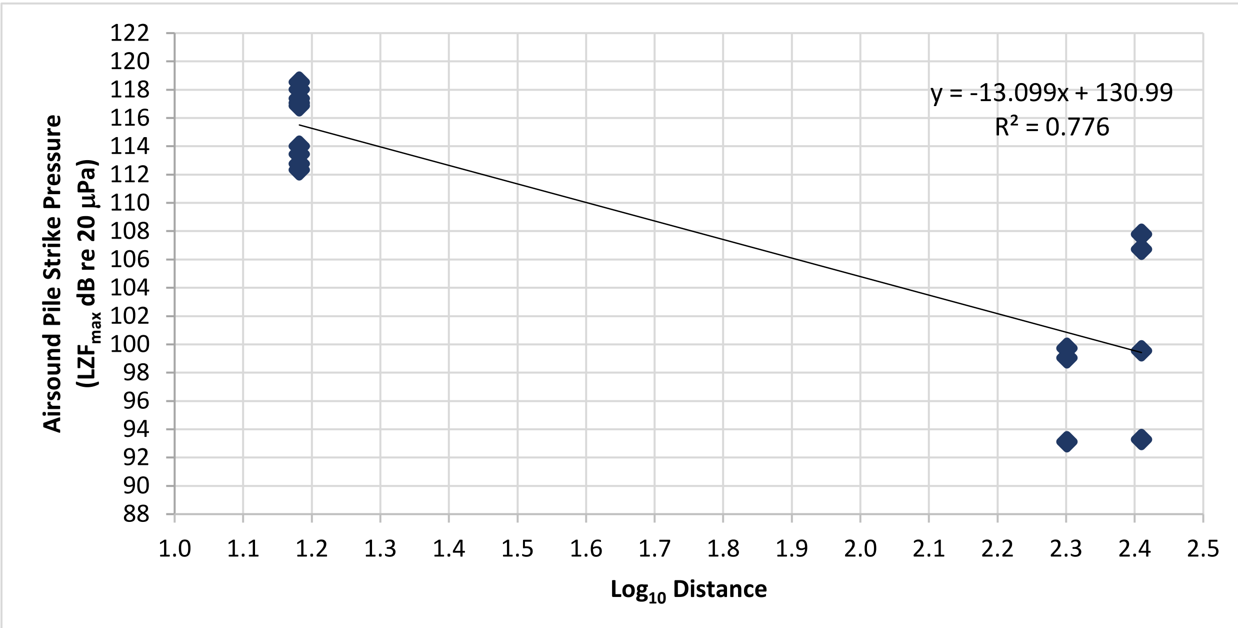

Figure 9. Maximum Airborne LZF_{max} for Impact Pile Driving of 30-inch Steel Pipe Piles at Source (15.2 m [50 ft]) and Graduated Distances.

3.1.1.3 36-inch Round Steel Pipe Structural Piles (Vibratory and Impact Driving, Underwater and Airborne Acoustics)

From November 2014 to April 2015, acoustic monitoring was conducted during installation of 36-inch steel pipe piles associated with the construction of the support structure for the trestle and main part of the new Fuel Pier. All piles were initially driven using the vibratory hammer with installation completed using the impact pile hammer.

<u>**Vibratory Pile Driving (Underwater Acoustics)**</u>

Acoustic monitoring of the 36-inch steel piles was completed using the Loggerhead USLM (Table 12, Figure 10). Maximum SPLs at source (10 m [33 ft) ranged from 164.0 to 175.0 dB rms (Table 13). Average SPL data were not reported. Figure 11 shows a representation of recorded pressures and SPLs at source from the analysis of the Loggerhead data. A TL could not be calculated for the 36-inch round steel piles because only source (10 m [33 ft]) data were collected. For expanded metrics see Appendix A.1 and Appendix B.2.

Table 12. Acoustic and Pile Installation Equipment Used for 36-inch Round Steel Pipe Piles at the NBPL Fuel Pier (Vibratory Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (kN [tons])
Loggerhead	2.0 - 9.0	Source	APE Variable Moment 250 VM Vibratory Hammer/Extractor	2,389 (269)

Figure 10. Installation of 36-inch Steel Pipe Piles Using an APE Variable Moment 250 VM Vibratory Hammer/Extractor.

Table 13. Underwater Sound Pressure Metrics for Vibratory Pile Driving of 36-inch Round Steel Pipe Piles at Source (10 m [33 ft]).

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
25-Nov-14	T7-TB	Source	10 (33)	No Data	170.0
	T7-TD				172.0
6-Jan-15	P11-PC				167.0
	P11-PD				172.0
	P12-PC				164.0
	P13-PC				165.0
	P13-PD				169.0
9-Jan-15	P8-PD				168.0

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
15-Apr-15	T33-TB	Source	10 (33)	No Data	169.0
	T33-TC				166.0
	T33-TE				174.0
	T33-TG				164.0
16-Apr-15	T34-TB				165.0
	T34-TC				170.0
	T34-TE				166.0
	T34-TG				164.0
21-Apr-15	P16-PD				175.0
	P17-PD				168.0
	P18-PD				172.0

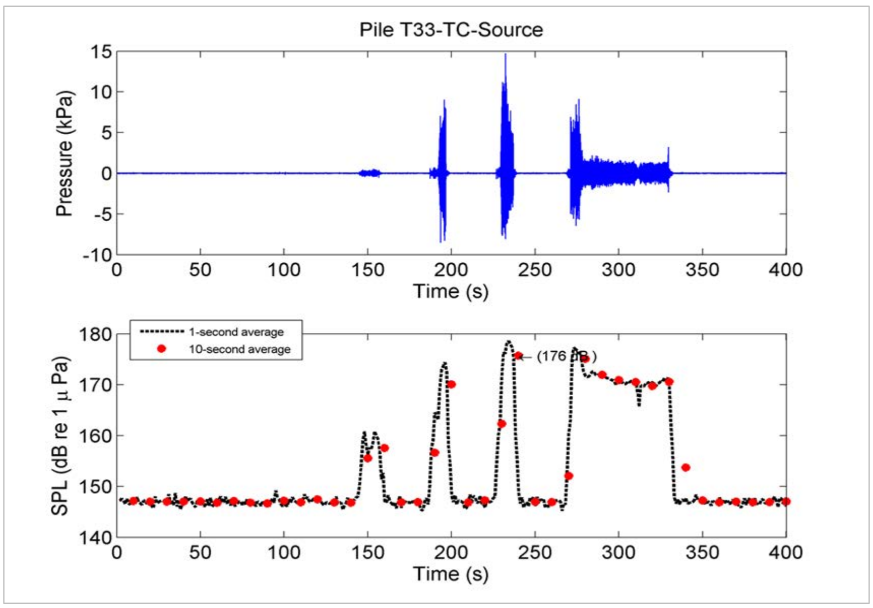

Figure 11. Representation of Pressures and Resulting SPLs for Vibratory Pile Driving of 36-inch Round Steel Pipe Piles at Source (10 m [33 ft]).

Impact Pile Driving (Underwater Acoustics)

Underwater acoustic monitoring of 36-inch steel piles during impact driving was completed using the Loggerhead USLM (Table 14, Figure 12). Data were collected at source (10 m [33 ft]) and far-field distances ranging from 202 to 305 m (603 to 1,001 ft). At source, maximum rms_{90} values ranged from 195.0 to 204.0 dB, maximum peak values ranged from 212.1 to 219.0 dB, and maximum single strike SEL_{90} values ranged from 188.4 to 201.0 dB (Table 15, Figure 13). At far-field distances, maximum rms_{90} values ranged from 181.0 to 184.0 dB, maximum peak values ranged from 192.0 to 197.0 dB, and maximum single strike SEL_{90} values ranged from 166.0 to 169.0 dB (Table 15, Figure 13). A logarithmic trendline provided a strong fit to the data (R^2 value of 0.977) (Figure 13). The calculated TL associated with the installation of 36-inch round steel piles was 13.6. Figure 14 shows a representation of recorded pressures and SPLs at source from the analysis of the Loggerhead data. For expanded metrics see Appendix A.1 and Appendix B.1.

Table 14. Acoustic and Pile Installation Equipment Used for 36-inch Round Steel Pipe Piles at the NBPL Fuel Pier (Impact Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (ft-lbs)
Loggerhead	2.0 - 9.0	Source, Far-Field	D62-22 DELMAG Diesel Impact Hammer	76,956 - 153,770

Figure 12. Installation of 36-inch Round Steel Pipe Piles Using a D62-22 Diesel Powered Impact Hammer.

Table 15. Maximum Underwater Sound Pressure Metrics for Impact Pile Driving of 36-inch Round Steel Pipe Piles at Source (10 m [33 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 µPa)		Maximum (dB re 1 µPa^2-sec)
				rms_{90}	Peak	SEL_{90}[1]
25-Nov-14	T7-TB	Source	10 (33)	195.0	213.0	195.0
	T7-TD			201.0	215.0	201.0
6-Jan-15	P11-PD			201.7	214.4	No Data
	P12-PC			200.7	213.8	
	P13-PC			201.0	213.2	
	P13-PD			201.1	214.0	
7-Jan-15	P12-PC			202.3	212.1	
	P12-PD			200.3	214.3	
	P13-PB			201.9	213.4	
8-Jan-15	P11-PB			202.2	215.7	
	P12-PB			201.6	213.3	
9-Jan-15	P8-PD			201.9	213.4	
12-Jan-15	P9-PD			200.9	214.1	
15-Jan-15	P6-PD			200.9	214.1	
	P7-PD			202.2	215.0	

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 µPa) rms90	Maximum (dB re 1 µPa) Peak	Maximum (dB re 1 µPa²-sec) SEL90[1]
16-Jan-15	P4-PD	Source	10 (33)	202.2	215.0	No Data
	P5-PD			202.2	215.0	
15-Apr-15	T33-TB			202.0	219.0	186.0
	T33-TC			202.0	214.0	186.0
	T33-TE			203.0	215.0	186.0
	T33-TG			204.0	217.0	187.0
16-Apr-15	T34-TB			203.0	215.0	186.0
	T34-TC			203.0	215.0	187.0
	T34-TE			203.0	215.0	187.0
	T34-TG			203.0	214.0	188.0
21-Apr-15	P16-PD			203.0	216.0	187.0
	P17-PD			201.0	214.0	184.0
22-Apr-15	P18-PC			201.0	214.0	186.0
	P18-PD			203.0	216.0	187.0
	P19-PD			201.0	216.0	186.0
	P20-PD			203.0	216.0	187.0
23-Apr-15	P19-PC			201.0	214.0	185.0
	P20-PC			202.0	214.0	187.0
	P20-PC	Far-Field	202 (663)	184.0	195.0	168.0
	P19-PC		206 (676)	184.0	197.0	168.0
16-Apr-15	T34-TG		219 (719)	183.0	193.0	168.0
	T34-TB		227 (745)	181.0	193.0	166.0
	T34-TE			182.0	195.0	169.0
	T34-TC		228 (748)	184.0	196.0	169.0
22-Apr-15	P19-PD		233 (764)	182.0	194.0	167.0
	P18-PD		238 (781)	184.0	194.0	169.0
21-Apr-15	P17-PD		242 (794)	183.0	192.0	167.0
22-Apr-15	P20-PD		248 (814)	182.0	194.0	167.0
21-Apr-15	P16-PD		249 (817)	182.0	192.0	166.0
22-Apr-15	P18-PC		280 (919)	184.0	195.0	168.0
15-Apr-15	T33-TB		304 (997)	181.0	194.0	168.0
	T33-TE			183.0	194.0	169.0
	T33-TC		305 (1,001)	181.0	194.0	168.0
	T33-TG			183.0	195.0	168.0

Note: [1]All SEL_{90} values are for a single strike.

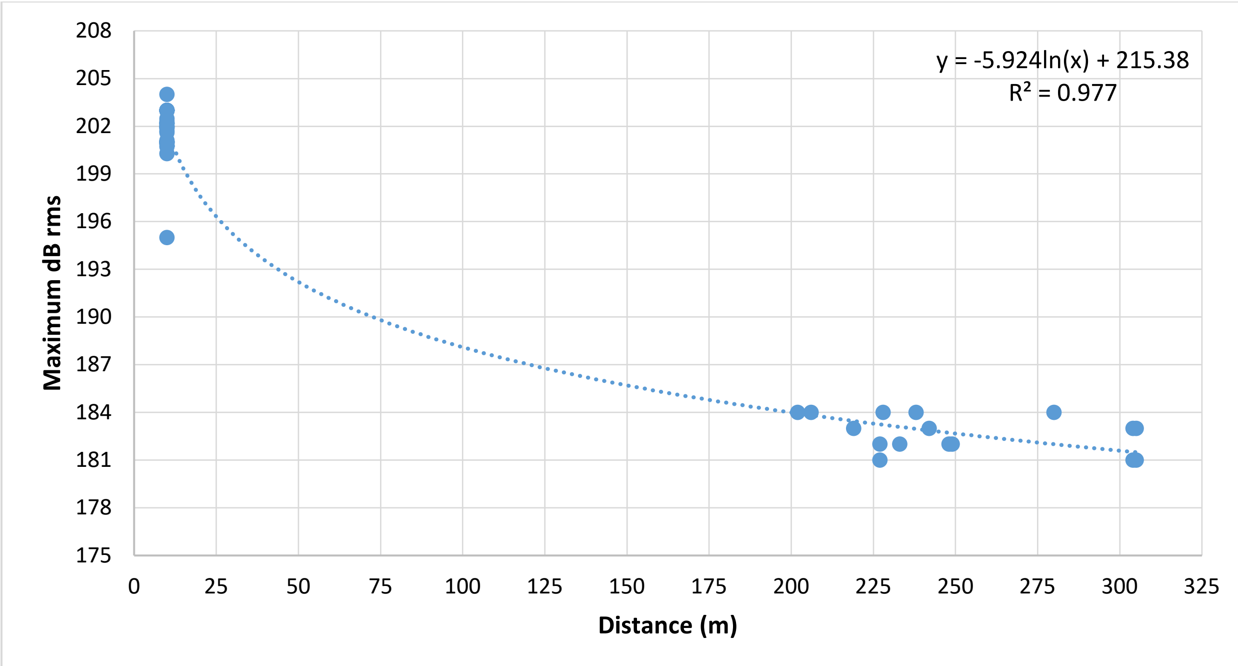

Figure 13. Maximum Underwater dB rms_{90} for Impact Pile Driving of 36-inch Round Steel Pipe Piles at Source (10 m [33 ft]) and Graduated Distances.

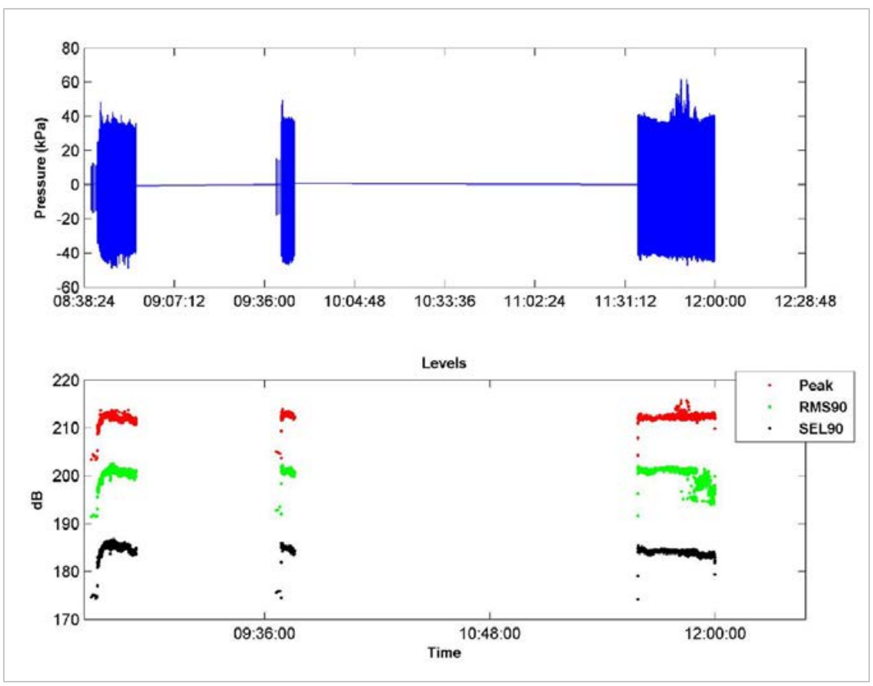

Figure 14. Representation of Pressure and Resulting SPLs for Impact Pile Driving of 36-inch Steel Pipe Piles at Source (10 m [33 ft]).

Impact Pile Driving (Airborne Acoustics)

In October and November 2014 and in January, February, and April 2015, airborne acoustic monitoring was conducted during the impact driving of the 36-inch steel piles. Airborne sound levels were below 90 dB rms (below the lowest regulatory acoustic threshold for marine mammals) and are not further reported herein. Data for impact pile driving was recorded using the LD 831 SLM, at both source (15.2 m [50 ft]) and far-field distances ranging from 50 to 235 m (164 to771 ft). At source, LZF_{max} values ranged from 108.3 to 118.4 dB, LZ_{Peak} values ranged from 122.0 to 136.0 dB, and LZ_{eq} values ranged from 101.0 to 111.6 dB (Table 16, Figure 15). At far-field distances, LZF_{max} values ranged from 89.1 to 110.3 dB, LZ_{Peak} values ranged from 104.8 to 128.8 dB, and LZ_{eq} values ranged from 84.5 to 103.6 dB (Table 16, Figure 15). A linear trendline had a relatively strong fit to the data (R^2 value of 0.850) (Figure 15). The TL for airborne sound during the 36-inch steel impact pile driving was 15.8. For expanded metrics see Appendix A.5.

Table 16. Maximum Airborne Sound Pressure Metrics for Impact Pile Driving of 36-inch Round Steel Pipe Piles at Source (15.2 m [50 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 µPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
17-Feb-15	P3-PC	Source	15.2 (50)	116.3	133.0	109.6
	P2-PD			118.4	136.0	111.6
22-Oct-14	T15-TB			115.2	134.6	108.3
	T15-TD			111.0	122.0	101.0
17-Feb-15	P4-PC			115.8	132.5	109.3
22-Oct-14	T16-TD			114.4	132.2	107.6
17-Feb-15	P2-PC			113.0	130.4	106.8
20-Oct-14	T12-TD			111.9	129.3	106.2
18-Nov-14	T23-TC			111.9	129.9	105.6
21-Oct-14	T12-TB			111.0	127.5	104.4
17-Feb-15	P3-PD			111.2	130.8	105.1
22-Oct-14	T14-TB			110.0	126.6	103.5
21-Oct-14	T10-TB			109.8	127.2	103.9
	T13-TB			108.3	126.9	102.2
20-Oct-14	T11-TD			109.2	126.8	103.4
7-Apr-15	T25-TB	Far-Field	50 (164)	103.9	123.2	97.5
	T25-TC			104.1	122.2	97.8
	T25-TE			110.3	128.8	103.6
	T25-TG			106.2	124.0	99.7
6-Apr-15	T24-TC		75 (246)	101.9	118.6	95.5
7-Apr-15	T24-TB			100.9	116.4	95.6
	T24-TE			101.1	119.8	95.1
17-Feb-15	P4-PC		105 (344)	104.0	120.6	102.2
	P3-PC			101.4	119.7	97.4
	P2-PC			99.9	117.8	93.8
	P3-PD			101.5	115.9	98.7
	P2-PD			100.3	115.8	94.6
	P1-PC			105.4	112.6	100.2
6-Jan-15	P11-PD		140 (459)	97.6	115.5	94.4
	P11-PC			96.5	114.1	91.0
	P12-PC			95.6	110.5	92.9
17-Nov-14	T21-TG		180 (591)	91.6	108.3	86.4
	T21-TE			90.1	106.9	88.0

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 µPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
7-Jan-15	P13-PC	Far-Field	210 (689)	91.2	107.8	87.0
	P12-PD			89.6	104.8	84.5
	P13-PD			89.1	105.4	85.9
21-Oct-14	T10-TB		225 (738)	96.0	109.2	91.4
	T13-TB			100.6	110.3	96.7
	T12-TB			98.4	107.5	94.8
21-Oct-14	T23-TC		230 (755)	93.6	108.7	86.4
22-Oct-14	T15-TD		235 (771)	99.6	109.4	94.1
	T15-TB			92.3	110.5	87.8
	T16-TD			95.0	111.8	90.6
	T14-TB			91.0	108.8	87.4

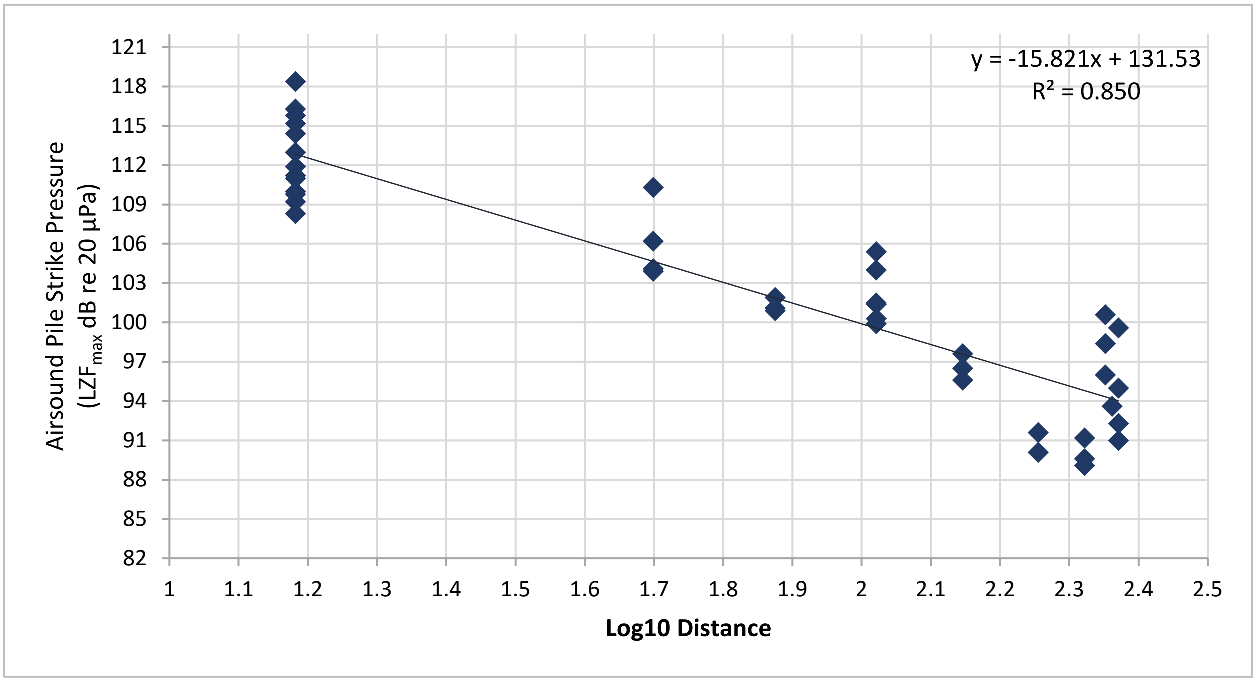

Figure 15. Maximum Airborne dB rms for Impact Pile Driving of 36-inch Steel Pipe Piles at Source (15.2 m [50 ft]) and Graduated Distances.

3.1.1.4 36-inch Round Steel Pipe Interlocking Abutment Piles (Vibratory and Impact Driving, Underwater and Airborne Acoustics)

In October 2017, underwater acoustic monitoring was conducted during the installation of 36-inch interlocking steel abutment piles, approximately 2 m (6.6 ft) from the waters' edge at a ground elevation of approximately +1.8 m (+6 ft) mean lower low water (Figure 16). All piles were initially driven using a vibratory hammer with installation completed using an impact hammer.

Figure 16. Configuration of 36-inch Steel Abutment Piles.

Vibratory Pile Driving (Underwater Acoustics)

Acoustic monitoring of the 36-inch steel abutment piles was completed using the APL-UW USLM (Table 17). Measurements were only collected at far field distances ranging from 53 m to 259 m (174 to 850 ft). Average SPL values ranged from 125.8 to 135.7 dB rms and maximum SPLs ranged from 128.2 to 140.9 dB rms (Table 18, Figure 17). A logarithmic trendline was considered applicable, but had a poor fit to the data (R^2 of 0.279) (Figure 17). The calculated TL associated with the installation of 36-inch round interlocking abutment steel piles was 7.0. It should be noted that these piles were driven "dry," with a berm separating the piles and the open water. The TL associated with these piles was likely influenced by the berm. Therefore, if abutment piles are driven and MMPA Level A/B calculations are required, a TL of 15 is suggested. Figure 18 shows an example of the APL-UW USLM data output at 53 m (174 ft) from the pile driving. For expanded metrics see Appendix A.1 and Appendix B.2.

Table 17. Acoustic and Pile Installation Equipment Used for 36-inch Steel Pipe Abutment Piles at the NBPL Fuel Pier (Vibratory Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (kN [tons])
APL-UW USLM	1.2 - 7.0	Far-Field	APE Variable Moment 250 VM Vibratory Hammer/Extractor	2,389 (269)

Table 18. Underwater Sound Pressure Metrics for Vibratory Pile Driving of 36-inch Round Steel Pipe Abutment Piles at Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 μPa)	
				Average	Maximum
13-Oct-17	Abutment09	Far-Field	53 (174)	132.4	140.9
				132.3	136.9
				135.7	136.7
	Abutment10		54 (177)	131.0	137.4
				133.7	135.4
				131.4	133.6
	Abutment04		95 (312)	129.1	133.2
				128.0	132.0
				127.1	129.8
				129.3	129.6
	Abutment05			130.6	139.1

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 μPa)	
				Average	Maximum
11-Oct-17	Abutment01	Far-Field	97 (318)	132.4	138.2
				131.5	131.9
				125.8	128.2
13-Oct-17	Abutment11		148 (486)	131.3	132.9
				130.0	131.5
	Abutment13			130.0	131.5
				129.4	129.7
	Abutment06		223 (732)	129.4	131.5
				130.0	131.2
	Abutment07		224 (735)	129.8	133.7
				130.4	133.0
				129.0	130.7
	Abutment08		259 (850)	129.9	132.8
				130.8	131.9

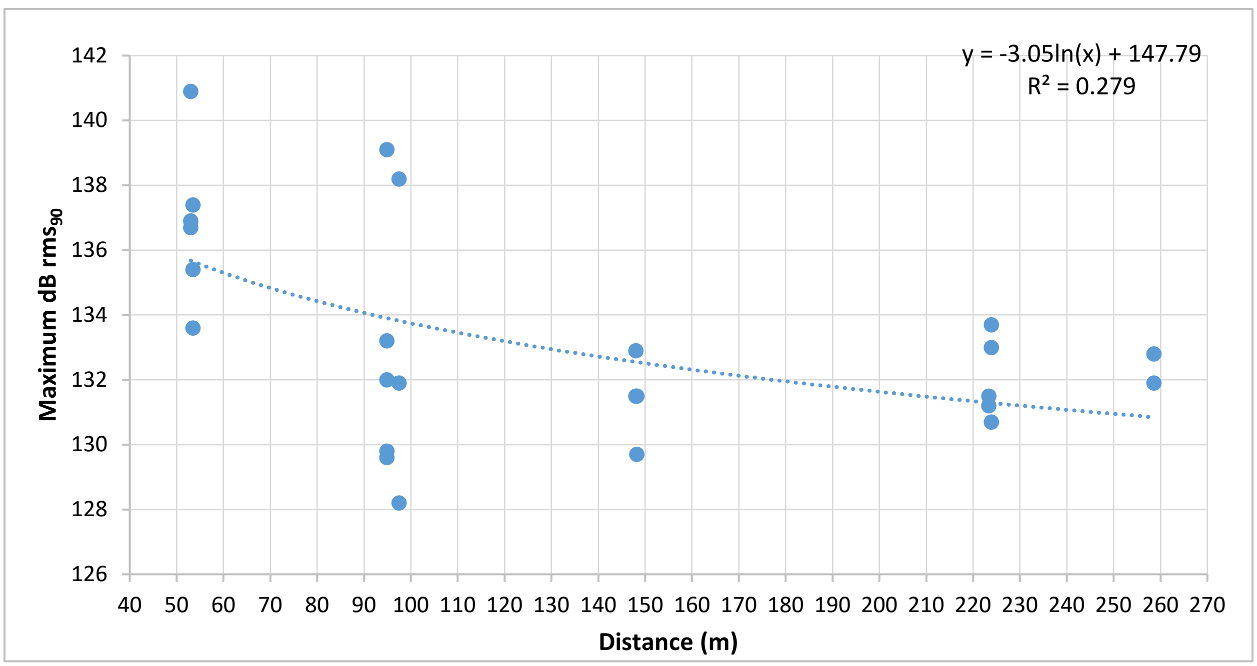

Figure 17. Maximum Underwater dB rms for Vibratory Pile Driving of 36-inch Round Steel Pipe Abutment Piles at Graduated Distances.

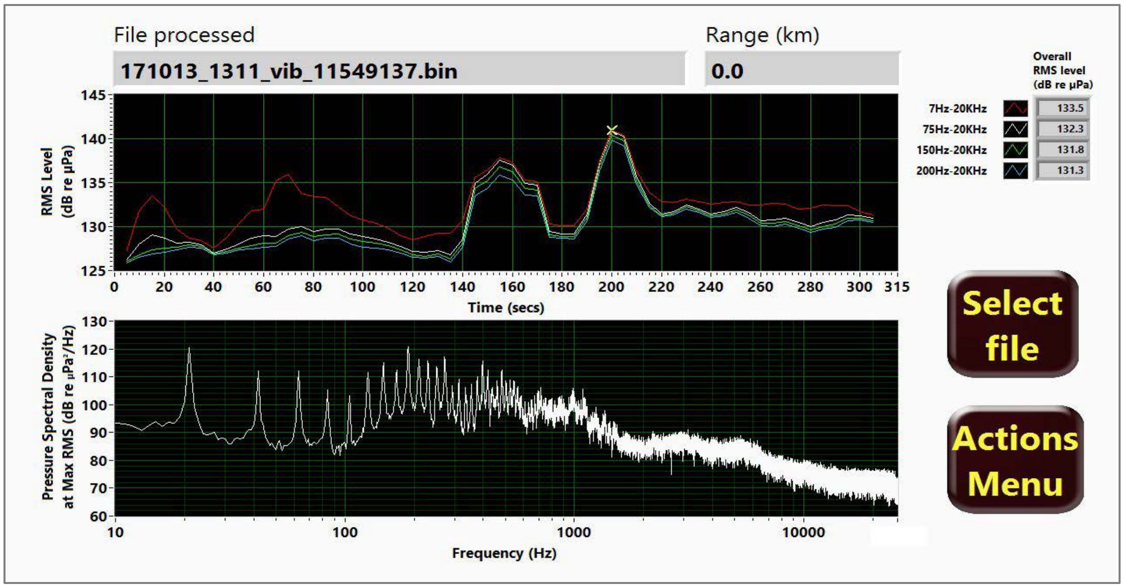

Figure 18. APL-UW USLM Acoustic Time Series Plot for Vibratory Pile Driving of 36-inch Round Steel Pipe Abutment at 53 m (174 ft) from Source.

Vibratory Pile Driving (Airborne Acoustics)

In October 2017, airborne acoustic monitoring was conducted during the vibratory driving of the 36-inch round steel pipe abutment piles. Data were recorded using the LD 831 SLM, at far-field distances ranging up to 97 m (318 ft). LZF_{max} values ranged from 95.2 to 102.2 dB, LZ_{Peak} values ranged from 103.1 to 111.4 dB, and LZ_{eq} values ranged from 91.0 to 101.9 dB (Table 19). Because so few values were recorded, TL was not calculated. For expanded metrics see Appendix A.5.

Table 19. Airborne Sound Pressure Metrics for Vibratory Pile Driving of 36-inch Steel Pipe Abutment Piles at Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 µPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
13-Oct-17	Abutment06	Far-Field	17 (56)	102.2	111.4	101.9
	Abutment07		50 (164)	95.2	104.5	94.8
	Abutment08		97 (318)	95.5	103.1	91.0

Impact Pile Driving (Underwater Acoustics)

Underwater acoustic monitoring during the installation of the 36-inch steel abutment piles was completed using the APL-UW USLM (Table 20). Data were collected at far-field distances ranging from 38 to 330 m (125 to 1,083 ft). Maximum rms_{90} values ranged from 152.7 to 184.9 dB, maximum peak values ranged from 172.4 to 194.7 dB, and maximum single strike SEL_{90} values ranged from 144.1 to 167.1 dB (Table 21, Figure 19). A linear trendline had a relatively strong fit to the data (R^2 value of 0.792) (Figure 19). The calculated TL associated with the installation of 36-inch round interlocking abutment steel piles was 24.6. It should be noted that these piles were driven "dry," with a berm separating the piles and the open water. Therefore, if abutment piles are driven and MMPA Level A/B calculations are required, a TL of 15 is suggested. Figure 20 shows an example of the impact pile driving data recorded 38 m (125 ft) from pile driving using the APL-UW USLM. For expanded metrics see Appendix A.1 and Appendix B.1.

Table 20. Acoustic and Pile Installation Equipment Used for 36-inch Steel Pipe Abutment Piles at the NBPL Fuel Pier (Impact Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (ft-lbs)
APL-UW USLM	1.1 - 7.0	Far-Field	D62-22 DELMAG Diesel Impact Hammer	76,956 - 153,770

Table 21. Maximum Underwater Sound Pressure Metrics for Impact Pile Driving of 36-inch Round Steel Pipe Abutment Piles at Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 µPa)		Maximum (dB re 1 µPa²-sec)
				rms_{90}	Peak	SEL_{90}[1]
19-Oct-17	Abutment10	Far-Field	38 (125)	183.9	194.4	166.9
	Abutment11		53 (174)	184.9	194.7	167.1
	Abutment12		54 (177)	181.2	192.0	163.8
	Abutment09		63 (207)	177.4	188.9	160.9
	Abutment10		64 (210)	179.2	190.1	162.1
18-Oct-17	Abutment12		96 (315)	180.8	191.4	163.9
	Abutment13			180.4	191.3	163.8
19-Oct-17	Abutment08		99 (325)	175.5	187.7	160.3
	Abutment09			177.8	188.8	162.5
18-Oct-17	Abutment11		192 (630)	168.9	182.3	155.4
19-Oct-17	Abutment07		239 (784)	170.4	179.7	155.0
	Abutment09		241 (791)	172.7	182.1	156.7
	Abutment06		255 (837)	173.7	183.2	157.8
	Abutment08		257 (843)	173.3	182.9	157.2
18-Oct-17	Abutment12		268 (879)	162.4	174.5	150.7
19-Oct-17	Abutment07		329 (1,079)	152.7	175.7	144.1
	Abutment06		330 (1,083)	155.4	172.4	144.2

Note: [1]All SEL_{90} values are for a single strike.

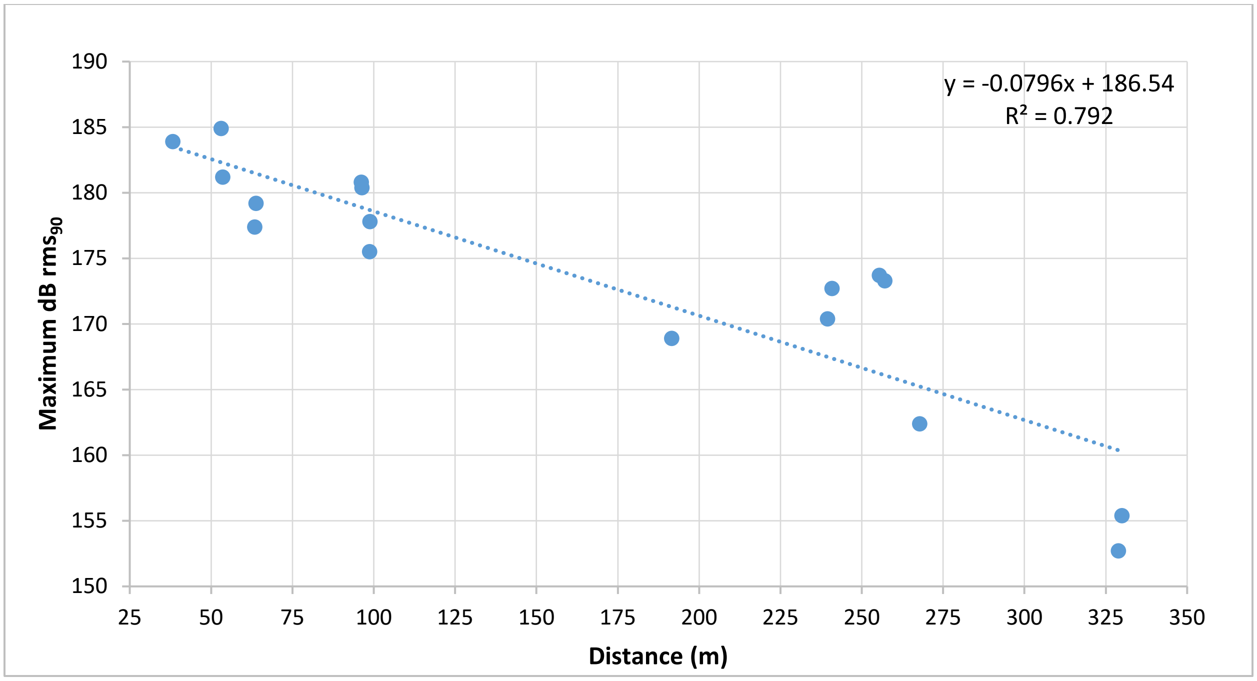

Figure 19. Maximum Underwater dB rms$_{90}$ for Impact Pile Driving of 36-inch Round Steel Pipe Abutment Piles at Graduated Distances.

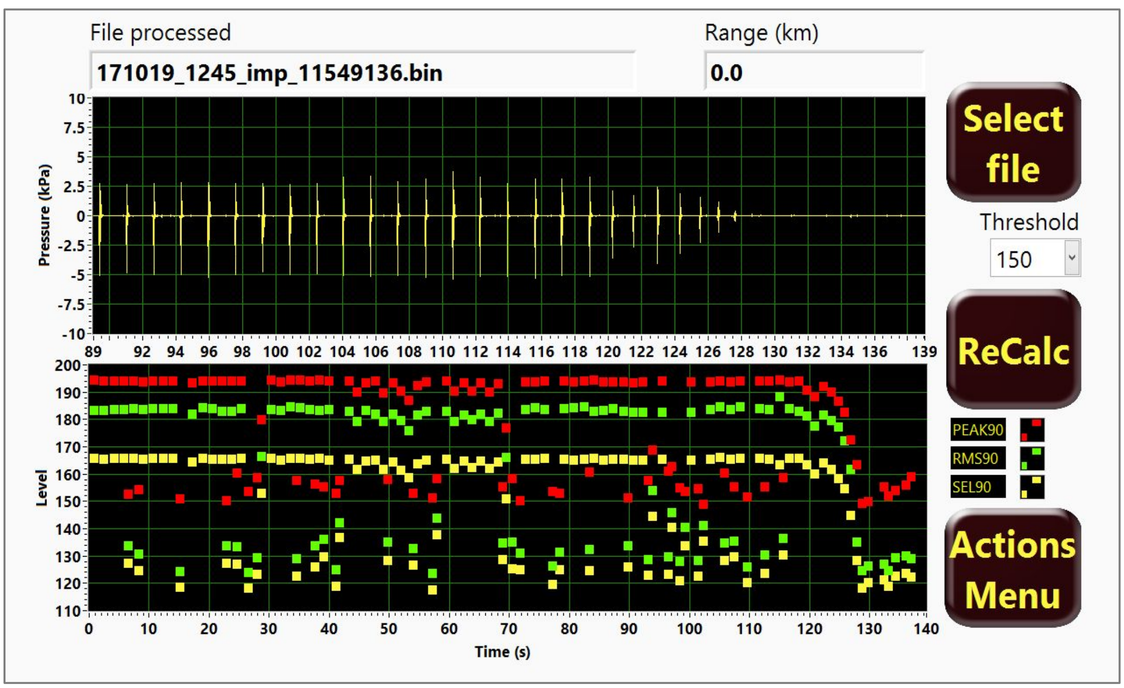

Figure 20. APL-UW USLM Acoustic Time Series Plot for Impact Pile Driving of 36-inch Round Steel Pipe Abutment Piles Recorded at 38 m [125 ft]) From Source.

Impact Pile Driving (Airborne Acoustics)

In October 2017, airborne acoustic monitoring was conducted during impact driving of the 36-inch steel abutment piles. Data was recorded using the LD 831 SLM, both near source (18 to 20 m [59 to 66 ft]) and far-field distances ranging from 54 to 149 m (177 to 489 ft). Near source, LZF_{max} values ranged from 113.9 to 114.8 dB, LZ_{Peak} values ranged from 129.9 to 131 dB, and LZ_{eq} values ranged from 108.0 to 109.2 dB (Table 22, Figure 21). At far-field distances, LZF_{max} values ranged from 91.5 to 103.6 dB, LZ_{Peak} values ranged from 105.6 to 119.4 dB, and LZ_{eq} values ranged from 86.5 to 97.9 dB (Table 22, Figure 21). A linear trendline had a relatively strong fit to the data (R^2 of 0.869) (Figure 21). The TL for airborne sound during 36-inch steel abutment impact pile driving was 21.9. For expanded metrics see Appendix A.5.

Table 22. Maximum Airborne Sound Pressure Metrics for Impact Pile Driving of 36-inch Round Steel Pipe Abutment Piles Near Source (18 to 20 m [59 to 66 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 µPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
18-Oct-17	Abutment11	Source	18 (59)	114.8	129.9	109.2
	Abutment12		19 (62)	114.2	130.0	108.2
	Abutment13		20 (66)	113.9	130.5	108.0
				114.4	131.0	108.3
	Abutment12	Far-Field	54 (177)	103.6	119.4	97.9
19-Oct-17	Abutment10		97 (318)	99.7	112.9	95.0
	Abutment11			91.5	105.6	86.5
	Abutment09		149 (489)	99.3	112.5	95.1

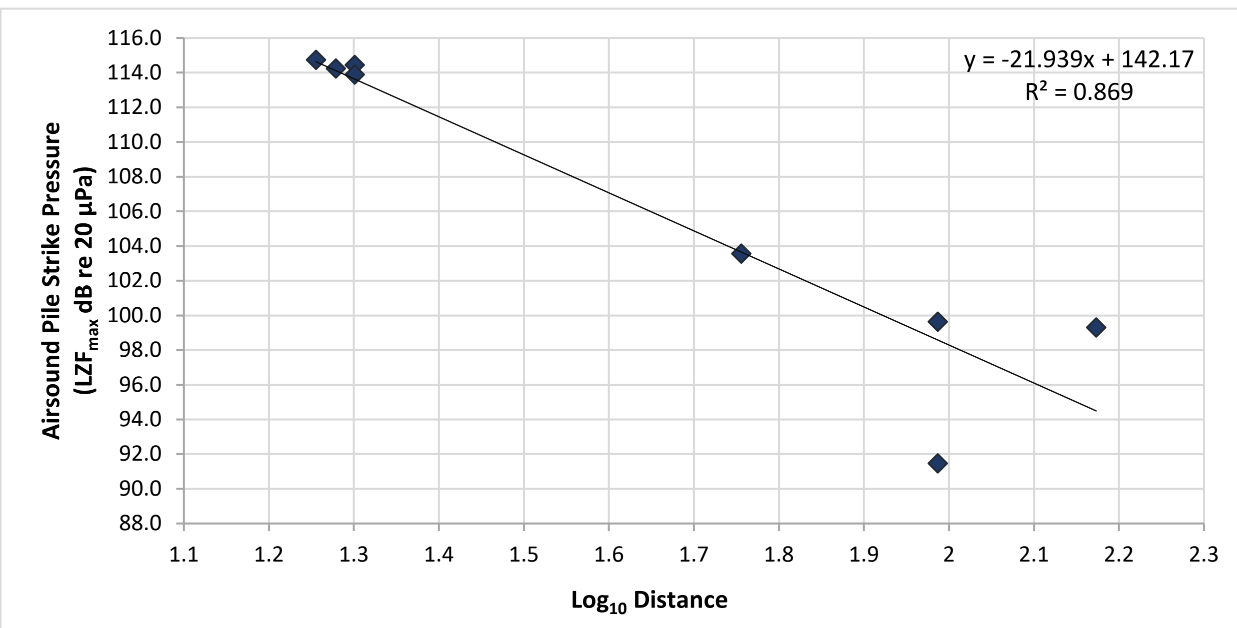

Figure 21. Maximum Airborne LZF_{max} for Impact Pile Driving of 36-inch Round Steel Pipe Abutment Piles Near Source (18 to 20 m [59 to 66 ft]) and Graduated Distances.

3.1.2 Concrete Pile Installation

3.1.2.1 24x30-inch Concrete Fender Piles (Impact Driving and Jetting, Underwater and Airborne Acoustics)

In March 2017, acoustic monitoring was conducted during the installation of 24x30-inch concrete non-structural fender piles using two different jetting methods and impact pile driving. All pile driving attempts included the use of an 8-inch plywood cushion in-between the pile and the "helmet" that fits over the pile as part of the pile driving rig.

Impact Pile Driving (Underwater Acoustics)

Acoustic monitoring during the impact pile driving of the 24x30-inch concrete fender piles was primarily completed using the APL-UW USLM (Table 23); however, three measurements at source (10 m [33 ft]) were also recorded using the Loggerhead USLM for comparison. Far-field measurements were made at distances ranging from 20 to 548 m (66 to 1,798 ft). At source, maximum rms_{90} values ranged from 181.3 to 193.8 dB, maximum peak values ranged from 192.5 to 204.3 dB, and maximum single strike SEL_{90} values ranged from 168.1 to 178.4 dB (Table 24, Figure 22). At far-field distances, maximum rms_{90} values ranged from 148.0 to 191.5 dB, maximum peak values ranged from 167.7 to 202.0 dB, and maximum single strike SEL_{90} values ranged from 142.2 to 175.0 dB (Table 24, Figure 22). A logarithmic trendline provided a relatively strong fit to the data (R^2 of 0.835) (Figure 22). The calculated TL associated with the installation of 24x30-inch concrete fender piles was 15.9. For expanded metrics see Appendix A.2 and Appendix B.1.

Table 23. Acoustic and Pile Installation Equipment Used for 24x30-inch Concrete Fender Piles at the NBPL Fuel Pier (Impact Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (ft-lbs)
Loggerhead	1.5 - 7.0	Source, Far-Field	D80-42 APE Diesel Impact Hammer	127,008 - 198,450
APL-UW USLM				

Table 24. Maximum Underwater Sound Pressure Metrics for Impact Pile Driving of 24x30-inch Concrete Fender Piles at Source (10 m [33 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 μPa) rms_{90}	Maximum (dB re 1 μPa) Peak	Maximum (dB re 1 μPa²-sec) SEL_{90}[2]
26-Sep-16	O-05A	Source	10 (33)	187.1	195.5	173.8
	O-03G			183.9	194.0	173.0
22-Apr-16	O-07D			191.1	201.1	176.6
23-Apr-16	O-07F			193.7	203.9	177.9
23-Apr-16	O-07E			190.9	201.4	176.0
27-Apr-16	O-08A			181.3	192.5	168.1
	O-08B			191.3	199.6	176.8
	O-08C			191.2	201.1	176.4
	O-08D			190.6	198.9	175.1
28-Apr-16	O-07G[1]			192.0	203.0	176.0
	O-07G			193.8	204.3	178.4
	O-07H[1]			188.0	197.0	172.0
	O-07H			189.3	198.4	174.1
	O-08G			190.1	198.4	175.0
	O-08H[1]			188.0	197.0	172.0
	O-08H			189.8	198.2	174.7

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 µPa) rms$_{90}$	Maximum (dB re 1 µPa) Peak	Maximum (dB re 1 µPa^2-sec) SEL$_{90}$^{2}
22-Apr-16	O-07D	Far-Field	20 (66)	191.5	202.0	175.0
23-Sep-16	O-04E		30 (98)	182.3	192.8	169.0
22-Apr-16	O-07D		40 (131)	183.2	192.0	168.1
23-Sep-16	O-03A		47 (154)	181.1	190.8	165.5
			54 (177)	178.8	188.3	164.1
25-Apr-16	O-09D		55 (180)	168.7	188.3	162.6
26-Sep-16	O-05H		60 (197)	177.9	185.9	162.2
			72 (236)	177.5	187.6	163.9
			83 (272)	173.5	185.0	160.5
23-Sep-16	O-04F		95 (312)	176.8	190.6	164.1
25-Apr-16	O-09D		100 (328)	168.3	186.2	161.6
23-Sep-16	O-04G		114 (374)	174.1	183.0	161.2
22-Apr-16	O-07D		125 (410)	172.0	182.3	158.8
23-Sep-16	O-04H		164 (538)	172.7	182.7	159.0
22-Apr-16	O-07D		165 (541)	168.8	181.9	157.3
	O-07D		171 (561)	168.0	178.2	154.8
25-Apr-16	O-09D		180 (591)	169.8	182.0	158.3
	O-09B		190 (623)	169.5	179.9	156.4
	O-09D		200 (656)	167.1	179.8	157.2
	O-09B		235 (771)	172.8	182.0	158.4
	O-09D		247 (810)	168.5	180.1	156.6
23-Sep-16	O-04F		250 (820)	176.8	190.6	164.1
25-Apr-16	O-09D		310 (1,017)	167.2	179.2	155.9
	O-09B		315 (1,033)	172.1	181.7	158.1
				159.2	170.2	145.8
	O-09D			173.4	185.3	159.0
			375 (1,230)	172.8	184.5	158.4
	O-09B		400 (1,312)	161.9	174.0	150.5
			410 (1,345)	148.0	167.7	142.2
			435 (1,427)	166.0	177.1	153.7
	O-09D		460 (1,509)	162.3	175.5	152.1
23-Sep-16	O-04F			170.4	179.8	155.9
25-Apr-16	O-09B		475 (1,558)	163.9	176.0	152.2
26-Sep-16	O-03B		490 (1,607)	164.9	176.2	152.2
			530 (1,739)	166.0	173.8	153.0
			533 (1,749)	154.2	176.9	148.5
			548 (1,798)	154.4	177.9	148.8

Notes: [1]Indicates Loggerhead data, all other data collected using the APL-UW USLM; [2]All SEL$_{90}$ values are for a single strike.

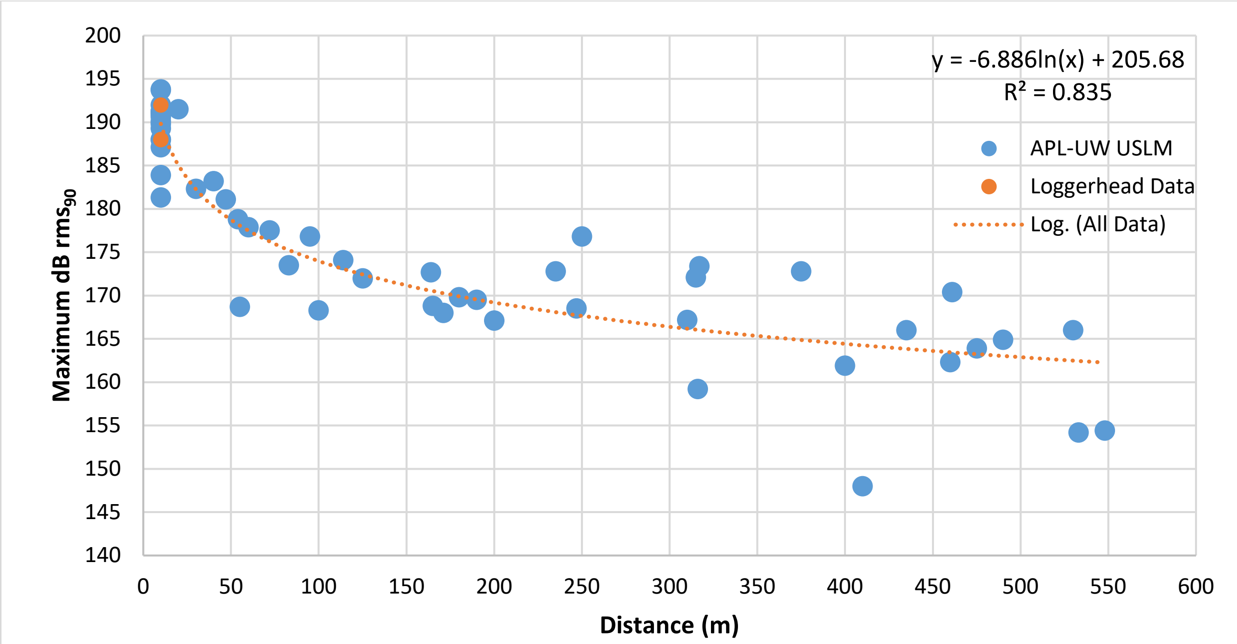

Figure 22. Maximum Underwater dB rms_{90} for Impact Pile Driving 24x30-inch Concrete Fender Piles at Source (10 m [33 ft]) and Graduated Distances.

Impact Pile Driving (Airborne Acoustics)

In April 2016, airborne acoustic monitoring was conducted during impact driving of the 24x30-inch concrete piles. Data were recorded using the LD 831 SLM, at both source (15.2 m [50 ft]) and far-field distances ranging from 157.0 to 257 m (515 to 843 ft). At source, LZF_{max} values ranged from 112.8 to 117.4 dB, LZ_{Peak} values ranged from 128.0 to 134.3 dB, and LZ_{eq} values ranged from 107.5 to 111.4 dB (Table 25, Figure 23). At far-field distances, LZF_{max} values ranged from 99.9 to 110.1 dB, LZ_{Peak} values ranged from 107.1 to 115.6 dB, and LZ_{eq} values ranged from 95.5 to 105.1 dB (Table 25, Figure 23). A linear trendline had a relatively strong fit to the data (R^2 of 0.819) (Figure 23). The TL for airborne sound during 36-inch steel abutment impact pile driving was 8.9. For expanded metrics see Appendix A.5.

Table 25. Maximum Airborne Sound Pressure Metrics for Impact Pile Driving of 24x30-inch Concrete Fender Piles at Source (15.2 m [50 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 µPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
25-Apr-16	O-09B	Source	15.2 (50)	115.8	131.7	110.7
	O-09A			117.4	134.3	111.4
27-Apr-16	O-09H			115.1	131.2	109.2
	O-08B			114.1	130.9	108.6
	O-08A			113.9	130.4	108.6
	O-08D			113.0	128.0	107.8
	O-08C			112.8	128.9	107.5
12-Apr-16	O-09G			113.3	131.0	107.7
26-Apr-16	O-09E	Far-Field	157 (515)	102.7	110.3	98.2
27-Apr-16	O-09H			110.1	115.6	105.1
26-Apr-16	O-09F			108.0	113.8	104.7
25-Apr-16	O-09D		257 (843)	103.6	109.5	99.0
	O-09C			99.9	107.1	95.5

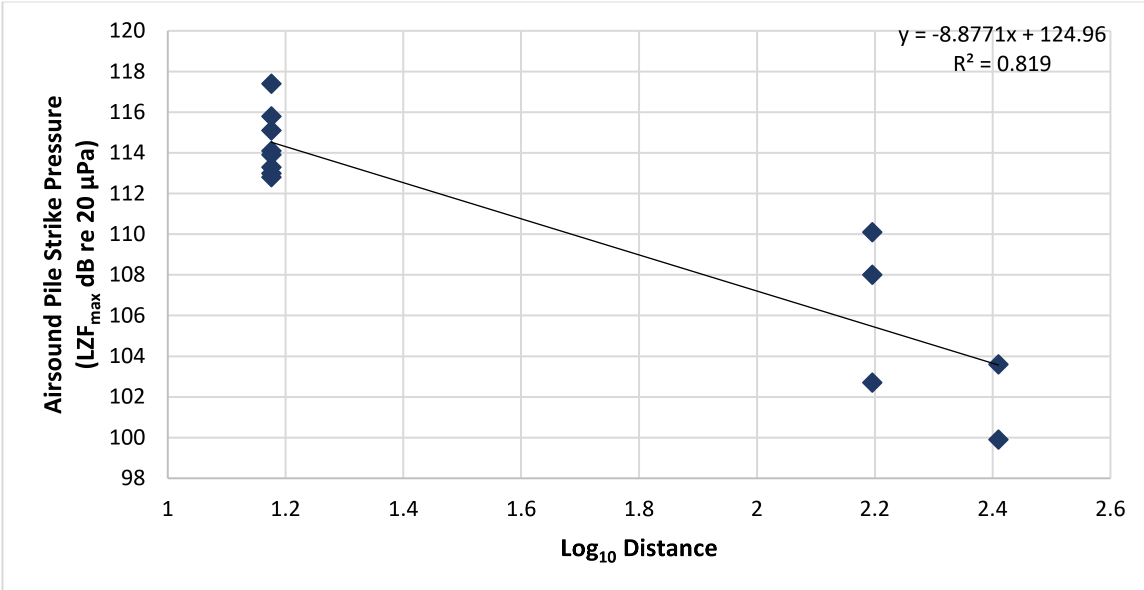

Figure 23. Maximum Airborne LZF_{max} for Impact Pile Driving of 24x30-inch Concrete Fender Piles at Source (15.2 m [50 ft]) and Graduated Distances.

High-Pressure Water Jetting (Underwater Acoustics)

Acoustic monitoring of 24x30-inch concrete fender pile jetting was completed using the APL-UW USLM, using two different methods, stationary and drift data collection (Table 26). Two different methods were used to jet the piles: 1) method 1 (M1) used a custom-made spud jet with four nozzles welded to the tip that used a high-pressure water system (900 gallons per minute with a maximum pounds per square inch [psi] of 300), to make the initial break through the bay point formation sediment layer (Figure 24), and 2) internal jet method 2 (M2) used the 24x30-inch pile, outfitted with two pipes running through the full length of the pile, to direct the high-pressure water (maximum psi of 300) immediately below the pile to remove sediment and advance the pile (Figure 24). A TL could not be calculated for high-pressure water jetting (M1) because data were only recorded at source (10 m [33 ft]). For the piles installed using M2, the sample size was insufficient to generate a TL.

Table 26. Acoustic and Pile Installation Equipment Used for 24x30-inch Concrete Fender Piles at the NBPL Fuel Pier (High-pressure Water Jetting).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	3.5 - 7.0	Source, Far-Field	High Pressure Water Jet	300 psi

Figure 24. Installation of 24x30-inch Concrete Fender Piles on the Southern Breasting Dolphin Using High-Pressure Water Jetting Methods: (A) M1 and (B) M2.

Stationary Data Collection

Stationary data collection was conducted at fixed source and far-field locations. For M1, the average SPLs at source ranged from 152.6 to 155.1 dB and maximum SPLs ranged from 156.5 to 159.9 dB (Table 27). At a far-field distance of 350 m (1,148 ft), the SPL average was 128.1 and the maximum was 134.0 dB. For M2, the average SPLs at source ranged from 133.0 to 149.8 dB and maximum SPLs ranged from 137.1 to 153.2 dB (Table 27). At far-field distances of 290-350 m (951-1,148 ft), average SPLs ranged from 129.5 to 132.4 dB and maximum SPLs ranged from 132.5 to 136.7 dB. Comparison of the data during which the two methods were used on the same pile, but at different times, showed that the source levels were lower for M2 (internal water jet; Figure 25) with average maximum source levels of 144.3 dB compared to 158.2 dB for M1. For expanded metrics see Appendix A.2 and Appendix B.2.

Table 27. Underwater Sound Pressure Metrics for M1 and M2 High-Pressure Water Jetting of 24x30-inch Concrete Fender Piles at Source (10 m [33 ft]) and Graduated Distances.

Date	Pile Number	Method Type	Station	Distance	dB rms (dB re 1 µPa)	
				(m [ft])	Average	Maximum
27-Mar-17	O-8	M1	Source	10 (33)	153.3	156.5
28-Mar-17	O-4				155.1	159.9
	O-5				153.0	159.0
	O-6				152.7	158.4
	O-7				152.6	157.2
30-Mar-17	O-1		Far-Field	350 (1,148)	128.1	134.0

Date	Pile Number	Method Type	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
					Average	Maximum
28-Mar-17	O-4	M2	Source	10 (33)	133.0	137.1
	O-5				149.8	153.2
	O-6				145.0	146.9
	O-7				141.5	143.4
	O-8				138.5	140.7
30-Mar-17	O-2		Far-Field	290 (951)	132.4	136.7
30-Mar-17	O-1			350 (1,148)	129.5	132.5

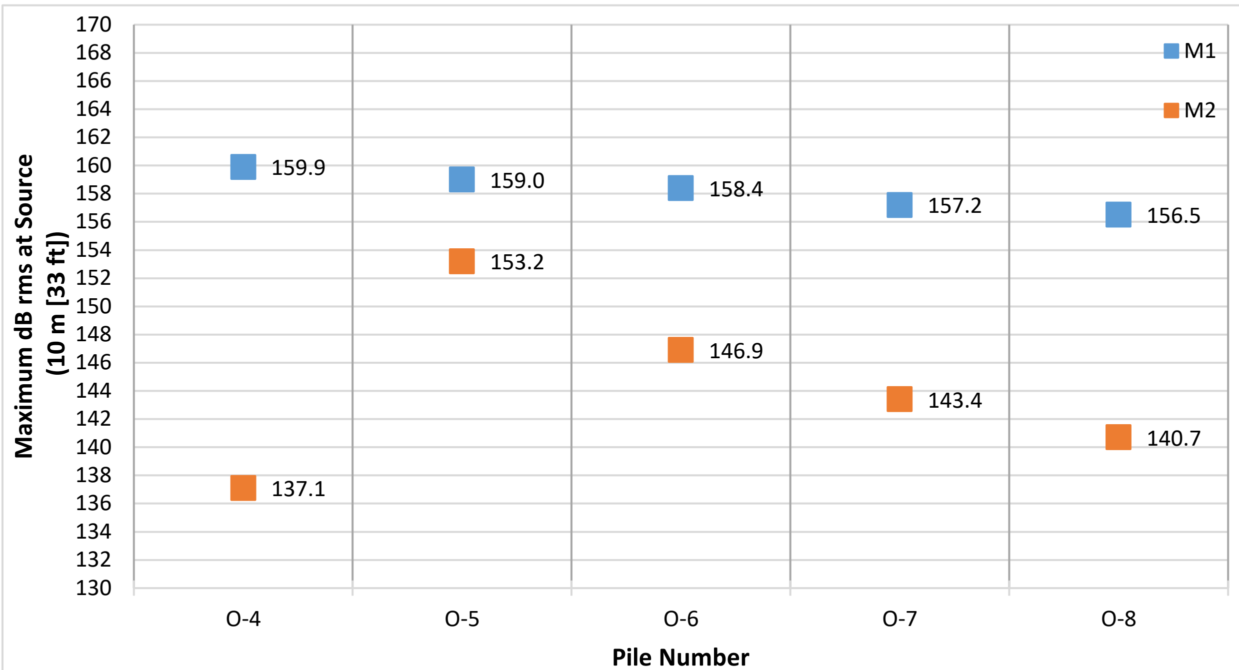

Figure 25. Comparison of Maximum Underwater dB rms at Source (10 m [33 ft]) for Two High-Pressure Water Jetting Methods.

Drift Data Collection

A vessel-based drift method was used to record underwater sound while the natural tidal current moved the vessel at increasing distance away from the pile until measurements reached near ambient SPLs. The SPLs during pile jetting M1 reached a near ambient level of 128.0 dB at 165 m (541 ft) from the pile (Figure 26).

The SPLs at far-field for the first drift using pile jetting M2 reached a near ambient level of 127.6 dB at 80 m (262 ft) from the pile (Figure 27). This acoustic drift recording was collected early in the morning and seemed to represent the best acoustic environment as there was limited vessel traffic in the area. Additional drift and non-drift, far-field recordings were collected throughout the day; however, vessel traffic within San Diego Bay increased during data collection making it difficult to find near ambient SPLs and replicate the values recorded during the morning (shown on Figure 26 and Figure 27). A decision was made to switch from drift to stationary data reporting due to the inability to collect additional data.

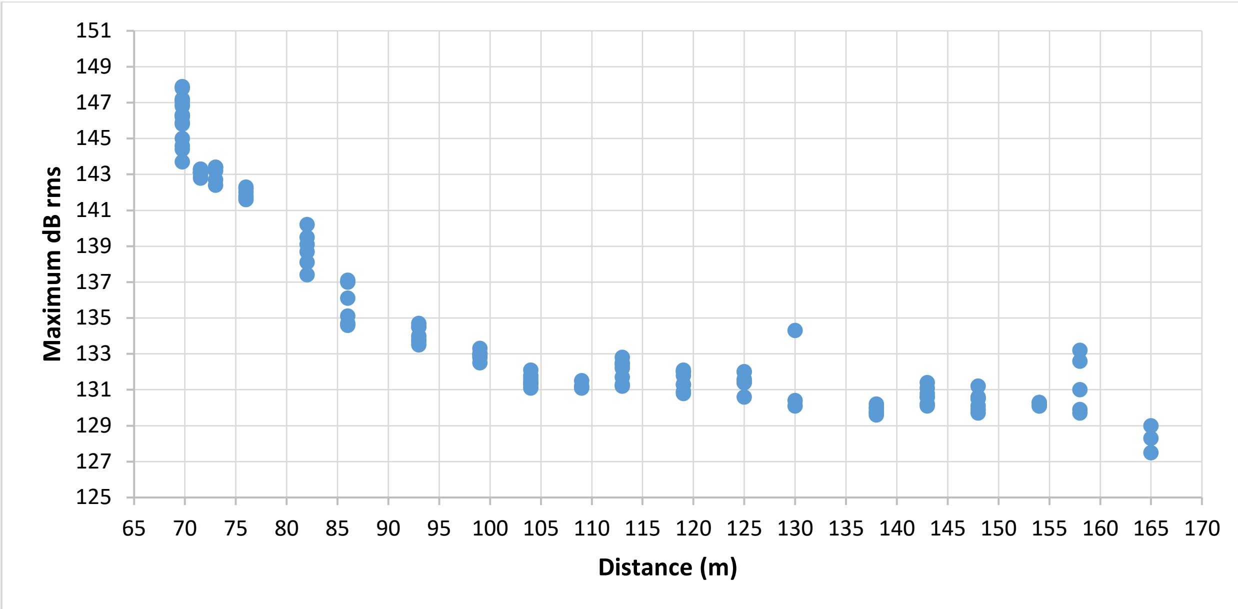

Figure 26. Underwater SPLs (Vessel Drift) for High-pressure Water Jetting (M1) of 24x30-inch Concrete Fender Piles at Graduated Distances.

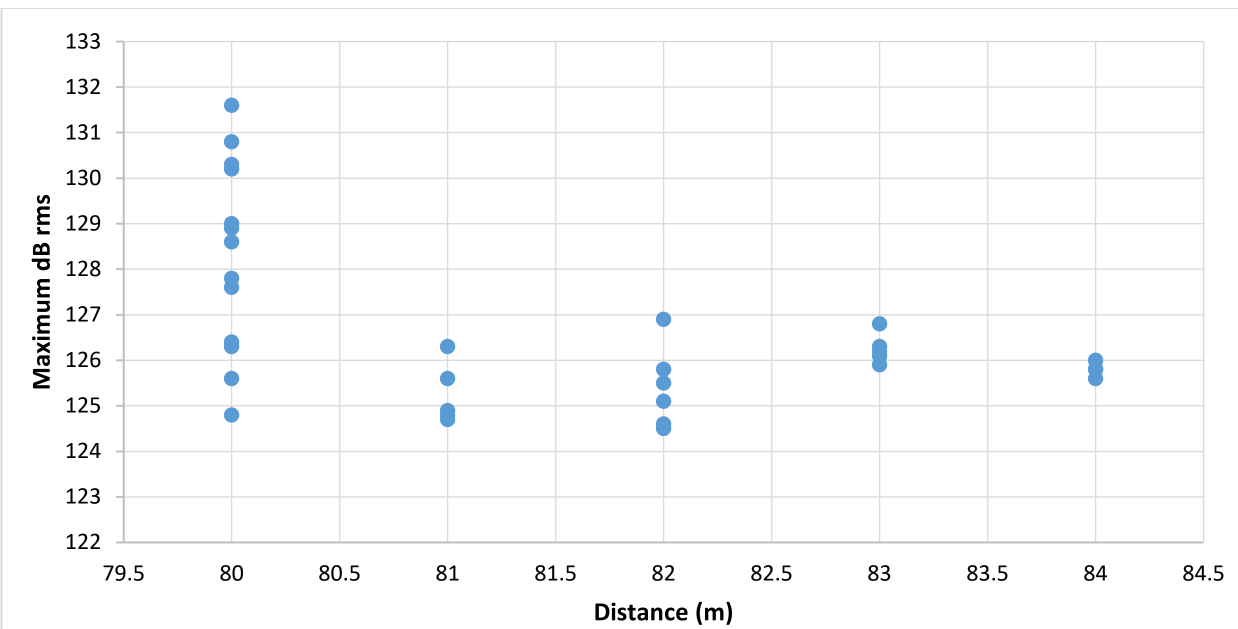

Figure 27. Underwater SPLs (Vessel Drift) for High-pressure Water Jetting (M2) of 24x30-inch Concrete Fender Piles at Graduated Distances.

3.1.3 Poly-Concrete Pile Installation

3.1.3.1 16-inch Round Poly-Concrete Fender Piles (Impact Driving, Underwater and Airborne Acoustics)

Impact Pile Driving (Underwater Acoustics)

In February 2016, acoustic monitoring was conducted during impact driving of 16-inch diameter concrete filled hollow polycarbonate pipe (poly-concrete) fender piles along the perimeter of the new Fuel Pier. Data at source (10 m [33 ft]) were collected using the Loggerhead USLM and the APL-UW USLM (Table 28). Far-field data were collected at distances ranging from 20 to 350 m (66 to 1,148 ft) using the APL-UW USLM. At source, maximum rms_{90} values ranged from 189.0 to 194.0 dB, maximum peak values ranged from 204.0 to 210.0 dB, and maximum single strike SEL_{90} values ranged from 170.4 to 176.0 dB (Table 29, Figure 28). At far-field distances, maximum rms_{90} values ranged from 152.3 to 177.8 dB, maximum peak values ranged from 171.0 to 195.1 dB, and maximum single strike SEL_{90} values ranged from 143.8 to 162.5 dB (Table 29, Figure 28). A logarithmic trendline provided a moderate fit to the data (R^2 of 0.628) (Figure 28). The calculated TL associated with the installation of 16-inch round poly-concrete fender piles was 17.8. For expanded metrics see Appendix A.3 and Appendix B.1.

Table 28. Acoustic and Pile Installation Equipment Used for 16-inch Round Poly-Concrete Fender Piles at the NBPL Fuel Pier (Impact Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (ft-lbs)
Loggerhead	1.5 - 7.0	Source, Far-Field	D25-32 APE Diesel Impact Hammer	29,484 - 58,245
APL-UW USLM				

Table 29. Maximum Underwater Sound Pressure Metrics for Impact Pile Driving of 16-inch Round Poly-Concrete Fender Piles at Source (10 m [33 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 μPa) rms90	Maximum (dB re 1 μPa) Peak	Maximum (dB re 1 μPa²-sec) SEL90[2]
5-Feb-16	TN-01A[1]	Source	10 (33)	189.0	204.0	174.0
	TN-01B[1]			191.0	208.0	175.0
	TN-01C[1]			194.0	210.0	176.0
3-Feb-16	TN-03A			191.1	206.9	170.4
		Far-Field	20 (66)	177.8	195.1	162.5
			50 (164)	170.4	189.6	155.6
4-Feb-16	TN-03D			163.5	182.9	151.4
			60 (197)	162.5	180.0	150.2
	TN-03C		70 (230)	158.6	173.2	145.9
	TN-03B		100 (328)	161.7	181.4	148.2
	TN-03D			152.3	171.0	143.8
	TN-03E			169.4	183.9	156.5
			107 (351)	168.8	181.3	154.9
			110 (361)	163.8	182.4	151.3
			120 (394)	165.9	176.1	152.9
			140 (459)	169.1	182.6	154.7
	TN-02B		180 (591)	165.4	181.7	152.7

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 µPa) rms$_{90}$	Maximum (dB re 1 µPa) Peak	Maximum (dB re 1 µPa^2-sec) SEL$_{90}$^{2}
5-Feb-16	TN-01A	Far-Field	185 (607)	160.2	173.9	148.5
4-Feb-16	TN-02B		200 (656)	168.5	182.4	154.7
5-Feb-16	TN-01A			168.5	177.9	152.7
4-Feb-16	TN-02B		206 (676)	177.2	184.6	151.9
			207 (679)	168.3	181.9	154.6
			240 (787)	165.9	178.7	152.3
5-Feb-16	TN-01B			160.7	173.3	148.6
			245 (804)	160.2	173.9	148.5
			247 (810)	152.7	171.2	146.8
			250 (820)	160.5	175.6	149.1
			260 (853)	164.3	180.9	152.0
			300 (984)	163.1	178.4	150.7
			350 (1,148)	160.7	174.7	148.7

Note: [1]Data collected using the Loggerhead, all other data was collected using the APL-UW USLM; [2]All SEL$_{90}$ values are for a single strike.

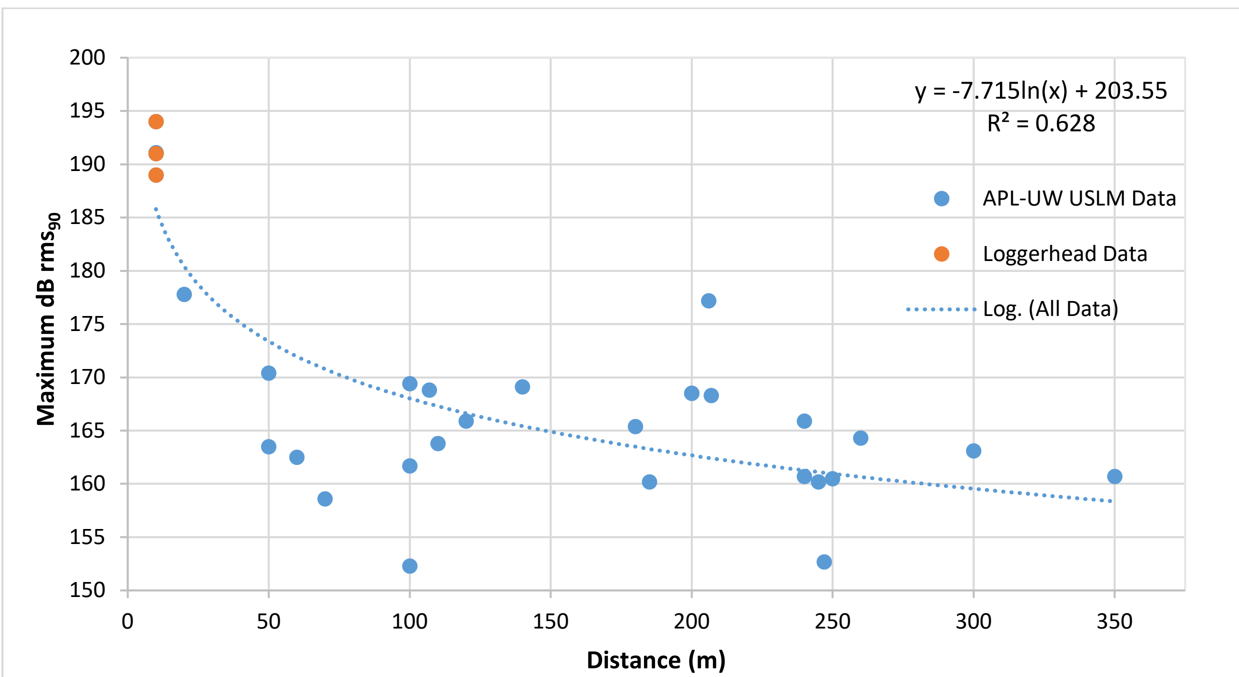

Figure 28. Maximum Underwater dB rms$_{90}$ for Impact Pile Driving of 16-inch Round Poly-Concrete Fender Piles at Source (10 m [33 ft]) and Graduated Distances.

Impact Pile Driving (Airborne Acoustics)

In February 2016, airborne acoustic monitoring was conducted during the impact driving of the 16-inch round poly-concrete fender piles. Data were recorded using the LD 831 SLM at source (15.2 m [50 ft]) only. The LZF_{max} values ranged from 109.0 to 114.5 dB, LZ_{Peak} values ranged from 125.7 to 132.0 dB, and LZ_{eq} values ranged from 103.7 to 108.2 dB (Table 30). A TL value could not be generated because only source data was recorded. For expanded metrics see Appendix A.5.

Table 30. Maximum Airborne Sound Pressure Metrics for Impact Pile Driving of 16-inch Round Poly-Concrete Fender Piles at Source (15.2 m [50 ft]).

Date	Pile Number	Station	Distance (m [ft])	Maximum dB (dB re 20 μPa)		
				LZF_{max}	LZ_{Peak}	LZ_{eq}
5-Feb-16	TN-01B	Source	15.2 (50)	114.5	132.0	108.2
	TN-01A			110.2	126.5	104.3
4-Feb-16	TN-02B			110.4	125.9	105.3
5-Feb-16	TN-03E			109.0	127.5	103.7
4-Feb-16	TN-02A			109.0	125.7	104.4
5-Feb-16	TN-01C			109.9	126.4	103.7

3.1.4 Demolition Activities

3.1.4.1 66-inch Round Caisson Removal (Wire Saw, Underwater Acoustics)

In December 2017, underwater acoustic measurements were collected using the LD 831 USLM during the cutting of 66-inch steel encased concrete-filled caisson (Table 31, Figure 29). Data were recorded using the LD 831 USLM because the APL-UW USLM was unavailable, and this USLM was considered appropriate for use since this demolition activity was not anticipated to have sound levels that would saturate the hydrophone. The LD 831 provides LZ metrics, and the only metric analyzed during monitoring was LZF_{max}, which was considered equivalent to dB rms values based on prior comparisons between the units during monitoring of the Fuel Pier project (except near source during impact driving). At source, average SPLs ranged from 155.6 to 156.9 dB and t maximum SPLs ranged from 160.7 to 162.4 dB (Table 32). At a far-field distance of 40 m (131 ft), the average SPL was 132.5 dB and the maximum SPL was 143.2 dB (Table 32). A TL could not be calculated for the 66-inch caissons due to a small sample size. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 31. Acoustic and Caisson Removal Equipment Used for 66-inch Round Caissons at the NBPL Fuel Pier (Wire Saw).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
LD 831 USLM	3.0	Source, Far-Field	Tetra Tech 92-inch inline hydraulic feed diamond wire saw	300 psi

Figure 29. Removal of a 66-inch Caisson Cutting Using the Tetra Tech 92-inch Inline Hydraulic Feed Diamond Wire Saw.

Table 32. Underwater Sound Pressure Metrics for Removal of 66-inch Round Caissons at Source (10 m [33 ft]) and Graduated Distances (Single Wire Saw).

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
13-Dec-17	TQ-06	Source	10 (33)	156.1	162.4
				155.6	161.3
				156.9	160.7
		Far-Field	40 (131)	132.5	143.2

3.1.4.2 84-inch Round Caisson Removal (Wire Saw, Underwater Acoustics)

In December 2016, acoustic measurements were collected using the APL-USLM during the cutting of 84-inch steel encased concrete-filled caissons with a diamond wire saw (Table 33, Figure 30). The caissons were initially cut at mid-depth and then again at the mudline, to reduce the load on the crane when removing the caissons. For some of the recordings, there were two caissons being cut simultaneously and the acousticians captured the SPLs for comparison between a single cutter and two cutters. For a single cutter, average SPLs at source (10 m [33 ft]) ranged from 136.1 to 141.4 dB rms and maximum SPLs ranged from 140.9 to 146.5 dB rms (Table 34, Figure 31). At far-field distances ranging from 20 to 283 m (66 to 928 ft), SPLs for a single cutter averaged 129.2 to 140.8 dB rms and maximum SPLs ranged from 136.6 to 144.5 dB rms (Table 34).

On average, there was an approximate 10-dB difference between a single cutter and two cutters at source. When two cutters were operating, average SPLs at source ranged from 146.5 to 151.0 dB rms and maximum SPLs ranged from 149.0 to 155.6 dB rms (Table 35, Figure 32). Figure 20 shows an example of the data output recorded at the source location using the APL-UW USLM. At far-field SPLs distances ranging from 85 to 810 m (279 to 2,657 ft) when two cutters were operating, average SPLs ranged from 130.1 to 137.9 dB rms and maximum SPL values ranged from 133.2 to 146.8 dB rms (Table 35). Differences in SPL values at distance reflected the variability in sound source levels of individual caissons and other anthropogenic noise at the time of the recordings.

The best fit data plots differed, depending on the number of saws, with a linear trendline providing the best fit for data obtained during operation of a single saw and logarithmic trendline providing the best fit of data obtained during operation of two saws (Figure 31). It should be noted that these trendlines had moderate fits to the data (R^2 values for one saw versus two saws were 0.658 and 0.514, respectively). The calculated TL was 4.9 during use of one saw and 7.0 during use of two saws. The far-field data appeared to be influenced by non-Project-related noise, most likely associated with vessel traffic. For determining the distance to Level A/B criteria thresholds, a TL of 15 is suggested. For expanded metrics see Appendix A.4 and Appendix B.2

Table 33. Acoustic and Caisson Removal Equipment Used for 84-inch Round Caissons at the NBPL Fuel Pier (Wire Saw).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	3.0	Far-Field	Mactech DWS-102i-102-inch inline hydraulic feed system diamond wire saw	300 psi

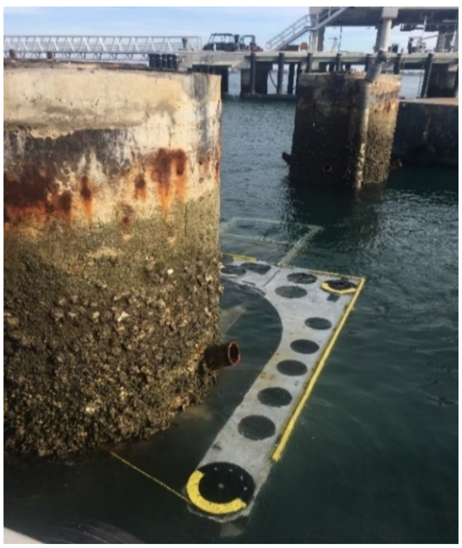


Figure 30. Removal of 84-inch Caissons using a Mactech DWS-102l 102-inch Inline Hydraulic Feed System Diamond Wire Saw.

Table 34. Underwater Sound Pressure Metrics for Removal of 84-inch Round Caissons at Source (10 m [33 ft]) and Graduated Distances (Single Wire Saw).

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 μPa)	
				Average	Maximum
14-Dec-16	P-H-10	Source	10 (33)	136.1	140.9
13-Dec-16	P-H-11			141.4	146.5
14-Dec-16	P-K-6	Far-Field	20 (66)	140.8	144.5
	P-H-6		40 (131)	134.8	140.1
15-Dec-16	P-K-9		60 (197)	137.1	140.6
13-Dec-16	P-H-11		85 (279)	136.0	139.5
15-Dec-16	P-K-9		110 (361)	135.3	136.6
19-Dec-16	P-K-5		200 (656)	129.2	139.1
			283 (928)	130.3	137.0

Table 35. Underwater Sound Pressure Metrics for Removal of 84-inch Round Caissons at Source (10 m [33 ft]) and Graduated Distances (Two Wire Saws).

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
13-Dec-16	P-H-11	Source	10 (33)	146.5	149.0
14-Dec-16	P-H-10			151.0	155.6
13-Dec-16	P-H-11	Far-Field	85 (279)	135.3	138.2
15-Dec-16	P-K-9		110 (361)	135.3	142.4
13-Dec-16	P-H-11		165 (541)	133.0	146.8
19-Dec-16	P-K-5		250 (820)	130.1	133.2
			537 (1,762)	137.9	140.9
			810 (2,657)	135.0	141.0

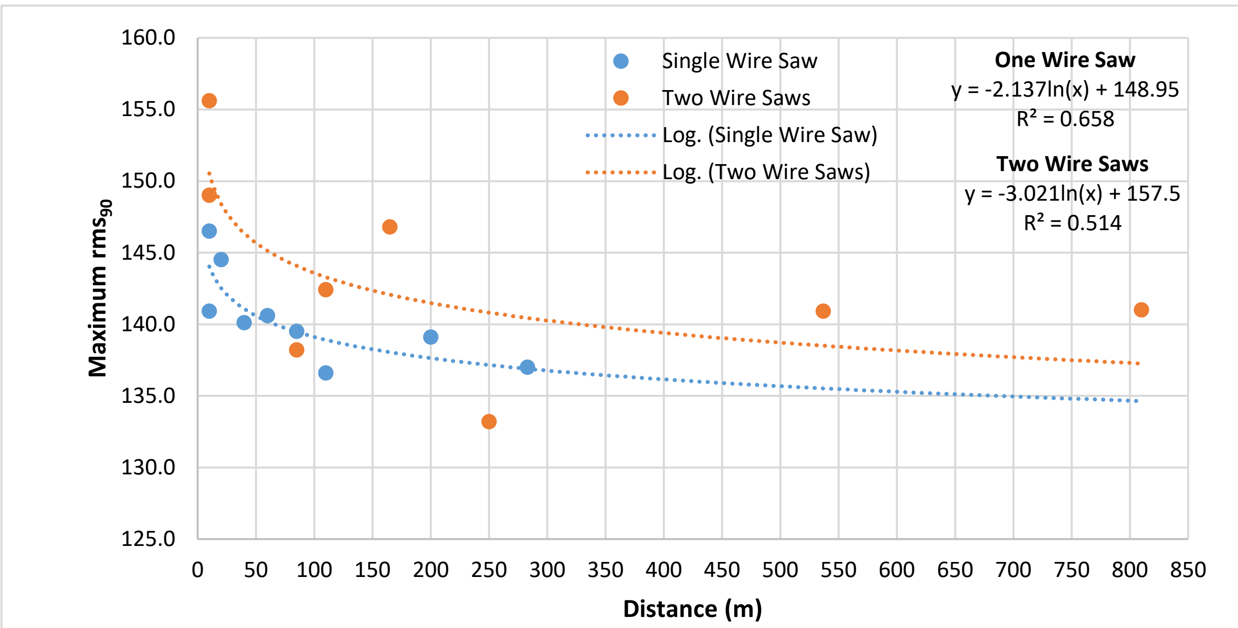

Figure 31. Comparison of Hydroacoustic Measurements at Multiple Distances During Removal of 84-inch Round Caissons using Two Wire Saws on Two Caissons Simultaneously and a Single Wire Saw on One Caisson.

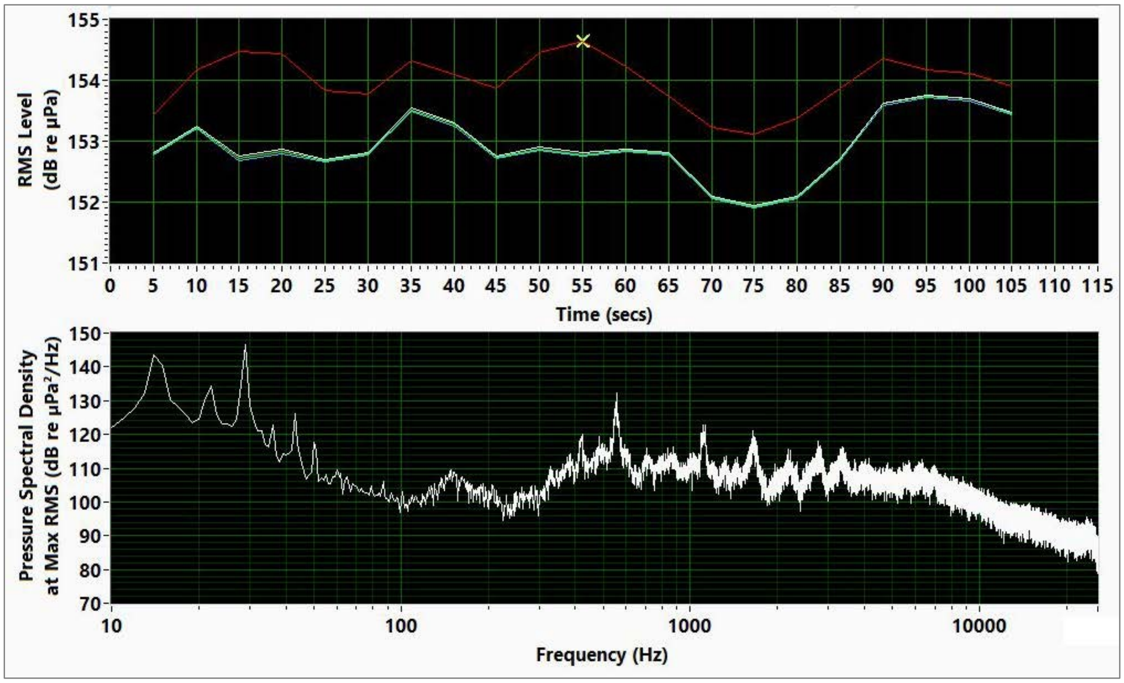

Figure 32. APL-UW USLM Acoustic Time Series Plot for Removal of 84-inch Round Caissons (With Two Wire Saws Simultaneously) at Source (10 m [33 ft]).

3.1.4.3 13-inch Round Polycarbonate Fender Pile Removal (Small Pile Clipper, Underwater Acoustics)

In February 2017, acoustic monitoring was conducted using the APL-USLM during removal of 13-inch round polycarbonate piles from the old Fuel Pier using a pile clipper (Table 36). At source (10 m [33 ft]), the average SPLs ranged from 137.7 to 145.9 dB rms and maximum SPLs ranged from 148.2 to 158.2 dB rms (Table 37, Figure 33). Figure 20 shows an example of the data output recorded at the source location using the APL-UW USLM. At far-field distances ranging from 55 to 350 m (180 to 1,148 ft), average SPLs ranged from 128.5 to 133.9 dB rms and maximum SPL values ranged from 133.2 to 150.3 dB rms (Table 37, Figure 34). A logarithmic trendline provided a relatively strong fit to the data (R^2 of 0.706) (Figure 33). The calculated TL was 11.7 based on the collected data during clipping of 13-inch round concrete piles. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 36. Acoustic and Pile Removal Equipment Used for 13-inch Round Polycarbonate Fender at the NBPL Fuel Pier (Pile Clipping).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	2.0–4.5	Source, Far-Field	Prime® Concrete Pile Clipper Model 24	3,500 psi

Table 37. Underwater Sound Pressure Metrics for Removal of 13-inch Round Polycarbonate Fender Piles (via a 24-inch Pile Clipper) at Source (10 m [33 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
15-Feb-17	SEC16	Source	10 (33)	145.9	156.2
	SEC15			141.2	158.2
	SEC14			143.6	154.6
16-Feb-17	SEC12			137.7	148.2
	SEC13			141.2	151.7
	SEC08	Far-Field	55 (180)	133.9	145.1
	SEC06		115 (377)	132.1	134.6
	SEC05		158 (518)	133.8	150.3
	SEC03		213 (699)	131.0	133.2
	SEC04		290 (951)	128.5	134.5
	SEC09		350 (1,148)	131.6	138.3

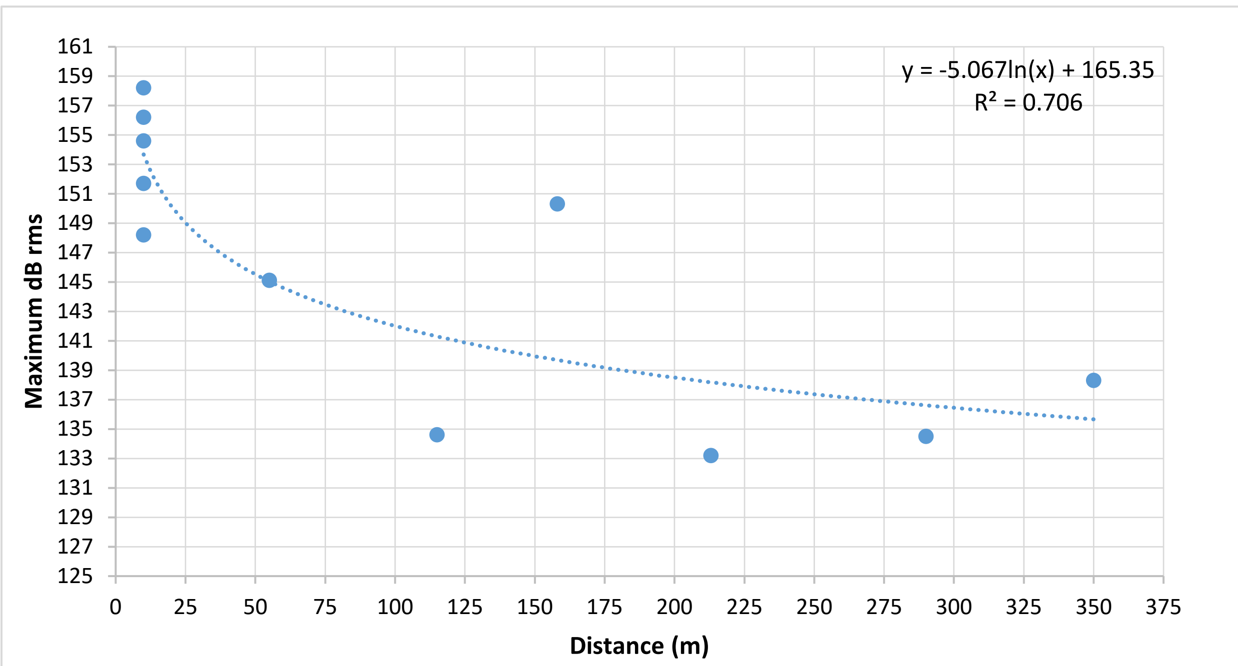

Figure 33. Maximum Underwater dB rms for Removal of 13-inch Round Polycarbonate Fender Piles (via a 24-inch Pile Clipper) at Source (10 m [33 ft]) and Graduated Distances.

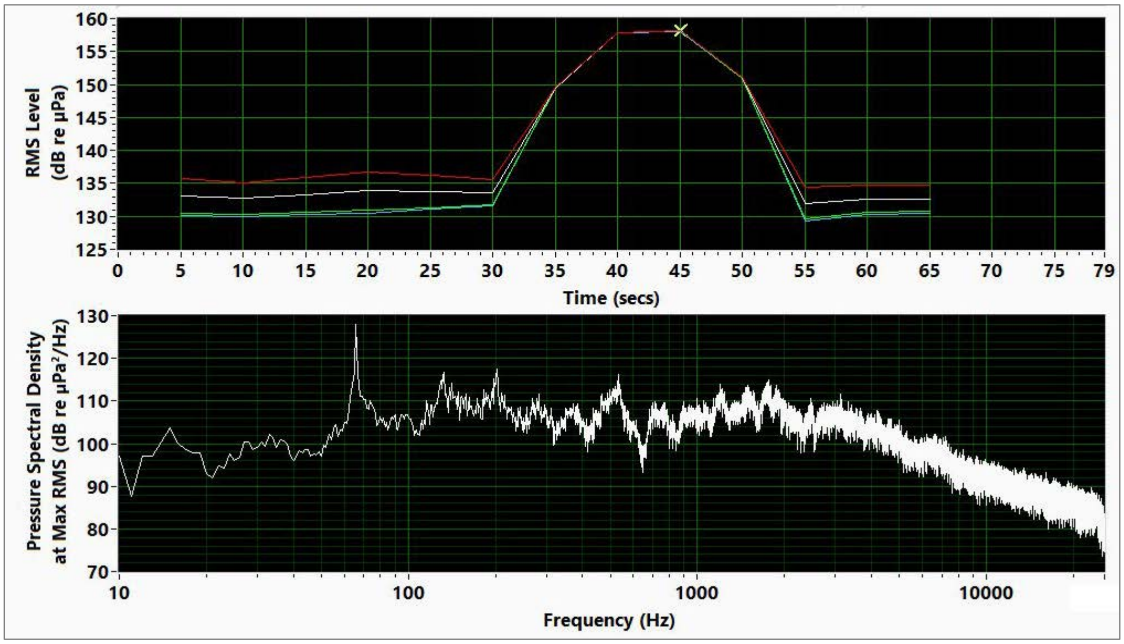

Figure 34. APL-UW USLM Acoustic Time Series Plot for Removal 13-inch Round Polycarbonate Fender Pile (via a 24-inch Pile Clipper) at Source (10 m [33 ft]).

3.1.4.4 16-inch Square Concrete Structural Pile Removal (Small and Large Pile Clipper, Underwater Hydraulic Chainsaw and Jetting, Underwater Acoustics)

Small and Large Clipper (Underwater Acoustics)

In April, July, October, and November 2017, acoustic monitoring was conducted using the APL-UW USLM during removal of 16-inch structural concrete piles from the old Fuel Pier. Two different pile clippers were used, a smaller cutter for the plumb piles and a larger cutter for plumb and batter pile combinations (Table 38). At source (10 to 11 m [33 to 36 ft]), average SPLs during operation of the smaller clipper ranged from 143.9 to 145.9 dB and maximum SPLs ranged from 146.5 to 147.3 dB (Table 39, Figure 35). Figure 36 shows an example of the APL-UW USLM data output at the source location. At far-field distances ranging from 27 to 309 m (89 to 1,014 ft), average SPLs ranged from 125.6 to 142.7 dB and maximum SPLs ranged from 129.9 to 144.1 dB (Table 39, Figure 35).

At source (10 to 12 m [33 to 39 ft]), average SPLs during operation of the larger clipper ranged from 138.5 to 142.4 dB and maximum SPLs ranged from 149.7 to 155.7 dB (Table 40, Figure 35). Figure 37 shows APL-UW USLM data output at the source location. At far-field ranging from 32 to 43 m (105 to 141 ft), average SPLs ranged from 131.6 to 138.6 dB and maximum SPLs ranged from 137.2 to 147.3 dB (Table 40, Figure 35).

The best fit data plots differed depending on the size of the clipper, with a logarithmic trendline providing the best fit for the small clipper data and linear trendline providing a best fit for the large clipper data; these trendlines had moderate to relatively strong fits to the data (R^2 values of 0.621 and 0.807 for the small and large clipper, respectively). However, the few available far-field data points for large clipper operation should be considered when referencing this result. The relatively poorer data fit for the small clipper was likely influenced by non-Project-related vessel noise associated with vessel traffic in the vicinity influencing the far-field measurements. The TL was calculated to be 10.3 for the small clipper and 17.9 for the large clipper. For determining the distance to Level A/B criteria thresholds, a TL of 15 is suggested. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 38. Acoustic and Pile Removal Equipment Used for 16-inch Concrete Structural Piles at the NBPL Fuel Pier (Pile Clipping).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	1.75 - 7.0	Source, Far-Field	Prime® Concrete Pile Clipper Model 24 (smaller) and Model 30 (larger)	3,500 psi

Table 39. Underwater Sound Pressure Metrics for Removal of 16-inch Square Concrete Structural Piles (via a 24-inch Pile Clipper) at Source (10 to 11 m [33 to 36 ft]) and Graduated Distances.

Date	Pile Number[1]	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
12-Jul-17	P03-C	Source	10 (33)	145.9	147.3
	P03-D		11 (36)	143.9	146.5
3-Jul-17	P10-AB	Far-Field	27 (89)	137.4	143.8
	P11-AB		101 (331)	133.1	138.5
17-Apr-17	P40-C		141 (463)	128.3	128.8
3-Jul-17	P08-AB		155 (509)	142.7	144.1
	P09-AB			139.1	142.2
17-Apr-17	P41-B		196 (643)	131.0	132.0
	P41-D		197 (646)	131.8	132.7
	P41-E		198 (650)	134.3	138.0
	P40-E		201 (659)	131.3	133.2
3-Jul-17	P08-AB		215 (705)	129.0	130.0
13-Jul-17	P03-AP		309 (1,014)	130.2	131.8
	P03-AB			125.6	129.9

Note: [1]The piles with "AB" refer to battered (angled) structural piles. The pile with "AP" refers to a battered (plumb [vertical]) structural pile. All other piles were plumb structural piles.

Table 40. Underwater Sound Pressure Metrics for Removal of 16-inch Square Concrete Structural Piles (via a 30-inch Pile Clipper) at Source (10 to 12 m [33 to 39 ft]) and Graduated Distances.

Date	Pile Number[1,2]	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
31-Oct-17	P27-AB/B	Source	12 (39)	138.5	155.7
1-Nov-17	P43-FB/E		10 (33)	142.4	150.0
31-Oct-17	P29-FB/E		12 (39)	141.5	149.7
	P31-FB/E	Far-Field	32 (105)	133.3	147.3
1-Nov-17	P41-FB/E		39 (128)	138.6	142.0
	P40-AB/B			131.6	137.2
	P37-FB/E		40 (131)	132.0	141.6
	P36-FB/E		43 (141)	131.6	140.1

Note: [1]The piles with "AB" refer to battered (angled) structural piles; [2]The 16-inch pile names in this table refer to structural battered (angled) and plumb (vertical) piles that crossed each other near the mudline. They were initially clipped with the 24-inch clipper above the crossed section, and then they were clipped again below the crossed section with the 30-inch clipper.

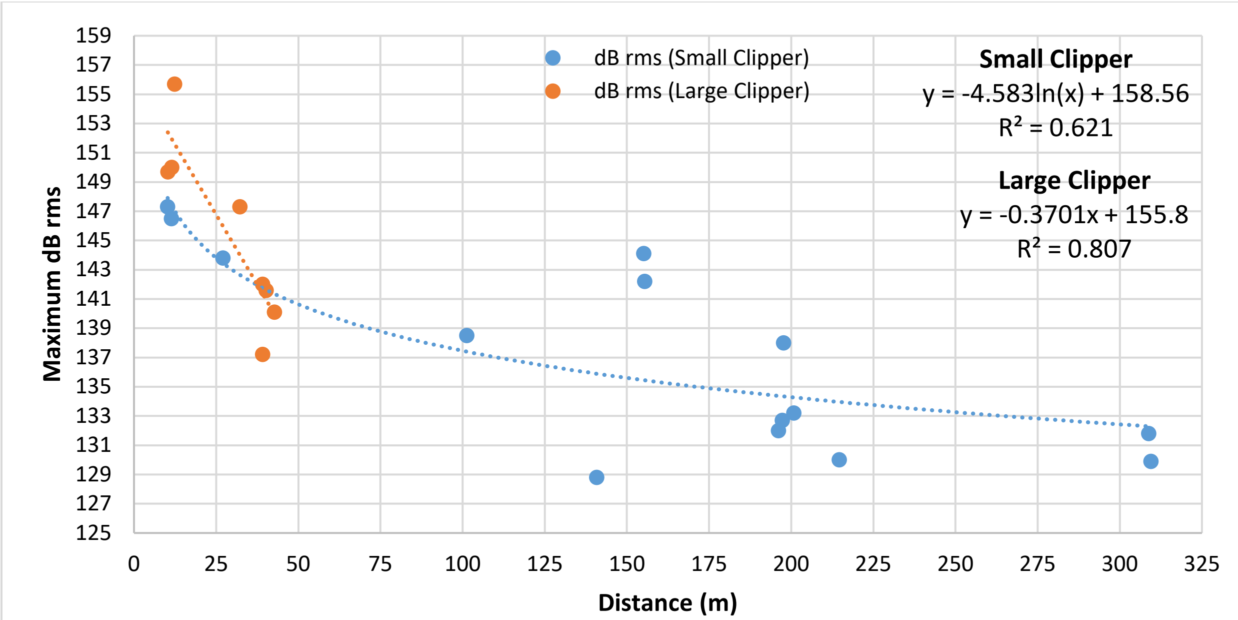

Figure 35. Maximum Underwater dB rms for Removal of 16-inch Square Concrete Structural Piles (via 24-inch and 30-inch Pile Clippers) at Source (10 to 12 m [33 to 39 ft]) and Graduated Distances.

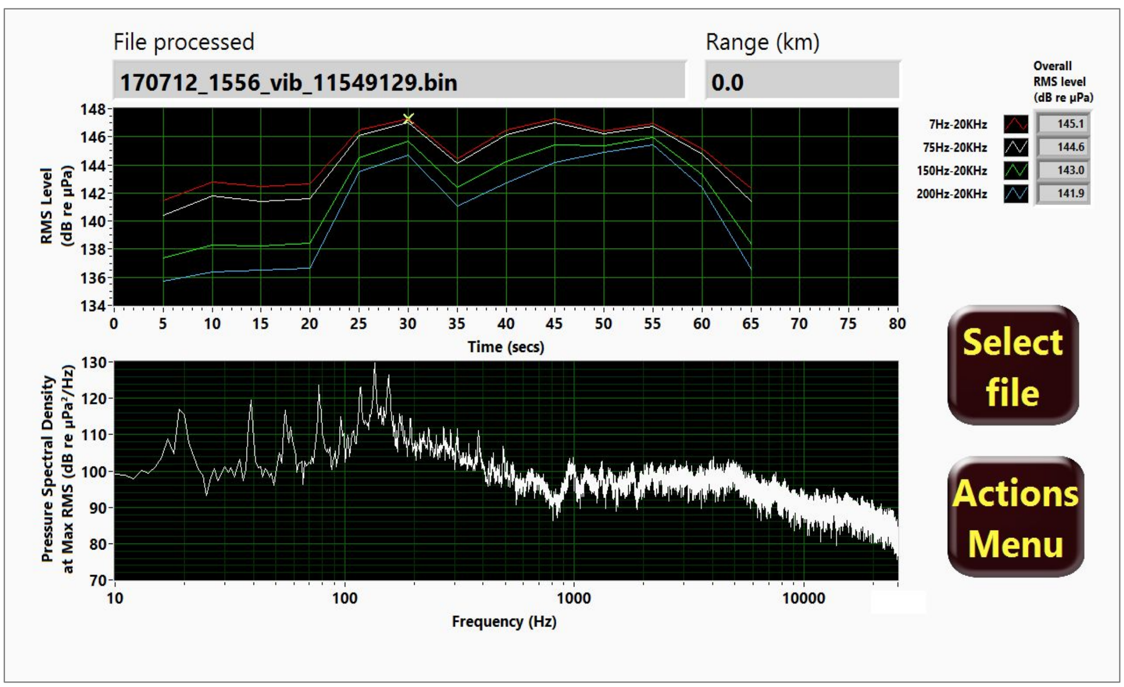

Figure 36. APL-UW USLM Acoustic Time Series Plot for Removal of 16-inch Square Concrete Structural Piles (via a 24-inch Pile Clipper) at Source (10 m [33 ft]).

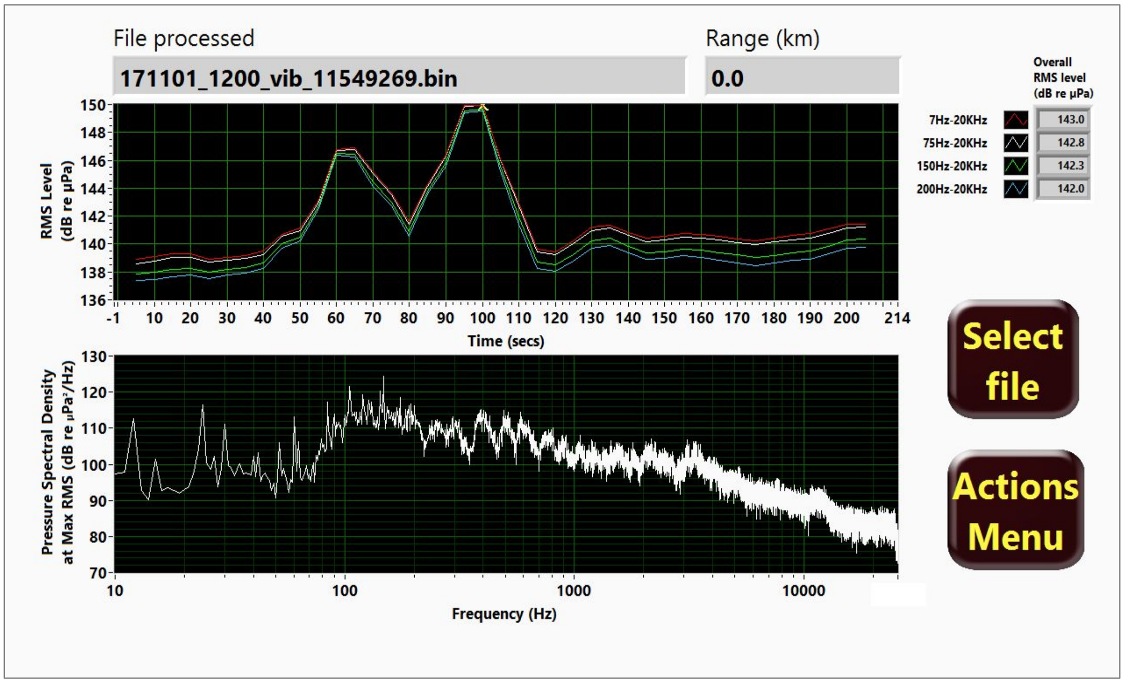

Figure 37. APL-UW USLM Acoustic Time Series Plot for Removal of 16-inch Square Concrete Structural Piles (via a 30-inch Pile Clipper) at Source (10 m [33 ft]).

Underwater Hydraulic Chainsaw (Underwater Acoustics)

Acoustic data were collected using the APL-UW USLM during the use of an underwater chainsaw to cut 16-inch square concrete structural piles that could not be removed with the pile clipper (Table 41, Figure 38). At the near source distance (17 m [56 ft]), average SPLs ranged from 136.3 to 146.4 dB and maximum SPLs value ranged from 146.2 to 149.8 dB (Table 42, Figure 39). Figure 40 shows an example of the APL-UW data output at source. At far-field distances, ranging from 20 to 70 m (66 to 230 ft), average SPLs ranged from 127.0 to 134.0 dB and maximum SPLs ranged from 129.3 to 137.7 dB (Table 42, Figure 39). A logarithmic trendline provided a relatively strong fit to the data (R^2 of 0.7257) (Figure 39). The calculated TL was 21.6 based on the collected data associated with the removal of 16-inch concrete piles via an underwater hydraulic chainsaw. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 41. Acoustic and Pile Removal Equipment Used for 16-inch Square Concrete Structural Piles at the NBPL Fuel Pier (Pile Cutting).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	4.0	Source, Far-Field	Stanley DS-11 hydraulically-actuated underwater chainsaw	2,000 psi

Figure 38. Hydraulically-Actuated Underwater Chainsaw.

Table 42. Underwater Sound Pressure Metrics for Removal of 16-inch Square Concrete Structural Piles (via an Underwater Chainsaw) Near Source (17 m [56 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 μPa)	
				Average	Maximum
4-Oct-17	P21-FB	Source	17 (56)	146.4	149.8
				136.8	149.5
				141.5	147.2
				141.0	146.8
				143.6	146.8
				140.3	146.7
				136.3	146.2
				142.9	145.6
		Far-Field	26 (87)	132.9	137.7
				132.4	135.8
				134.0	135.7
				132.7	135.2
				131.5	134.6
				132.5	133.8
				131.7	133.3
				131.1	133.1
				132.1	132.7
				131.2	132.2
11-Oct-17	P13-FB		42 (137)	128.6	133.6
				128.8	133.0
				128.1	132.1
			45 (148)	128.4	132.9
				127.6	131.7
				127.8	129.6
			60 (197)	128.8	133.9
				127.3	129.4
				127.7	129.4
				127.7	129.3
			76 (251)	127.2	130.3
				127.0	129.5

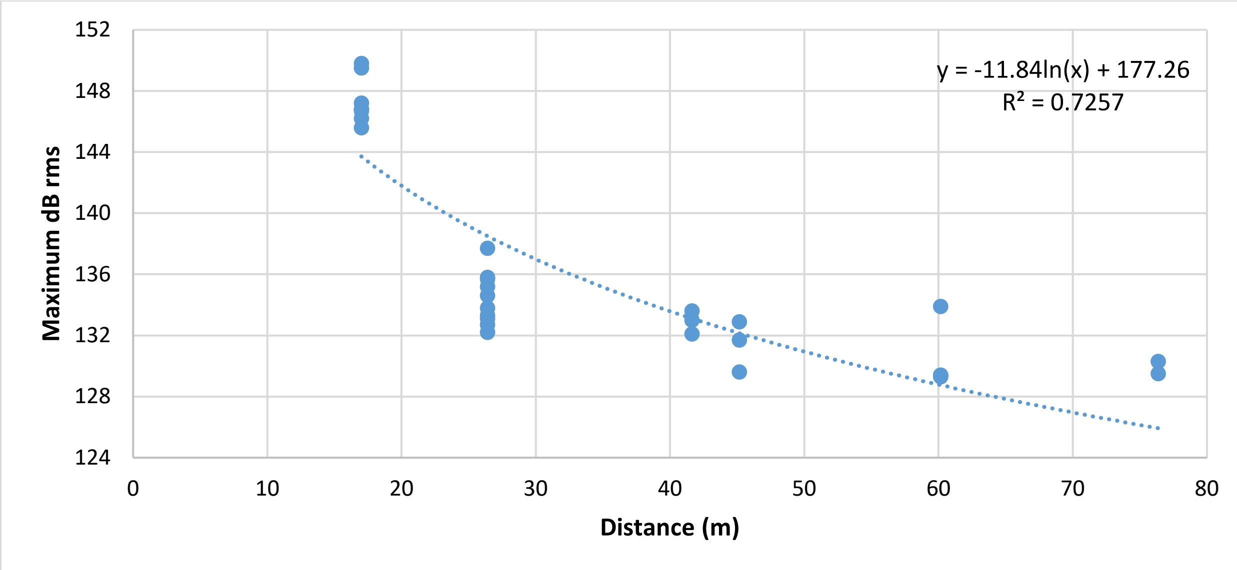

Figure 39. Maximum Underwater dB rms for Removal of 16-inch Square Concrete Structural Piles (via an Underwater Chainsaw) Near Source (17 m [56 ft]) and Graduated Distances.

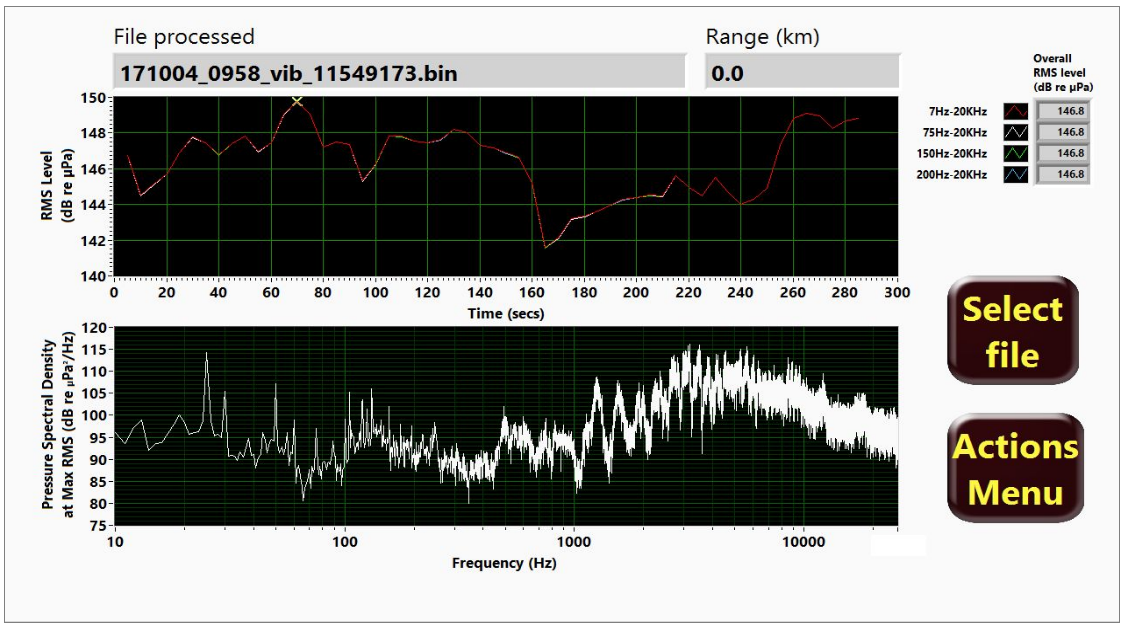

Figure 40. APL-UW USLM Acoustic Time Series Plot for Removal of 16-inch Square Concrete Structural Piles (via an Underwater Chainsaw) Near Source (17 m [56 ft]).

<u>High-Pressure Water Jetting (Underwater Acoustics)</u>

In June and July 2017, acoustic monitoring was conducted for 16-inch square concrete pile jetting removal using a single 2-inch pipe to create a high-pressure water jet (Table 43). The pipe was dropped into the water next to the pile and then worked around the base of the pile. This method was used as a means of loosening sediment around the pile base so that it could be dead-pulled out as a whole pile. After a few successful pile removals via pile jetting, many other unsuccessful attempts were made where the pile would not pull out. After these failures pile jetting was aborted. The values in Table 44 are a mix of successful and unsuccessful attempts.

Data were collected at source (9 to 10 m [30 to 33 ft]) and far-field distances ranging from 12 to 231 m (40 to 759 ft). At source, average SPLs ranged from 138.5 to 148.5 dB and maximum SPLs ranged from 141.9 to 151.4 dB (Table 44, Figure 41). Figure 42 shows an example of the data recorded at source using the APL-UW USLM. At far-field distances, average SPLs ranged from 125.7 to 145.5 dB and maximum SPLs ranged from 126.6 to 152.3 dB (Table 44, Figure 41). A logarithmic trendline had a relatively strong fit to the data based on the R^2 value of 0.758 (Figure 41). The calculated TL associated with the removal of 16-inch square concrete piles via a high-pressure water jet was 12.5. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 43. Acoustic and Pile Removal Equipment Used for 16-inch Square Concrete Structural Piles at the NBPL Fuel Pier (High-pressure Water Jetting)

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	1.9 - 4.5	Source, Far-Field	High Pressure Water Jet	300 psi

Table 44. Underwater Sound Pressure Metrics for Removal of 16-inch Square Concrete Structural Piles (via a High-Pressure Water Jet) at Source (9 to 10 m [30 to 33 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 μPa)	
				Average	Maximum
30-Jun-17	P11-B	Source	9 (30)	140.6	150.7
			9 (30)	141.3	148.7
			9 (30)	139.8	143.7
			9 (30)	139.5	143.1
			9 (30)	140.8	143.1
			9 (30)	139.6	142.0
			9 (30)	138.9	141.9
	P09-B		10 (33)	143.9	151.4
			10 (33)	148.5	150.7
			10 (33)	140.9	149.8
			10 (33)	147.2	149.6
			10 (33)	141.5	148.2
			10 (33)	142.9	148.0
			10 (33)	141.0	145.9
			10 (33)	145.0	145.4
			10 (33)	138.5	145.2
			10 (33)	140.7	144.7
			10 (33)	140.1	144.1
			10 (33)	139.0	143.8
	P10-B	Far-Field	12 (40)	139.9	149.3
			12 (40)	138.0	148.3
			12 (40)	139.9	145.2
21-Jun-17	P20-E		13 (43)	143.0	152.3
			13 (43)	141.3	149.7
			13 (43)	137.6	144.7
			13 (43)	137.5	138.8
			13 (43)	135.8	138.4
			13 (43)	136.0	137.2

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 μPa)	
				Average	Maximum
12-Jul-17	P04-B	Far-Field	16 (52)	145.5	147.4
			16 (52)	142.8	145.6
	P03-B		19 (61)	143.0	145.7
			19 (61)	143.4	145.0
			19 (61)	142.4	144.1
03-Jul-17	P06-B		49 (161)	135.2	135.4
			49 (161)	128.6	135.3
			70 (229)	133.9	139.3
			70 (229)	129.3	133.1
	P08-B		102 (334)	129.4	131.6
			102 (334)	126.3	128.6
	P07-B		104 (342)	128.4	134.1
			145 (474)	131.7	135.0
			145 (474)	129.7	133.3
			145 (474)	127.4	130.6
	P06-B		231 (759)	130.6	132.3
			231 (759)	126.1	130.2
			231 (759)	125.9	130.0
			231 (759)	125.7	126.6

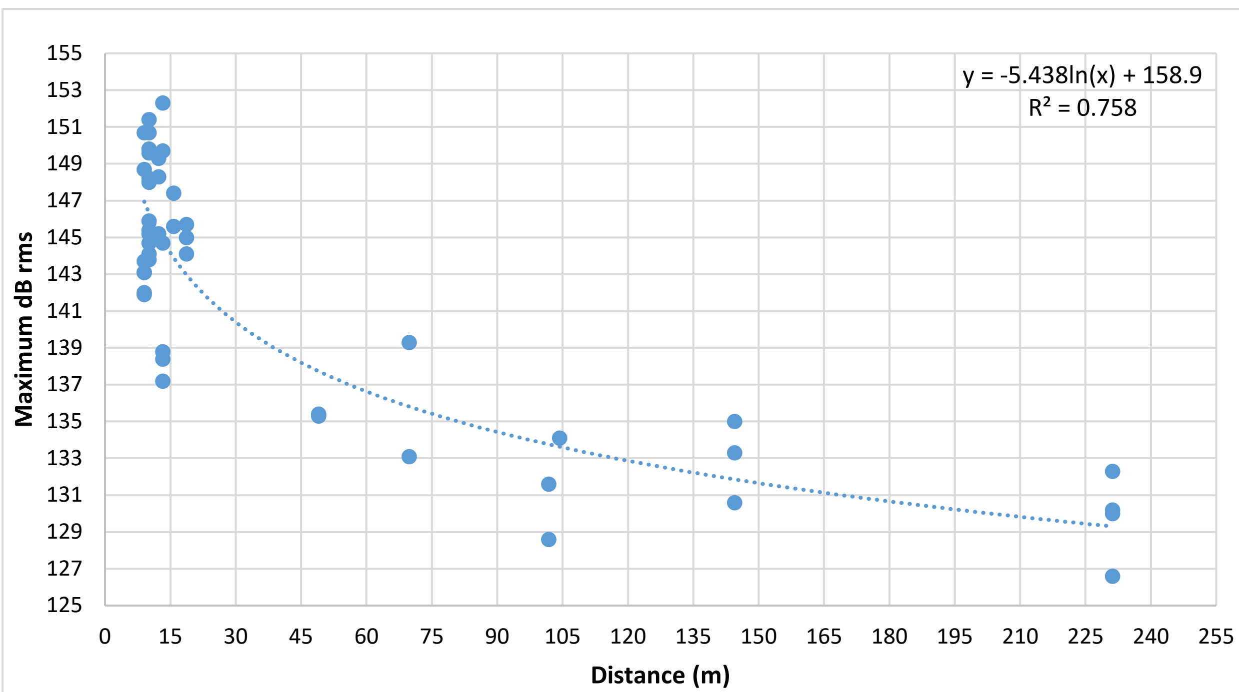

Figure 41. Maximum Underwater dB rms for Removal of 16-inch Square Concrete Structural Piles (via a High-Pressure Water Jet) at Source (9 to 10 m [30 to 33 ft]) and Graduated Distances.

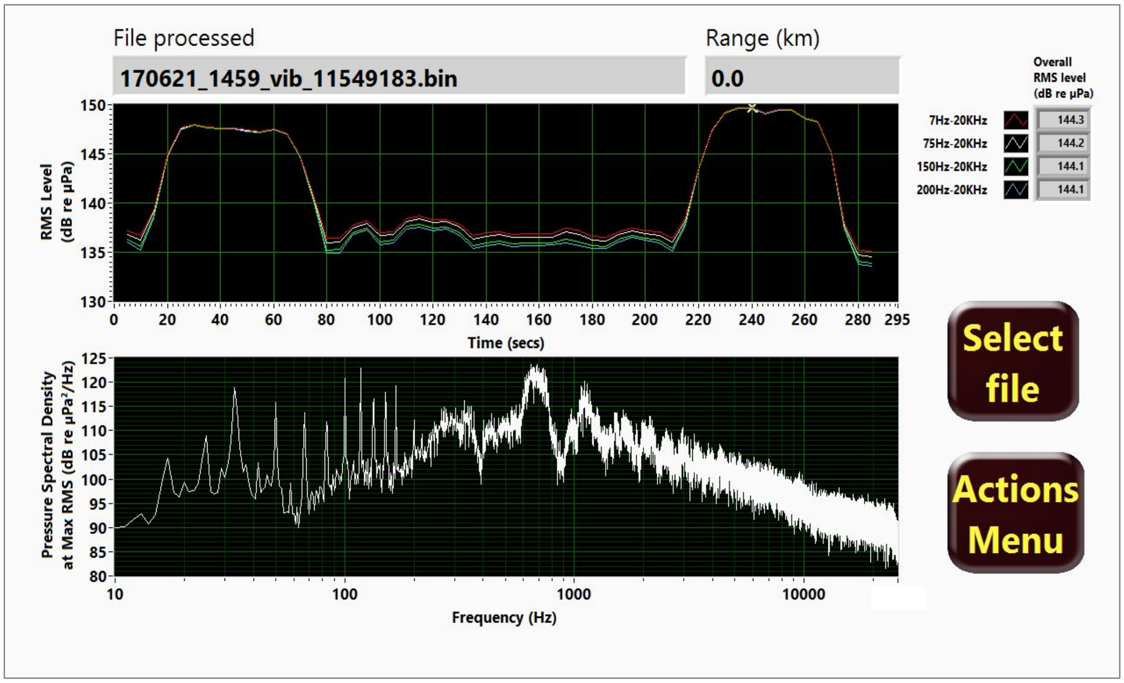

Figure 42. APL-UW USLM Acoustic Time Series Plot for Removal of 16-inch Square Concrete Structural Pile (via a High-Pressure Water Jet) at Source (10 m [33 ft]).

3.1.4.5 18-inch Square Concrete Fender Pile Removal (Small Clipper, Underwater Acoustics)

In September 2016 and July and August 2017, acoustic monitoring was conducted using the APL-UW USLM during the cutting of 18-inch square concrete fender piles (Table 45). At source (10 to 11 m [33 to 36 ft]), average SPLs ranged from 137.8 to 140.0 dB rms and maximum SPLs ranged from 146.4 to 154.3 dB rms (Table 46, Figure 43). At far-field distances ranging from 92 to 388 m (301 to 1,272 ft), average SPLs ranged from 124.3 to 136.8 dB rms and maximum SPL values ranged from 125.0 to 142.8 dB (Table 46, Figure 43). A linear trendline had a relatively strong fit to the data (R^2 of 0.7205) (Figure 43). The calculated TL was 13.5 during use of the small clipper for the removal of 18-inch square concrete piles. Figure 44 shows an example of the data recorded at source using the APL-UW USLM. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 45. Acoustic and Pile Removal Equipment Used for 18-inch Concrete Fender Piles at the NBPL Fuel Pier (Pile Clipping).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	1.75 - 7.0	Source, Far-Field	Prime® Concrete Pile Clipper, Model 24	3,500 psi

Table 46. Underwater Sound Pressure Metrics for Removal of 18-inch Square Concrete Fender Piles (via a 24-inch Pile Clipper) at Source (10 to 11 m [33 to 36 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
19-Sep-16	NWF05	Source	11 (36)	140.0	154.3
	NWF01		10 (33 ft)	137.8	150.5
	NWF03		11 (36)	138.2	146.4
	NWF08	Far-Field	92 (301)	136.8	139.6
	NWF10		169 (555)	135.8	139.3
	NWF12		175 (574)	128.6	142.8
9-Aug-17	TFS02		187 (614)	128.1	131.8
14-Aug-17	TFS11		206 (677)	134.6	141.3
	TFS08		223 (733)	126.1	126.7
	TFS09		224 (736)	135.1	137.3
	TFS10		226 (741)	135.8	137.8
13-Jul-17	SWF01		238 (781)	125.4	127.9
14-Aug-17	TFS12		253 (830)	131.4	135.0
	TFS06		280 (918)	123.9	126.6
	TFS13		297 (975)	129.3	130.9
	TFS14		335 (1,099)	126.6	132.3
				127.1	127.6
	TFS15		388 (1,272)	128.8	131.9
				124.3	125.0

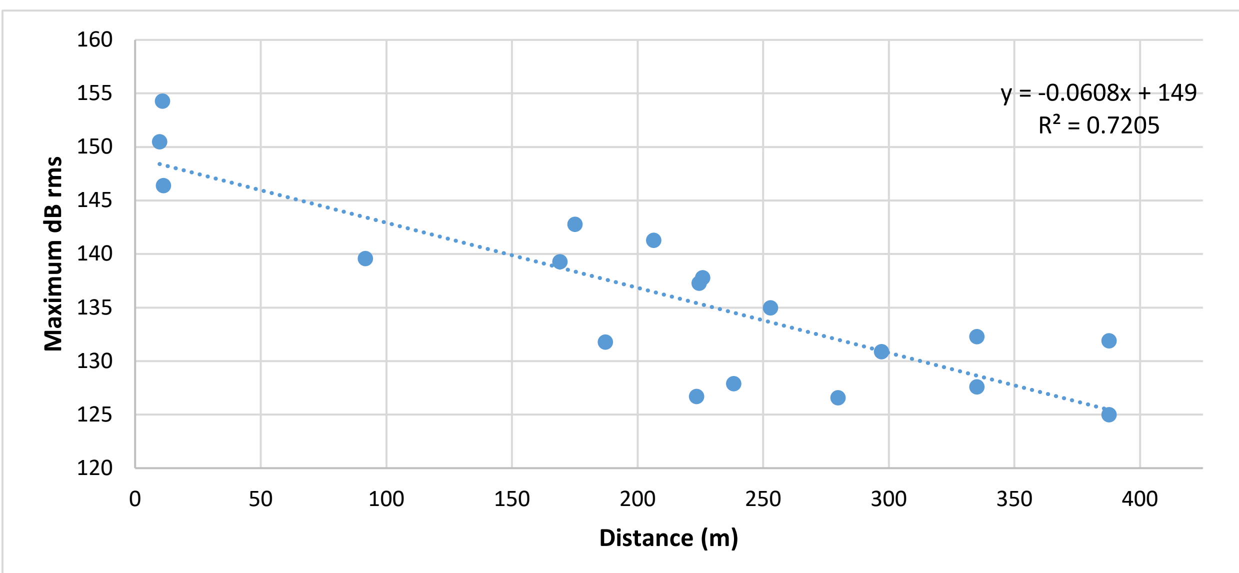

Figure 43. Maximum Underwater dB rms for 18-inch Square Concrete Fender Piles (via a 24-inch Pile Clipper) at Source (10 to 11 m [33 to 36 ft]) and Graduated Distances.

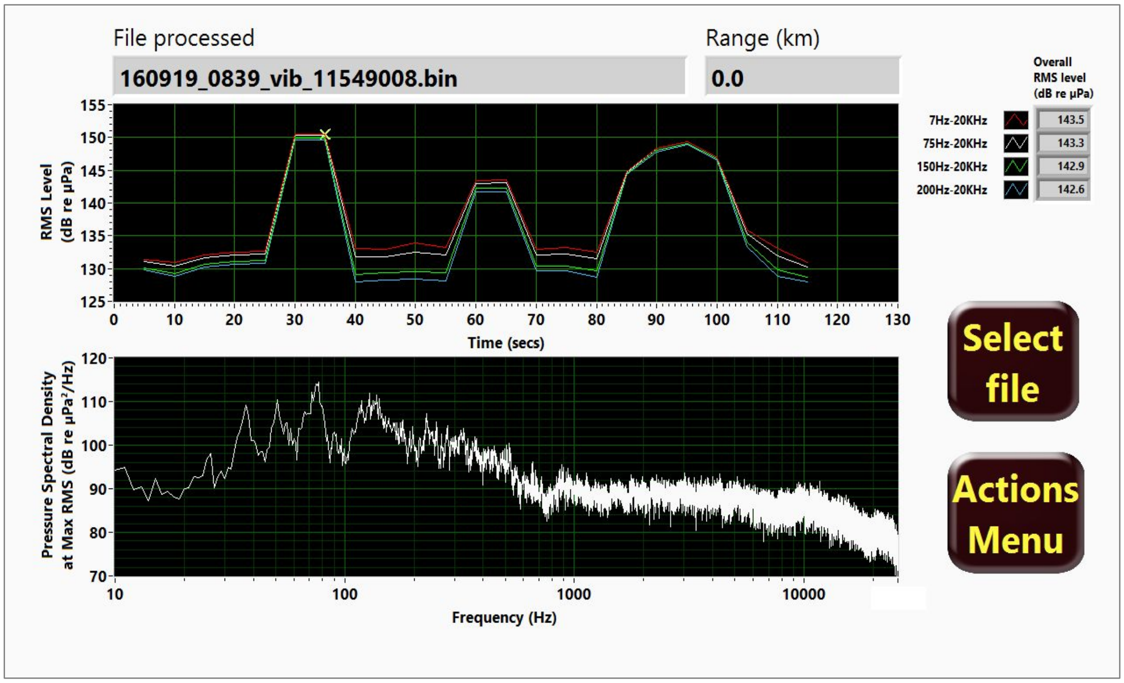

Figure 44. APL-UW USLM Acoustic Time Series Plot for Removal of 18-inch Square Concrete Fender Piles (via a 24-inch Pile Clipper) at Source (10 m [33 ft]).

3.1.4.6 24-inch Square Concrete Fender Pile Removal (Large Clipper, Underwater Acoustics)

In October 2016 and November 2017, acoustic monitoring was conducted using the APL-UW USLM during the cutting of 24-inch square concrete fender piles (Table 47, Figure 45). At source (7 to 10 m [23 to 33 ft]), average SPLs ranged from 138.0 to 144.6 dB and maximum SPLs ranged from 156.1 to 165.3 dB (Table 48, Figure 46). Figure 20 shows an example of the data recorded at source using the APL-UW USLM. At far-field distances ranging from 17 to 340 m (56 to 1,115 ft), average SPLs ranged from 125.0 to 135.7 dB rms and maximum SPLs ranged from 129.1 to 157.7 dB rms (Table 48, Figure 47). A logarithmic trendline had a strong fit to the data (R^2 of 0.908) (Figure 46). The calculated TL was 17.5 during the removal of 24-inch square concrete piles via a large clipper. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 47. Acoustic and Pile Removal Equipment Used for 24-inch Square Concrete Fender Piles at the NBPL Fuel Pier (Pile Clipping).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	2.5 - 7.0	Source, Far-Field	Prime® Concrete Pile Clipper, Model 30	3,500 psi

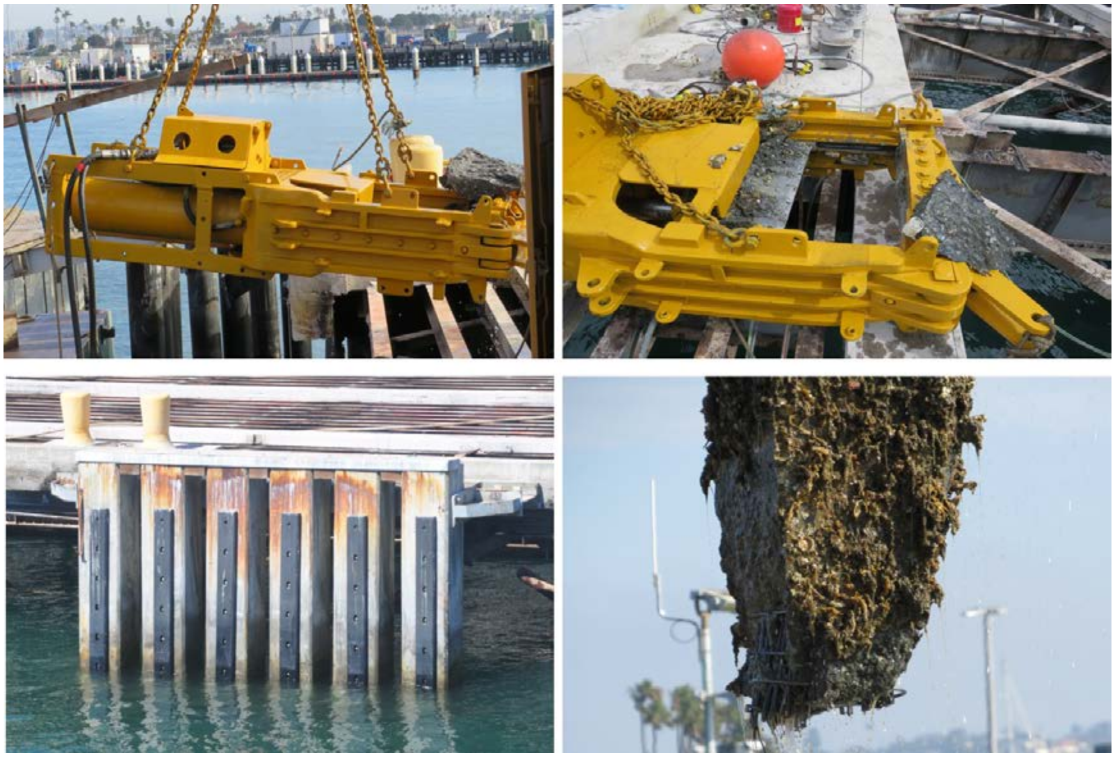

Figure 45. Series of Images Detailing the Cutting and Removal of a 24-inch Square Concrete Fender Pile.

Table 48. Underwater Sound Pressure Metrics for Removal of 24-inch Square Concrete Fender Piles (via a 30-inch Pile Clipper) at Source (7 to 10 m [23 to 33 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
8-Nov-17	SEB-05	Source	7 (23)	138.5	161.1
12-Oct-16	NEB-12		10 (33)	143.5	165.3
13-Oct-17	NEB-02		10 (33)	139.5	163.8
	NEB-01			144.6	159.9
	NEB-03			138.0	156.1
15-Nov-17	SEB-28	Far-Field	17 (56)	134.9	153.8
	SEB-29		19 (62)	135.7	157.7
	SEB-27		39 (128)	130.8	147.7
	SEB-26		44 (144)	127.8	146.8
9-Nov-17	SEB-08		50 (164)	131.5	147.6
	SEB-09		53 (174)	131.7	145.1
13-Nov-17	SEB-18		90 (295)	131.0	146.8
	SEB-19		107 (351)	135.4	142.0
7-Nov-17	SEB-06		165 (541)	128.0	132.3
14-Nov-17	SEB-23		195 (640)	129.4	137.6
	SEB-24			135.2	136.6
7-Nov-17	SEB-02		235 (771)	127.1	138.8
	SEB-03			125.0	129.1
9-Nov-17	SEB-07		265 (869)	125.2	137.8
14-Nov-17	SEB-22		290 (951)	129.1	137.2
	SEB-20		340 (1,115)	128.1	137.8
	SEB-21			129.5	135.8

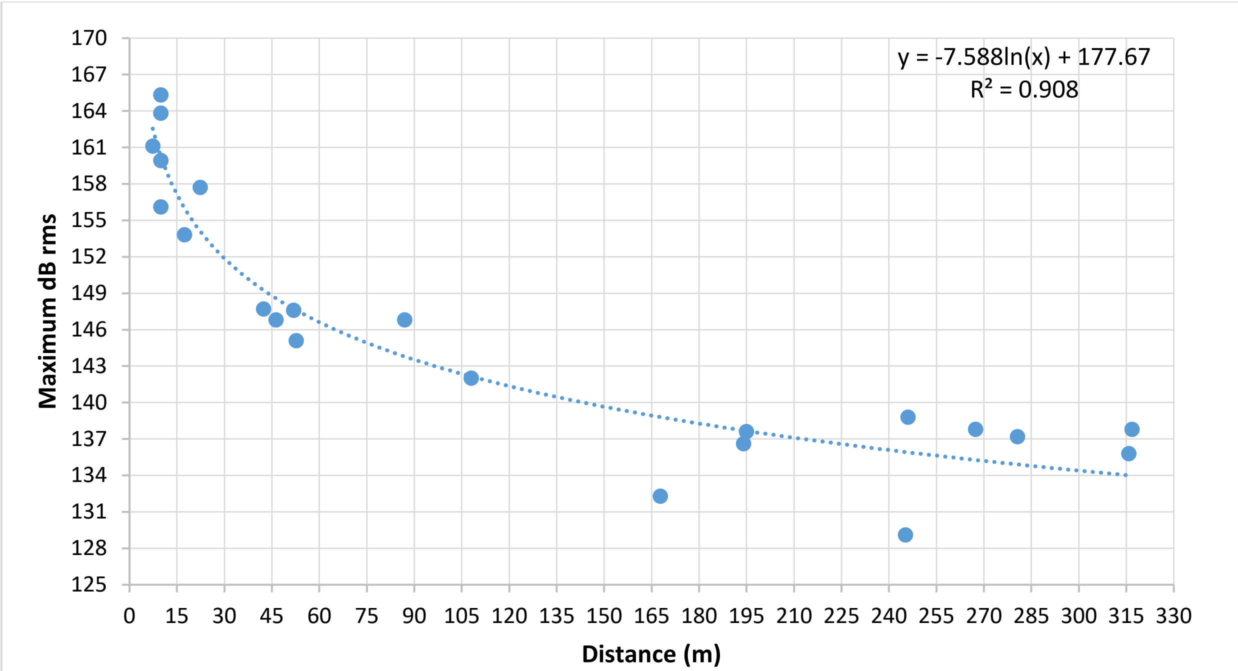

Figure 46. Maximum Underwater dB rms for Removal of 24-inch Square Concrete Fender Piles (via a 30-inch Pile Clipper) at Source (7 to 10 m [23 to 33 ft]) and Graduated Distances.

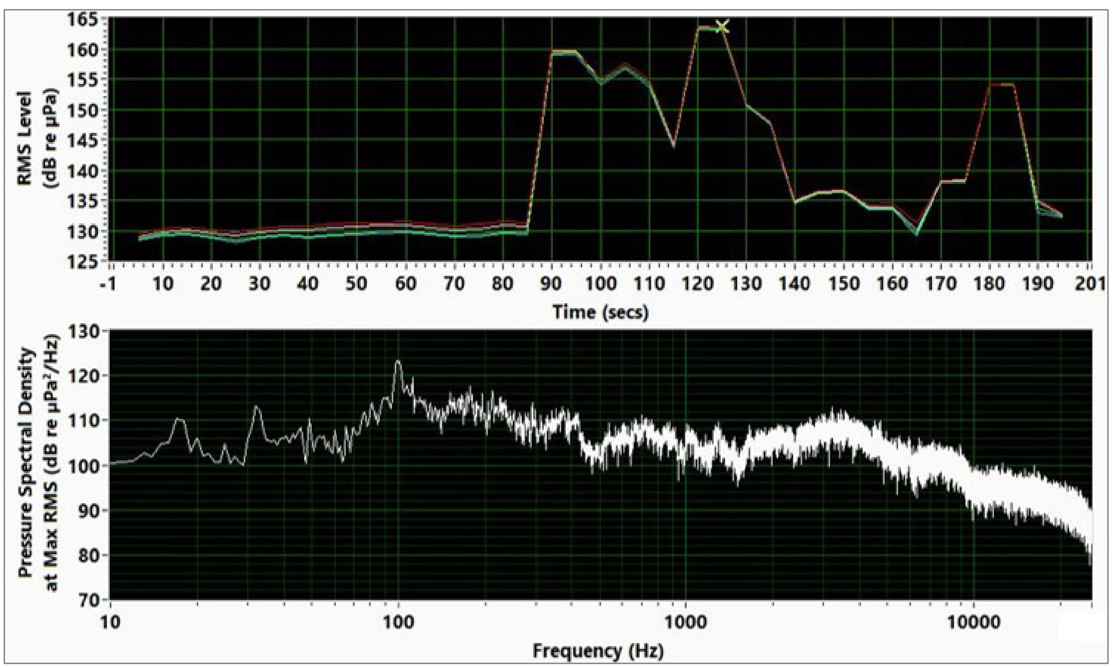

Figure 47. APL-UW USLM Acoustic Time Series Plot of Removal 24-inch Square Concrete Fender Piles (via a 30-inch Pile Clipper) at Source (10 m [33 ft]).

3.1.5 Ambient Acoustics

3.1.5.1 Ambient Underwater Acoustics

Underwater ambient data collection efforts were conducted during IHA Years 2 and 3 of the Fuel Pier Replacement Project at two locations with distances referenced to the center-line of the outer portion of the new pier: (1) near a shoaling marker that was approximately 750 m (2,461 ft) to the north of Project area, and (2) near a cluster of mooring piles that was approximately 400 m (1,312 ft) to the south of the Project area. The recording periods were timed to occur before Project-related activities had commenced as part of the IHA monitoring period, during construction when no in-water work was scheduled for at least three days, and after Project-related activities had stopped as part of the IHA monitoring period. All underwater ambient data were collected using a Loggerhead USLM and analyzed at the APL-UW. Ambient noise metrics were evaluated for frequencies between 3 Hz and 25,000 Hz. Noise levels were reported as exceedance level percentiles, where Lx indicates the SPL exceeded x% of the measurement period. The median (L_{50}) as statistical measure is more resilient against high amplitude transient events, and thus is viewed as an indicator of typically observed values of ambient noise. For a measure of the variation we also report the characteristic low level (L_{90}) and high level (L_{10}).

During IHA Year 2, ambient data were collected December 2014, and March, April, and May 2015. Ambient sound levels typically exceeded 120 dB rms. Ambient L_{90} SPLs ranged from 122.0 to 131.0 dB, L_{50} SPLs ranged from 126.0 to 137.0 dB, and L_{10} SPLs ranged from 130 to 147 dB (Table 49). The average values of the L_{90}, L_{50}, and L_{10} across all measurement dates were 124.4, 129.6, and 136.2 rms, respectively.

During IHA Year 3, ambient data were collected in December 2015, and April and May 2016 at approximately the same locations as in IHA Year 2. Similar to the prior year, the Year 3 ambient sound levels typically exceeded 120 dB rms. The L_{90} SPLs ranged from 123.0 to 144.0 dB, the median L_{50} SPLs ranged from 127.0 to 146.0 dB, and the L_{10} SPLs ranged from 132.0 to 153.0 dB (Table 49). For the Year 3 measurement period, the average values of the L_{90}, L_{50}, and L_{10} across all measurement dates were 129.3, 134.8, and 140.2 rms, respectively.

Measurement periods in December 2014, December 2015, and April 5, 2016 (Table 49), which were collected to the south of the Project area near a cluster of mooring piles, had data records much higher than the other data collected. If those dates are screened from the analysis, the average L_{50} SPL over both years was 129.2 dB rms.

Table 49. Average Underwater Ambient Sound Levels During IHA Year 2 and 3 for Two Locations in San Diego Bay.

Date	Location	Deployed Depth (m [ft])	Water Depth (m [ft])	Average dB (dB re 1 μPa)		
				L_{90}	L_{50}	L_{10}
IHA Year #2						
11 Dec – 13 Dec 2014	Mooring Dolphin[1]	5 (16.4)	10 (33)	131.0	137.0	147.0
26 Mar – 28 Mar 2015	Mooring Dolphin	5 (16.4)	10 (33)	122.0	128.0	134.0
2 April – 4 April 2015	Mooring Dolphin	5 (16.4)	10 (33)	123.0	126.0	130.0
18 May – 20 May 2015	Mooring Dolphin	5 (16.4)	10 (33)	122.0	128.0	134.0
18 May – 20 May 2015	Shoaling Marker	6 (19.6)	13 (43)	124.0	129.0	136.0
IHA Year #3						
16 Dec – 18 Dec 2015	Shoaling Marker	6 (19.6)	13 (43)	123.0	128.0	135.0
	Mooring Dolphin[1]	5 (16.4)	10 (33)	144.0	146.0	153.0
5 April – 7 April 2016	Shoaling Marker	6 (19.6)	13 (43)	125.0	132.0	137.0
5 April 2016 (Only)	Mooring Dolphin[1]	5 (16.4)	10 (33)	133.0	140.0	142.0
4 May – 6 May 2016	Shoaling Marker	5 (16.4)	10 (33)	126.0	136.0	142.0
10 May – 12 May 2016	Mooring Dolphin	6 (19.6)	13 (43)	125.0	127.0	132.0

Note: [1]These periods had data records with higher SPLs than other measurement periods.

3.1.5.2 Ambient Airborne Acoustics

Ambient airborne sound level recordings were taken using the LD 831 SLM on four occasions during fall and spring when underwater construction activities were not occurring. The average LZF_{max} values ranged from 77.0 to 81.6 dB, LZ_{Peak} values ranged from 84.7 to 90.1 dB, and LZ_{eq} values ranged from 74.5 to 81.6 dB (Table 50).

Table 50. Average Airborne Ambient Sound Levels Near the Fuel Pier, San Diego Bay.

Season	Date	Average dB (dB re 20 µPa)		
		LZF_{max}	LZ_{Peak}	LZ_{eq}
Fall	12-Nov-2014	77.3	84.9	74.7
	13-Nov-2014	77.0	84.8	74.6
	17-Nov-2014	77.4	86.1	74.8
Spring	17-Mar-2015	77.3	85.2	75.0
	18-Mar-2015	77.2	85.6	75.3
	19-Mar-2015	77.1	85.4	75.1
	01-May-2015	77.1	84.7	74.5
	04-May-2015	77.2	84.9	74.7
	05-May-2015	77.5	85.2	74.9
Fall	17-Nov-2015	81.6	90.1	81.6
	25-Nov-2015	77.1	86.7	77.1

3.2 Naval Base Point Loma Fuel Pier Replacement Project – Harbor Drive Annex

3.2.1 Concrete Pile Installation

3.2.1.1 16-inch Round Concrete Guide Pile Installation (Impact Driving and Jetting, Underwater Acoustics)

Impact Pile Driving (Underwater Acoustics)

In September 2017, acoustic monitoring was conducted using the APL-UW USLM during impact pile driving of 16-inch round concrete piles (Table 51). The piles were primarily driven at the Level 1 (lowest) power setting except for the last two entries in Table 52 (Level 4). Near source (9 to 15 m [30 to 49 ft]), maximum rms_{90} values ranged from 170.0 to 181.3 dB, maximum peak values ranged from 182.0 to 189.8 dB, and maximum single strike SEL_{90} values ranged from 157.5 to 164.4 dB (Table 52, Figure 48). At far-field distances ranging from 73 to 374 m (239 to 1,228 ft), maximum rms_{90} values ranged from 135.3 to 160.2 dB, maximum peak values ranged from 153.7 to 173.3 dB, and maximum single strike SEL_{90} values ranged from 129.3 to 142.5 dB (Table 52, Figure 48). A logarithmic trendline had a relatively strong fit to the data (R^2 of 0.8232) (Figure 48). The regression was based on Level 1 data only because piles were most often driven at this power setting. The calculated TL was 20.0 during the impact driving of these 16-inch round concrete piles. For expanded metrics see Appendix A.3 and Appendix B.1.

Table 51. Acoustic and Pile Installation Equipment Used for 16-inch Round Concrete Guide Piles at the NBPL HDA (Impact Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (ft-lbs)
APL-UW USLM	1.75 - 4.0	Source, Far-Field	D25-32 APE Diesel Impact Hammer	29,484 - 58,245

Table 52. Maximum Underwater Sound Pressure Metrics for Impact Pile Driving of 16-inch Round Concrete Guide Piles Near Source (9 to 15 m [30 to 49 ft]) and Graduated Distances at the NBPL HDA.

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 µPa)		Maximum (dB re 1 µPa²-sec)
				rms_{90}	Peak	SEL_{90}[1]
20-Sep-17	607N-B9	Source	15 (49)	181.3	189.8	164.4
27-Sep-17	548-K10		9 (30)	179.8	189.0	163.6
	548-L10		11 (36)	179.6	188.4	162.4
	548-M10		9 (30)	177.2	187.7	161.5
	548-M9		9 (30)	173.6	185.2	159.9
	548-D10		9 (30)	170.0	182.0	157.5
25-Sep-17	548-B10	Far-Field	73 (239)	160.2	169.4	142.5
	548-A10		83 (273)	150.1	173.3	137.6
	548-A9			151.0	162.5	138.4
21-Sep-17	607N-E9		328 (1,076)	143.6	157.2	133.3
	607N-F9		338 (1,110)	154.1	163.5	141.3
19-Sep-17	607N-A9[2]		353 (1,160)	142.2	160.1	135.5
	607N-C9[2]		374 (1,228)	135.3	153.7	129.3

Note: [1]All SEL_{90} values are for a single strike; [2]Data recorded during Level 4 pile driving (the most powerful setting), all other data were recorded during pile driving with a Level 1 (lowest) power setting.

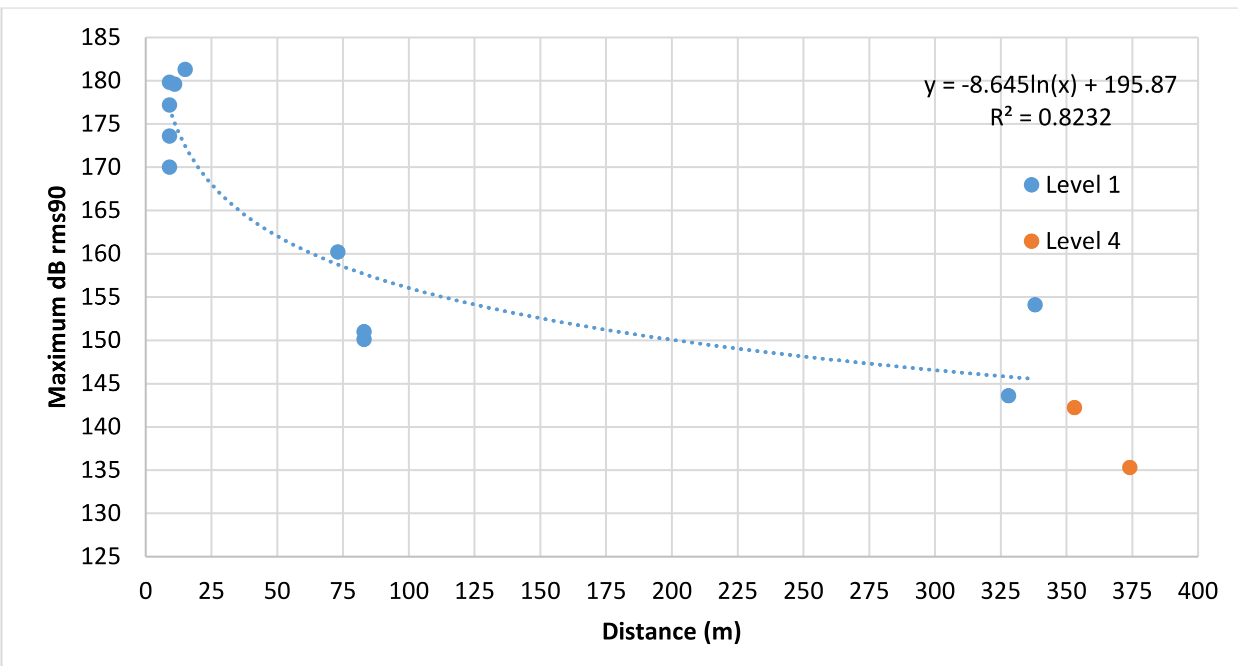

Figure 48. Maximum Underwater dB rms_{90} for Impact Pile Driving of 16-inch Round Concrete Guide Piles Near Source (9 to 15 m [30 to 49 ft]) and Graduated Distances at the NBPL HDA.

High-Pressure Water Jetting (Underwater Acoustics)

In September 2017, acoustic monitoring was conducted using the APL-UW USLM during jetting installation of 16-inch round concrete piles using an internal 2-inch jet (Table 53). At source (10 to 12 m, 33 to 39 ft), SPLs ranged from 123.7 to 130.2 dB and maximum SPLs ranged from 127.9 to 137.7 dB (Table 54, Figure 49). At far-field distances ranging from 19 to 338 m (62 to 1,109 ft, respectively), average SPLs ranged from 124.5 to 130.9 dB and maximum SPLs ranged from 128.6 to 134.0 dB (Table 54, Figure 49). A logarithmic regression was considered applicable, but the trendline had a poor fit to the data (R^2 of 0.0598), most likely due to the recordings at far-field locations (>300 m [984 ft]) being influenced by some other noise source (Figure 49). Those far-field locations were close to the entrance of America's Cup Harbor, where recreational motorized boats leave or enter the harbor on a regular basis. The calculated TL was 0.9 based on the collected data. Due to the apparent influence of other noise sources, a TL of 15 is suggested if high-pressure water jetting is used under similar conditions and MMPA Level A/B calculations are required. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 53. Acoustic and Pile Installation Equipment Used for 16-inch Round Concrete Guide Piles at the NBPL HDA (High-pressure Water Jetting).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	1.75 - 4.0	Source, Far-Field	High Pressure Water Jet	300 psi

Table 54. Underwater Sound Pressure Metrics for High-Pressure Water Jetting of 16-inch Round Concrete Guide Piles at Source (10 to 12 m [33 to 39 ft]) and Graduated Distances.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 μPa)	
				Average	Maximum
21-Sep-17	548-M9	Source	10 (33)	130.2	137.7
			10 (33)	130.1	135.9
			10 (33)	128.9	130.9
13-Sep-17	607N-A9		12 (39)	123.7	130.5
			12 (39)	123.7	127.9
22-Sep-17	548-A10		10 (33)	128.5	131.9
	548-H10	Far-Field	19 (62)	124.5	131.5
	548-A10		175 (574)	127.3	131.3
				127.6	129.8
				127.0	129.2
	548-C10		196 (643)	126.1	128.6
	548-D10		206 (676)	127.2	130.0
				126.7	129.8
21-Sep-17	607N-E9		328 (1,076)	130.9	134.0
				128.4	132.6
	607N-F9		338 (1,109)	128.7	132.7
				128.6	131.2

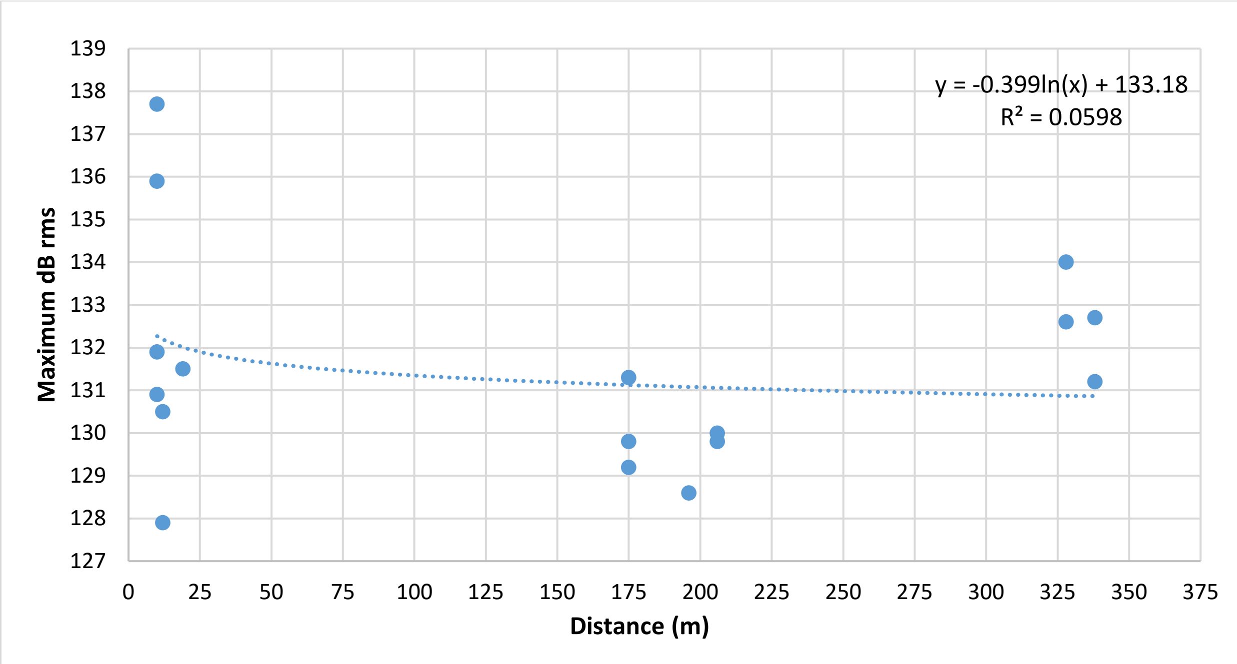

Figure 49. Maximum Underwater dB rms for Installation of 16-inch Round Concrete Guide Piles (via a High-Pressure Water Jet) at Source (10 to 12 m [30 to 39 ft]) and Graduated Distances.

3.2.2 Demolition Activities

3.2.2.1 16-inch Round Concrete Guide Pile Removal (Jetting, Underwater Acoustics)

In August and September 2017, acoustic monitoring was conducted using the APL-UW USLM during high-pressure water jetting removal of 16-inch round concrete piles (Table 55). At source (8 to 9 m [26 to 30 ft]), average SPLs ranged from 141.8 to 154.8 dB and maximum SPLs ranged from 152.3to 157.6 dB (Table 56, Figure 50). Figure 20 shows an example of the data recorded at source using the APL-UW USLM. At far-field recordings distances, ranging from 94 to 240 m (308 to 786 ft), average SPLs ranged from 125.8 to 131.0 dB and maximum SPLs ranged from 130.2 to 142.5 dB (Table 56, Figure 51). A logarithmic trendline provided a strong fit to the data (R^2 of 0.9379) (Figure 50). The calculated TL was 15.2 for the removal of 16-inch round concrete piles via a high-pressure water jet. For expanded metrics see Appendix A.4 and Appendix B.2.

Table 55. Acoustic and Pile Removal Equipment Used for 16-inch Round Concrete Guide Piles at the NBPL HDA (High-pressure Water Jetting).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Maximum Pressure
APL-UW USLM	1.9 - 4.5	Source, Far-Field	High Pressure Water Jet	300 psi

Table 56. Underwater Sound Pressure Metrics for Removal of 16-inch Round Concrete Guide Piles (via a High-Pressure Water Jet) at Source (8 to 9 m [26 to 30 ft]) and Graduated Distances at NBPL HDA.

Date	Pile Number	Station	Distance (m [ft])	dB rms (dB re 1 µPa)	
				Average	Maximum
22-Aug-17	548-B31	Source	9 (30)	154.5	157.6
	548-B32		9 (30)	153.2	157.2
	548-B31		9 (30)	154.4	156.3
	548-B32		9 (30)	151.6	155.7
	548-B30		8 (26)	150.2	155.1
	548-B31		9 (30)	154.2	154.9
	548-B32		9 (30)	154.8	154.8
	548-B30		8 (26)	141.8	153.2
			8 (26)	149.7	153.1
	548-B31		9 (30)	150.4	152.9
	548-B30		8 (26)	149.2	152.3
23-Aug-17	548-B34	Far-Field	94 (308)	131.0	142.5
				130.1	140.2
				130.3	139.9
				129.4	134.4
25-Sep-17	619-B1		149 (488)	128.1	136.9
				127.3	135.4
				126.9	130.7
23-Aug-17	548-B33		151 (494)	128.7	135.6
				125.8	133.8
				127.0	133.5
25-Sep-17	619-B2		160 (524)	127.5	137.3
				129.3	137.2
				126.8	136.1
23-Aug-17	548-B29		240 (786)	129.0	137.9
				129.0	133.5
				127.1	130.2

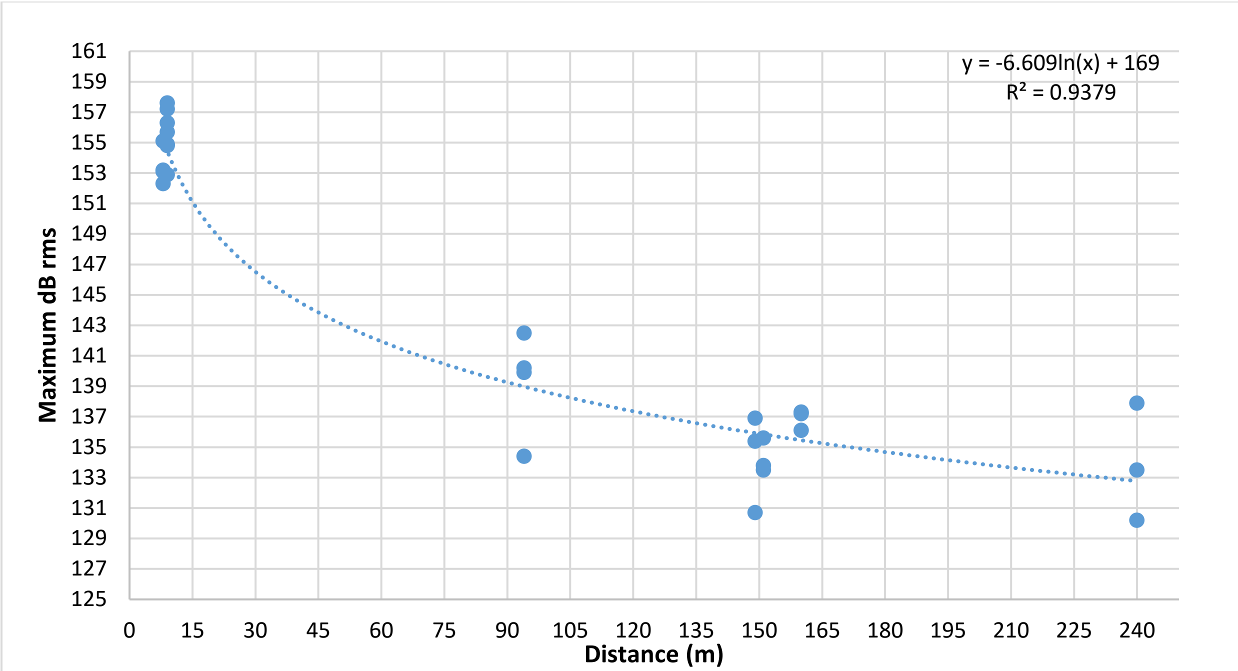

Figure 50. Maximum Underwater dB rms for Removal of 16-inch Round Concrete Guide Piles (via a High-Pressure Water Jet) at Source (8 to 9 m [26 to 30 ft]) and Graduated Distances at the NBPL HDA.

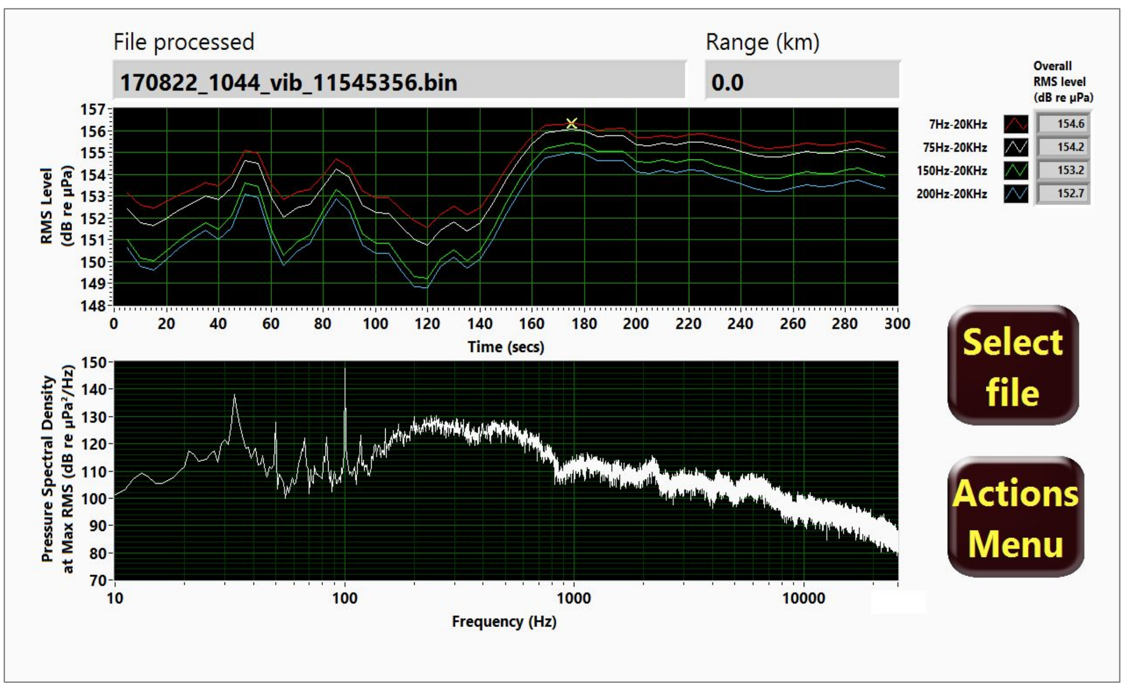

Figure 51. APL-UW USLM Acoustic Time Series Plot for Removal of 16-inch Round Concrete Guide Pile (via a High-Pressure Water Jet) at Source (9 m [33 ft]) at the NBPL HDA.

3.3 Nimitz Marine Facility Pier Replacement Project

3.3.1 Concrete Pile Installation

3.3.1.1 18-inch Square Concrete Piles (Impact Driving, Underwater Acoustics)

On January 15 and 28, 2015, acoustic monitoring was conducted with the APL-UW USLM during impact driving of three 18-inch square concrete piles as part of the SIO/UCSD MarFac pier replacement project (Table 57). Recordings were made at far-field distances ranging from 40 to 80 m (131 to 262 ft) from the pile driving. Figure 52 shows an example of the data recorded by the APL-UW USLM at 40 m (131 ft). The maximum rms_{90} values ranged from 159.2 to 161.4 dB, maximum peak values ranged from 170.6 to 176.0 dB, and maximum single strike SEL_{90} values ranged from 147.4 to 152.0 dB (Table 58). A TL could not be calculated for the 18-inch square concrete piles due to a small sample size and no data being recorded at source (10 m [33 ft]). For expanded metrics see Appendix A.2 and Appendix B.1.

Table 57. Acoustic and Pile Installation Equipment Used for 18-inch Square Concrete Piles at SIO/UCSD MarFac (Impact Pile Driving).

Acoustic Monitoring Equipment	Depth of Hydrophone (m)	Stations Monitored	Installation Equipment	Hammer Power Level (ft-lbs)
APL-UW USLM	3.0	Far-Field	D80-42 APE Diesel Impact Hammer	127,008 - 198,450

Table 58. Maximum Underwater Sound Pressure Metrics for Impact Pile Driving of 18-inch Square Concrete Piles at Graduated Distances at SIO/UCSD MarFac.

Date	Pile Number	Station	Distance (m [ft])	Maximum (dB re 1 μPa)		Maximum (dB re 1 μPa²-sec)
				rms_{90}	Peak	SEL_{90}[1]
15-Jan-15	1	Far-Field	40 (131)	160.6	176.0	152.0
	2		45 (148)	161.4	173.6	150.5
28-Jan-15	3		80 (262)	159.2	170.6	147.4

Note: [1]All SEL_{90} values are for a single strike.

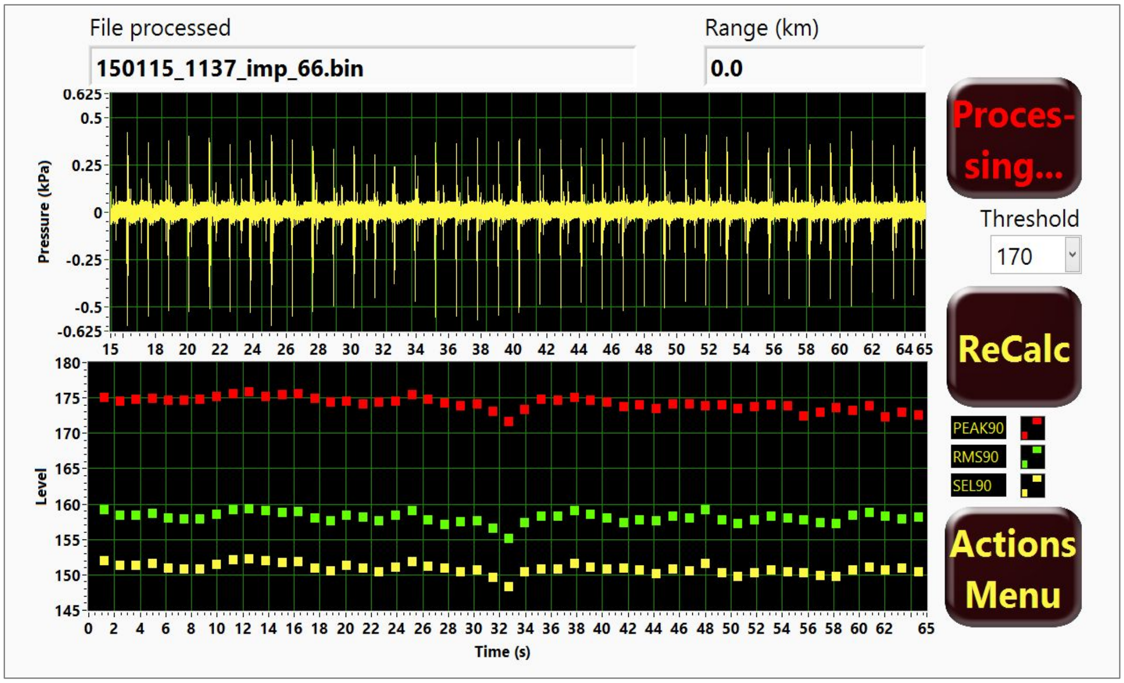

Figure 52. APL-UW USLM Acoustic Time Series Plot for Impact Pile Driving of 18-inch Square Concrete Piles at 40 m (131 ft) From Source at SIO/UCSD MarFac.

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4.0 References

Bradley, D.L. and R. S. Stern. 2008. Underwater Sound and the Marine Mammal Acoustic Environment, A Guide to Fundamental Principles. Prepared for the U.S. Marine Mammal Commission. Available online (accessed September 2020) at *https://www.mmc.gov/wp-content/uploads/sound_bklet.pdf*

California Department of Transportation (Caltrans). 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Available online (accessed August 2020) at *https://dot.ca.gov/-/media/dot-media/programs/environmental-analysis/documents/env/bio-tech-guidance-hydroacoustic-effects-110215-a11y.pdf*

Dahl, P. H., P. G. Reinhall, D. M. Farrell. 2012. Transmission loss and range, depth scales associated with impact pile driving, In Proceedings of the 11th European Conference on Underwater Acoustics, 34: 1860-1867.

Dahl, Peter (Applied Physics Laboratory-University of Washington). 2020. Personal communications with Karen Green, Tierra Data, Inc. Program Manager/Senior Scientist for this report.

Discovery of Sound in the Sea. 2020. Units Page for Regulators. Available online (accessed October 2020) at *https://dosits.org/decision-makers/units-page-for-regulators/*

Ketten, D. R. 2004. Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and Implications for Underwater Acoustic Impacts. *Polarforschung*, 72 (2/3): 79-92.

National Marine Fisheries Service (NMFS). 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing, Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. NOAA Technical Memorandum NMFS-OPR-55. July 2016.

_____. 2018a. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

_____. 2018b. Manual for Optional User Spreadsheet Tool (Version 2.0) for: 2018 Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. Silver Spring, Maryland: Office of Protected Resources, National Marine Fisheries Service.

National Oceanic and Atmospheric Administration (NOAA). 2012. Guidance Document: Data Collection Methods to Characterize Underwater Background Sound Relevant to Marine Mammals in Coastal Nearshore Waters and Rivers of Washington and Oregon. NMFS Northwest Region and Northwest Fisheries Science Center: 5 pp

Naval Facilities Engineering Command Southwest (NAVFAC SW). 2014. Naval Base Point Loma Fleet Logistics Center Fuel Pier Replacement Project: Acoustic, Marine Mammal, Green Sea Turtle, and California Least Tern Monitoring Report.

_____. 2015. Naval Base Point Loma Fleet Logistics Center Fuel Pier Replacement Project: Acoustic, Marine Mammal, Green Sea Turtle, and California Least Tern Monitoring Report.

_____. 2016a. Naval Base Point Loma Fleet Logistics Center Fuel Pier Replacement Project: Acoustic, Marine Mammal, Green Sea Turtle, and California Least Tern Monitoring Report.

_____. 2016b. Naval Base Point Loma Fleet Logistics Center Fuel Pier Replacement Project: Acoustic, Marine Mammal, Green Sea Turtle, and California Least Tern Monitoring Report, Addendum.

_____. 2017a. Naval Base Point Loma Fleet Logistics Center Fuel Pier Replacement Project: Acoustic, Marine Mammal, Green Sea Turtle, and California Least Tern Monitoring Report.

_____. 2017b. Naval Base Point Loma Fleet Logistics Center Fuel Pier Replacement Project: Acoustic, Marine Mammal, Green Sea Turtle, and California Least Tern Monitoring Report, Addendum.

_____. 2018. Naval Base Point Loma Fleet Logistics Center Fuel Pier Replacement Project: Acoustic, Marine Mammal, Green Sea Turtle, and California Least Tern Monitoring Report.

Normandeau Associates, Inc. 2012. Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities. A Workshop Report for the U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Contract # M11PC00031. 72 pp. plus Appendices. Available online (accessed September 2020) at *https://www.cbd.int/doc/meetings/mar/mcbem-2014-01/other/mcbem-2014-01-submission-boem-04-en.pdf*

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33(4): 411-521.

Southall, B.L, J.J. Finneran, C. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals*, 45(2):125-232.

Stadler, J. H. and D. P. Woodbury. 2009. Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria. 8th International Congress and Exposition on Noise Control Engineering 2009, INTER-NOISE 2009. 5. Available online (accessed September 2010) at *https://www.researchgate.net/publication/266212932_Assessing_the_effects_to_fishes_from_pile_driving_Application_of_new_hydroacoustic_criteria.*

U.S. Department of the Navy (Navy). 2013. Incidental Harassment Authorization Application for the Navy's Fuel Pier 15 Replacement Project at Naval Base Point Loma. Submitted to Office of Protected 16 Resources, NMFS, NOAA. Prepared by NAVFAC, Update 2 – April.

U.S. Department of the Navy (Navy) and Port of San Diego. 2013. San Diego Bay Integrated Natural Resources Management Plan, Final March 2013. San Diego, California. Prepared by Tierra Data Inc., Escondido, California.

Washington State Department of Transportation (WSDOT). 2005. Underwater sound levels associated with restoration of the Friday Harbor Ferry Terminal. Prepared for Washington Department of Transportation. May 2005.

_____. 2007a. Underwater Acoustics Measurements from Washington State Ferries 2006 Mukilteo Ferry Terminal Test Pile Project. March 2007.

_____. 2007b. Sound Level Measurements for Over-Water Geotechnical Test Boring Activities. Technical Memorandum. December 2017.

_____. 2012. Columbia River Crossing Test Pile Project Vibratory Extraction Sound Levels. Prepared by J. Coleman, David Evans and Associates, Inc. 1 August 2011.

_____. 2020. Construction Noise Impact Assessment. Chapter 7 *in* Biological Assessment Preparation Manual for Transportation Projects. Available online (accessed September 2020) at *https://wsdot.wa.gov/environment/technical/fish-wildlife/esa-efh/BA-preparation-manual*

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Appendix A:

Underwater and Airborne Acoustic Data for Pile Installation and In-Water Demolition Activities in San Diego Bay

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Appendix A.1: Hydroacoustic Data for Steel Pile Installation

Date (mm/dd/yy)	Pile Number[1]	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms[2] (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)								SEL90 (Single Strike) (dB re 1 µPa²-sec)			SELcum[3] (dB re 1 µPa²-sec)	TRUE Cum SEL
						Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.		
PILE INSTALLATION - VIBRATORY PILE DRIVING																
30-inch Round Steel Pipe Piles - NBPL Fuel Pier																
05/07/14	D1-DB[1]	10 (33)			01:24	-	-	172.0							-	-
02/22/17	D7-DA	10 (33)			00:04	166.0	168.0	172.4							-	-
02/22/17	D8-DA	10 (33)			00:07	169.5	169.4	174.0							-	-
10/24/14	TD1-TDA[1]	10 (33)			00:04	-	-	165.0							-	-
05/08/14	TD2-TDB[1]	10 (33)			00:50	-	-	168.0							-	-
10/24/14	TD2-TDB[1]	10 (33)	N/A	N/A	00:11	-	-	160.0	N/A						-	-
05/07/14	D1-DB[1]	154 (505)			01:24	-	-	162.0							-	-
03/08/17	D7-DA-B1	200 (656)			00:02	149.3	150.5	152.8							-	-
02/28/17	D8-DB-B2	200 (656)			00:14	148.5	150.3	155.9							-	-
05/08/14	TD2-TDB[1]	272 (892)			00:50	-	-	155.0							-	-
03/18/17	D6-PB-B2	480 (1,575)			00:03	146.0	147.3	149.5							-	-
36-inch Round Steel Pipe Piles - NBPL Fuel Pier																
11/25/14	T7-TB[1]	10 (33)			00:11	-	-	170.0							-	-
11/24/14	T7-TD[1]	10 (33)			00:07	-	-	172.0							-	-
01/06/15	P11-PC[1]	10 (33)			00:06	-	-	167.0							-	-
01/06/15	P11-PD[1]	10 (33)			00:05	-	-	172.0							-	-
01/06/15	P12-PC[1]	10 (33)			00:09	-	-	164.0							-	-
01/06/15	P13-PC[1]	10 (33)			00:08	-	-	165.0							-	-
01/06/15	P13-PD[1]	10 (33)			00:05	-	-	169.0							-	-
01/09/15	P8-PD[1]	10 (33)			01:00	-	-	168.0							-	-
04/15/15	T33-TB[1]	10 (33)			00:02	-	-	169.0							-	-
04/15/15	T33-TC[1]	10 (33)	N/A	N/A	00:03	-	-	166.0	N/A						-	-
04/15/15	T33-TE[1]	10 (33)			00:03	-	-	174.0							-	-
04/15/15	T33-TG[1]	10 (33)			00:02	-	-	164.0							-	-
04/16/15	T34-TB[1]	10 (33)			00:02	-	-	165.0							-	-
04/16/15	T34-TC[1]	10 (33)			00:02	-	-	170.0							-	-
04/16/15	T34-TE[1]	10 (33)			00:11	-	-	166.0							-	-
04/16/15	T34-TG[1]	10 (33)			00:01	-	-	164.0							-	-
04/21/15	P16-PD[1]	10 (33)			00:04	-	-	175.0							-	-
04/21/15	P17-PD[1]	10 (33)			00:07	-	-	168.0							-	-
04/21/15	P18-PD[1]	10 (33)			00:07	-	-	172.0							-	-
36-inch Round Steel Pipe Interlocking Abutment Piles - NBPL Fuel Pier																
10/13/17	Abutment09	53 (174)			00:05	132.3	132.1	136.9							-	-
10/13/17	Abutment09	53 (174)	N/A	N/A	00:05	132.4	132.4	140.9	N/A						-	-
10/13/17	Abutment09	53 (174)			00:02	135.7	136.0	136.7							-	-

Date (mm/dd/yy)	Pile Number[1]	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms[2] (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)								SEL_{90} (Single Strike) (dB re 1 μPa^2-sec)			SEL_{cum}[3] (dB re 1 μPa^2-sec)	TRUE Cum SEL
						Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.		
10/13/17	Abutment10	54 (177)			00:05	131.4	131.3	133.6							-	-
10/13/17	Abutment10	54 (177)			00:04	131.0	131.1	137.4							-	-
10/13/17	Abutment10	54 (177)			00:03	133.7	133.8	135.4							-	-
10/13/17	Abutment04	95 (312)			00:04	129.3	129.4	129.6							-	-
10/13/17	Abutment04	95 (312)			00:04	127.1	126.3	129.8							-	-
10/13/17	Abutment04	95 (312)			00:04	128.0	127.8	132.0							-	-
10/13/17	Abutment04	95 (312)			00:04	129.1	128.8	133.2							-	-
10/13/17	Abutment05	95 (312)			00:05	130.6	130.6	139.1							-	-
10/11/17	Abutment01	97 (318)			00:05	125.8	125.9	128.2							-	-
10/11/17	Abutment01	97 (318)			00:05	132.4	132.1	138.2							-	-
10/11/17	Abutment01	97 (318)	N/A	N/A	00:04	131.5	131.4	131.9	N/A						-	-
10/13/17	Abutment11	148 (486)			00:00	130.0	130.1	131.5							-	-
10/13/17	Abutment11	148 (486)			00:04	131.3	131.5	132.9							-	-
10/13/17	Abutment13	148 (486)			00:05	130.0	130.1	131.5							-	-
10/13/17	Abutment13	148 (486)			00:03	129.4	129.3	129.7							-	-
10/13/17	Abutment06	223 (732)			00:05	129.4	129.4	131.5							-	-
10/13/17	Abutment06	223 (732)			00:04	130.0	130.3	131.2							-	-
10/13/17	Abutment07	224 (735)			00:05	129.0	129.1	130.7							-	-
10/13/17	Abutment07	224 (735)			00:05	129.8	129.6	133.7							-	-
10/13/17	Abutment07	224 (735)			00:05	130.4	130.3	133.0							-	-
10/13/17	Abutment08	259 (850)			00:06	129.9	129.5	132.8							-	-
10/13/17	Abutment08	259 (850)			00:15	130.8	131.1	131.9							-	-
PILE INSTALLATION - IMPACT PILE DRIVING																
18-inch Round Steel Pipe Piles - NBPL Fuel Pier																
03/11/15	T1	10 (33)	-	-		-	-	184.4	-	-	200.7	-	-	171.1	-	-
03/11/15	T3	10 (33)	-	-	N/A	-	-	187.0	-	-	201.7	-	-	172.6	-	-
03/11/15	T2	12 (39)	-	-		-	-	186.4	-	-	201.9	-	-	173.1	-	-
03/11/15	T4	12 (39)	-	-		-	-	187.1	-	-	202.4	-	-	174.4	-	-
30-inch Round Steel Pipe Piles - NBPL Fuel Pier																
05/07/14	D1-DB[1]	10 (33)	698	0.045		191.4	-	195.5	-	-	-	177.9	-	180.0	206.0	-
02/22/17	D7-DA	10 (33)	-	-		193.6	193.6	198.2	207.6	207.6	213.5	179.5	179.8	182.8	-	-
02/22/17	D8-DA	10 (33)	-	-		195.9	195.9	200.6	211.0	211.0	216.4	181.4	181.2	184.8	-	-
10/24/14	TD1-TDA[1]	10 (33)	443	0.025		194.0	-	196.0	-	-	210.0	178.0	-	179.0	204.0	205.0
05/08/14	TD2-TDB[1]	10 (33)	377	0.039		191.3	-	194.6	-	-	-	177.2	-	178.5	202.8	-
10/24/14	TD2-TDB[1]	10 (33)	312	0.036	N/A	189.0	-	192.0	-	-	206.0	174.0	-	176.0	199.0	199.0
05/07/14	D1-DB[1]	124 (407)	699	0.024		187.0	-	188.0	-	-	-	170.9	-	171.8	198.8	-
03/08/17	D7-DA-B1	200 (656)	-	-		185.7	185.8	187.3	197.0	196.9	197.9	169.1	169.1	170.7	-	-
05/08/14	TD2-TDB[1]	279 (915)	401	0.027		183.5	-	184.8	-	-	-	167.8	-	169.0	193.2	-
03/18/17	D6-PB-B2	480 (1,575)	-	-		164.5	164.5	167.0	181.3	181.4	185.3	156.3	156.2	157.9	-	-
03/09/17	D8-DA-B1	525 (1,722)	-	-		160.9	161.4	162.7	179.8	180.1	182.7	153.8	154.4	155.4	-	-

Date (mm/dd/yy)	Pile Number[1]	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms[2] (dB re 1 μPa)			Peak (dB re 1 μPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	SEL_{90} (Single Strike) (dB re 1 μPa^2-sec) Mean	Med.	Max.	SEL_{cum}[3] (dB re 1 μPa^2-sec)	TRUE Cum SEL
05/08/14	TD2-TDB[1]	2,157 (7,077)	400	0.058		160.0	-	161.2	-	-	-	147.7	-	148.9	173.2	-
05/07/14	D1-DB[1]	2,385 (7,825)	695	0.046	N/A	159.7	-	162.6	-	-	-	146.3	-	148.1	174.7	-
05/08/14	TD2-TDB[1]	3,045 (9,990)	394	0.060		147.9	-	152.4	-	-	-	135.6	-	139.7	162.1	-
36-inch Round Steel Pipe Piles - NBPL Fuel Pier																
04/15/15	T33-TG[1]	10 (33)	916	0.024		202.0	-	204.0	-	-	217.0	186.0	-	187.0	215.0	215.0
04/16/15	T34-TG[1]	10 (33)	821	0.022		202.0	-	203.0	-	-	214.0	185.0	-	188.0	214.0	214.0
04/15/15	T33-TE[1]	10 (33)	788	0.027		201.0	-	203.0	-	-	215.0	185.0	-	186.0	214.0	214.0
04/16/15	T34-TB[1]	10 (33)	920	0.023		201.0	-	203.0	-	-	215.0	184.0	-	186.0	214.0	214.0
04/16/15	T34-TC[1]	10 (33)	833	0.023		201.0	-	203.0	-	-	215.0	185.0	-	187.0	214.0	214.0
04/16/15	T34-TE[1]	10 (33)	818	0.023		201.0	-	203.0	-	-	215.0	185.0	-	187.0	214.0	214.0
04/21/15	P16-PD[1]	10 (33)	1,476	0.021		201.0	-	203.0	-	-	216.0	184.0	-	187.0	216.0	216.0
04/22/15	P20-PD[1]	10 (33)	1,553	0.026		201.0	-	203.0	-	-	216.0	184.0	-	187.0	216.0	216.0
04/23/15	P20-PC[1]	10 (33)	1,442	0.024		201.0	-	202.0	-	-	214.0	184.0	-	187.0	216.0	216.0
01/08/15	P11-PB[1]	10 (33)	-	-		200.9	-	202.2	-	-	215.7	184.2	-	-	-	-
01/07/15	P12-PC[1]	10 (33)	-	-		200.6	-	202.3	-	-	212.1	183.1	-	-	-	-
01/15/15	P7-PD[1]	10 (33)	-	-		200.5	-	202.2	-	-	215.0	184.7	-	-	-	-
01/16/15	P4-PD[1]	10 (33)	-	-		200.5	-	202.2	-	-	215.0	184.7	-	-	-	-
01/16/15	P5-PD[1]	10 (33)	-	-		200.5	-	202.2	-	-	215.0	184.7	-	-	-	-
01/09/15	P8-PD[1]	10 (33)	-	-		200.1	-	201.9	-	-	213.4	183.7	-	-	-	-
04/15/15	T33-TB[1]	10 (33)	779	0.026		200.0	-	202.0	-	-	219.0	184.0	-	186.0	213.0	213.0
04/15/15	T33-TC[1]	10 (33)	720	0.029		200.0	-	202.0	-	-	214.0	185.0	-	186.0	213.0	214.0
04/22/15	P18-PC[1]	10 (33)	1,827	0.022	N/A	200.0	-	201.0	-	-	214.0	183.0	-	186.0	216.0	216.0
04/22/15	P18-PD[1]	10 (33)	2,129	0.025		200.0	-	203.0	-	-	216.0	184.0	-	187.0	217.0	217.0
04/22/15	P19-PD[1]	10 (33)	1,500	0.025		200.0	-	201.0	-	-	216.0	184.0	-	186.0	215.0	215.0
01/08/15	P12-PB[1]	10 (33)	-	-		200.0	-	201.6	-	-	213.3	183.3	-	-	-	-
01/07/15	P13-PB[1]	10 (33)	-	-		199.7	-	201.9	-	-	213.4	183.0	-	-	-	-
01/06/15	P11-PD[1]	10 (33)	-	-		199.6	-	201.7	-	-	214.4	182.9	-	-	-	-
01/12/15	P9-PD[1]	10 (33)	-	-		199.3	-	200.9	-	-	214.1	183.1	-	-	-	-
01/15/15	P6-PD[1]	10 (33)	-	-		199.3	-	200.9	-	-	214.1	183.1	-	-	-	-
04/23/15	P19-PC[1]	10 (33)	1,523	0.025		199.0	-	201.0	-	-	214.0	183.0	-	185.0	215.0	215.0
01/06/15	P12-PC[1]	10 (33)	-	-		199.0	-	200.7	-	-	213.8	183.1	-	-	-	-
01/07/15	P12-PD[1]	10 (33)	-	-		198.8	-	200.3	-	-	214.3	182.6	-	-	-	-
01/06/15	P13-PD[1]	10 (33)	-	-		198.6	-	201.1	-	-	214.0	181.8	-	-	-	-
01/06/15	P13-PC[1]	10 (33)	-	-		198.2	-	201.0	-	-	213.2	182.2	-	-	-	-
04/21/15	P17-PD[1]	10 (33)	1,995	0.032		198.0	-	201.0	-	-	214.0	182.0	-	184.0	215.0	216.0
11/25/14	T7-TD[1]	10 (33)	673	0.028		197.0	-	201.0	-	-	215.0	197.0	-	201.0	210.0	209.0
11/25/14	T7-TB[1]	10 (33)	632	0.032		193.0	-	195.0	-	-	213.0	193.0	-	195.0	206.0	205.0
04/23/15	P20-PC[1]	202 (663)	1,442	0.027		182.0	-	184.0	-	-	195.0	166.0	-	168.0	198.0	198.0

Date (mm/dd/yy)	Pile Number[1]	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms[2] (dB re 1 μPa)			Peak (dB re 1 μPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	SEL_{90} (Single Strike) (dB re 1 μPa^2-sec) Mean	Med.	Max.	SEL_{cum}[3] (dB re 1 μPa^2-sec)	TRUE Cum SEL
04/23/15	P19-PC[1]	206 (676)	1,523	0.027		182.0	-	184.0	-	-	197.0	167.0	-	168.0	198.0	199.0
04/16/15	T34-TG[1]	219 (719)	821	0.045		180.0	-	183.0	-	-	193.0	166.0	-	168.0	195.0	195.0
04/16/15	T34-TE[1]	227 (745)	818	0.045		180.0	-	182.0	-	-	195.0	166.0	-	169.0	195.0	195.0
04/16/15	T34-TB[1]	227 (745)	920	0.042		179.0	-	181.0	-	-	193.0	165.0	-	166.0	195.0	195.0
04/16/15	T34-TC[1]	228 (748)	833	0.037		181.0	-	184.0	-	-	196.0	166.0	-	169.0	195.0	195.0
04/22/15	P19-PD[1]	233 (764)	1,500	0.036		179.0	-	182.0	-	-	194.0	165.0	-	167.0	196.0	196.0
04/22/15	P18-PD[1]	238 (781)	2,129	0.028		181.0	-	184.0	-	-	194.0	165.0	-	169.0	199.0	199.0
04/21/15	P17-PD[1]	242 (794)	1,995	0.028	N/A	181.0	-	183.0	-	-	192.0	165.0	-	167.0	198.0	198.0
04/22/15	P20-PD[1]	248 (814)	1,553	0.031		180.0	-	182.0	-	-	194.0	164.0	-	167.0	196.0	196.0
04/21/15	P16-PD[1]	249 (817)	1,476	0.029		180.0	-	182.0	-	-	192.0	164.0	-	166.0	196.0	196.0
04/22/15	P18-PC[1]	280 (919)	1,827	0.024		182.0	-	184.0	-	-	195.0	166.0	-	168.0	199.0	199.0
04/15/15	T33-TB[1]	304 (997)	779	0.046		179.0	-	181.0	-	-	194.0	166.0	-	168.0	194.0	195.0
04/15/15	T33-TE[1]	304 (997)	788	0.047		179.0	-	183.0	-	-	194.0	166.0	-	169.0	195.0	195.0
04/15/15	T33-TG[1]	305 (1,001)	916	0.041		180.0	-	183.0	-	-	195.0	166.0	-	168.0	196.0	196.0
04/15/15	T33-TC[1]	305 (1,001)	720	0.050		178.0	-	181.0	-	-	194.0	165.0	-	168.0	194.0	194.0
36-inch Round Steel Pipe Interlocking Abutment Piles - NBPL Fuel Pier																
10/19/17	Abutment10	38 (125)	-	-		181.1	181.3	183.9	192.8	193.3	194.4	164.5	164.7	166.9	-	-
10/19/17	Abutment11	53 (174)	-	-		182.4	183.5	184.9	192.7	193.7	194.7	164.4	165.4	167.1	-	-
10/19/17	Abutment12	54 (177)	-	-		177.6	178.2	181.2	188.8	190.1	192.0	160.6	161.4	163.8	-	-
10/19/17	Abutment09	63 (207)	-	-		175.2	175.5	177.4	187.6	188.0	188.9	159.4	159.6	160.9	-	-
10/19/17	Abutment10	64 (207)	-	-		177.8	177.9	179.2	189.0	189.2	190.1	161.0	161.2	162.1	-	-
10/18/17	Abutment13	96 (315)	-	-		177.5	178.3	180.4	189.4	190.2	191.3	161.9	162.7	163.8	-	-
10/18/17	Abutment12	96 (315)	-	-		177.5	179.4	180.8	189.0	190.2	191.4	161.4	162.7	163.9	-	-
10/19/17	Abutment09	99 (325)	-	-		175.9	177.3	177.8	187.0	187.6	188.8	160.9	162.1	162.5	-	-
10/19/17	Abutment08	99 (325)	-	-	N/A	174.4	174.8	175.5	185.5	185.6	187.7	159.4	159.6	160.3	-	-
10/18/17	Abutment11	192 (630)	-	-		165.8	168.2	168.9	179.3	181.2	182.3	152.7	154.8	155.4	-	-
10/19/17	Abutment07	239 (784)	-	-		167.8	169.4	170.4	178.7	179.4	179.7	153.3	154.6	155.0	-	-
10/19/17	Abutment09	241 (791)	-	-		171.6	171.7	172.7	181.2	181.3	182.1	155.6	155.7	156.7	-	-
10/19/17	Abutment06	255 (837)	-	-		171.1	171.9	173.7	182.0	182.4	183.2	155.7	156.3	157.8	-	-
10/19/17	Abutment08	257 (843)	-	-		170.2	171.2	173.3	180.2	180.2	182.9	155.3	156.1	157.2	-	-
10/18/17	Abutment12	268 (879)	-	-		158.2	157.8	162.4	173.6	173.7	174.5	150.3	150.4	150.7	-	-
10/19/17	Abutment07	329 (1,079)	-	-		146.3	151.5	152.7	164.4	164.4	175.7	138.3	142.6	144.1	-	-
10/19/17	Abutment06	330 (1,083)	-	-		146.7	152.1	155.4	163.2	13.2	172.4	138.6	143.4	144.2	-	-

Note: Dashes in fields indicate that data were not available; "Med." = Median; "Max." = Maximum; and "N/A" = Not Applicable. [1]Pile numbers are denoted with the superscript "1" when data were collected using the Loggerhead, all other data were collected using the APL-UW USLM. The Loggerhead data files were analyzed to the extent necessary to support calculation of ZOIs associated with regulatory acoustic thresholds or for comparison with data collected with the APL-USLM, and not all metrics were analyzed. [2]SPLs are reported as rms_{90} for impulsive sound (impact hammer) and rms for continuous noise source (vibratory hammer). [3]Based on mean single strike SEL + $10\log_{10}$ (# strikes).

Appendix A.2: Hydroacoustic Data for Concrete Pile Installation

Date (mm/dd/yy)	Pile Number[1]	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms[2] (dB re 1 μPa)			Peak (dB re 1 μPa)			SEL				
												SEL$_{90}$ (Single Strike) (dB re 1 μPa^2-sec)			SEL$_{cum}$[3] (dB re 1 μPa^2-sec)	TRUE Cum SEL
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.		
PILE INSTALLATION - IMPACT PILE DRIVING																
16-inch Round Concrete Guide Piles - NBPL HDA																
09/20/17	607N-B9	15 (49)	-	-		179.4	179.6	181.3	188.1	188.1	189.8	163.2	163.4	164.4	-	-
09/27/17	548-L10	11 (36)	-	-		178.0	178.0	179.6	186.6	186.5	188.4	161.5	161.6	162.4	-	-
09/27/17	548-K10	9 (30)	-	-		176.5	176.2	179.8	186.1	186.0	189.0	161.1	161.0	163.6	-	-
09/27/17	548-M10	9 (30)	-	-		176.2	176.2	177.2	186.0	185.7	187.7	159.9	159.4	161.5	-	-
09/27/17	548-M9	9 (30)	-	-		173.6	173.6	173.6	185.2	185.2	185.2	159.9	159.9	159.9	-	-
09/27/17	548-D10	9 (30)	-	-		151.9	154.4	170.0	165.8	167.1	182.0	142.9	146.5	157.5	-	-
09/25/17	548-B10	73 (239)	-	-	N/A	158.0	157.7	160.2	167.5	167.4	169.4	142.1	142.2	142.5	-	-
09/25/17	548-A10	83 (273)	-	-		147.2	147.2	150.1	162.6	161.7	173.3	136.7	136.5	137.6	-	-
09/25/17	548-A9	83 (273)	-	-		138.1	140.7	151.0	155.7	155.9	162.5	129.9	132.6	138.4	-	-
09/21/17	607N-E9	328 (1,076)	-	-		134.2	133.1	143.6	149.8	148.6	157.2	127.0	126.6	133.3	-	-
09/21/17	607N-F9	338 (1,110)	-	-		153.0	153.1	154.1	162.9	162.9	163.5	139.6	139.4	141.3	-	-
09/19/17	607N-A9	353 (1,160)	-	-		141.2	141.1	142.2	159.0	159.2	160.1	134.4	134.3	135.5	-	-
09/19/17	607N-C9	374 (1,228)	-	-		134.8	134.8	135.3	150.6	150.0	153.7	128.3	128.2	129.3	-	-
18-inch Square Concrete Piles - SIO/UCSD MarFac																
01/15/15	1	40 (131)	-	-		159.2	160.1	160.6	175.4	175.8	176.0	152.0	152.0	152.0	-	-
01/15/15	2	45 (148)	-	-	N/A	162.6	162.0	161.4	174.8	174.2	173.6	151.3	150.9	150.5	-	-
01/28/15	3	80 (262)	-	-		159.1	159.1	159.2	170.4	170.5	170.6	147.4	147.4	147.4	-	-
24x30 Concrete Fender Piles - NBPL Fuel Pier																
04/28/16	O-07G	10 (33)	-	-		190.6	190.1	193.8	200.1	199.1	204.3	175.4	174.8	178.4	-	-
04/27/16	O-08B	10 (33)	-	-		190.1	190.6	191.3	199.2	199.3	199.6	176.0	176.4	176.8	-	-
04/23/16	O-07F	10 (33)	-	-		190.1	190.7	193.7	199.5	199.7	203.9	174.7	175.1	177.9	-	-
04/27/16	O-08C	10 (33)	-	-		189.3	189.3	191.2	198.9	198.8	201.1	174.8	174.7	176.4	-	-
04/28/16	O-08G	10 (33)	-	-		189.1	189.3	190.1	197.9	197.9	198.4	174.1	174.2	175.0	-	-
04/28/16	O-07G[1]	10 (33)	1,092	0.0274		189.0	-	192.0	-	-	203.0	173.0	-	176.0	203.0	203.0
04/27/16	O-08D	10 (33)	-	-		188.7	188.8	190.6	197.9	198.2	198.9	173.7	173.9	175.1	-	-
04/23/16	O-07E	10 (33)	-	-		188.7	188.7	190.9	198.1	198.2	201.4	173.9	174.0	176.0	-	-
04/22/16	O-07D	10 (33)	-	-		188.1	188.1	191.1	197.8	197.7	201.1	173.7	173.5	176.6	-	-
09/26/16	O-05A	10 (33)	-	-	N/A	186.7	186.7	187.1	195.2	195.2	195.5	173.5	173.5	173.8	-	-
04/28/16	O-08H	10 (33)	-	-		186.4	189.0	189.8	195.2	197.3	198.2	171.8	174.0	174.7	-	-
04/28/16	O-07H	10 (33)	-	-		183.8	181.9	189.3	193.6	191.8	198.4	169.7	168.1	174.1	-	-
09/26/16	O-03G	10 (33)	-	-		183.6	183.6	183.9	193.8	193.7	194.0	172.7	172.7	173.0	-	-
04/28/16	O-07H[1]	10 (33)	1,192	0.0319		183.0	-	188.0	-	-	197.0	167.0	-	172.0	-	-
04/28/16	O-08H[1]	10 (33)	507	0.0308		183.0	-	188.0	-	-	197.0	168.0	-	172.0	195.0	195.0
04/27/16	O-08A	10 (33)	-	-		180.8	180.8	181.3	191.5	191.5	192.5	167.6	167.7	168.1	-	-
04/22/16	O-07D	20 (66)	-	-		189.2	188.2	191.5	199.6	198.6	202.0	173.5	173.0	175.0	-	-
09/23/16	O-04E	30 (98)	-	-		181.8	181.8	182.3	191.4	191.2	192.8	168.6	168.6	169.0	-	-

Date (mm/dd/yy)	Pile Number[1]	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms[2] (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	SEL_{90} (Single Strike) (dB re 1 µPa²-sec) Mean	Med.	Max.	SEL_{cum}[3] (dB re 1 µPa²-sec)	TRUE Cum SEL
04/22/16	O-07D	40 (131)	-	-	N/A	182.9	182.9	183.2	191.5	191.4	192.0	167.9	167.8	168.1	-	-
09/23/16	O-03A	47 (154)	-	-		178.9	178.7	181.1	188.7	187.9	190.8	164.1	163.8	165.5	-	-
09/23/16	O-03A	54 (177)	-	-		178.1	178.2	178.8	187.8	187.8	188.3	163.5	163.6	164.1	-	-
04/25/16	O-09D	55 (180)	-	-		167.9	168.0	168.7	187.0	187.1	188.3	161.9	162.0	162.6	-	-
09/26/16	O-05H	60 (197)	-	-		174.3	173.4	177.9	185.1	184.9	185.9	161.4	161.4	162.2	-	-
09/26/16	O-05H	72 (236)	-	-		177.2	177.1	177.5	187.4	187.4	187.6	163.6	163.6	163.9	-	-
09/26/16	O-05H	83 (272)	-	-		173.3	173.3	173.5	184.7	184.7	185.0	160.4	160.4	160.5	-	-
09/23/16	O-04F	95 (312)	-	-		176.5	176.5	176.8	190.4	190.5	190.6	164.0	164.0	164.1	-	-
04/25/16	O-09D	100 (328)	-	-		166.3	166.7	168.3	183.9	184.7	186.2	159.7	160.3	161.6	-	-
09/23/16	O-04G	114 (374)	-	-		172.6	172.9	174.1	182.0	182.4	183.0	160.0	160.4	161.2	-	-
04/22/16	O-07D	125 (410)	-	-		171.4	171.6	172.0	181.7	182.1	182.3	158.3	158.5	158.8	-	-
09/23/16	O-04H	164 (538)	-	-		171.8	171.7	172.7	182.1	182.0	182.7	158.2	158.2	159.0	-	-
04/22/16	O-07D	165 (541)	-	-		167.6	167.7	168.8	179.6	179.3	181.9	155.7	155.3	157.3	-	-
04/22/16	O-07D	171 (561)	-	-		167.5	167.5	168.0	177.5	177.5	178.2	154.5	154.4	154.8	-	-
04/25/16	O-09D	180 (591)	-	-		168.2	168.0	169.8	179.4	179.4	182.0	157.5	157.5	158.3	-	-
04/25/16	O-09B	190 (623)	-	-		168.9	168.8	169.5	179.4	179.5	179.9	156.2	156.1	156.4	-	-
04/25/16	O-09D	200 (656)	-	-		165.9	165.9	167.1	179.7	179.7	179.8	155.6	155.6	157.2	-	-
04/25/16	O-09B	235 (771)	-	-		172.4	172.3	172.8	181.9	181.9	182.0	158.2	158.2	158.4	-	-
04/25/16	O-09D	247 (810)	-	-		167.7	167.5	168.5	179.6	179.6	180.1	156.2	156.1	156.6	-	-
09/23/16	O-04F	250 (820)	-	-		170.4	167.6	176.8	182.1	178.3	190.6	157.2	154.1	164.1	-	-
04/25/16	O-09D	310 (1,017)	-	-		165.1	165.2	167.2	177.0	177.0	179.2	154.1	154.1	155.9	-	-
04/25/16	O-09D	315 (1,033)	-	-		173.0	172.9	173.4	184.9	184.9	185.3	158.6	158.6	159.0	-	-
04/25/16	O-09B	315 (1,033)	-	-		166.3	166.3	172.1	177.4	177.4	181.7	153.9	153.9	158.1	-	-
04/25/16	O-09B	315 (1,033)	-	-		158.2	158.0	159.2	169.6	169.4	170.2	145.4	145.3	145.8	-	-
04/25/16	O-09D	375 (1,230)	-	-		156.7	156.8	172.8	175.9	176.0	184.5	150.9	151.0	158.4	-	-
04/25/16	O-09B	400 (1,312)	-	-		146.4	146.4	161.9	167.9	167.9	174.0	140.7	140.7	150.5	-	-
04/25/16	O-09B	410 (1,345)	-	-		147.7	147.6	148.0	166.9	166.9	167.7	141.9	141.8	142.2	-	-
04/25/16	O-09B	435 (1,427)	-	-		164.4	164.3	166.0	176.4	176.4	177.1	152.4	152.5	153.7	-	-
09/23/16	O-04F	460 (1,509)	-	-		168.6	168.3	170.4	178.1	178.2	179.8	154.5	154.3	155.9	-	-
04/25/16	O-09D	460 (1,509)	-	-		161.0	161.1	162.3	175.0	175.2	175.5	151.6	151.7	152.1	-	-
04/25/16	O-09B	475 (1,558)	-	-		162.5	162.4	163.9	174.4	174.4	176.0	150.6	150.6	152.2	-	-
09/26/16	O-03B	490 (1,607)	-	-		162.6	162.2	164.9	174.7	174.4	176.2	152.0	152.0	152.2	-	-
09/26/16	O-03B	530 (1,739)	-	-		165.4	165.4	166.0	173.5	173.5	173.8	152.6	152.6	153.0	-	-
09/26/16	O-03B	533 (1,749)	-	-		153.9	153.9	154.2	176.3	176.1	176.9	148.2	148.2	148.5	-	-
09/26/16	O-03B	548 (1,798)	-	-		146.6	143.5	154.4	175.6	174.5	177.9	140.9	137.8	148.8	-	-
PILE INSTALLATION – HIGH-PRESSURE WATER JETTING																
16-inch Round Concrete Guide Piles - NBPL HDA																
09/21/17	548-M9	10 (33)	N/A	N/A	00:19	130.2	129.3	137.7	N/A						-	-
09/21/17	548-M9	10 (33)			00:19	130.1	130.2	135.9							-	-
09/21/17	548-M9	10 (33)			00:19	128.9	129.2	130.9							-	-

Date (mm/dd/yy)	Pile Number[1]	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms[2] (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)								SEL_{90} (Single Strike) (dB re 1 µPa²-sec)			SEL_{cum}[3] (dB re 1 µPa²-sec)	TRUE Cum SEL
						Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.		
09/13/17	607N-A9	12 (39)	N/A	N/A	00:12	123.7	122.9	130.5	N/A						-	-
09/13/17	607N-A9	12 (39)			00:12	123.7	123.6	127.9							-	-
09/22/17	548-A10	10 (33)			00:05	128.5	128.1	131.9							-	-
09/22/17	548-H10	19 (62)			00:05	124.5	123.7	131.5							-	-
09/22/17	548-A10	175 (574)			00:16	127.3	126.9	131.3							-	-
09/22/17	548-A10	175 (574)			00:16	127.6	127.5	129.8							-	-
09/22/17	548-A10	175 (574)			00:16	127.0	127.0	129.2							-	-
09/22/17	548-C10	196 (643)			00:10	126.1	126.1	128.6							-	-
09/22/17	548-D10	206 (676)			00:10	127.2	126.8	130.0							-	-
09/22/17	548-D10	206 (676)			00:10	126.7	126.5	129.8							-	-
09/21/17	607N-E9	328 (1,076)			00:10	130.9	130.6	134.0							-	-
09/21/17	607N-E9	328 (1,076)			00:10	128.4	127.9	132.6							-	-
09/21/17	607N-F9	338 (1,109)			00:11	128.7	128.4	132.7							-	-
09/21/17	607N-F9	338 (1,109)			00:11	128.6	128.6	131.2							-	-
24x30-inch Concrete Fender Piles - NBPL Fuel Pier (Method 1 [M1])																
03/27/17	O-8	10 (33)	N/A	N/A	00:08	153.3	155.4	156.5	N/A						-	-
03/28/17	O-4	10 (33)			00:09	155.1	156.1	159.9							-	-
03/28/17	O-5	10 (33)			00:08	153.0	154.0	159.0							-	-
03/28/17	O-6	10 (33)			00:08	152.7	153.2	158.4							-	-
03/28/17	O-7	10 (33)			00:06	152.6	153.0	157.2							-	-
03/30/17	O-1	350 (1,148)			00:08	128.1	127.4	134.0							-	-
24x30-inch Concrete Fender Piles - NBPL Fuel Pier (Method 2 [M2])																
03/28/17	O-4	10 (33)	N/A	N/A	00:01	133.0	132.0	137.1	N/A						-	-
03/28/17	O-5	10 (33)			00:02	149.8	150.1	153.2							-	-
03/28/17	O-6	10 (33)			00:02	145.0	145.9	146.9							-	-
03/28/17	O-7	10 (33)			00:02	141.5	141.4	143.4							-	-
03/28/17	O-8	10 (33)			00:04	138.5	138.9	140.7							-	-
03/30/17	O-2	290 (951)			00:04	132.4	132.4	136.7							-	-
03/30/17	O-1	350 (1,148)			00:05	129.5	129.4	132.5							-	-

Note: Dashes in fields indicate that data were not available; "Med." = Median; "Max." = Maximum; "N/A" = Not Applicable. [1]Pile numbers are denoted with the superscript "1" when data were collected using the Loggerhead, all other data collected using the APL-UW USLM. The Loggerhead data files were analyzed to the extent necessary to support calculation of ZOIs associated with regulatory acoustic thresholds, and not all metrics were analyzed. [2]SPLs are reported as rms_{90} for impulsive sound (impact hammer) and rms for continuous noise source (jetting). [3]Based on mean single strike SEL + $10\log_{10}$ (# strikes).

Appendix A.3: Hydroacoustic Data for Poly-Concrete Pile Installation

Date (mm/dd/yy)	Pile Number	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms_{90} (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)								SEL_{90} (Single Strike) (dB re 1 µPa^2-sec)			SEL_{cum}[1] (dB re 1 µPa^2-sec)	TRUE Cum SEL
						Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.		
PILE INSTALLATION - IMPACT PILE DRIVING																
16-inch Round Poly-Concrete Fender Piles - NBPL Fuel Pier																
02/05/16	TN-01B[2]	10 (33)	1,271	0.024		187.0	174.0	191.0	-	-	208.0	170.0	158.0	175.0	201.0	201.0
02/05/16	TN-01C[2]	10 (33)	1,406	0.022		187.0	177.0	194.0	-	-	210.0	170.0	162.0	176.0	201.0	201.0
02/05/16	TN-01A[2]	10 (33)	1,071	0.027		185.0	173.0	189.0	-	-	204.0	169.0	159.0	174.0	199.0	199.0
02/03/16	TN-03A	10 (33)	-	-		179.5	179.4	191.1	195.2	193.9	206.9	165.0	165.0	170.4	-	-
02/03/16	TN-03A	20 (66)	-	-		175.6	175.3	177.8	192.4	192.6	195.1	160.9	160.7	162.5	-	-
02/03/16	TN-03A	50 (164)	-	-		168.6	168.8	170.4	185.1	185.7	189.6	154.2	154.4	155.6	-	-
02/04/16	TN-03D	50 (164)	-	-		163.1	163.1	163.5	178.3	177.3	182.9	150.8	150.9	151.4	-	-
02/04/16	TN-03D	60 (197)	-	-		157.8	157.9	162.5	178.5	178.5	180.0	148.9	149.1	150.2	-	-
02/04/16	TN-03C	70 (230)	-	-		157.5	157.4	158.6	172.2	172.5	173.2	145.3	145.2	145.9	-	-
02/04/16	TN-03E	100 (328)	-	-		165.7	165.7	169.4	180.0	180.1	183.9	152.7	152.7	156.5	-	-
02/04/16	TN-03B	100 (328)	-	-		156.4	156.0	161.7	175.1	174.9	181.4	145.4	144.7	148.2	-	-
02/04/16	TN-03D	100 (328)	-	-		151.7	151.6	152.3	168.8	168.6	171.0	143.5	143.5	143.8	-	-
02/04/16	TN-03E	107 (351)	-	-		168.1	168.0	168.8	181.0	181.0	181.3	154.4	154.4	154.9	-	-
02/04/16	TN-03E	110 (361)	-	-		163.6	163.7	163.8	180.9	180.8	182.4	150.9	150.8	151.3	-	-
02/04/16	TN-03E	120 (394)	-	-		164.2	163.8	165.9	174.6	174.4	176.1	151.8	151.7	152.9	-	-
02/04/16	TN-03E	140 (459)	-	-	N/A	167.4	167.4	169.1	181.2	181.4	182.6	153.8	153.7	154.7	-	-
02/04/16	TN-02B	180 (591)	-	-		161.6	161.2	165.4	177.5	177.9	181.7	149.9	149.9	152.7	-	-
02/05/16	TN-01A	185 (607)	-	-		159.9	159.9	160.2	173.6	173.6	173.9	148.2	148.2	148.5	-	-
02/04/16	TN-02B	200 (656)	-	-		168.1	168.1	168.5	181.5	181.3	182.4	154.4	154.5	154.7	-	-
02/05/16	TN-01A	200 (656)	-	-		161.4	161.3	168.5	177.5	177.5	177.9	152.3	152.3	152.7	-	-
02/04/16	TN-02B	206 (676)	-	-		164.8	163.4	177.2	177.3	176.6	184.6	150.6	150.4	151.9	-	-
02/04/16	TN-02B	207 (679)	-	-		167.4	167.2	168.3	180.3	180.2	181.9	154.0	153.9	154.6	-	-
02/04/16	TN-02B	240 (787)	-	-		165.3	165.3	165.9	178.0	177.9	178.7	152.0	151.9	152.3	-	-
02/05/16	TN-01B	240 (787)	-	-		160.1	160.0	160.7	173.0	173.0	173.3	148.1	148.1	148.6	-	-
02/05/16	TN-01B	245 (804)	-	-		159.9	159.9	160.2	173.6	173.6	173.9	148.2	148.2	148.5	-	-
02/05/16	TN-01B	247 (810)	-	-		152.2	152.1	152.7	170.9	170.9	171.2	146.2	146.2	146.8	-	-
02/05/16	TN-01B	250 (820)	-	-		159.7	159.7	160.5	173.8	173.6	175.6	148.4	148.4	149.1	-	-
02/05/16	TN-01B	260 (853)	-	-		163.2	162.8	164.3	178.9	178.7	180.9	151.2	151.3	152.0	-	-
02/05/16	TN-01B	300 (984)	-	-		162.4	162.6	163.1	177.1	177.0	178.4	150.2	150.2	150.7	-	-
02/05/16	TN-01B	350 (1,148)	-	-		160.0	160.0	160.7	173.9	173.9	174.7	148.1	148.1	148.7	-	-

Note: Dashes in fields indicate that the data is not available; "Med." = Median; "Max." = Maximum; and "N/A" = Not Applicable.
[1]Based on mean single strike SEL + $10\log_{10}$ (# strikes); [2]Data collected using the Loggerhead, all other data was collected using the APL-UW USLM

Appendix A.4: Hydroacoustic Data for Demolition Activities

Date (mm/dd/yy)	Pile Number[1]	Distance. (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)								SEL90 (Single Strike) (dB re 1 µPa²-sec)			SELcum (dB re 1 µPa²-sec)	TRUE Cum SEL
						Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.		
CAISSON REMOVAL - UNDERWATER WIRE SAW																
66-inch Round Caissons (Single Wire Saw) - NBPL Fuel Pier																
12/13/17	TQ-06[1]	10 (33)	N/A	N/A	00:22	156.1	157.1	162.4	N/A						-	-
12/13/17	TQ-06[1]	10 (33)			00:13	155.6	155.7	161.3							-	-
12/13/17	TQ-06[1]	10 (33)			00:14	156.9	156.9	160.7							-	-
12/13/17	TQ-06[1]	40 (131)			00:13	132.5	132.7	143.2							-	-
84-inch Round Caissons (Single Wire Saw) - NBPL Fuel Pier																
12/14/16	P-H-10	10 (33)	N/A	N/A	00:08	136.1	136.7	140.9	N/A						-	-
12/13/16	P-H-11	10 (33)			00:10	141.4	141.5	146.5							-	-
12/14/16	P-K-6	20 (66)			00:27	140.8	141.0	144.5							-	-
12/14/16	P-H-6	40 (131)			00:12	134.8	134.9	140.1							-	-
12/15/16	P-K-9	60 (197)			00:21	137.1	137.2	140.6							-	-
12/13/16	P-H-11	85 (279)			00:04	136.0	135.7	139.5							-	-
12/15/16	P-K-9	110 (361)			00:15	135.3	135.4	136.6							-	-
12/19/16	P-K-5	200 (656)			00:05	129.2	127.6	139.1							-	-
12/19/16	P-K-5	283 (928)			00:05	130.3	130.4	137.0							-	-
84-inch Round Caissons (Two Wire Saws) - NBPL Fuel Pier																
12/13/16	P-H-11	10 (33)	N/A	N/A	00:10	146.5	146.5	149.0	N/A						-	-
12/14/16	P-H-10	10 (33)			00:38	151.0	151.0	155.6							-	-
12/13/16	P-H-11	85 (279)			00:05	135.3	135.3	138.2							-	-
12/15/16	P-K-9	110 (361)			00:03	135.3	135.2	142.4							-	-
12/13/16	P-H-11	165 (541)			00:11	133.0	132.1	146.8							-	-
12/19/16	P-K-5	250 (820)			00:10	130.1	130.0	133.2							-	-
12/19/16	P-K-5	537 (1,762)			00:05	137.9	138.2	140.9							-	-
12/19/16	P-K-5	810 (2,657)			00:05	135.0	135.0	141.0							-	-
PILE REMOVAL - PILE CLIPPING																
13-inch Round Polycarbonate Fender Piles (Small Clipper) - NBPL Fuel Pier																
02/15/17	SEC16	10 (33)	N/A	N/A	00:01	145.9	144.8	156.2	N/A						-	-
02/15/17	SEC14	10 (33)			00:01	143.6	148.5	154.6							-	-
02/15/17	SEC15	10 (33)			00:01	141.2	135.8	158.2							-	-
02/16/17	SEC13	10 (33)			00:00	141.2	141.1	151.7							-	-
02/15/17	SEC12	10 (33)			00:03	137.7	133.9	148.2							-	-
02/16/17	SEC08	55 (180)			00:04	133.9	130.6	145.1							-	-
02/16/17	SEC06	115 (377)			00:00	132.1	132.3	134.6							-	-
02/16/17	SEC05	158 (518)			00:00	133.8	129.8	150.3							-	-
02/16/17	SEC03	213 (699)			00:05	131.0	130.8	133.2							-	-
02/16/17	SEC04	290 (951)			00:04	128.5	126.4	134.5							-	-

Date (mm/dd/yy)	Pile Number[1]	Distance. (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	SEL90 (Single Strike) (dB re 1 µPa²-sec) Mean	Med.	Max.	SELcum (dB re 1 µPa²-sec)	TRUE Cum SEL
02/16/17	SEC09	350 (1,148)	N/A	N/A	00:07	131.6	131.4	138.3	N/A						-	-
16-inch Square Concrete Structural Piles (Small Clipper) - NBPL Fuel Pier																
07/12/17	P03-C	10 (33)	N/A	N/A	00:01	145.9	146.5	147.3	N/A						-	-
07/12/17	P03-D	11 (36)			00:01	143.9	142.9	146.5							-	-
07/03/17	P10-AB	27 (89)			00:01	137.4	136.5	143.8							-	-
07/03/17	P11-AB	101 (331)			00:01	133.1	132.9	138.5							-	-
04/17/17	P40-C	141 (463)			00:01	128.3	128.3	128.8							-	-
07/03/17	P08-AB	155 (509)			00:01	142.7	142.5	144.1							-	-
07/03/17	P09-AB	155 (509)			00:01	139.1	140.7	142.2							-	-
04/17/17	P40-E	196 (643)			00:01	131.3	130.9	133.2							-	-
04/17/17	P41-B	197 (646)			00:01	131.0	131.0	132.0							-	-
04/17/17	P41-D	198 (650)			00:01	131.8	131.7	132.7							-	-
04/17/17	P41-E	201 (659)			00:01	134.3	134.6	138.0							-	-
07/03/17	P08-AB	215 (705)			00:01	129.0	128.9	130.0							-	-
07/13/17	P03-AP	309 (1,014)			00:02	130.2	130.0	131.8							-	-
07/13/17	P03-AB	309 (1,014)			00:01	125.6	124.6	129.9							-	-
16-inch Square Concrete Structural Piles (Large Clipper, 2 piles at once) - NBPL Fuel Pier																
10/31/17	P27-AB/B	12 (39)	N/A	N/A	00:04	138.5	132.4	155.7	N/A						-	-
10/31/17	P29-FB/E	10 (33)			00:03	141.5	142.5	149.7							-	-
11/01/17	P43-FB/E	12 (39)			00:02	142.4	141.1	150.0							-	-
10/31/17	P31-FB/E	32 (105)			00:02	133.3	131.9	147.3							-	-
11/01/17	P41-FB/E	39 (128)			00:03	138.6	138.7	142.0							-	-
11/01/17	P40-AB/B	39 (128)			00:05	131.6	131.2	137.2							-	-
11/01/17	P37-FB/E	40 (131)			00:03	132.0	130.8	141.6							-	-
11/01/17	P36-FB/E	43 (141)			00:09	131.6	129.4	140.1							-	-
18-inch Square Concrete Fender Piles (Small Clipper) - NBPL Fuel Pier																
09/19/16	NWF05	11 (36)	N/A	N/A	00:01	140.0	141.7	154.3	N/A						-	-
09/19/16	NWF01	10 (33)			00:02	137.8	133.2	150.5							-	-
09/19/16	NWF03	11 (36)			00:01	138.2	135.4	146.4							-	-
09/19/16	NWF08	92 (301)			00:01	136.8	136.7	139.6							-	-
09/19/16	NWF10	169 (555)			00:02	135.8	136.5	139.3							-	-
09/19/16	NWF12	175 (574)			00:01	128.6	127.3	142.8							-	-
08/09/17	TFS02	187 (614)			00:03	128.1	128.2	131.8							-	-
08/14/17	TFS11	206 (677)			00:03	134.6	132.9	141.3							-	-
08/14/17	TFS08	223 (733)			00:03	126.1	126.1	126.7							-	-
08/14/17	TFS09	224 (736)			00:05	135.1	135.2	137.3							-	-
08/14/17	TFS10	226 (741)			00:04	135.8	135.6	137.8							-	-

Date (mm/dd/yy)	Pile Number[1]	Distance. (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	SEL_{90} (Single Strike) (dB re 1 µPa²-sec)			SEL_{cum} (dB re 1 µPa²-sec)	TRUE Cum SEL
												Mean	Med.	Max.		
07/13/17	SWF01	238 (781)			00:01	125.4	125.1	127.9							-	-
08/14/17	TFS12	253 (830)			00:03	131.4	131.2	135.0							-	-
08/14/17	TFS06	280 (918)			00:04	123.9	123.5	126.6							-	-
08/14/17	TFS13	297 (975)	N/A	N/A	00:01	129.3	129.1	130.9	N/A						-	-
08/14/17	TFS14	335 (1,099)			00:05	126.6	126.5	132.3							-	-
08/14/17	TFS14	335 (1,099)			00:01	127.1	127.1	127.6							-	-
08/14/17	TFS15	388 (1,272)			00:03	128.8	127.8	131.9							-	-
08/14/17	TFS15	388 (1,272)			00:05	124.3	124.2	125.0							-	-
24-inch Square Concrete Fender Piles (Large Clipper) - NBPL Fuel Pier																
11/08/17	SEB-05	7 (23)			00:14	138.5	136.1	161.1								
10/12/16	NEB-12	10 (33)			00:01	143.5	140.3	165.3							-	-
10/13/17	NEB-01	10 (33)			00:01	144.6	141.4	159.9							-	-
10/13/17	NEB-02	10 (33)			00:01	139.5	134.2	163.8							-	-
10/13/17	NEB-03	10 (33)			00:02	138.0	133.8	156.1							-	-
11/15/17	SEB-28	17 (56)			00:10	134.9	131.7	153.8							-	-
11/15/17	SEB-29	19 (62)			00:06	135.7	131.5	157.7							-	-
11/15/17	SEB-27	39 (128)			00:14	130.8	128.5	147.7							-	-
11/15/17	SEB-26	44 (144)			00:07	127.8	124.8	146.8							-	-
11/09/17	SEB-08	50 (164)			00:04	131.5	127.5	147.6							-	-
11/09/17	SEB-09	53 (174)	N/A	N/A	00:10	131.7	129.4	145.1							-	-
11/13/17	SEB-18	90 (295)			00:17	131.0	130.7	146.8	N/A						-	-
11/13/17	SEB-19	107 (351)			00:09	135.4	135.1	142.0							-	-
11/07/17	SEB-06	165 (541)			00:02	128.0	127.1	132.3							-	-
11/14/17	SEB-23	195 (640)			00:14	129.4	128.9	137.6							-	-
11/14/17	SEB-24	195 (640)			00:07	135.2	130.9	136.6							-	-
11/07/17	SEB-02	235 (771)			00:11	127.1	126.7	138.8							-	-
11/07/17	SEB-03	235 (771)			00:29	125.0	124.8	129.1							-	-
11/09/17	SEB-07	265 (869)			00:36	125.2	124.1	137.8							-	-
11/14/17	SEB-22	290 (951)			00:10	129.1	128.7	137.2							-	-
11/14/17	SEB-20	340 (1,115)			00:12	128.1	127.5	137.8							-	-
11/14/17	SEB-21	340 (1,115)			00:11	129.5	129.0	135.8							-	-
PILE REMOVAL - UNDERWATER HYDRAULIC CHAINSAW																
16-inch Square Concrete Structural Piles - NBPL Fuel Pier																
10/04/17	P21-FB	17 (56)			00:05	146.4	146.9	149.8							-	-
10/04/17	P21-FB	17 (56)	N/A	N/A	00:05	136.8	138.6	149.5	N/A						-	-
10/04/17	P21-FB	17 (56)			00:05	141.5	142.8	147.2							-	-
10/04/17	P21-FB	17 (56)			00:05	141.0	141.5	146.8							-	-

Date (mm/dd/yy)	Pile Number[1]	Distance. (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms (dB re 1 μPa)			Peak (dB re 1 μPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	SEL90 (Single Strike) (dB re 1 μPa²-sec) Mean	Med.	Max.	SELcum (dB re 1 μPa²-sec)	TRUE Cum SEL
10/04/17	P21-FB	17 (56)			00:05	143.6	143.7	146.8							-	-
10/04/17	P21-FB	17 (56)			00:05	140.3	142.5	146.7							-	-
10/04/17	P21-FB	17 (56)			00:05	136.3	137.6	146.2							-	-
10/04/17	P21-FB	17 (56)			00:03	142.9	142.7	145.6							-	-
10/04/17	P21-FB	26 (87)			00:05	132.9	132.5	137.7							-	-
10/04/17	P21-FB	26 (87)			00:05	132.4	132.5	135.8							-	-
10/04/17	P21-FB	26 (87)			00:04	134.0	134.0	135.7							-	-
10/04/17	P21-FB	26 (87)			00:05	132.7	132.5	135.2							-	-
10/04/17	P21-FB	26 (87)			00:05	131.5	131.4	134.6							-	-
10/04/17	P21-FB	26 (87)			00:05	132.5	132.6	133.8							-	-
10/04/17	P21-FB	26 (87)			00:05	131.7	132.1	133.3							-	-
10/04/17	P21-FB	26 (87)			00:05	131.1	131.3	133.1							-	-
10/04/17	P21-FB	26 (87)	N/A	N/A	00:05	132.1	132.3	132.7	N/A						-	-
10/04/17	P21-FB	26 (87)			00:05	131.2	131.1	132.2							-	-
10/11/17	P13-FB	42 (137)			00:05	128.6	128.1	133.6							-	-
10/11/17	P13-FB	42 (137)			00:05	128.8	128.4	133.0							-	-
10/11/17	P13-FB	42 (137)			00:05	128.1	128.2	132.1							-	-
10/11/17	P13-FB	45 (148)			00:04	128.4	128.1	132.9							-	-
10/11/17	P13-FB	45 (148)			00:05	127.6	127.7	131.7							-	-
10/11/17	P13-FB	45 (148)			00:05	127.8	127.9	129.6							-	-
10/11/17	P13-FB	60 (197)			00:06	128.8	128.8	133.9							-	-
10/11/17	P13-FB	60 (197)			00:05	127.3	127.5	129.4							-	-
10/11/17	P13-FB	60 (197)			00:05	127.7	127.7	129.4							-	-
10/11/17	P13-FB	60 (197)			00:05	127.7	127.8	129.3							-	-
10/11/17	P13-FB	76 (251)			00:04	127.2	126.9	130.3							-	-
10/11/17	P13-FB	76 (251)			00:05	127.0	127.0	129.5							-	-
PILE REMOVAL – HIGH-PRESSURE WATER JETTING																
16-inch Square Concrete Structural Piles - NBPL Fuel Pier																
06/30/17	P11-B	9 (30)			00:05	140.6	139.2	150.7							-	-
06/30/17	P11-B	9 (30)			00:05	141.3	140.1	148.7							-	-
06/30/17	P11-B	9 (30)			00:05	139.8	139.2	143.7							-	-
06/30/17	P11-B	9 (30)			00:04	139.5	138.5	143.1							-	-
06/30/17	P11-B	9 (30)	N/A	N/A	00:05	140.8	140.9	143.1	N/A						-	-
06/30/17	P11-B	9 (30)			00:05	139.6	139.5	142.0							-	-
06/30/17	P11-B	9 (30)			00:03	138.9	139.0	141.9							-	-
06/30/17	P09-B	10 (33)			00:04	143.9	144.4	151.4							-	-
06/30/17	P09-B	10 (33)			00:01	148.5	148.2	150.7							-	-

Date (mm/dd/yy)	Pile Number[1]	Distance. (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms (dB re 1 μPa)			Peak (dB re 1 μPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	SEL_{90} (Single Strike) (dB re 1 μPa^2-sec)			SEL_{cum} (dB re 1 μPa^2-sec)	TRUE Cum SEL
												Mean	Med.	Max.		
06/30/17	P09-B	10 (33)			00:05	140.9	141.0	149.8							-	-
06/30/17	P09-B	10 (33)			00:05	147.2	148.4	149.6							-	-
06/30/17	P09-B	10 (33)			00:04	141.5	141.2	148.2							-	-
06/30/17	P09-B	10 (33)			00:04	142.9	142.0	148.0							-	-
06/30/17	P09-B	10 (33)			00:01	141.0	140.3	145.9							-	-
06/30/17	P09-B	10 (33)			00:01	145.0	144.9	145.4							-	-
06/30/17	P09-B	10 (33)			00:05	138.5	137.3	145.2							-	-
06/30/17	P09-B	10 (33)			00:05	140.7	140.8	144.7							-	-
06/30/17	P09-B	10 (33)			00:05	140.1	140.3	144.1							-	-
06/30/17	P09-B	10 (33)			00:05	139.0	138.8	143.8							-	-
06/30/17	P10-B	12 (40)			00:05	139.9	137.5	149.3							-	-
06/30/17	P10-B	12 (40)			00:04	138.0	137.7	148.3							-	-
06/30/17	P10-B	12 (40)			00:05	139.9	139.5	145.2							-	-
06/21/17	P20-E	13 (43)			00:02	143.0	142.8	152.3							-	-
06/21/17	P20-E	13 (43)			00:04	141.3	138.3	149.7							-	-
06/21/17	P20-E	13 (43)			00:05	137.6	137.2	144.7							-	-
06/21/17	P20-E	13 (43)			00:02	137.5	137.5	138.8							-	-
06/21/17	P20-E	13 (43)			00:04	135.8	135.2	138.4							-	-
06/21/17	P20-E	13 (43)	N/A	N/A	00:04	136.0	136.0	137.2	N/A						-	-
07/12/17	P04-B	16 (52)			00:04	145.5	145.8	147.4							-	-
07/12/17	P04-B	16 (52)			00:04	142.8	142.5	145.6							-	-
07/12/17	P03-B	19 (61)			00:04	143.0	142.4	145.7							-	-
07/12/17	P03-B	19 (61)			00:03	143.4	143.4	145.0							-	-
07/12/17	P03-B	19 (61)			00:04	142.4	142.2	144.1							-	-
07/03/17	P06-B	49 (161)			00:00	135.2	135.2	135.4							-	-
07/03/17	P06-B	49 (161)			00:03	128.6	128.1	135.3							-	-
07/03/17	P06-B	70 (229)			00:05	133.9	133.4	139.3							-	-
07/03/17	P06-B	70 (229)			00:05	129.3	129.3	133.1							-	-
07/03/17	P08-B	102 (334)			00:04	129.4	130.0	131.6							-	-
07/03/17	P08-B	102 (334)			00:05	126.3	126.3	128.6							-	-
07/03/17	P07-B	104 (342)			00:05	128.4	127.4	134.1							-	-
07/03/17	P07-B	145 (474)			00:05	131.7	132.8	135.0							-	-
07/03/17	P07-B	145 (474)			00:05	129.7	131.5	133.3							-	-
07/03/17	P07-B	145 (474)			00:01	127.4	126.5	130.6							-	-
07/03/17	P06-B	231 (759)			00:06	130.6	131.0	132.3							-	-
07/03/17	P06-B	231 (759)			00:05	126.1	125.5	130.2							-	-
07/03/17	P06-B	231 (759)			00:03	125.9	125.4	130.0							-	-
07/03/17	P06-B	231 (759)			00:03	125.7	125.6	126.6							-	-

Date (mm/dd/yy)	Pile Number[1]	Distance. (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	dB rms (dB re 1 µPa)			Peak (dB re 1 µPa)			SEL				
			No. of Strikes	Mean Strike Duration (sec)								SEL_{90} (Single Strike) (dB re 1 µPa²-sec)			SEL_{cum} (dB re 1 µPa²-sec)	TRUE Cum SEL
						Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.		
16-inch Round Concrete Guide Piles - NBPL HDA																
08/22/17	548-B31	10 (33)			00:05	154.5	154.5	157.6							-	-
08/22/17	548-B32	10 (33)			00:04	153.2	153.2	157.2							-	-
08/22/17	548-B31	10 (33)			00:04	154.4	155.0	156.3							-	-
08/22/17	548-B32	10 (33)			00:05	151.6	152.1	155.7							-	-
08/22/17	548-B30	10 (33)			00:01	150.2	149.9	155.1							-	-
08/22/17	548-B31	10 (33)			00:05	154.2	154.5	154.9							-	-
08/22/17	548-B32	10 (33)			00:05	154.8	154.8	154.8							-	-
08/22/17	548-B30	10 (33)			00:04	141.8	147.8	153.2							-	-
08/22/17	548-B30	10 (33)			00:04	149.7	149.5	153.1							-	-
08/22/17	548-B31	10 (33)			00:04	150.4	151.9	152.9							-	-
08/22/17	548-B30	10 (33)			00:04	149.2	148.6	152.3							-	-
08/23/17	548-B34	94 (308)			00:05	131.0	131.1	142.5							-	-
08/23/17	548-B34	94 (308)			00:04	130.1	129.6	140.2							-	-
08/23/17	548-B34	94 (308)	N/A	N/A	00:04	130.3	129.9	139.9	N/A						-	-
08/23/17	548-B34	94 (308)			00:03	129.4	129.6	134.4							-	-
09/25/17	619-B1	149 (488)			00:04	128.1	127.3	136.9							-	-
09/25/17	619-B1	149 (488)			00:04	127.3	126.3	135.4							-	-
09/25/17	619-B1	149 (488)			00:04	126.9	126.3	130.7							-	-
08/23/17	548-B33	151 (494)			00:05	128.7	127.4	135.6							-	-
08/23/17	548-B33	151 (494)			00:04	125.8	125.6	133.8							-	-
08/23/17	548-B33	151 (494)			00:04	127.0	126.4	133.5							-	-
09/25/17	619-B2	160 (524)			00:04	127.5	126.8	137.3							-	-
09/25/17	619-B2	160 (524)			00:04	129.3	128.1	137.2							-	-
09/25/17	619-B2	160 (524)			00:02	126.8	125.4	136.1							-	-
08/23/17	548-B29	240 (786)			00:05	129.0	127.9	137.9							-	-
08/23/17	548-B29	240 (786)			00:03	129.0	128.6	133.5							-	-
08/23/17	548-B29	240 (786)			00:05	127.1	127.1	130.2							-	-

Note: Dashes in fields indicate that the data were not available; "Med." = Median; "Max." = Maximum; and "N/A" = Not Applicable. [1]Pile numbers are denoted with the superscript "1" when data were collected using the LD 831 USLM, which provides LZ metrics; the LZF_{max} values are listed under the dB rms heading herein because they were considered equivalent based on prior comparisons between data collected with the LD 831 and APL-UW USLM during activities with relatively low SPLs that did not saturate the hydrophone. All other data were collected using the APL-UW USLM.

Appendix A.5: Airborne Acoustic Data for Steel, Concrete, and Poly-Concrete Pile Installation (Impact and Vibratory Hammers)

Date (mm/dd/yy)	Pile Number	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	LZF_{max} (dB re 20 µPa)			LZ_{Peak} (dB re 20 µPa)			LZ_{eq} (dB re 20 µPa)		
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.
PILE INSTALLATION - IMPACT PILE DRIVING														
30-inch Round Steel Pipe Piles - NBPL Fuel Pier														
03/01/17	D8-DB-B1	15.2 (50)	-	-	N/A	112.5	-	118.0	124.0	-	135.7	104.8	-	111.3
02/22/17	D7-DA	15.2 (50)	-	-		111.5	-	117.4	122.4	-	135.0	102.9	-	110.9
03/17/17	D5-PD-B1	15.2 (50)	-	-		111.3	-	118.5	121.8	-	135.7	101.8	-	111.5
02/22/17	D8-DA	15.2 (50)	-	-		109.7	-	117.1	120.5	-	134.6	101.5	-	110.8
03/16/17	D5-PD-B2	15.2 (50)	-	-		109.6	-	116.9	119.6	-	133.4	100.4	-	110.6
02/28/17	D8-DB-B2	15.2 (50)	-	-		109.2	-	114.0	119.9	-	130.9	100.7	-	107.8
03/17/17	D5-PB-B2	15.2 (50)	-	-		108.7	-	113.4	119.2	-	129.0	100.6	-	107.0
03/18/17	D6-PB-B2	15.2 (50)	-	-		107.2	-	112.8	117.2	-	130.0	98.2	-	107.0
03/16/17	D6-PD-B1	15.2 (50)	-	-		105.8	-	112.4	116.7	-	129.8	97.1	-	105.6
03/08/17	D7-DA-B1	200 (656)	-	-		88.6	-	93.1	101.1	-	110.8	82.9	-	88.1
03/16/17	D5-PD-B2	200 (656)	-	-		86.5	-	99.7	96.6	-	107.3	83.3	-	97.2
03/16/17	D6-PD-B1	200 (656)	-	-		86.0	-	99.1	97.8	-	109.1	81.8	-	95.8
03/18/17	D6-PB-B2	257 (843)	-	-		93.3	-	107.8	102.3	-	114.9	89.5	-	102.8
03/17/17	D5-PB-B2	257 (843)	-	-		92.9	-	106.7	101.5	-	111.9	89.4	-	102.4
02/20/17	D5-PB-B1	257 (843)	-	-		87.3	-	93.3	99.6	-	111.9	81.7	-	88.3
03/17/17	D5-PD-B1	257 (843)	-	-		84.8	-	99.6	96.3	-	107.2	80.3	-	93.7
36-inch Round Steel Pipe Piles - NBPL Fuel Pier														
02/17/15	P3-PC	15.2 (50)	-	-	N/A	112.2	113.6	116.3	123.5	129.0	133.0	102.9	107.3	109.6
02/17/15	P2-PD	15.2 (50)	-	-		111.4	112.6	118.4	122.7	128.0	136.0	101.7	105.7	111.6
10/22/14	T15-TB	15.2 (50)	-	-		111.0	112.9	115.2	122.1	127.8	134.6	100.7	105.6	108.3
10/22/14	T15-TD	15.2 (50)	-	-		110.9	110.9	111.0	121.4	121.4	122.0	100.7	100.7	101.0
02/17/15	P4-PC	15.2 (50)	-	-		110.2	111.6	115.8	121.8	127.0	132.5	101.5	105.0	109.3
10/22/14	T16-TD	15.2 (50)	-	-		110.1	111.2	114.4	121.6	125.9	132.2	100.6	104.5	107.6
02/17/15	P2-PC	15.2 (50)	-	-		109.4	111.3	113.0	119.9	125.7	130.4	100.2	105.0	106.8
10/20/14	T12-TD	15.2 (50)	-	-		109.1	110.3	111.9	120.8	125.0	129.3	100.3	103.7	106.2
11/18/14	T23-TC	15.2 (50)	-	-		108.8	109.8	111.9	120.9	124.8	129.9	99.9	103.4	105.6
10/21/14	T12-TB	15.2 (50)	-	-		107.5	108.5	111.0	119.0	123.4	127.5	98.7	102.2	104.4
02/17/15	P3-PD	15.2 (50)	-	-		107.0	108.3	111.2	118.7	123.2	130.8	98.7	102.0	105.1
10/22/14	T14-TB	15.2 (50)	-	-		106.5	108.0	110.0	117.8	122.6	126.6	97.8	102.0	103.5
10/21/14	T10-TB	15.2 (50)	-	-		105.6	107.1	109.8	117.1	122.1	127.2	96.8	100.3	103.9
10/21/14	T13-TB	15.2 (50)	-	-		105.3	106.6	108.3	117.1	121.6	126.9	96.9	100.4	102.2
10/20/14	T11-TD	15.2 (50)	-	-		105.3	106.4	109.2	116.8	121.3	126.8	96.6	100.6	103.4
04/07/15	T25-TB	50 (164)	-	-		100.2	100.9	103.9	113.2	115.8	123.2	92.8	95.0	97.5
04/07/15	T25-TC	50 (164)	-	-		100.1	100.8	104.1	112.5	115.9	122.2	92.3	94.4	97.8

Date (mm/dd/yy)	Pile Number	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	LZFmax (dB re 20 µPa)			LZPeak (dB re 20 µPa)			LZeq (dB re 20 µPa)		
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.
04/07/15	T25-TE	50 (164)	-	-		106.2	107.5	110.3	118.6	122.6	128.8	97.2	100.4	103.6
04/07/15	T25-TG	50 (164)	-	-		102.5	103.7	106.2	114.5	119.9	124.0	93.9	97.5	99.7
04/06/15	T24-TC	75 (246)	-	-		95.9	97.1	101.9	107.8	111.4	118.6	89.8	91.6	95.5
04/07/15	T24-TB	75 (246)	-	-		96.7	98.1	100.9	108.9	113.0	116.4	90.2	92.4	95.6
04/07/15	T24-TE	75 (246)	-	-		96.2	97.0	101.1	108.7	111.7	119.8	89.9	91.5	95.1
02/17/15	P4-PC	105 (344)	-	-		98.3	99.1	104.0	110.5	113.6	120.6	92.1	93.3	102.2
02/17/15	P3-PC	105 (344)	-	-		97.1	98.0	101.4	110.0	113.0	119.7	90.6	92.1	97.4
02/17/15	P2-PC	105 (344)	-	-		95.8	96.8	99.9	108.6	112.0	117.8	88.9	90.9	93.8
02/17/15	P3-PD	105 (344)	-	-		95.1	95.1	101.5	107.2	109.0	115.9	90.0	90.4	98.7
02/17/15	P2-PD	105 (344)	-	-		93.6	94.0	100.3	106.1	108.5	115.8	86.8	88.3	94.6
02/17/15	P1-PC	105 (344)	-	-		93.5	93.5	105.4	105.1	106.9	112.6	89.2	89.3	100.2
01/06/15	P11-PD	140 (459)	-	-		93.1	93.4	97.6	106.1	108.4	115.5	88.2	88.6	94.4
01/06/15	P11-PC	140 (459)	-	-		92.9	93.5	96.5	105.9	108.9	114.1	86.4	87.9	91.0
01/06/15	P12-PC	140 (459)	-	-	N/A	90.5	90.6	95.6	103.6	105.2	110.5	86.3	86.6	92.9
11/17/14	T21-TG	180 (591)	-	-		89.1	90.0	91.6	101.4	104.8	108.3	82.8	84.5	86.4
11/17/14	T21-TE	180 (591)	-	-		87.3	87.9	90.1	100.7	103.4	106.9	82.2	83.2	88.0
01/07/15	P13-PC	210 (689)	-	-		88.1	88.7	91.2	100.2	102.4	107.8	83.5	84.3	87.0
01/07/15	P12-PD	210 (689)	-	-		87.1	87.8	89.6	98.8	101.4	104.8	81.3	82.6	84.5
01/07/15	P13-PD	210 (689)	-	-		86.1	86.8	89.1	99.2	102.1	105.4	81.5	82.2	85.9
10/21/14	T10-TB	225 (738)	-	-		88.2	88.6	96.0	100.7	102.9	109.2	82.8	83.7	91.4
10/21/14	T13-TB	225 (738)	-	-		88.1	88.0	100.6	100.7	102.7	110.3	83.4	83.7	96.7
10/21/14	T12-TB	225 (738)	-	-		87.3	86.8	98.4	99.2	100.4	107.5	83.5	83.0	94.8
11/18/14	T23-TC	230 (755)	-	-		87.6	88.0	93.6	100.7	104.1	108.7	80.2	81.6	86.4
10/22/14	T15-TD	235 (771)	-	-		89.0	89.6	99.6	101.7	104.5	109.4	83.9	84.6	94.1
10/22/14	T15-TB	235 (771)	-	-		88.8	89.5	92.3	101.4	103.3	110.5	83.5	84.6	87.8
10/22/14	T16-TD	235 (771)	-	-		86.4	86.7	95.0	99.4	100.7	111.8	81.9	82.5	90.6
10/22/14	T14-TB	235 (771)	-	-		84.6	84.8	91.0	97.1	98.0	108.8	80.9	81.2	87.4
36-inch Round Steel Pipe Interlocking Abutment Piles - NBPL Fuel Pier														
10/18/17	Abutment11	18 (50)	-	-		109.2	110.7	114.8	120.4	125.6	129.9	100.4	105.1	109.2
10/18/17	Abutment12	19 (62)	-	-		108.2	109.6	114.2	119.3	123.5	130.0	99.8	103.8	108.2
10/18/17	Abutment13	20 (66)	-	-		109.8	112.2	113.9	120.4	126.2	130.5	100.7	105.4	108.0
10/18/17	Abutment13	20 (66)	-	-		109.6	111.4	114.4	120.4	125.9	131.0	100.5	105.4	108.3
10/18/17	Abutment12	54 (177)	-	-	N/A	100.2	101.9	103.6	111.2	115.6	119.4	92.0	95.5	97.9
10/19/17	Abutment10	97 (318)	-	-		93.2	93.9	99.7	104.8	107.4	112.9	87.2	88.7	95.0
10/19/17	Abutment11	97 (318)	-	-		80.3	80.5	91.5	90.0	89.8	105.6	79.4	79.8	86.5
10/19/17	Abutment09	149 (489)	-	-		89.3	89.8	99.3	101.5	103.0	112.5	84.8	85.5	95.1
24x30 Concrete Fender Piles - NBPL Fuel Pier														
04/25/16	O-09B	15.2 (50)	-	-		112.5	-	115.8	123.8	-	131.7	105.3	-	110.7
04/25/16	O-09A	15.2 (50)	-	-	N/A	112.4	-	117.4	124.8	-	134.3	105.2	-	111.4
04/27/16	O-09H	15.2 (50)	-	-		111.6	-	115.1	122.9	-	131.2	103.5	-	109.2

Date (mm/dd/yy)	Pile Number	Distance (m [ft])	Strikes		Continuous Noise Duration (hh:mm)	LZFmax (dB re 20 µPa)			LZPeak (dB re 20 µPa)			LZeq (dB re 20 µPa)		
			No. of Strikes	Mean Strike Duration (sec)		Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.
04/27/16	O-08B	15.2 (50)	-	-	N/A	111.3	-	114.1	123.3	-	130.9	103.7	-	108.6
04/27/16	O-08A	15.2 (50)	-	-		111.2	-	113.9	123.7	-	130.4	103.9	-	108.6
04/27/16	O-08D	15.2 (50)	-	-		110.5	-	113.0	122.0	-	128.0	103.3	-	107.8
04/27/16	O-08C	15.2 (50)	-	-		110.4	-	112.8	122.5	-	128.9	103.2	-	107.5
04/12/16	O-09G	15.2 (50)	-	-		109.5	-	113.3	122.1	-	131.0	102.6	-	107.7
04/26/16	O-09E	157 (515)	-	-		91.3	-	102.7	100.7	-	110.3	87.8	-	98.2
04/27/16	O-09H	157 (515)	-	-		90.7	-	110.1	102.1	-	115.6	86.8	-	105.1
04/26/16	O-09F	157 (515)	-	-		90.2	-	108.0	99.7	-	113.8	86.5	-	104.7
04/25/16	O-09D	257 (843)	-	-		84.2	-	103.6	92.0	-	109.5	80.9	-	99.0
04/25/16	O-09C	257 (843)	-	-		83.7	-	99.9	92.0	-	107.1	80.4	-	95.5
16-inch Round Poly-Concrete Fender Piles - NBPL Fuel Pier														
02/05/16	TN-01B	15.2 (50)	1,271	0.024	N/A	110.0	-	114.5	121.8	-	132.0	101.6	-	108.2
02/05/16	TN-01A	15.2 (50)	1,071	0.027		106.7	-	110.2	118.6	-	126.5	98.4	-	104.3
02/04/16	TN-02B	15.2 (50)	1,007	0.032		105.3	-	110.4	117.3	-	125.9	97.7	-	105.3
02/05/16	TN-03E	15.2 (50)	1,336	0.029		105.0	-	109.0	117.0	-	127.5	97.4	-	103.7
02/04/16	TN-02A	15.2 (50)	-	-		105.0	-	109.0	116.8	-	125.7	97.8	-	104.4
02/05/16	TN-01C	15.2 (50)	1,406	0.022		104.4	-	109.9	116.4	-	126.4	97.0	-	103.7
PILE INSTALLATION - VIBRATORY PILE DRIVING														
30-inch Round Steel Pipe Piles - NBPL Fuel Pier														
03/17/17	D5-PD-B1	15.2 (50)	N/A	N/A	00:05	102.7	-	104.8	113.8	-	117.0	102.3	-	104.2
03/16/17	D5-PD-B2	15.2 (50)			00:10	101.8	-	105.2	113.3	-	117.2	101.3	-	104.8
03/17/17	D5-PB-B2	15.2 (50)			00:05	101.4	-	104.1	113.0	-	116.0	100.9	-	103.6
03/18/17	D6-PB-B2	15.2 (50)			00:04	100.5	-	102.8	112.1	-	115.5	99.9	-	102.1
03/01/17	D8-DB-B1	15.2 (50)			00:04	100.1	-	106.3	109.6	-	116.6	99.6	-	106.0
02/22/17	D8-DA	15.2 (50)			00:06	97.8	-	102.4	108.6	-	114.6	97.2	-	102.3
02/22/17	D7-DA	15.2 (50)			00:05	96.0	-	103.0	106.4	-	116.0	95.4	-	102.5
03/16/17	D5-PD-B2	200 (656)			00:10	86.0	-	97.5	94.8	-	103.4	83.7	-	94.5
03/15/17	D6-PD-B2	200 (656)			00:05	84.7	-	93.8	102.3	-	114.9	89.5	-	102.8
03/08/17	D7-DA-B1	200 (656)			00:02	83.7	-	86.9	94.1	-	97.7	82.6	-	85.4
02/28/17	D8-DB-B2	200 (656)			00:13	83.2	-	94.9	93.1	-	102.0	81.7	-	91.3
03/16/17	D6-PD-B1	200 (656)			00:04	82.6	-	92.3	92.5	-	99.9	81.2	-	89.5
03/17/17	D5-PB-B2	257 (843)			00:05	94.2	-	104.4	100.9	-	111.7	90.8	-	100.9
03/17/17	D5-PD-B1	257 (843)			00:05	88.2	-	102.3	95.8	-	108.0	85.3	-	99.0
36-inch Round Steel Pipe Interlocking Abutment Piles - NBPL Fuel Pier														
10/13/2017	Abutment06	17 (56)	N/A	N/A	00:09	95.2	95.0	102.2	105.4	105.4	111.4	94.7	94.4	101.9
10/13/2017	Abutment07	50 (164)			00:12	88.7	88.1	95.2	99.2	99.0	104.5	88.0	87.5	94.8
10/13/2017	Abutment08	97 (318)			00:09	86.2	86.3	95.5	95.8	95.8	103.1	85.1	85.1	91.0

Note: All data were collected using the LD 831 SLM. Dashes in fields indicate that these data were not available; “Med.” = Median; “Max.” = Maximum; and “N/A” = Not Applicable.

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Appendix B:

Applicable Metrics for NOAA/NMFS Hydroacoustic Level A/B Threshold Criteria

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Appendix B.1: Impact Pile Driving

Project Location	Pile Type/Size and Activity	Maximum dB rms_{90}[1]	Maximum Peak (dB)[1]	Maximum # of Strikes[2]	Mean Strike Duration (sec)[2]	Approximate Measurement Distance (m [ft])	Transmission Loss (TL)[2,3]
Steel Pipe Piles							
NBPL Fuel Pier	18-inch Round	187.1	202.4	-	-	12 (39)	-
NBPL Fuel Pier	30-inch Round	200.6	216.4	699	0.040	10 (33)	15.5
NBPL Fuel Pier	36-inch Round	204.0	219.0	2,129	0.031	10 (33)	13.6
NBPL Fuel Pier	36-inch Round Interlocking Abutment	184.9	194.7	-	-	53 (174)	15.0[4]
Concrete Piles							
NBPL HDA	16-inch Round Guide	181.3	189.8	-	-	10 (33)	20.0
SIO/UCSD MarFac	18-inch Square Guide	161.4	176.0	-	-	45 (148)[5] 40 (131)[6]	-
NBPL Fuel Pier	24x30-inch Fender	193.8	204.3	1,192	0.030	10 (33)	15.9
Poly-Concrete Piles							
NBPL Fuel Pier	16-inch Round Fender	194.0	210.0	1,406	0.024	10 (33)	17.8

Note: [1]These values represent the maximum dB rms_{90} and peak SPL measurements during all data recordings. [2]A dash indicates that the data were not available from the annual monitoring reports. [3]For Level A threshold criteria, the NMFS user spreadsheet (NMFS 2018b) allows input of the "Transmission Loss" or "Propagation" coefficients if known or input of a default value of 15; the TL values presented in this table may be applicable for input as the coefficients in the NMFS user spreadsheet for similar projects using the same equipment, pile type and size, and locations in San Diego Bay. [4]While the TL value was calculated to be 24.6, this value was likely adversely affected by the pile driving conditions, and a TL of 15 is suggested. [5]Measurement distance of 45 m (148 ft) corresponds to maximum dB rms_{90} value. [6]Mesurement distance of 40 m (131 ft) corresponds to maximum peak dB rms value.

Appendix B.2: Continuous Noise Sources

Project Location	Pile Type/Size and Activity	dB rms[1]		Average Continuous Noise Duration (mm:ss)[2]	Approximate Measurement Distance (m [ft])	Transmission Loss (TL)[2,3]
		Mean of Maximum	Maximum			
Steel Pipe Piles - Vibratory Installation						
NBPL Fuel Pier	30-inch Round	168.6	174.0	28:27	10 (33)	10.1
NBPL Fuel Pier	36-inch Round	168.4	175.0	08:09	10 (33)	-
NBPL Fuel Pier	36-inch Round Interlocking Abutment	138.2	140.9	-	53 (174)	15.0[4]
Concrete Piles - High-pressure Water Jetting (Installation)						
NBPL HDA	16-inch Round Concrete Guide	132.5	137.7	12:25	10 (33)	15.0[4]
NBPL Fuel Pier	24x30-inch Concrete Fender (Method 1 [M1])	158.2	159.9	07:50	10 (33)	-
NBPL Fuel Pier	24x30-inch Concrete Fender (Method 2 [M2])	144.3	153.2	02:51	10 (33)	-
Concrete Piles - High-pressure Water Jetting (Removal)						
NBPL Fuel Pier	16-inch Square Concrete Structural	145.8	152.3	03:57	10 (33)	12.5
NBPL HDA	16-inch Round Concrete Guide	154.8	157.6	04:02	10 (33)	15.2
Concrete Piles - Pile Clipping						
NBPL Fuel Pier	16-inch Square Structural (Small Clipper)	146.9	147.3	01:04	10 (33)	10.6
NBPL Fuel Pier	16-inch Square Structural (Large Clipper)	151.8	155.7	03:53	10 (33)	19.1
NBPL Fuel Pier	18-inch Square Fender (Small Clipper)	150.4	154.3	02:35	10 (33)	13.5
NBPL Fuel Pier	24-inch Square Fender (Large Clipper)	161.2	165.3	10:22	10 (33)	17.5
Concrete Piles - Hydraulic Chainsaw						
NBPL Fuel Pier	16-inch Concrete Structural	147.3	149.8	04:51	17 (56)	27.0
Polycarbonate Piles - Pile Clipping						
NBPL Fuel Pier	13-inch Round Fender (Small Clipper)	153.8	158.2	02:22	10 (33)	11.7
Concrete Filled/Steel Exterior Caissons - Wire Saw						
NBPL Fuel Pier	66-inch Round (Single Wire Saw)	161.5	162.4	15:30	10 (33)	-
NBPL Fuel Pier	84-inch Round (Single Wire Saw)	143.7	146.5	11:53	10 (33)	15.0[4]
NBPL Fuel Pier	84-inch Round (Two Wire Saws)	152.3	155.6	10:53	10 (33)	15.0[4]

Note: [1]The mean of the maximum values measured for all recordings of these pile sizes/types and the highest maximum value measured are provided. [2]A dash indicates that the data were not available from the annual monitoring reports or were insufficient for calculating transmission loss (TL). [3]For Level A threshold criteria, the NMFS user spreadsheet (NMFS 2018b) allows input of the "Transmission Loss" or "Propagation" coefficients if known or input of a default value of 15; the TL values presented in this table may be applicable for input as the coefficients in the NMFS user spreadsheet for similar projects using the same equipment, pile type and size, and locations in San Diego Bay. [4]While the TL value was calculated to be 7.0 for 36-inch round interlocking abutment piles, 0.9 for 16-in round concrete piles, and 4.9 and 7.0 for 84-inch caissons (one saw and two saws, respectively), these values were likely adversely affected by recording conditions during those activities, and a TL coefficient of 15 is suggested.