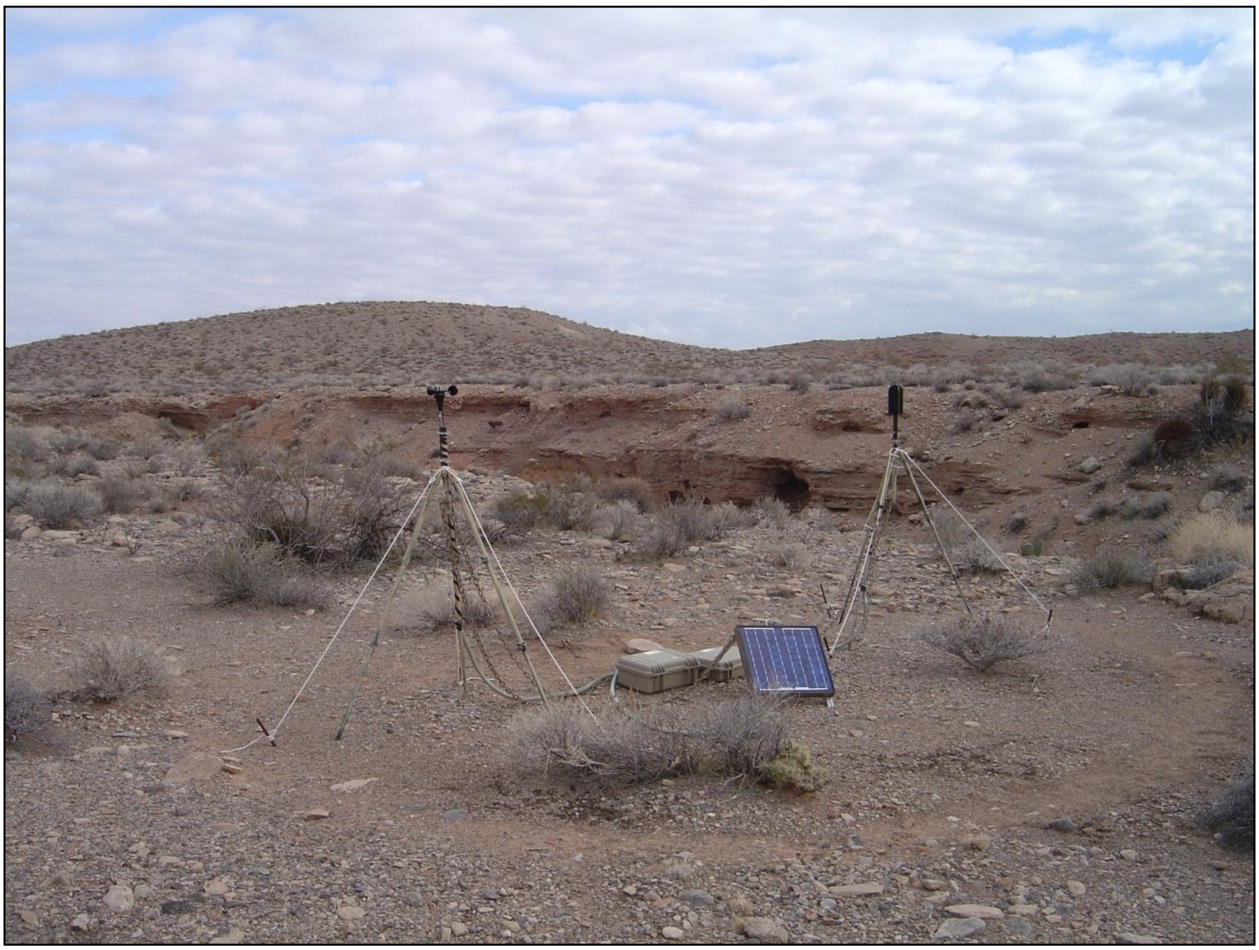
National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Acoustic Monitoring 2007-2012

Lake Mead National Recreation Area

Natural Resource Technical Report NPS/NRSS/NRTR—2013/785



ON THE COVER
Acoustical monitoring station in Lake Mead National Recreation Area
Photograph by: Jessie Rinella

Acoustic Monitoring 2007-2012

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Natural Resource Technical Report NPS/NRSS/NRTR—2013/785

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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INTRODUCTION

Lake Mead National Recreation Area (NRA) is located in both Nevada and Arizona. It includes both Lake Mead and Lake Mohave, created by Hoover Dam (1936) and Davis Dam (1951) respectively. Nearby population centers include Las Vegas, Henderson, and Boulder City, Nevada and Bullhead City and Kingman, Arizona. Between 1935 and 1964, the Lake Mead area was cooperatively managed by federal agencies including the National Park Service. The park was officially established in 1964.

Figure 1. Wildflowers at Lake Mead, NPS photo

The park encompasses a vast array of habitats within its 1.5 million acres. Lake Mead NRA offers a wealth of activities and a variety of places to go year-round. It is home to thousands of desert plants and animals, adapted to survive in an extreme place where rain is scarce and temperatures vary widely. In 2002, approximately 184,439 acres of Lake Mead NRA was designated as wilderness. Other areas are currently being considered for wilderness designation. Lake Mead NRA is often represented with the binomials LAME for LAke MEad or LAKE for LAKE Mead and the monitoring sites herein are named similarly.

An important part of the National Park Service (NPS) mission is to preserve and restore the natural resources of the parks, including the natural soundscapes associated with units of the national park system. National Park Service Management Policies 2006 state,

> Park natural soundscape resources encompass all the natural sounds that occur in parks, including the physical capacity for transmitting those natural sounds and the interrelationships among park natural sounds of different frequencies and volumes. Natural sounds occur within and beyond the range of sounds that humans can perceive, and they can be transmitted through air, water, or solid materials. The National Park Service will preserve, to the greatest extent possible, the natural soundscapes of parks.

The collection of sound level data provides valuable information about a park's acoustic conditions for use in developing planning documents, management plans and soundscape management plans. In 2007, Lake Mead NRA began an acoustic monitoring program to analyze the long-term baseline acoustics in designated and proposed wilderness areas. Monitoring equipment was deployed for a minimum of 30 days at each location. From 2007 through 2012, 25 acoustic monitoring units were deployed within Lake Mead NRA and on surrounding lands administered by the Bureau of Land Management (BLM). Together, these stations cover a range of terrain from shoreline areas to upland hills and cover most regions of the park. Focus was given to areas which are in existing or proposed designated wilderness areas.

The purpose of this monitoring effort was to characterize existing sound levels, estimate natural ambient sound levels, and identify audible sound sources in support of future and pending management decisions. This report provides a summary of results of these measurements, representing all seasons over several years. Figure 2 shows a map of the area with the locations of the monitoring sites.

In efforts to collect baseline ambient data for a future Air Tour Management Plan, an acoustic monitoring unit was placed specifically at Indian Pass AR72 (LAME007). This acoustic monitoring unit will help managers determine possible noise impacts for the future. Predicting and understanding potential impacts is critical to determining future management actions. To meet this objective, monitoring occurred for an extended time period of just under one year. This monitoring location was intended to collected baseline acoustical data prior to the development of the proposed Ivanpah Airport.

STUDY AREA

Many sites within Lake Mead NRA were monitored throughout varying seasons over several years. They were selected with focus on acoustic monitoring near the designated and proposed wilderness areas of the Lake Mead NRA region or in relation to a proposed Air Tour Management Plan. Figure 2 shows a map of the area with monitoring site locations. Table 1 lists the monitoring sites, dates of data collection, area description, and number of hours that data were collected.

Monitoring sites were established at 15 locations throughout the NRA and adjacent BLM lands.

Sites were selected to:
a) be representative of the overall area or
b) to determine a baseline for potential or existing wilderness areas or
c) to monitor a specific resource impact – such as overflights at site LAME007.

Several of the initial monitoring sites are described here and demonstrate representative sites throughout the study area.

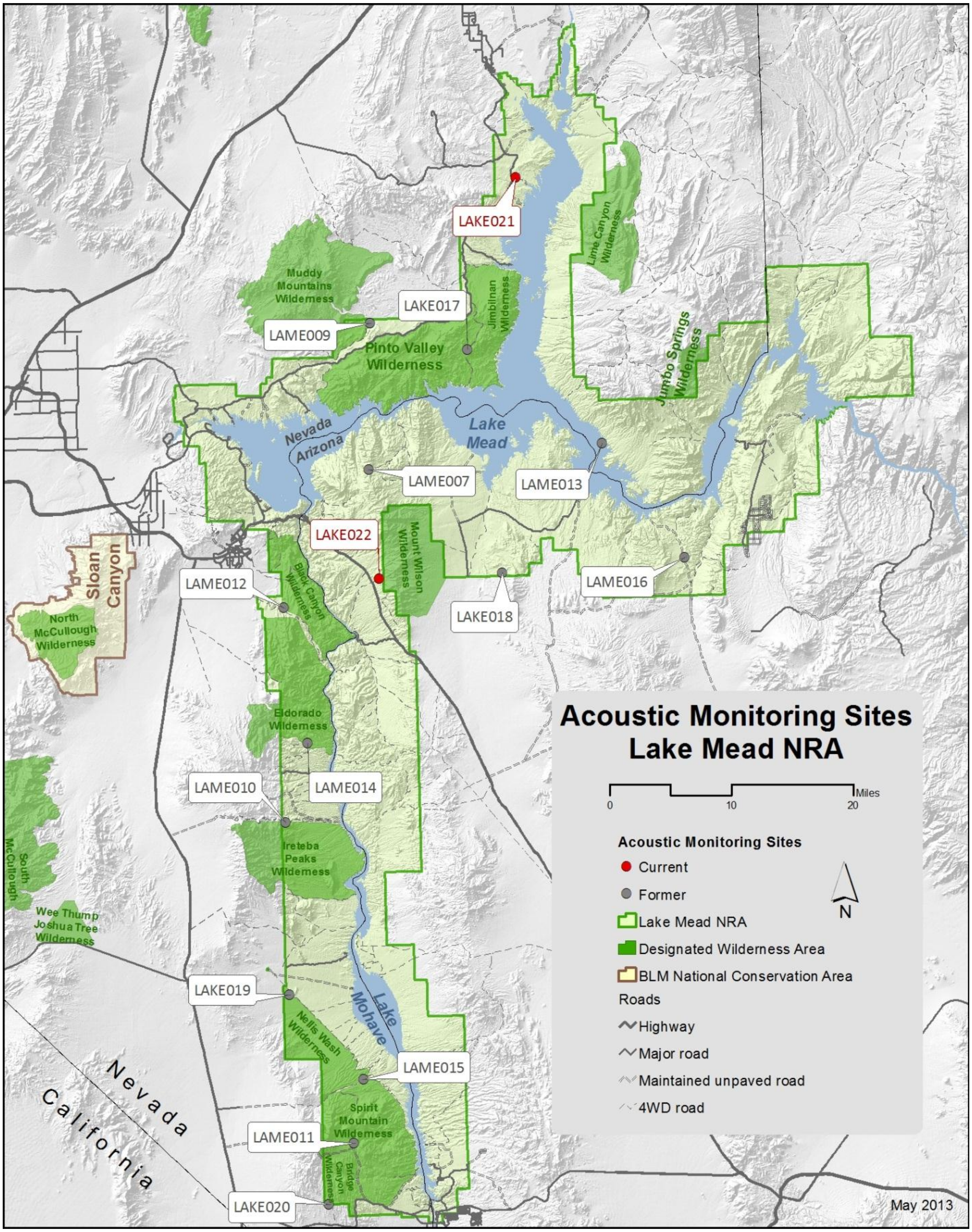

Figure 2. Acoustic monitoring site locations in Lake Mead NRA.

Table 1. Monitoring sites with descriptions

Site	Site Name	Dates Deployed	Habitat	Elevation	*Duration Analyzed	Location (*See* Figure 2)
LAME007 (Summer)	Indian Pass AR72	6/28/2007 to 9/30/2007	Low desert scrub	1037 m	2060 Hours	-114.63823597900 36.06882969860
LAME007 (Winter)	Indian Pass AR72	10/1/2007 to 3/31/2008	Low desert scrub	1037 m	3145 Hours	-114.63823597900 36.06882969860
LAME009 (Summer)	Callville Wash	6/26/2007 to 8/31/2007	Low desert scrub	2175 ft	1377 Hours	11 S 0712813 4013450
LAME009 (Winter)	Callville Wash	11/1/2007 to 2/29/2008	Low desert scrub	2175 ft	2129 Hours	11 S 0712813 4013450
LAME010 (Summer)	West Powerline Wash Road AR42B	5/29/2009 to 8/31/2008	Low desert scrub	2248 ft	2235 Hours	11 S 0701734 3947588
LAME010 (Fall)	West Powerline Wash Road AR42B	9/1/2008 to 10/31/2008	Low desert scrub	2248 ft	950 Hours	11 S 0701734 3947588
LAME010 (Winter)	West Powerline Wash Road AR42B	11/10/2009 to 3/31/2009	Low desert scrub	2248 ft	1019 Hours	11 S 0701734 3947588
LAME011 (Summer)	Pipe Spring Road AR20A	7/8/2008 to 8/31/2008	Low desert scrub	2746 ft	1072 Hours	11S 0710723 3905277
LAME011 (Fall)	Pipe Spring Road AR20A	9/1/2008 to 10/31/2008	Low desert scrub	2746 ft	756 Hours	11S 0710723 3905277
LAME011 (Winter)	Pipe Spring Road AR20A	11/1/ 2008 to 2/28/2009	Low desert scrub	2746 ft	1118 Hours	11S 0710723 3905277
LAME011 (Spring)	Pipe Spring Road AR20A	3/1/ 2009 to 4/19/2009	Low desert scrub	2746 ft	825 Hours	11S 0710723 3905277
LAME012 (Summer)	Burro Wash AR60	7/1/ 2009 to 9/24/2009	Low desert scrub	681 m	884 Hours	-114.76767683300 35.90656337660
LAME012 (Winter)	Burro Wash AR60	11/5/2009 to 3/31/2010	Low desert scrub	681 m	1604 Hours	-114.76767683300 35.90656337660
LAME013 (Summer)	Haystacks, Scanlon Wash	7/16/ 2009 to 8/31/2009	Shoreline	341 m	1106 Hours	-114.29519268000 36.09307038090
LAME013 (Fall)	Haystacks, Scanlon Wash	9/1/ 2009 to 10/31/2009	Shoreline	341 m	1162 Hours	-114.29519268000 36.09307038090

Table 2. Monitoring sites with descriptions (continued).

Site	Site Name	Dates Deployed	Habitat	Elevation	*Duration Analyzed	Location (*See* Figure 2)
LAME013 (Winter)	Haystacks, Scanlon Wash	11/1/2009 to 2/28/2010	Shoreline	341 m	749 Hours	-114.29519268000 36.09307038090
LAME014 (Winter)	AR 49 Eldorado Wilderness	11/2/2009 to 2/25/2010	Low desert scrub	389 m	2511Hours	-114.73733741200 35.74496772890
LAME014 (Summer)	AR 49 Eldorado Wilderness	6/21/2010 to 8/13/2010	Low desert scrub	389 m	973 Hours	-114.73733741200 35.74496772890
LAME015 (Fall)	AR22 Nellis Wash	10/2/2009 to 10/31/2009 and 9/1/ 2010 to 10/18/2010	Low desert scrub	683m	1814 Hours	-114.6671851 35.3439909
LAME015 (Winter)	AR22 Nellis Wash	11/1/2009 to 2/28/2010	Low desert scrub	683m	1334 Hours	-114.6671851 35.3439909
LAME015 (Spring)	AR22 Nellis Wash	3/1/2010 to 4/1/2010	Low desert scrub	683m	741 Hours	-114.6671851 35.3439909
LAME015 (Summer)	AR22 Nellis Wash	5/4/2010 to 8/31/2010	Low desert scrub	683m	2020 Hours	-114.6671851 35.3439909
LAME016 (Summer)	AR136 Gregg's Hide-Out	5/10/2010 to 8/31/2010	Low desert scrub	655m	2154 Hours	11 S 0754425 3982530
LAME016 (Fall)	AR136 Gregg's Hide-Out	9/1/2010 to 10/31/2010	Low desert scrub	655m	1188 Hours	11 S 0754425 3982530
LAME016 (Winter)	AR136 Gregg's Hide-Out	11/1/2010 to 3/12/2011	Low desert scrub	655m	2163 Hours	11 S 0754425 3982530
LAME017 (Winter)	AR97 Boathouse Cove Road	12/1/2010 to 3/31/2011	Low desert scrub	631m	1072 Hours	11 S 0725713 4009929
LAME017 (Summer)	AR97 Boathouse Cove Road	5/26/2011 to 9/3/2011	Low desert scrub	631m	1305 Hours	11 S 0725713 4009929
LAME018 (Summer)	Temple Bar Area	4/1/2011 to 7/28/2011	Low desert scrub	1989 ft	715 Hours	N 35.94167 W114.44666
LAME019 (Summer)	AR30 Mead-Davis Powerline Road	8/13/2011 to 8/31/2011 and 5/1/2012 to 8/31/2012	Low desert scrub	1798 ft	714 Hours	N 35.44662 W114.77151
LAME019 (Winter)	AR30 Mead-Davis Powerline Road	11/1/ 2011 to 2/23/2012	Low desert scrub	1798 ft	1130 Hours	N 35.44662 W114.77151

Table 2. Monitoring sites with descriptions (continued).

Site	Site Name	Dates Deployed	Habitat	Elevation	*Duration Analyzed	Location (*See* Figure 2)
LAME020 (Winter)	AR18 Upper Bridge Canyon Road	11/7/2011 to 2/29/2012	Low desert scrub	2887 ft	1368 Hours	N35.19665 W114.72098
LAME020 (Spring)	AR18 Upper Bridge Canyon Road	3/1/ 2012 to 4/30/2012	Low desert scrub	2887 ft	1081 Hours	N 35 11'47.9" W114 43' 15.5"
LAME020 (Summer)	AR18 Upper Bridge Canyon Road	5/1/2012 to 9/26/2012	Low desert scrub	2887 ft	2534 Hours	N 35 11'47.9" W114 43' 15.5"
LAKE021	AR64 Boundary Mine Road	10/2/2012 to present	Low desert scrub	1350 ft	Currently in field: No Data Analyzed	N 36.41128 W114.41130
LAKE022	AR106 Fire Cove Road	10/15/2012 to present	Low desert scrub	2454 ft	Currently in field: No Data Analyzed	N 35.93845 W114.62695

LAME009 is one of the original monitoring sites selected in 2007. It was established at Callville Wash (Figure 3), located near both the Muddy Mountains and Pinto Valley Wilderness areas. These wilderness areas are comprised of rugged hills, scenic valleys, and red sandstone outcroppings which merge with the green desert vegetation and the grays, browns, and yellows of the desert floor. This unique place is habitat for the rare Las Vegas bearpaw poppy plant.

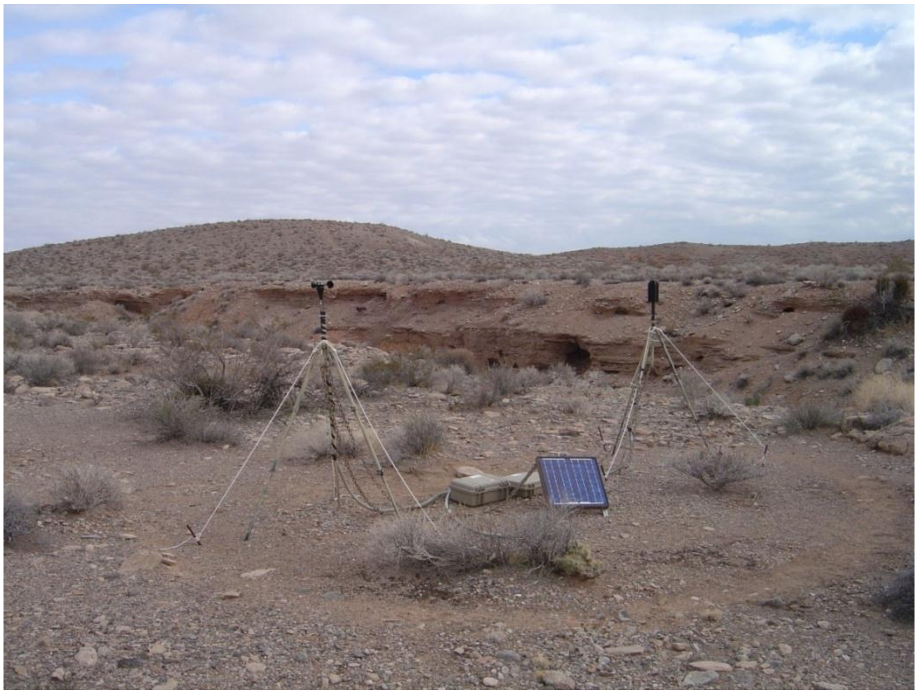

Figure 3. LAME009 Callville Wash site (near Muddy Mountains Wilderness Area and Pinto Valley Wilderness Area).

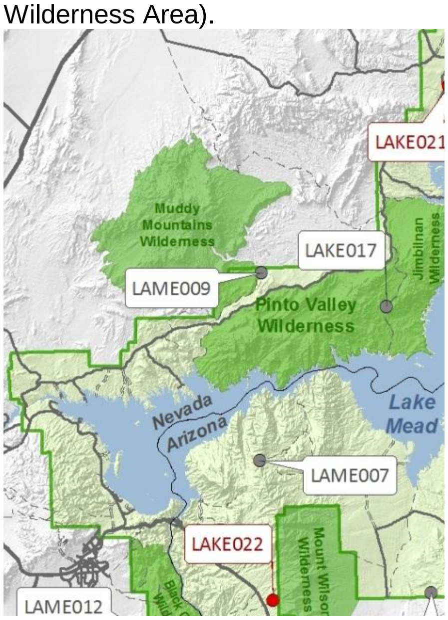

Figure 4. Cropped location map for LAME009.

LAME010 (Figure 5) is located within Ireteba Wilderness Area near AR42B West Powerline Wash Road. Within this wilderness is a portion of the Eldorado Mountains, gently rolling hills and wandering washes extending to Lake Mohave. Rugged mountains, secluded valleys, and flat alluvial fans provide opportunities for seclusion and isolation in a setting of scenic splendor. Sparse desert vegetation at LAME010 includes teddy-bear cholla forests and barrel cactus. This area is home to the threatened desert tortoise and Townsend's western big-eared bats, which are just some of the unique species surviving in this part of the Mojave Desert.

Figure 5. LAME010 site near AR42B West Powerline Wash Road (Ireteba Peaks Wilderness Area).

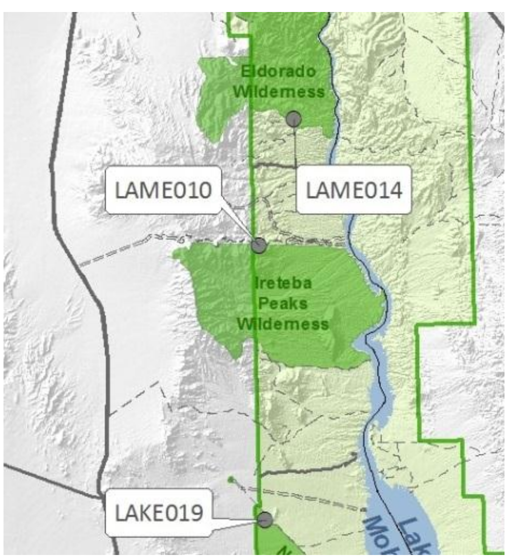

Figure 6. Cropped location map for LAME010.

LAME011 (Figure 7) is located within the Spirit Mountain Wilderness Area near AR20A Pipe Springs Road. The Spirit Mountain Wilderness is located in the Newberry Mountains. This area contains granite boulders and rock outcrops. There is a place held sacred to the Native American cultures found in this area. The mountain plays a prominent role in the religion and mythology of the Yuman tribes of the lower Colorado River.

Figure 7. LAME011 site near AR20A Pipe Springs Road (Spirit Mountain Wilderness Area).

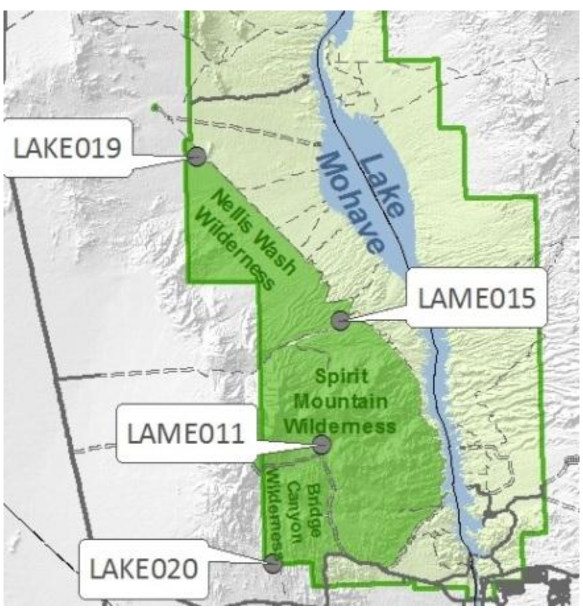

Figure 8. Cropped location map for LAME011.

LAME013 (Figure 9) is located along the shoreline at Haystacks.

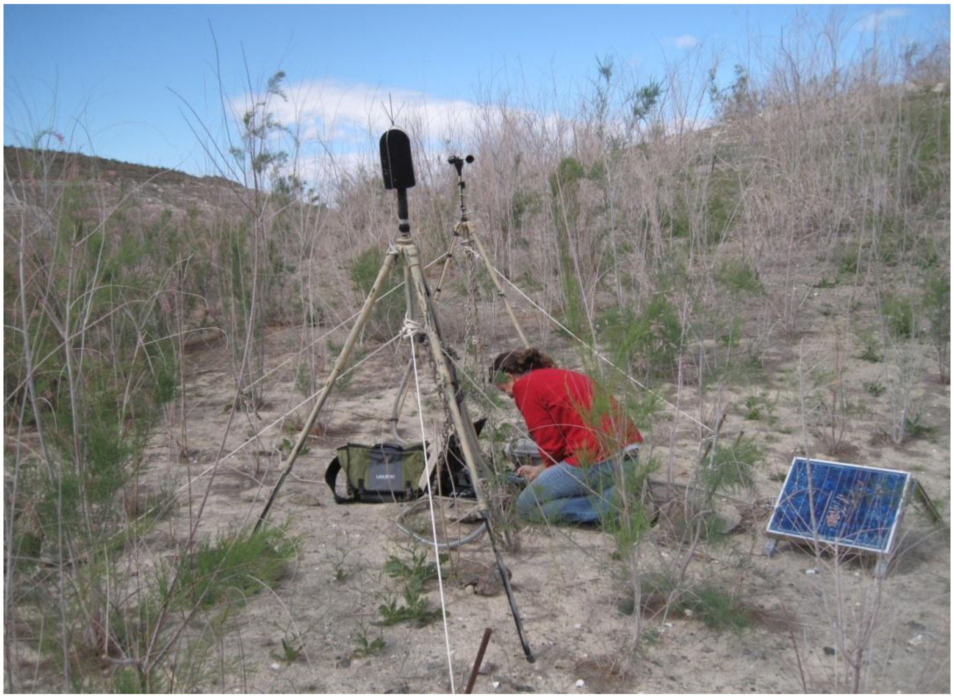

Figure 9. LAME013 Haystacks Shoreline (Scanlon Wash Proposed Wilderness Area).

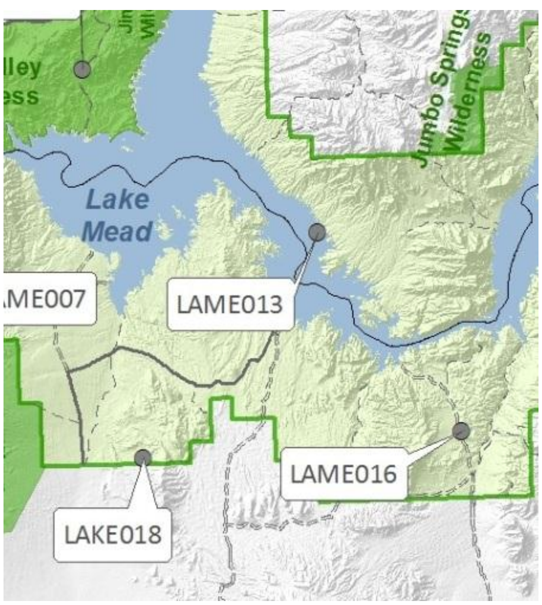

Figure 10. Cropped location map for LAME013.

METHODS

Automated Monitoring

Larson Davis 831 sound level meters (SLM) were employed over several long term (generally 30 days) monitoring periods at Lake Mead NRA. The Larson Davis SLM is a hardware-based, real-time analyzer which constantly records one second sound pressure level (SPL) and 1/3 octave band data, and exports these data to a portable storage device (thumb drive). These Larson Davis-based sites met American National Standards Institute (ANSI) Type 1 standards.

Each Larson Davis sampling station consisted of:

- Microphone with environmental shroud
- Preamplifier
- Solar panel and batteries
- MP3 recorder
- Anemometer
- Meteorological data logger

Each acoustic sampling station collected:

- SPL data in the form of A-weighted decibel readings (dBA) every second
- Continuous digital audio recordings
- One third octave band data every second ranging from 12.5 Hz – 20,000 Hz
- Meteorological data

On-Site Listening

On-site listening is the practice of placing an observer near the acoustic monitoring station with handheld Personal Digital Assistants (PDAs). The observer listens for a designated period of time (in this case, one hour), and identifies all sound sources and their durations. On-site listening takes full advantage of human binaural hearing capabilities, and most closely matches the experience of park visitors. Logistic constraints prevent comprehensive sampling by this technique, but selective samples of on-site listening provide a basis for relating the results of off-site listening (see below) to the probable auditory perception of events by park visitors and wildlife. On-site listening sessions are also an excellent screening tool for parks initiating acoustic environment studies. They produce an extensive inventory of sound sources, require little equipment or training, and can help educate park staff and volunteers.

Thus, periods of on-site listening were conducted in order to discern the type, timing, and duration of sound-level data collected at Lake Mead NRA. In accordance with NPS Natural Sounds Program protocol, these sessions generally began at the top of an hour and lasted for one hour. Staff recorded the beginning and ending times of all audible sound sources using custom-designed PDA software. These on-site listening sessions provided the basis for the calculation of metrics including the period of time between noise events (average noise free interval [NFI]), percent time each sound source was audible, and maximum, minimum, and mean length (in seconds) of sound source events.

Off-Site Listening

For each day of monitoring data, Lake Mead NRA staff visually analyzed a subset of SPL samples (minimum of eight days) in order to identify durations of audible sound sources. Audio

samples were employed to confirm identification. See Appendix B for further information on visual analysis. Hourly time audible statistics are then inserted into a formula which produces natural ambient sound level estimates (see Calculation of Metrics below). The total percent time extrinsic sounds were audible was then used to calculate the natural ambient sound level. Bose Quiet Comfort Noise Canceling headphones were used for off-site audio playback to minimize limitations imposed by the office acoustic environment.

Calculation of Metrics

The current status of the acoustic environment can be characterized by a number of measurements including sound levels across the 1/3 octave band spectrum (from 12.5 Hz to 20,000 Hz), overall sound levels, and percent time audible durations for various sound sources. Two fundamental descriptors of the acoustic environment are existing and natural ambient sound levels. Measured in A-weighted decibel levels (dBA), the existing ambient or median sound level (L_{50}) isa statistical descriptor describing the sound level exceeded 50% of a specific time period. It is the uncensored composite of all sounds at a site, both human-caused and natural.

In order to understand the implications of the acoustical data fully, it is important to describe the distribution of sound levels in relation to potential functional effects. Table 3 presents park sound sources and common sound sources with their corresponding dBA. The dBA is a logarithmic measure of sound energy that approximates human hearing sensitivity (Harris, 1998, p. 1.16).

Table 3. Interpreting sound levels

Park Sound Sources	Common Sound Sources	dBA
Volcano crater (Haleakala NP)	Human breathing at 3m	10
Leaves rustling (Canyonlands NP)	Whispering	20
Crickets at 5m (Zion NP)	Residential area at night	40
Conversation at 5m (Whitman Mission NHS)	Busy restaurant	60
Snowcoach at 30m (Yellowstone NP)	Curbside of busy street	80
Thunder (Arches NP)	Jackhammer at 2m	100
Military jet, 100m above ground level (Yukon-Charley Rivers NP)	Train horn at 1m	120

Note: An increase of 10dBA represents a tenfold multiplication of energy

NPS staff calculates L_{10} and L_{90}, which describe the sound levels exceeded 10% and 90% of the time, respectively. While L_{90} describes the sound level exceeded 90% of the time, only the quietest 10 percent of the sample can be found below this point

The natural ambient (L_{nat}) is an estimate of what the ambient level for a site would be if all extrinsic or anthropogenic sources were removed. Unlike the existing ambient, the natural ambient is comprised of spectra drawn from a subset of the original data. The differences between L_{50} and L_{nat} values allow NPS staff to answer the following questions:

- What are the listening opportunities in the absence of human development and activities?
- How are these listening opportunities compromised by increased sound levels due to noise?

To calculate L_{nat}, the NPS protocol includes the following:

- Calculate the percentage of all samples containing extrinsic sounds for each hour of the day (P_H) by either listening to samples, or analyzing daily spectrograms, for eight days.

P_H is used to complete this formula for every hour:

$$X = \frac{1-P_H}{2} + P_H$$

Hourly x_H values are entered into a database of all octave band information.

Example: if extrinsic sounds are audible 50% of the time (P_H =0.5), then x_H is 0.75.
L_{nat} is computed as the sound level that is exceeded 100*x_H percent of the time.
(In practice, L_{nat} is calculated by sorting the relevant sound level measurements and using x_H to extract the appropriate order statistic).

This procedure approximates the sound levels that would have been measured in the absence of extrinsic noise. The procedure is guaranteed to produce an estimate that is equal to or below the existing ambient sound levels, and the results of this calculation have produced consistent results at most backcountry sites. Refer to Figure 11- Figure 47 to see the results of these calculations.

RESULTS

Exceedence Levels

In order to determine the effect extrinsic noise audibility has on the acoustic environment, it is useful to examine the median hourly exceedence metrics. Figure 11 to Figure 47 show existing ambient sound levels (L_{10}, L_{50}, L_{90}) and calculated natural ambient levels (L_{nat}). The existing ambient (or median, L_{50}) level for each hour is marked by the upper limit of the black boxes while natural ambient levels (L_{nat}) are marked by the lower limit of the black boxes.

The height of the black box is a measure of the contribution of anthropogenic noise to the existing ambient sound levels at this site. The size of these boxes is directly related to the percent time that human caused sounds are audible. When boxes do not appear, the natural and existing ambient levels were either very close to each other, or equal for that hour. These figures also show exceedence metrics L_{10} and L_{90}, which essentially mark the average maximum and minimum levels over the monitoring periods.

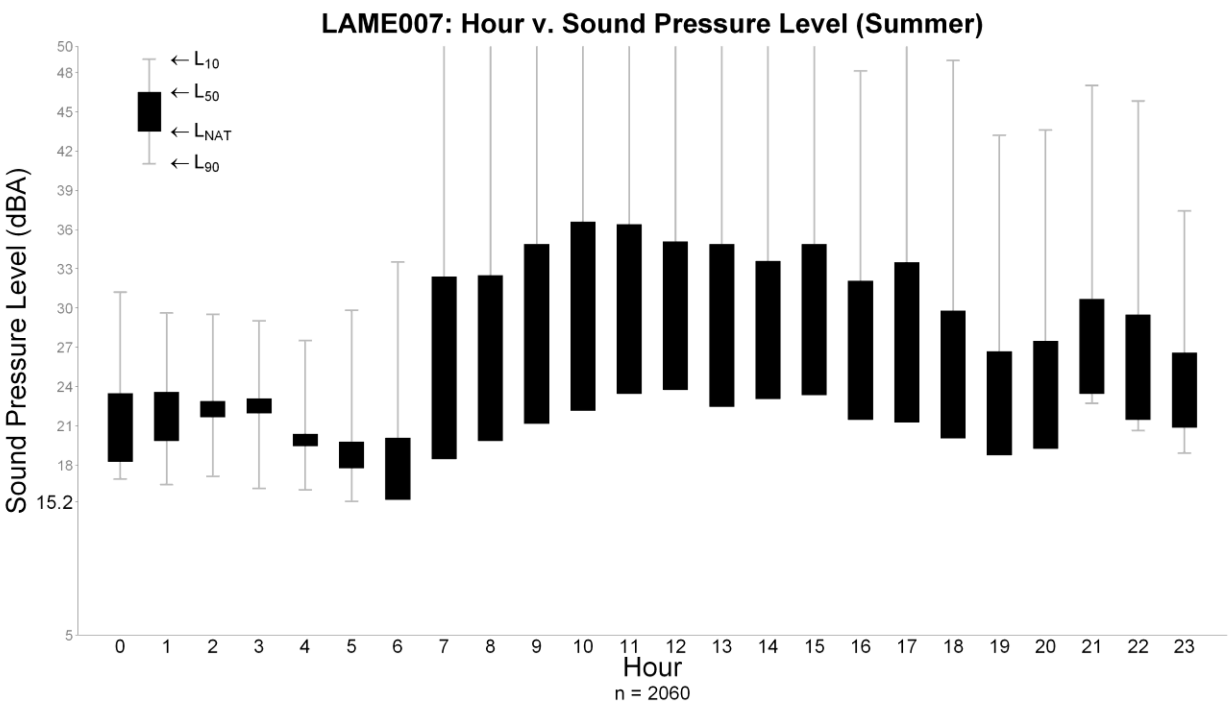

Figure 11. Hourly exceedence levels at LAME007 Summer (Indian Pass).

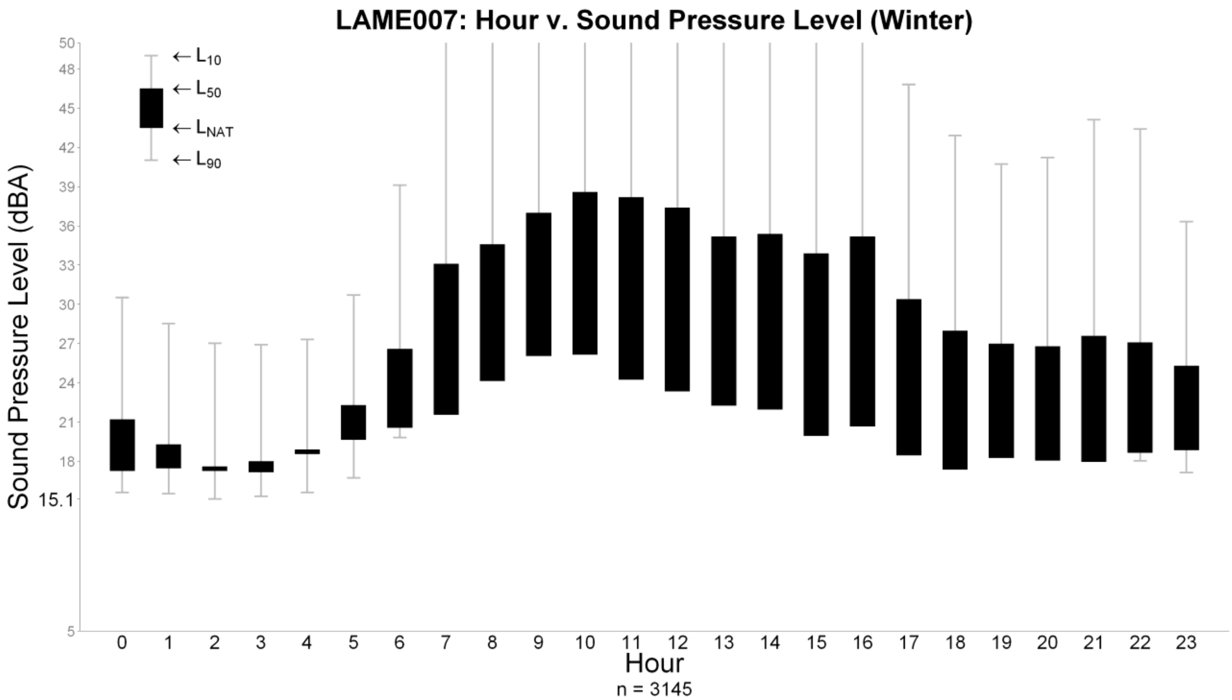

Figure 12. Hourly exceedence levels at LAME007 Winter (Indian Pass).

When examining natural quiet, the quietest hours at LAME007 (Summer) occurred at 0500 and 0600. During this time the median value for the natural ambient sound level fell as low as 15.4 dBA. By 1200 hours, the natural ambient levels increased to a peak median value of 23.8 dBA. From off-site listening, it is determined that this is primarily from light winds.

The existing ambient or median sound level of both human and natural causes (L_{50}) is also represented in Figure 12 . The L_{50} fell as low as 19.7 dBA at 0500. Also noteworthy, the L_{50} raised significantly at 0700 as scenic helicopter overflights began their daily tours. The L_{50} increased to a peak median value of 36.5 dBA at 1000.

Hourly exceedence figures are shown below for each site and for each data collection season. Note the hours during which the natural ambient is low or high as well as the hours when L_{50} is increased to its peak.

Figure 13 represents the initial data from the original field season in 2007. (The graphical presentation is slightly different from the newer figures, but the information is comparable.) The quietest hours at LAME009 occurred at 0100 and 0500 hours. During these hours the median dBA for the natural ambient was 15.3. By 1500 hours, the natural ambient levels increased slightly to a median dBA of 25.4.

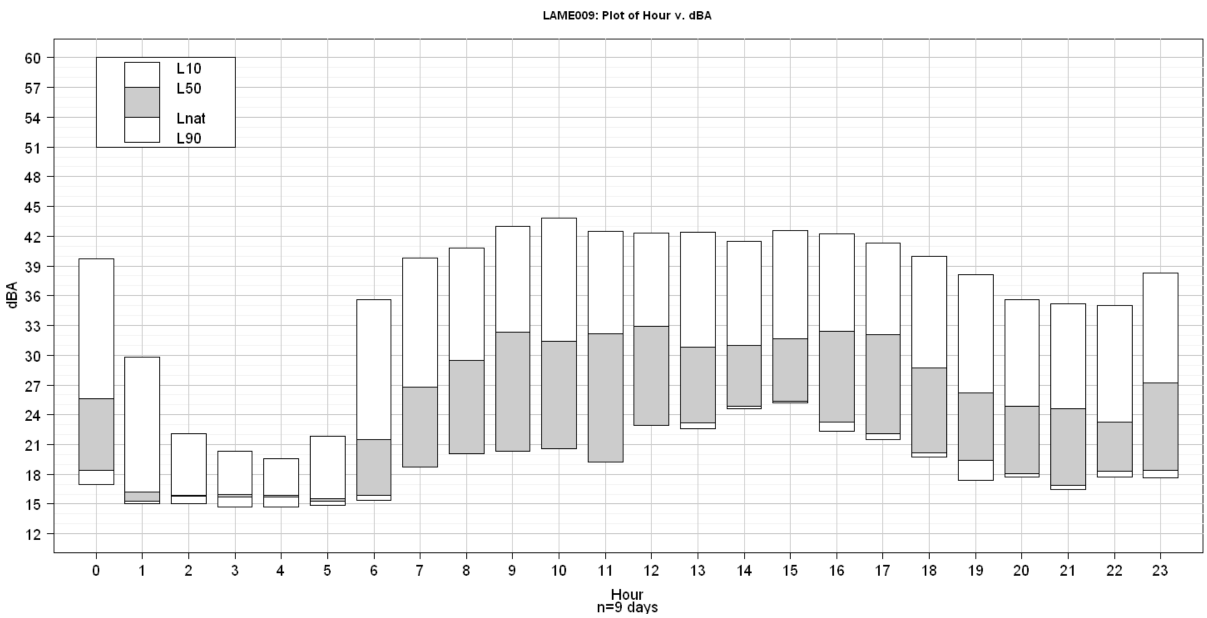

Figure 13. Hourly exceedence levels at LAME009 (Original, 2007, Callville Wash).

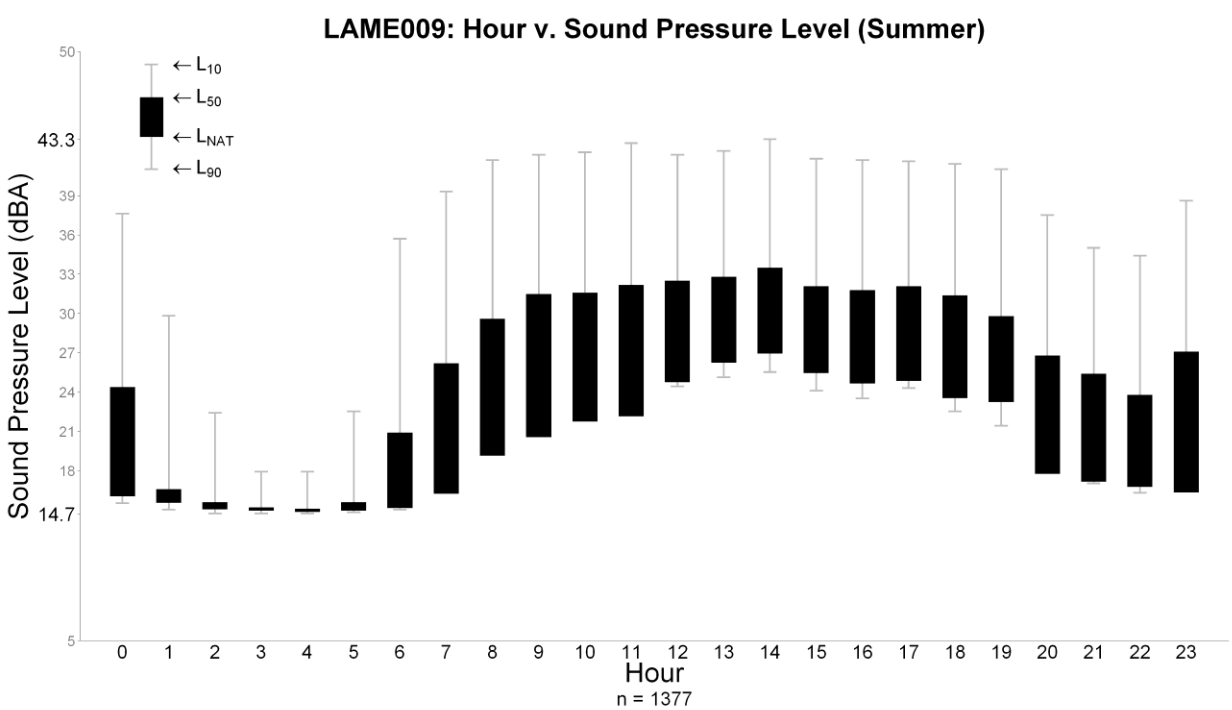

Figure 14. Hourly exceedence levels at LAME009 Summer.

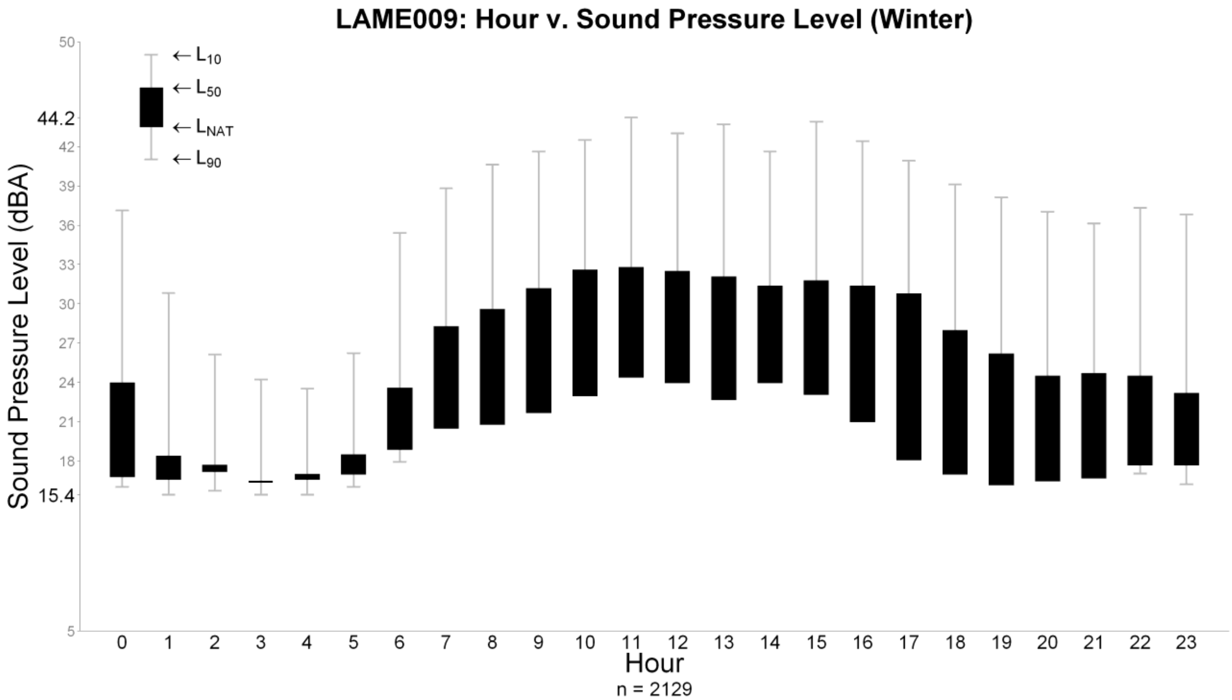

Figure 15. Hourly exceedence levels at LAME009 Winter (Callville Wash).

Figure 16 represents the initial data from the original field season in 2007. (The graphical presentation is slightly different from the newer figures, but the information is comparable.) The quietest hours at LAME010 were 0000 and 0300 hours. During these hours the median dBA for the natural ambient was 14.7. By 1500 hours, the ambient levels increased slightly to a median dBA of 17.2. Noteworthy, LAME010 has less human contributions from visitors or aircraft than LAME009 or LAME011.

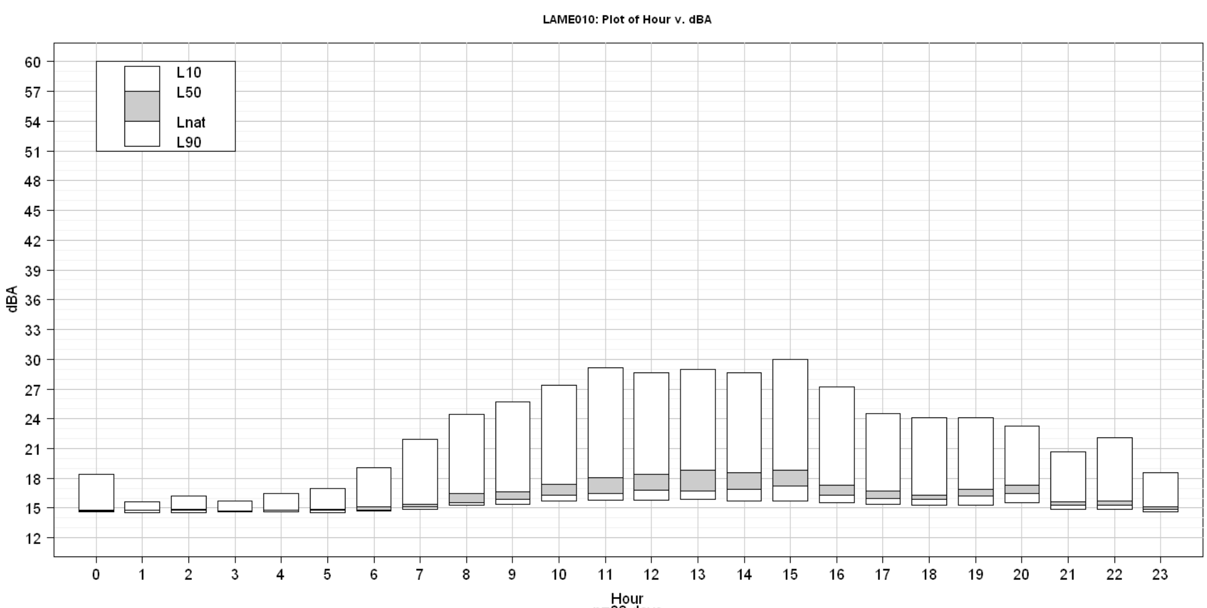

Figure 16. Hourly exceedence levels at LAME010 (Original, 2007, AR42B).

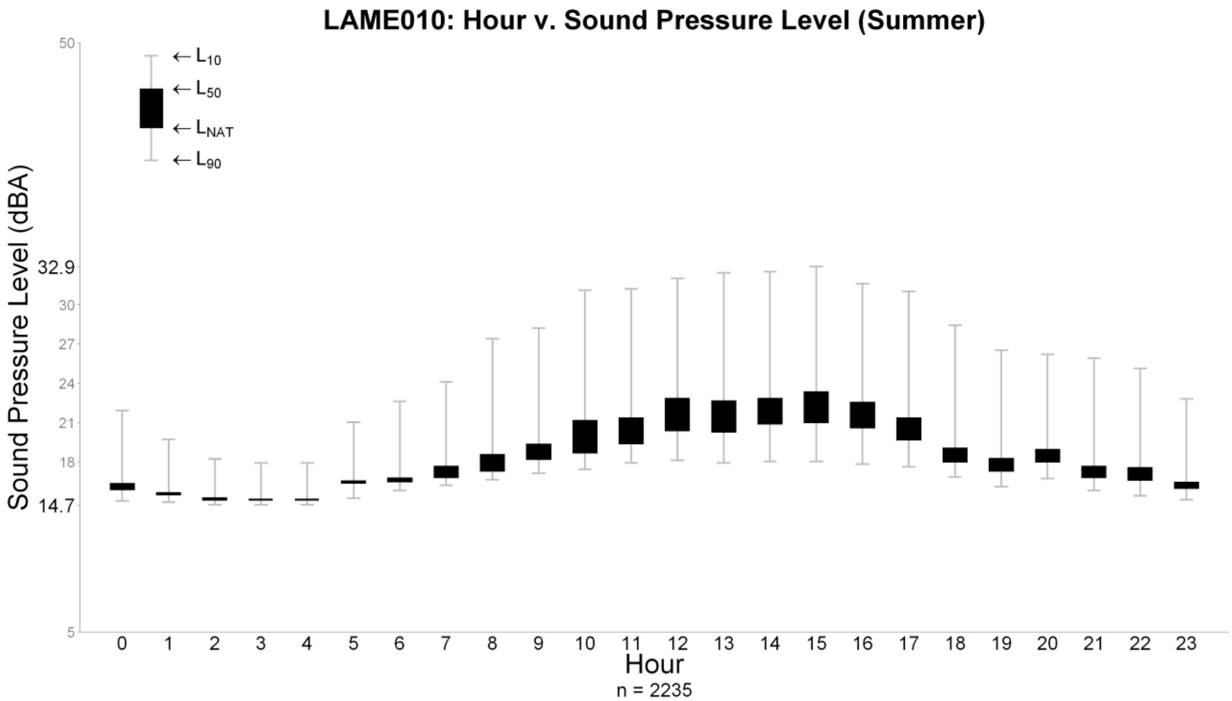

Figure 17. Hourly exceedence levels at LAME010 Summer (AR42B).

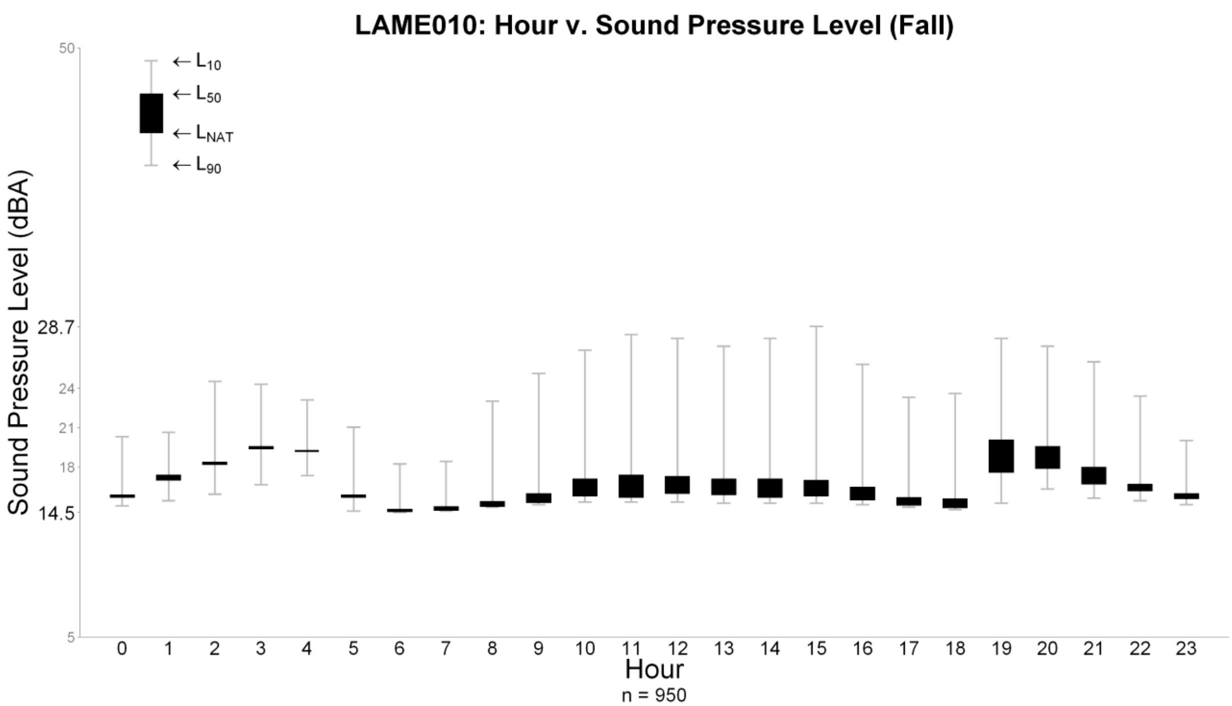

Figure 18. Hourly exceedence levels at LAME010 Fall (AR42B).

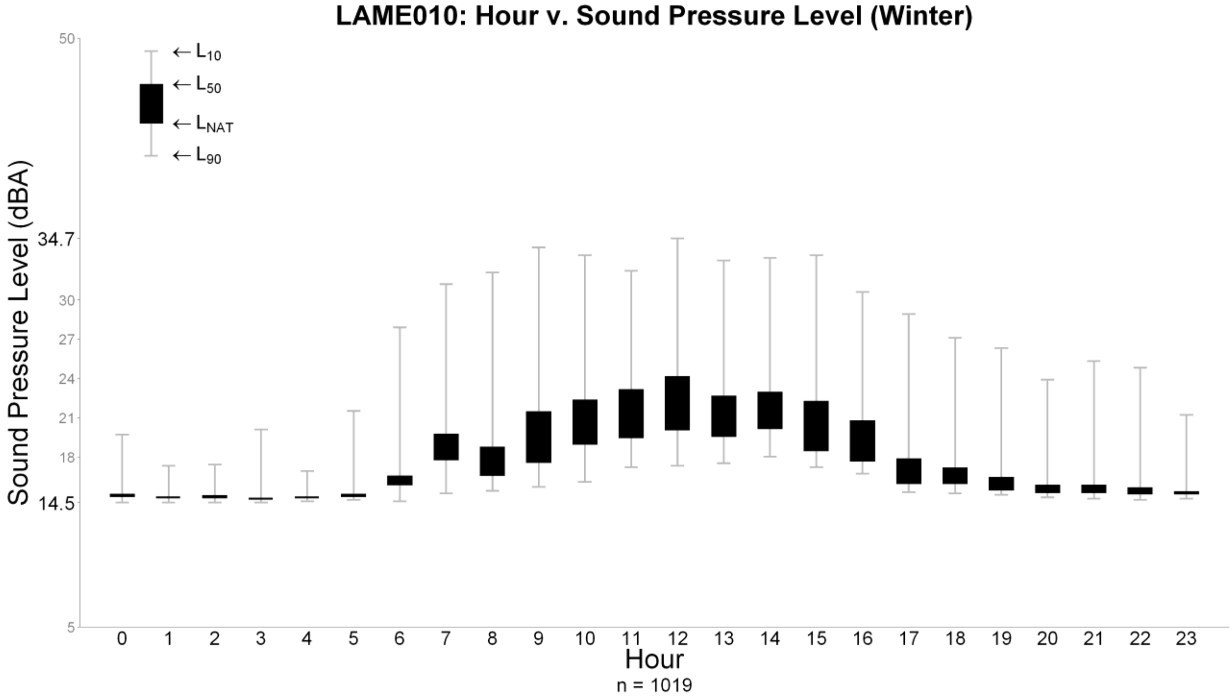

Figure 19. Hourly exceedence levels at LAME010 Winter (AR42B).

The ambient levels at LAME011 (Figure 20 to Figure 24) were the quietest during the 0600 hour, with a median dBA for the natural ambient of 15.1. The highest natural ambient levels at LAME011 occurred during the 0000 hour, with a median dBA of 26.5.

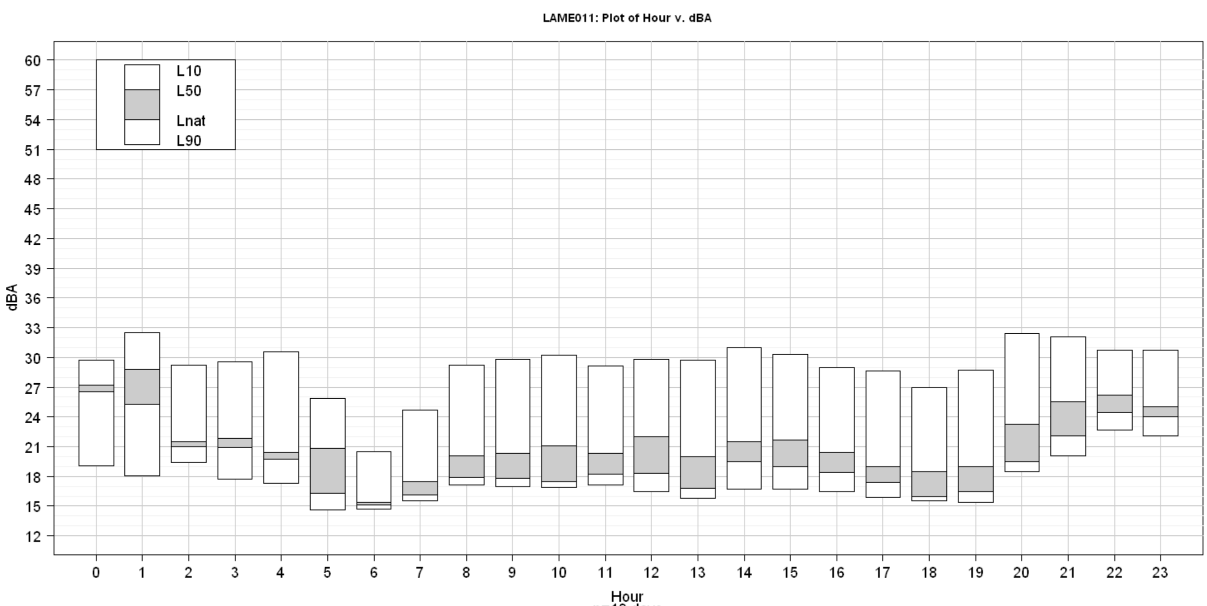

Figure 20. Hourly exceedence levels at LAME011 (Original, 2007, AR20A).

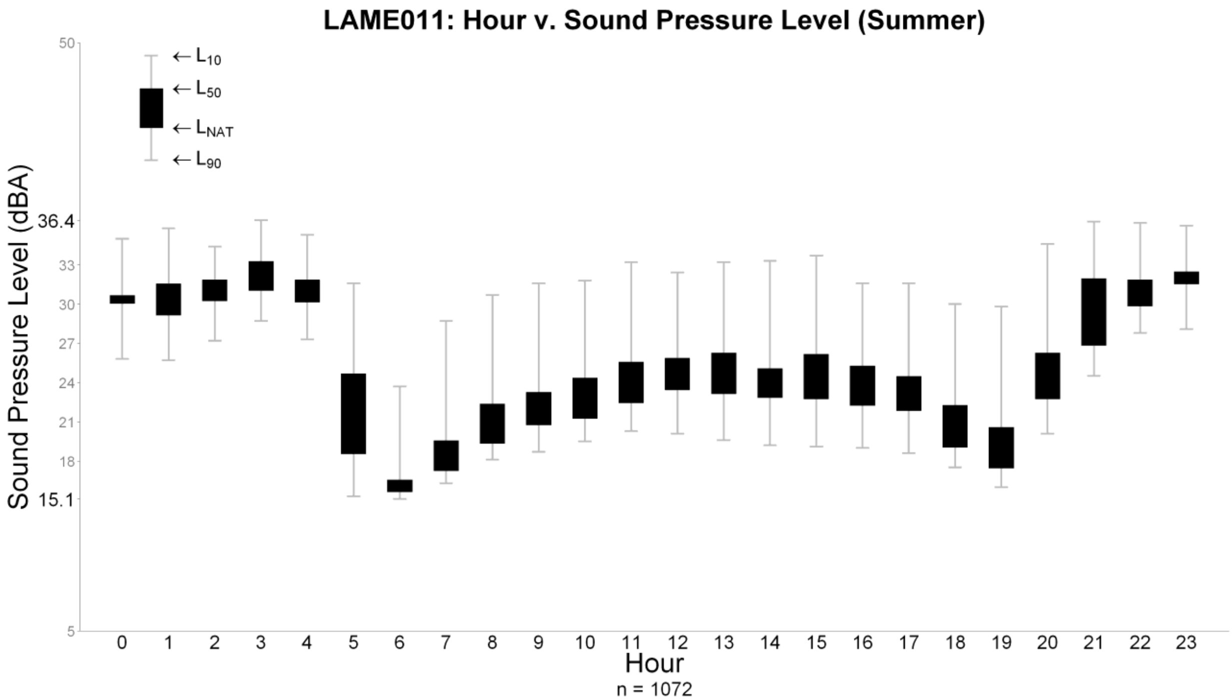

Figure 21. Hourly exceedence levels at LAME011 Summer (AR20A).

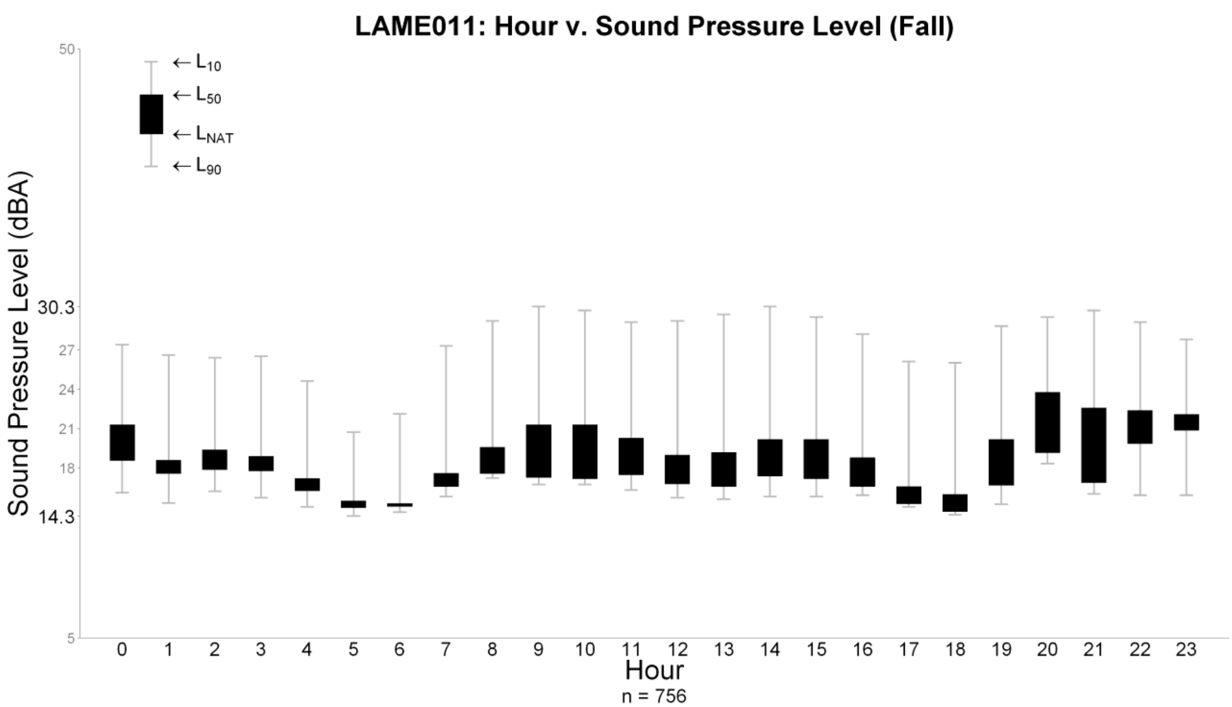

Figure 22. Hourly exceedence levels at LAME011 Fall (AR20A).

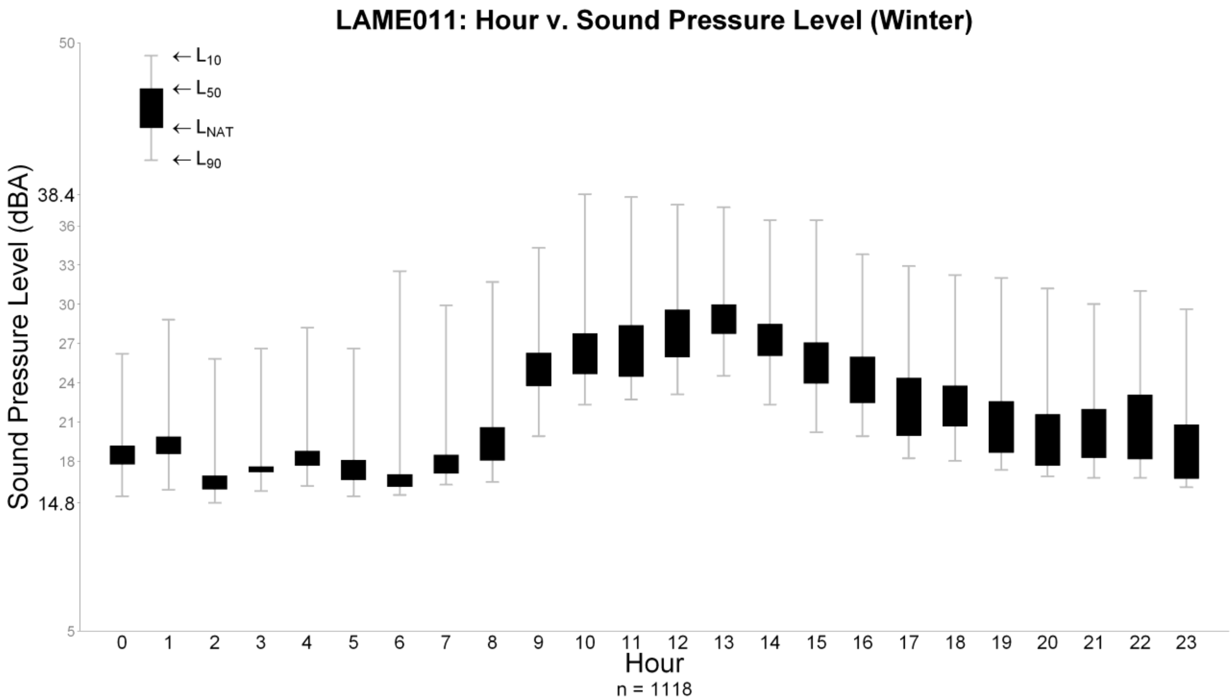

Figure 23. Hourly exceedence levels at LAME011 Winter (AR20A).

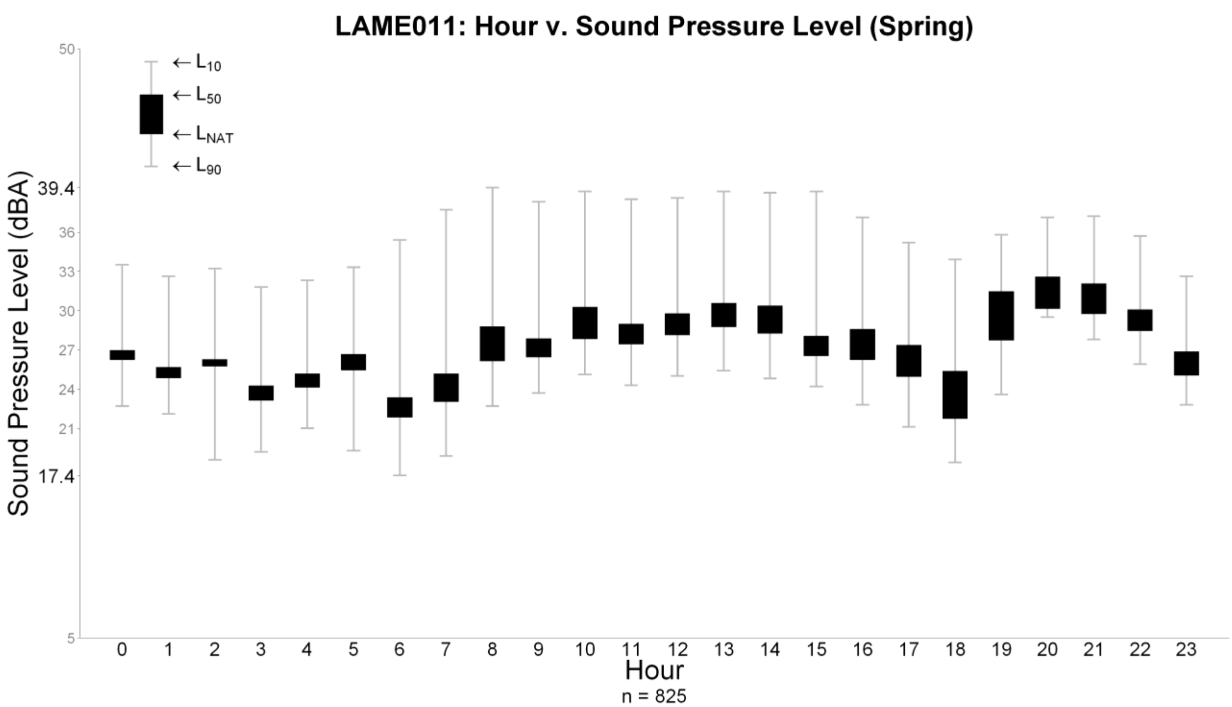

Figure 24. Hourly exceedence levels at LAME011 Spring (AR20A).

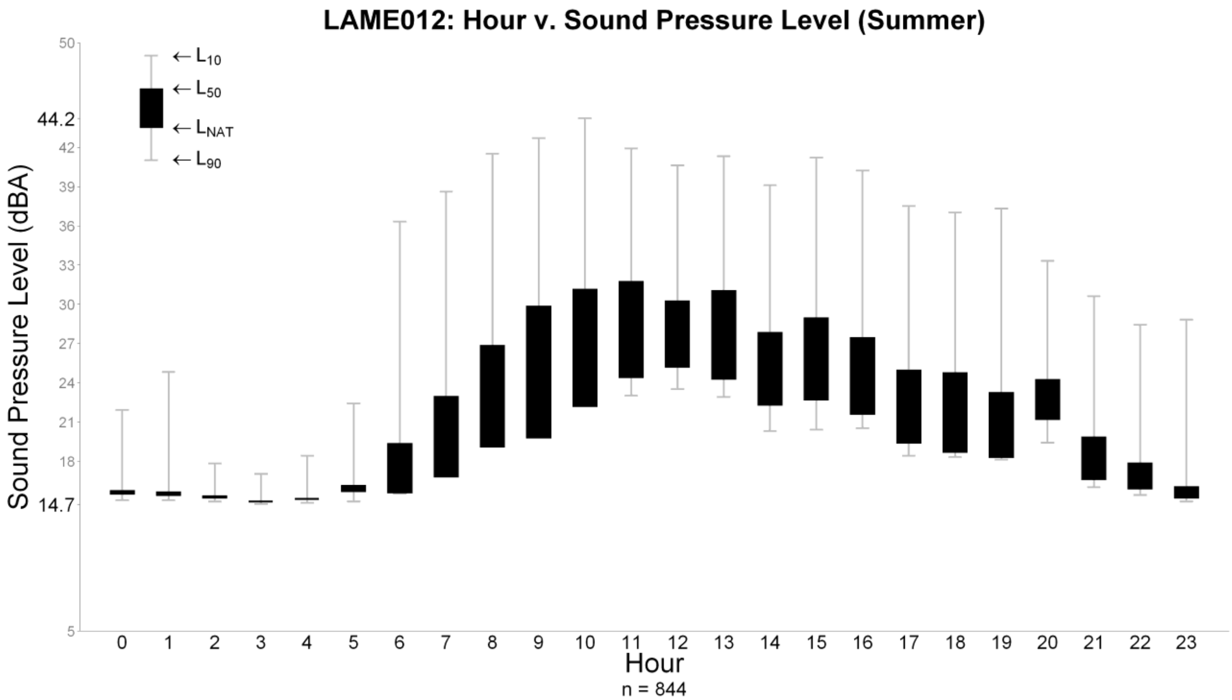

Figure 25. Hourly exceedence levels at LAME012 Summer (AR60 Burro Wash).

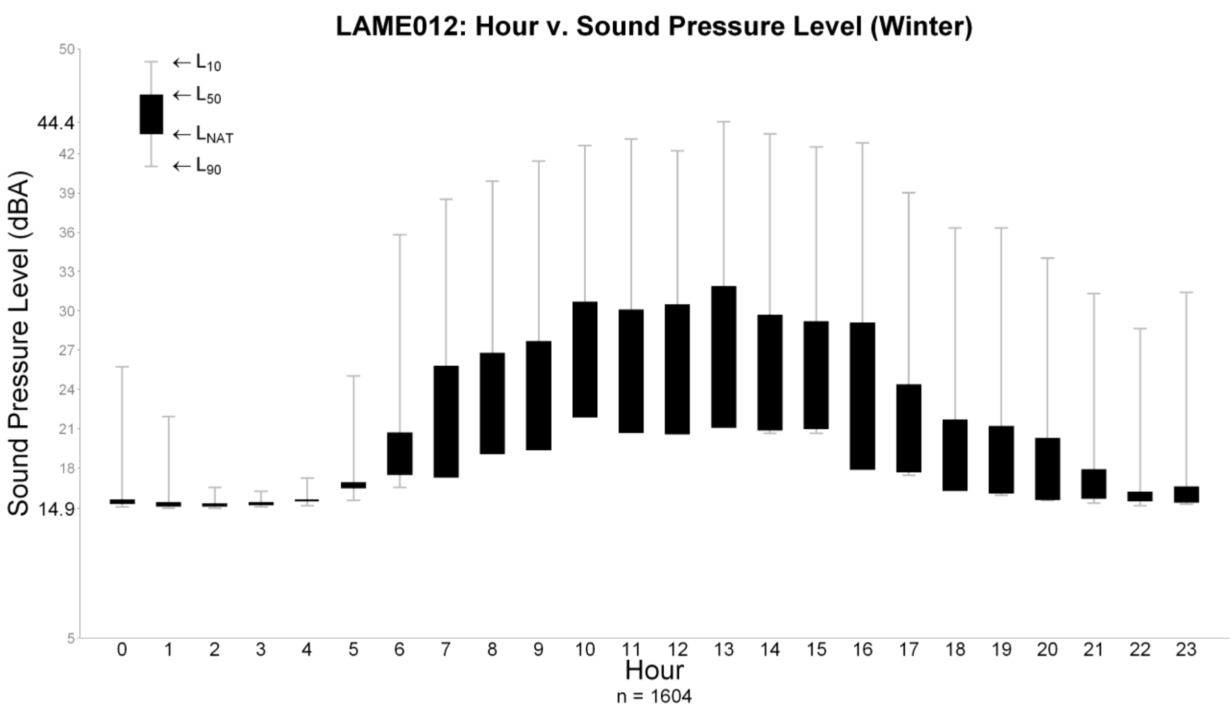

Figure 26. Hourly exceedence levels at LAME012 Winter (AR60 Burro Wash).

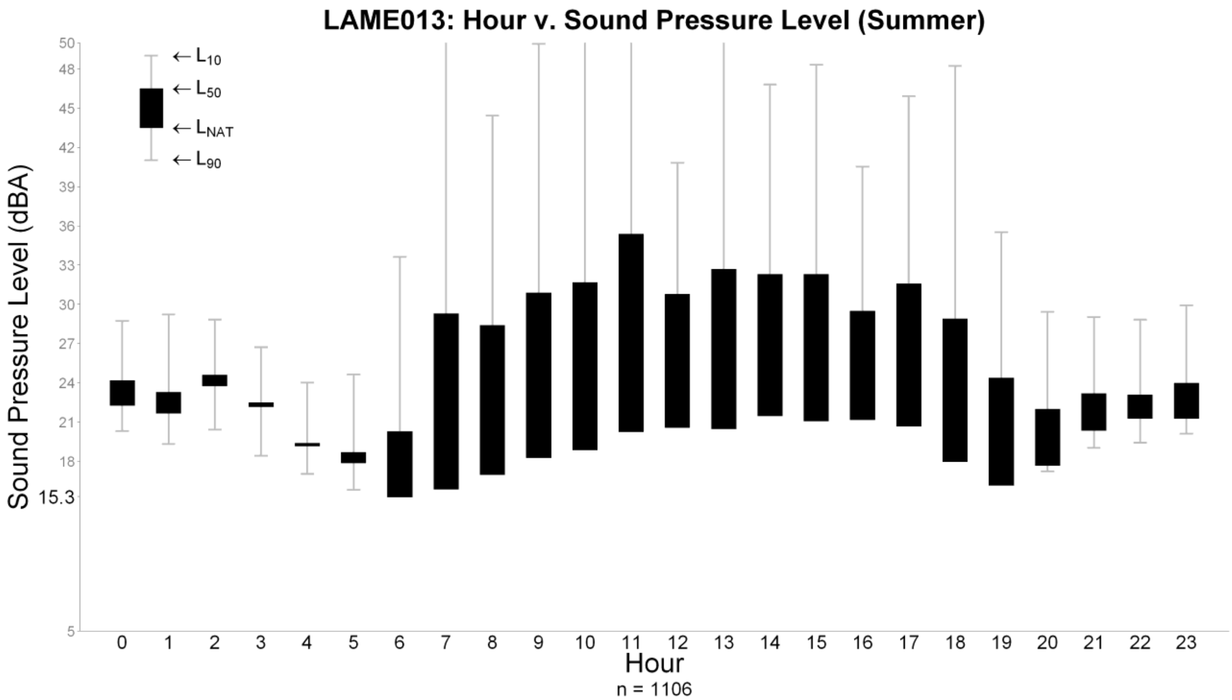

Figure 27. Hourly exceedence levels at LAME013 Summer (Haystacks)

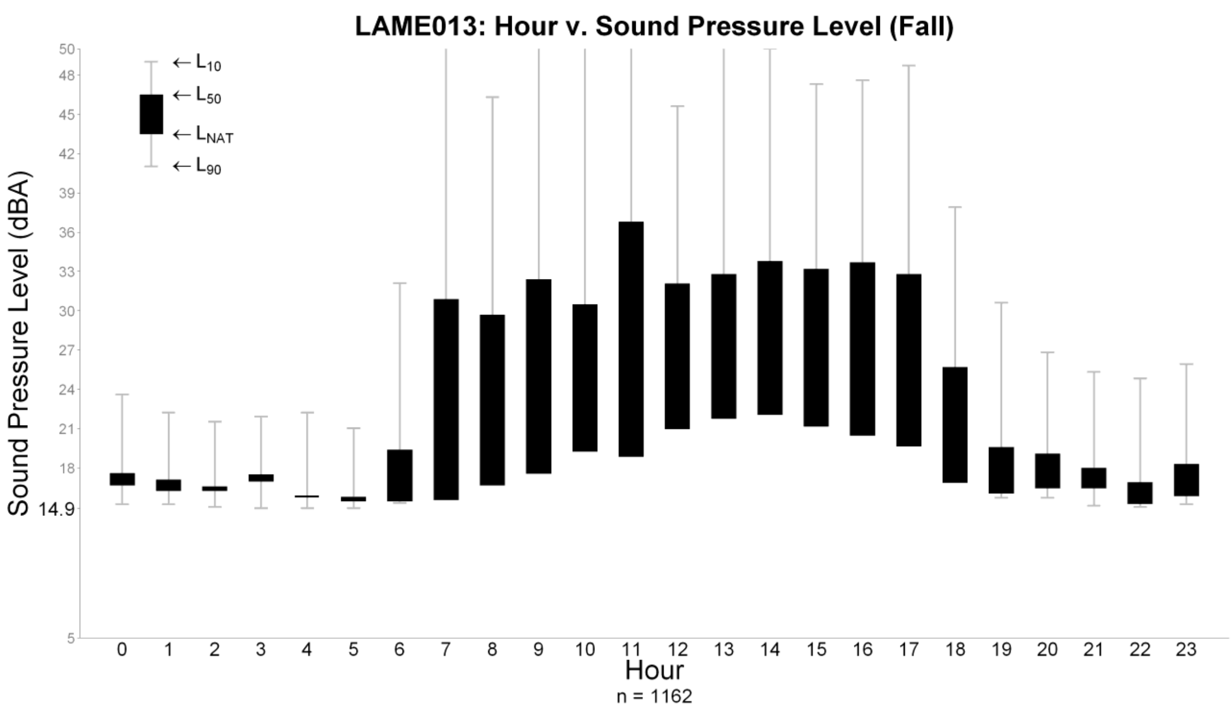

Figure 28. Hourly exceedence levels at LAME013 Fall (Haystacks)

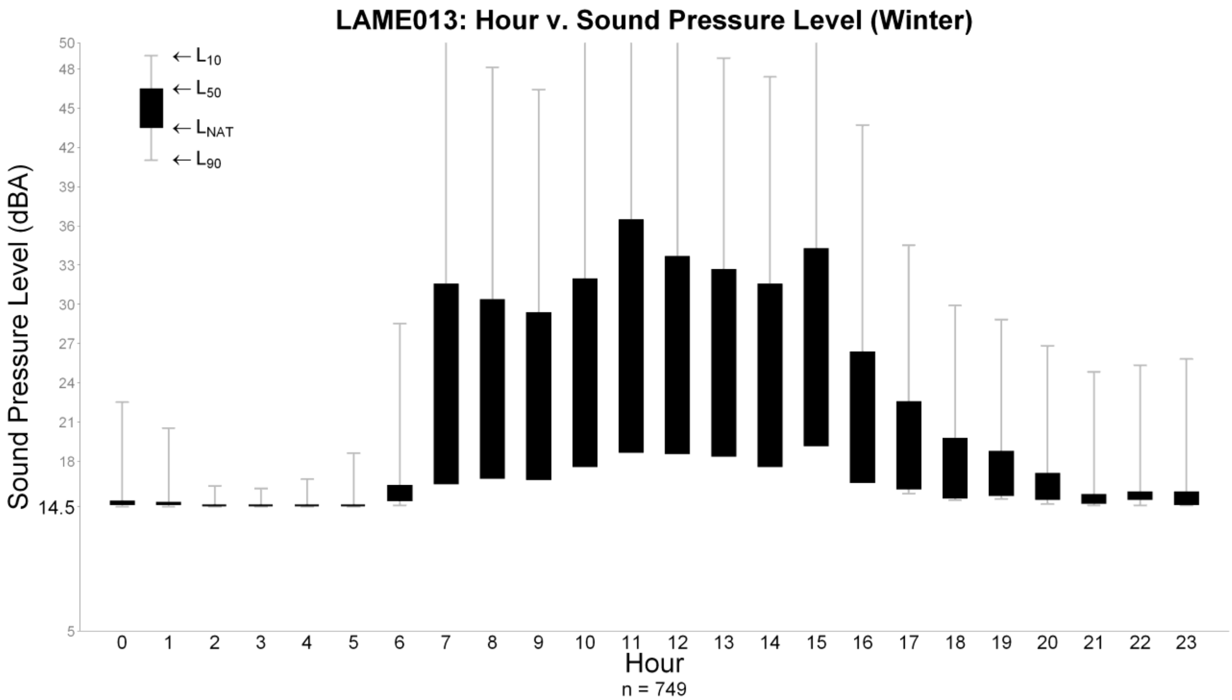

Figure 29. Hourly exceedence levels at LAME013 Winter (Haystacks)

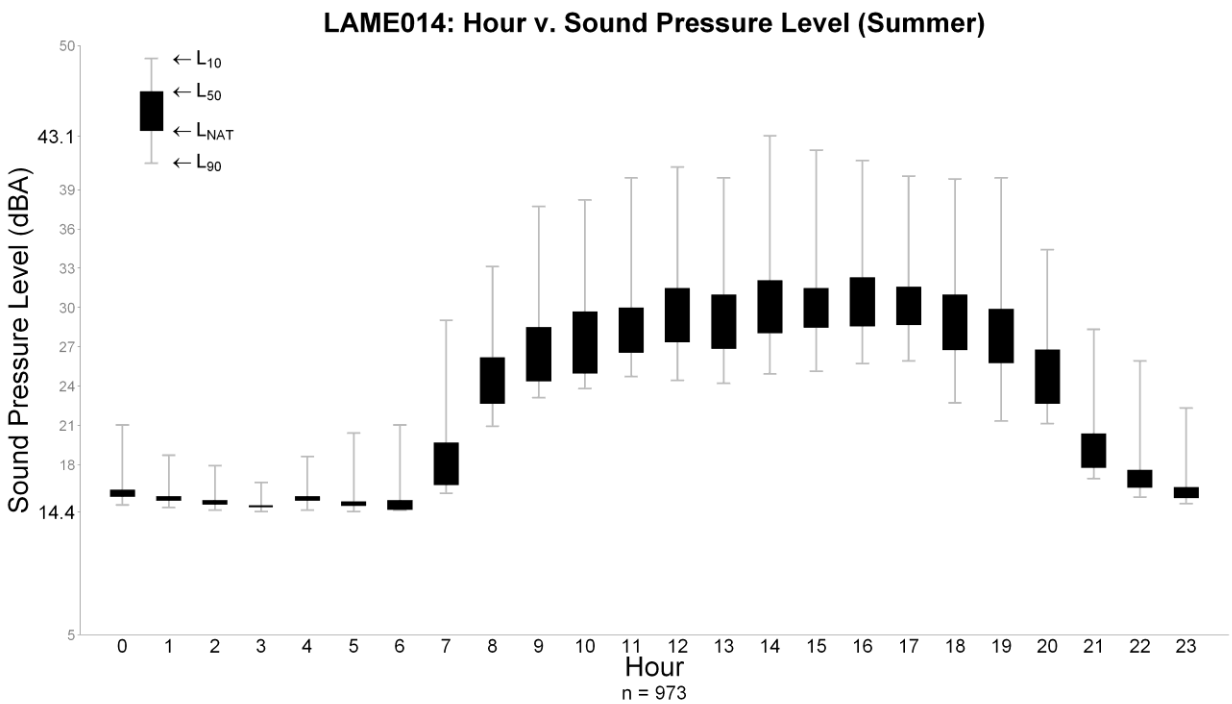

Figure 30. Hourly exceedence levels at LAME014 Summer (AR49)

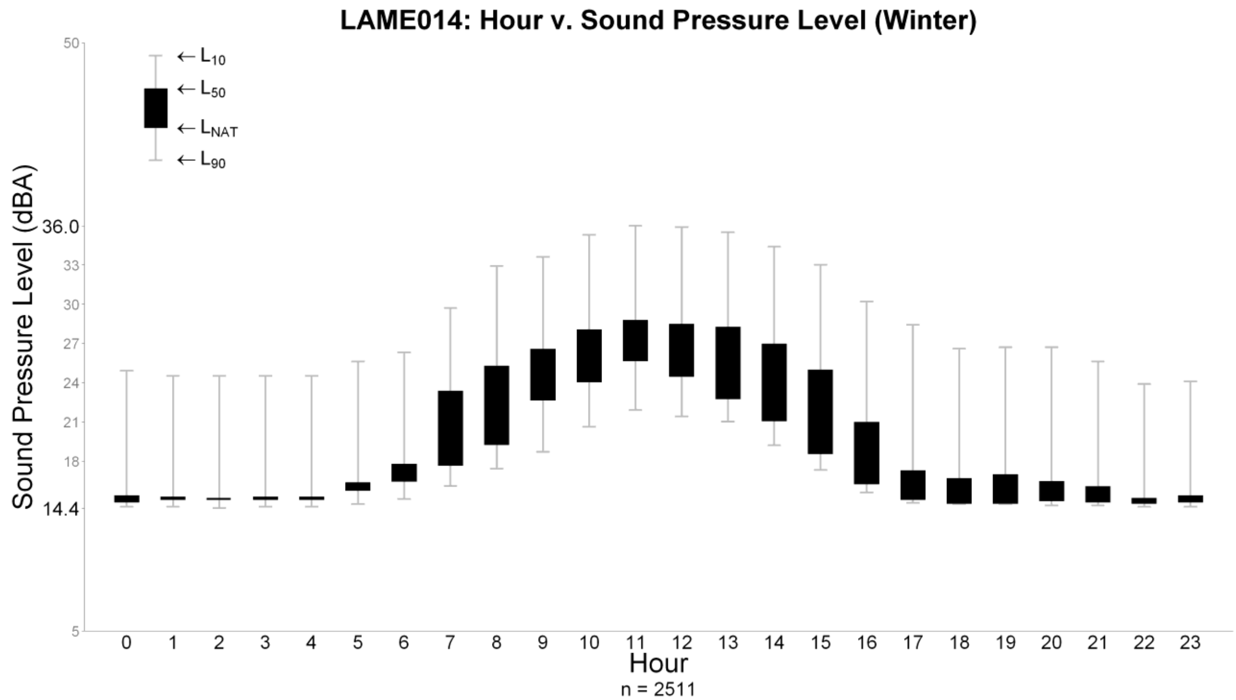

Figure 31. Hourly exceedence levels at LAME014 Winter (AR49)

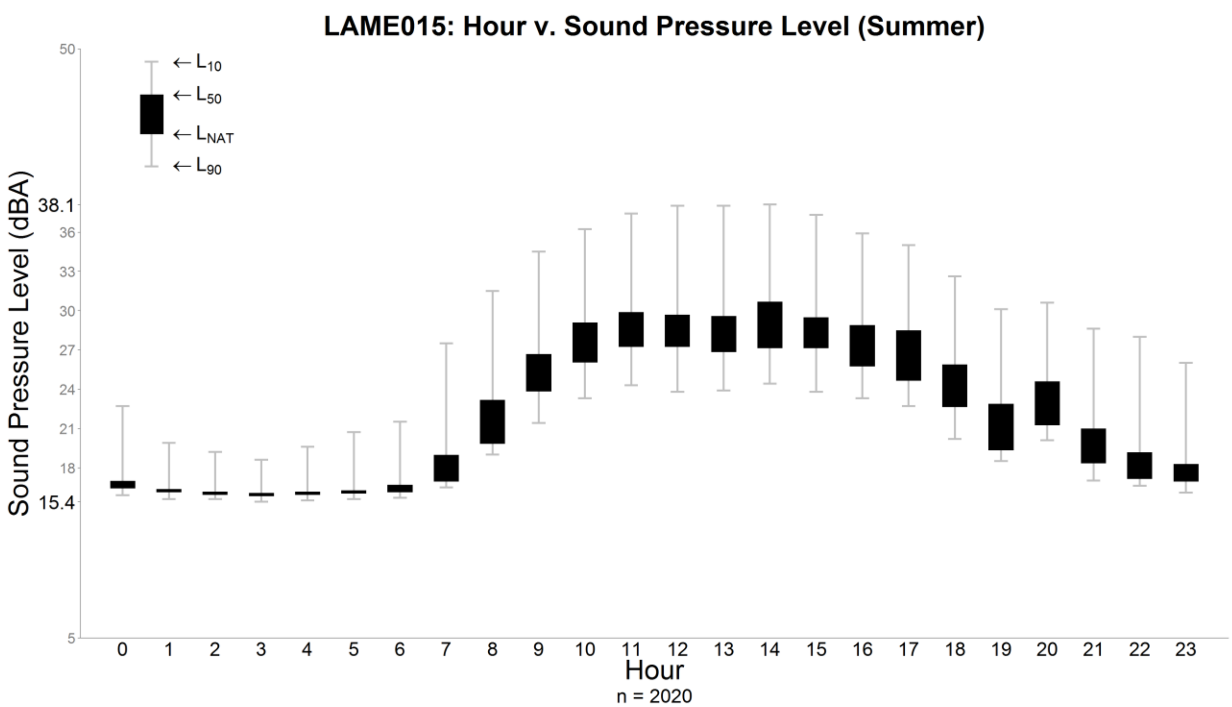

Figure 32. Hourly exceedence levels at LAME015 Summer (AR22)

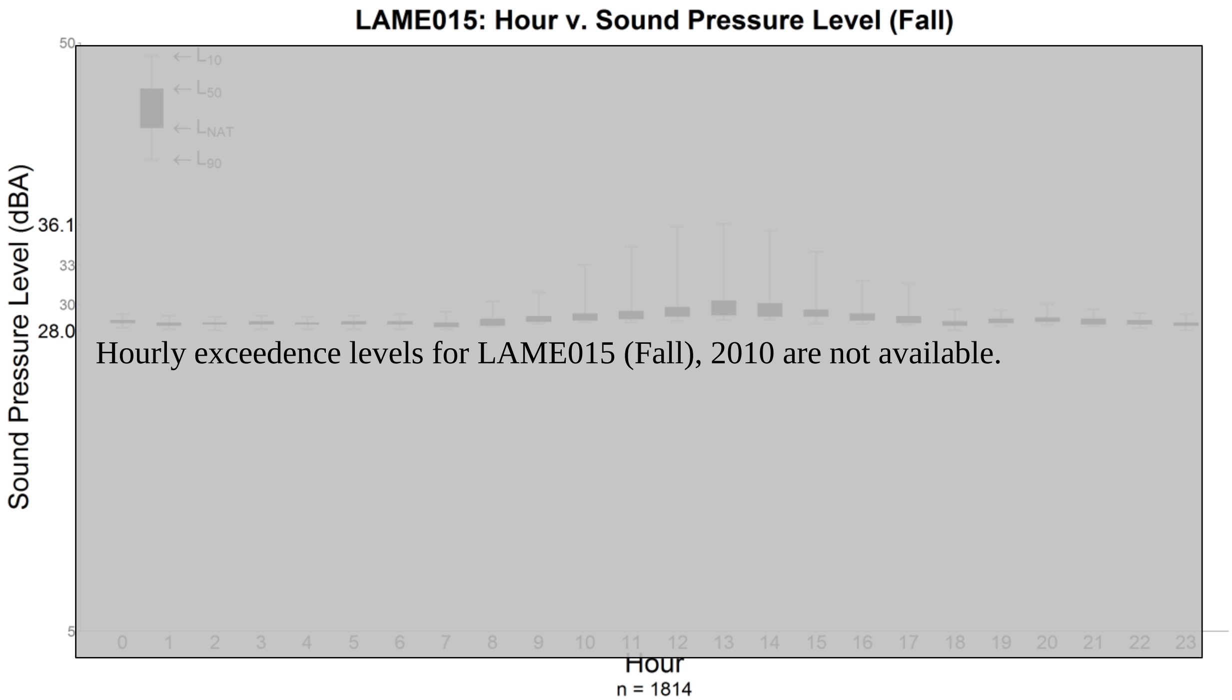

Figure 33. Hourly exceedence levels at LAME015 Fall (AR22)

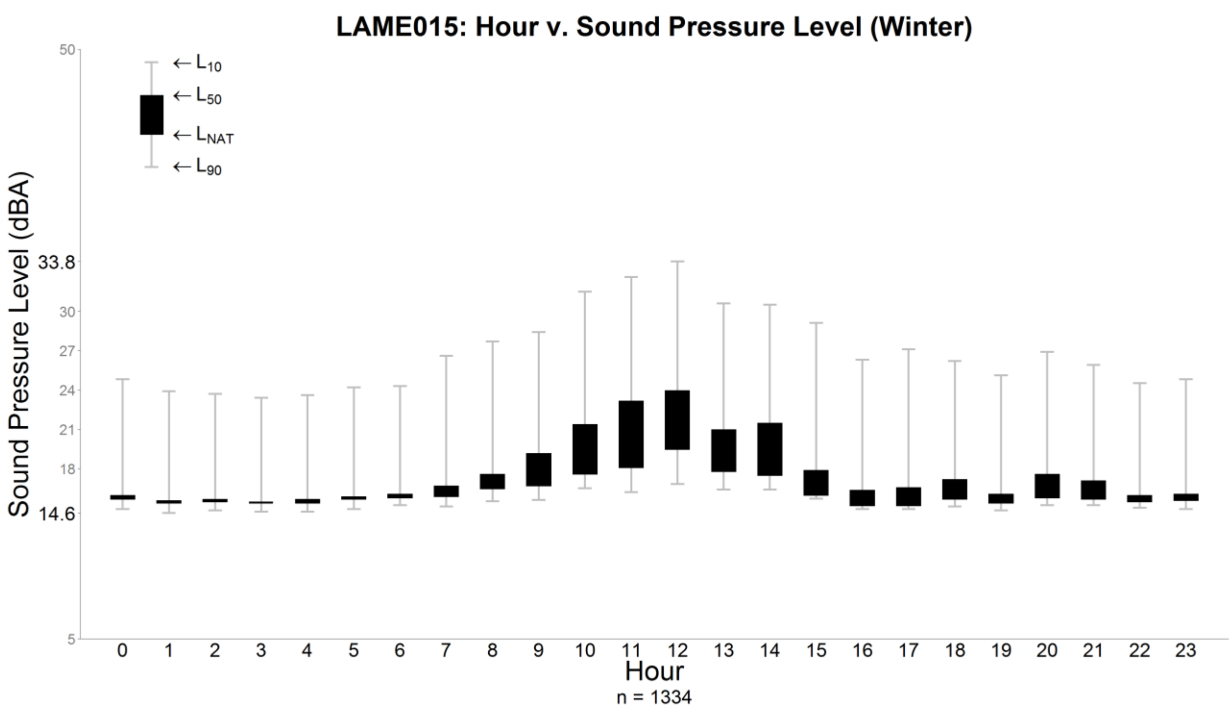

Figure 34. Hourly exceedence levels at LAME015 Winter (AR22)

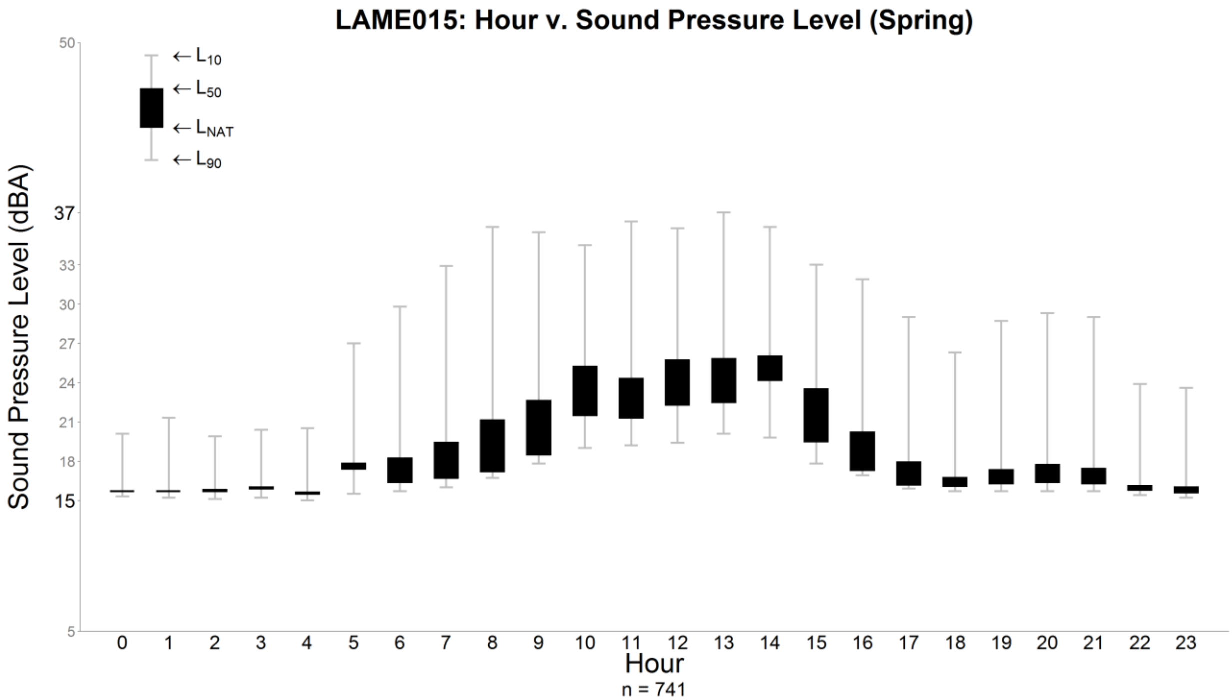

Figure 35. Hourly exceedence levels at LAME015 Spring (AR22)

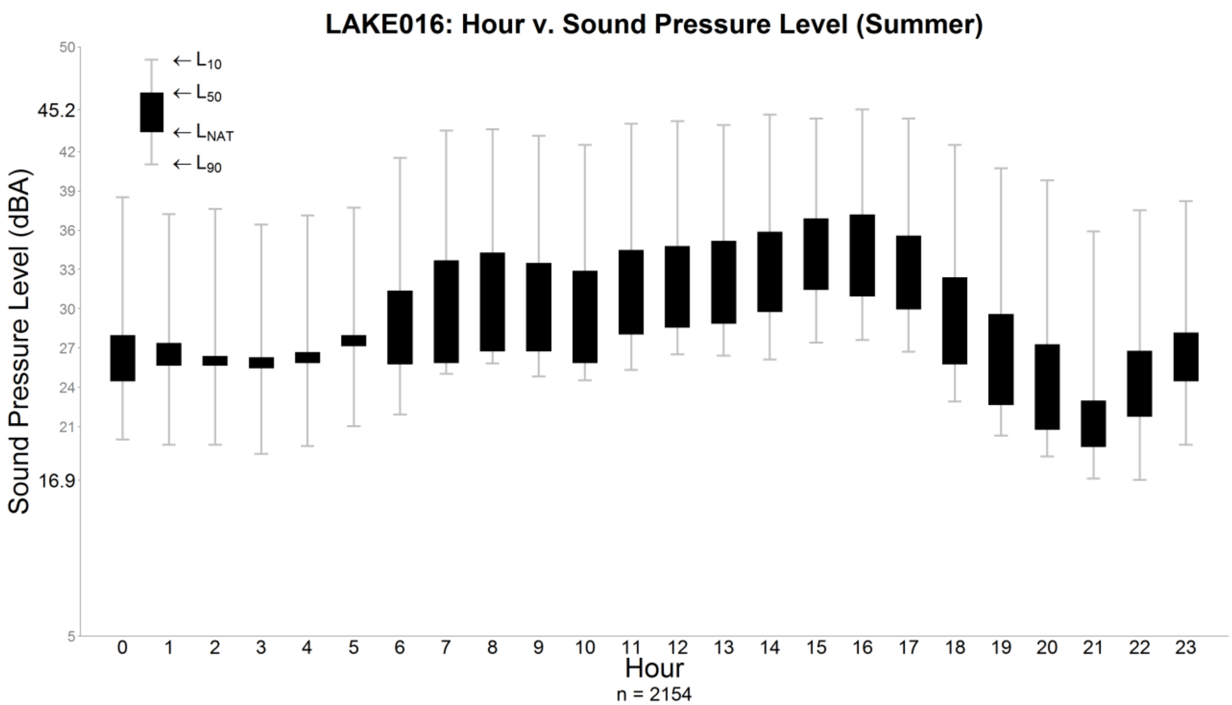

Figure 36. Hourly exceedence levels at LAME016 Summer (AR136 Gregg's Hide-Out)

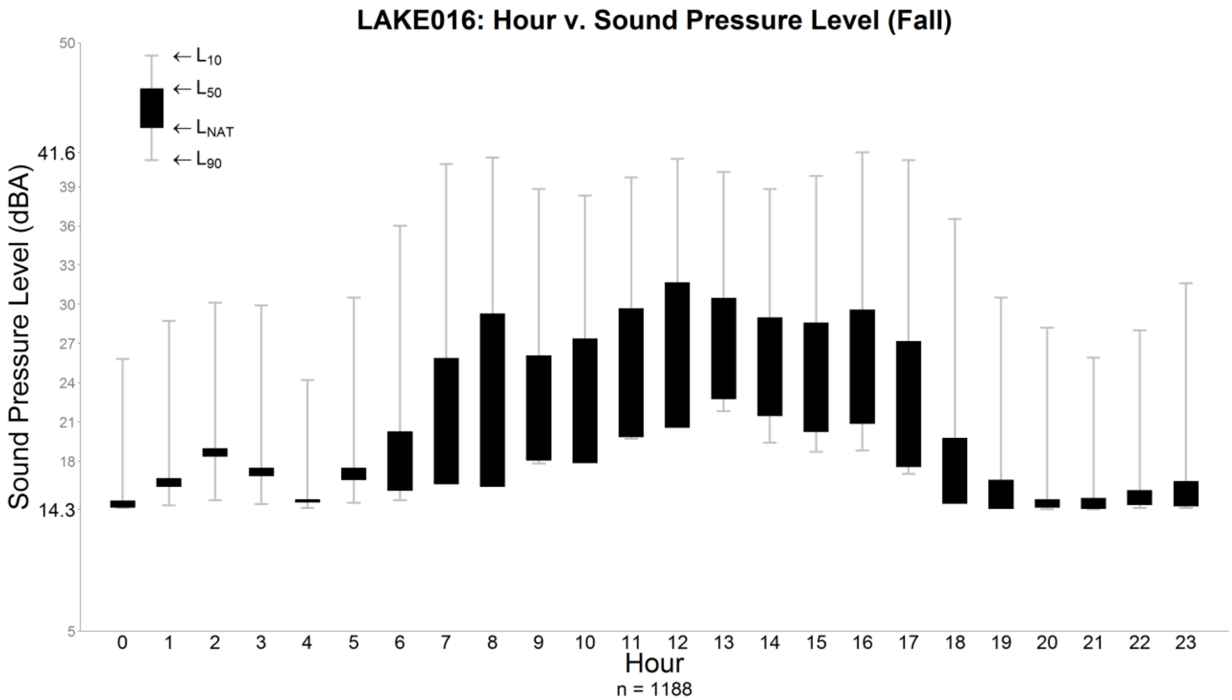

Figure 37. Hourly exceedence levels at LAME016 Fall (AR136 Gregg's Hide-Out)

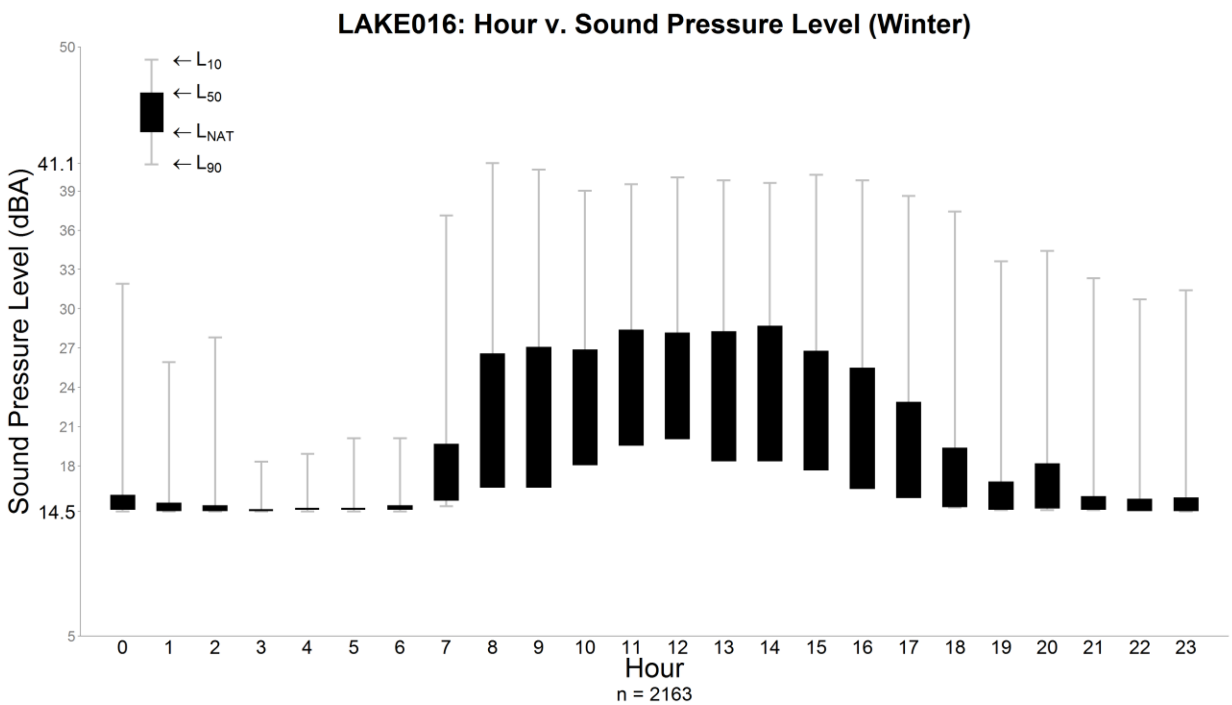

Figure 38. Hourly exceedence levels at LAME016 Winter (AR136 Gregg's Hide-Out)

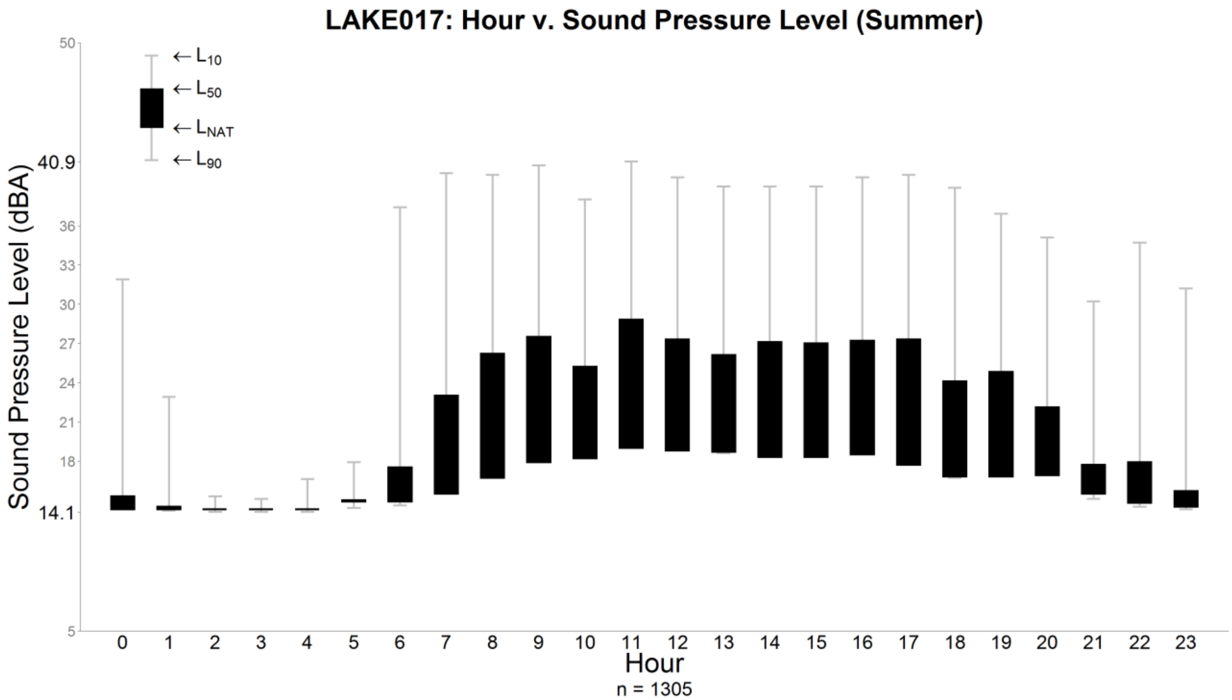

Figure 39. Hourly exceedence levels at LAKE017 Summer (AR97 Boathouse Cove Road)

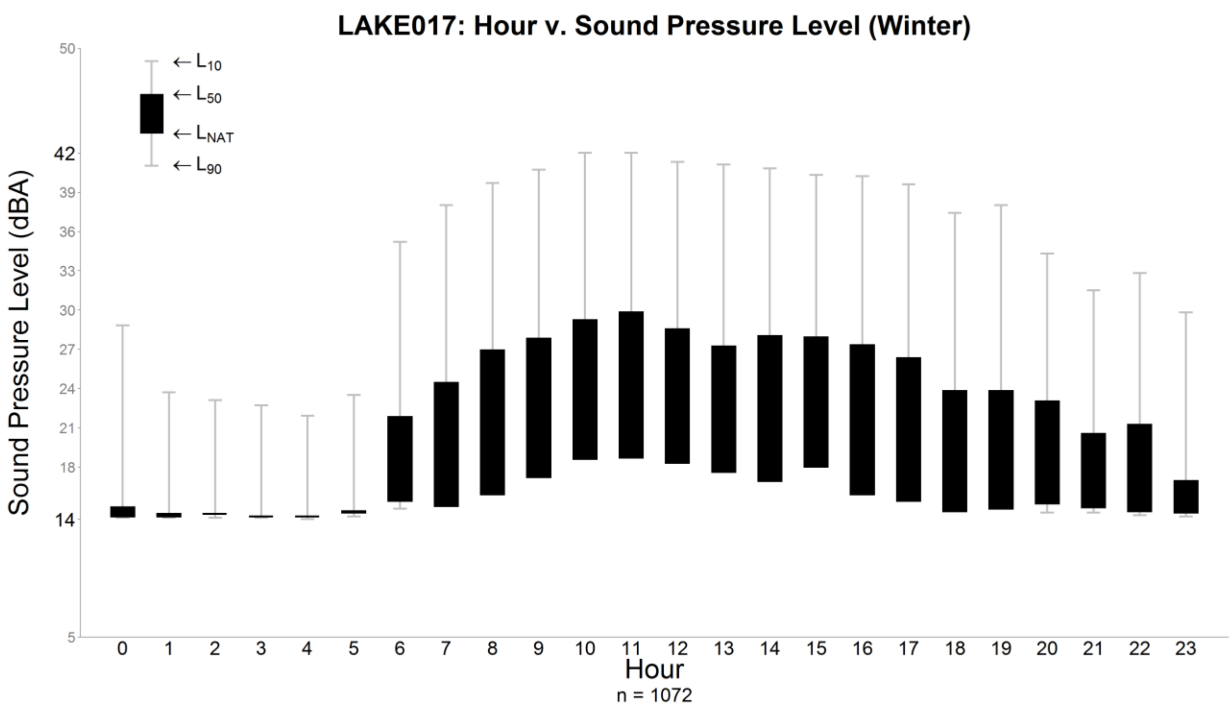

Figure 40. Hourly exceedence levels at LAKE017 Winter (AR97 Boathouse Cove Road)

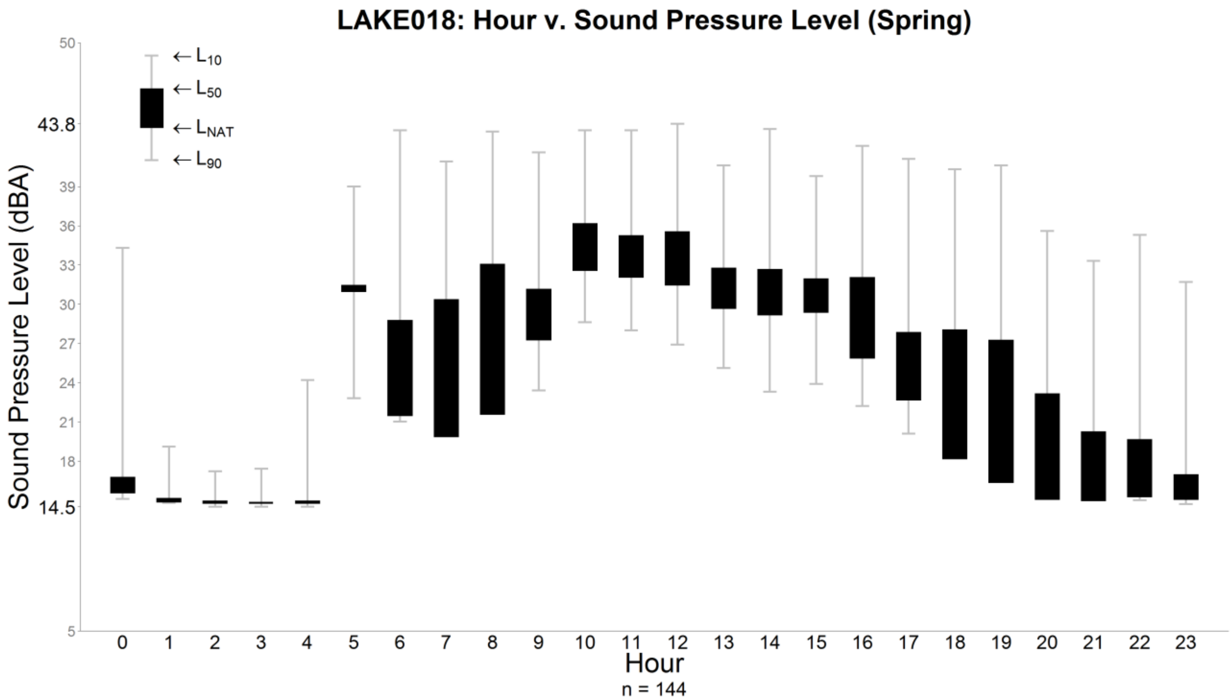

Figure 41. Hourly exceedence levels at LAKE018 Summer (Temple Bar Area)

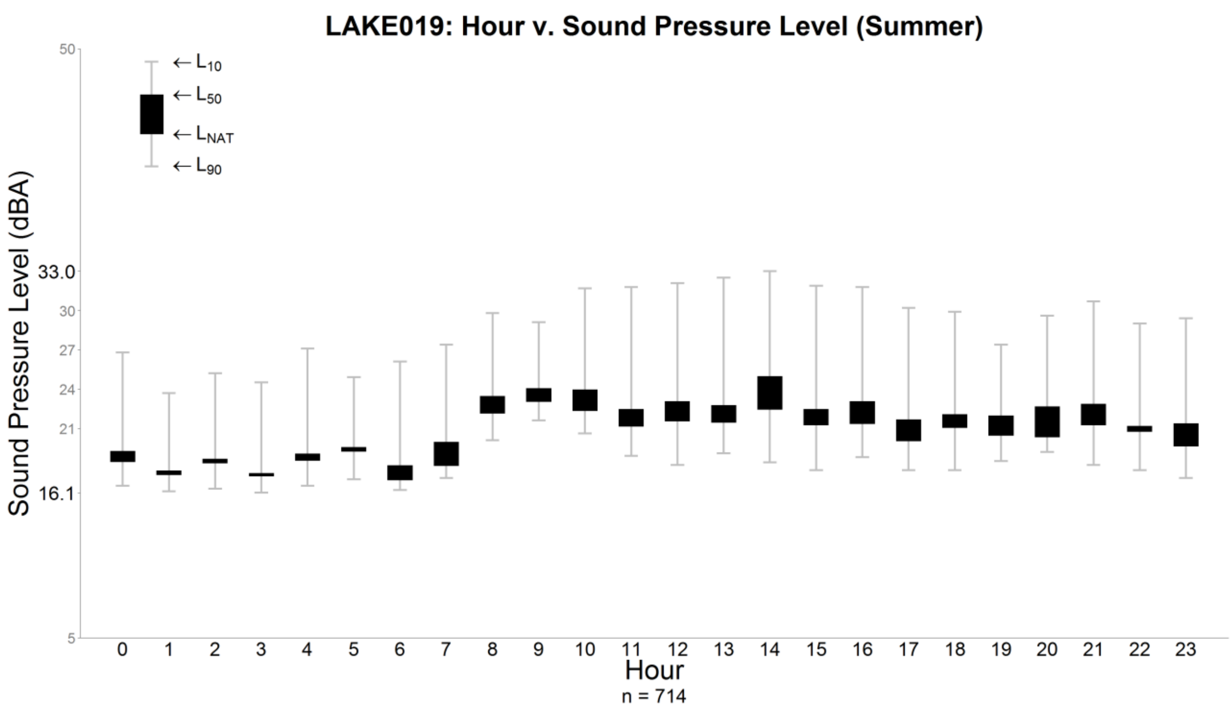

Figure 42. Hourly exceedence levels at LAKE019 Summer (AR30)

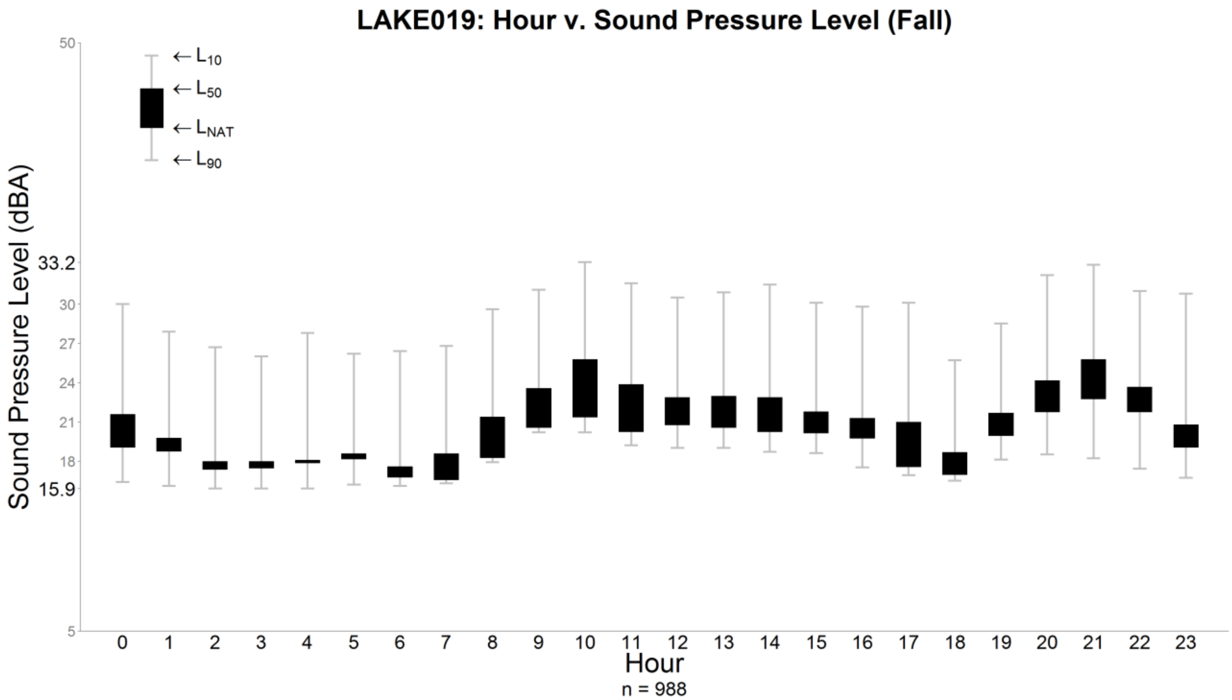

Figure 43. Hourly exceedence levels at LAKE019 Fall (AR30)

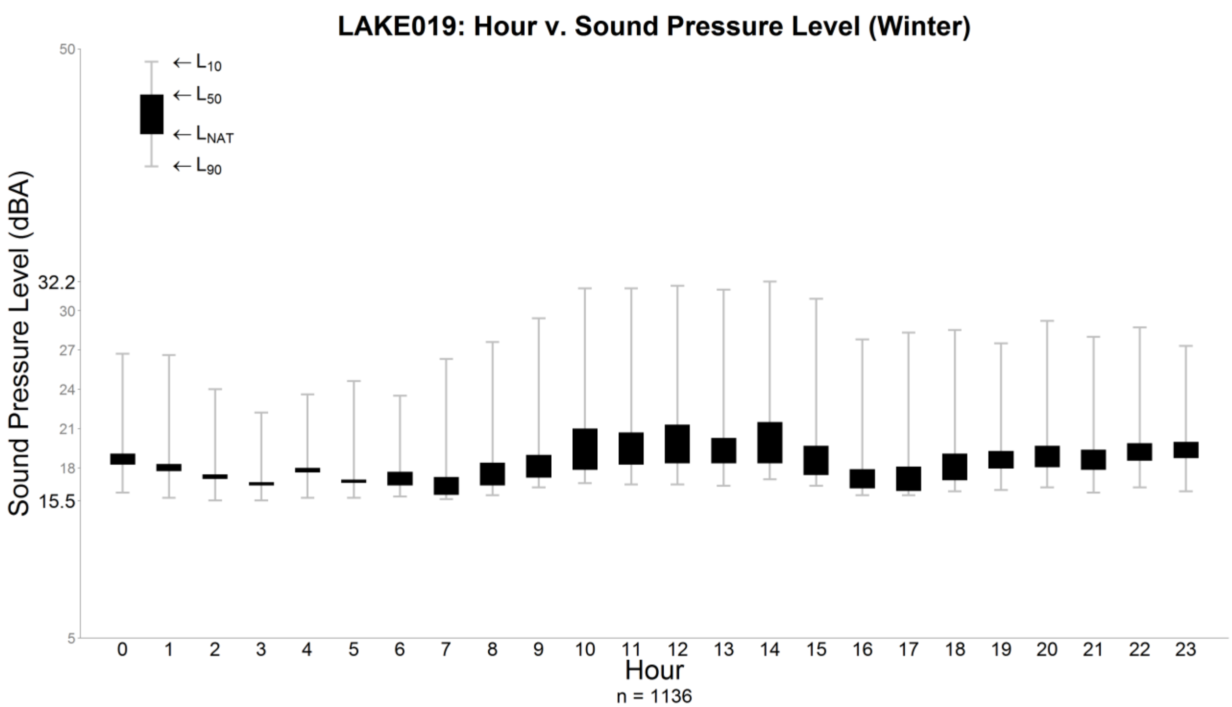

Figure 44. Hourly exceedence levels at LAKE019 Winter (AR30)

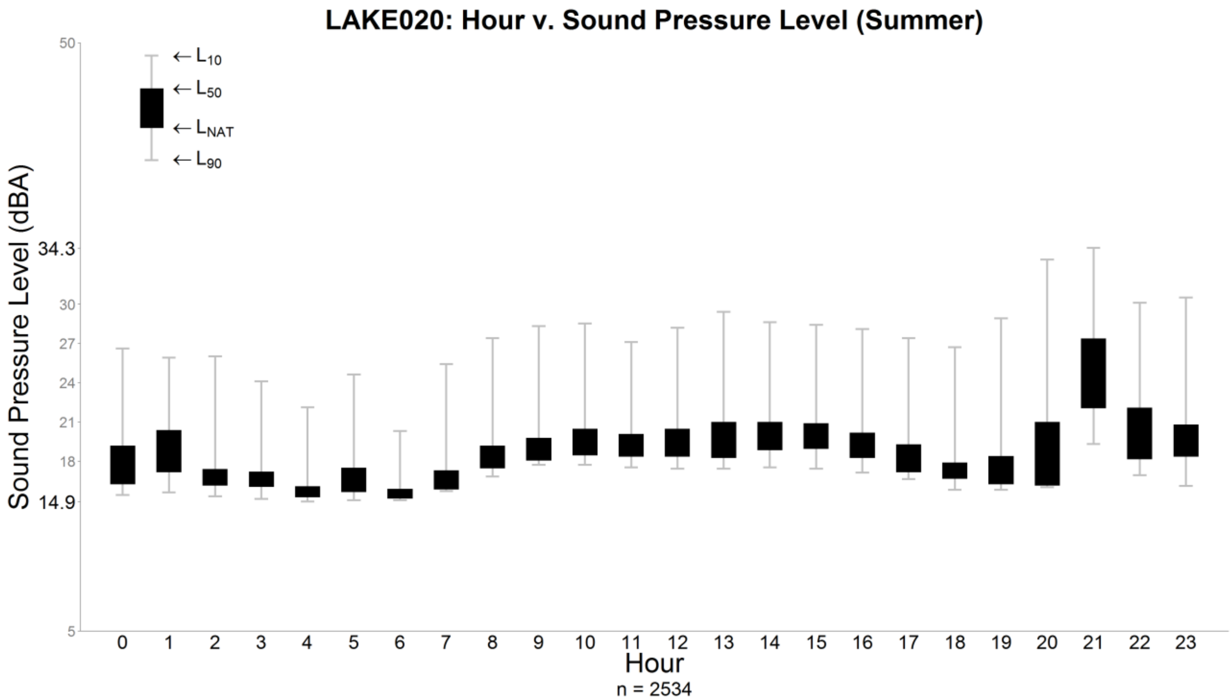

Figure 45. Hourly exceedence levels at LAKE020 Summer (AR18)

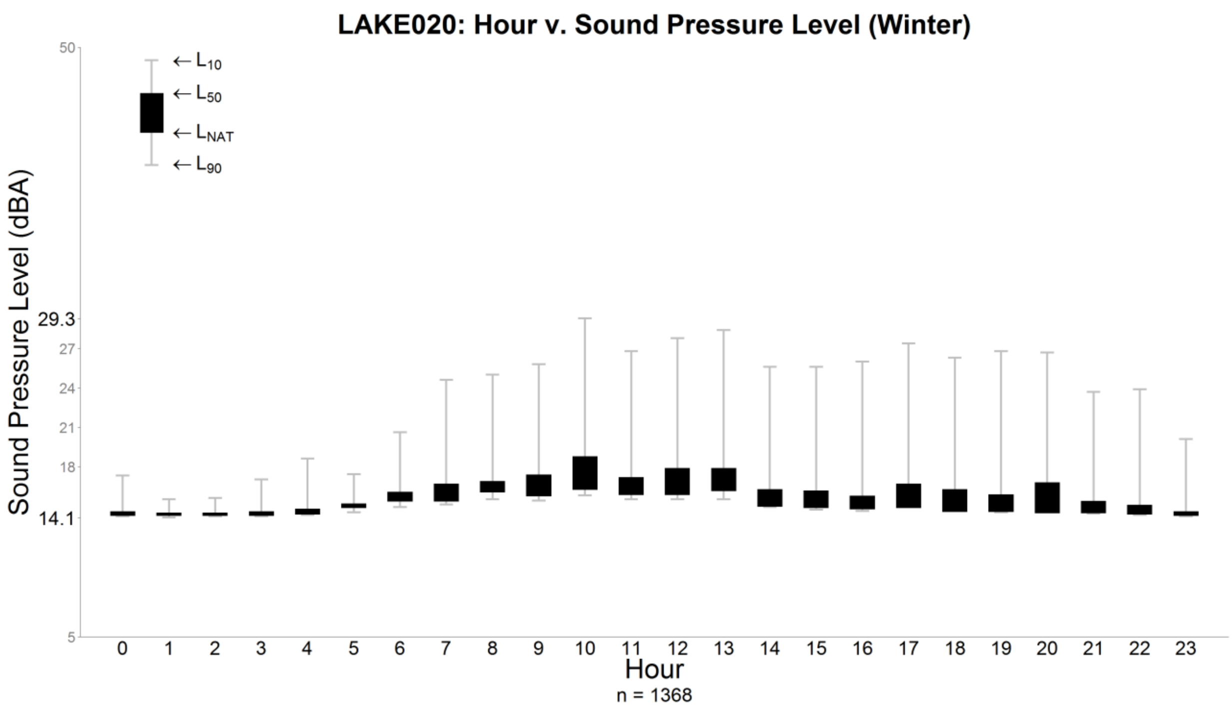

Figure 46. Hourly exceedence levels at LAKE020 Winter (AR18)

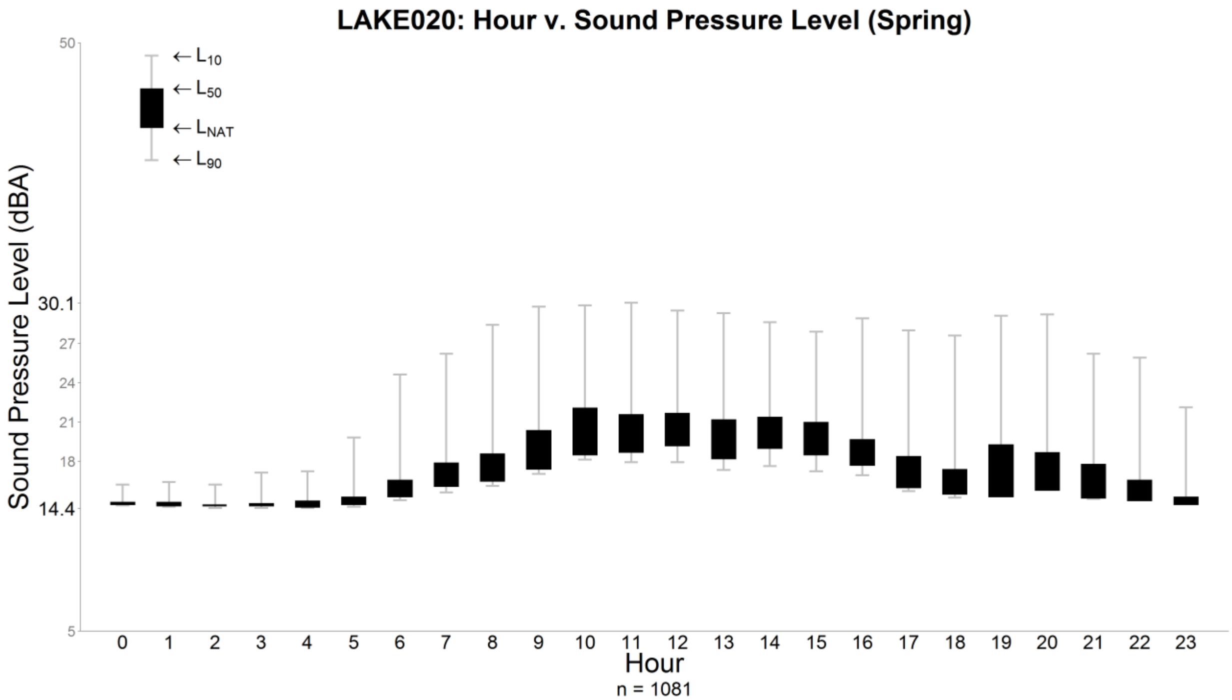

Figure 47. Hourly exceedence levels at LAKE020 Spring (AR18)

Discussion

As is evident in Figure 11-Figure 47, human-caused sounds raised the natural ambient levels more during the daytime hours and into the night. During the early morning hours at most sites, the existing and natural ambient levels were very near the noise floor of the recording equipment (the lowest limit of recording equipment), indicating that these sites were at times remarkably quiet. For example, the data for LAME013 (Winter) in Figure 29 show almost no variation between existing and natural ambient sound levels from 0 – 0600 hours. By 0700, there is a significant variation between L_{nat} and L_{50}. By 2000, the overall sound levels are lower again and the difference between L_{nat} and L_{50} is smaller.

From examining the figure of exceedence levels, utilizing the on-site and off-site listening analysis, and comparing the data to maps and visual assessments, the Callville site (LAME009, Figure 13- Figure 15) seems to have inherently higher existing ambient levels due to the site's proximity to McCarran Airport in Las Vegas, NV. When the hourly L_{10} and L_{90} lines differ greatly from each other, this implies that there is large variation in the ambient levels for that hour. This happens often in the midday and evening hours on the graph for LAME009. Such variation is likely due to wind and aircraft over-flights. The peak hours of human contributions can be inferred from this graph by comparing the size of the black or gray boxes. Generally, the larger the box, the larger the contribution of human-caused sound during that hour will be. The size of the boxes is directly related to the percent time audible.

Percent Exceedence Metrics

In determining the current conditions of an acoustic environment, the NPS examines how often sound pressure levels exceed certain decibel values that relate to interference with human health and speech. The NPS uses these values for making comparisons, but should not be construed as thresholds of impact. When assessing current conditions at a site, it is important to document the distribution of sound levels in relation to potential functional effects. Table 4 summarizes various sound level values that relate to human health and speech, as documented in scientific literature. These sound pressure metrics are often useful in planning documents as a measure of where the majority of sound energy is located. They are also useful in measuring the effects of sound on wildlife. Human responses can serve as a proxy for potential impacts to other vertebrates because we have more sensitive hearing at low frequencies than most species.

Table 4. Explanation of sound pressure levels.

Sound Level (dBA)	Relevance
35	Blood pressure and heart rate increase in sleeping humans[1]
45	WHO's recommendation for max noise levels inside bedrooms[2]
52	Speech interference for interpretive programs[3]
60	Speech interruption for normal conversations[3]

1. (Haralabidis et al., 2008)
2. (Berglund, Lindvall, and Schwela, 1999)
3. (U.S. Environmental Protection Agency, 1974)

Table 5 reports the percent of time that measured levels were above these values at each of the monitoring sites. The first decibel value, 35 dBA, addresses the health effects of sleep interruption (Haralabidis et al. 2008). The second value addresses the World Health Organization's recommendations that noise levels inside bedrooms remain below 45 dBA (Berglund et al. 1999). The third value, 52 dBA, is based on the Environmental Protection Agency's (EPA 1974) speech interference threshold for speaking in a raised voice to an audience at 10 meters. This value addresses the effects of sound on interpretive presentations in parks. The final value, 60 dBA, provides a basis for estimating impacts on normal voice communications at 1 m (3 ft). Hikers and visitors viewing scenic vistas in the park would likely be conducting such conversations.

To demonstrate the measurements, we will use LAME009. The LAME009 acoustic monitoring station was located in the flight pathway of aircraft to the Las Vegas McCarran International Airport, thus sound pressure levels were slightly louder than the other sites.

The low percent exceedence metrics for all sound levels at most sites suggest that very loud sounds occur infrequently in these wilderness areas. The top value in each cell in Table 5 focuses on frequencies affected by transportation noise whereas the lower values use the conventional full frequency range. A-weighting measurements are often used to measure low-frequency transportation noise and as an indicator for the quality of acoustic environments in rooms. They are also used to determine the potential for speech interferences, sleep interruption, and physiological responses to noise. However, in wilderness areas, dBA measurements can be misleading because much of the sound energy comes from high frequency sounds that are naturally occurring like birds, frogs, and insects. Thus, when using dBA as a means of comparison, wilderness areas with a preponderance of birdsong could appear as loud as a noisy urban environment. Therefore, in order to obtain an accurate measure of natural ambient dBA levels, NPS has extracted another dBA measurement which focuses on the frequencies where motorized

vehicles produce sound (20 Hz – 1250 Hz). This allows NPS to compare levels of sound in parks to transportation noise measurements.

Table 5. Percent time above metrics for night and day.

	% Total above sound level: 0700 -1900				% Total above sound level: 1900 - 0700			
Site Name	35dBA	45dBA	52dBA	60dBA	35dBA	45dBA	52dBA	60dBA
LAME007 (Summer)	45.31	20.91	10.27	4.38	11.61	4.24	1.25	0.10
	46.46	21.65	10.91	4.95	13.00	4.57	1.30	0.12
LAME007 (Winter)	47.23	23.00	12.08	5.16	12.87	4.14	1.39	0.14
	48.13	23.15	12.11	5.26	13.74	4.21	1.39	0.14
LAME009 (2007)	32.55	5.53	1.98	0.54	10.70	1.27	0.25	0.03
	33.15	5.72	2.18	0.64	10.71	1.29	0.30	0.05
LAME009 (Summer)	32.51	5.78	1.46	0.35	10.88	1.24	0.25	0.05
	33.89	5.92	1.51	0.38	11.20	1.24	0.26	0.05
LAME009 (Winter)	30.32	6.19	2.27	0.69	11.35	1.49	0.21	0.00
	30.93	6.24	2.29	0.73	11.49	1.48	0.20	0.00
LAME010 (2007)	2.61	0.46	0.08	0.00	0.40	0.11	0.01	0.00
	2.95	0.48	0.08	0.00	0.72	0.14	0.03	0.00
LAME010 (Summer)	4.29	0.61	0.10	0.00	1.51	0.21	0.03	0.00
	4.79	0.68	0.12	0.00	1.51	0.21	0.03	0.00
LAME010 (Fall)	2.39	0.54	0.11	0.00	0.45	0.05	0.00	0.00
	2.57	0.54	0.11	0.00	0.94	0.06	0.00	0.00
LAME010 (Winter)	5.28	0.83	0.14	0.00	1.72	0.17	0.05	0.00
	8.33	1.14	0.20	0.01	1.87	0.17	0.05	0.00
LAME011 (2007)	2.42	0.24	0.04	0.00	0.43	0.04	0.00	0.00
	3.11	0.31	0.05	0.00	7.14	0.11	0.00	0.00
LAME011 (Summer)	4.51	0.42	0.05	0.00	0.86	0.04	0.00	0.00
	5.81	0.55	0.06	0.00	20.23	0.55	0.01	0.00
LAME011 (Fall)	2.33	0.26	0.04	0.00	0.43	0.07	0.00	0.00
	2.98	0.32	0.06	0.00	1.28	0.09	0.00	0.00
LAME011 (Winter)	12.76	1.20	0.11	0.01	4.38	0.38	0.08	0.00
	18.87	1.59	0.19	0.01	7.82	0.40	0.08	0.00
LAME011 (April)	13.62	1.55	0.23	0.02	4.43	0.33	0.02	0.00
	22.41	3.19	0.52	0.03	25.13	1.42	0.08	0.00
LAME012 (Summer)	24.36	5.52	2.25	0.57	5.81	0.85	0.15	0.03
	26.65	5.53	2.29	0.58	5.82	0.87	0.15	0.03
LAME012 (Winter)	25.26	6.03	2.04	0.68	5.12	0.79	0.10	0.00
	25.25	6.01	2.05	0.69	5.57	0.83	0.10	0.00
LAME013 (Summer)	34.59	13.05	6.04	0.42	2.51	0.35	0.08	0.00
	35.73	13.34	6.14	0.48	3.80	0.41	0.08	0.00
LAME013 (Fall)	37.63	16.06	6.86	0.44	1.44	0.18	0.01	0.00
	38.12	16.36	6.91	0.50	1.78	0.25	0.02	0.00
LAME013 (Winter)	35.13	14.84	6.98	1.00	0.96	0.08	0.00	0.00
	35.76	14.76	6.95	1.06	0.97	0.10	0.00	0.00
LAME014 (Winter)	8.48	0.86	0.16	0.00	1.18	0.13	0.00	0.00
	9.19	0.87	0.16	0.00	1.20	0.13	0.00	0.00
LAME014 (Summer)	18.41	2.63	0.16	0.00	3.51	0.31	0.02	0.00
	22.95	2.72	0.18	0.00	3.69	0.33	0.02	0.00
LAME015 (Fall)	Not							
	available							

Table 6. Percent time above metrics for night and day (continued).

	% Total above sound level: 0700 -1900				% Total above sound level: 1900 - 0700			
Site Name	35dBA	45dBA	52dBA	60dBA	35dBA	45dBA	52dBA	60dBA
LAME015 (Winter)	3.35	0.59	0.14	0.00	0.98	0.12	0.02	0.00
	3.52	0.61	0.13	0.01	1.15	0.13	0.02	0.00
LAME015 (Spring)	7.50	1.27	0.21	0.00	1.73	0.14	0.02	0.00
	11.85	1.37	0.26	0.00	3.28	0.19	0.02	0.00
LAME015 (Summer)	10.98	1.17	0.26	0.04	1.34	0.11	0.01	0.00
	14.58	1.34	0.28	0.03	2.18	0.14	0.02	0.00
LAME016 (Summer)	41.71	7.75	1.00	0.04	18.72	1.95	0.18	0.01
	49.52	8.85	1.05	0.04	21.39	2.63	0.22	0.01
LAME016 (Fall))	22.84	4.02	0.69	0.02	4.66	0.29	0.02	0.00
	23.33	4.06	0.68	0.02	5.32	0.28	0.02	0.00
LAME016 (Winter)	21.63	3.26	0.51	0.03	4.99	0.46	0.04	0.00
	22.02	3.33	0.53	0.02	5.14	0.47	0.04	0.00
LAME017 (Winter)	21.67	4.42	0.62	0.05	5.04	0.81	0.07	0.00
	21.96	4.40	0.64	0.05	5.15	0.83	0.07	0.00
LAME017 (Summer)	20.38	3.47	0.59	0.04	5.29	0.72	0.06	0.00
	22.43	3.55	0.61	0.04	5.96	0.73	0.07	0.00
LAME018 (Summer)	24.13	4.57	0.57	0.01	7.97	0.92	0.12	0.00
	28.45	4.75	0.61	0.01	11.85	1.26	0.20	0.00
LAME019 (Summer)	2.28	0.24	0.02	0.00	1.02	0.06	0.00	0.00
	2.72	0.24	0.02	0.00	1.40	0.09	0.00	0.00
LAME019 (Fall)	3.07	0.31	0.04	0.00	2.89	0.04	0.00	0.00
	3.38	0.33	0.05	0.00	3.35	0.04	0.00	0.00
LAME019 (Winter)	3.12	0.38	0.08	0.00	1.08	0.05	0.00	0.00
	3.42	0.38	0.09	0.00	1.24	0.04	0.00	0.00
LAME020 (Winter)	1.70	0.24	0.05	0.00	0.50	0.07	0.00	0.00
	2.11	0.25	0.05	0.00	0.63	0.08	0.00	0.00
LAME020 (Spring)	1.92	0.25	0.05	0.00	0.67	0.06	0.00	0.00
	2.79	0.33	0.06	0.00	1.32	0.15	0.02	0.00
LAME020 (Summer)	1.27	0.13	0.01	0.00	0.38	0.03	0.00	0.00
	1.92	0.18	0.03	0.00	7.61	0.09	0.01	0.00

Exceedence levels (L_x) are metrics used to describe acoustical data. They represent the dBA exceeded x percent of the time during the given measurement period (e.g. L_{90} is the dBA that has been exceeded 90% of the time). Table 7 reports the L_{90}, L_{nat}, L_{50}, and L_{10} values for the sites measured at Lake Mead NRA. The top value in each cell focuses on frequencies affected by transportation noise whereas the lower values use the conventional full frequency range.

Table 7. Natural ambient (Lnat) and exceedence levels for existing conditions.

Site	Exceedence levels (dBA): 0700 to 1900				Exceedence levels (dBA): 1900 to 0700			
	L_{90}	L_{nat}	L_{50}	L_{10}	L_{90}	L_{nat}	L_{50}	L_{10}
LAME007 (Summer)	21.6	20.3	33.5	52.5	13.4	14.6	20.5	33.1
	23.0	21.8	33.8	53.0	17.9	19.4	25.3	35.4
LAME007 (Winter)	24.2	21.6	34.9	54.1	16.4	17.6	23.1	35.5
	25.3	22.3	35.1	54.2	17.1	18.4	24.6	35.8
LAME009 (old app.)	21.0	20.0	30.7	42.2	11.6	13.1	18.9	33.8
	22.3	21.4	31.2	42.2	15.8	16.6	20.4	34.3
LAME009 (Summer)	21.1	21.1	30.6	41.7	13.5	14.0	19.5	33.1
	22.9	22.8	31.3	41.9	15.4	15.9	21.5	33.2
LAME009 (Winter)	22.7	21.3	30.7	41.7	16.1	16.8	21.5	34.8
	23.1	21.6	31.0	41.9	16.2	17.0	22.4	34.9
LAME010 (old app)	10.8	11.8	13.4	25.0	9.2	9.5	9.6	11.8
	15.5	16.2	17.1	26.8	14.7	15.0	15.2	19.0
LAME010 (Summer)	15.6	17.4	19.0	29.5	13.2	13.8	14.1	19.4
	17.3	19.0	20.8	30.6	15.4	16.4	16.9	23.0
LAME010 (Fall)	13.4	13.8	14.9	24.9	12.7	12.8	12.9	14.3
	15.1	15.4	16.3	26.4	15.3	16.3	16.8	22.3
LAME010 (Winter)	15.0	16.4	18.2	29.7	13.4	14.0	14.3	20.8
	16.3	18.0	21.4	32.2	14.7	15.2	15.5	23.8
LAME011 (old app)	12.1	13.6	16.2	27.5	9.4	9.6	10.0	15.8
	16.3	17.4	20.1	29.4	16.4	18.5	21.6	29.2
LAME011 (Summer)	16.6	18.8	21.4	30.6	13.1	13.4	14.0	22.5
	18.9	21.4	24.4	31.9	21.1	25.2	28.6	34.3
LAME011 (Fall)	14.7	15.7	17.6	27.9	12.6	12.8	13.1	19.2
	15.8	16.6	18.9	29.0	15.5	17.1	19.4	26.8
LAME011 (Winter)	19.5	21.6	24.5	33.2	14.6	15.8	17.4	27.0
	20.6	23.1	26.6	34.8	15.9	17.5	20.2	29.6
LAME010 (Spring)	22.2	24.8	26.3	34.9	14.6	16.6	17.7	27.3
	23.8	26.9	28.7	38.0	22.6	26.4	28.1	34.4
LAME012 (Summer)	19.2	19.6	26.9	40.6	14.2	14.9	18.0	26.8
	20.4	21.0	27.9	40.7	15.1	15.7	16.9	27.2
LAME012 (Winter)	20.3	20.2	27.7	41.5	15.1	16.0	18.5	28.1
	19.8	19.3	28.5	41.5	15.2	15.6	16.6	28.7
LAME013 (Summer)	21.4	18.9	31.2	48.3	13.8	14.0	14.7	23.6
	21.9	19.5	31.3	48.3	18.0	19.9	22.4	29.2
LAME013 (Fall)	20.7	18.4	31.8	49.1	13.6	13.9	14.6	23.0
	21.3	19.0	32.0	49.2	15.3	15.9	18.0	25.3
LAME013 (Winter)	18.9	17.0	30.3	48.1	13.6	13.9	14.4	21.7
	18.8	17.3	31.1	48.1	14.6	14.7	15.1	24.1

Table 8. Natural ambient (Lnat) and exceedence levels for existing conditions (continued).

Site	Exceedence levels (dBA): 0700 to 1900				Exceedence levels (dBA): 1900 to 0700			
	L_{90}	L_{nat}	L_{50}	L_{10}	L_{90}	L_{nat}	L_{50}	L_{10}
LAKE014 (Winter)	16.9	18.6	23.0	32.5	13.5	14.1	15.0	22.8
	17.6	19.5	25.2	33.0	14.6	15.1	15.8	25.2
LAKE014 (Summer)	16.8	19.7	25.7	38.0	12.6	12.9	13.1	19.3
	22.8	25.4	29.2	38.4	14.8	15.6	16.2	22.8
LAKE015 (Fall)	Not							
	available							
LAKE015 (Winter)	14.1	15.2	17.0	28.1	13.4	14.3	14.8	21.6
	15.5	16.3	18.4	28.9	14.9	15.6	16.0	24.7
LAKE015 (Spring)	15.9	17.6	20.7	32.1	13.3	14.1	14.6	22.6
	17.8	19.1	22.1	34.3	15.4	15.9	16.5	24.4
LAKE015 (Summer)	18.9	21.7	25.0	34.3	13.0	13.7	14.5	20.9
	22.4	25.4	28.3	35.8	16.0	16.6	17.4	24.3
LAKE016 (Summer)	22.7	25.3	33.3	43.6	18.4	23.3	26.4	37.6
	25.7	28.0	34.8	44.0	19.6	24.5	27.8	38.3
LAKE016 (Fall)	20.1	20.4	27.9	40.0	18.0	18.3	18.9	28.3
	18.9	19.3	28.5	40.0	14.5	14.8	16.2	29.4
LAKE016 (Winter)	18.2	17.4	26.3	39.4	14.9	15.1	15.7	29.5
	18.2	17.4	26.6	39.4	14.5	14.7	15.6	29.7
LAKE017 (Winter)	15.3	12.8	26.0	40.1	7.3	8.0	10.9	27.0
	18.9	16.7	27.2	40.2	14.3	14.5	16.8	27.6
LAKE017 (Summer)	14.9	14.3	25.8	39.6	6.9	7.4	9.8	27.2
	18.2	17.9	26.5	39.8	14.4	14.6	15.5	27.8
LAKE018 (Summer)	18.5	20.0	28.1	40.6	9.1	11.4	15.8	30.8
	21.5	22.6	29.6	41.1	16.1	17.5	20.3	32.8
LAKE019 (Summer)	10.6	15.4	18.3	29.3	8.8	13.7	15.3	26.4
	19.0	21.2	22.7	30.3	17.0	19.1	19.9	27.1
LAKE019 (Fall)	10.2	12.4	17.8	29.7	9.6	15.9	18.1	28.3
	18.5	19.5	21.9	30.4	16.6	19.1	20.4	28.6
LAKE019 (Winter)	11.0	13.2	16.8	29.3	10.1	14.8	16.4	26.0
	16.3	17.1	18.9	29.5	16.0	17.8	18.6	26.5
LAKE020 (Winter)	9.6	10.2	13.4	25.4	6.9	7.5	8.9	17.3
	15.1	15.4	17.0	26.6	14.3	14.5	14.9	20.8
LAKE020 (Spring)	13.1	14.3	17.6	27.1	6.9	7.2	9.1	18.4
	16.9	17.6	20.0	28.7	14.7	14.9	15.8	23.0
LAKE020 (Summer)	12.0	13.7	16.8	26.5	6.7	7.0	8.1	16.6
	17.0	17.9	19.7	27.8	15.5	16.1	17.9	27.6

Frequency v. Sound Pressure Level

Figure 48 - Figure 84 plot the dB levels for 33 one-third octave band frequencies over the day and night periods at the monitoring sites. The grayed area represents sound levels outside of the typical range of human hearing. The typical frequency levels for transportation, conversation and songbirds are presented on the figure as examples for interpretation of the data. These ranges are estimates and are not vehicle-, species-, or habitat- specific.

The day and night dB levels for 33 one-third octave bands illustrate that song birds typically sing at a lower level dB but a higher frequency; while transportation sounds are typically at a lower frequency. An examination of one-third octave level variation in Figure 49 reveals that overflight activity contributes much of the higher dB values at the lower frequencies, especially during the daytime hours.

The day and night dB levels for 33 one-third octave bands illustrate that song birds typically sing at a lower level dB but a higher frequency; while transportation sounds are typically at a lower frequency. Research has indicated, in some instances, a masking of song birds by transportation.

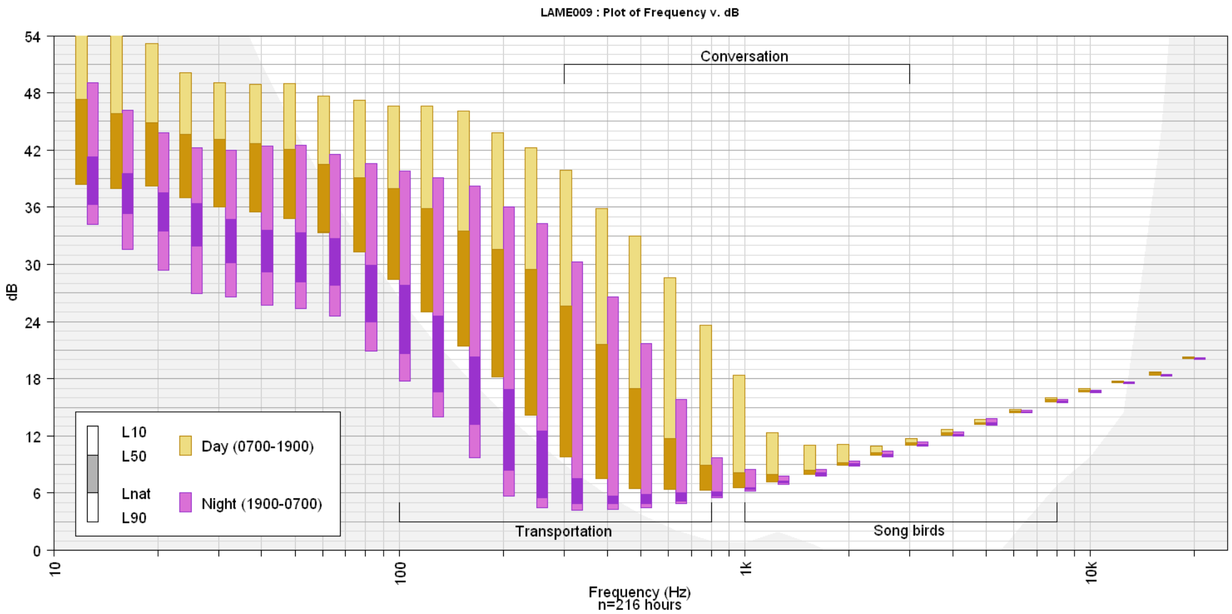

Figure 48. Day/night dB levels for 33 one-third octave bands, LAME009 (Original, 2007, Callville Wash).

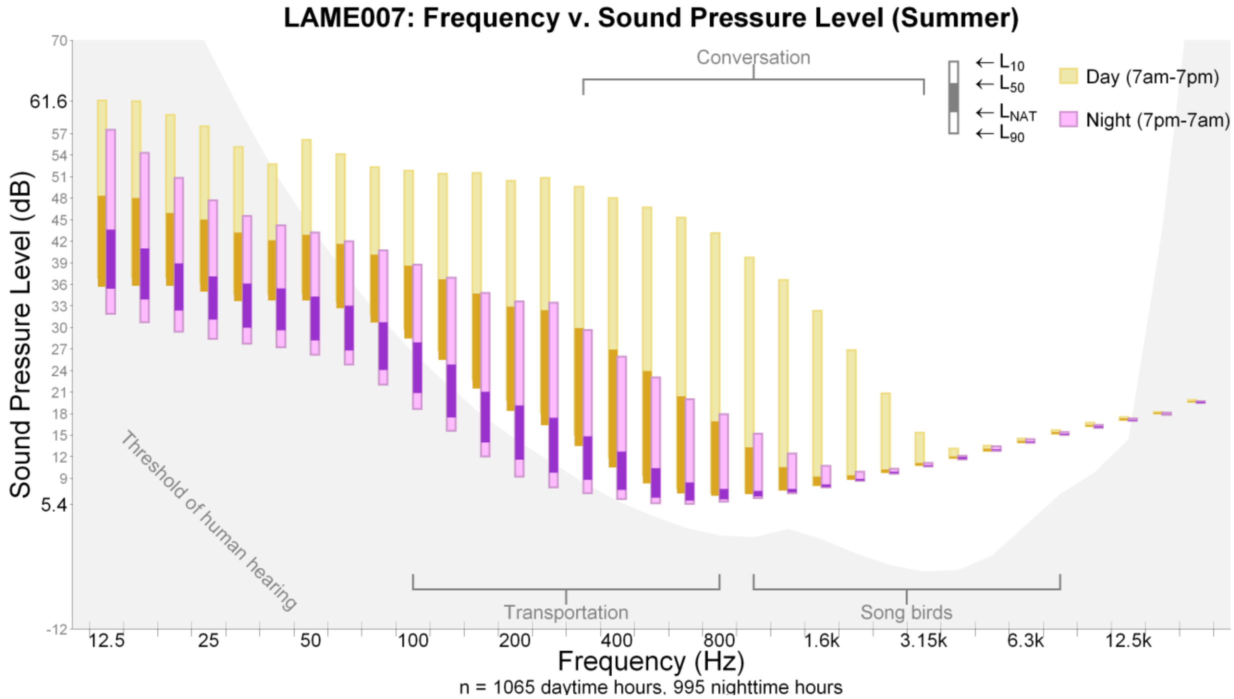

Figure 49. Day/night dB levels for 33 one-third octave bands, LAME007 Summer (Indian Pass).

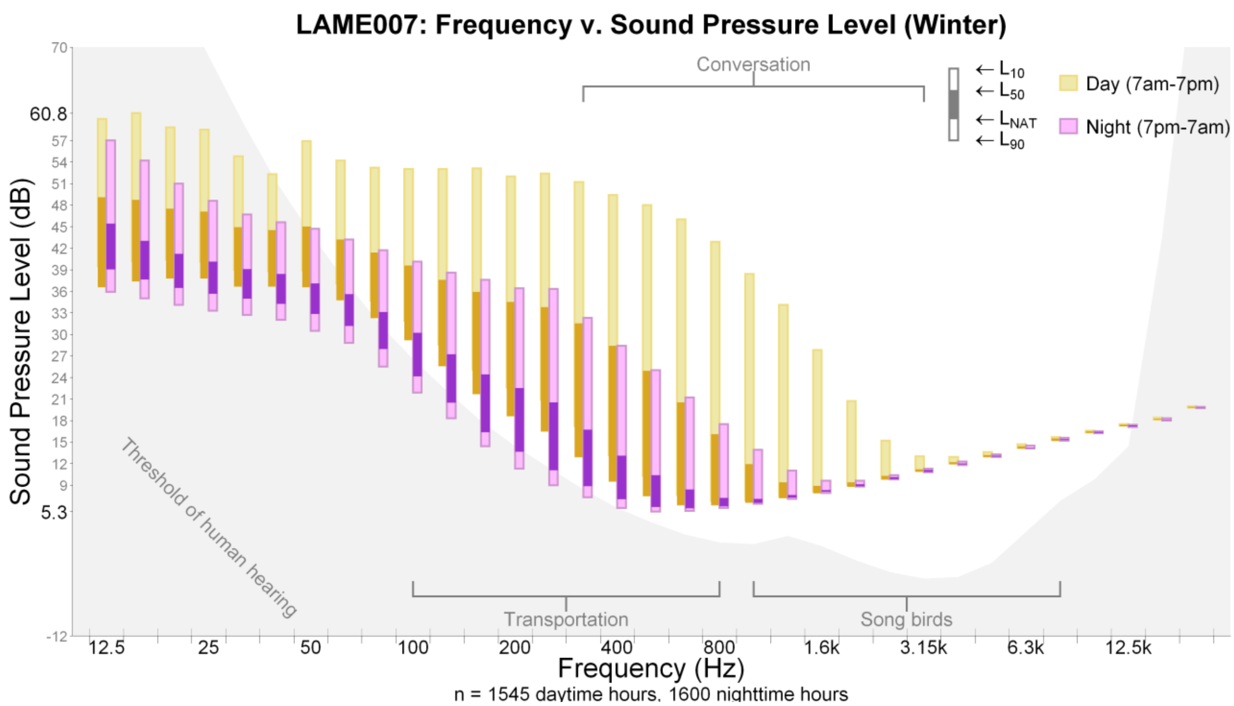

Figure 50. Day/night dB levels for 33 one-third octave bands, LAME007 Winter (Indian Pass).

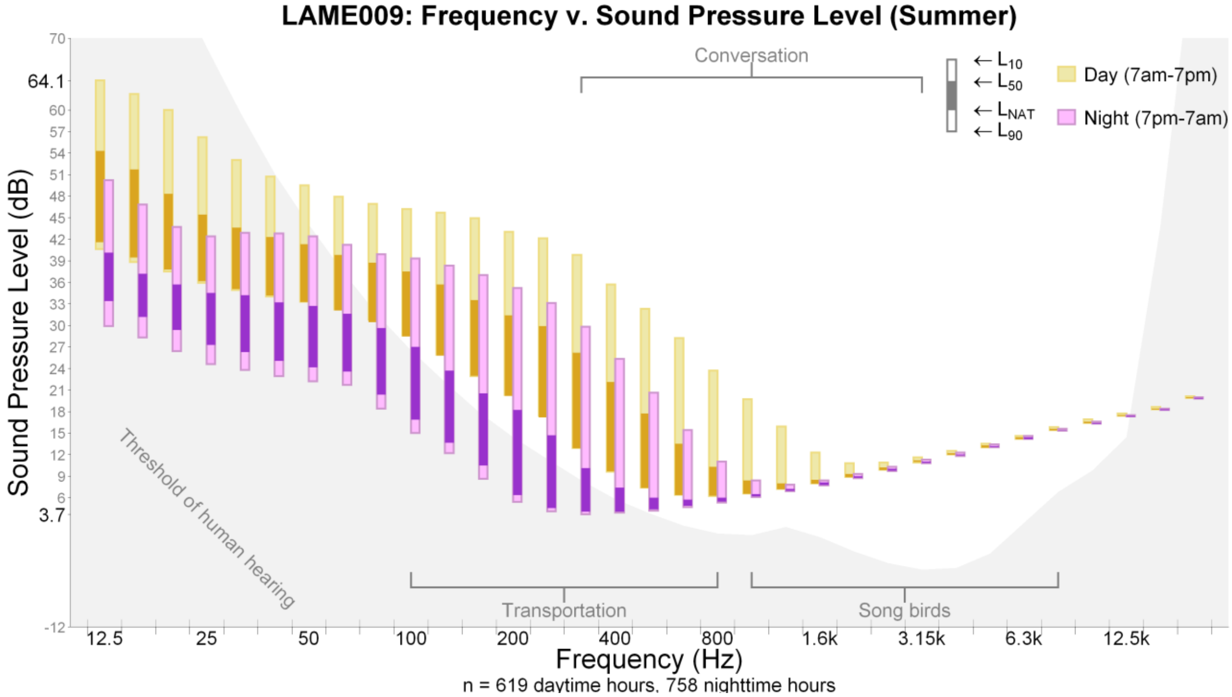

Figure 51. Day/night dB levels for 33 one-third octave bands, LAME009 Summer (Callville Wash).

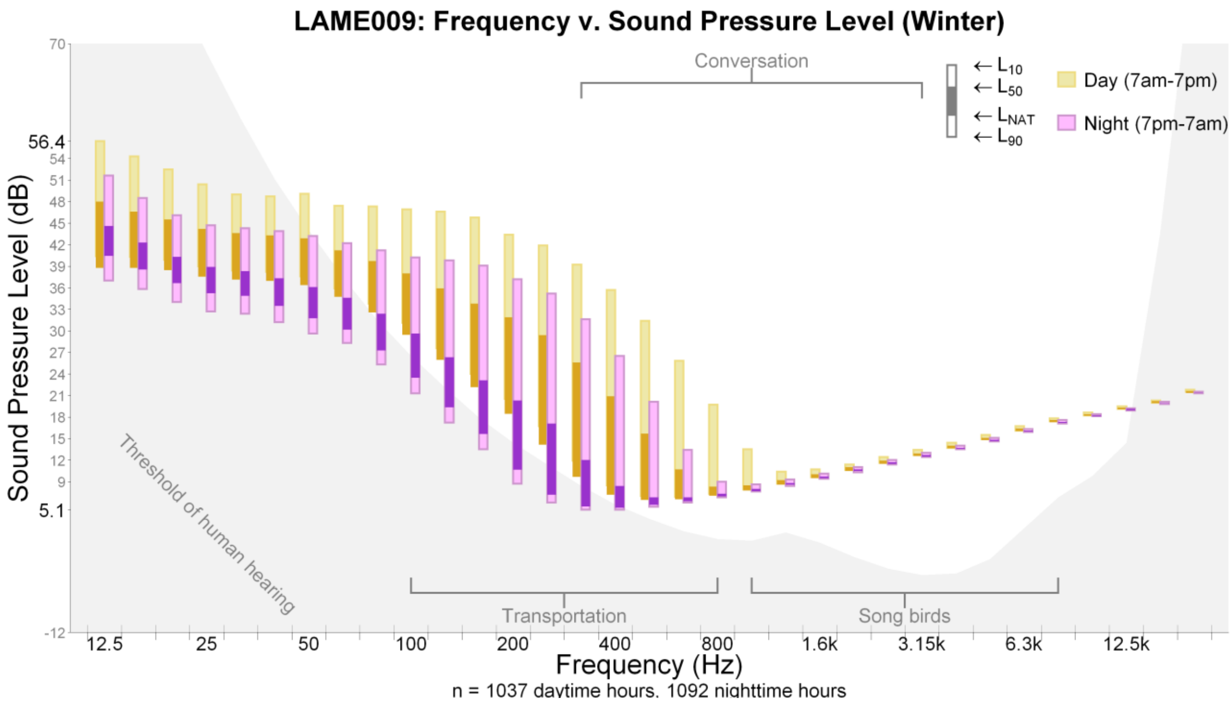

Figure 52. Day/night dB levels for 33 one-third octave bands, LAME009 Winter (Callville Wash).

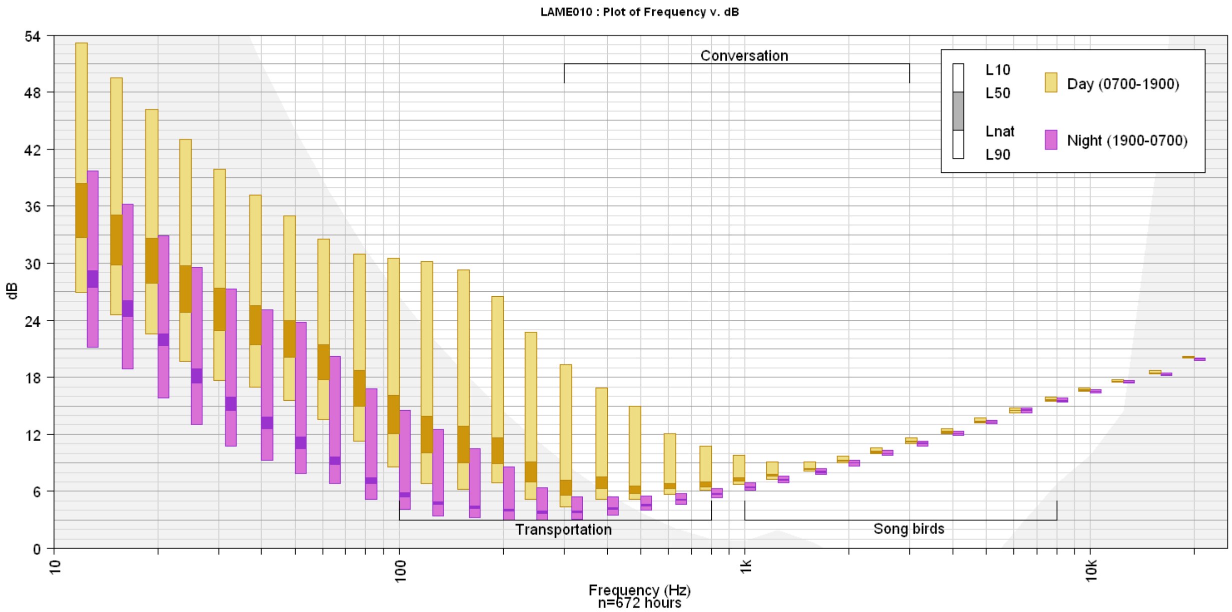

Figure 53. Day/night dB levels for 33 one-third octave bands, LAME010 (Original, 2007, AR42B).

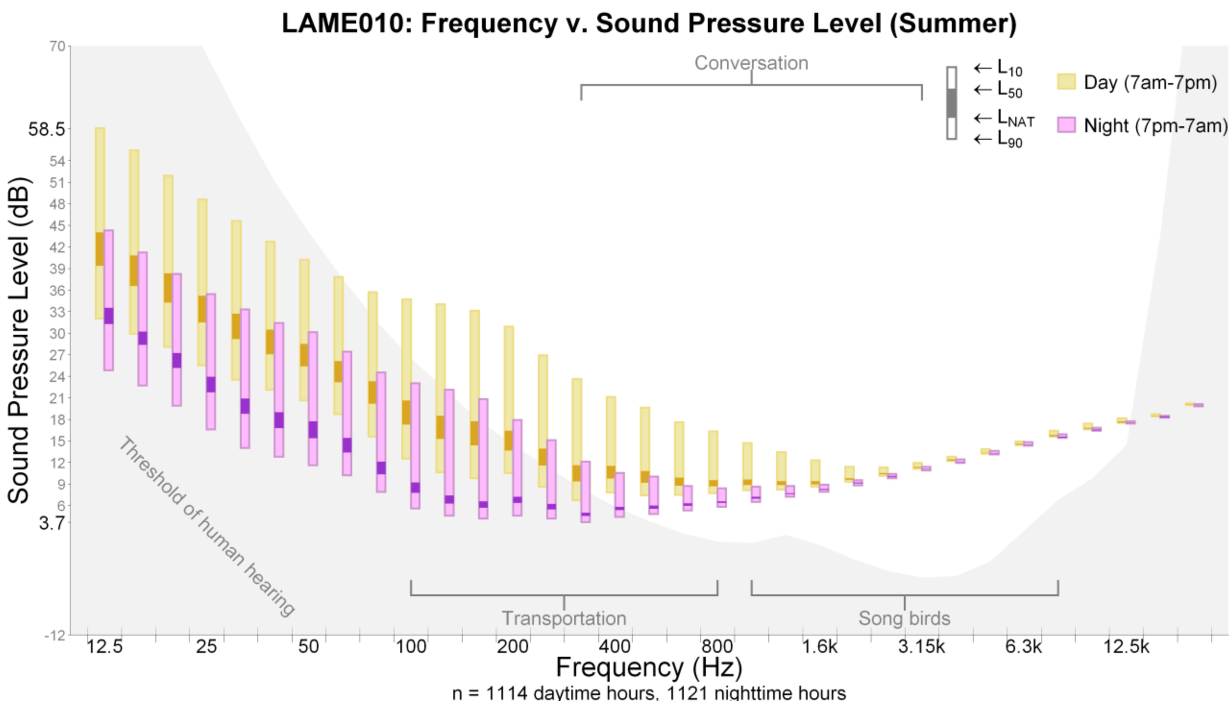

Figure 54. Day/night dB levels for 33 one-third octave bands, LAME010 Summer (AR42B).

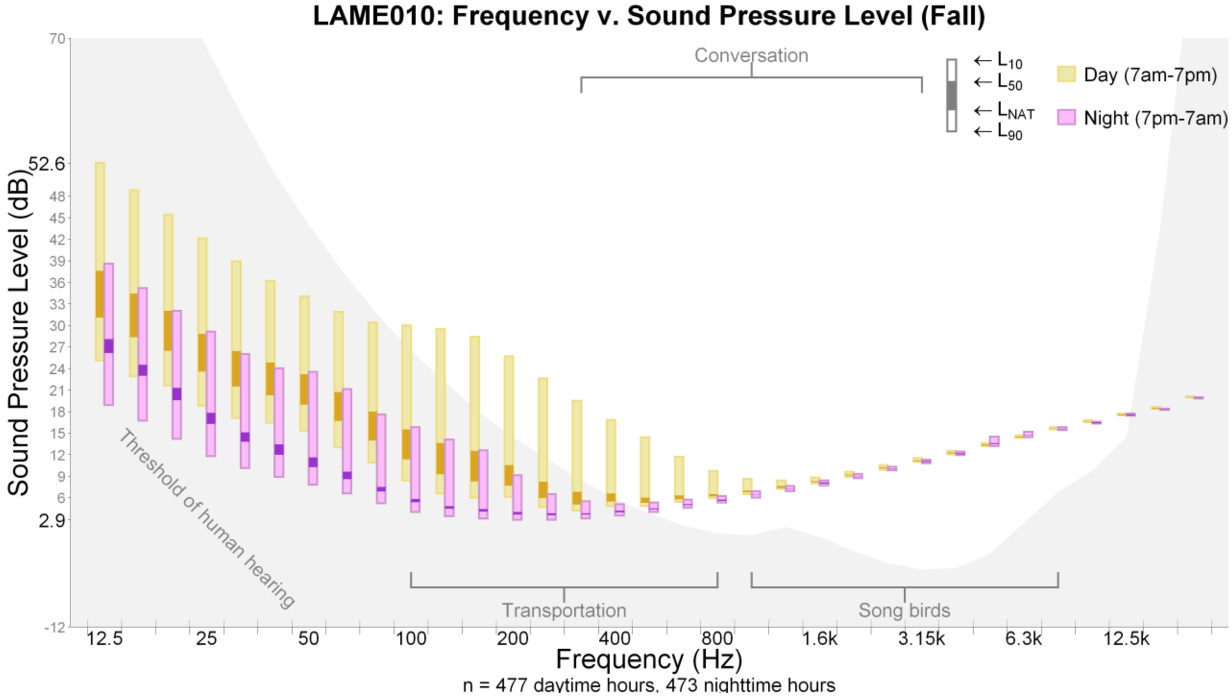

Figure 55. Day/night dB levels for 33 one-third octave bands, LAME010 Fall (AR42B).

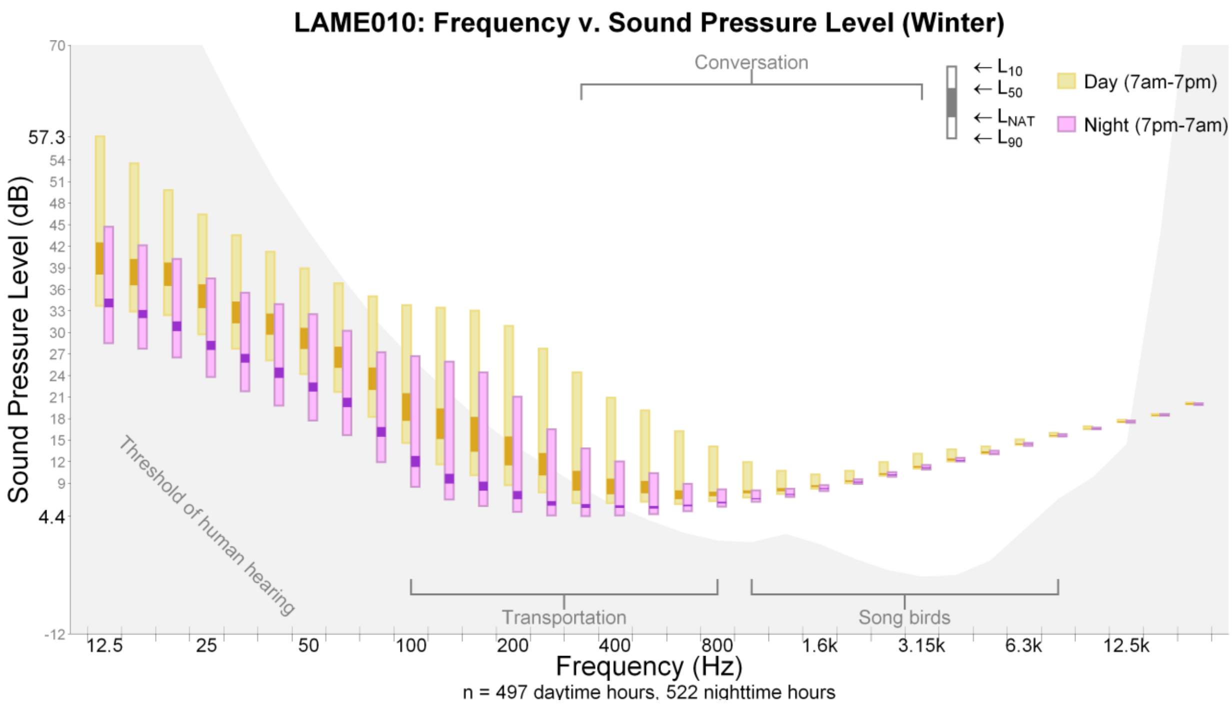

Figure 56. Day/night dB levels for 33 one-third octave bands, LAME010 Winter (AR42B).

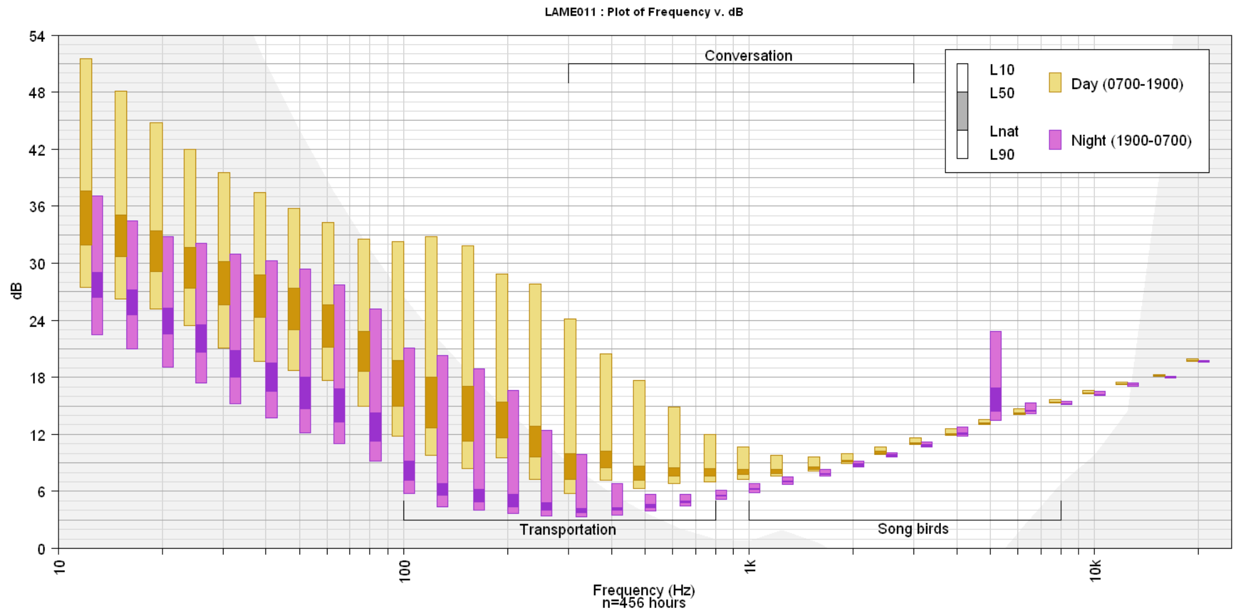

Figure 57. Day/night dB levels for 33 one-third octave bands, LAME011 (Original, 2007, AR20A).

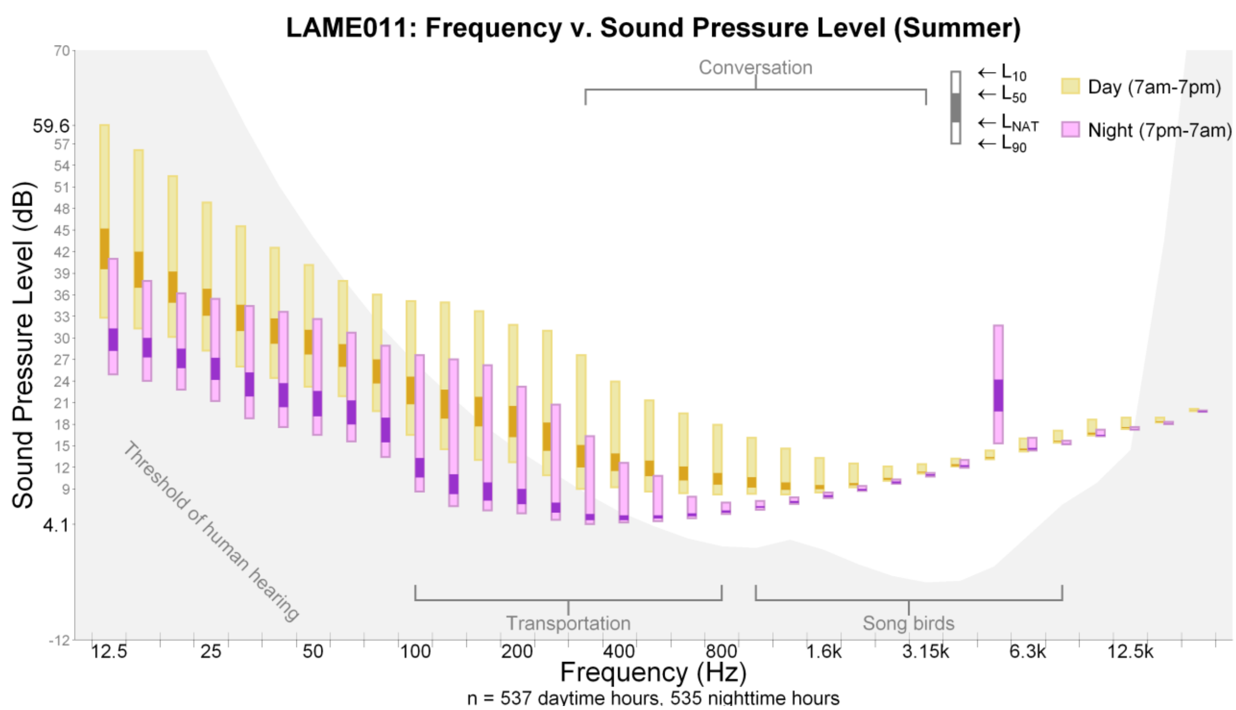

Figure 58. Day/night dB levels for 33 one-third octave bands, LAME011 Summer (AR20A).

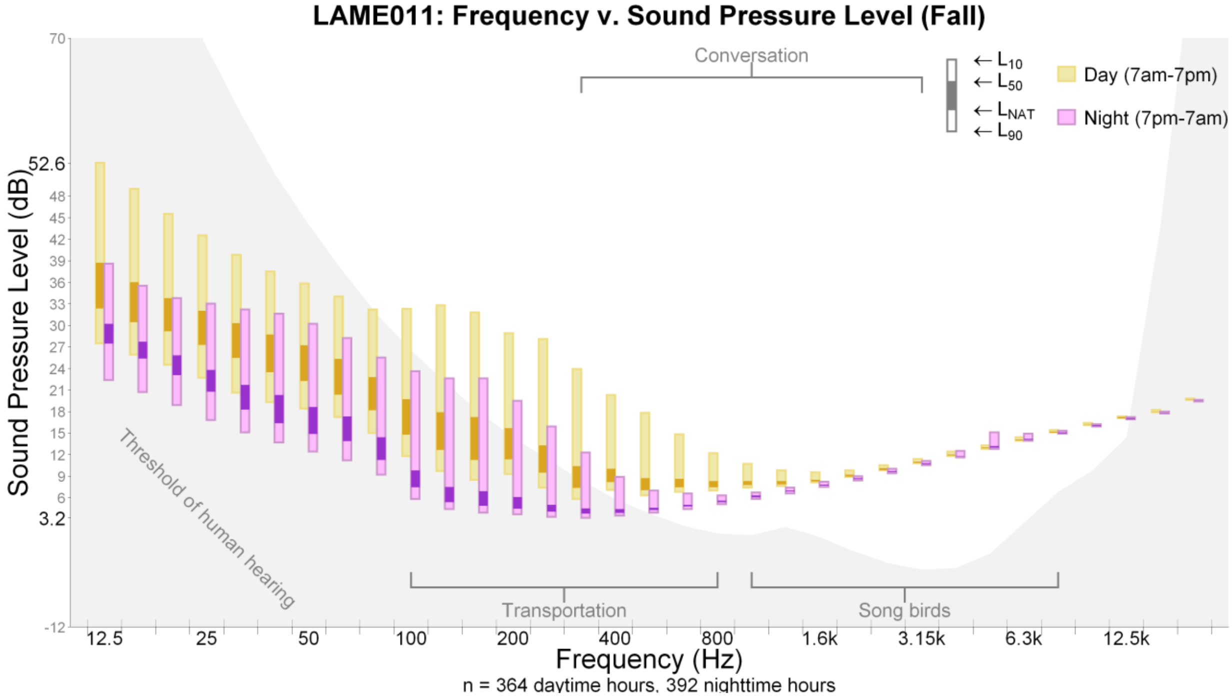

Figure 59. Day/night dB levels for 33 one-third octave bands, LAME011 Fall (AR20A).

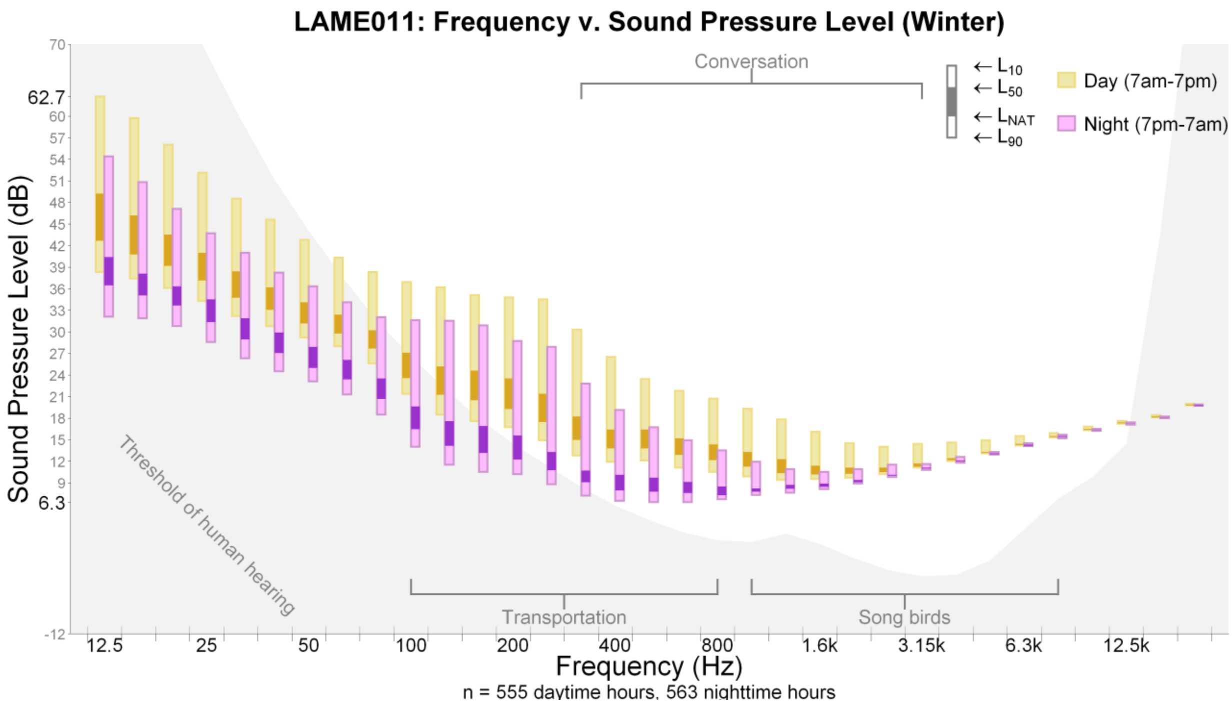

Figure 60. Day/night dB levels for 33 one-third octave bands, LAME011 Winter (AR20A).

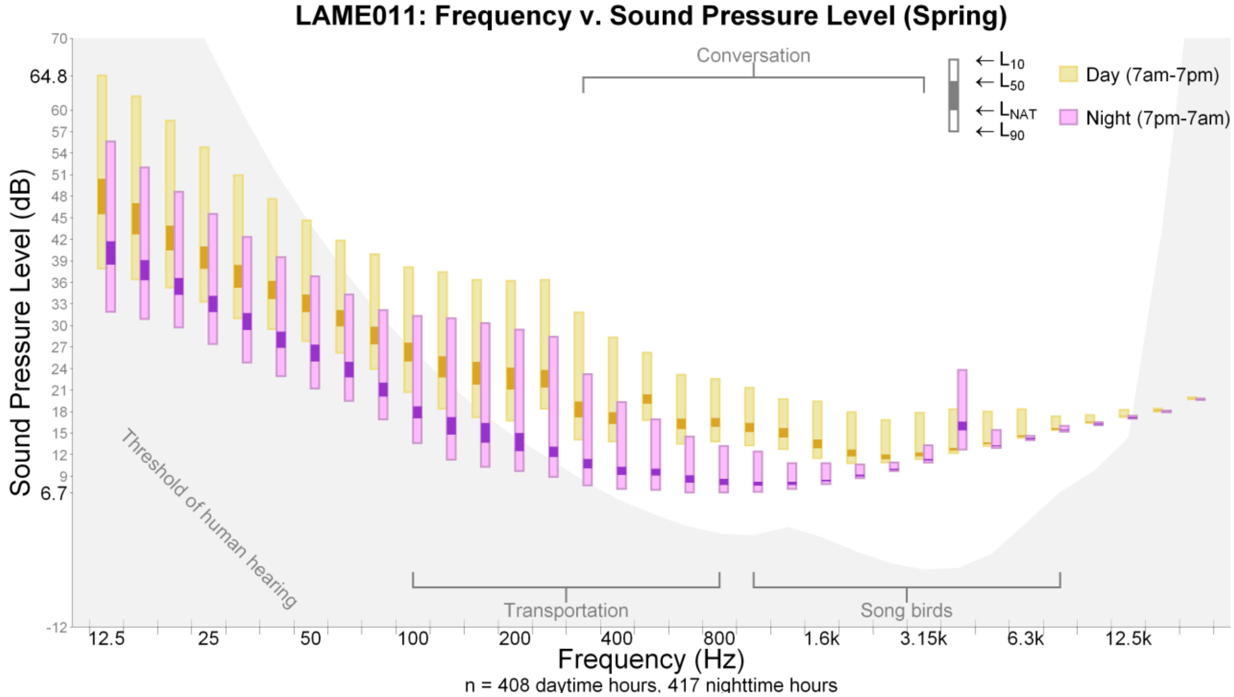

Figure 61. Day/night dB levels for 33 one-third octave bands, LAME011 Spring (AR20A).

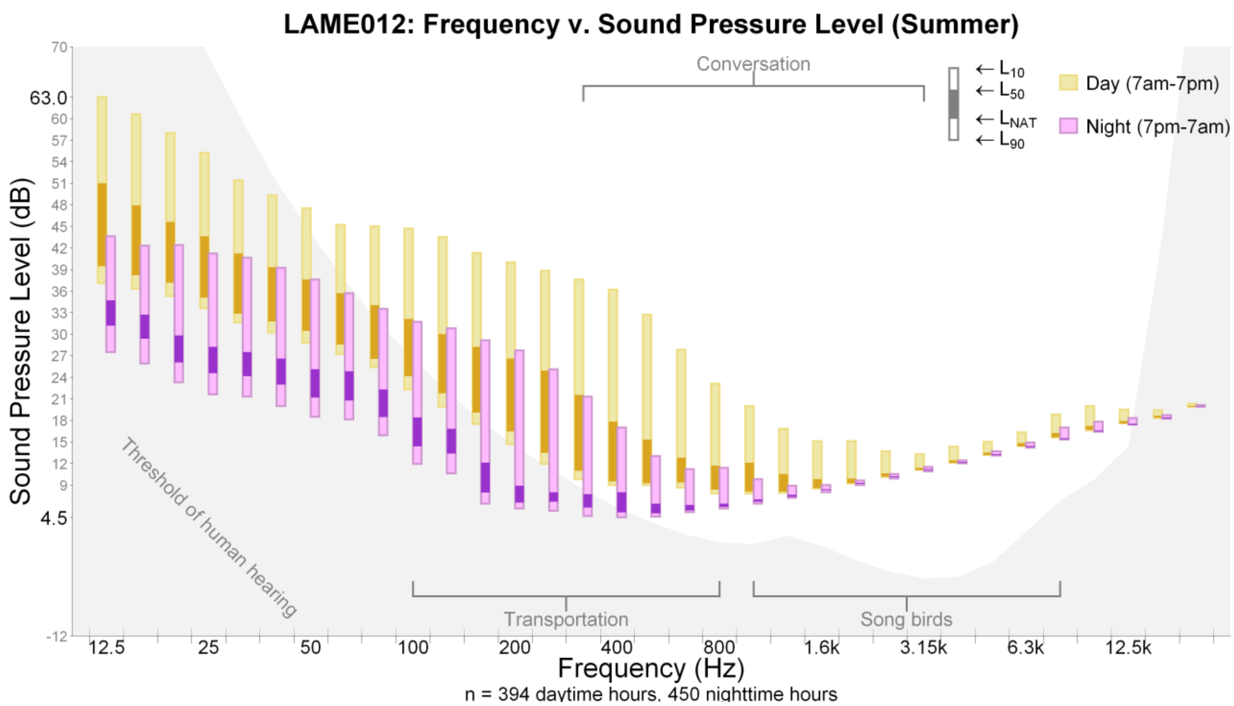

Figure 62. Day/night dB levels for 33 one-third octave bands, LAME012 Summer (AR60 Burro Wash).

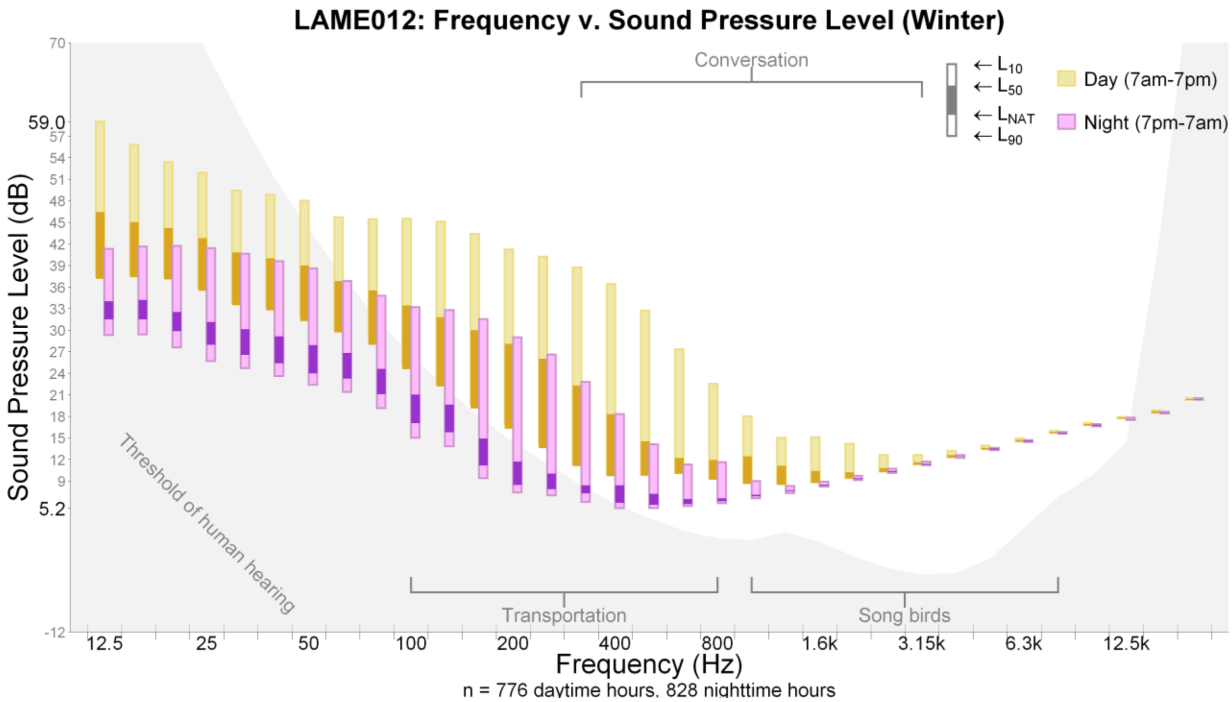

Figure 63. Day/night dB levels for 33 one-third octave bands, LAME012 Winter (AR60 Burro Wash).

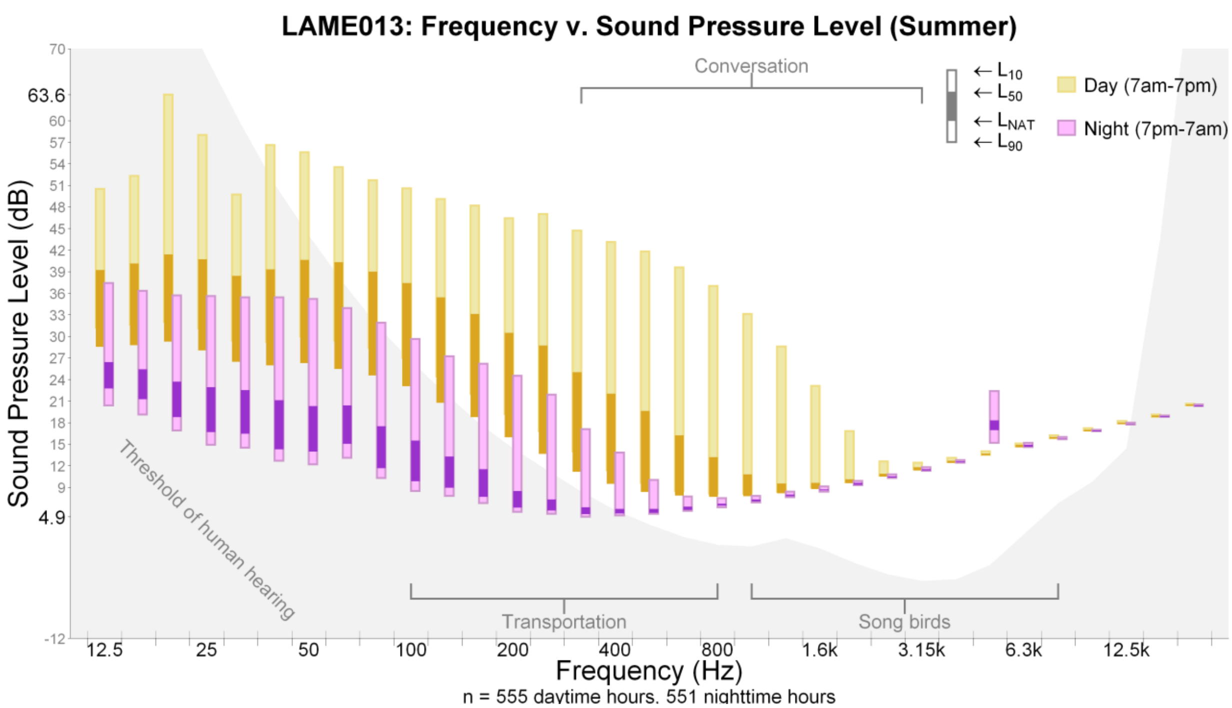

Figure 64. Day/night dB levels for 33 one-third octave bands, LAME013 Summer (Haystacks).

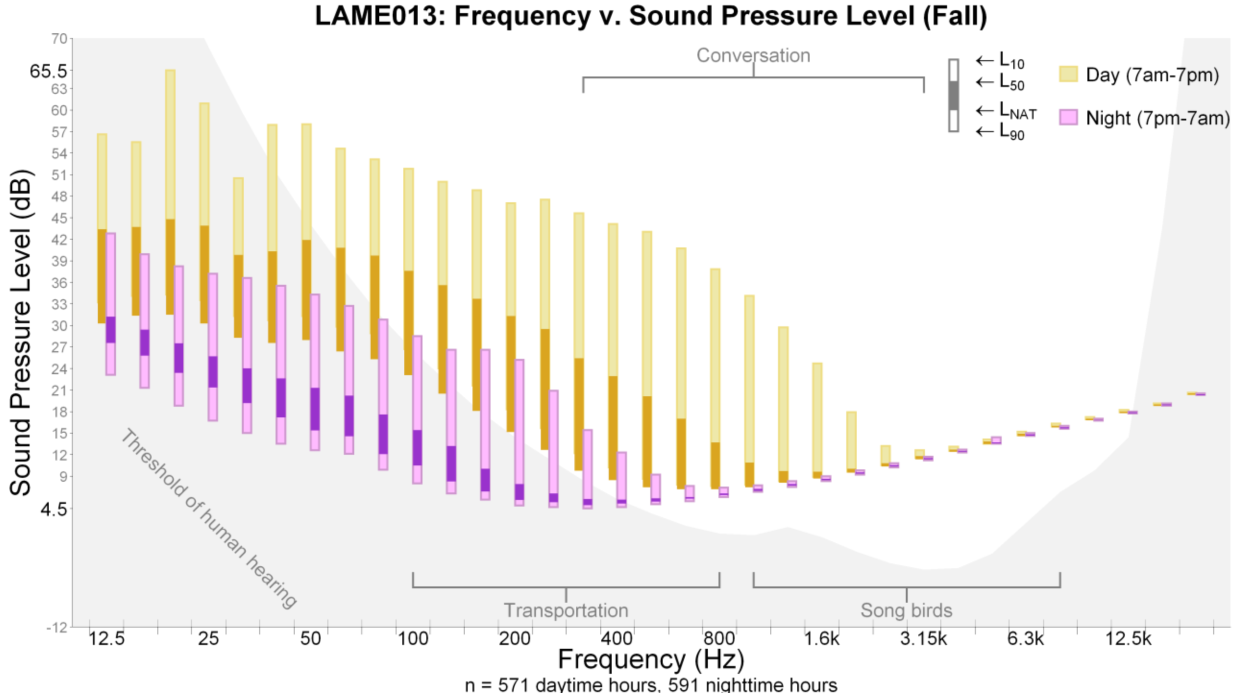

Figure 65. Day/night dB levels for 33 one-third octave bands, LAME013 Fall (Haystacks).

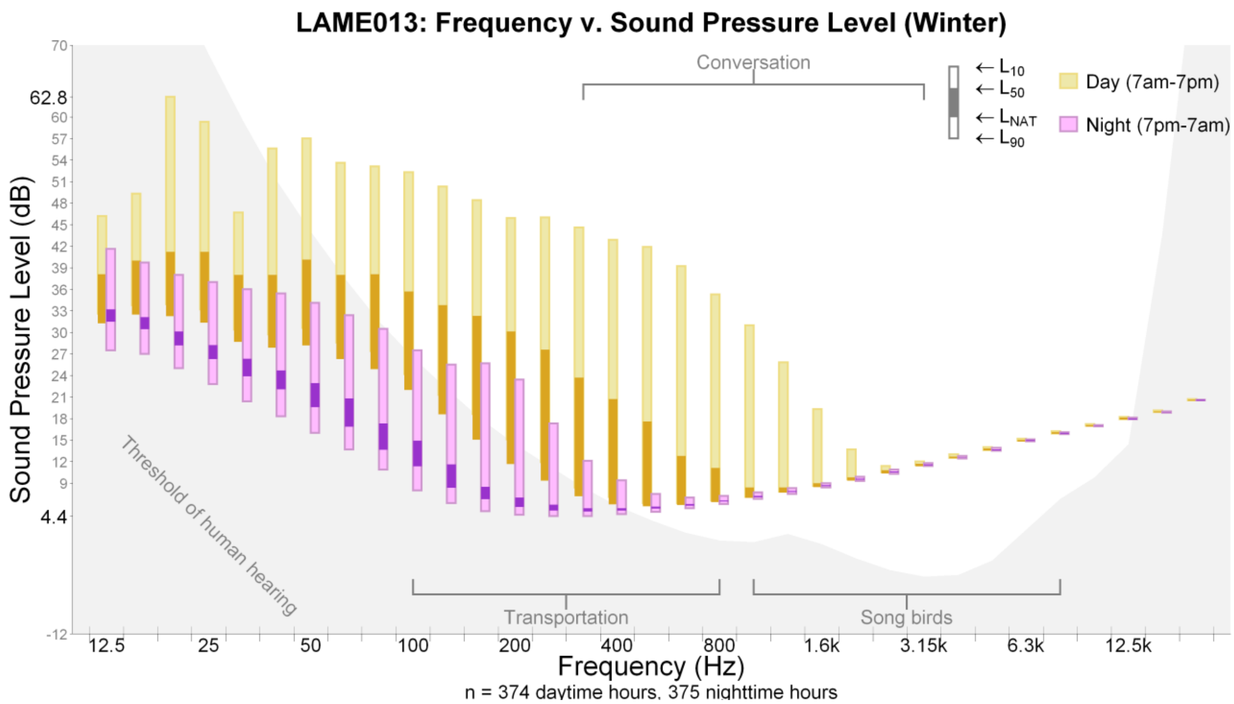

Figure 66. Day/night dB levels for 33 one-third octave bands, LAME013 Winter (Haystacks).

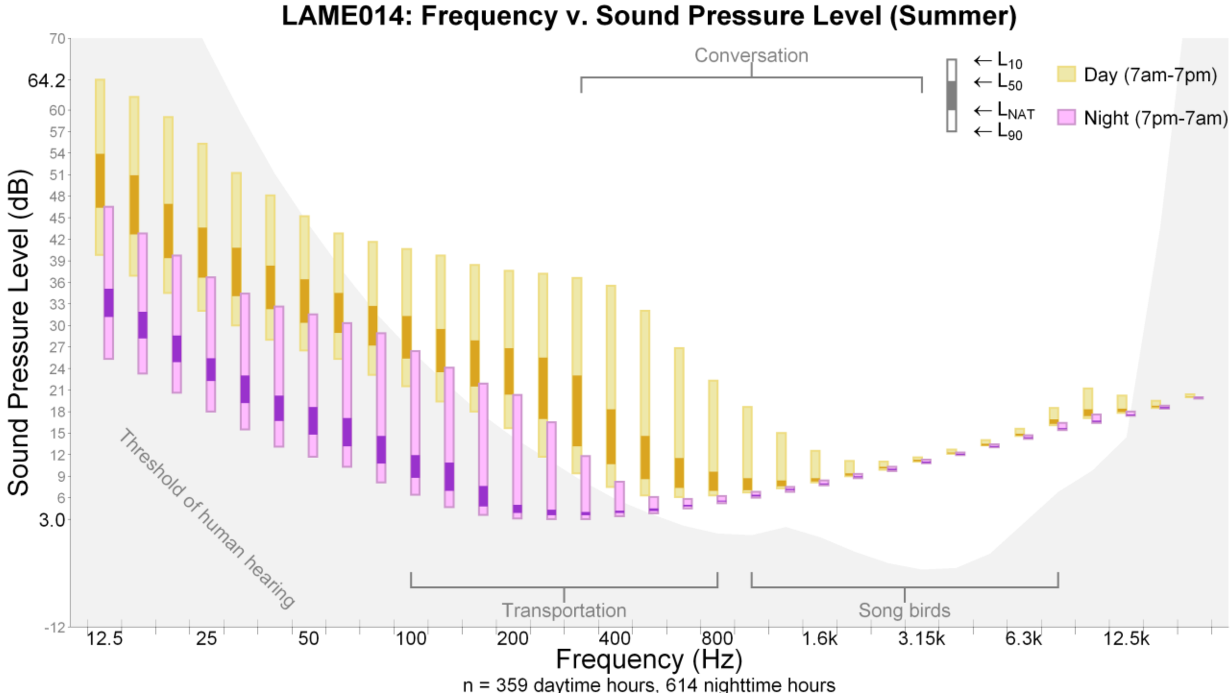

Figure 67. Day/night dB levels for 33 one-third octave bands, LAME014 Summer (Haystacks).

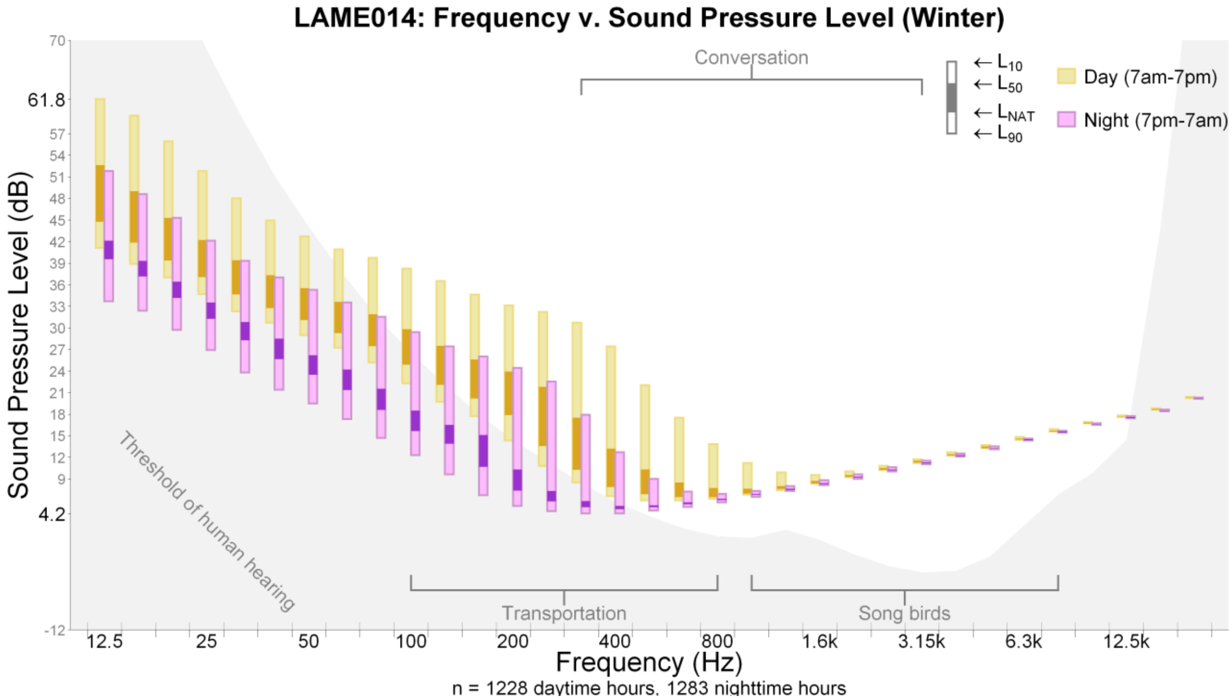

Figure 68. Day/night dB levels for 33 one-third octave bands, LAME014 Winter (Haystacks).

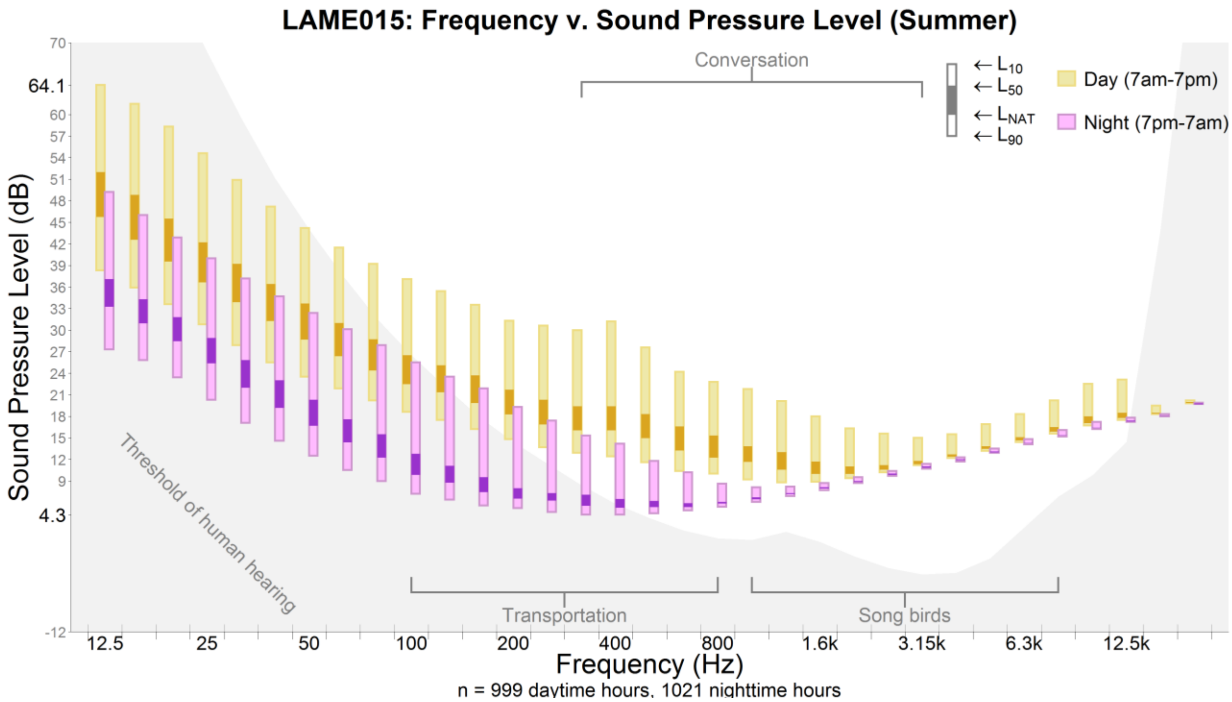

Figure 69. Day/night dB levels for 33 one-third octave bands, LAME015 Summer (AR22).

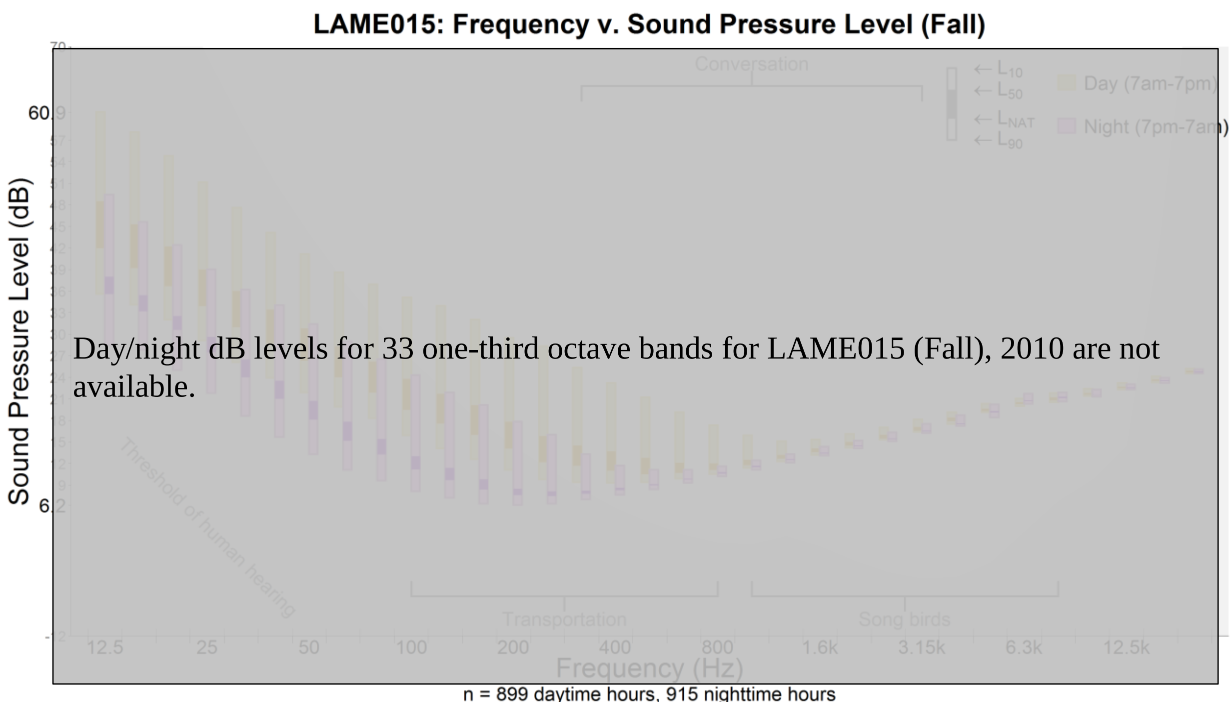

Figure 70. Day/night dB levels for 33 one-third octave bands, LAME015 Fall (AR22).

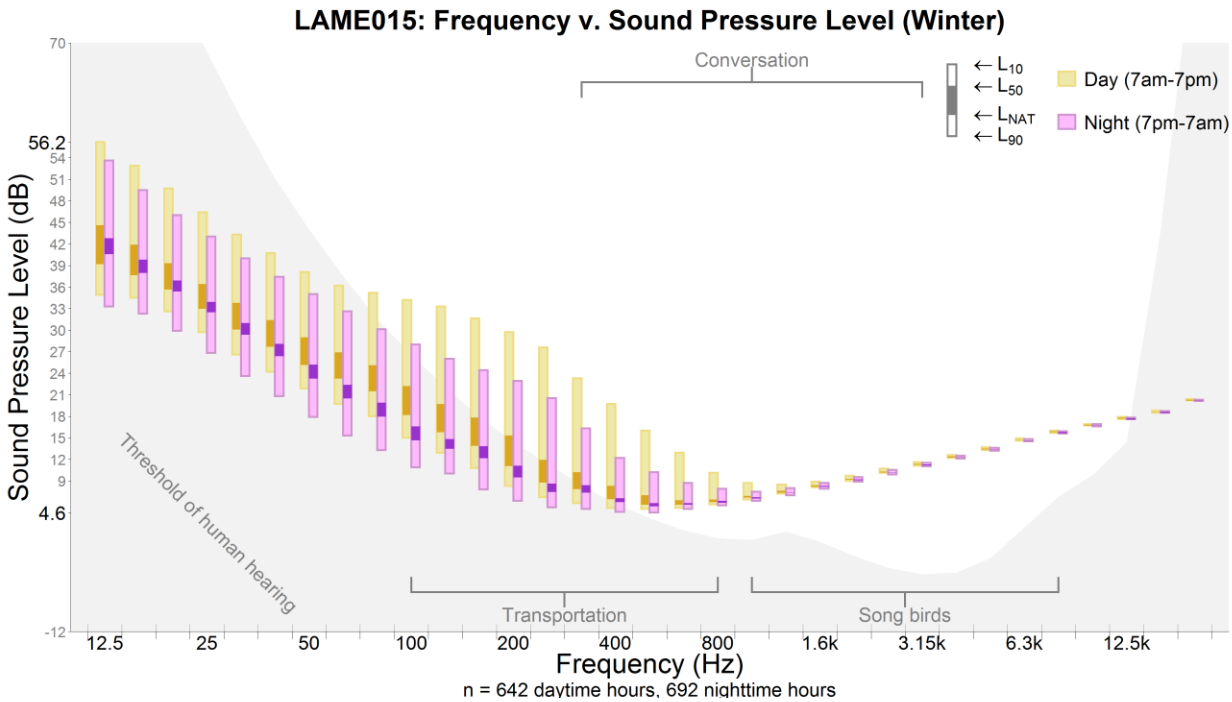

Figure 71. Day/night dB levels for 33 one-third octave bands, LAME015 Winter (AR22).

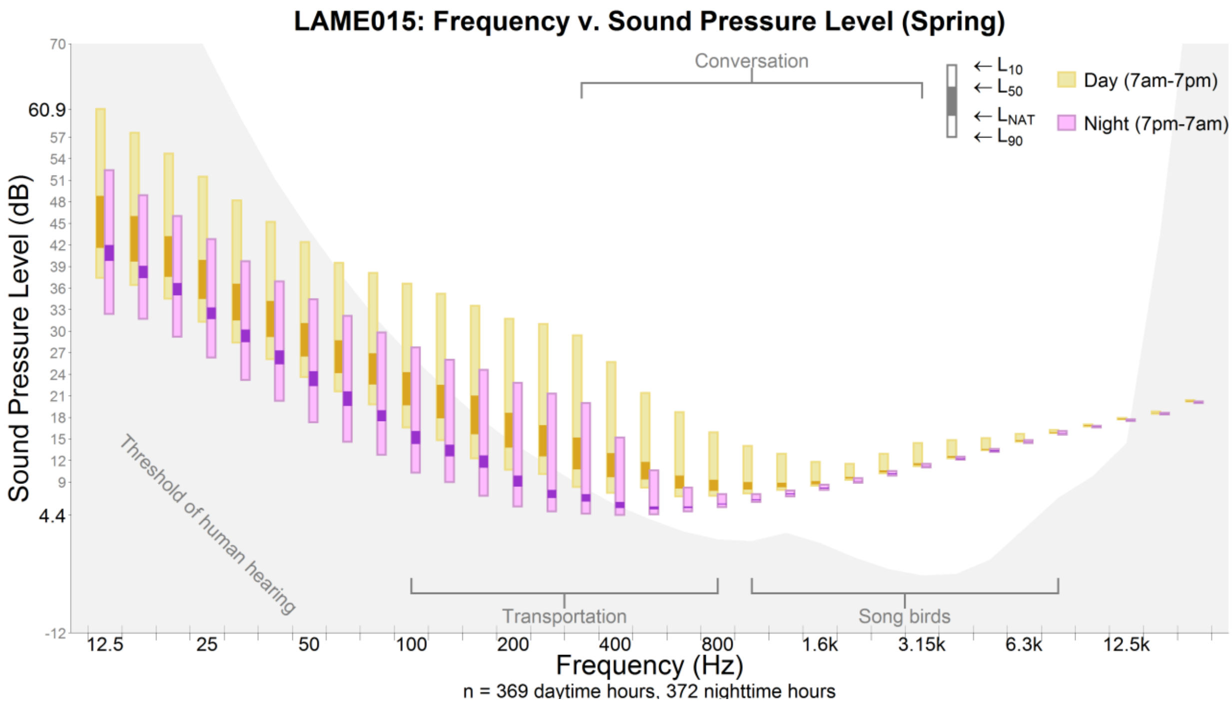

Figure 72. Day/night t dB levels for 33 one-third octave bands, LAME015 Spring (AR22).

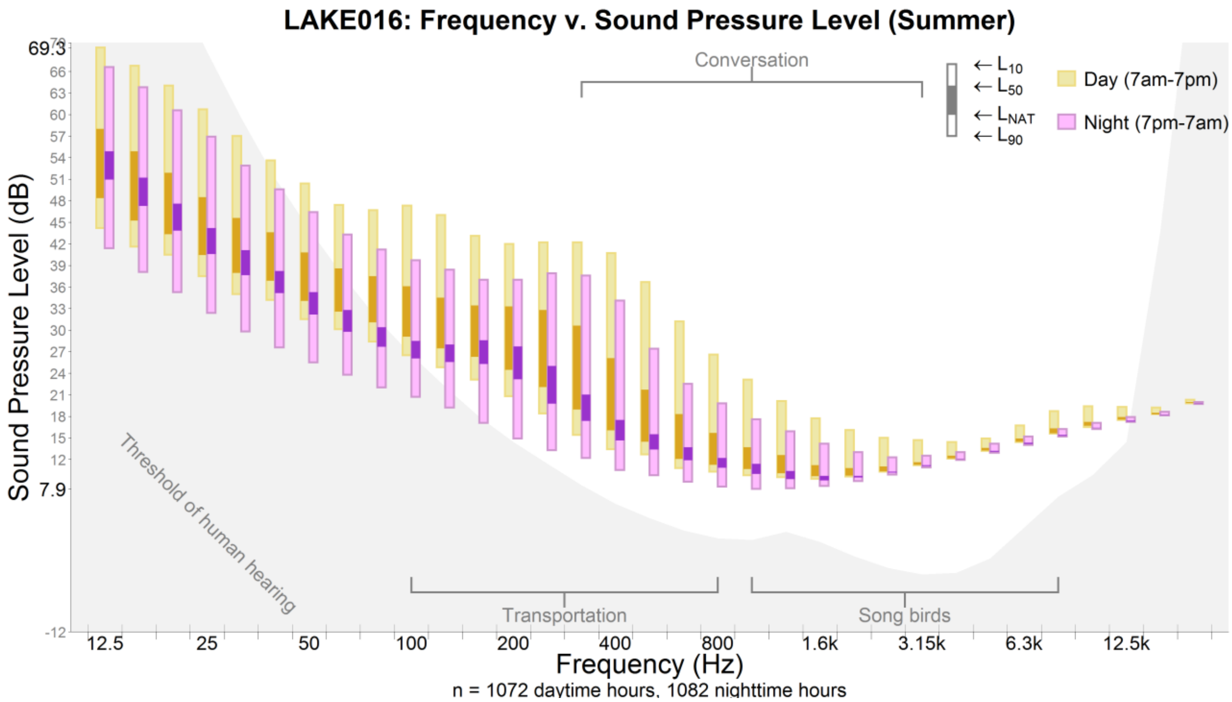

Figure 73. Day/night dB levels for 33 one-third octave bands, LAME016 Summer (AR136 Gregg's Hide-Out).

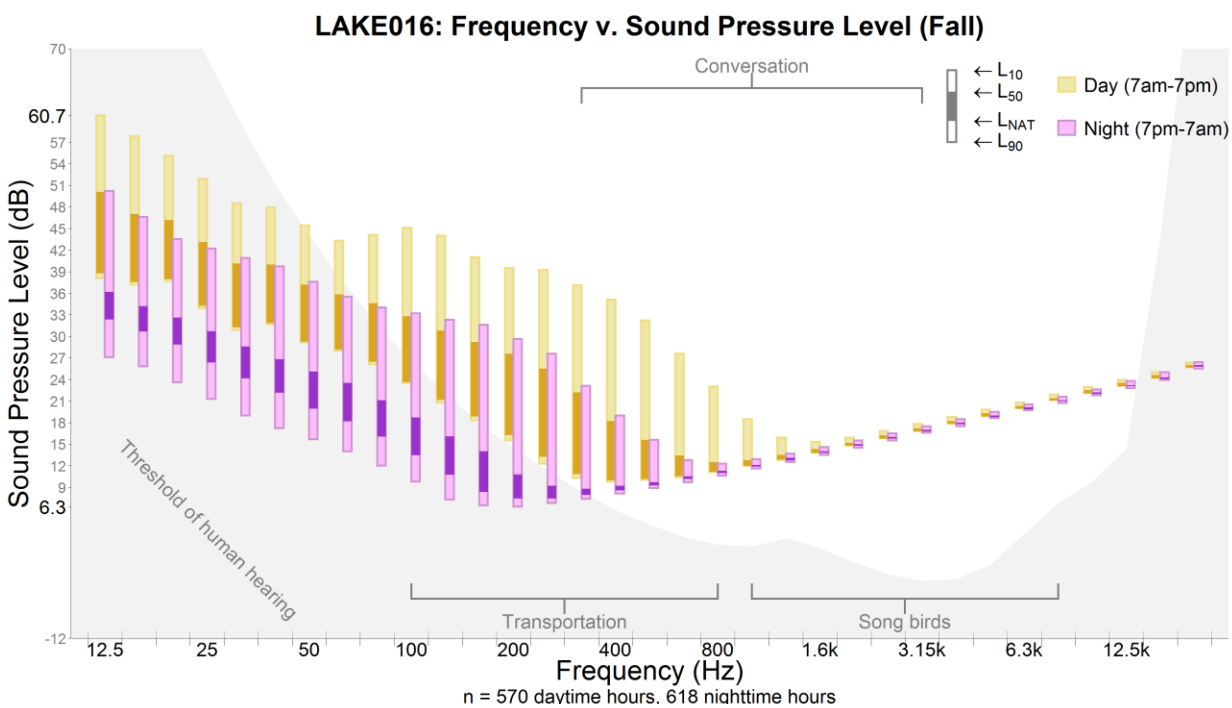

Figure 74. Day/night dB levels for 33 one-third octave bands, LAME016 Fall (AR136 Gregg's Hide-Out).

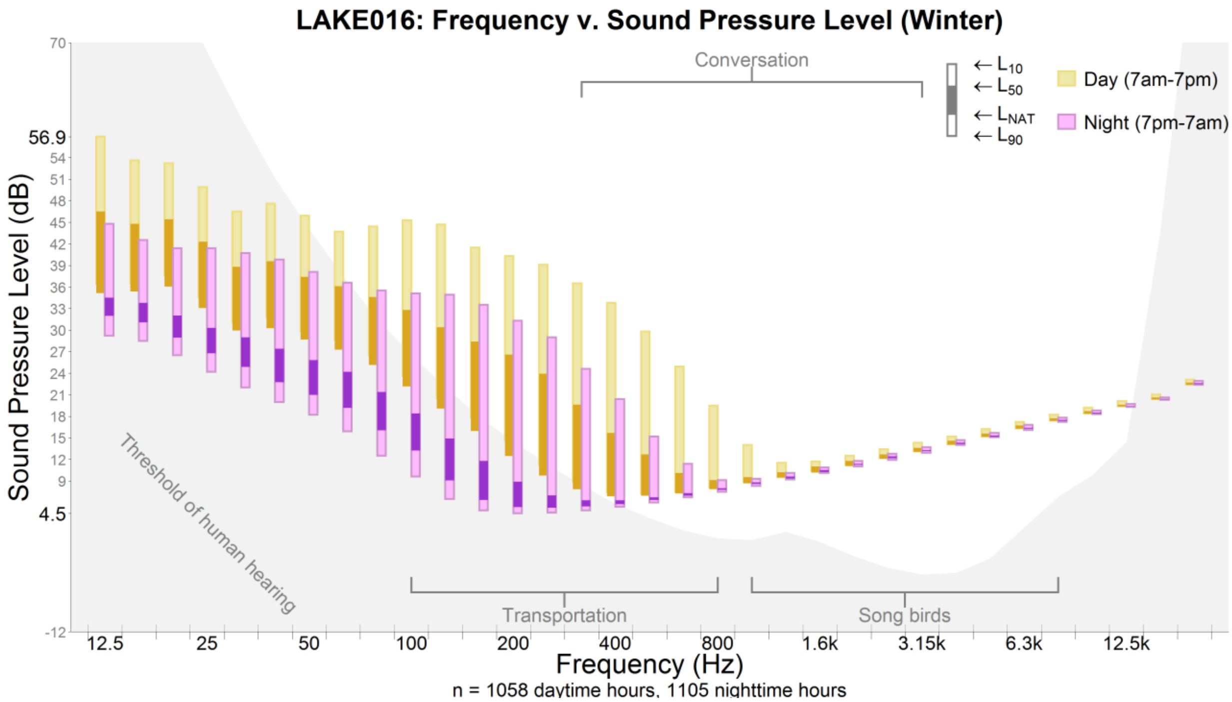

Figure 75. Day/night dB levels for 33 one-third octave bands, LAME016 Winter (AR136 Gregg's Hide-Out).

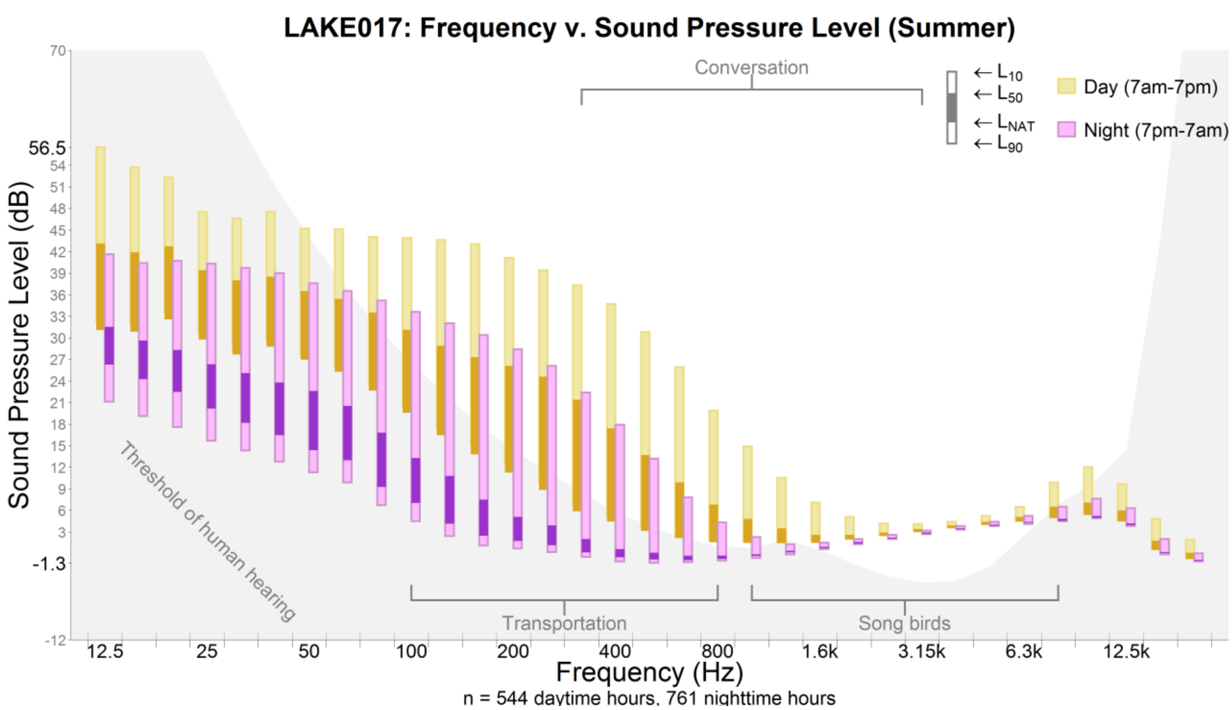

Figure 76. Day/night dB levels for 33 one-third octave bands, LAME017 Summer (AR97 Boathouse Cove Road).

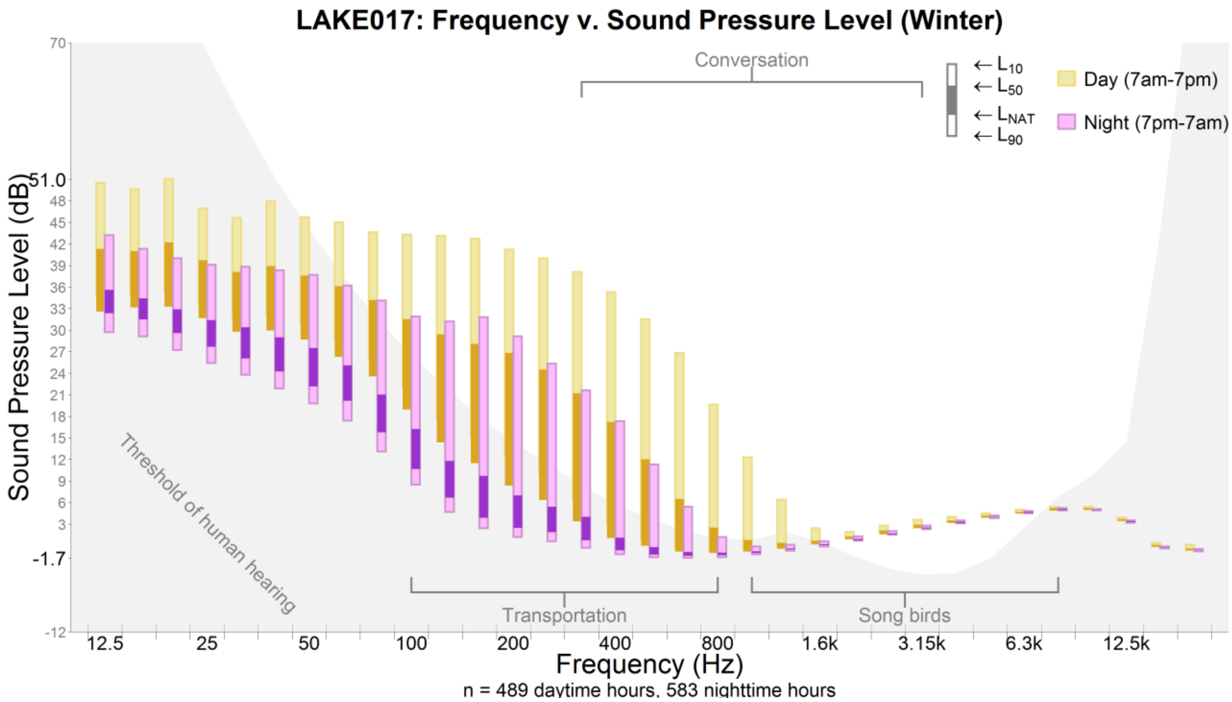

Figure 77. Day/night dB levels for 33 one-third octave bands, LAME017 Winter (AR97 Boathouse Cove Road).

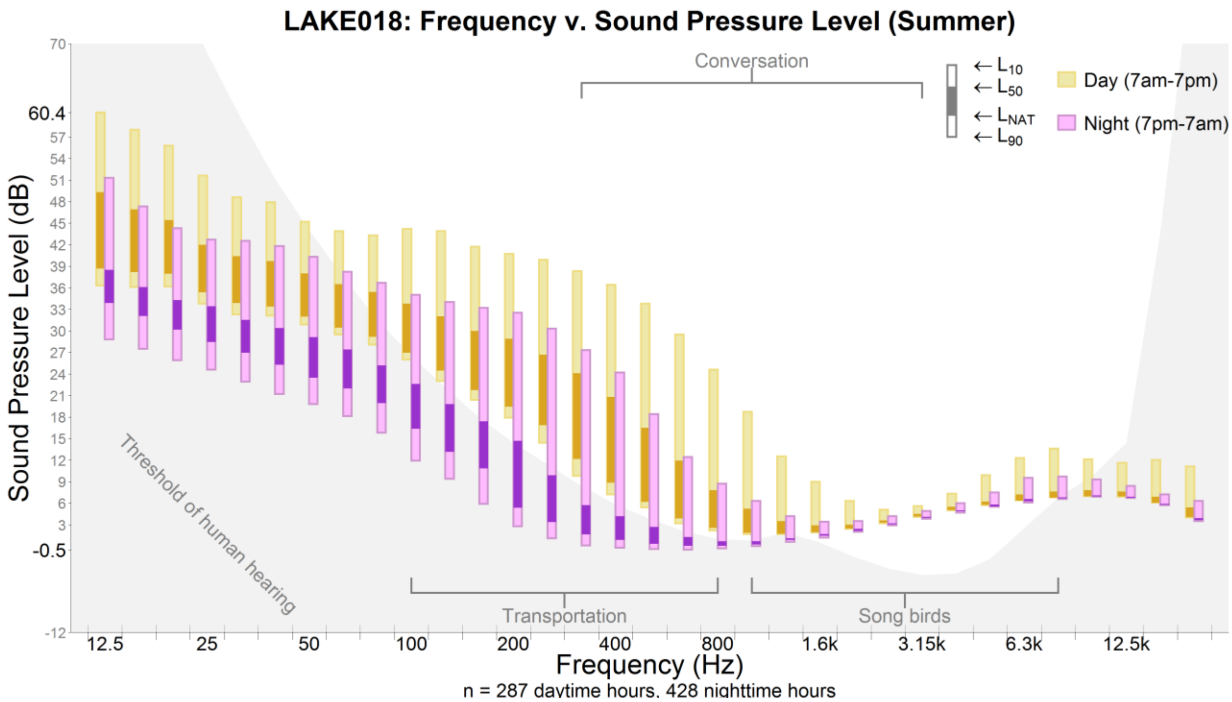

Figure 78. Day/night dB levels for 33 one-third octave bands, LAME018 Summer (Temple Bar Area).

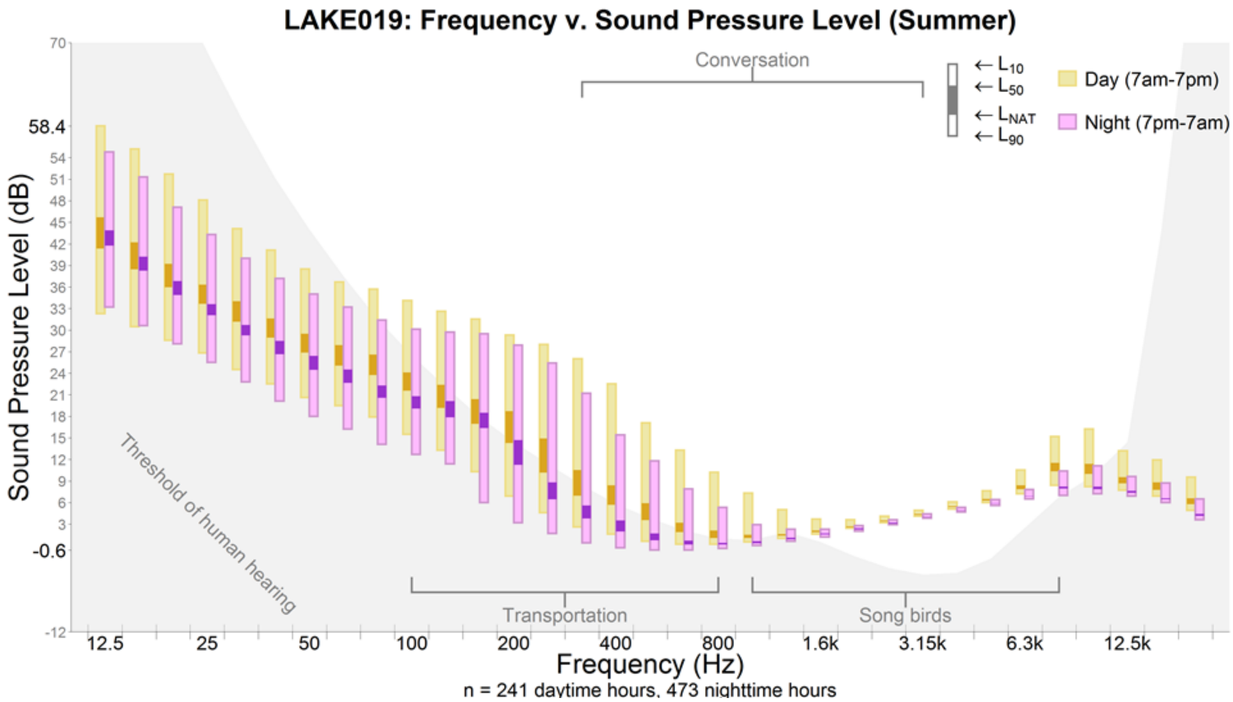

Figure 79. Day/night dB levels for 33 one-third octave bands, LAME019 Summer (AR30).

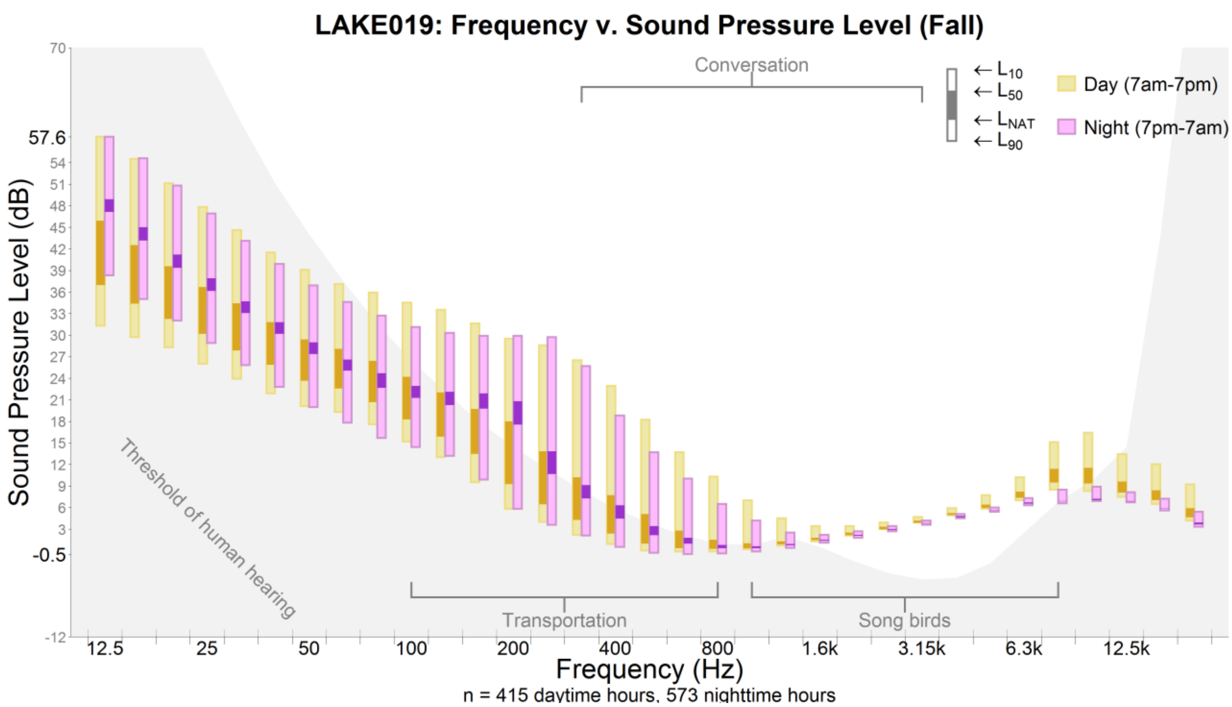

Figure 80. Day/night dB levels for 33 one-third octave bands, LAME019 Fall (AR30).

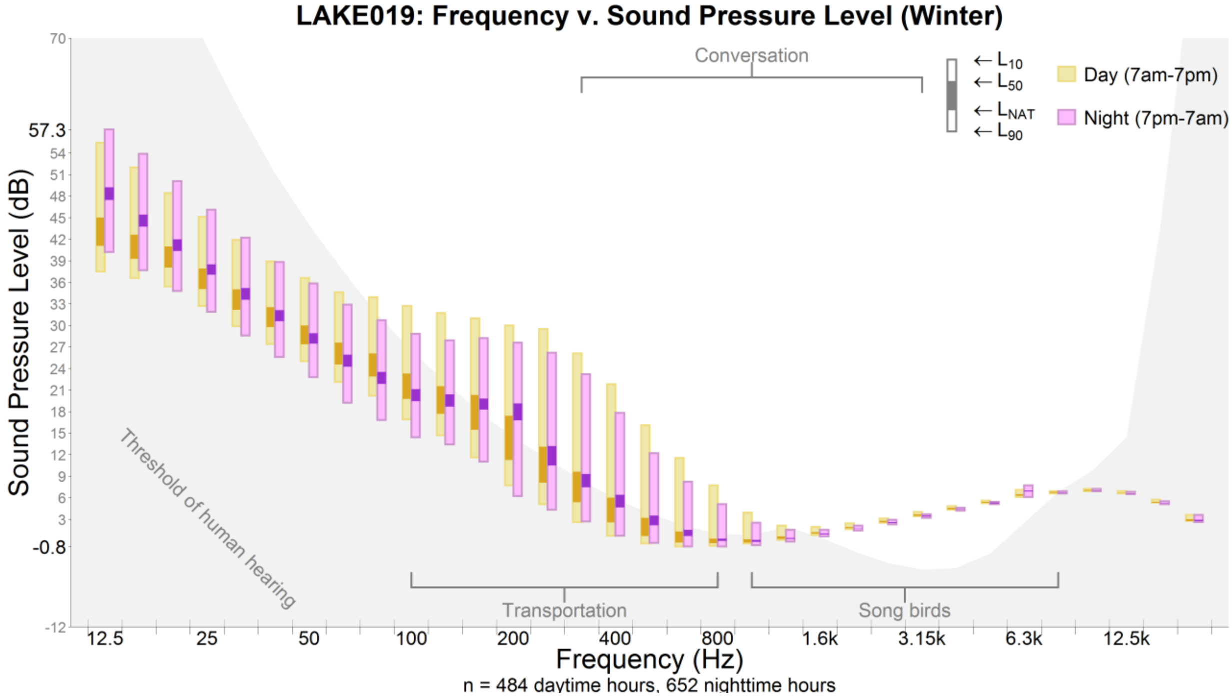

Figure 81. Day/night dB levels for 33 one-third octave bands, LAME019 Winter (AR30).

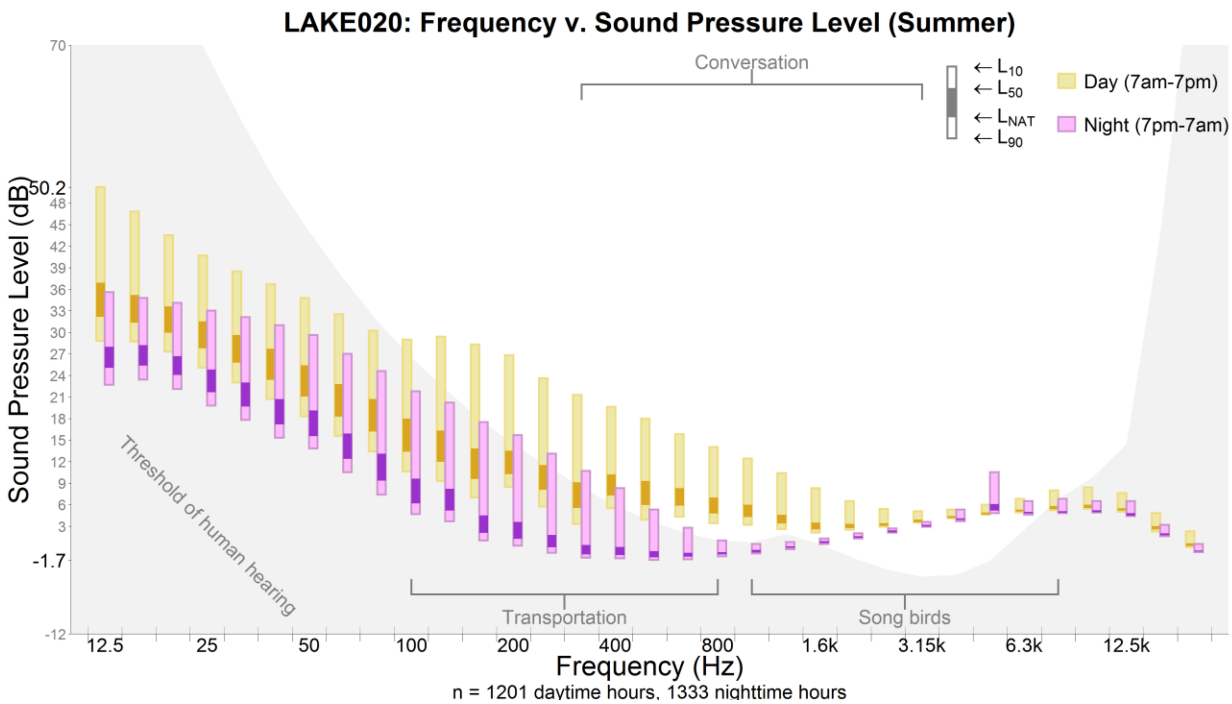

Figure 82. Day/night dB levels for 33 one-third octave bands, LAME020 Summer (AR18).

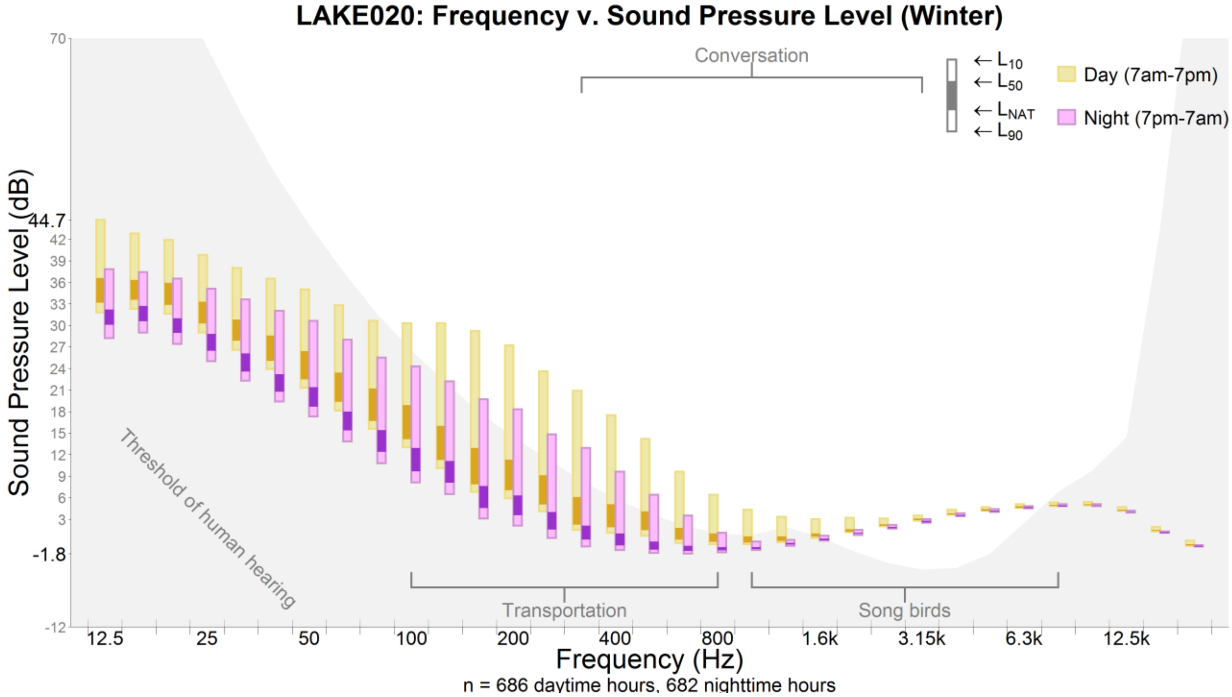

Figure 83. Day/night dB levels for 33 one-third octave bands, LAME020 Winter (AR18).

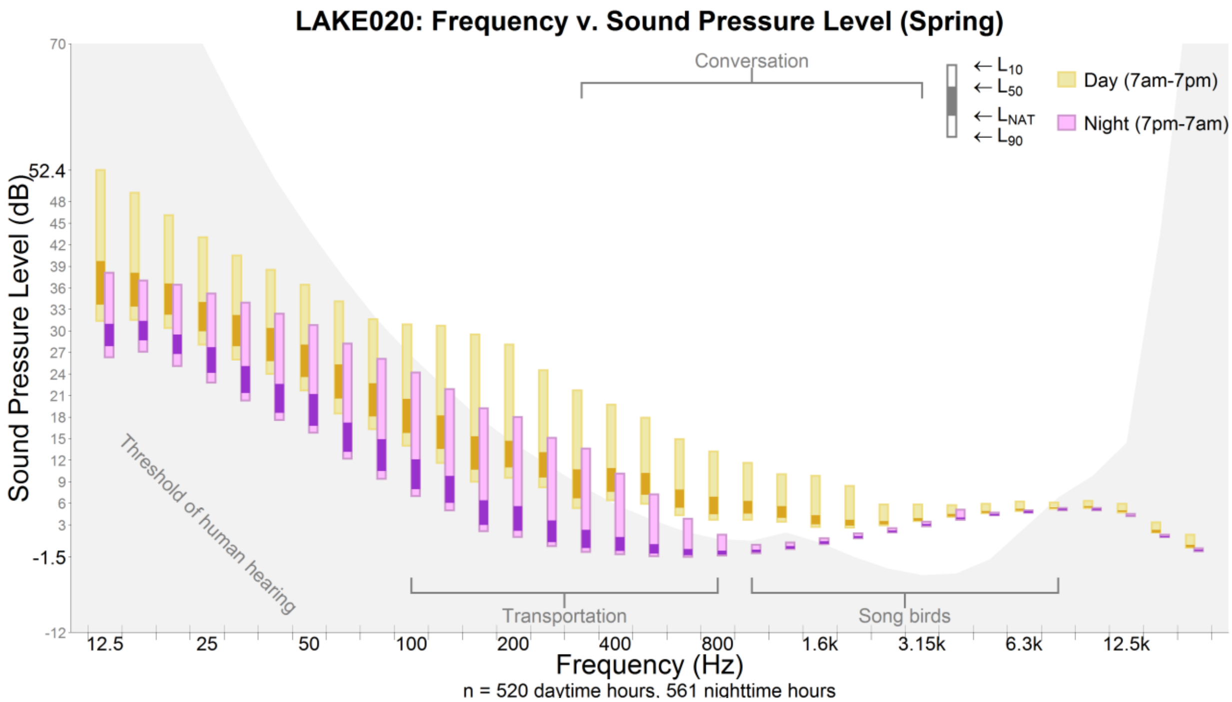

Figure 84. Day/night dB levels for 33 one-third octave bands, LAME020 Spring (AR18).

Existing Ambient

Figure 85 - Figure 121 illustrate the variation in natural ambient dB across all frequencies by hour. Darker shades denote lower dB values while lighter shades denote higher dB values. The onset of loud low frequency sounds reflects increased aircraft activity as well as an increase in intrinsic sounds such as wind.

For example, Figure 85 for LAME007 (Summer) shows an increase in sound around 0630, which represents aircraft overflight activity that occurs throughout the day light hours.

Figure 85 - Figure 121 are very similar in shape, showing an increase in sound during the middle of the day for most sites. LAME009 (Figure 87- Figure 89) has a larger orange contour than the other sites. This is an indication of the increased overflight activity at this site.

Additionally, the contour plots for LAME011 (Figure 94-Figure 98) are slightly different from the other sites, when focusing on the high frequency portion of the plot. From off-site listening, we determined that the orange band at the 5K Hz frequency represents the sounds of birds and insects during the morning and late night hours.

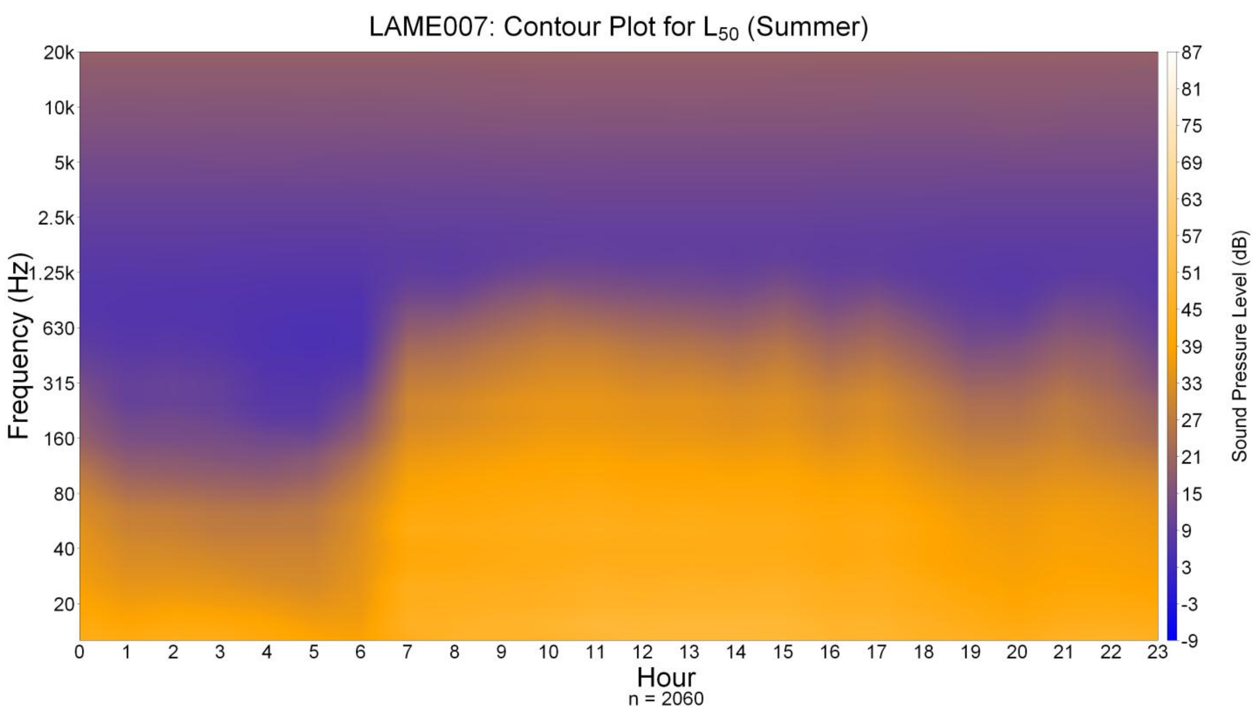

Figure 85. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME007 Summer (Indian Pass).

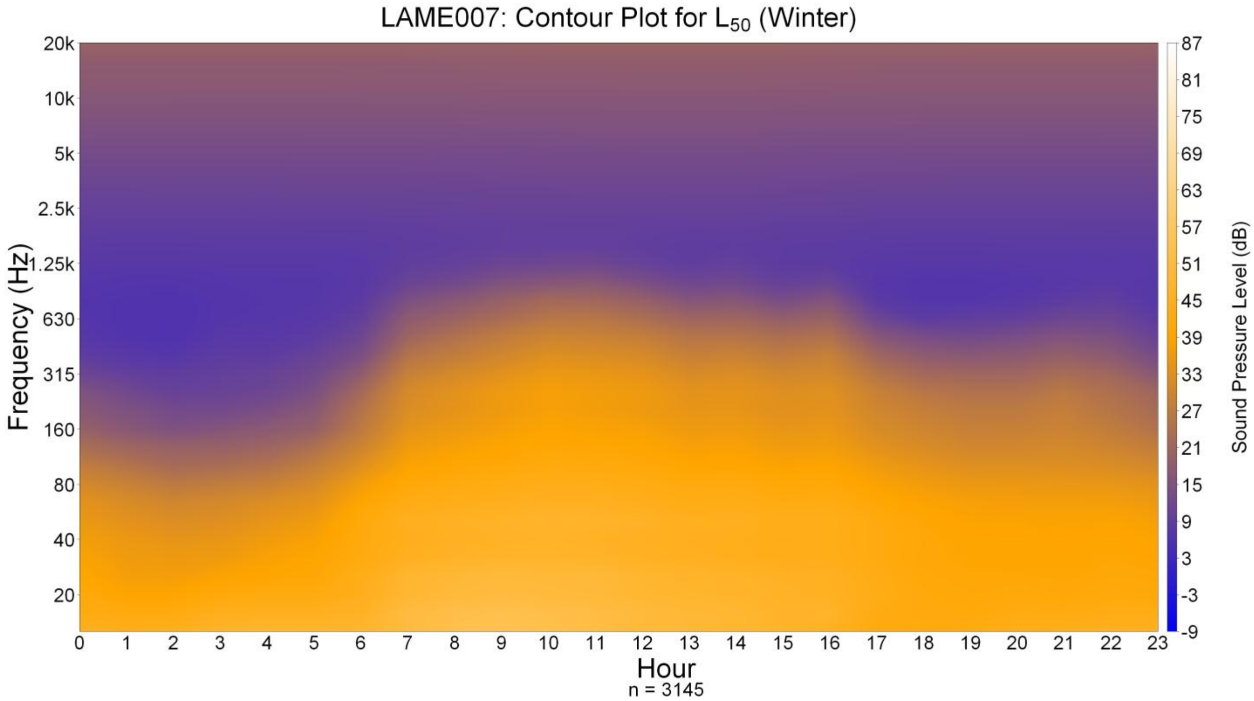

Figure 86. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME007 Winter (Indian Pass).

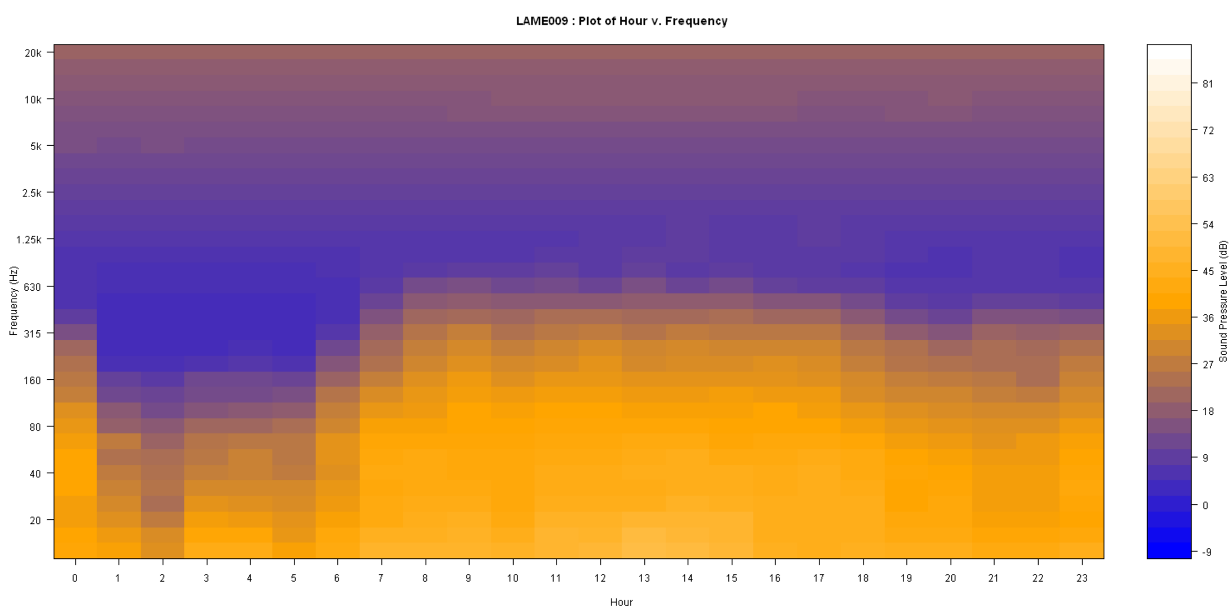

Figure 87. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME009 (Original, 2007, Callville Wash).

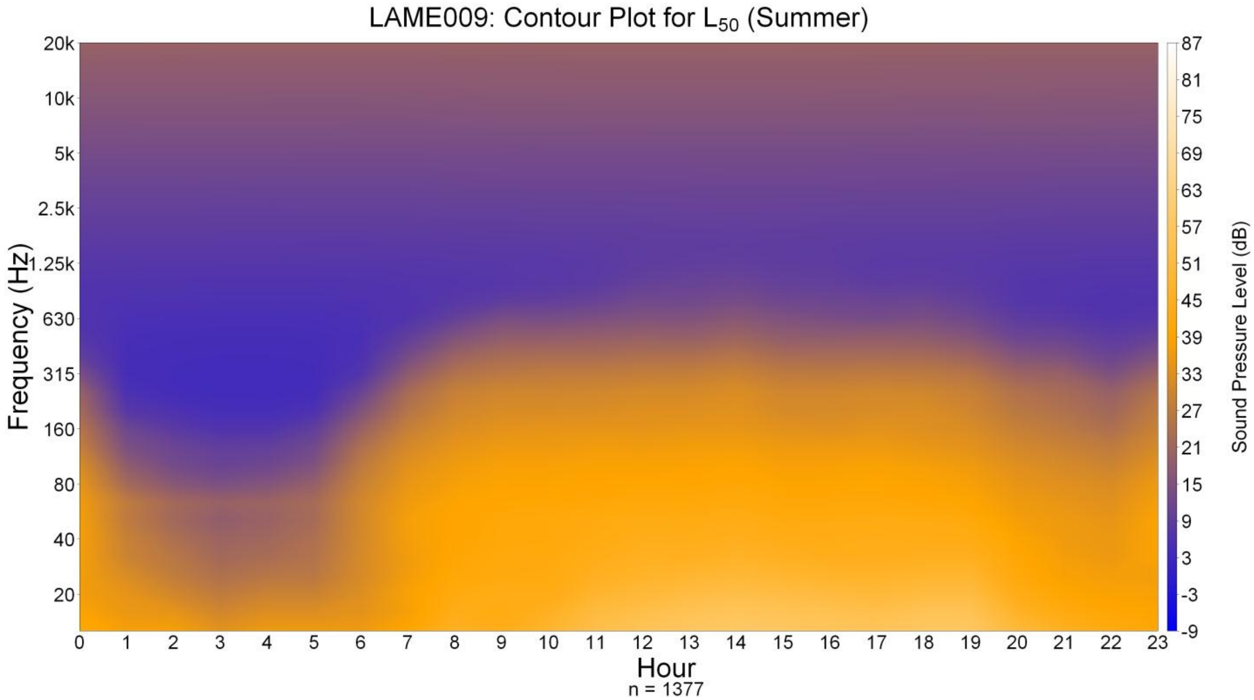

Figure 88. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME009 Summer (Callville Wash).

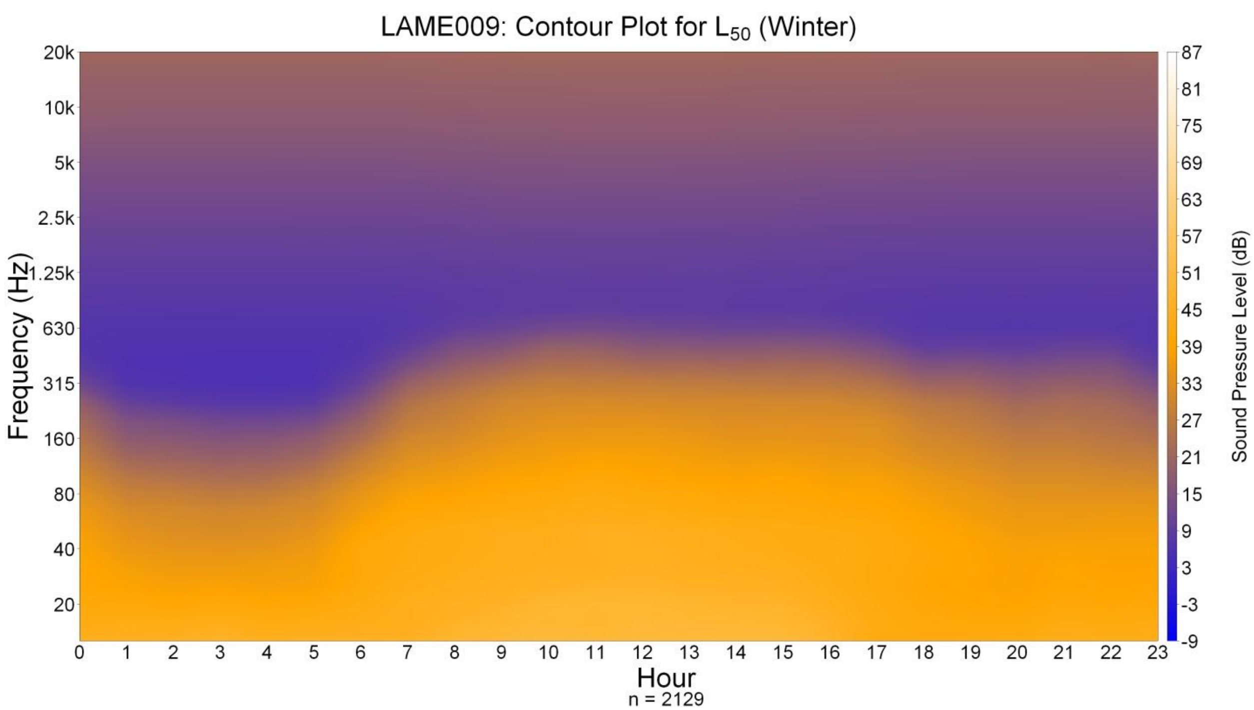

Figure 89. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME009 Winter (Callville Wash).

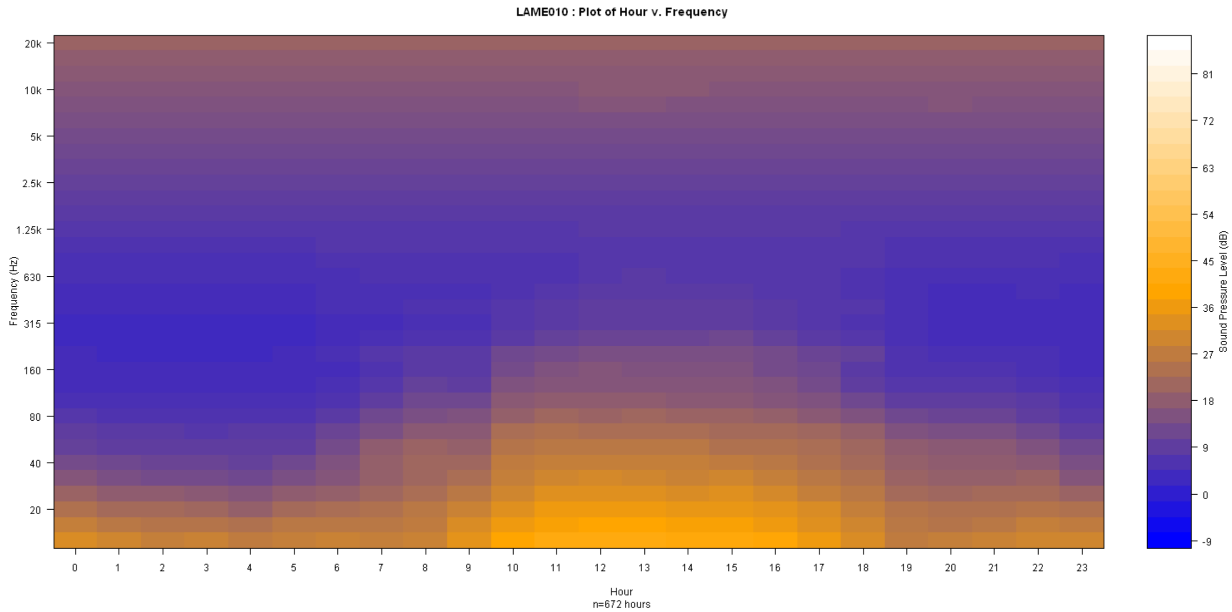

Figure 90. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME010 (Original. 2007, AR42B).

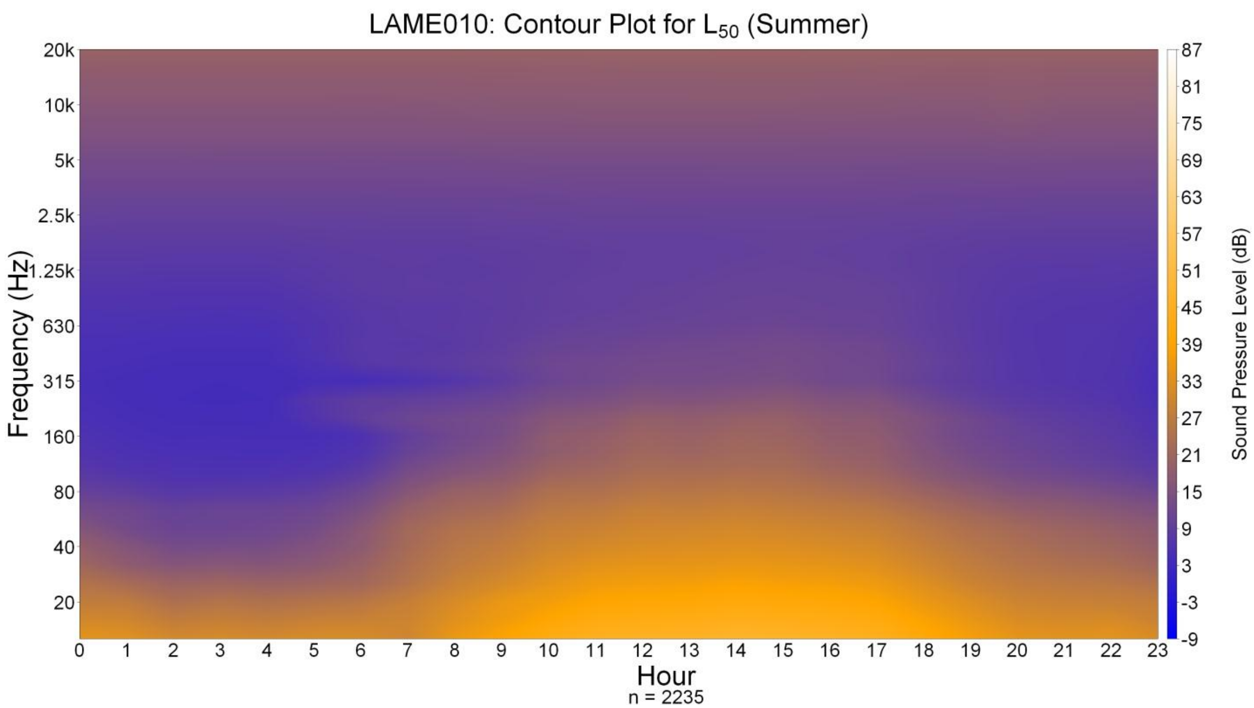

Figure 91. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME010 Summer (AR42B).

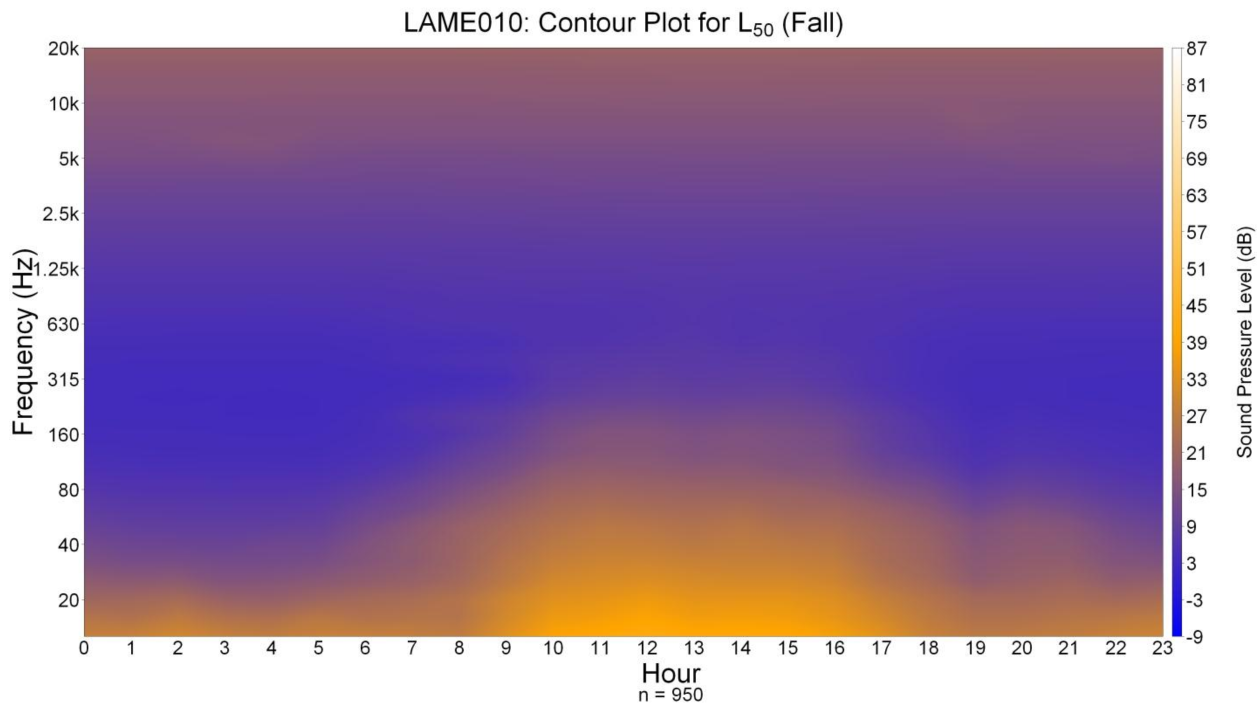

Figure 92. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME010 Fall (AR42B).

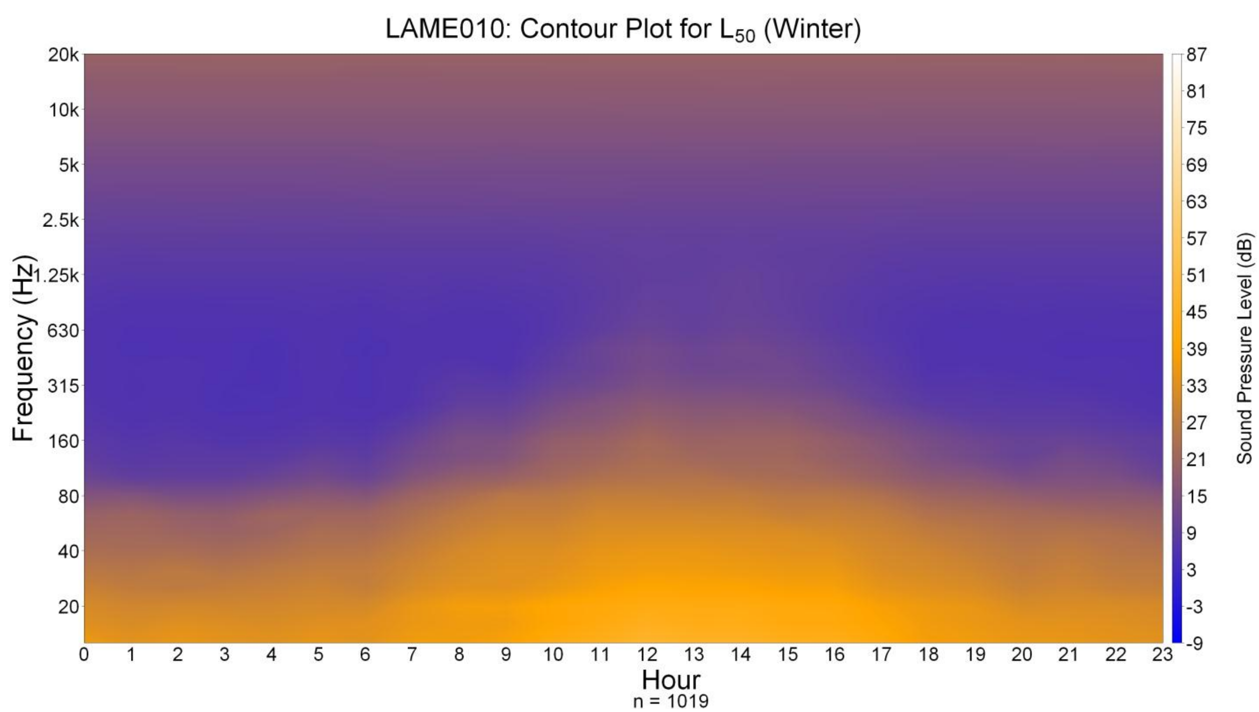

Figure 93. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME010 Winter (AR42B).

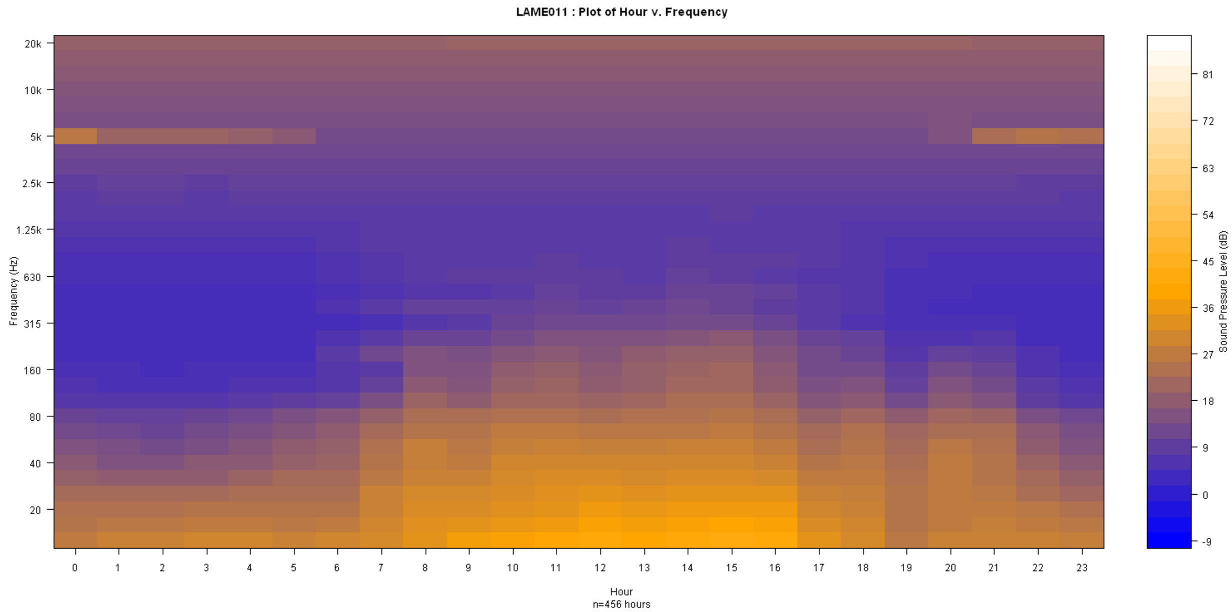

Figure 94. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME011 (Original, 2007, AR20A).

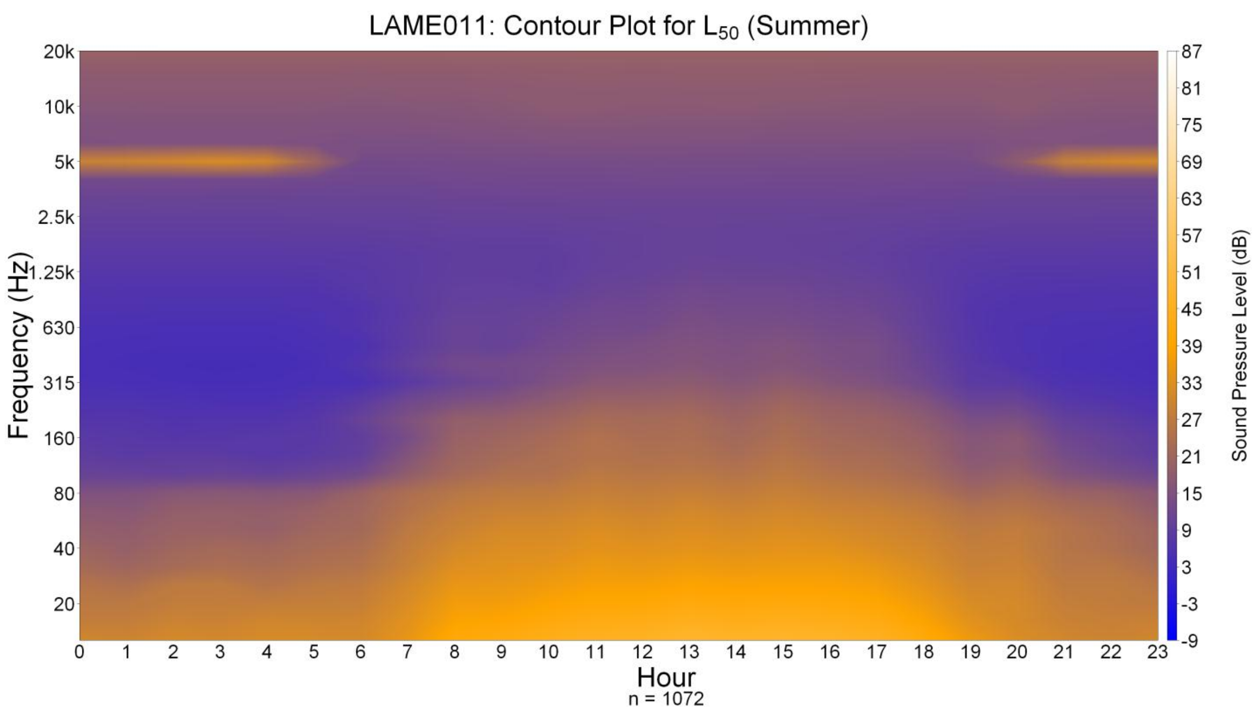

Figure 95. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME011 Summer (AR20A).

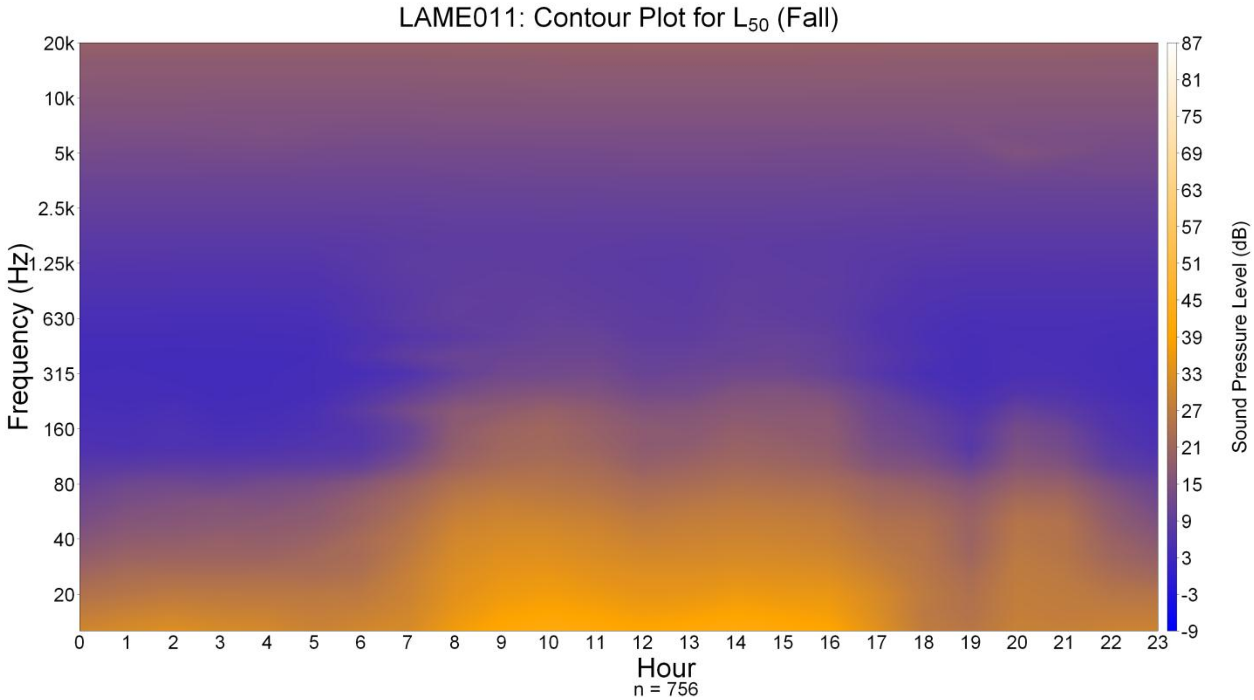

Figure 96. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME011 Fall (AR20A).

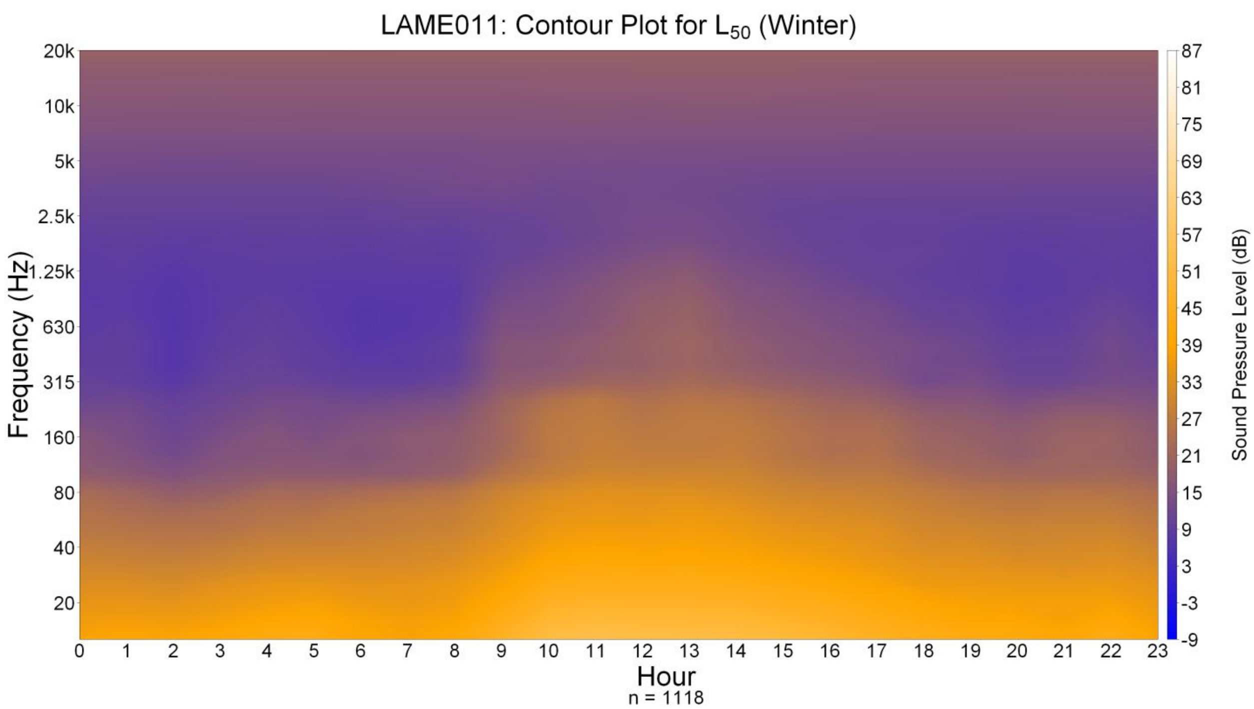

Figure 97. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME011 Winter (AR20A).

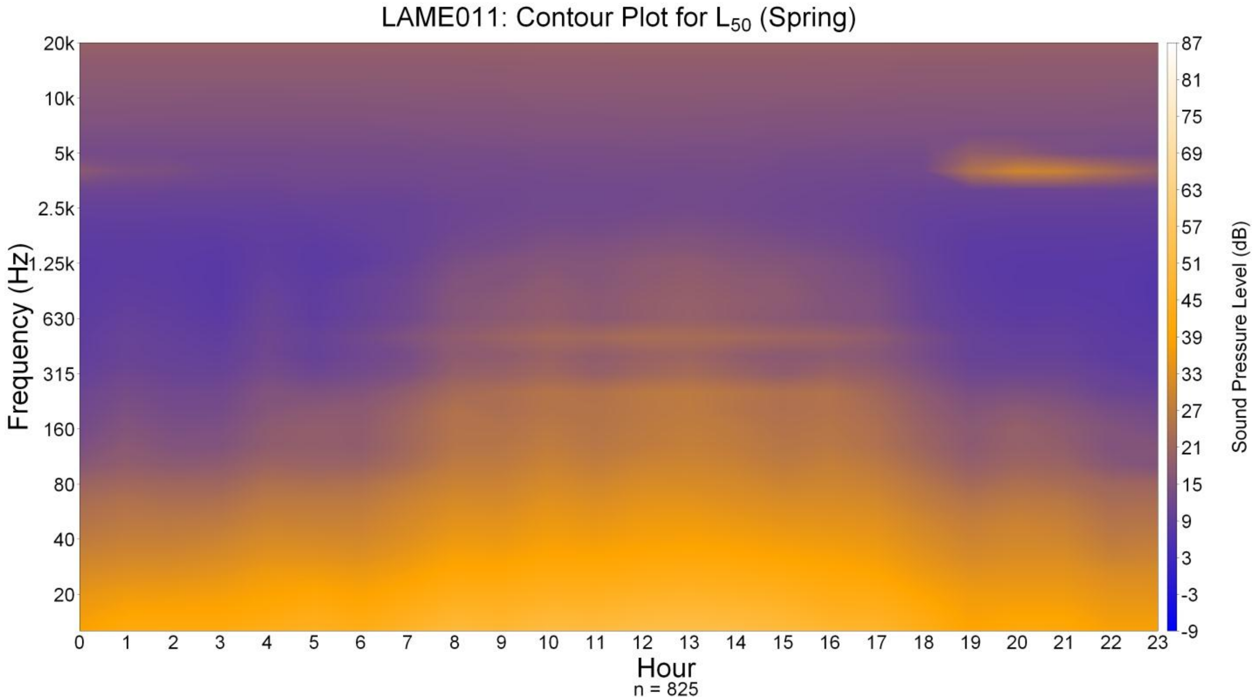

Figure 98. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME011 Spring (AR20A).

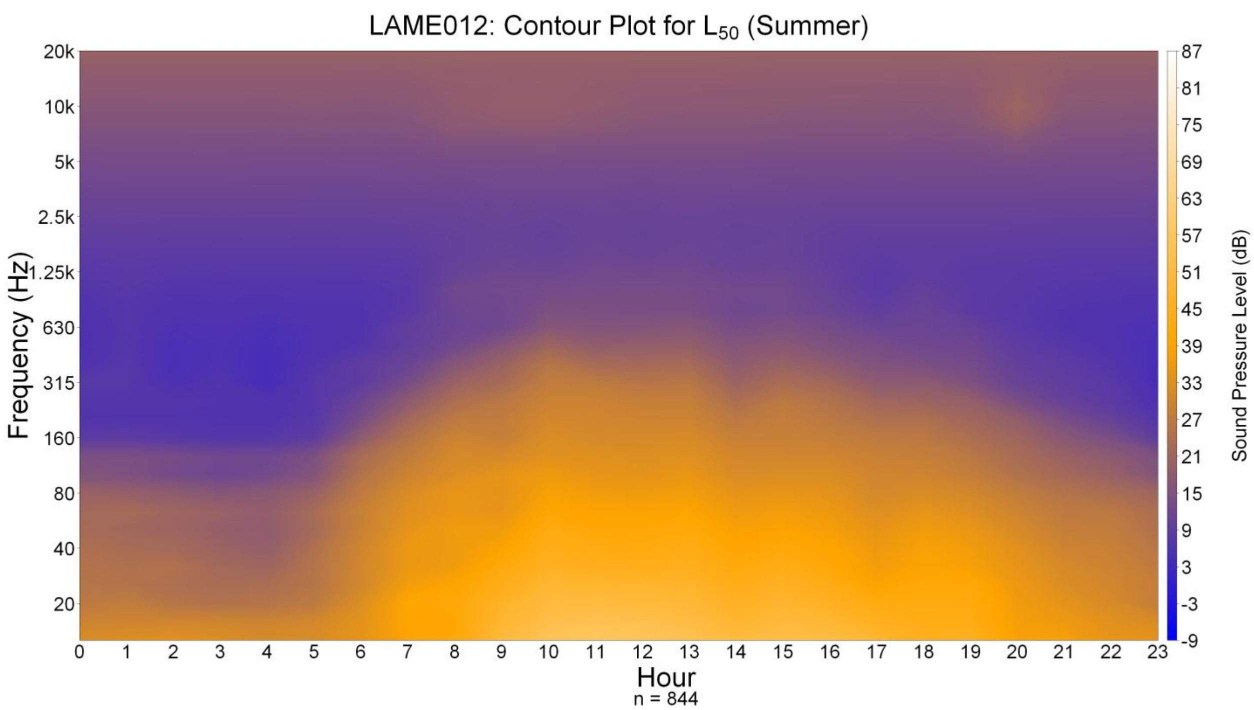

Figure 99. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME012 Summer (AR60 Burro Wash).

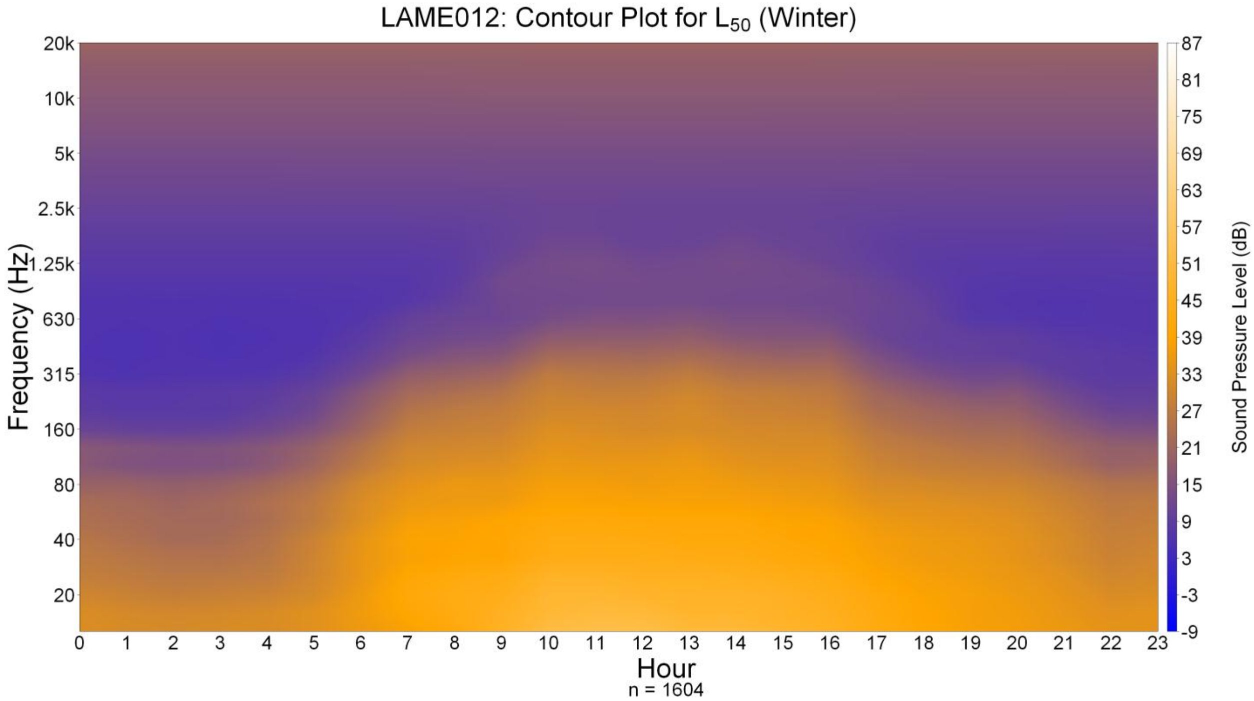

Figure 100. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME012 Winter (AR60 Burro Wash).

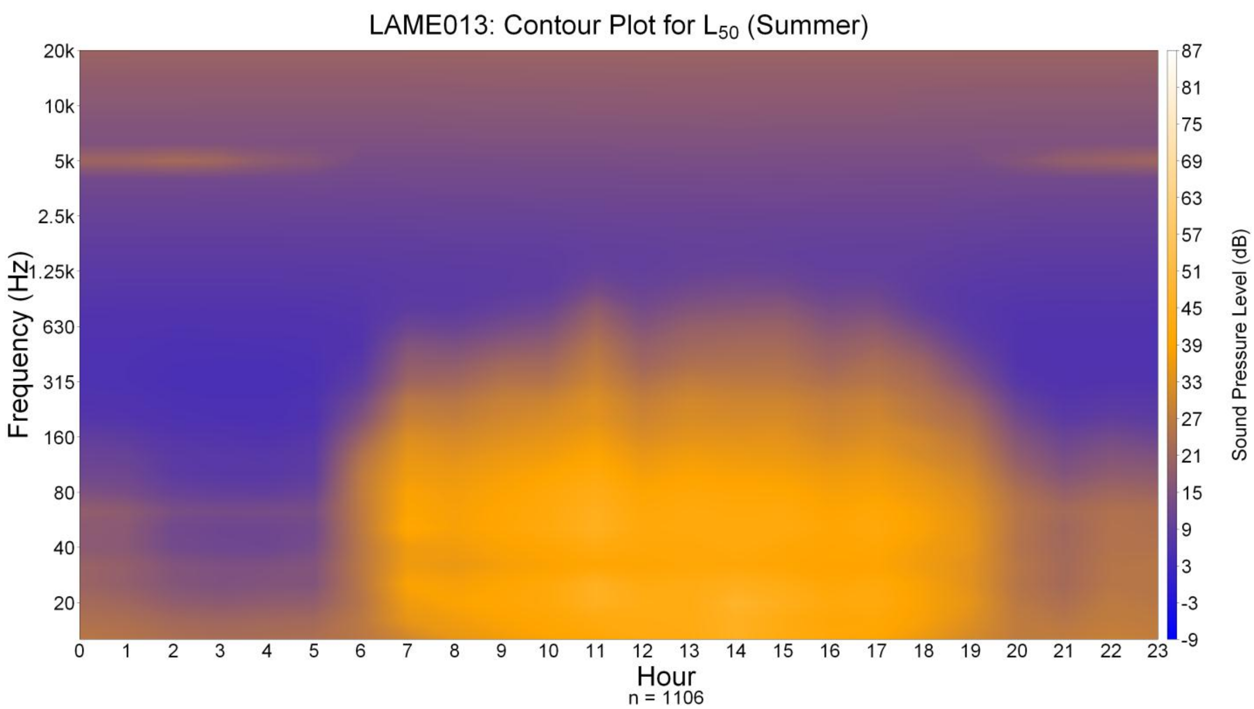

Figure 101. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME013 Summer (Haystacks).

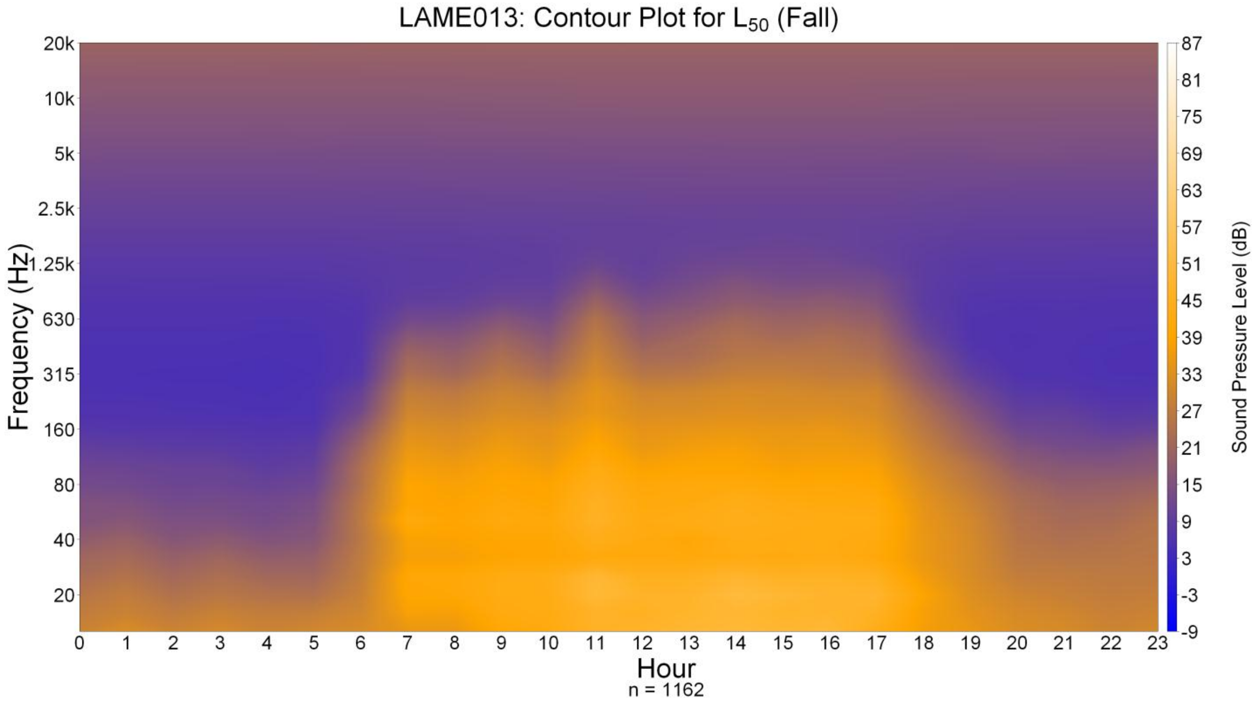

Figure 102. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME013 Fall (Haystacks).

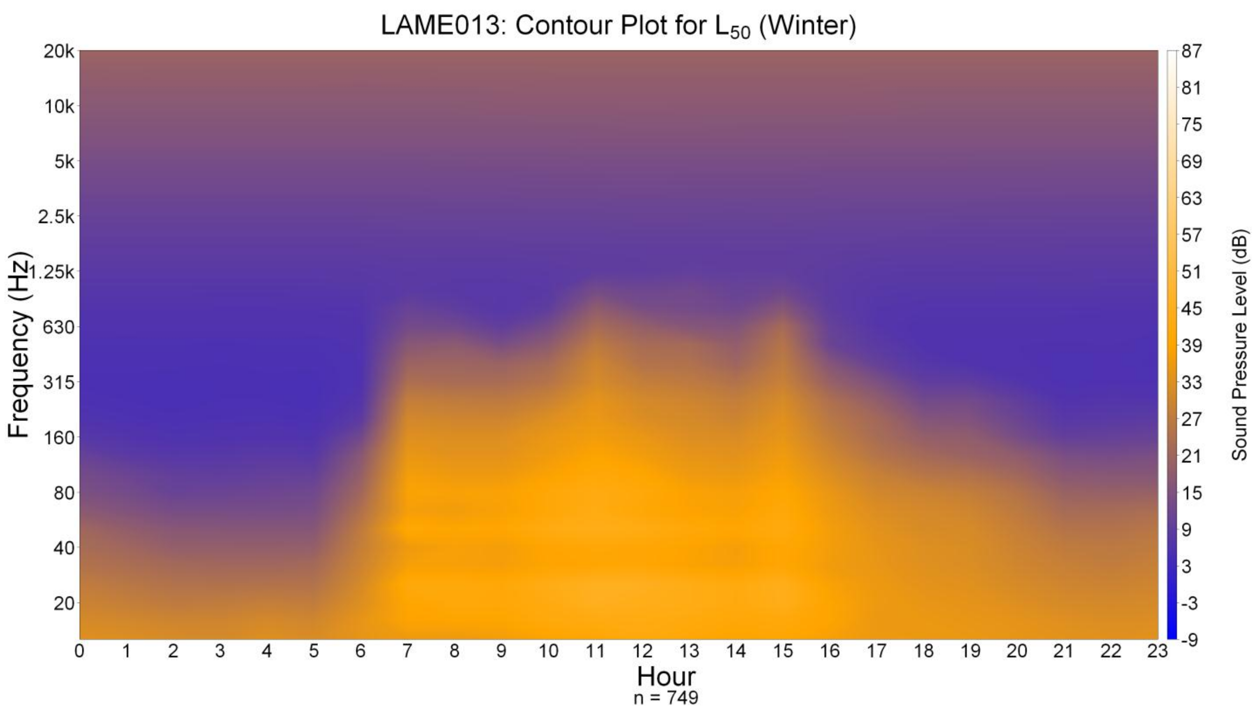

Figure 103. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME013 Winter (Haystacks).

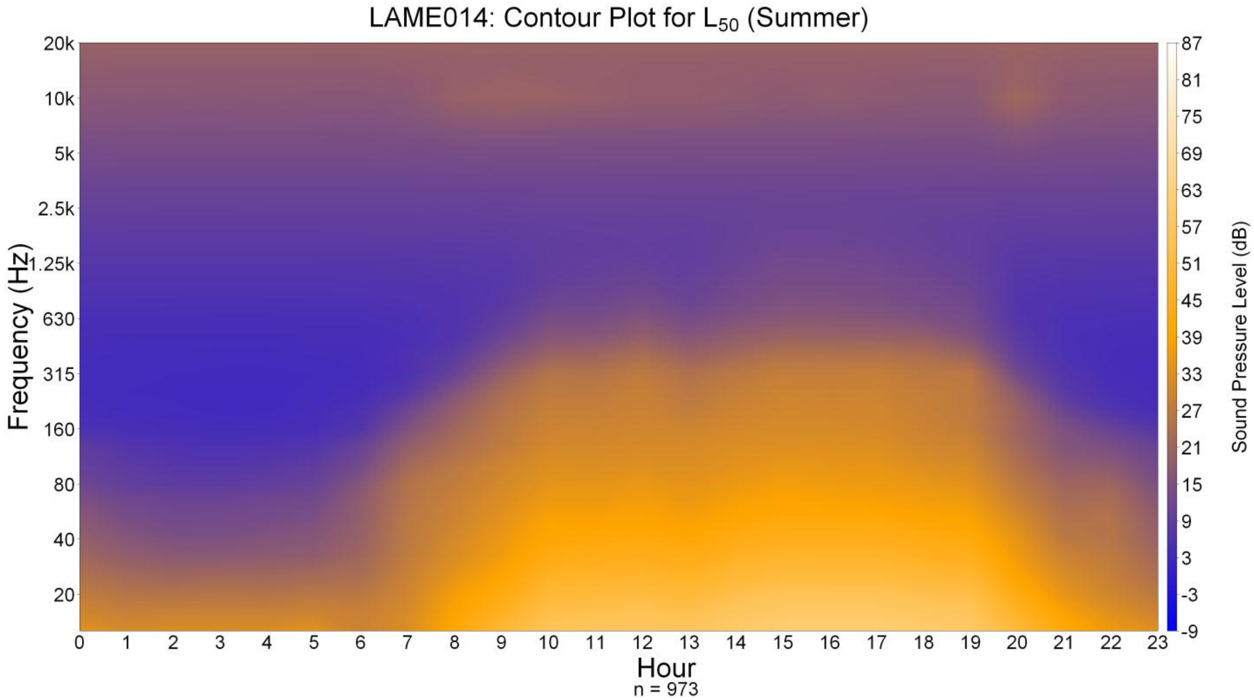

Figure 104. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME014 Summer (AR49).

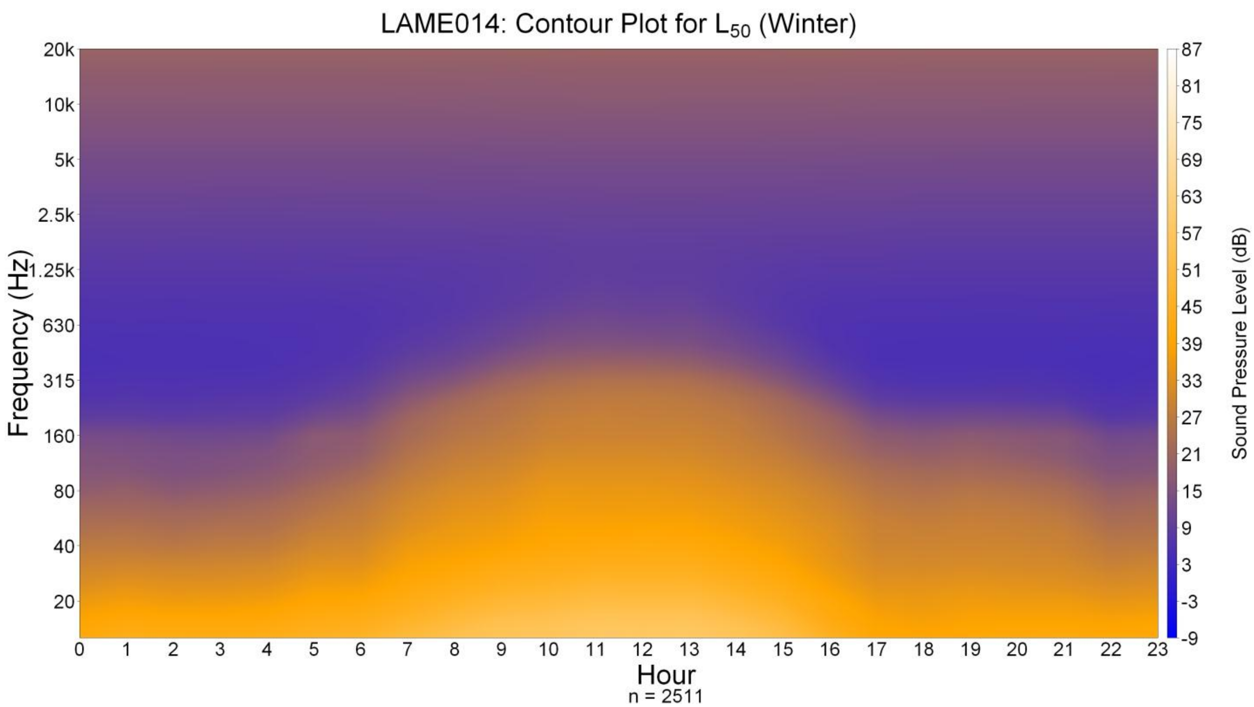

Figure 105. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME014 Winter (AR49).

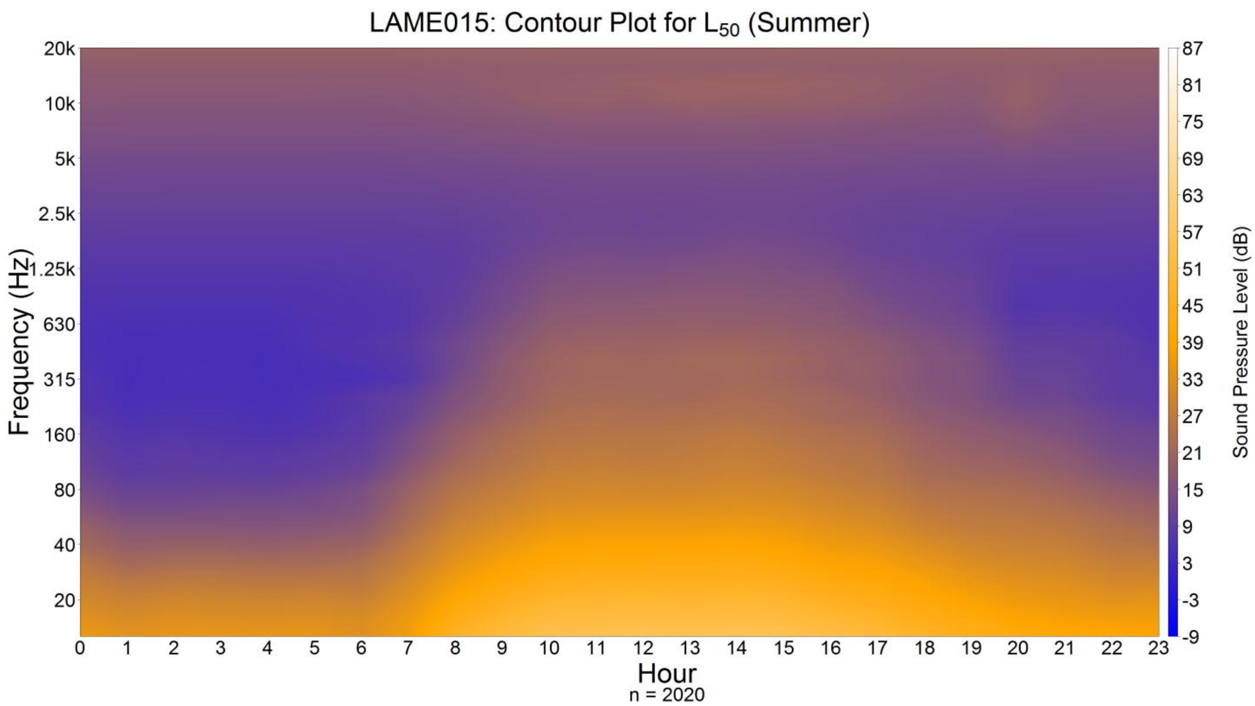

Figure 106. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME015 Summer (AR22).

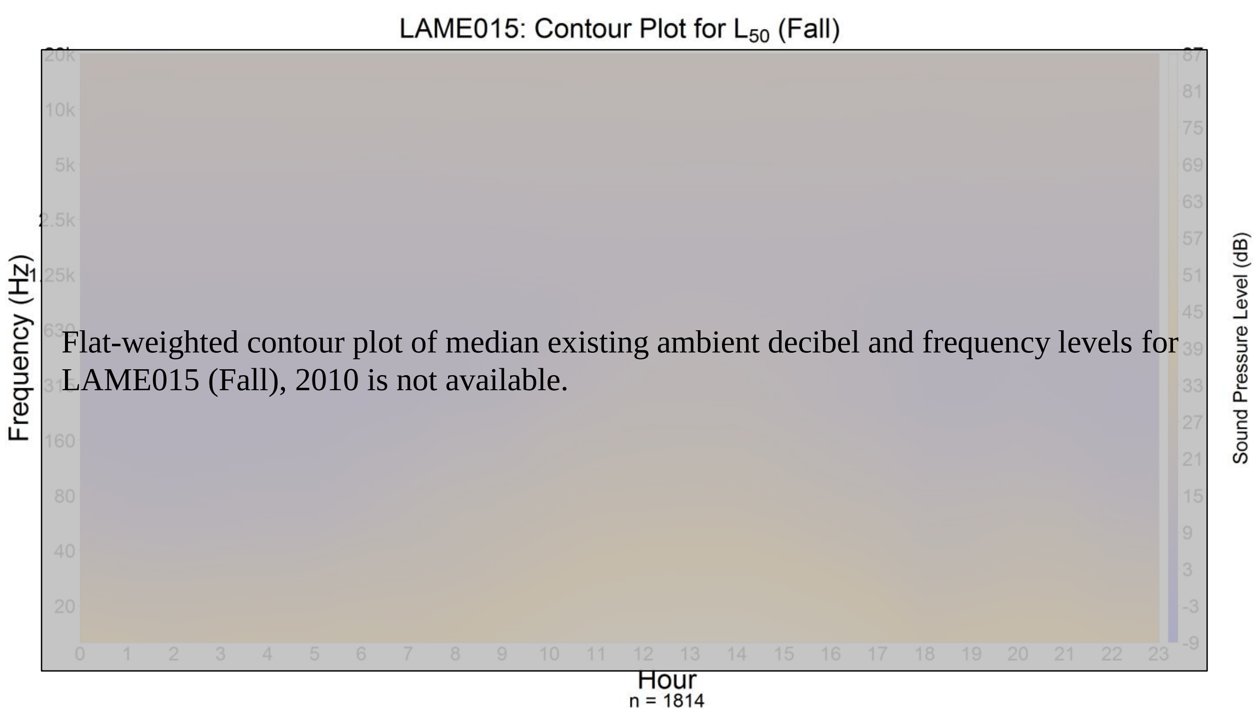

Figure 107. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME015 Fall (AR22).

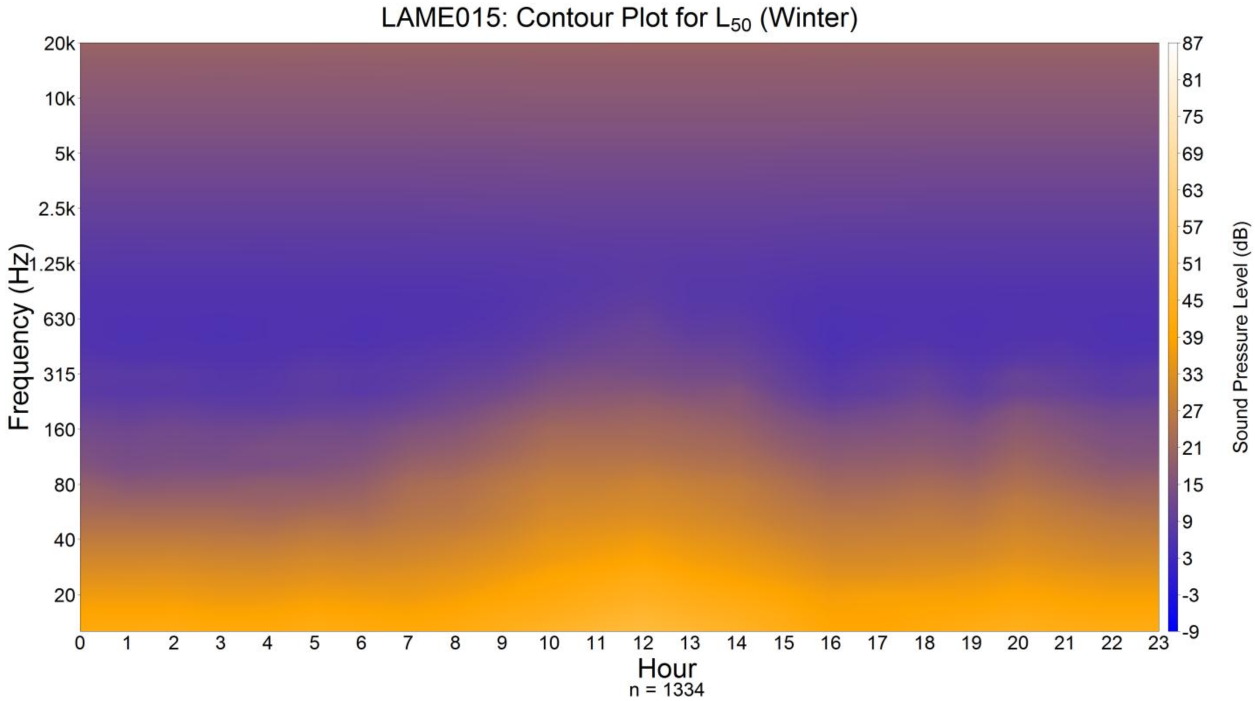

Figure 108. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME015 Winter (AR22).

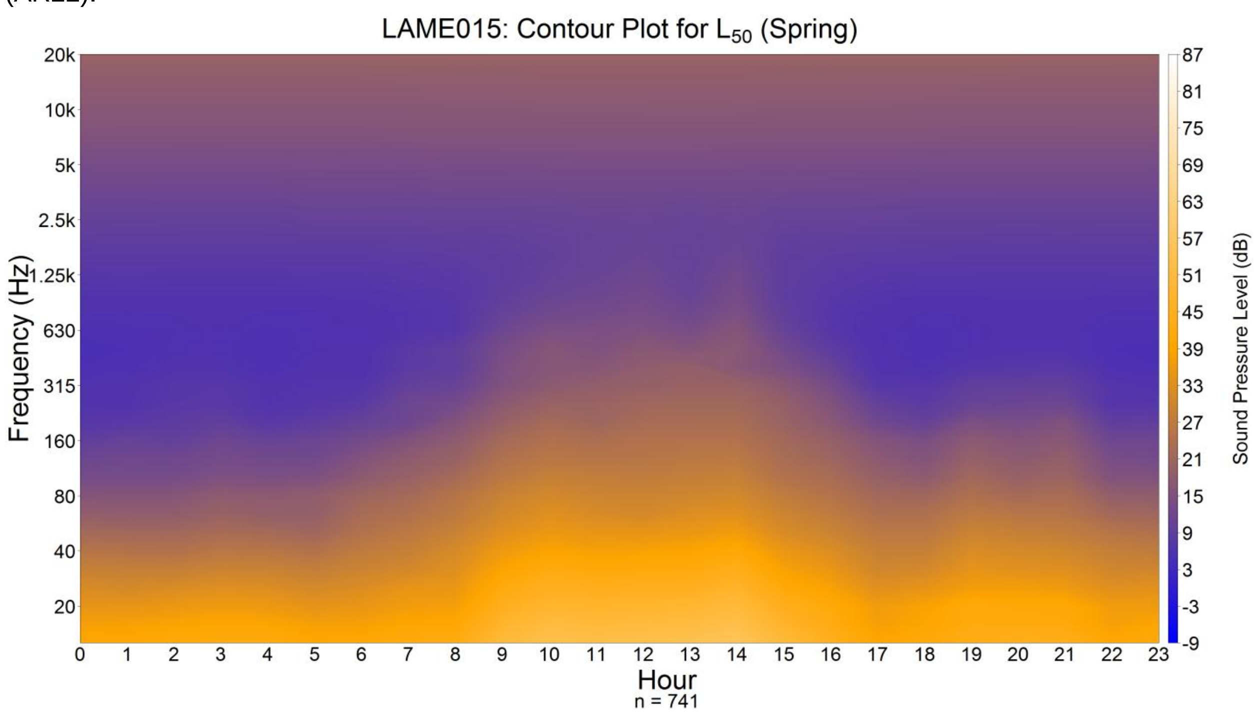

Figure 109. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME015 Spring (AR22).

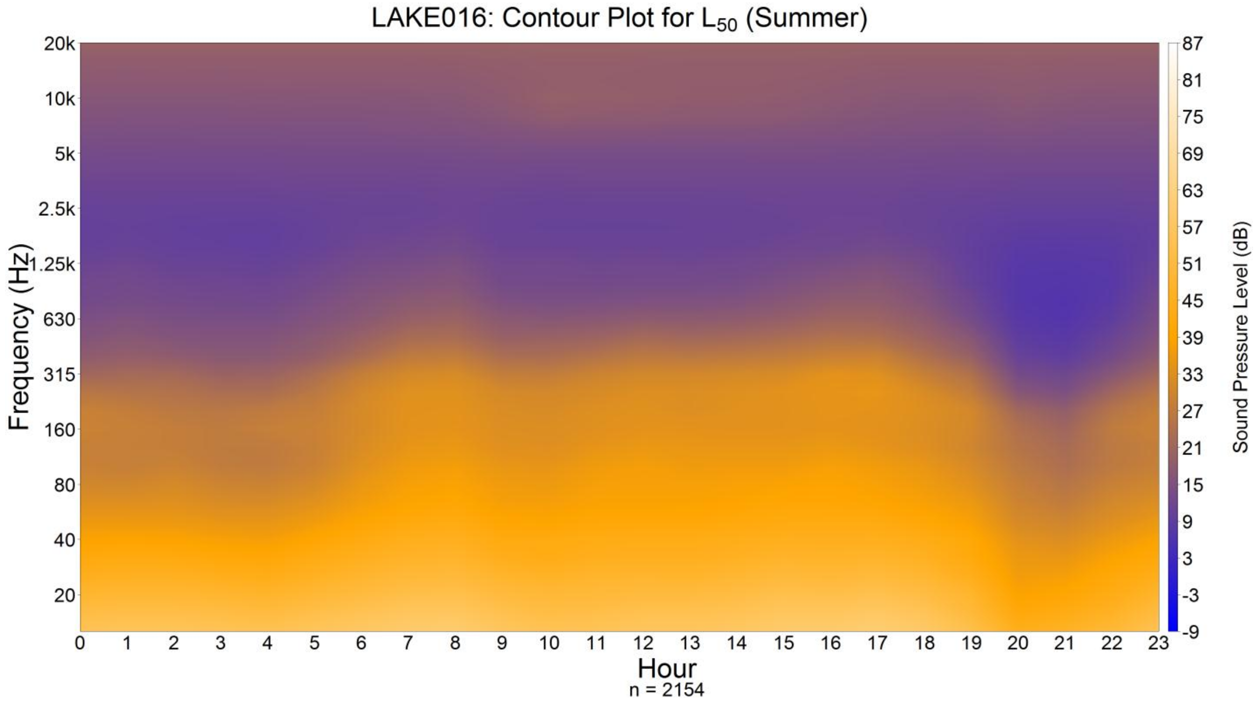

Figure 110. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME016 Summer (AR136 Gregg's Hide-Out).

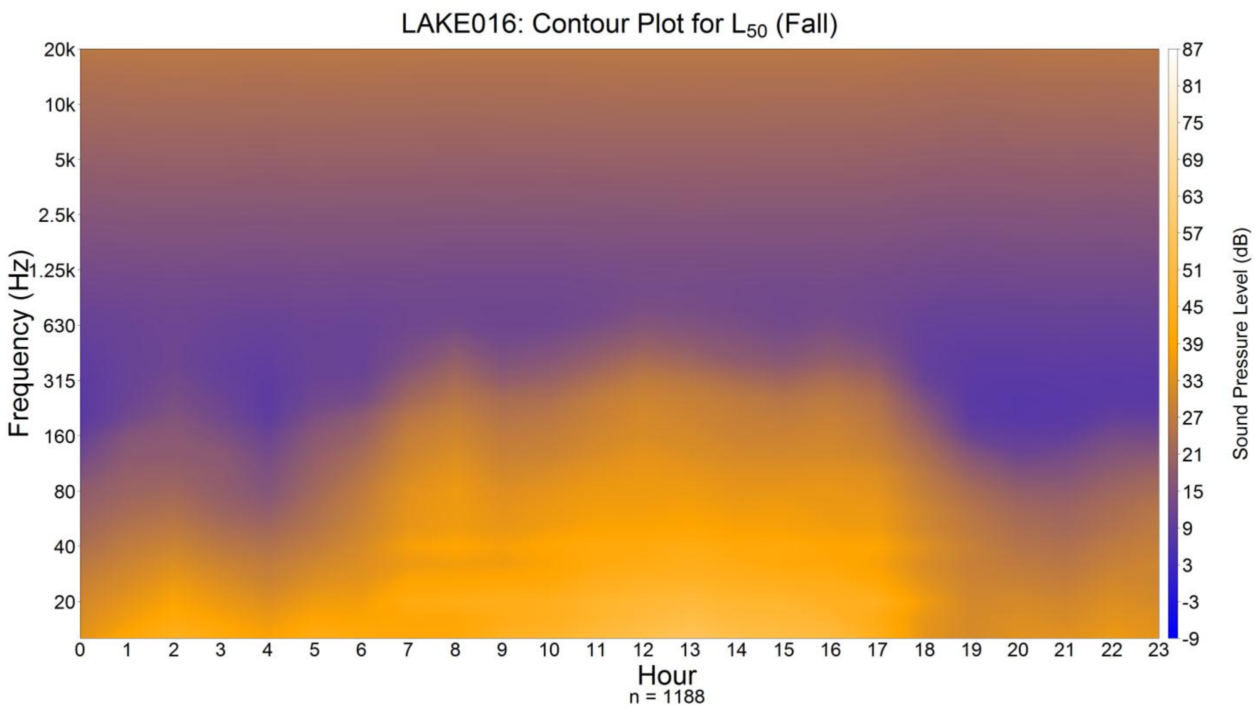

Figure 111. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME016 Fall (AR136 Gregg's Hide-Out).

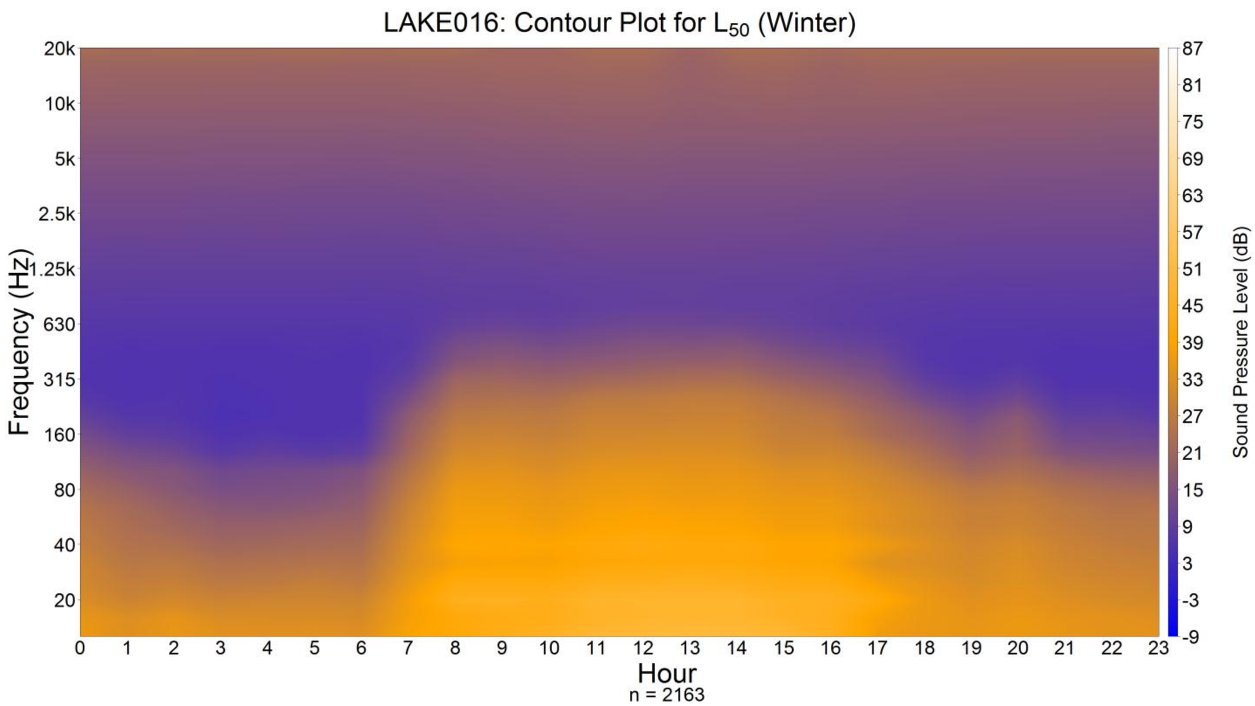

Figure 112. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAME016 Winter (AR136 Gregg's Hide-Out).

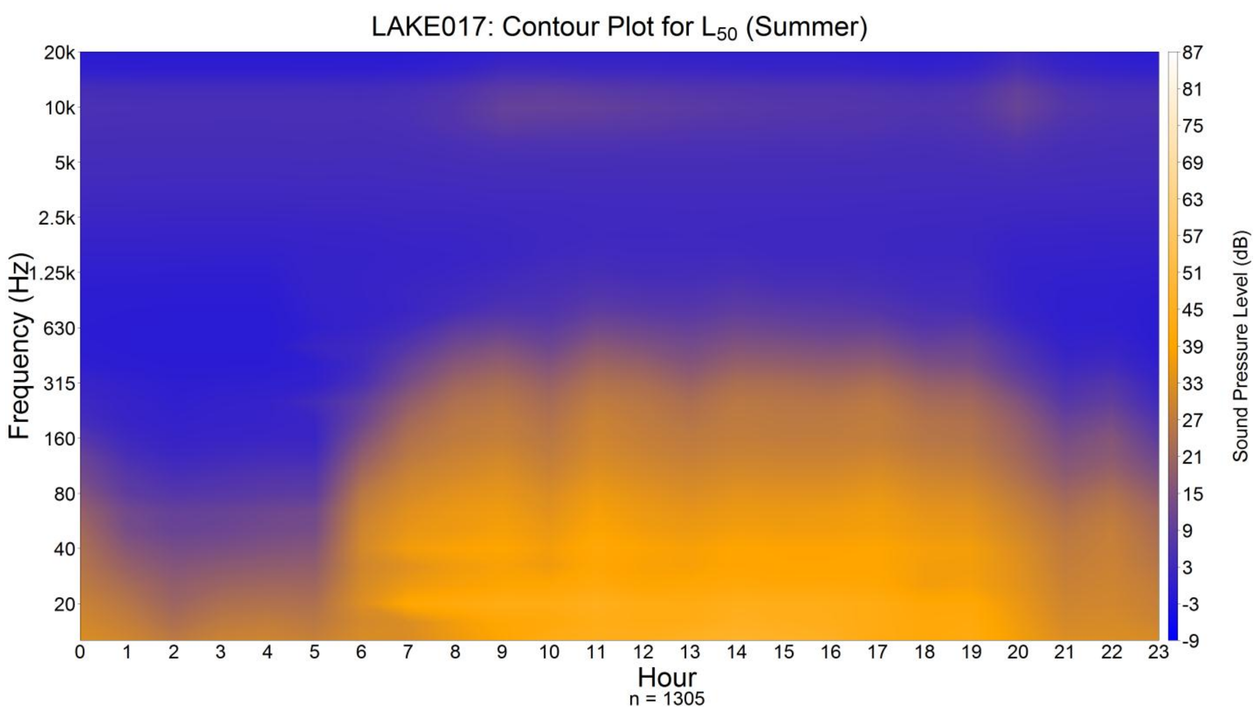

Figure 113. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE017 Summer (AR136 Gregg's Hide-Out).

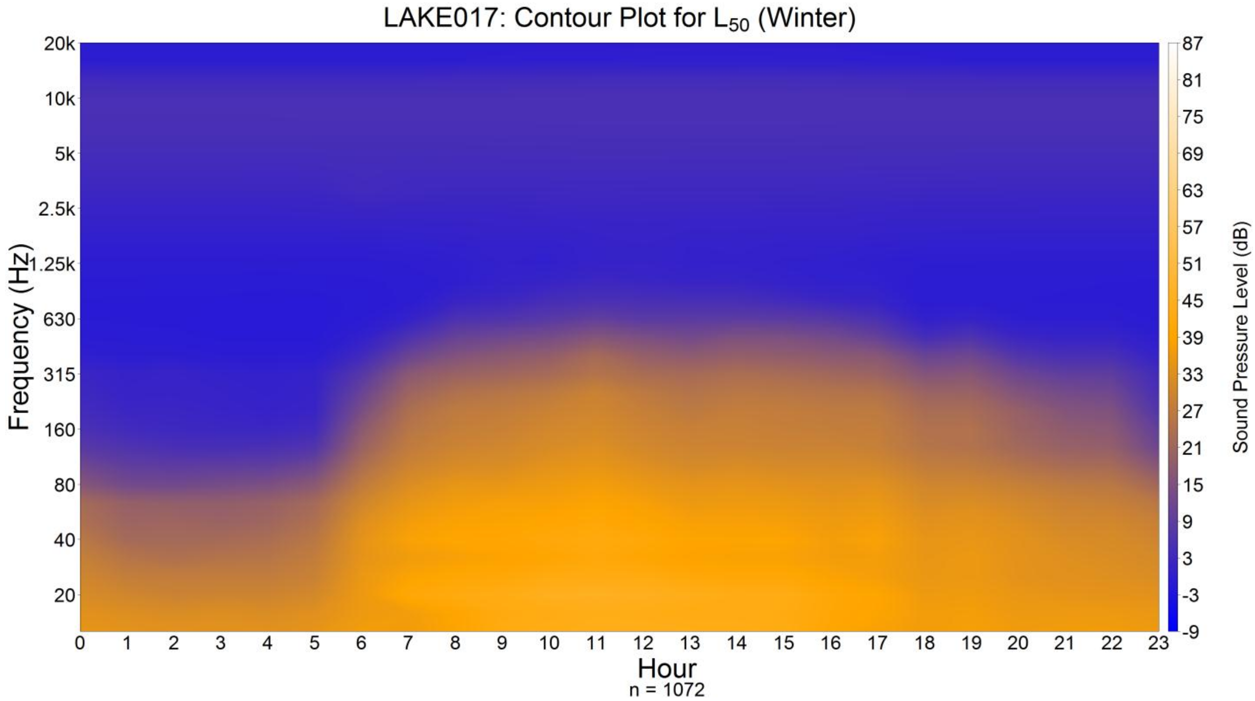

Figure 114. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE017 Winter (AR136 Gregg's Hide-Out).

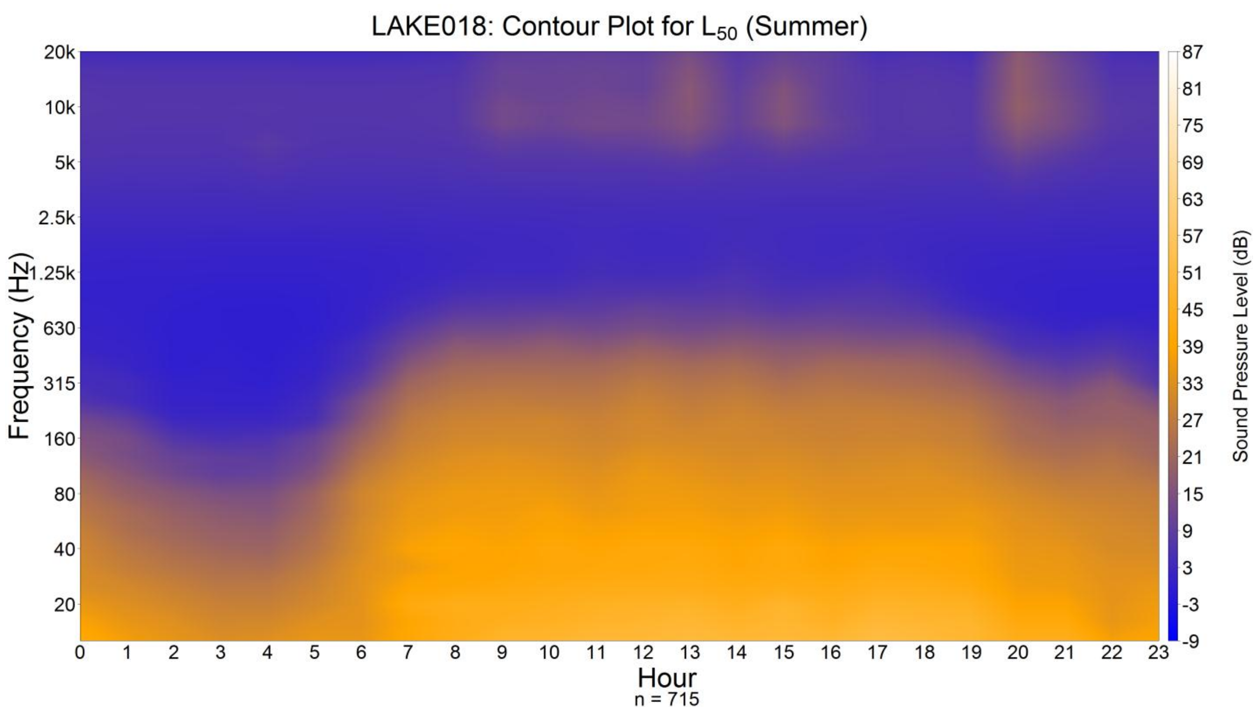

Figure 115. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE018 Summer (AR136 Gregg's Hide-Out).

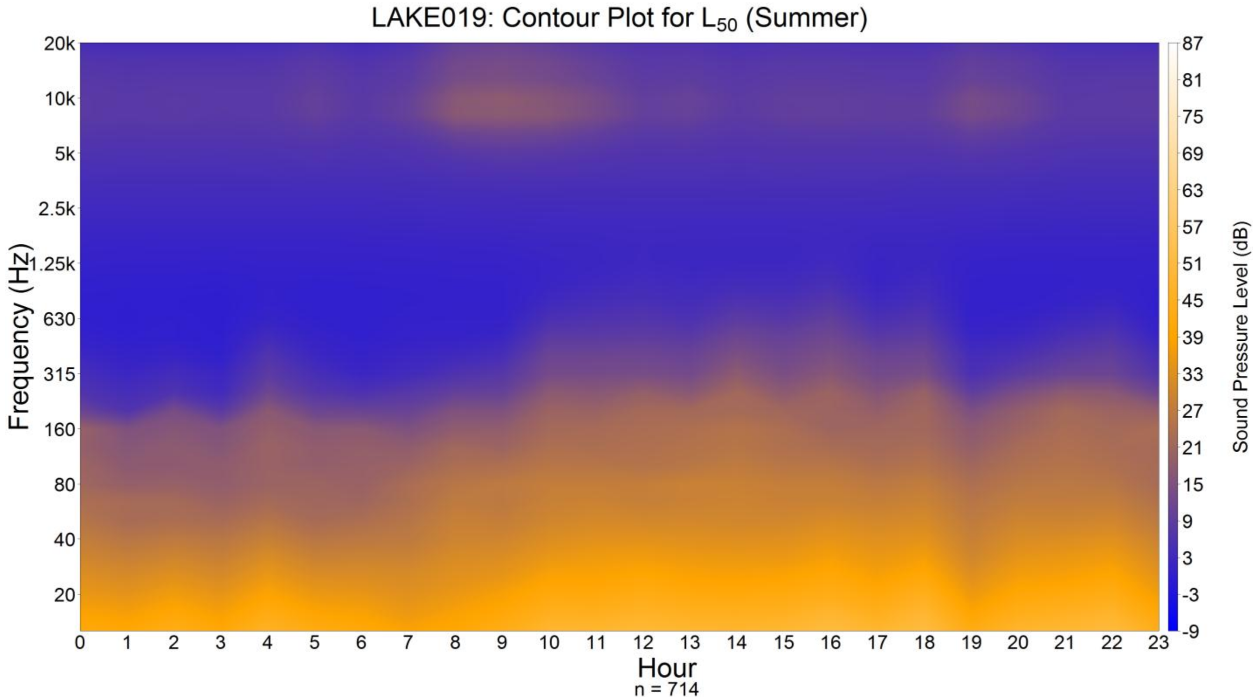

Figure 116. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE019 Summer (AR30).

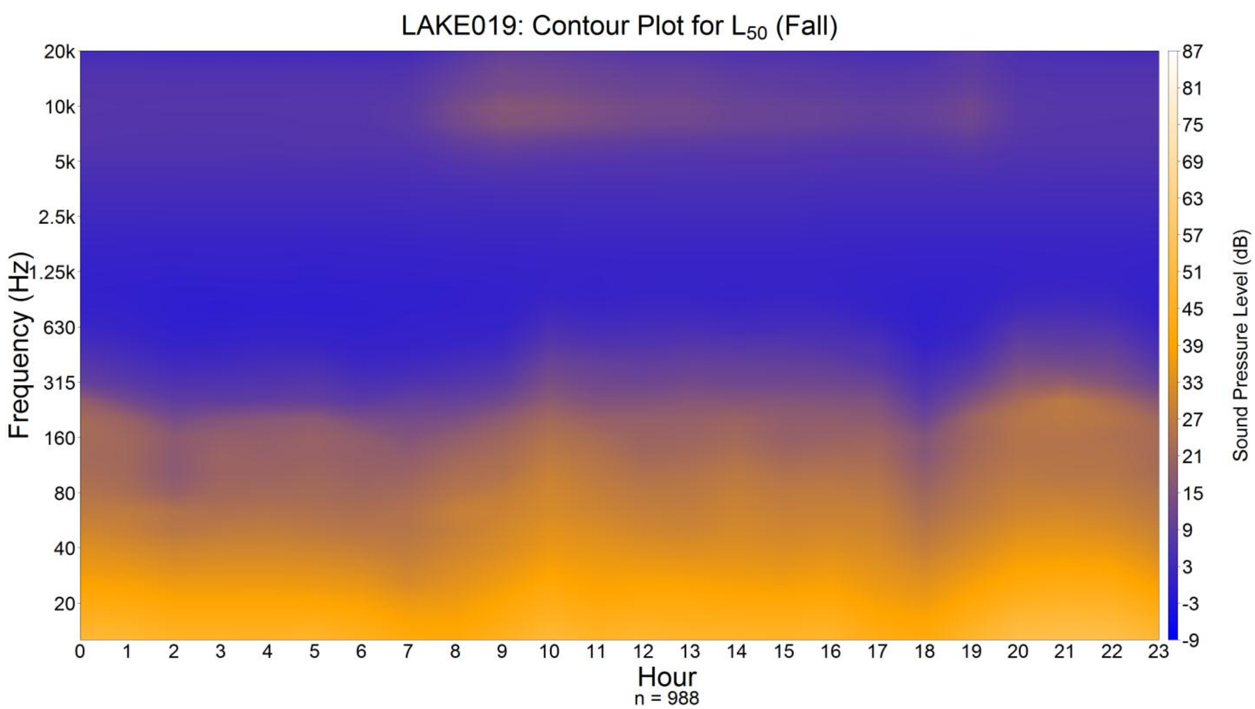

Figure 117. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE019 Fall (AR30).

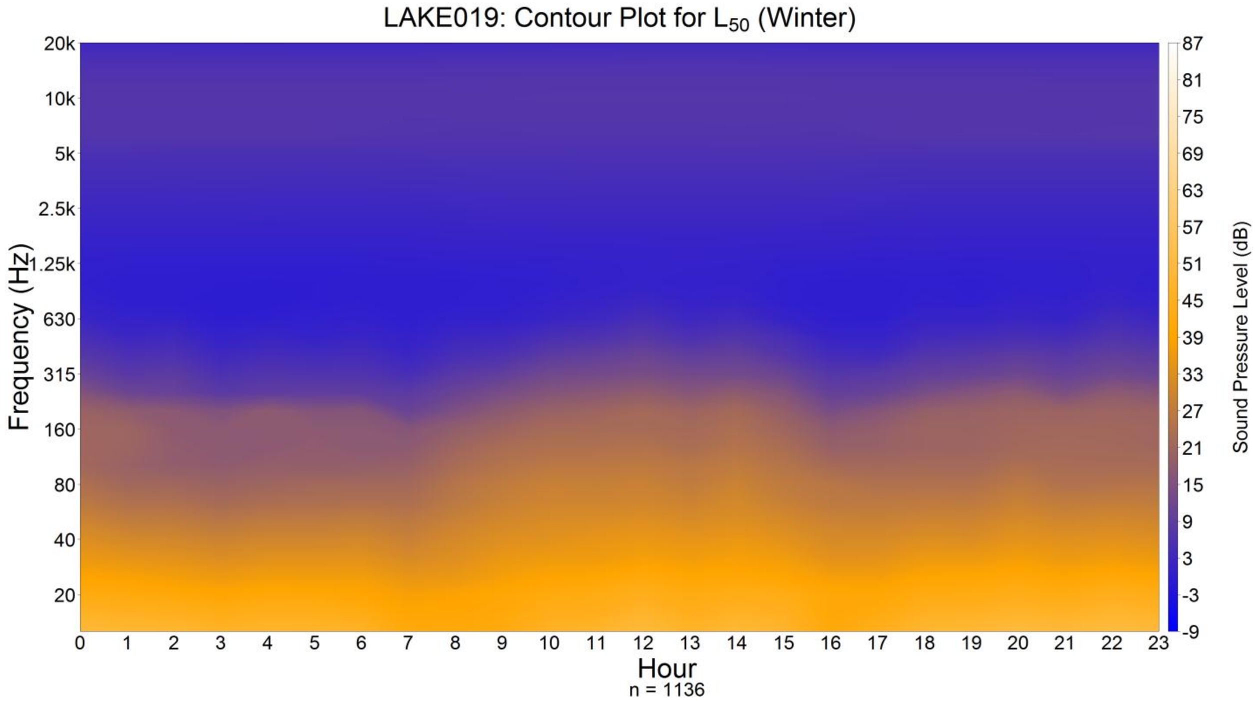

Figure 118. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE019 Winter (AR30).

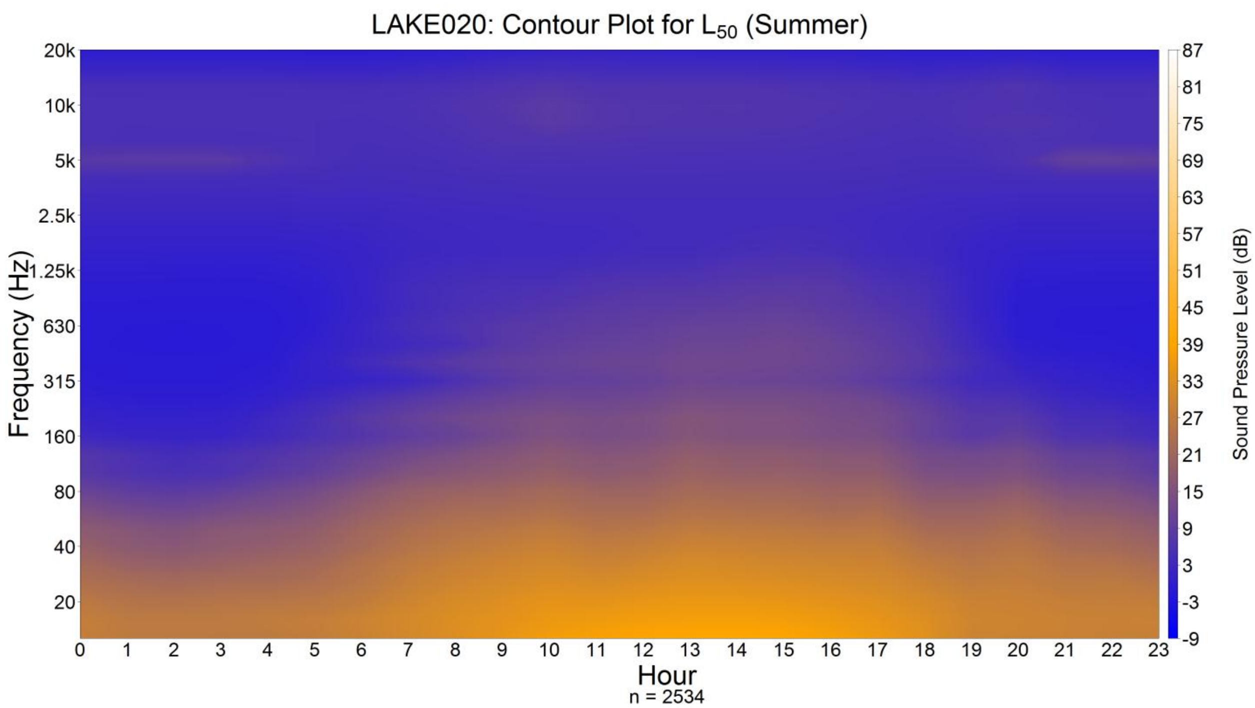

Figure 119. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE020 Summer (AR18).

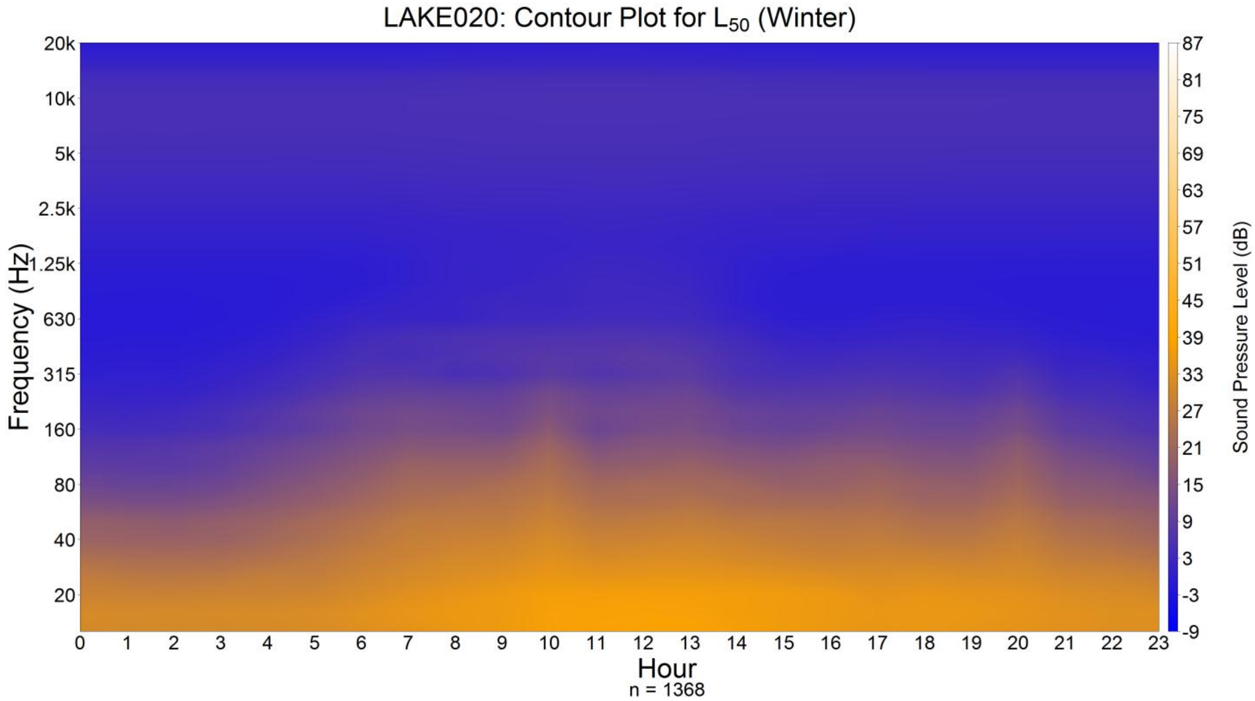

Figure 120. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE020 Winter (AR18).

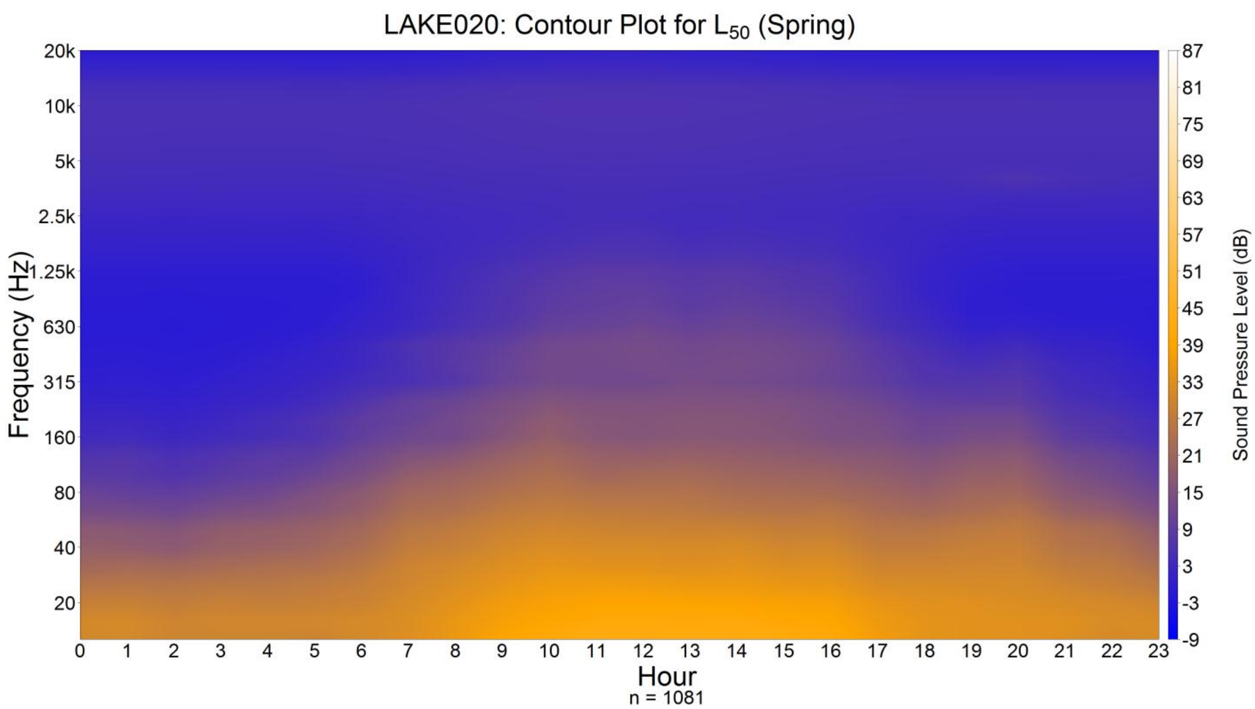

Figure 121. Flat-weighted contour plot of median existing ambient decibel and frequency levels, LAKE020 Spring (AR18).

Percent Time Audible

The overall percentage of samples in which extrinsic sounds were audible is demonstrated in Figure 122 - Figure 155. In addition to aircraft, road vehicles were also occasionally audible at these sites. In addition to the figures, percent time audibility is explained for a few of the sites below as compared to recorded sounds during on-site and off-site listening.

Figure 122 - Figure 123 demonstrate the aircraft overflight pattern at LAME007. As scenic helicopter tours begin their routes and high altitude jets fly over this location there is a rise in activity around 0700. Aircraft audibility increase to over 90% during the mid-morning hours. In contrast, aircraft overflights were the quietest during the 0400 hour, with an audibility of only 8.6 percent. This figure also demonstrates that aircraft are by far the most dominant extrinsic sound source at this site, for all hours.

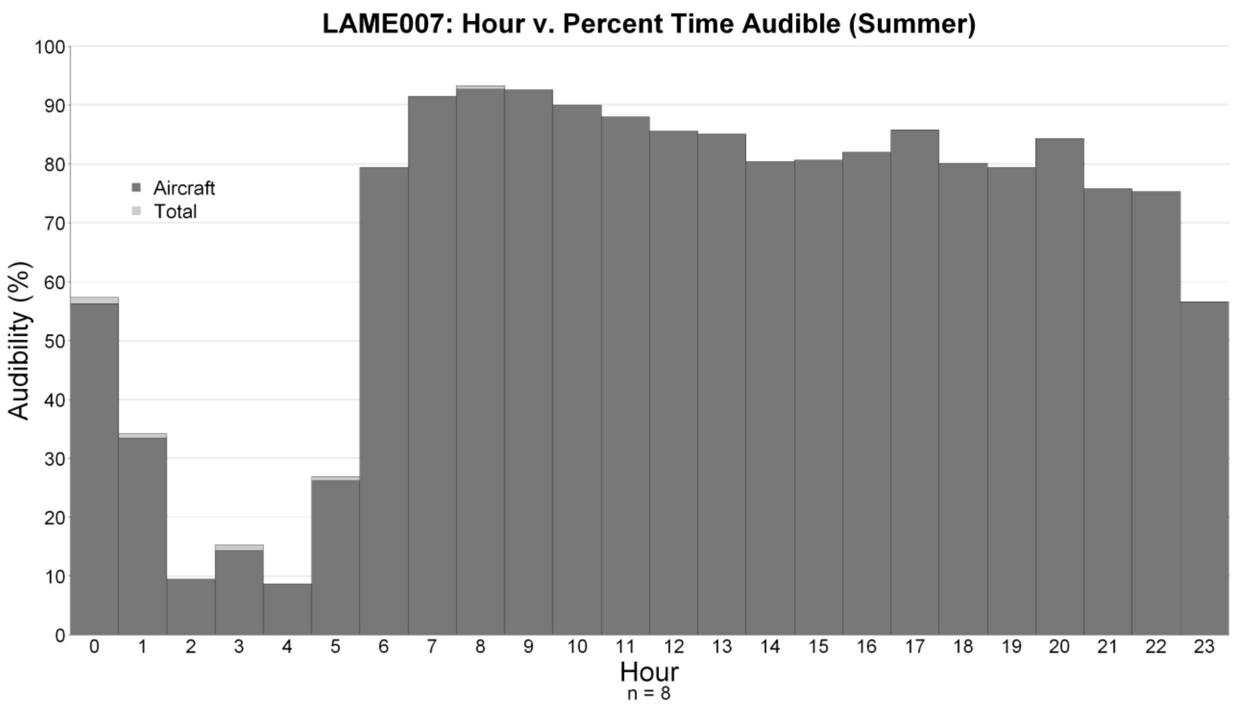

Figure 122. Audibility of extrinsic and aircraft sounds, LAME007 Summer (Indian Pass).

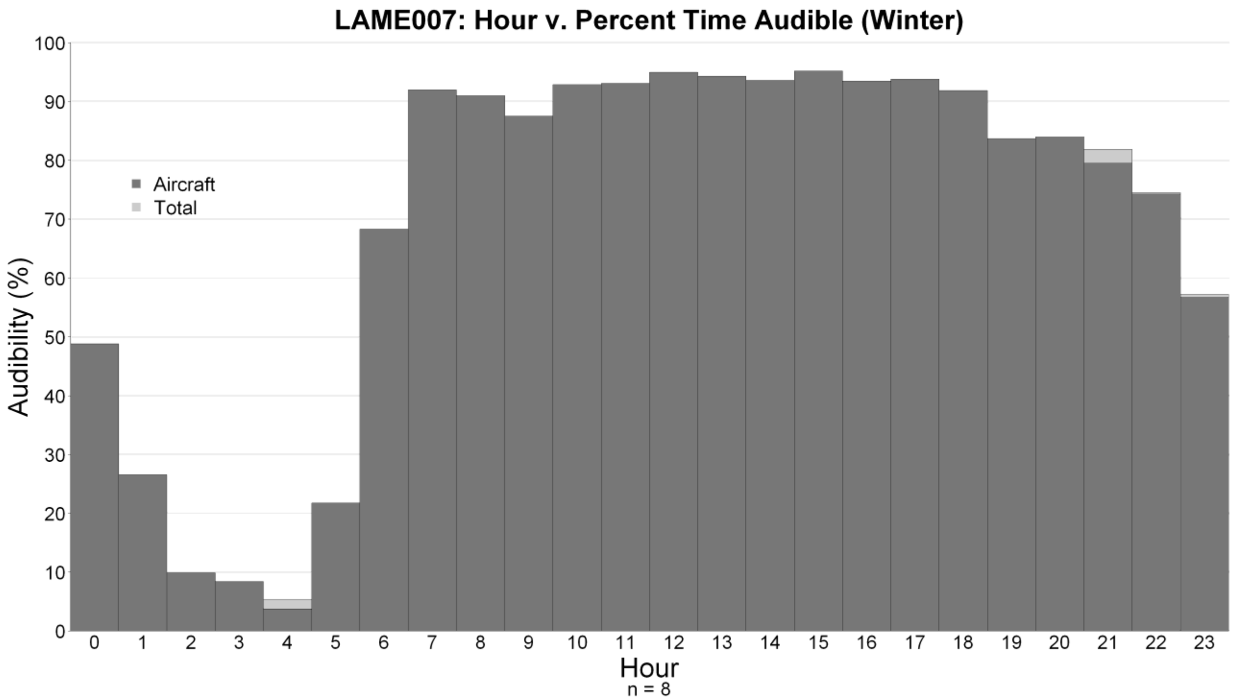

Figure 123. Audibility of extrinsic and aircraft sounds, LAME007 Winter (Indian Pass).

Figure 124 and Figure 125 demonstrate the aircraft overflight pattern at LAME009. The overall percent of samples in which extrinsic sounds were audible is highest at this site. There is a peak in the morning at 0800 hours. In addition to aircraft, road vehicles were also just barely audible at this site. Aircraft overflights were the quietest during the 0400 hour, when aircraft was audible only 8.5 percent of the time.

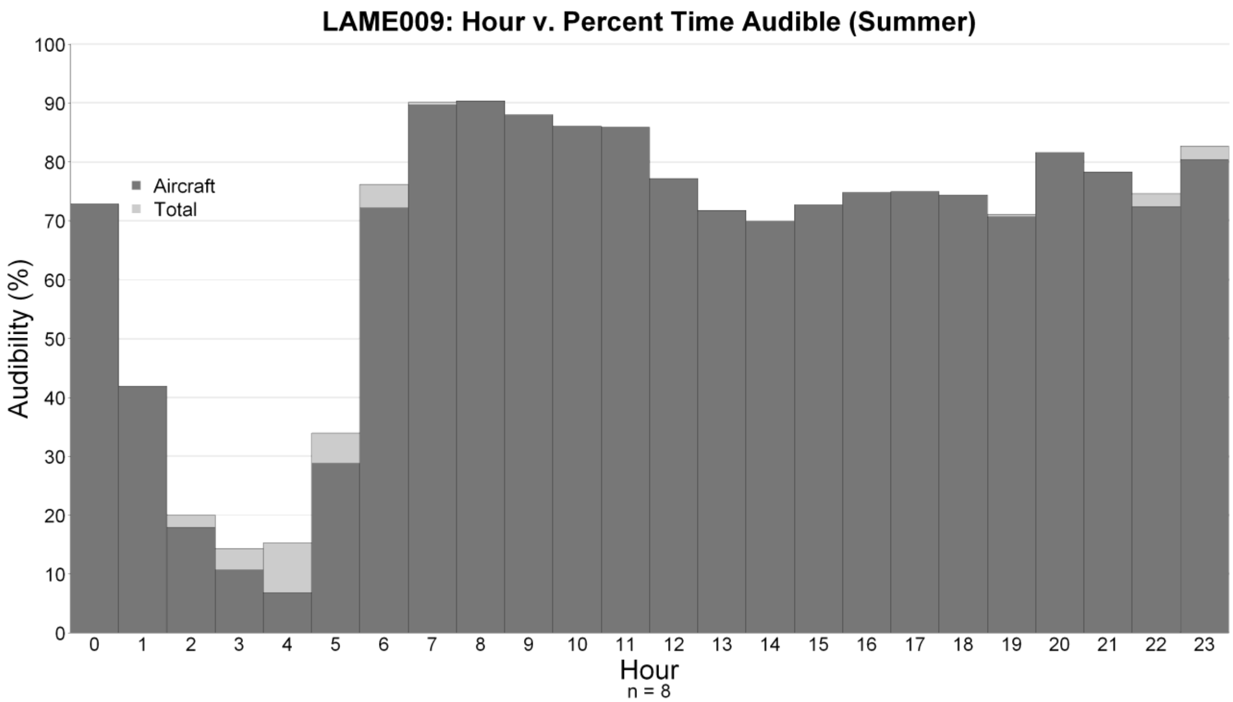

Figure 124. Audibility of extrinsic and aircraft sounds, LAME009 Summer (Callville Wash).

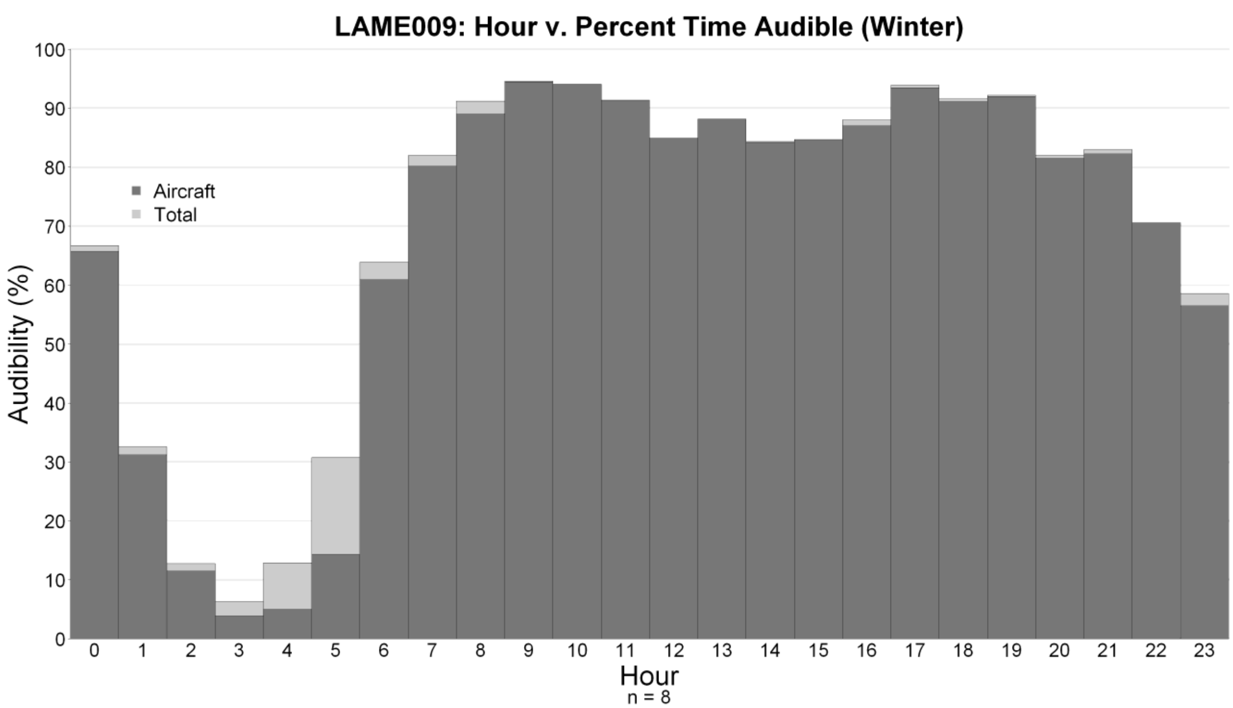

Figure 125. Audibility of extrinsic and aircraft sounds, LAME009 Winter (Callville Wash).

Figure 126 - Figure 128 demonstrate the aircraft overflight pattern at LAME010. The overall percent of samples in which extrinsic sounds were audible is lowest at this site. There is a peak in the morning at 0800 hours. In addition to aircraft, road vehicles were on rare occasions just barely audible at this site. LAME010 is the quietest site in regards to human caused contributions. Aircraft overflights were the quietest during the 0400 hour when aircraft was audible only 3.3 percent of the time.

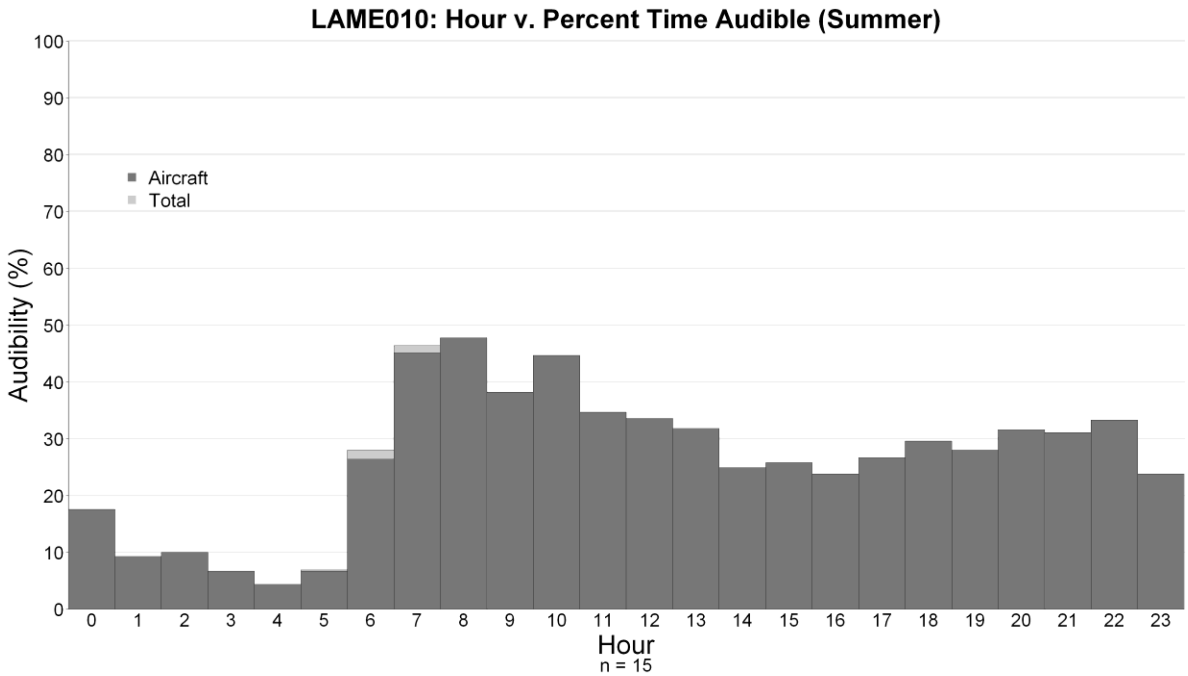

Figure 126. Audibility of extrinsic and aircraft sounds, LAME010 Summer.

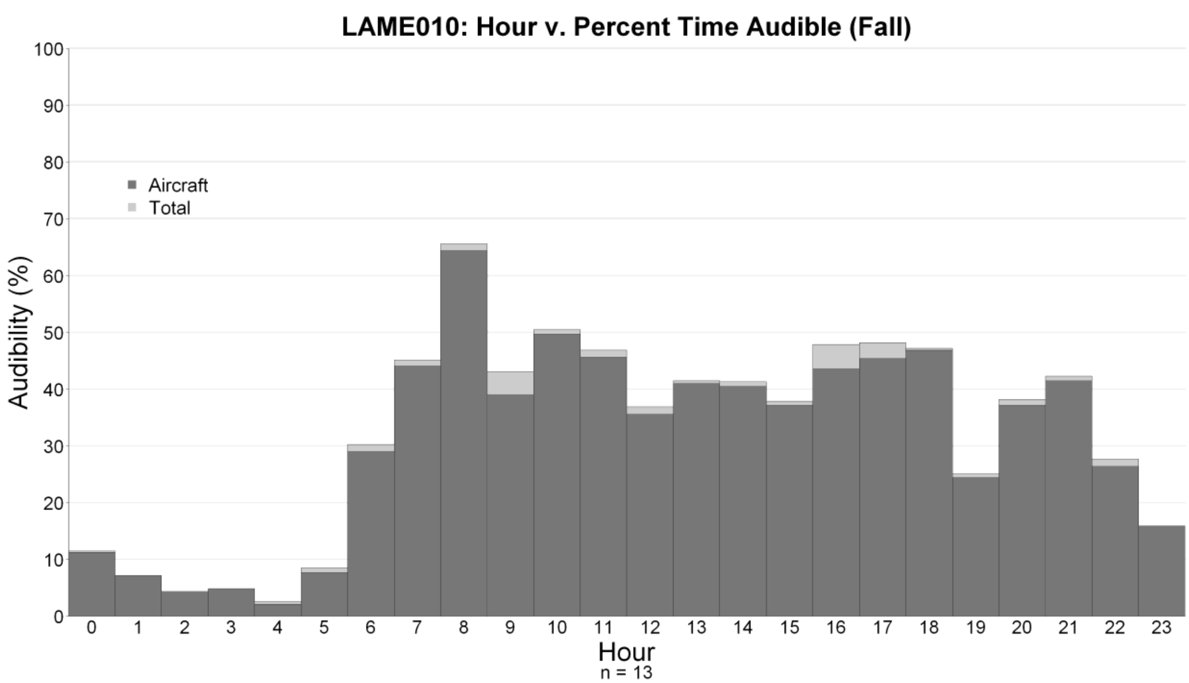

Figure 127. Audibility of extrinsic and aircraft sounds, LAME010 Fall.

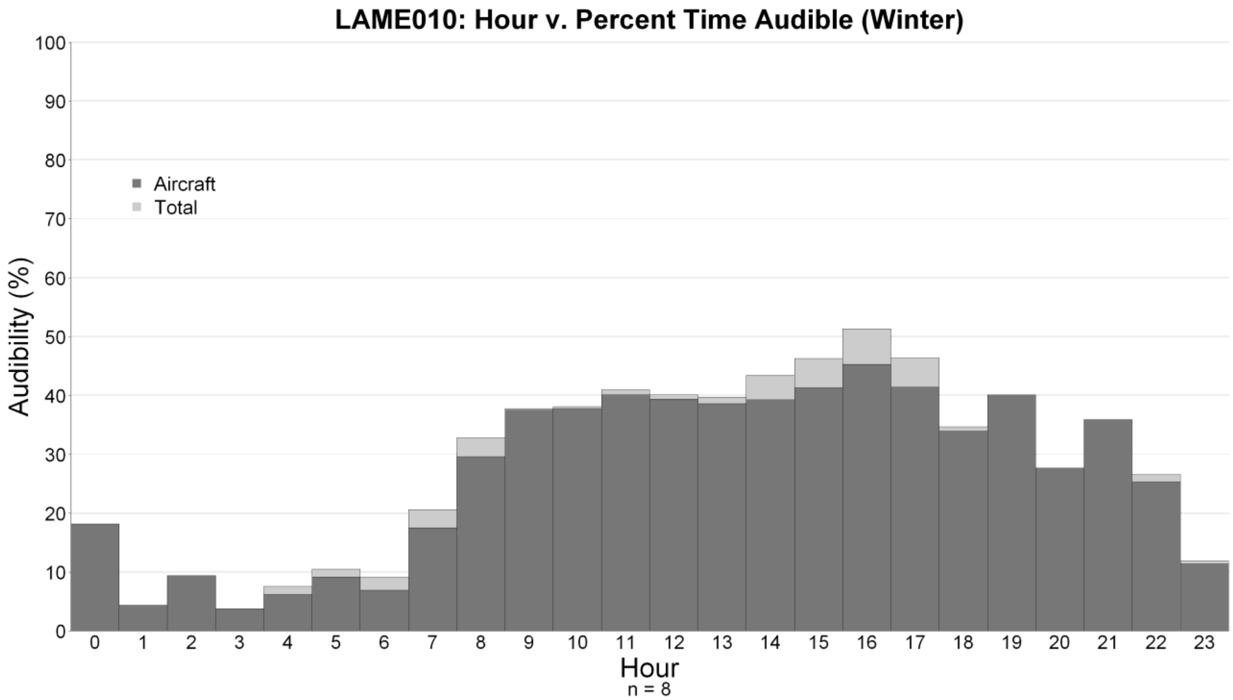

Figure 128. Audibility of extrinsic and aircraft sounds, LAME010 Winter.

Figure 129-Figure 132 demonstrate the aircraft overflight pattern at LAME011. This site was most affected by aircraft overflights during the late night hours. The audibility of overflights at LAME011 peaked at the 2000 hour, with an averaged audibility of approximately 57.4 percent. Aircraft overflights were the quietest during the 0100 hour, with an audibility of only 7.7 percent. This graph also demonstrates a bi-modal pattern in terms of aircraft audibility. There seems to be two “rush hours” for high altitude commercial aircraft: mid-morning and mid-evening when many people tend to travel.

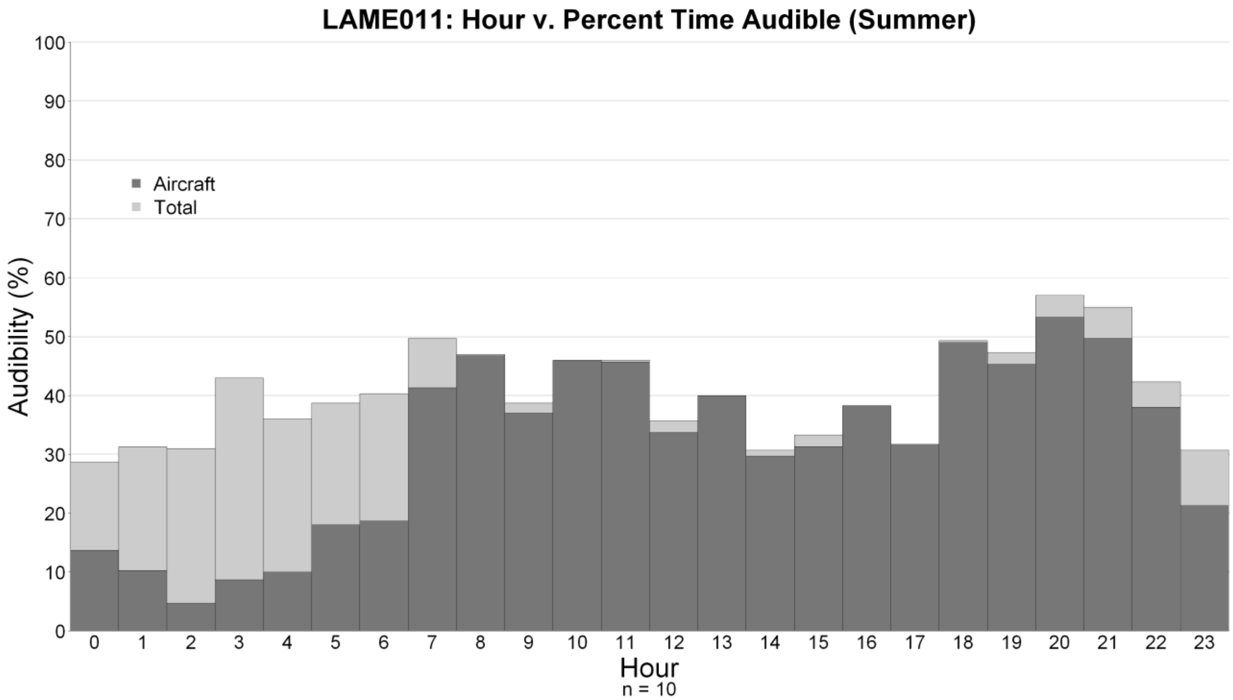

Figure 129.Audibility of extrinsic and aircraft sounds, LAME011 Summer.

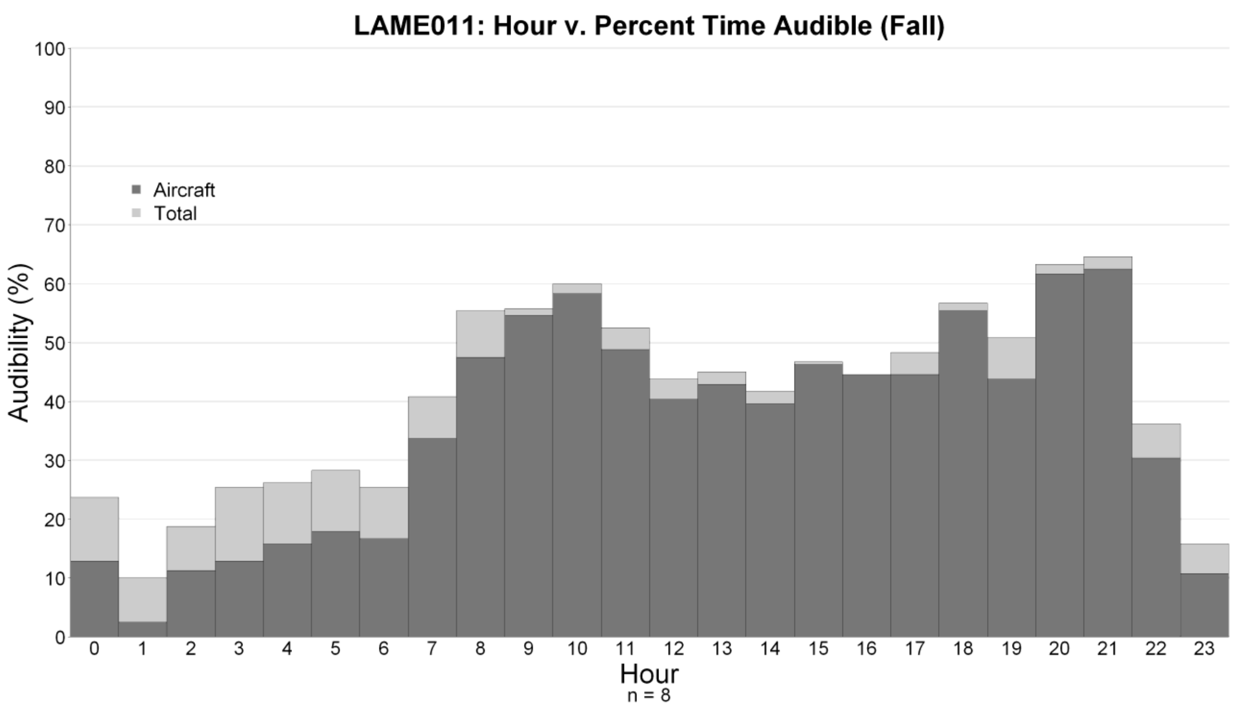

Figure 130. Audibility of extrinsic and aircraft sounds, LAME011 Fall.

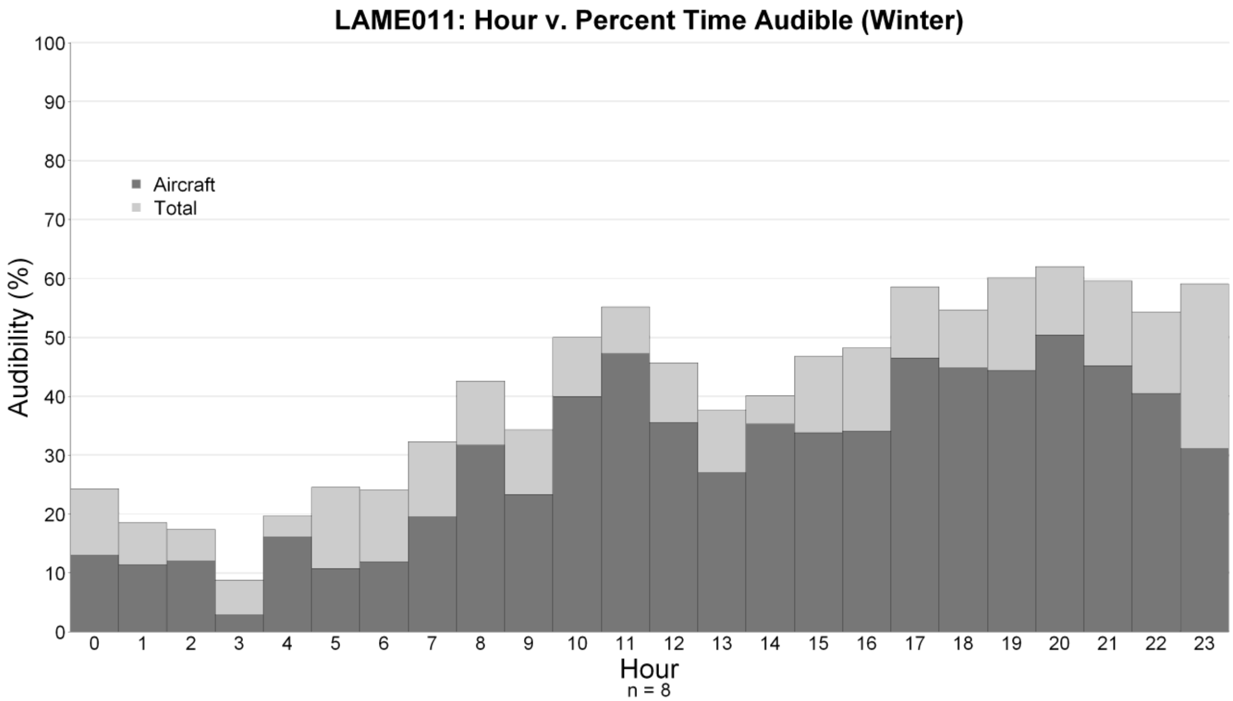

Figure 131. Audibility of extrinsic and aircraft sounds, LAME011 Winter.

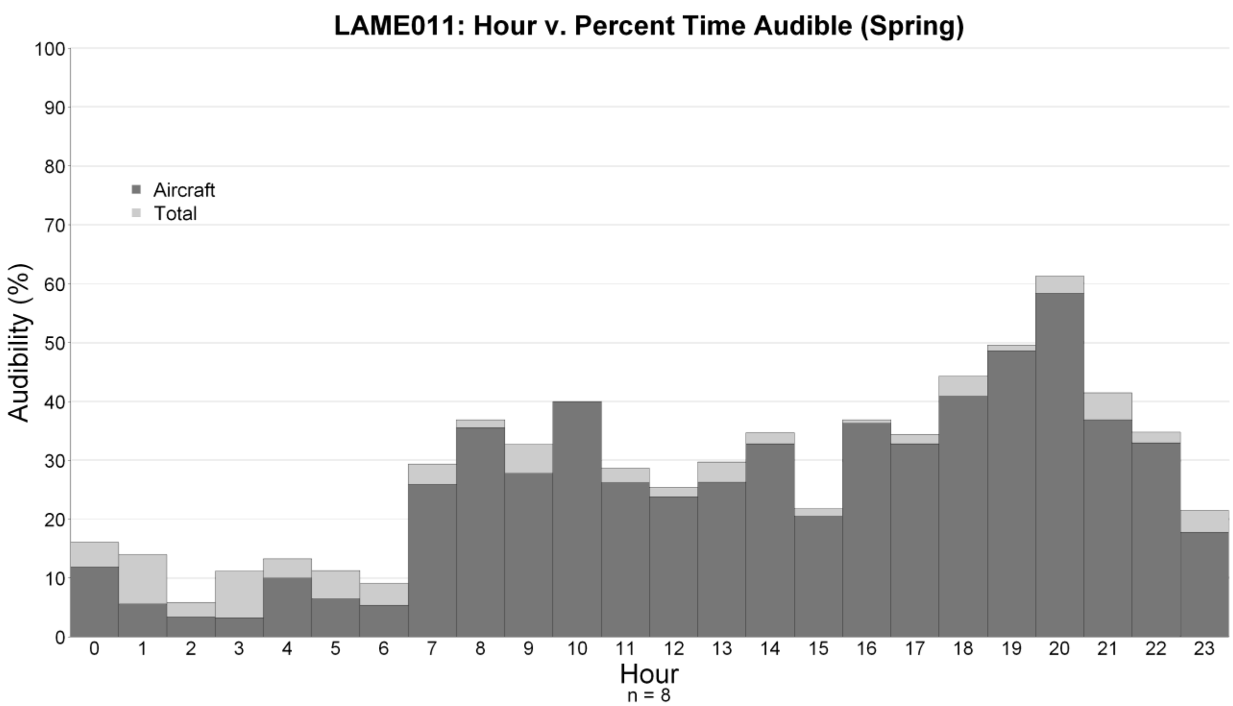

Figure 132. Audibility of extrinsic and aircraft sounds, LAME011 Spring.

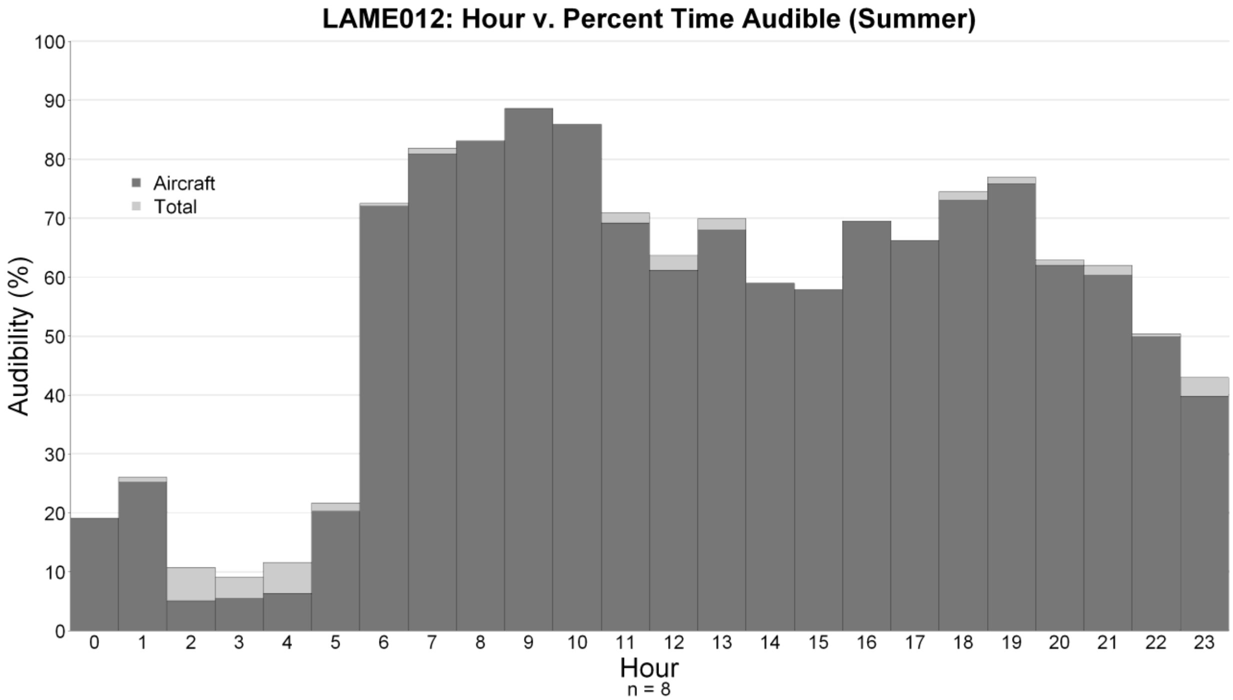

Figure 133. Audibility of extrinsic and aircraft sounds, LAME012 Summer.

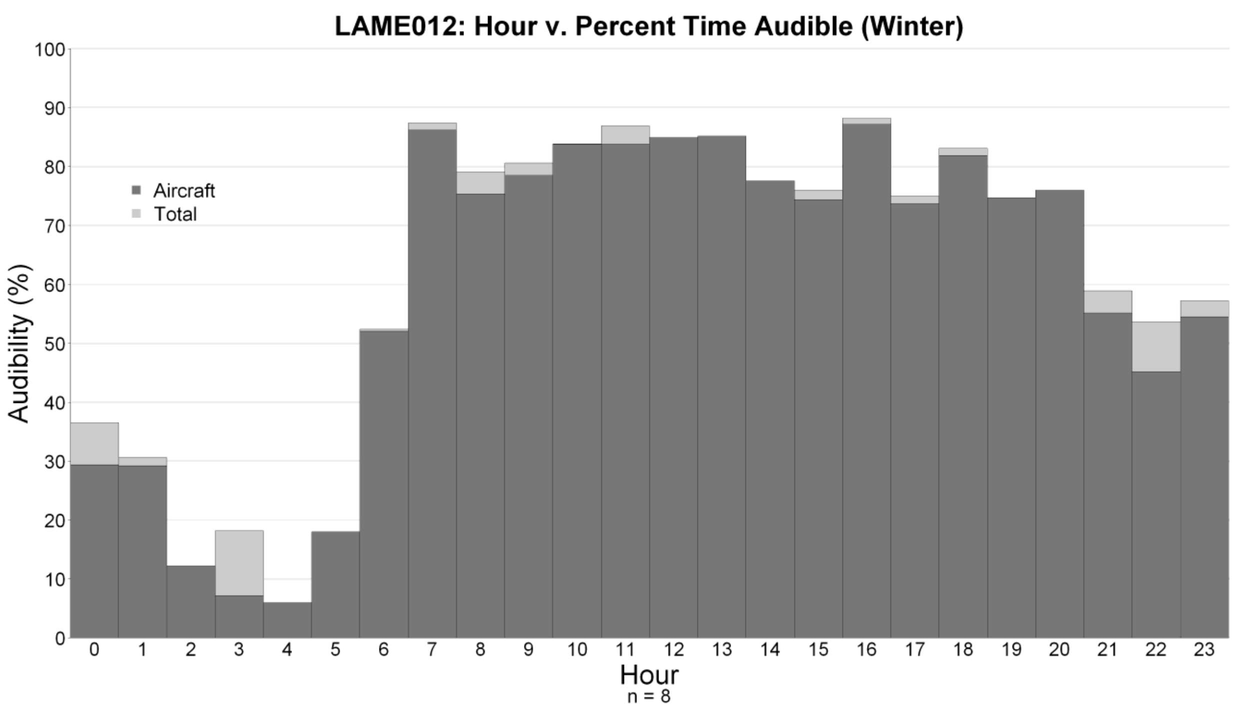

Figure 134. Audibility of extrinsic and aircraft sounds, LAME012 Winter.

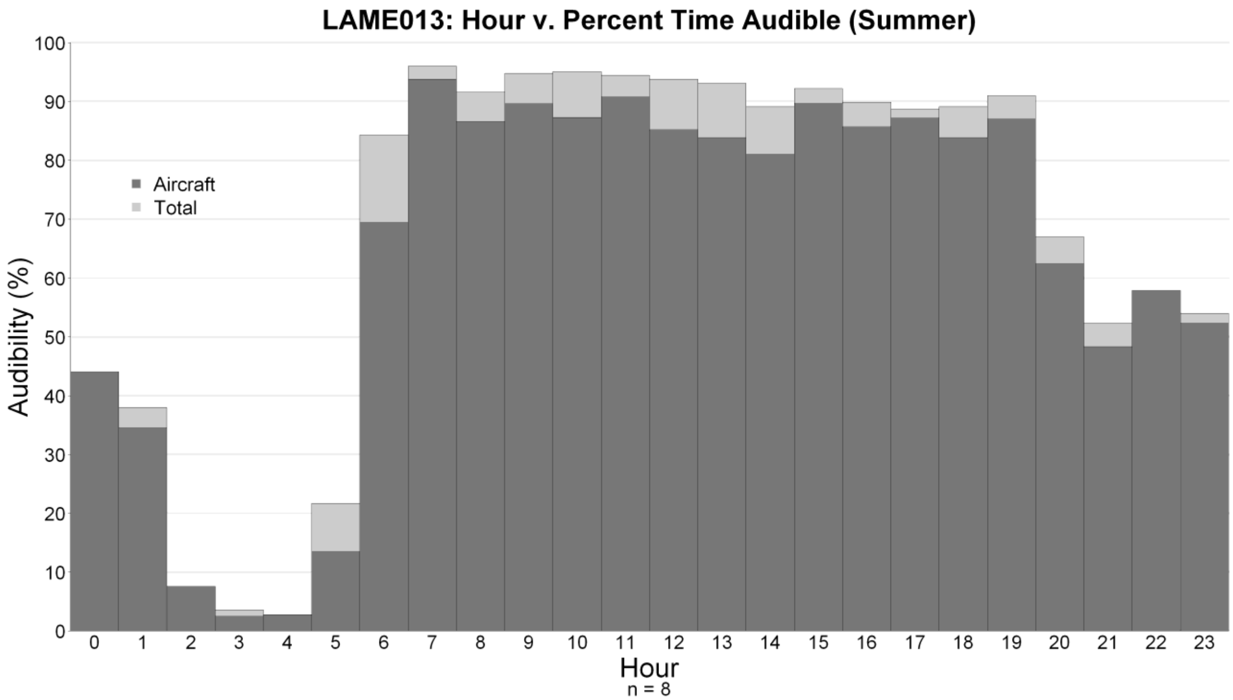

Figure 135. Audibility of extrinsic and aircraft sounds, LAME013 Summer.

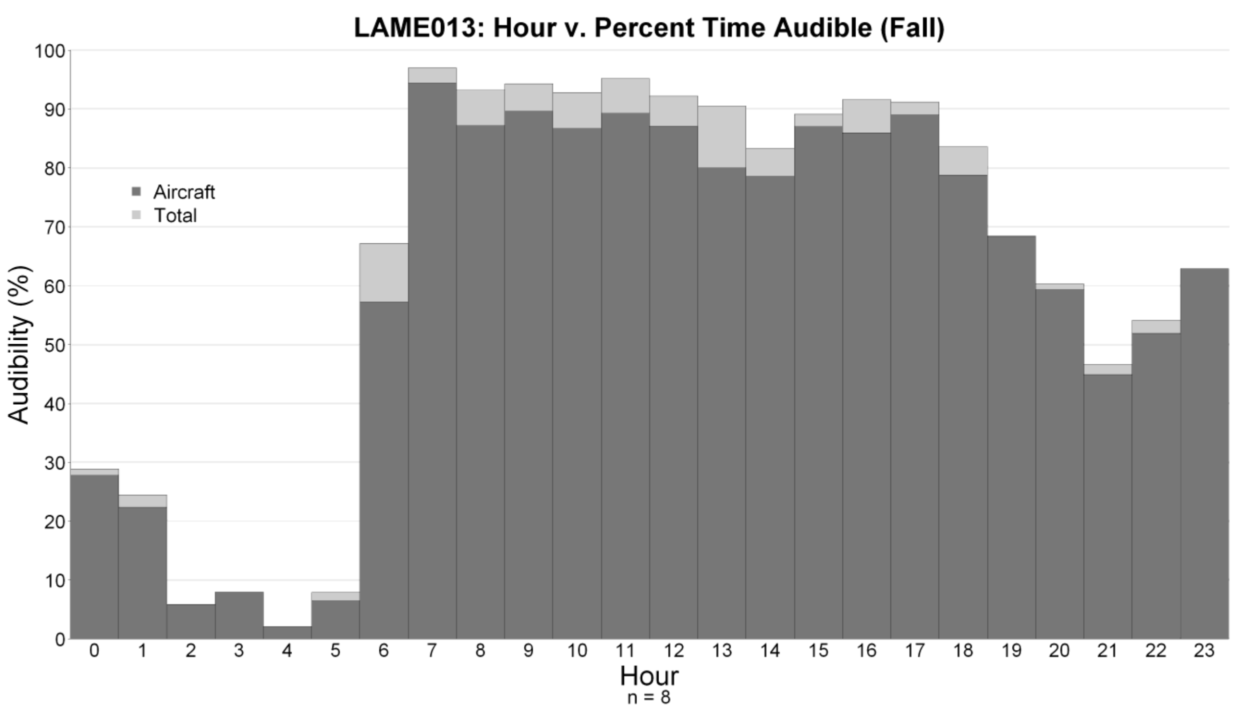

Figure 136. Audibility of extrinsic and aircraft sounds, LAME013 Fall.

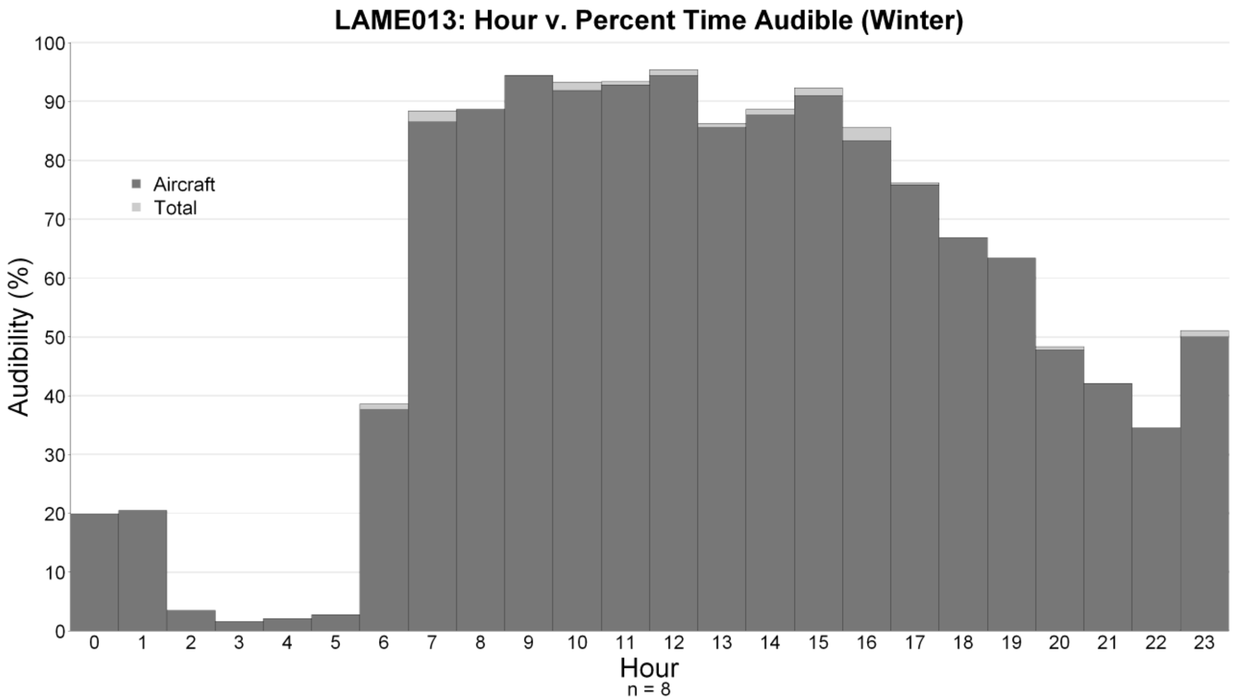

Figure 137. Audibility of extrinsic and aircraft sounds, LAME013 Winter.

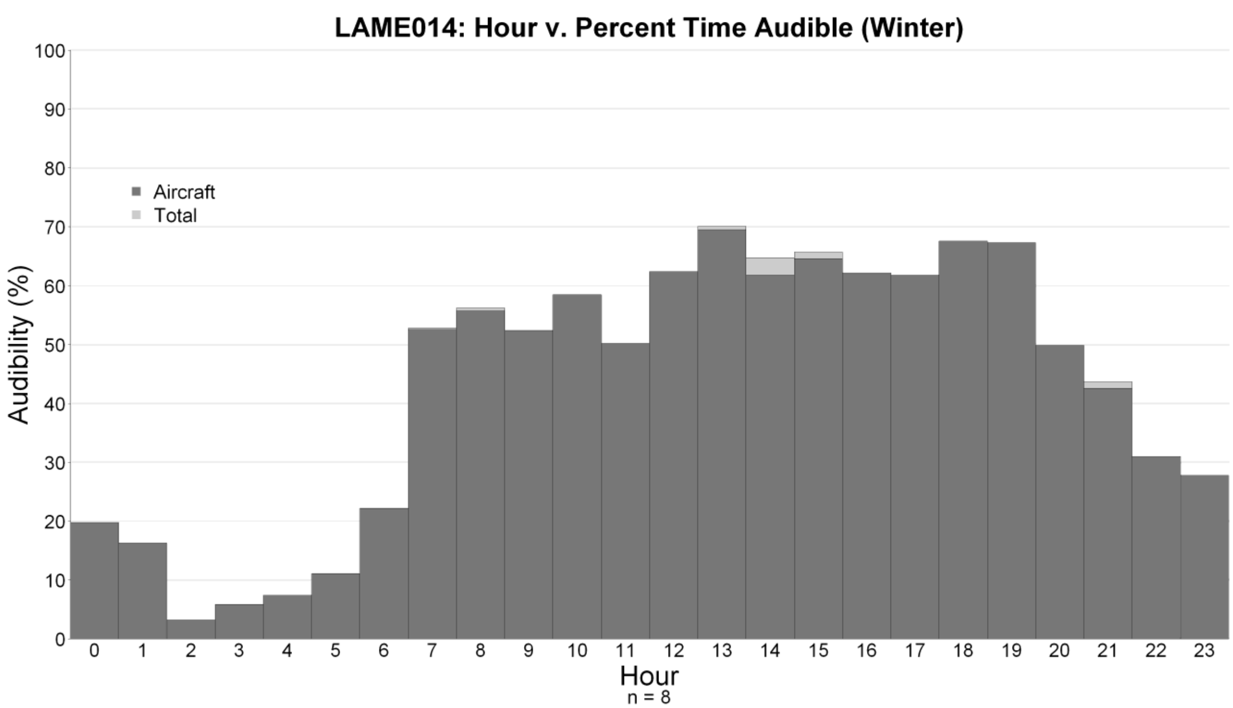

Figure 138. Audibility of extrinsic and aircraft sounds, LAME014 Winter.

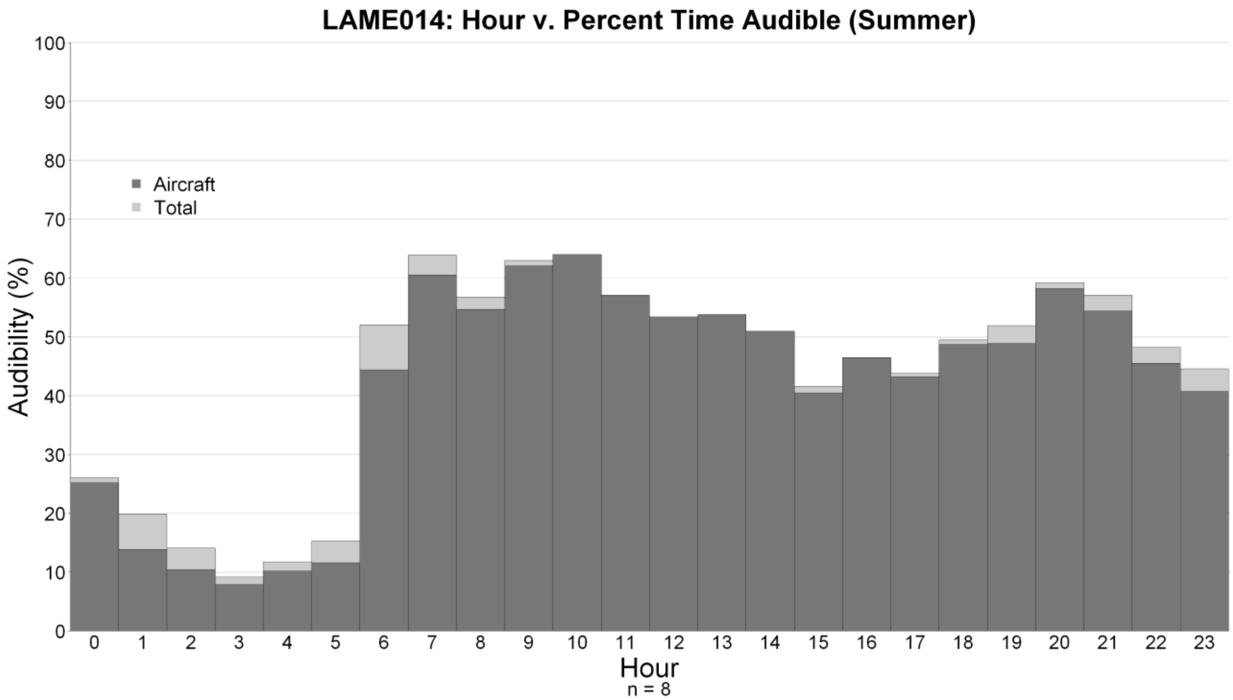

Figure 139. Audibility of extrinsic and aircraft sounds, LAME014 Summer.

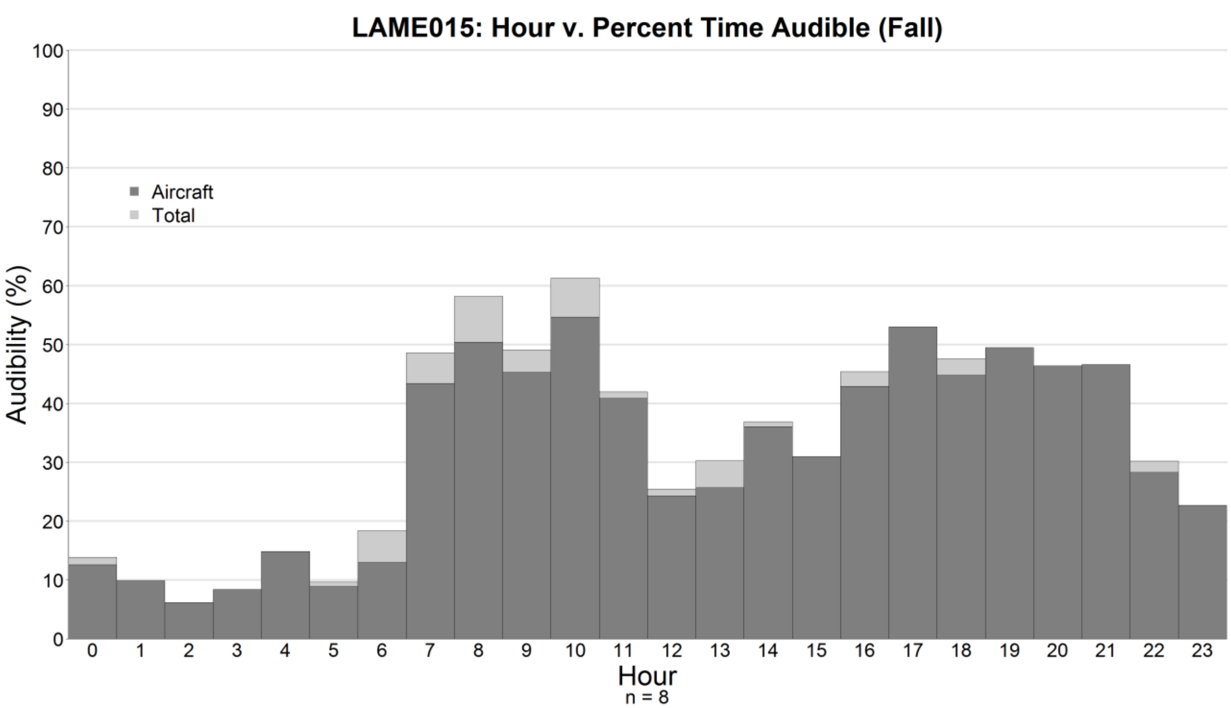

Figure 140. Audibility of extrinsic and aircraft sounds, LAME015 Fall.

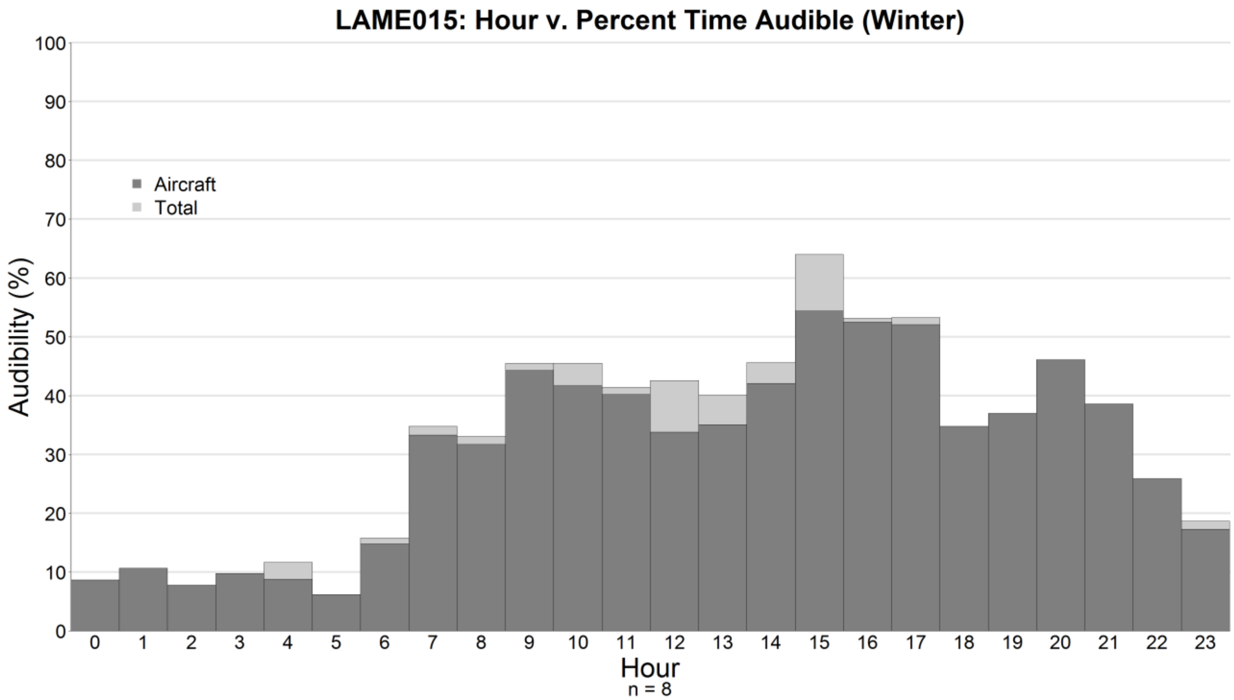

Figure 141. Audibility of extrinsic and aircraft sounds, LAME015 Winter.

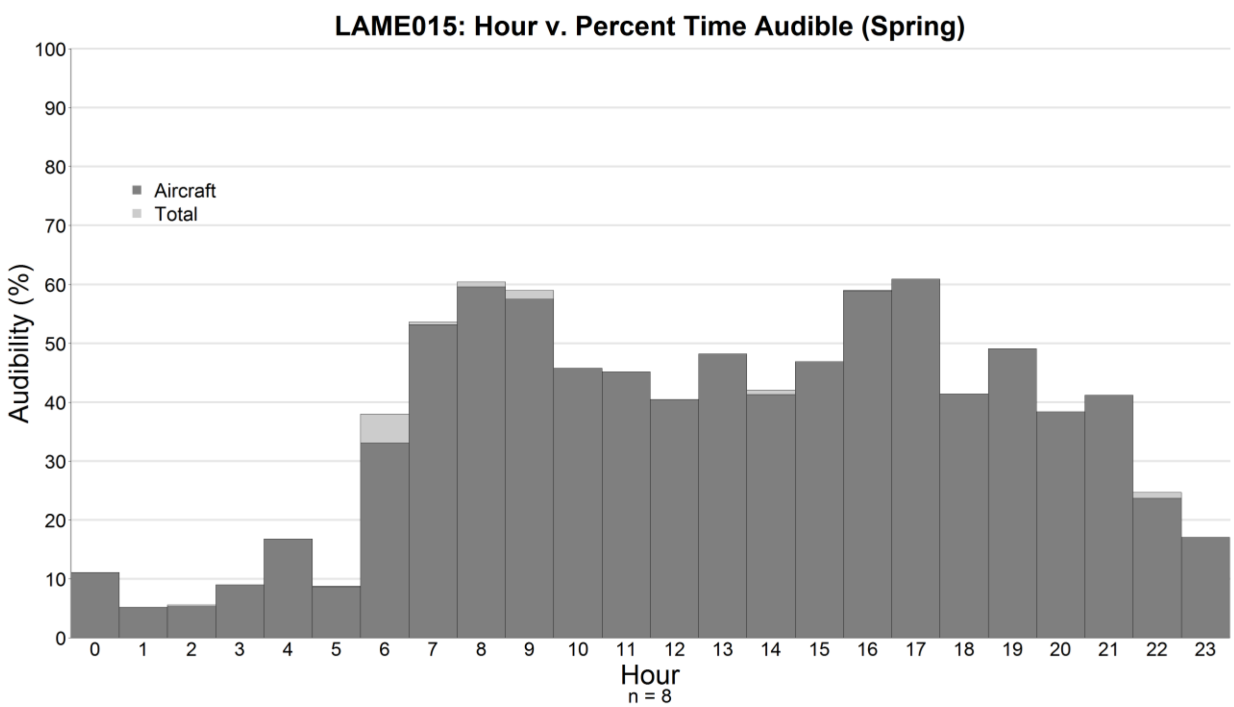

Figure 142. Audibility of extrinsic and aircraft sounds, LAME015 Spring.

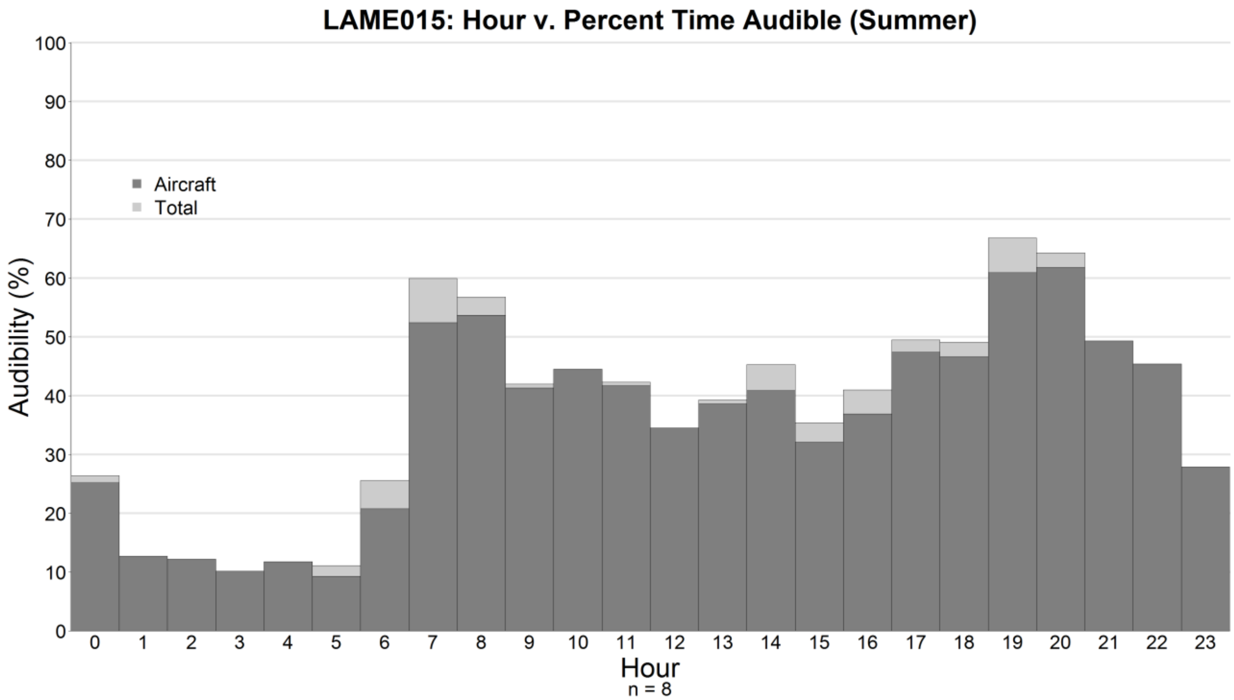

Figure 143. Audibility of extrinsic and aircraft sounds, LAME015 Summer.

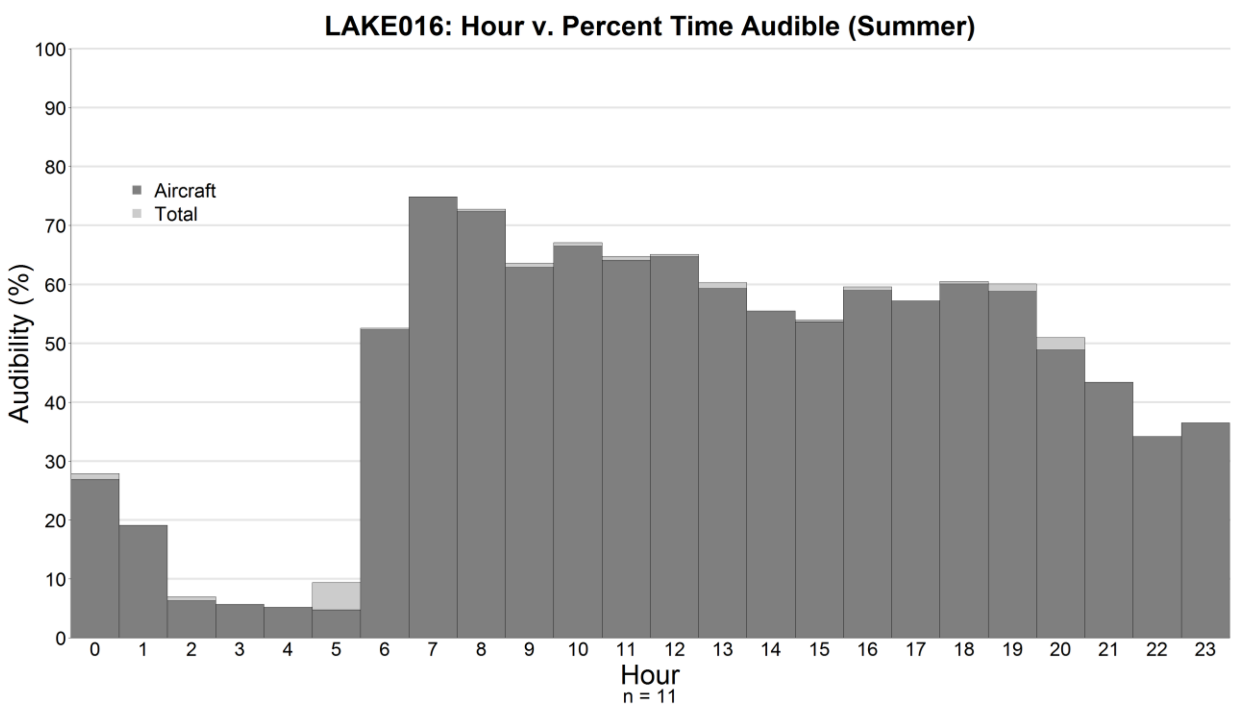

Figure 144. Audibility of extrinsic and aircraft sounds, LAME016 Summer.

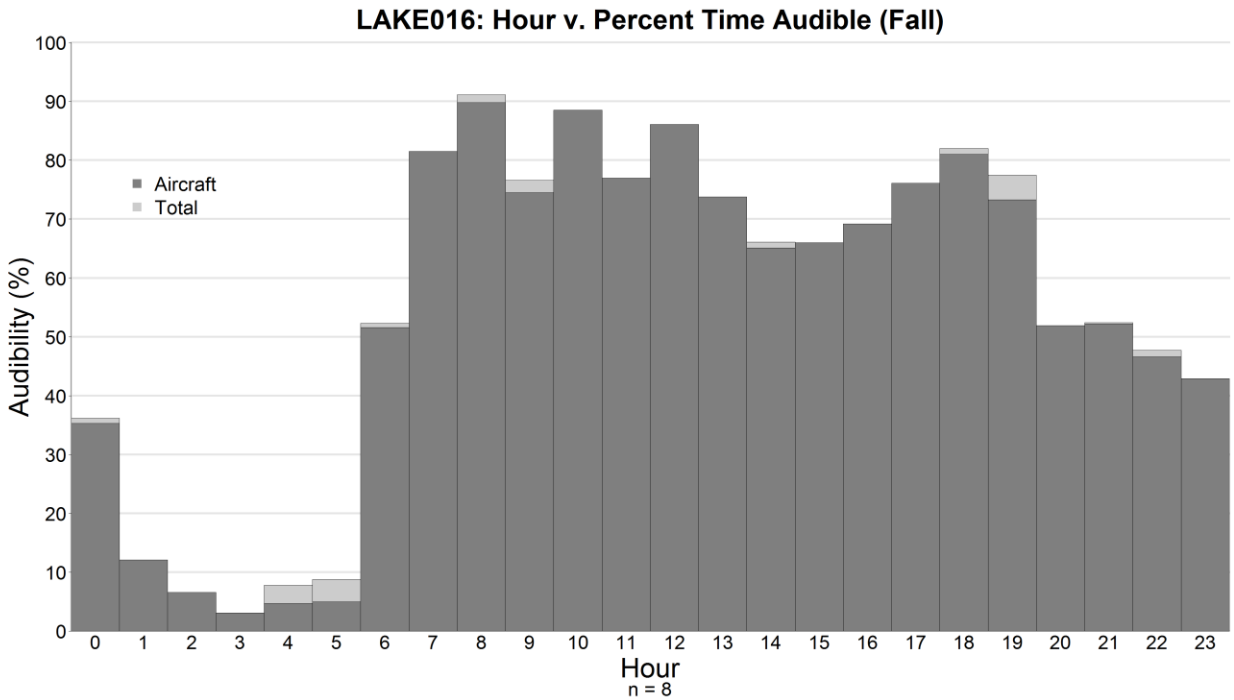

Figure 145. Audibility of extrinsic and aircraft sounds, LAME016 Fall.

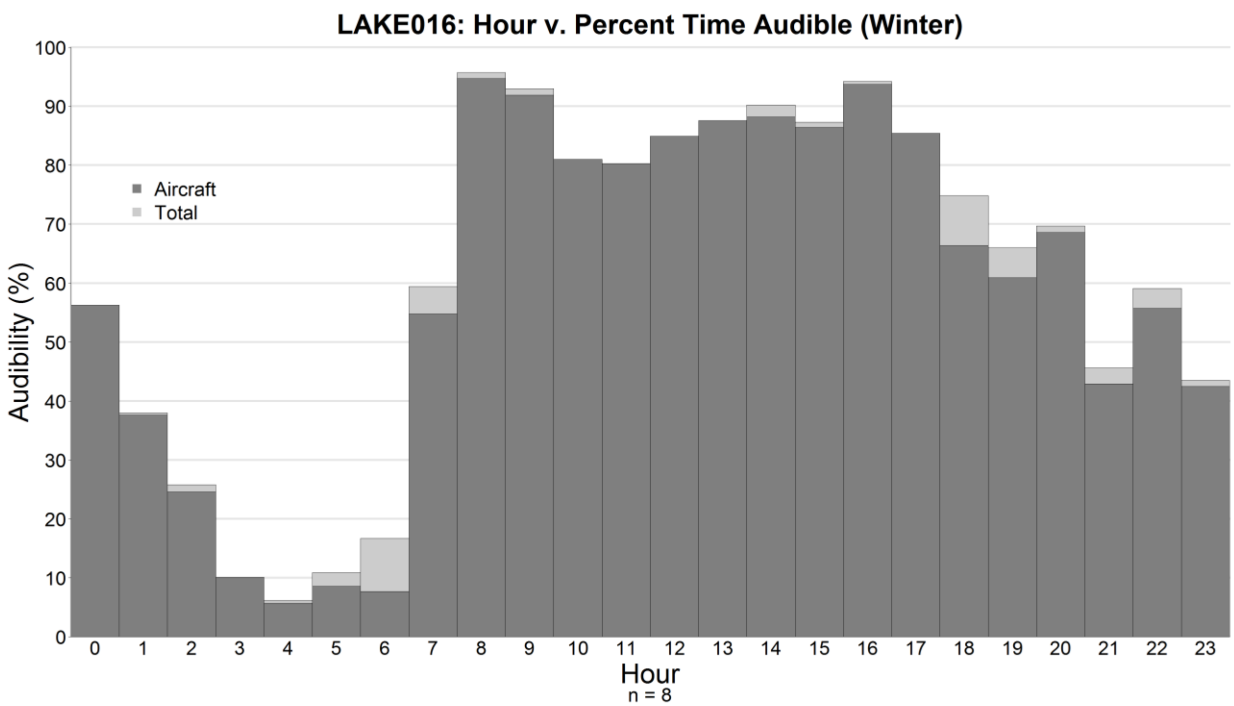

Figure 146. Audibility of extrinsic and aircraft sounds, LAME016 Fall.

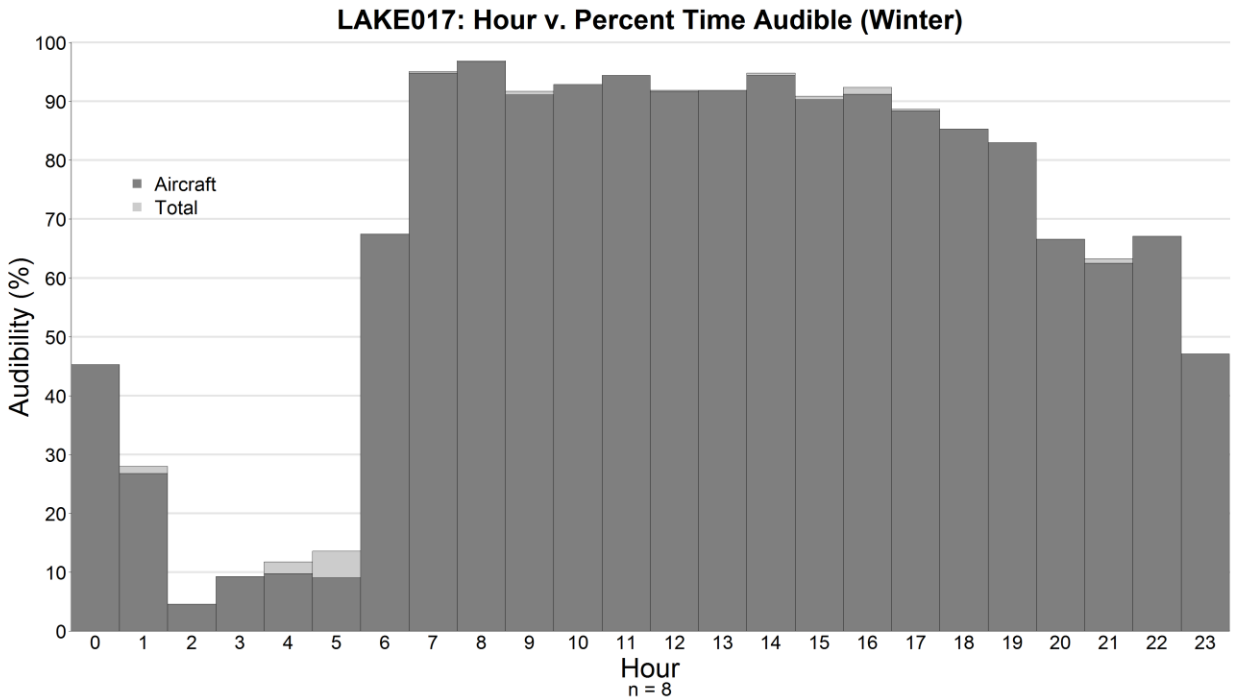

Figure 147. Audibility of extrinsic and aircraft sounds, LAME017 Winter.

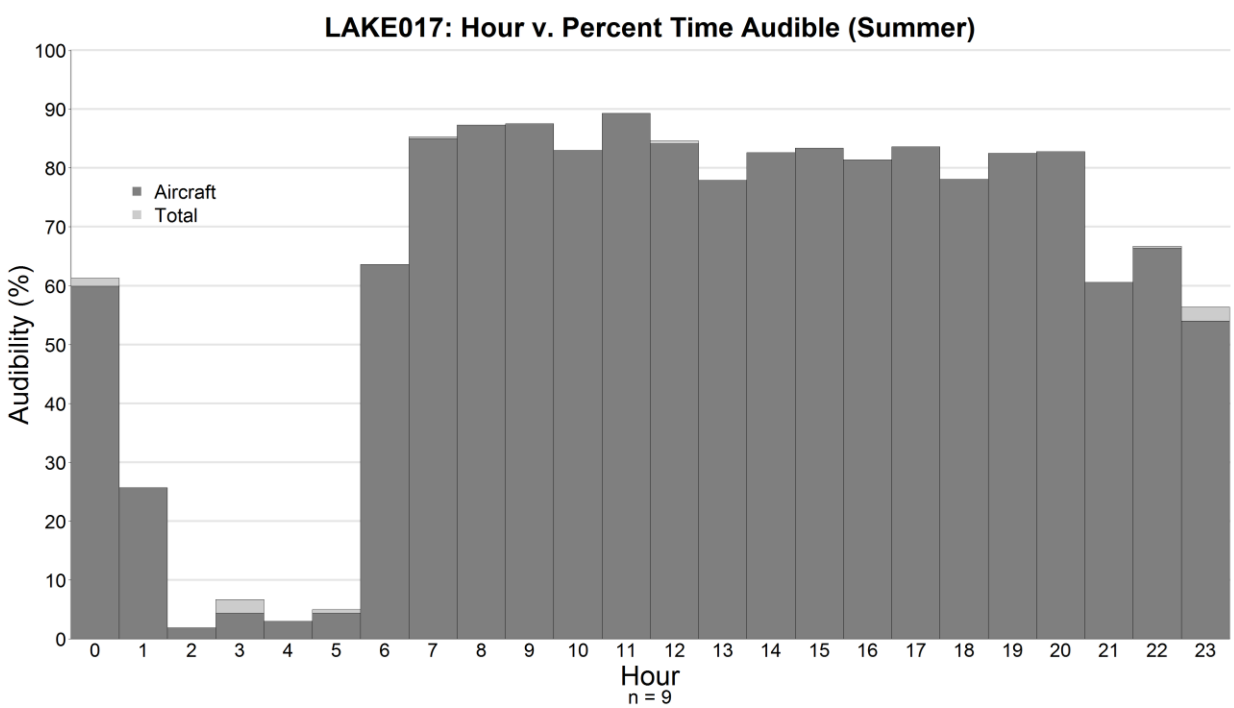

Figure 148. Audibility of extrinsic and aircraft sounds, LAME017 Summer.

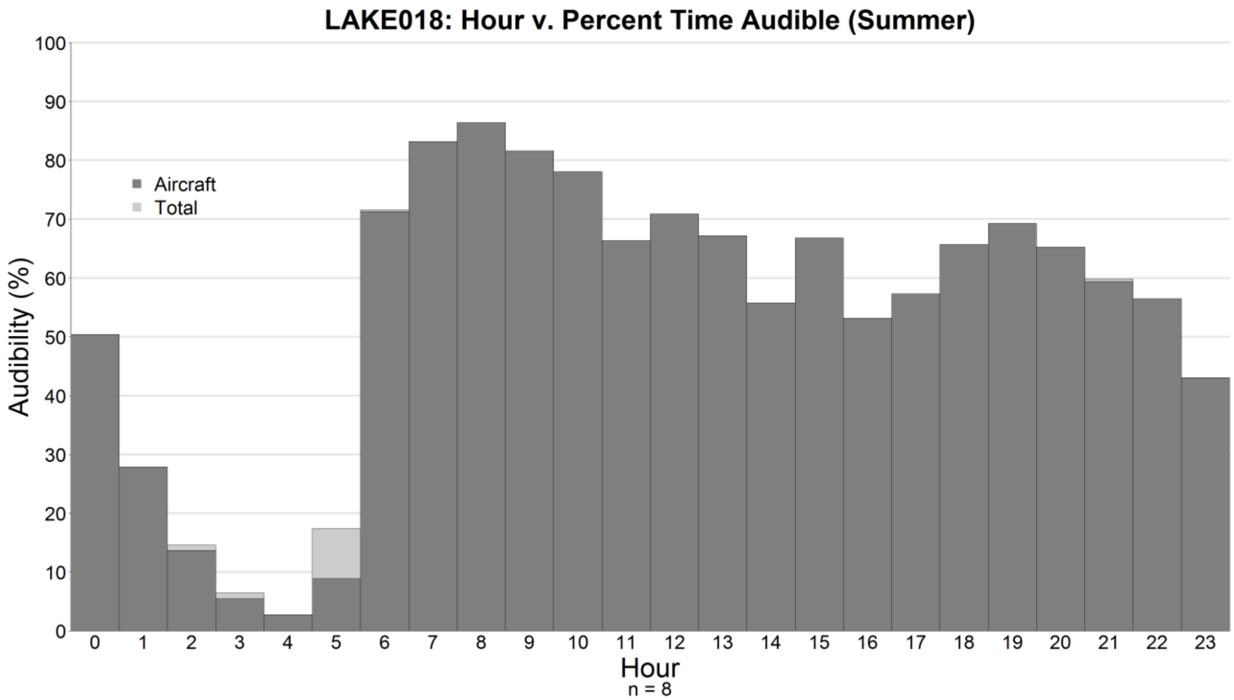

Figure 149. Audibility of extrinsic and aircraft sounds, LAME018 Summer.

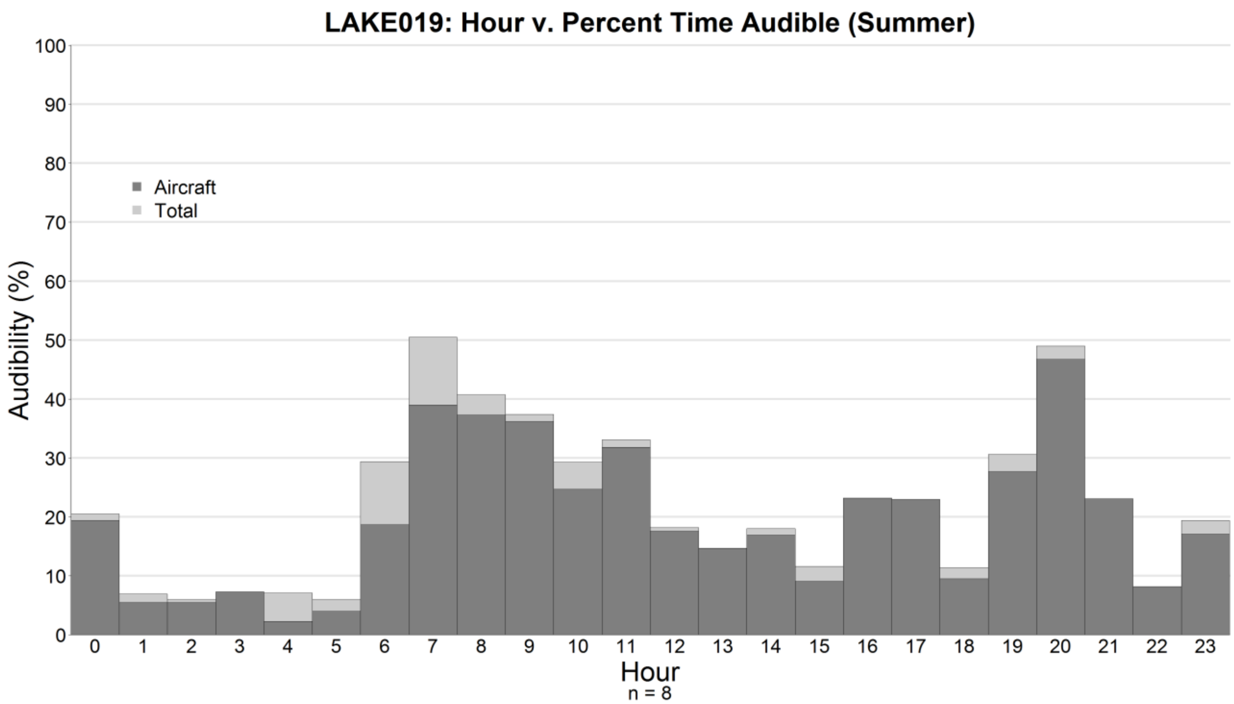

Figure 150. Audibility of extrinsic and aircraft sounds, LAME019 Summer.

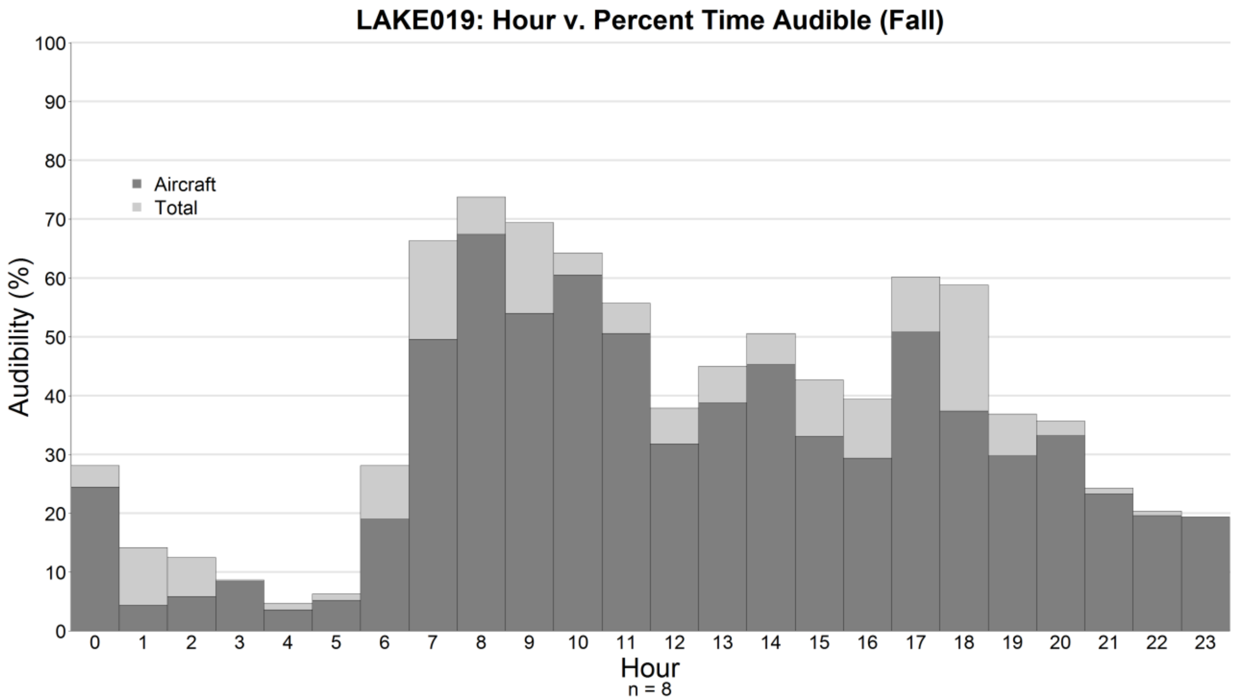

Figure 151. Audibility of extrinsic and aircraft sounds, LAME019 Fall.

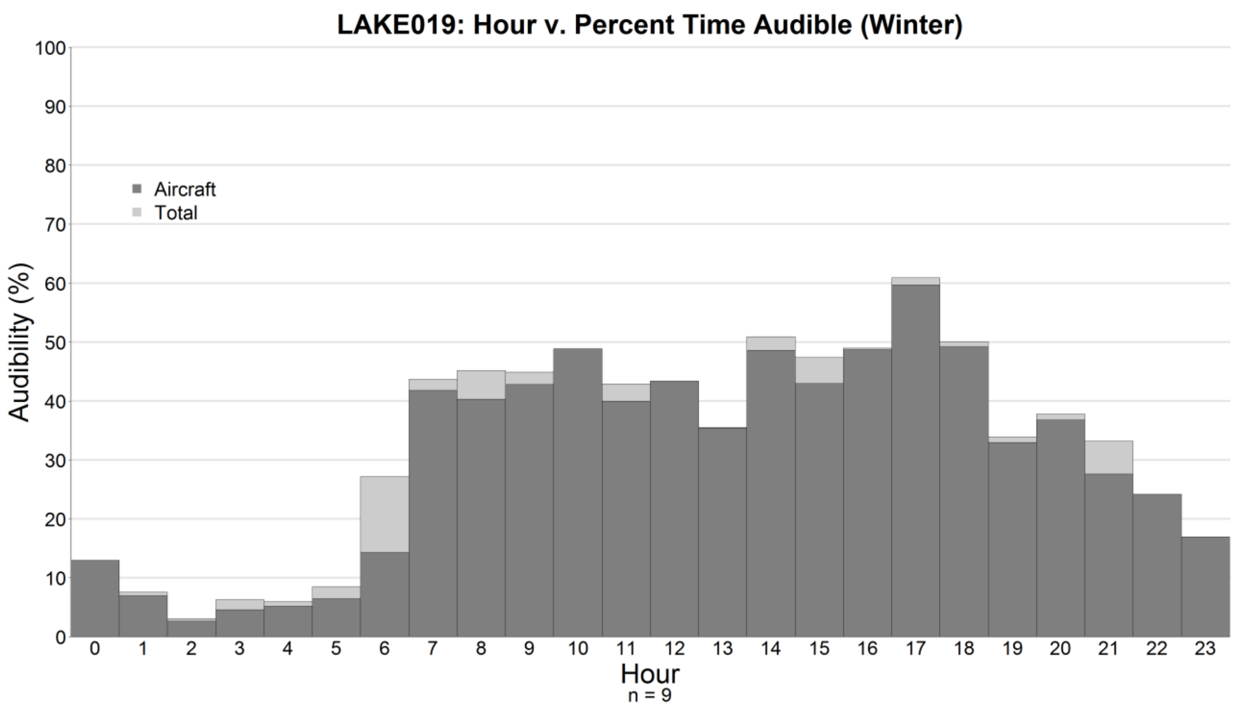

Figure 152. Audibility of extrinsic and aircraft sounds, LAME019 Winter.

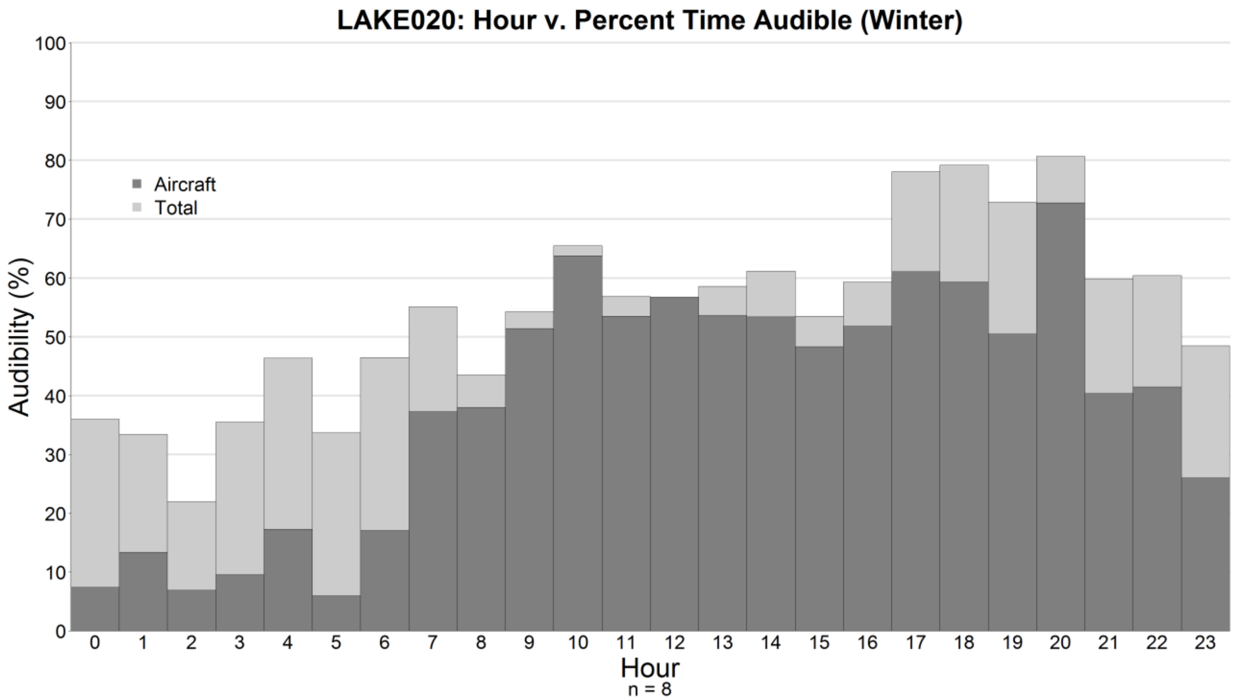

Figure 153. Audibility of extrinsic and aircraft sounds, LAME020 Winter.

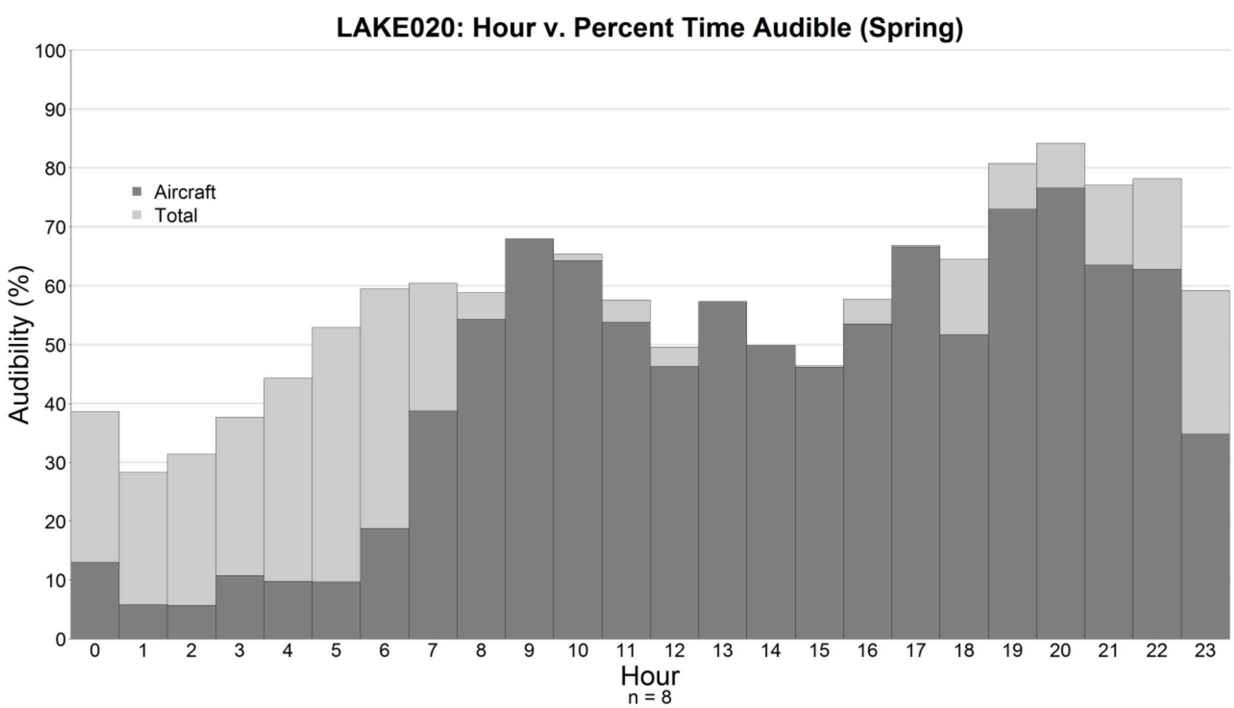

Figure 154. Audibility of extrinsic and aircraft sounds, LAME020 Spring.

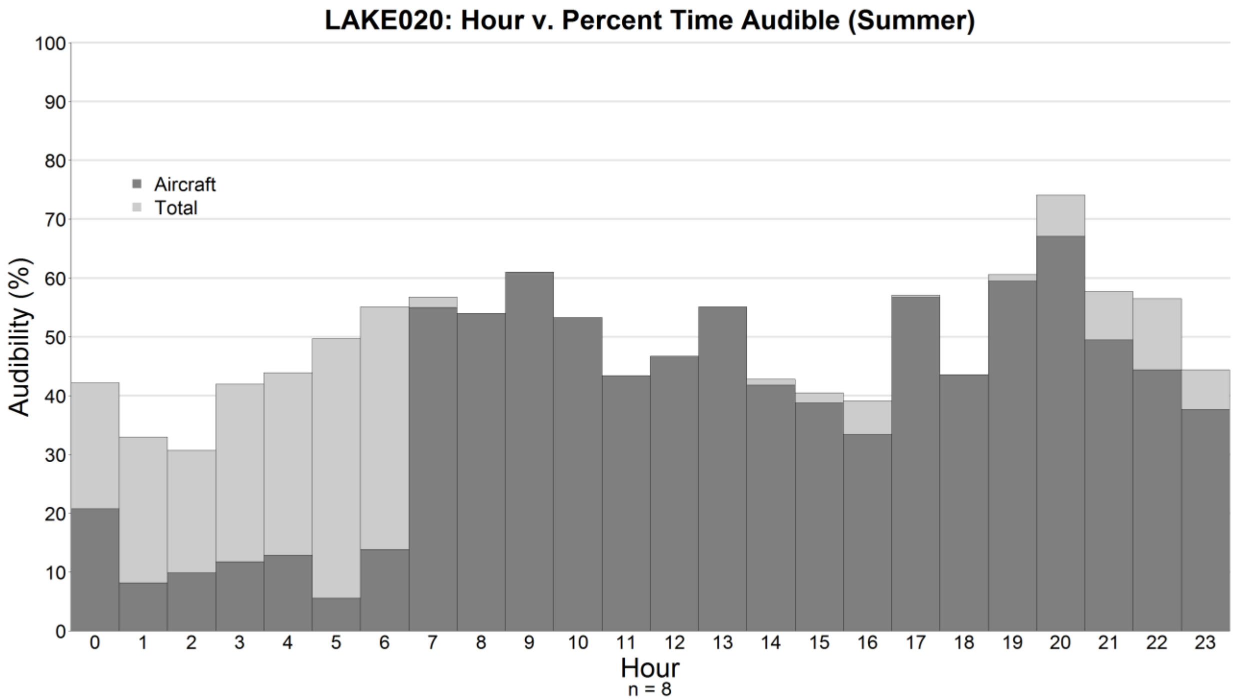

Figure 155. Audibility of extrinsic and aircraft sounds, LAME020 Summer.

On-site Listening

Table 9, Table 10, and Table 11 below display results of on-site listening sessions. Each audible sound source is listed in the first column. Percent time audible, or PA, is the second column. The third column, max event length, reports the maximum event length among the sessions for each sound source in minutes and seconds (mm:ss). Likewise, the mean event column reports the mean length of the events in minutes and seconds (mm:ss). The last row in the table, noise free interval (NFI), is a metric which describes the length of time between extrinsic or human-caused events. These on-site listening tables are essentially a sound inventory of each site. They reveal the sounds one is likely to hear at or near each location.

While this data wasn't collected for each site, the following helps demonstrate the sounds sources audible at Lake Mead NRA and the surrounding BLM land. These sounds can be used while viewing the previous figures for a better overall understanding of the acoustic environment.

At LAME007, the attended listening session was conducted on April 22, 2008, during removal of the acoustic monitoring equipment. Table 9 and Figure 156 report the results of on-site listening for LAME007. The audibility report is based on two hours of data between the hours of 1000-1100 and 1200-1300. The natural sound sources for this site consisted of wind, insects, and birds. The noise free interval occurred for a maximum length of 34 seconds. Figure 156 illustrates the data in Table 9 graphically.

Table 9. On-site Listening Report for Indian Pass AR72 (LAME007)

Sound Source	Percent Time Audible (PA)	Max Event Length, mm:ss	Mean Event Length, mm:ss	Count
All natural sources	94.1			
All non-natural sources	96.7			
All aircraft	96.7			
Aircraft, propeller	8.2	02:25	00:59	10
Helicopter	23.8	04:17	01:47	16
Jet	71.8	07:44	01:16	68
Bird	64.5	04:21	00:32	145
Insect	78.6	05:27	00:38	150
Wind	6.9	00:49	00:11	46
Noise free interval		00:34	00:06	41

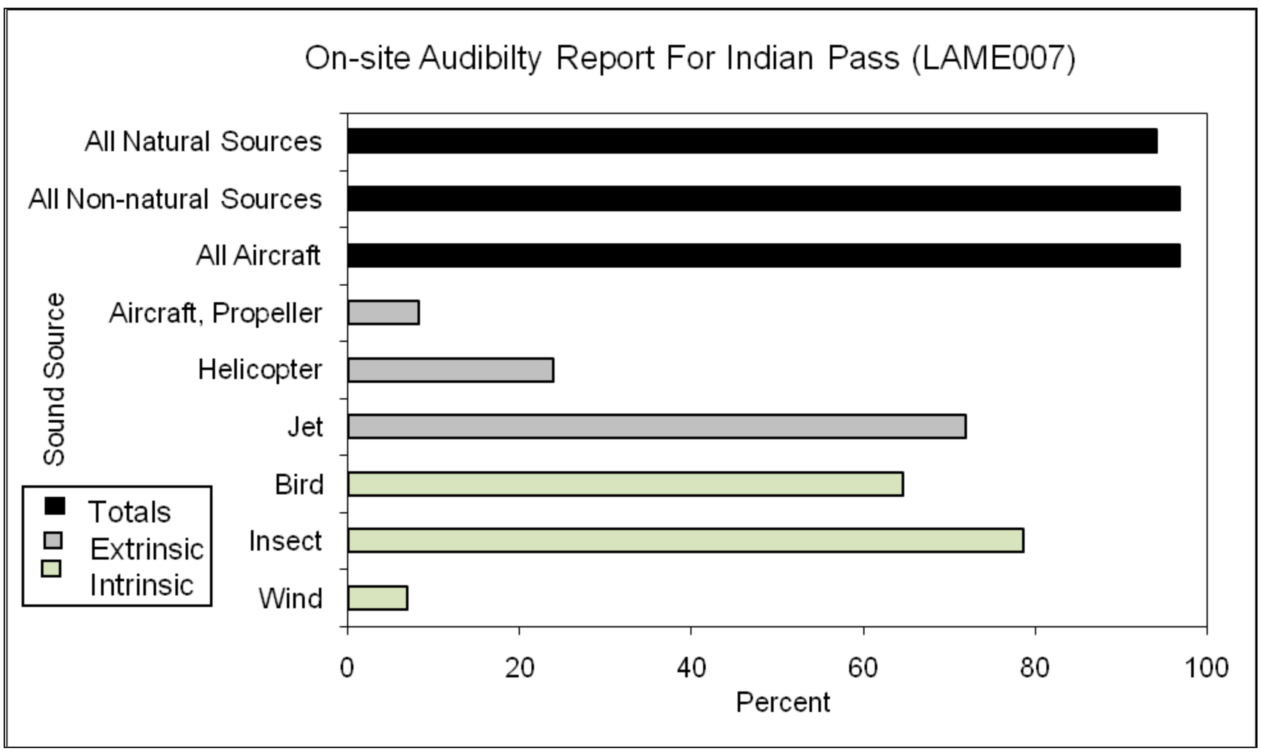

Figure 156. Percent time present during sampling period, LAME007.

The attended listening session was conducted on April 16, 2008, during removal of the acoustic monitoring equipment at LAME009 (Callville Wash). Table 10 and Figure 157 report the results of on-

site listening for LAME009. The audibility report is based on 3 hours of data between the hours of 0930-1030, 1100-1200, and 1330-1430. The natural sound sources for this site consisted of wind, insects, and bird calls (Figure 157). The noise free interval occurred for a maximum length of 1 minute and 8 seconds.

Table 10. On-site Listening Report for Callville (LAME009).

Sound Source	Percent Time Audible (PTA)	Max Event Length (mm:ss)	Mean Event Length (mm:ss)	Count
All natural sources	99.9			
All non-natural sources	89.6			
All aircraft	89.6			
Jet	72.8	05:18	01:08	115
Helicopter	13.2	03:29	01:29	16
Aircraft, propeller	0.4	00:44	00:44	1
Aircraft, unknown	6.4	01:37	00:50	14
Wind	99.7	59:58	44:53	4
Bird	53.0	03:35	00:23	244
Insect	13.0	01:38	00:06	218
Natural, unknown	0.0	00:02	00:02	2
Noise free interval		01:08	00:10	110

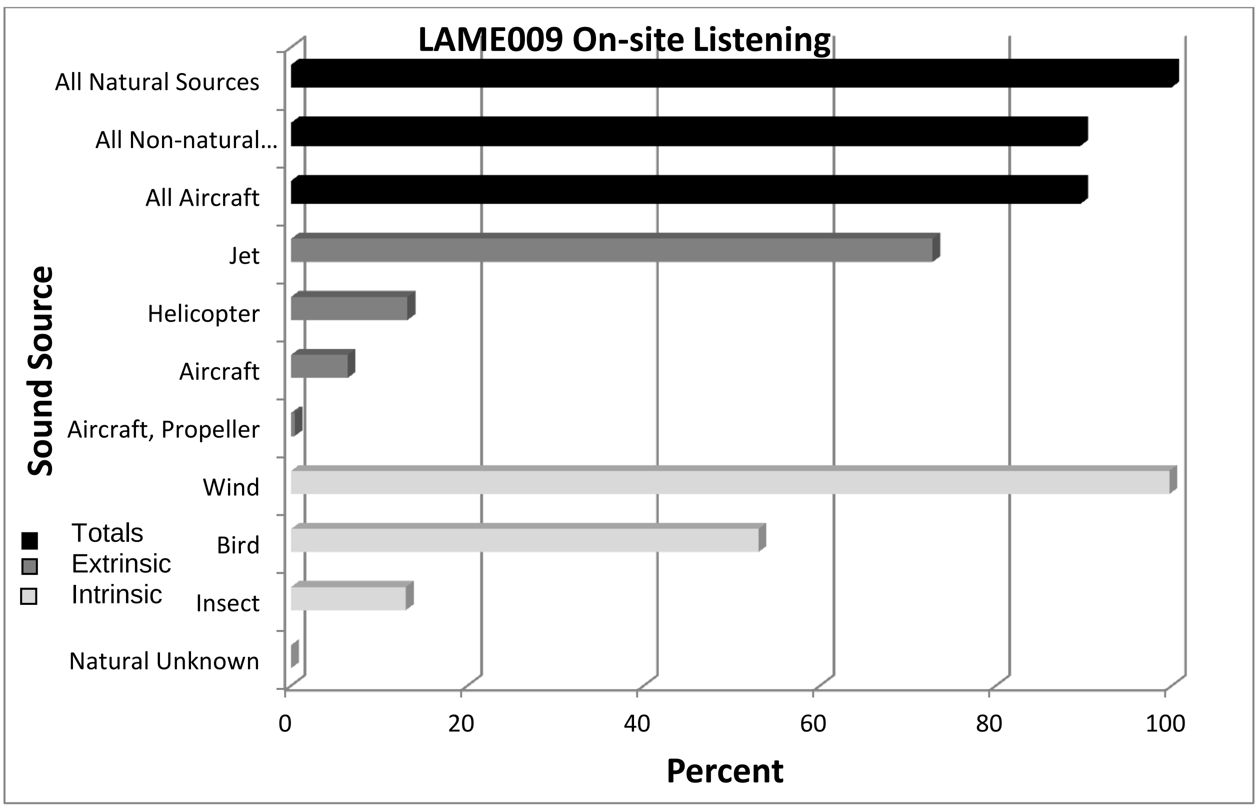

Figure 157. Percent time present during sampling period, LAME009 (Callville Wash).

The attended listening session at LAME010 was conducted on February 25, 2009. Table 11 and Figure 158 report the results of on-site listening for LAME010. The audibility report is based on 2 hours of data

between the hours of 1100-1200 and 1230-1330. The natural sound sources for this site consisted of wind, insects, and bird calls (Figure 158). The noise free interval occurred for a maximum length of 10 minutes and 31 seconds.

Table 11. On-site Listening Report for AR42B West Powerline Wash Road (LAME010).

Sound Source	Percent Time Audible (PTA)	Max Event Length (mm:ss)	Mean Event Length (mm:ss)	Count
All natural sources	98.5			
All non-natural sources	47.6			
All aircraft	47.6			
Aircraft, unknown	8	03:36	00:44	13
Jet	19.8	02:42	00:48	30
Aircraft, propeller	19.9	06:06	02:23	10
Insect	47.2	01:21	00:14	245
Bird	74.8	03:33	00:40	133
Wind	77.8	20:21	01:20	70
Natural, unknown	0.3	00:09	00:04	5
Noise free interval		10:31	01:13	52

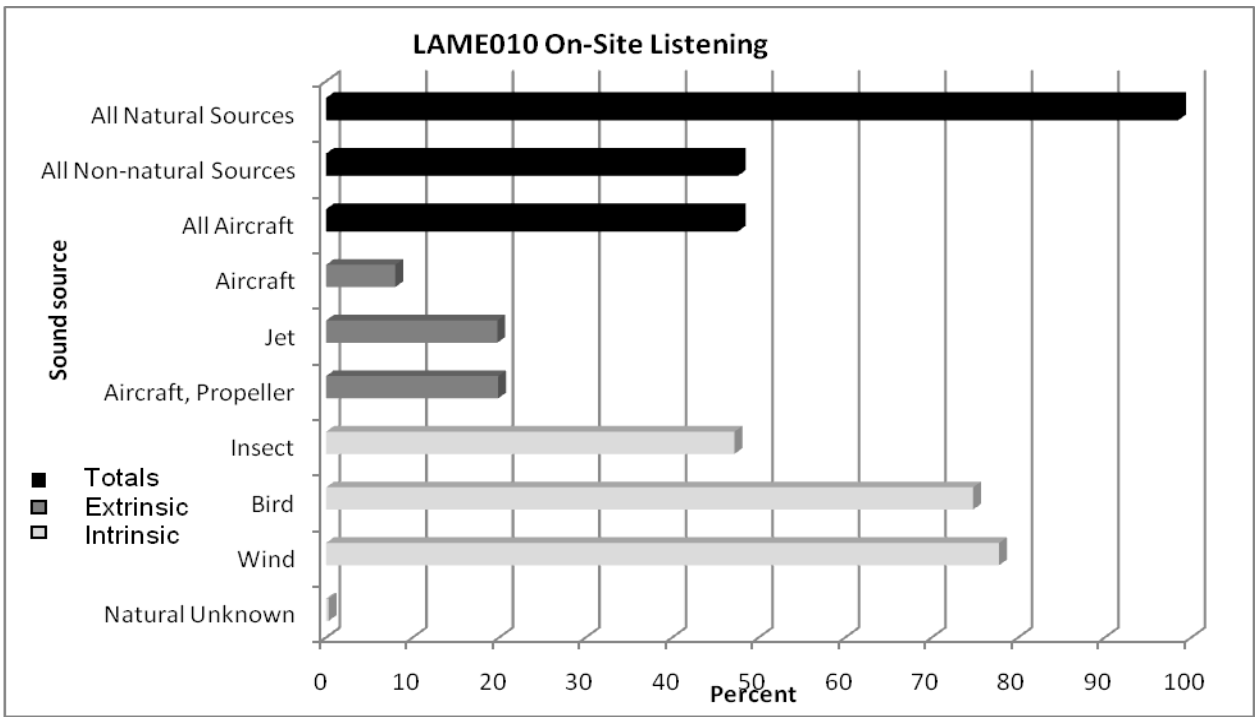

Figure 158. Percent time present during sampling period, LAME010 (AR42B West Powerline Wash Road).

The attended listening session for LAME011 was conducted on February 26, 2009. Table 12 and Figure 159 report the results. The audibility report is based on 2 hours of data between the hours of 1130-1230 and 1250-1350. The natural sound sources for this site consisted of wind, insects, and bird calls, with the

primary intrinsic sound source being bird calls (> 96% of the time), see Figure 159. LAME011 had the longest noise free interval, with a maximum of 16:43.

Table 12. On-site Listening Report for Pipe Springs AR20A (LAME011).

Sound Source	Percent Time Audible (PTA)	Max Event Length (mm:ss)	Mean Event Length (mm:ss)	Count
All natural sources	99.6			
All non-natural sources	31.4			
All road vehicles	8.2			
All aircraft	24.2			
Aircraft, unknown	1.9	01:49	01:08	2
Jet	13.4	04:45	01:21	12
Aircraft, propeller	3.8	02:06	01:32	3
Helicopter	5.1	04:07	03:02	2
Vehicle	8.2	02:25	00:54	11
People	<0.1	00:02	00:02	1
Non-natural, unknown	0.1	00:07	00:07	1
Natural, unknown	0.1	00:03	00:03	2
Wind	25	03:59	01:15	24
Insect	48.3	09:58	00:25	139
Bird	96.4	59:01	10:31	11
Noise free interval		16:43	05:56	28

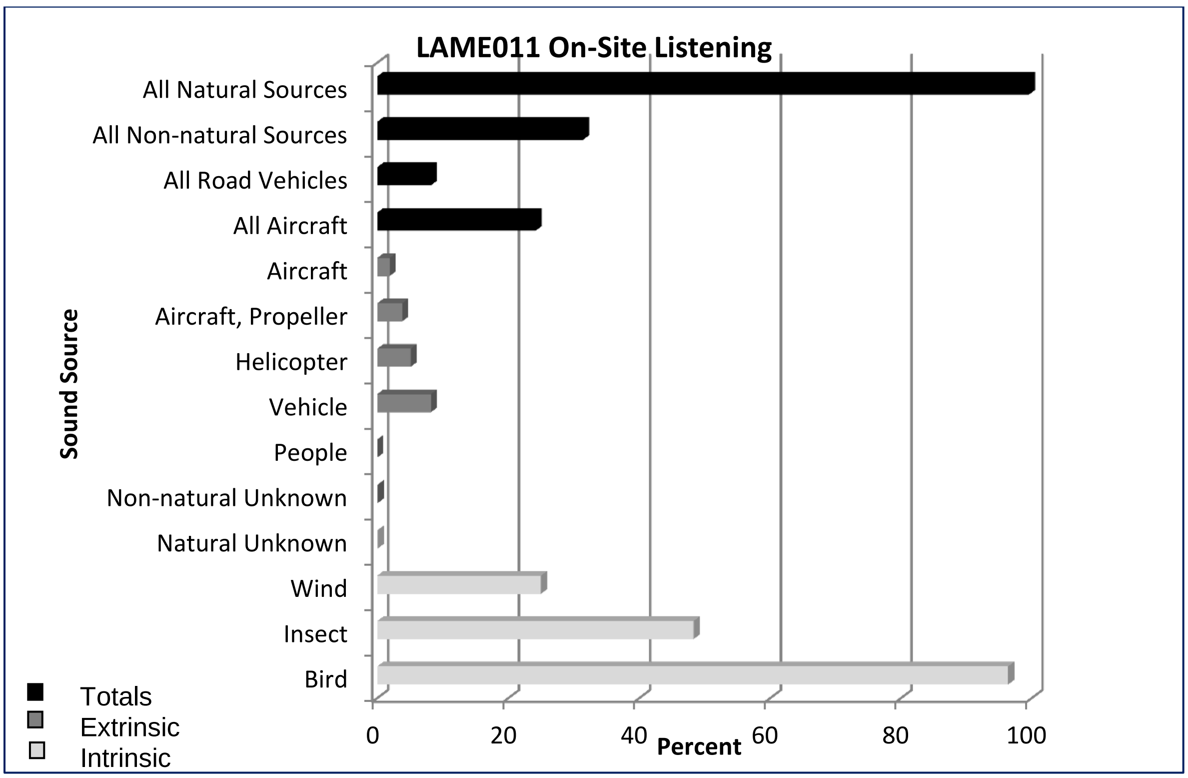

Figure 159. Percent time present during sampling period, LAME011 (Pipe Springs AR20A).

CONCLUSION

This study was intended to provide current baseline sound level and overflight data throughout and nearby Lake Mead NRA. It was intended to inform and facilitate the formulation of an Air Tour Management Plan for the park (a Congressional mandate), wilderness planning, and general park planning. Overall, park staff found the current conditions at the selected sites to be fairly quiet. Data show that the sites were most affected by extrinsic noise during daytime and evening hours. The dominant extrinsic noise source at all sites was high-altitude jets.

The acoustic monitoring systems also collected detailed records of ambient sound pressure levels. These data can be used to report existing ambient levels, and in conjunction with percent time audible statistics, can help estimate the natural ambient acoustical conditions. The existing ambient (L_{50}) level is the median sound level. It is the composite of all sounds at a site, both human caused and natural. The natural ambient (L_{nat}) estimates what the acoustic environment would be without the contribution of anthropogenic sounds. Throughout the study area, natural and existing ambient levels were relatively quiet. In fact, in the early morning hours, sound pressure levels at LAME009 and LAME010 were very close to the noise floor of acoustic monitoring equipment, which is the lowest recording limit. Sound levels as low as these are extremely rare and highly sensitive to the influence of extrinsic sound events. While wind and location of monitoring equipment can affect the ambient sound pressure levels, the data presents a likely range of ambient levels for the sampling areas in the park, regardless of slight variations in ambient values.

Acoustic monitoring at Lake Mead NRA and surrounding BLM lands not only offers insight into the prevalence of extrinsic noise, but also allows managers to determine the presence of biological (or geologic) activity. Both on-site and off-site listening sessions produced a number of informative biological, meteorologic, and geologic sound recordings, such as bighorn sheep, bird calls, coyote howls, thunder storms, and rock falls.

Natural Ambient Sound Level and Audibility

Park staff was able to assess common noise sources at each site using off-site analysis (either visual or auditory). By a large margin, the most common noise source was aircraft (with audibility at or near 90% for some hours in some locations), followed by vehicles. The natural ambient levels at Lake Mead NRA were quietest during the early morning hours. As the day progressed into the night; birds, wind, and extrinsic sounds occurred.

The quietest nighttime L_{nat} levels occurred at LAME017 and LAME020, with a dBA of 14.5. The loudest daytime L_{nat} levels occurred at LAME016, with a dBA of 28.0, where local measured wind speed was the greatest. When L_{nat} levels were analyzed by frequency, each site displayed a similar pattern. The low frequencies were always the loudest, and the high frequencies were typically the quietest.

This trend was slightly different for LAME011, where the late night and early morning hours ambient levels were increased from bird and insect sound sources. The lowest median L_{nat} dBA for LAME009 occurred at 0100 and 0500 hours and registered at 15.3 dBA. LAME010 had a slightly lower median L_{nat} dBA of 14.7 at 0000 and 0300 hours. The lowest median dBA for LAME011 occurred during the 0600 hour with 15.1 dBA. In contrast, the highest median natural ambient dBA at LAME009 occurred at 1500 at 25.4. Also at 1500, LAME010 reached a median natural ambient high of 17.2 dBA. LAME011 had a median natural ambient high dBA, similar to LAME009, of 26.5 at 0000.

Looking at nighttime ambient, using only frequencies affected by transportation noise, or dBT, (20 Hz – 1250 Hz), the data indicate a lower L_{nat} for each of the sites. The nighttime dBT at LAME009 was as low as 13.1, LAME010 at 9.5, and LAME011 at 9.6.

In addition to the percent time audible metrics, off-site analysis of acoustic (.wav) samples yielded a number of interesting wildlife sound recordings. In the process of listening to the selected days for each site, park staff located recordings of many different species of bird calls including the rock wren, mockingbird, phainopepla, and cactus wren. Other interesting intrinsic sounds heard include bighorn sheep passing by, coyote calls, rainstorms, and insects. Presumably, if continuous recordings had been analyzed instead of ten second samples every two minutes, these sounds might have been discovered more frequently.

Future Monitoring and Adaptive Management

Acoustic monitoring efforts in Lake Mead NRA yielded valuable results that allow park managers to better understand the existing acoustic environment of the park. Monitoring existing conditions and trends allows managers to take action to move towards desired future conditions. The acoustical data in this report provide the necessary information for the application of acoustic indicators and standards or the development of a management plan.

The wilderness areas listed in this report are relatively quiet in comparison to other portions of the park and even other parks in the nation. The sounds in and around Lake Mead NRA are an issue which deserves further consideration. The wilderness areas within Lake Mead NRA are impacted by extrinsic sounds of transportation, mainly high-altitude jets, helicopters, and vehicles. Limiting or mitigating the human caused contributions of sounds could improve the natural acoustic environment.

The data collected are an initial baseline for these wilderness areas. Future management at Lake Mead should focus on maintaining this baseline. It is recommended that Lake Mead NRA continue to make soundscape monitoring a priority. These areas should be monitored for trends every 2-5 years or more frequently if any significant impact is expected.

Biological monitoring with the use of continuous recording acoustic equipment offers many opportunities to extend surveys to places and intervals when it is inconvenient or impossible for observers to be present. Furthermore, many animals may react to the presence of an observer; a small piece of equipment presents a much smaller potential for disturbance.

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APPENDIX A. Glossary of Acoustic Terms

Acoustic Environment - The actual physical sound resources, regardless of audibility, at a particular location.

Amplitude - The instantaneous magnitude of an oscillating quantity such as sound pressure. The peak amplitude is the maximum value.

Audibility - The ability of animals with normal hearing, including humans, to hear a given sound. Audibility is affected by the hearing ability of the animal, the masking effects of other sound sources, and by the frequency content and amplitude of the sound.

dBA - A-weighted decibel. A-Weighted sum of sound energy across the range of human hearing. Humans do not hear well at very low or very high frequencies. Weighting adjusts for this.

dBT - Truncated measurements focus on general transportation noise (~100-800 hertz). These results allow park staff to confidently draw conclusions about human-caused sounds.

Decibel - A logarithmic measure of acoustic or electrical signals. The formula for computing decibels is: 10(Log10(sound level/reference sound level)). 0 dB represents the lowest sound level that can be perceived by a human with healthy hearing. Conversational speech is about 65 dB.

Diel - A 24-hour period usually consisting of a day and the adjoining night.

Extrinsic Sound - Any sound not forming an essential part of the park unit, or a sound originating from outside the park boundary.

Frequency - The number of times per second that the sine wave of sound repeats itself. It can be expressed in cycles per second, or Hertz (Hz). Frequency equals Speed of Sound/ Wavelength.

Hearing Range (frequency) - By convention, an average, healthy, young person is said to hear frequencies from approximately 20Hz to 20000 Hz.

Hertz - A measure of frequency, or the number of pressure variations per second. A person with normal hearing can hear between 20 Hz and 20,000 Hz.

Human-Caused Sound - Any sound that is attributable to a human source

Intrinsic sound - A sound which belongs to a park by its very nature, based on the park unit purposes, values, and establishing legislation. The term “intrinsic sounds” has replaced “natural sounds” in order to incorporate both cultural and historic sounds as part of the acoustic environment of a park.

Listening Horizon - The range or limit of one’s hearing capabilities. Just as smog limits the visual horizon, so noise limits the acoustic horizon.

Leq - Energy Equivalent Sound Level. The level of a constant sound over a specific time period that has the same sound energy as the actual (unsteady) sound over the same period.

Lx - A metric used to describe acoustic data. It represents the level of sound exceeded x percent of the time during the given measurement period. Thus, L50 is the level exceeded 50% of the time (it is also referred to as existing ambient).

Lnat - An estimate of what the acoustic environment might sound like without the contribution of extrinsic (anthropogenic) sounds.

Masking - The process by which the threshold of audibility for a sound is raised by the presence of another sound.

Noise-Free Interval - The period of time between noise events (not silence).

Noise - Sound which is unwanted, either because of its effects on humans, its effect on fatigue or malfunction of physical equipment, or its interference with the perception or detection of other sounds (Source: McGraw Hill Dictionary of Scientific and Technical Terms).

Off-site Listening - The systematic identification of sound sources using digital recordings previously collected in the field.

On-site Listening - The systematic identification of sound sources at a specific monitoring site using a personal digital assistant (PDA). Custom PDA software records begin and end times of audible sound sources. These sessions often last for one hour.

Sound - Variations in local pressure that propagate through a medium (e.g. the atmosphere) in space and time.

Soundscape - Human perception of the acoustic environment.

Sound Pressure - The difference between instantaneous pressure and local barometric pressure. Measured in Pascals (Pa), Newtons per square meter, which is the metric equivalent of pounds per square inch.

Sound Pressure Level (SPL) - A calibrated measure of sound level, expressed in decibels, and referred to an atmospheric standard of 20 micro Pascals.

Time Audible - The amount of time that a sound source is audible to an animal with normal hearing.

APPENDIX B. Analyzing Audibility Visually

Sound pressure levels (SPL) from a 24 hour spectogram at an acoustic monitoring site at Lake Mead National Recreation Area are shown below. Twenty four hours of SPL data are displayed over 12 lines. Each line shows SPL values from low frequency to high frequency. Values are represented with a color scale, where dark purple is quiet and orange/white is loud (Figure 160).

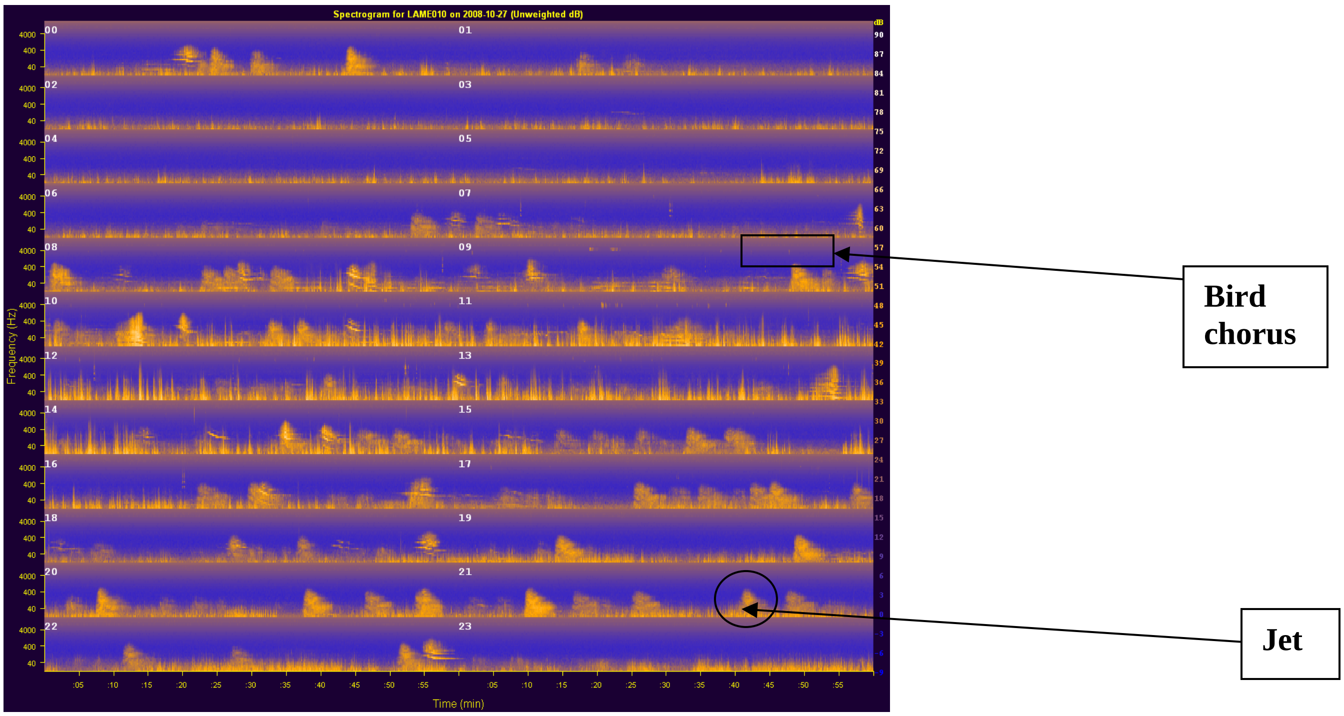

Figure 160. Example of a 24 hour spectrogram from LAME.

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