National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Acoustic Monitoring Report, Denali National Park and Preserve – 2010

Natural Resource Data Series NPS/DENA/NRDS—2013/441

ON THE COVER
A soundscape monitoring system collects data on the lateral moraine of the glacier which feeds Ohio Creek, on the south side of the Alaska Range in Denali National Park.
NPS Photo by Jared Withers

Acoustic Monitoring Report, Denali National Park and Preserve – 2010

Natural Resource Data Series NPS/DENA/NRDS—2013/441

Jared Withers
Physical Scientist
PO Box 9
Denali National Park, AK 99755

Davyd Betchkal
Physical Science Technician
PO Box 9
Denali National Park, AK 99755

January 2013

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

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.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. 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.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Denali website (http://www.nps.gov/dena/naturescience/index.htm), and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

Please cite this publication as:

Withers, J. and D. Betchkal. 2013. Acoustic monitoring report, Denali National Park and Preserve – 2010. Natural Resource Data Series NPS/DENA/NRDS—2013/441. National Park Service, Fort Collins, Colorado.

NPS 184/119672, January 2013

Contents

Figures

Page

Figures (continued)

Page

Figures (continued)

Page

Tables

Page

Executive Summary

Park staff deployed acoustic monitoring systems to nine locations in Denali National Park and Preserve in 2010. The purpose of this monitoring effort was to inventory the ambient acoustic conditions and amount of non-natural sound in Denali National Park as called for in the 2006 Backcountry Management Plan. Data collected included existing ambient sound pressure levels, natural ambient sound pressure levels, percentage of time audible, and loud acoustic event statistics for intrinsic and extrinsic sound sources. Deployed systems were configured to log sound pressure levels every second and continuous mp3 audio recordings, 24 hours per day. These data serve as a permanent record of existing acoustical conditions at these locations for the summer of 2010.

Table 1 shows summarized results of 2010 monitoring, including ambient and natural ambient sound statistics in dBA (A-weighted decibels) and average percentage of time audible, number of events per day, and maximum sound pressure level (SPL) for aircraft sound sources, which are the most prominent of extrinsic sounds occurring at these sites. Median ambient (L_{50}) describes the acoustical environment as is, including both natural and extrinsic sounds. Natural ambient (L_{nat}) estimates what the acoustical environment might sound like without the contribution of extrinsic sounds. This table also shows exceedence metrics L_{10} and L_{90}, which mark the average maximum and minimum exceedence levels over the monitoring periods.

Table 1. Median natural sound, existing ambient sound, and mean aircraft statistics for all sites*.

Site Name	L_{nat}	L_{10}	L_{50}	L_{90}	% Aircraft	# Aircraft/Day	Aircraft Max SPL
Beaver Lake	19.62	25.10	19.82	15.59	3.3	8.8	46.9
Kahiltna Pass	18.33	25.43	18.81	12.32	7.1	30.4	44.7
Lower Kantishna River	11.25	17.60	11.46	8.16	4.0	9.4	39.4
Myrtle	6.19	10.41	6.30	4.21	3.3	5.1	31.9
Tokositna Toe [1]	7.10	12.98	7.53	4.24	5.2	16.0	34.3
Upper Dall Glacier	28.25	33.25	28.28	24.64	1.2	4.5	43.1
Upper Ohio Glacier	25.88	30.44	25.93	21.38	1.6	10.5	45.3
Upper West Fork Yentna	37.97	40.87	38.00	35.74	1.1	4.6	--
West Buttress	16.62	24.79	17.07	12.16	7.6	18.7	--

*L_{nat}, L_{10}, L_{50}, L_{90}, and SPL in dBA. [1] : Winter season site.

When interpreting sound pressure level data, it should be noted that the decibel scale is logarithmic. As such, a three decibel increase in sound pressure level is a doubling of sound energy. Overall, the acoustic conditions of these 2010 sites varied. The Myrtle site experienced the lowest ambient and natural ambient sound levels, as well as relatively low levels of aircraft activity. Of the flights which occurred at Myrtle during the measurement period, the average maximum sound pressure level for an event was the lowest measured thus far in Denali.

Introduction

Natural sound is both a resource in its own right as well as an important aspect of Denali National Park and Preserve's (Denali) wilderness resource values, and the influence of motorized noise on visitor experience is a key concern throughout the park. Denali's Backcountry Management Plan (BCMP), finalized in 2006, established indicators and standards for the natural sound environment and called for monitoring to evaluate whether the standards are being satisfied. Soundscape measurements are objective and employ methods for monitoring that are easily reviewed by the public, which will provide strong support for future management decisions. Without these data, the park will have little information to make management guidelines or support management decisions that may affect the quality of Denali's soundscape.

The initial push for Denali to begin soundscape inventories began with Director's Order 47 (DO-47). Robert Stanton issued the order in 2000 directing park managers to identify baseline soundscapes and related measures. DO-47 states that "natural sounds are intrinsic elements of the environment that are often associated with parks and park purposes…They are inherent components of 'the scenery and the natural and historic objects and the wild life' protected by the NPS Organic Act." DO-47 directed park managers to "(1) measure baseline acoustic conditions, (2) determine which existing or proposed human-made sounds are consistent with park purposes, (3) set acoustic management goals and objectives based on those purposes, and (4) determine which noise sources are impacting the park and need to be addressed by management." Furthermore, it requires park managers to "(1) evaluate and address self-generated noise, and (2) constructively engage with those responsible for other noise sources that impact parks to explore what can be done to better protect parks." (NPS 2000).

The primary purpose behind the Denali soundscape study has been to measure the level of influence overflight traffic and snowmachine traffic has on the Park's soundscape. Understanding the natural soundscape is important to evaluate the level of impact human-generated sounds may have on this important resource. The natural soundscape is generally comprised of two main sound categories, physical and biological. Physical sounds are created by physical forces (wind, rock fall, rivers, etc.), whereas biological sounds are created by organisms (birds, frogs, plants, etc.). The presence and abundance of sounds from these two categories is used to characterize different habitats. (Dunholter et al. 1989) Different habitats have specific soundscape characteristics that are an important attribute of the natural system, with distinct impacts on the human perception of the environment. Impacts on the natural soundscape and on visitor experiences come from human-generated sounds.

Soundscape Planning Authorities

The National Park Service (NPS) Organic Act of 1916 states that the purpose of national parks is "… to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." (NPS 1916) In addition to the NPS Organic Act, the Redwoods Act of 1978 affirmed that, "the protection, management, and administration of these areas shall be conducted in light of the high value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for

which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress." (NPS 1978)

Direction for management of natural soundscapes[1] is represented in 2006 Management Policy 4.9:

> "The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts. Using appropriate management planning, superintendents will identify what levels and types of unnatural sound constitute acceptable impacts on park natural soundscapes. The frequencies, magnitudes, and durations of acceptable levels of unnatural sound will vary throughout a park, being generally greater in developed areas. In and adjacent to parks, the Service will monitor human activities that generate noise that adversely affects park soundscapes [acoustic resources], including noise caused by mechanical or electronic devices. The Service will take action to prevent or minimize all noise that through frequency, magnitude, or duration adversely affects the natural soundscape [acoustic resource] or other park resources or values, or that exceeds levels that have been identified through monitoring as being acceptable to or appropriate for visitor uses at the sites being monitored" (NPS 2006a).

It should be noted that the Management Policy 8.2.3: Use of Motorized Equipment states "the natural ambient sound level—that is, the environment of sound that exists in the absence of human-caused noise—is the baseline condition, and the standard against which current conditions in a soundscape [acoustic resource] will be measured and evaluated" (NPS 2006b). However, the desired acoustic condition may also depend upon the resources and the values of the park. For instance, "culturally appropriate sounds are important elements of the national park experience in many parks" (NPS 2006b). In this case, "the Service will preserve soundscape resources and values of the parks to the greatest extent possible to protect opportunities for appropriate transmission of cultural and historic sounds that are fundamental components of the purposes and values for which the parks were established" (NPS 2006b).

Sampling Plan

Denali's soundscape sampling plan was designed using a coarse grid derived from the Long Term Ecological Monitoring (LTEM) grid (NPS 2006c). The number of points sampled in the coarse grid is driven by the number of acoustic monitoring stations available (five), and the length of time each station should be established at each location. To properly characterize the natural soundscape, stations should be established such that at least one month of continuous data is collected at each site during the field/tourist season (Ambrose and Burson 2004). To maximize the spatial coverage with only five stations it was decided to sample two locations through the entire field season, while rotating three stations over two sites each – two months as each site. Four of the two month-long sites would be established on the LTEM sampling grid, with two free to allow park managers to collect data at sites of specific interest which may not

[1] The 2006 Management Policy 4.9 and related documents refer to "soundscapes" instead of "acoustic resources." When quoting from this authority, it is advisable to note that the term often refers to resources rather than visitor perceptions.

fall on a grid point. As such, six LTEM grid locations will be sampled each year, with 60 grid points to be sampled overall (Figure 1). In addition, opportunistic sampling may be attempted during the winter months as permitted by funding, personnel, and ease of access to provide some indication of acoustic conditions outside the field/tourist season.

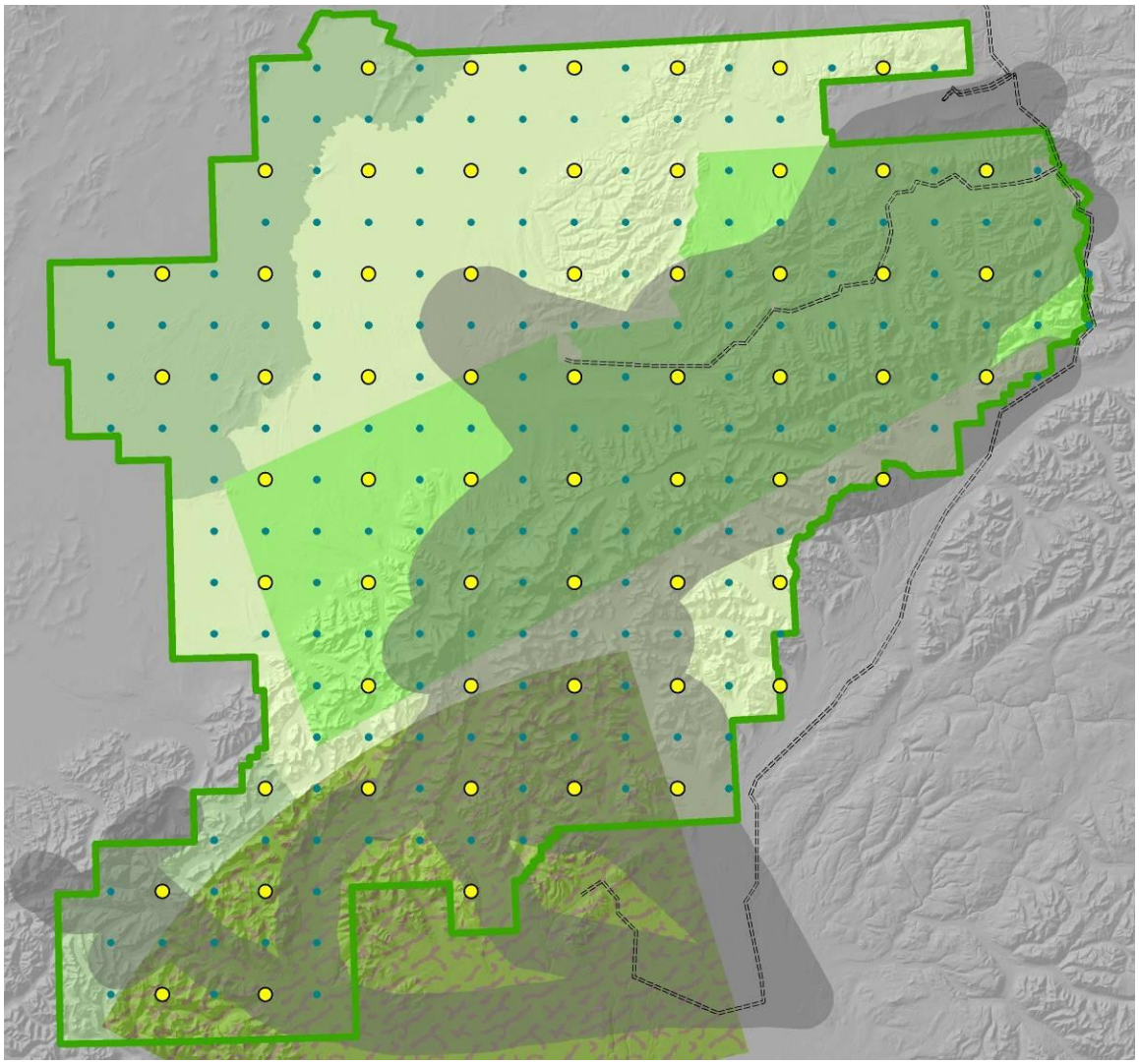


Figure 1. Map showing the coarse grid of sixty points to be sampled, marked by yellow dots.

Study Area

Park staff deployed acoustic monitoring systems to nine locations in Denali National Park in 2010, as shown in Table 3 and Figure 2.

Table 2. Sites sampled in 2010.

Site Location	Elevation (meters)	Latitude	Longitude	Sampling Period*
Beaver Lake	260	63.63097	-152.42043	Aug-24 to Sept-19
Kahiltna Pass	3003	63.07547	-151.17464	May-28 to Jun-26
Lower Kantishna River	168	63.96405	-151.20627	Jun-06 to Jul-10
Myrtle	947	63.59731	-150.40863	Aug-06 to Sept-19
Tokositna Toe [1]	273	62.54195	-150.79065	Mar-13 to Apr-12
Upper Dall Glacier	1241	62.72931	-152.08225	Jul-02 to Jul-20
Upper Ohio Glacier	1504	63.22536	-150.02376	May-29 to Jun-30
Upper West Fork Yentna	343	62.54351	-152.47501	May-29 to Jun-24
West Buttress	4345	63.06929	-151.07126	May-28 to Jun-22

[1] : Winter season site.

*One month of continuous data is the goal, but some sites do not achieve this goal due to equipment failure, animal tampering, insufficient solar radiation, and access scheduling. If a full month of data was not collected, an acoustic profile is compiled using the available data.

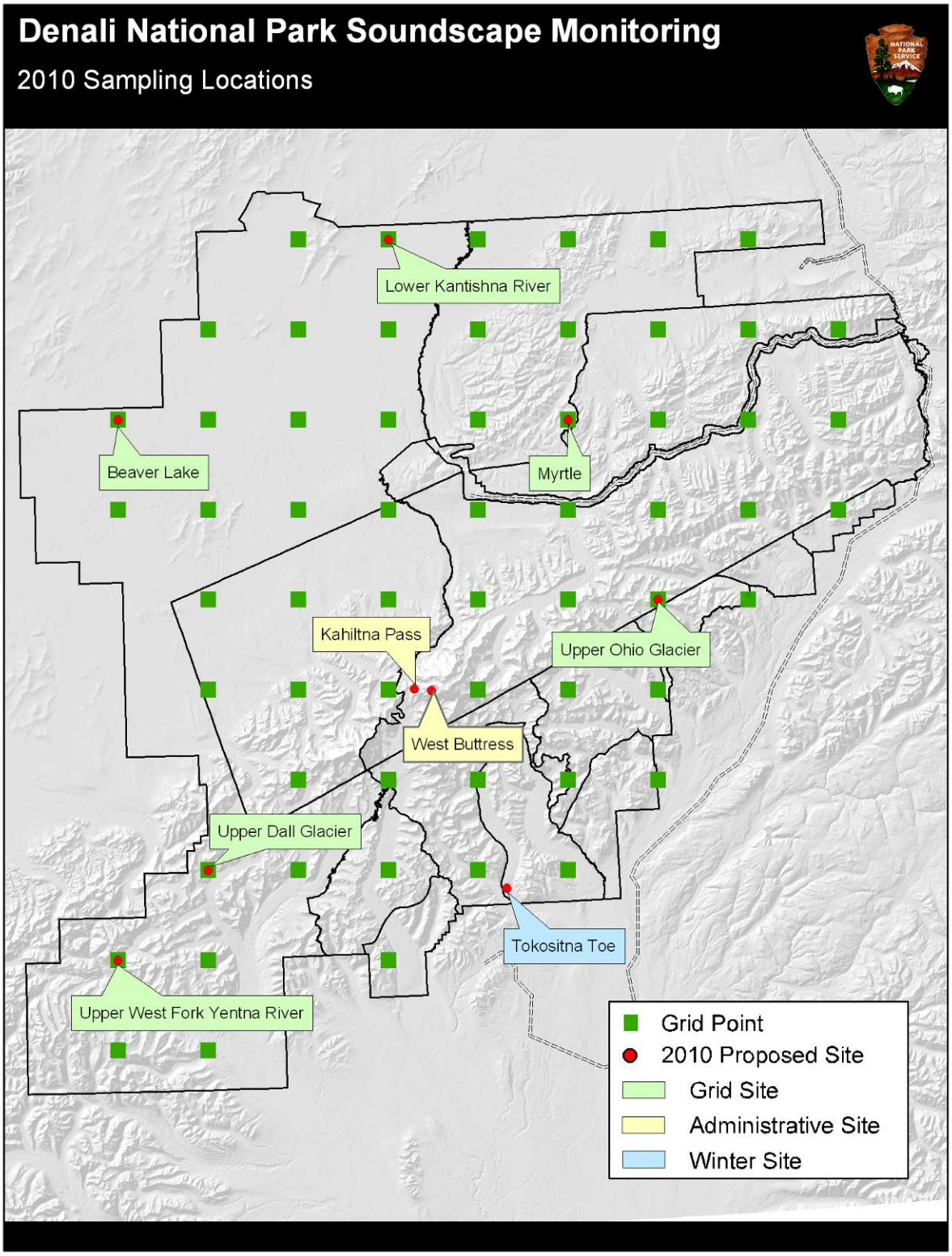


Figure 2. 2010 Acoustic monitoring sites in Denali National Park.

Methods

Automated Monitoring

The Larson Davis 831 sound level meter (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 USB storage device. These Larson Davis-based sites met American National Standards Institute (ANSI) Type 1 standards (ANSI 1992, 1968). To supplement the SPL data, Edirol R-09HR field recorders make mp3 recordings via the Larson Davis 831 audio output.

Each Larson Davis sampling station consisted of:

- Microphone with environmental shroud and Rycote windscreen
- Preamplifier
- Edirol R-09HR mp3 recorder
- Solar panel and batteries
- Anemometer

Each acoustic sampling station collected:

- SPL data in the form of A-weighted decibel readings (dBA) every second
- Continuous digital audio recordings
- 1/3 octave band data every second ranging from 12.5 Hz – 20,000 Hz

Visual Analysis

For each monitoring site, staff visually analyzed thirty days of collected SPL samples in order to identify the frequency and durations of mechanized sound sources. See Appendix C for further information on visual analysis. Hourly time audible statistics are then used to calculate natural ambient sound level estimates (see Calculation of Metrics below).

Audibility Analysis

For each monitoring site, staff analyzed a subset of audio samples (every other day of the thirty days which were analyzed visually) to identify natural and quiet sound sources which are difficult to reliably identify though visual analysis. Listening headphones are calibrated with a 94dB, 1000Hz tone which was recorded at the time of data collection. This approximates a playback volume similar to what would be heard if the observer were actually listening at the sample site. This audibility data results in an estimate of total percent time audible and makeup of the natural components of the soundscape.

Calculation of Metrics

Several metrics are calculated in order to provide some detail about the characteristics of the acoustical environment. The current status of the acoustical 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 ambient

and natural ambient sound levels which are presented as exceedence levels (L_x). They represent the dBA exceeded x percent of the time during the given measurement period. For example, measured in dBA, the existing ambient (L_{50}) is the sound level exceeded 50% of the time, or median sound level. It is the uncensored composite of all sounds at a site, both human caused and natural. The natural ambient (L_{nat}) estimates the acoustic environment without the contribution of anthropogenic sounds. L_{10} and L_{90} are also presented which describe the sound levels exceeded 10% and 90% of the time, respectively.

The differences between L_{50} and L_{nat} values allow NPS to answer the following questions:

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

To calculate L_{nat}, the following method is utilized:

- NPS staff calculate the percentage of all samples containing extrinsic sounds for each hour of the day (P_H) by either listening to samples, or visually analyzing daily spectrograms.
- 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 analyzed by the NPS Natural Sounds Program. (NPS 2008)

Results

Table 3 is a summary of 2009 data. Presented are the existing and natural ambient sound statistics in dBA and average percentage of time audible, number of events per day, and maximum sound pressure level (SPL) for aircraft sound sources, which are the most prominent extrinsic sound at these sites. Median existing ambient (L_{50}) describes the acoustical environment as is, including both natural and extrinsic sounds. Natural ambient (L_{nat}) estimates what the acoustical environment might sound like without the contribution of extrinsic sounds. This table also shows exceedence metrics L_{10} and L_{90}, which essentially mark the average maximum and minimum exceedence levels over the monitoring periods.

Table 3. Median natural and existing ambient sound* and mean aircraft statistics for all sites.

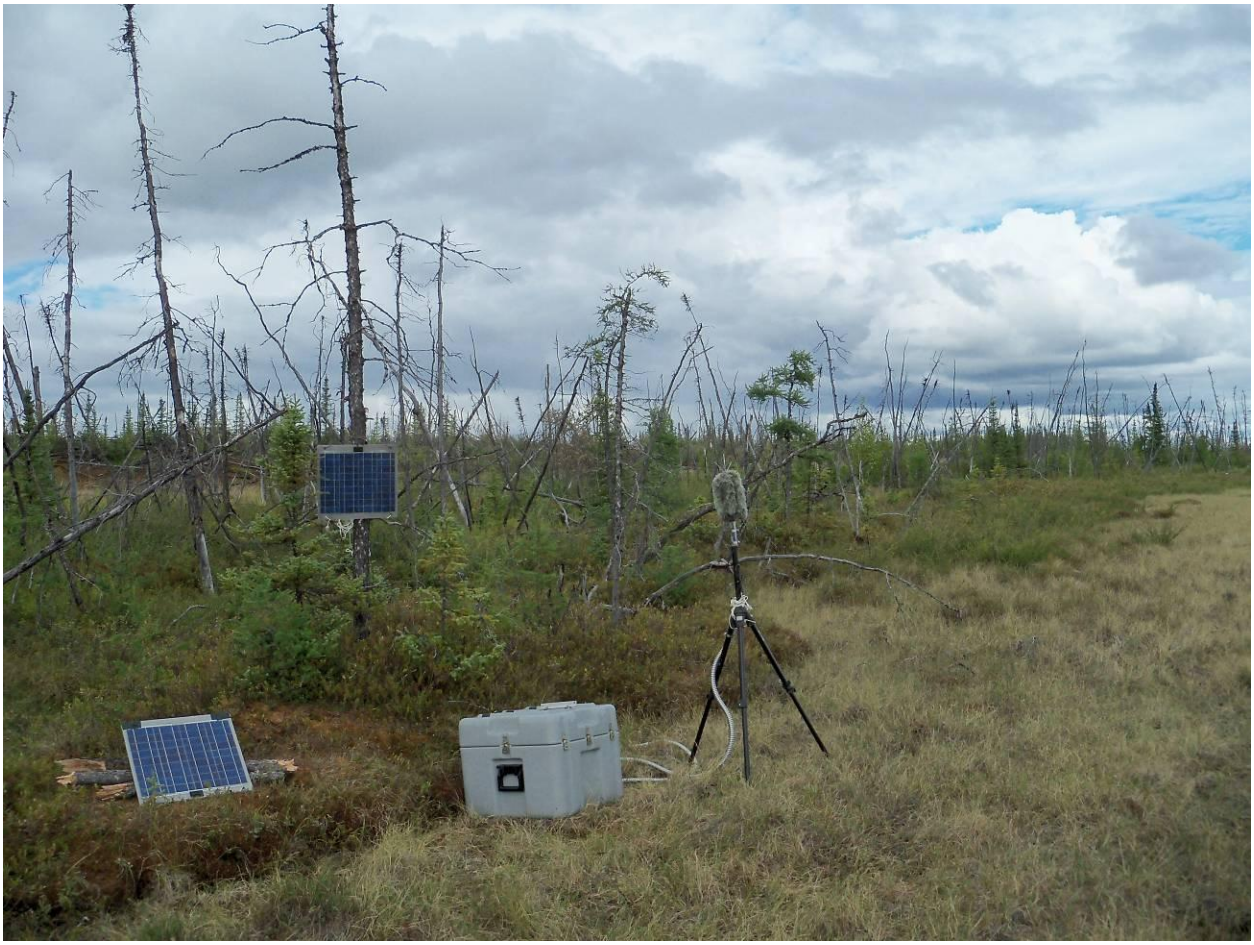
Site Name	L_{nat}	L_{10}	L_{50}	L_{90}	% Aircraft	# Aircraft/Day	Aircraft Max SPL
Beaver Lake	19.62	25.10	19.82	15.59	3.3	8.8	46.9
Kahiltna Pass	18.33	25.43	18.81	12.32	7.1	30.4	44.7
Lower Kantishna River	11.25	17.60	11.46	8.16	4.0	9.4	39.4
Myrtle	6.19	10.41	6.30	4.21	3.3	5.1	31.9
Tokositna Toe [1]	7.10	12.98	7.53	4.24	5.2	16.0	34.3
Upper Dall Glacier	28.25	33.25	28.28	24.64	1.2	4.5	43.1
Upper Ohio Glacier	25.88	30.44	25.93	21.38	1.6	10.5	45.3
Upper West Fork Yentna	37.97	40.87	38.00	35.74	1.1	4.6	--
West Buttress	16.62	24.79	17.07	12.16	7.6	18.7	--

*L_{nat}, L_{10}, L_{50}, L_{90}, and SPL in dBA. [1] : Winter season site.

When interpreting sound pressure level data, it should be noted that the decibel scale is logarithmic. As such, a three decibel increase in sound pressure level is a doubling of sound energy. Overall, the acoustic conditions of these 2010 sites varied. The Myrtle site experienced the lowest ambient and natural ambient sound levels, as well as relatively low levels of aircraft activity. Of the flights which occurred at Myrtle during the measurement period, the average maximum sound pressure level of the events was the lowest measured thus far in Denali.

The following summaries and figures represent the reduced data for each of the 2010 sites. These include percent audibility for natural sounds and mechanized noise, hourly natural ambient and exceedence sound levels, and figures which speak directly to the soundscape indicators and standards outlined in Denali's Backcountry Management Plan: percentage of time audible, number of events per day, and maximum sound pressure levels. (NPS 2006c) A separate section is devoted to each site, and should be considered a summary site profile for Denali purposes.

Beaver Lake



Location Description: Approx. half way between Beaver Lake and Spectacle Lake, 2.5Km South of the North Park Boundary.

Purpose/Project: Location randomly chosen from the LTEM grid as part of the long-term Denali Soundscape inventorying and monitoring sampling plan.

Coordinates: Lat. 63.63097, Long. -152.42043 Elevation: 260 meters

BCMP Management Zone: Low Park Ecoregion: Eolian Lowlands

Analysis Period: 24-August-2010 – 19-September-2010

Access: Helicopter

Summary/Notes: The purpose of the Beaver Lake location was to collect data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #191 was stratified as a New Park location and randomly selected from all locations requiring aircraft access.

The most commonly heard sounds at this site were silence (audible 56% of the time), wind (19%), birds (18%), and insects (3%). Human made sound was audible 3.3% of the time

on average. Conditions exceeded the BCMP percent audible standard 21% of the time, number of events per day 96% of the time, and maximum SPL 71% of the time.

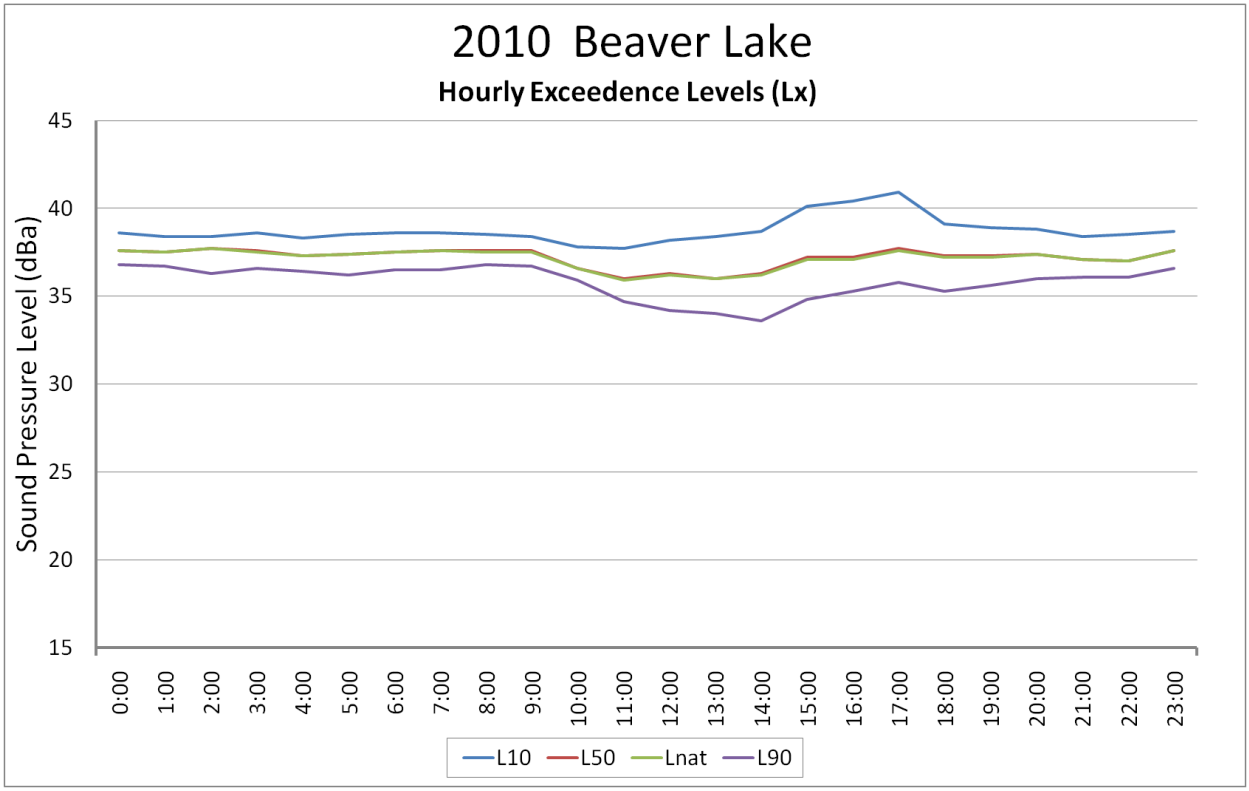


Figure 3. Exceedence levels for Beaver Lake.

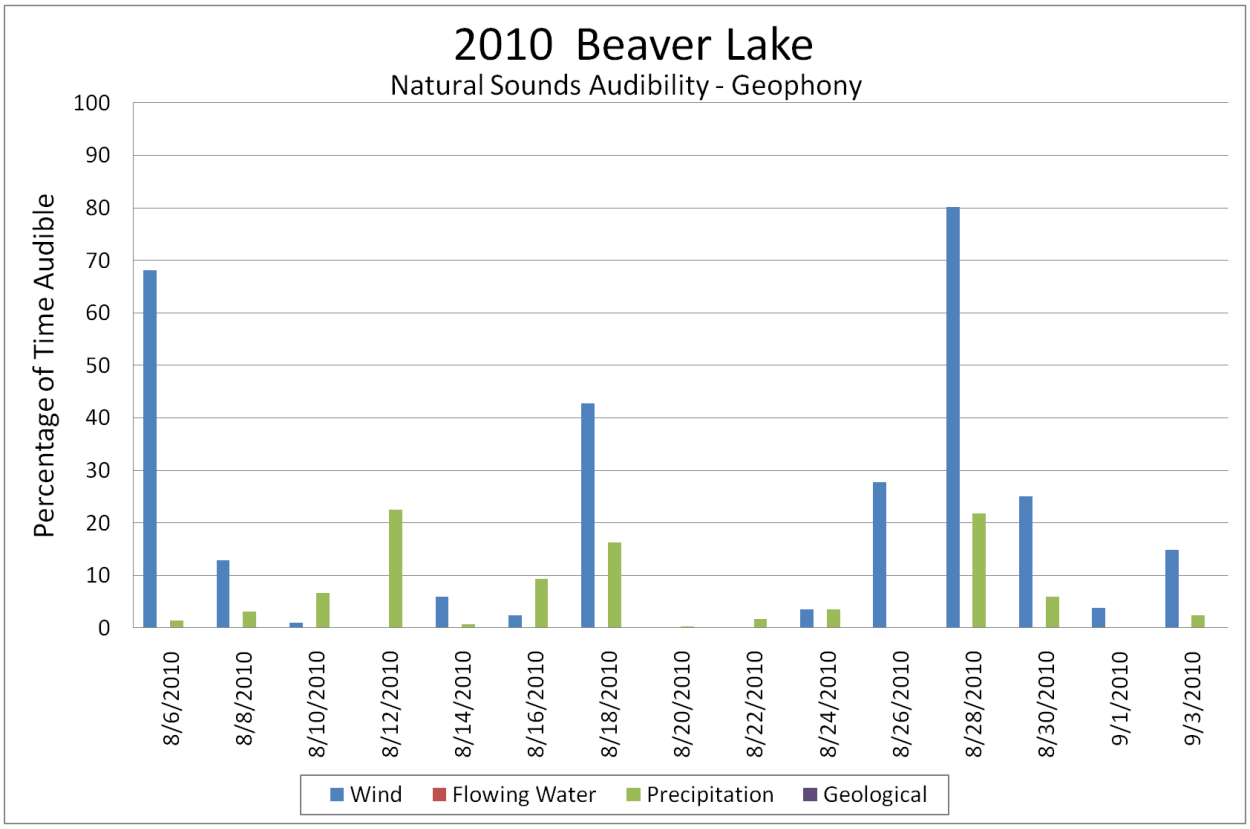


Figure 4. Percentage of time audible for geophonic sounds at Beaver Lake.

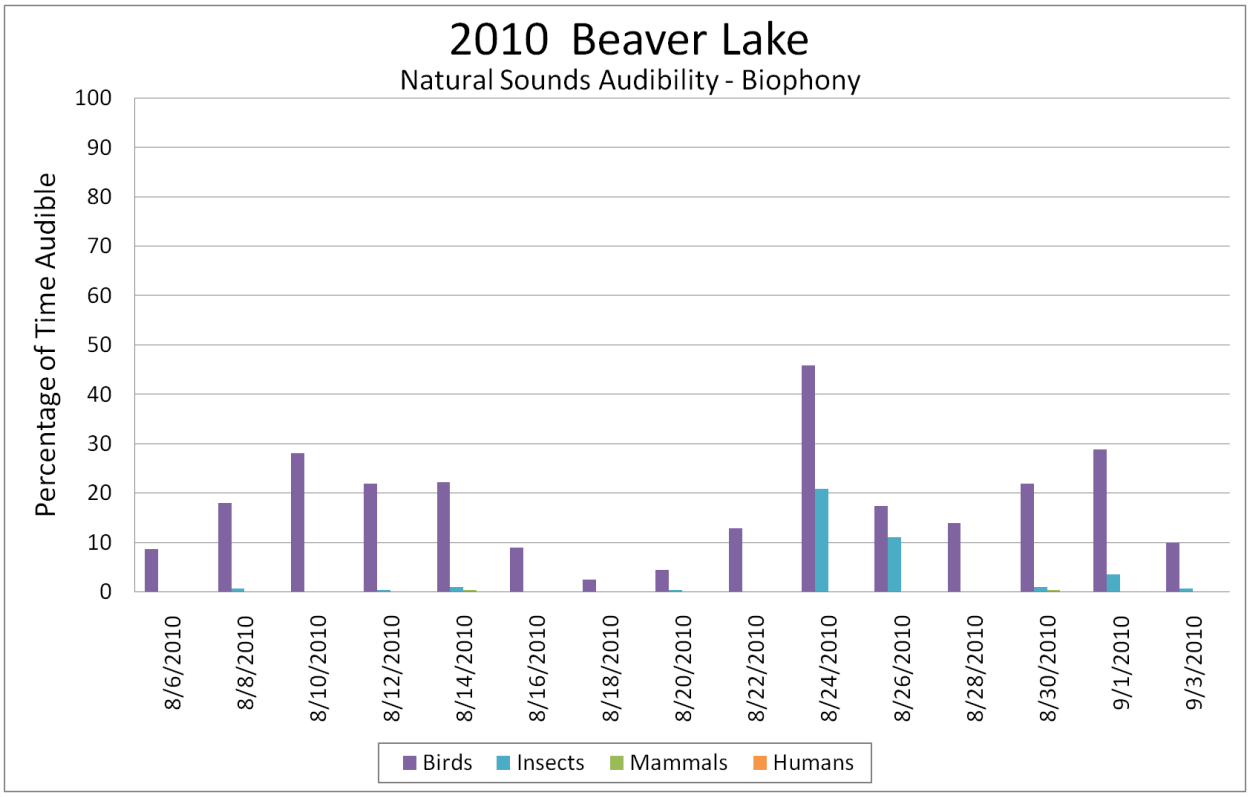


Figure 5. Percentage of time audible for biophonic sounds at Beaver Lake.

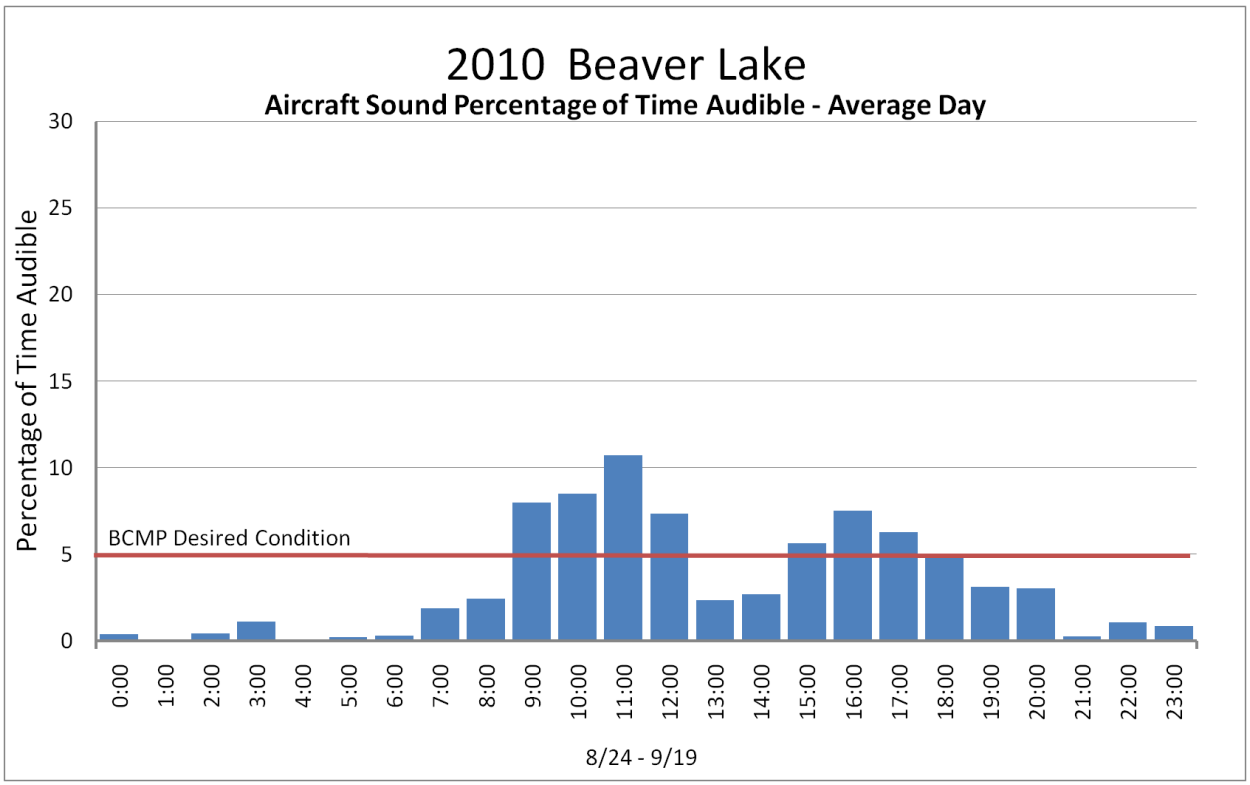


Figure 6. Audibility of aircraft noise for an average day, by hour, at Beaver Lake.

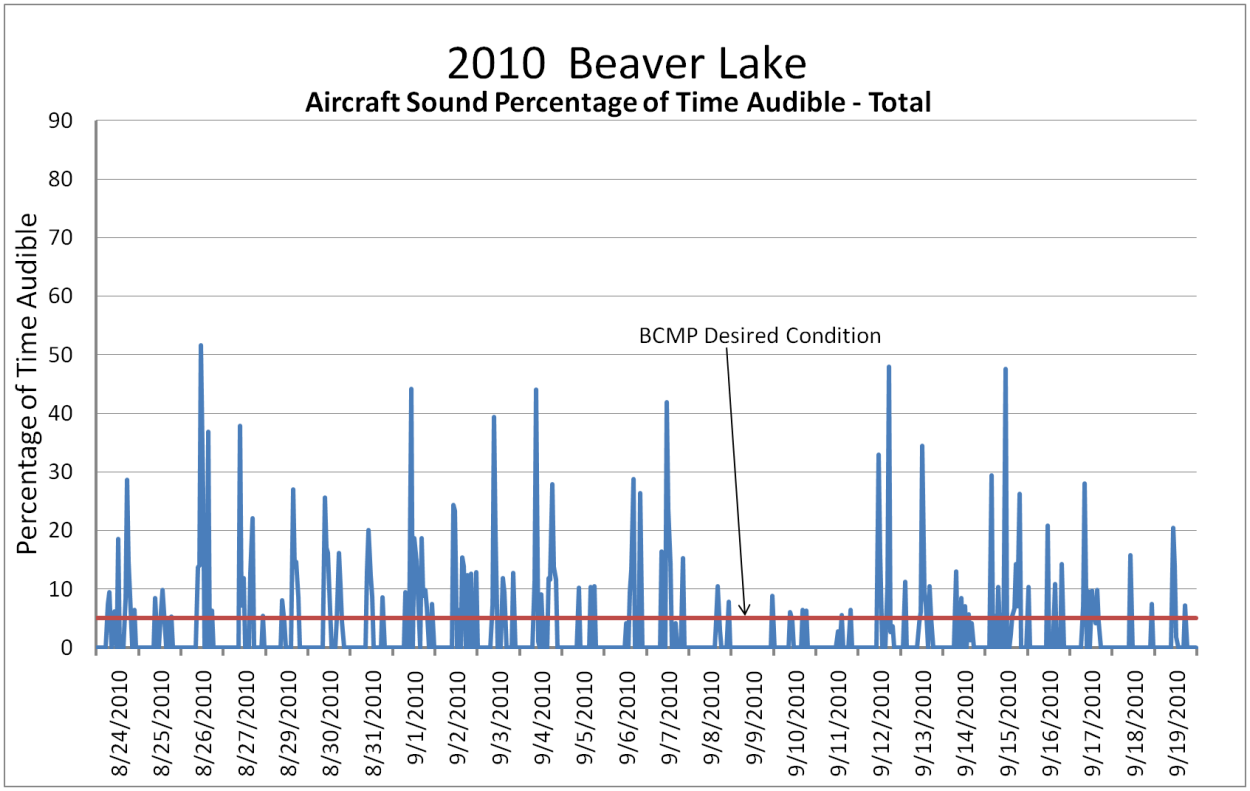


Figure 7. Audibility of aircraft noise at Beaver Lake.

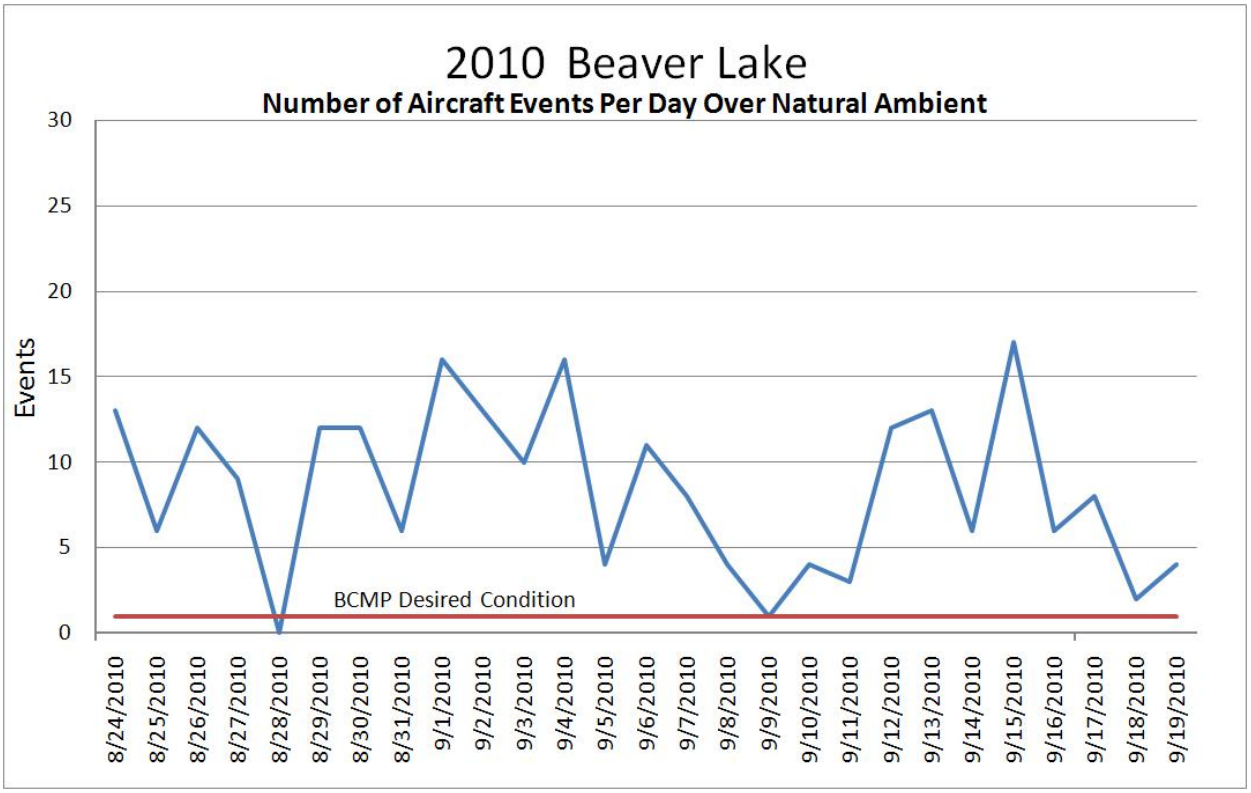


Figure 8. Number of aircraft noise events identified per day at Beaver Lake.

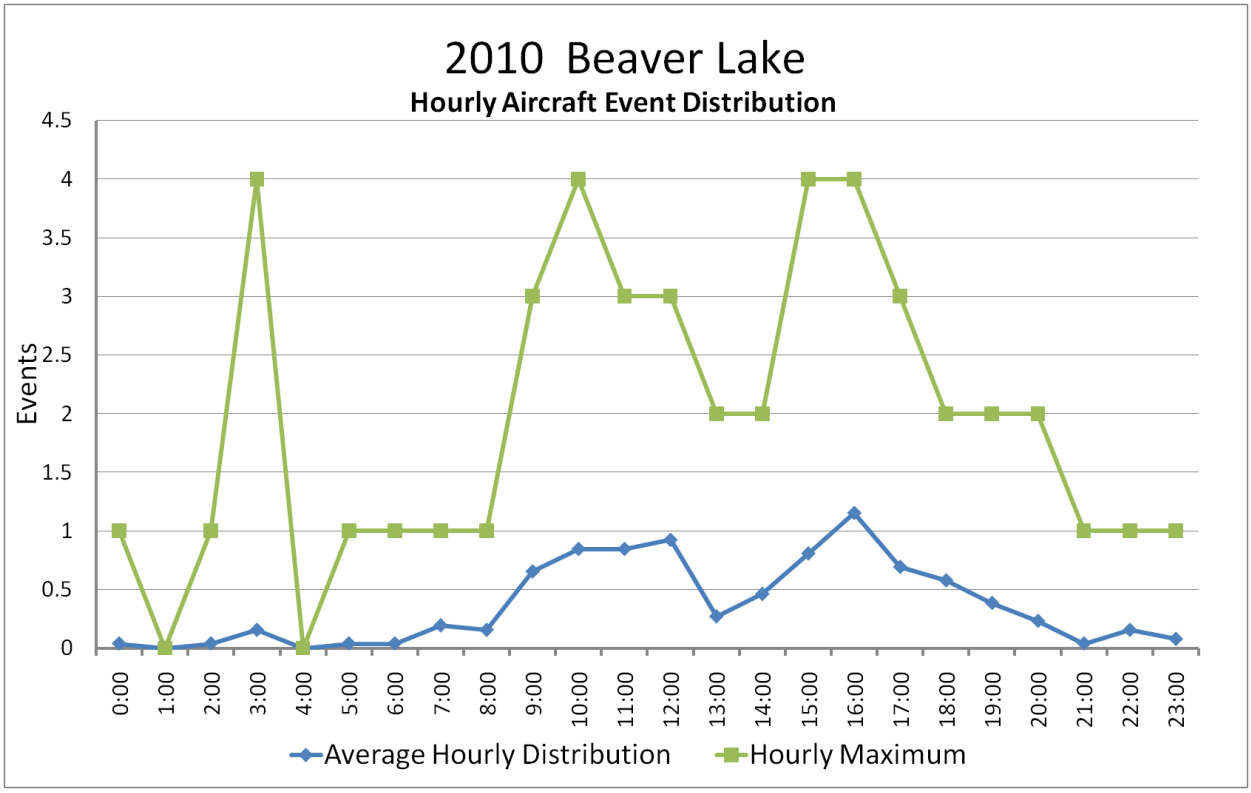


Figure 9. Hourly average and maximum aircraft event distribution at Beaver Lake.

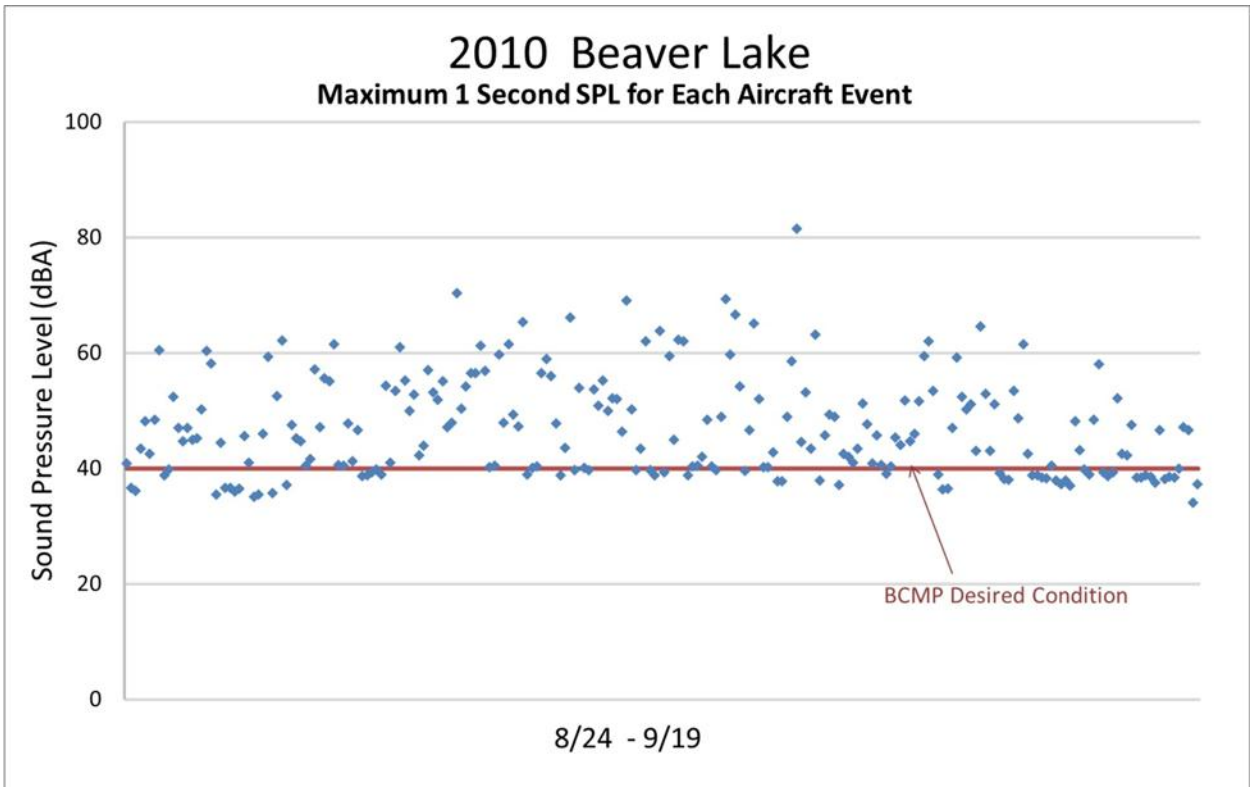
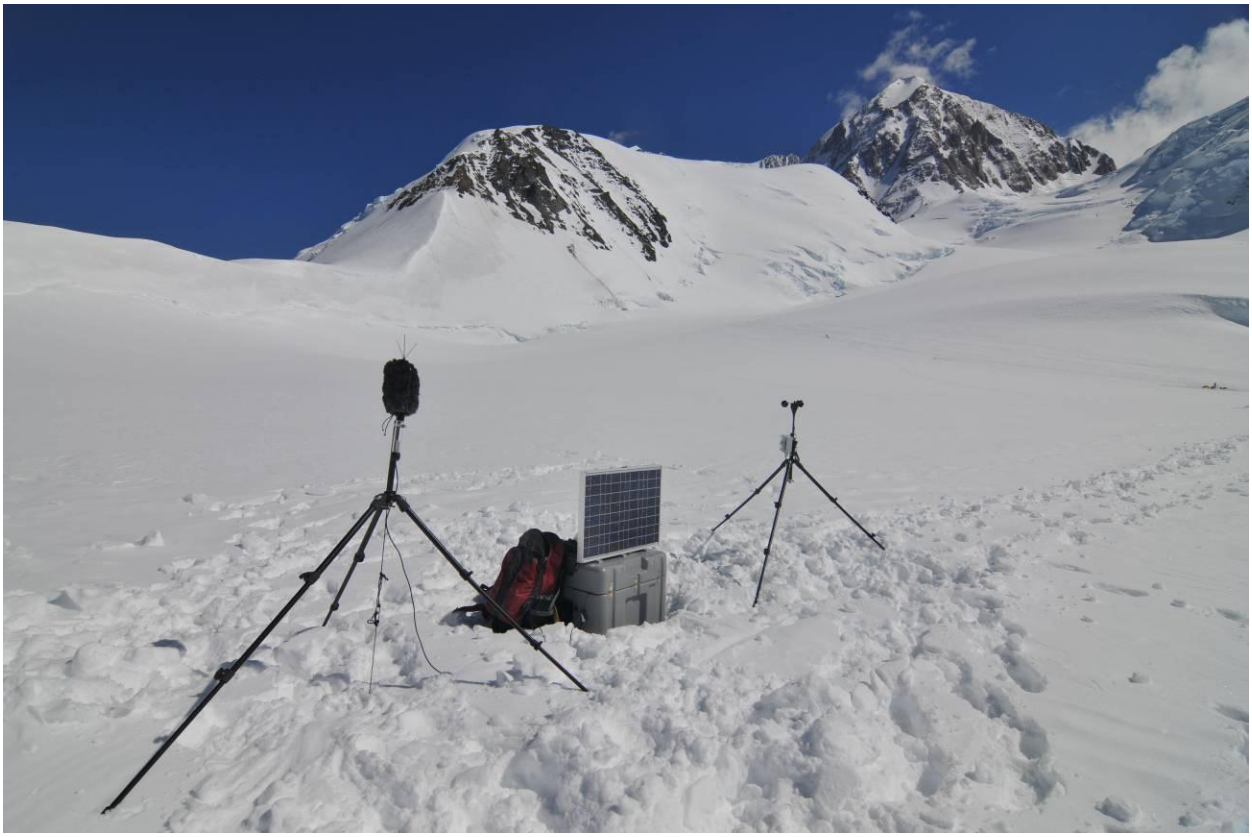


Figure 9. Maximum one-second SPL for each aircraft event identified at Beaver Lake.

Kahiltna Pass



Location Description: ~1km south of Kahiltna Pass proper.

Purpose/Project: Location chosen on the request of the Denali Overflight Advisory Committee to provide an indication of trends on the West Buttress climbing route. Kahiltna pass was first sampled in 2007.

Coordinates: Lat. 63.07547, Long. -151.17464 Elevation: 3003 Meters

Time at Location: 28-May-2010 – 26-June-2010

BCMP Management Zone: Low Park Ecoregion: Nonvegetated Alpine Mountains

Access: Helicopter

Summary: The purpose of the Kahiltna Pass location was to resample this location to provide indication of the effectiveness of the Aircraft Overflights Advisory Committee's best practices document, which was distributed to the major airtouring and airtaxi operators in May of 2009.

The most commonly heard sounds at this site were wind (audible 66% of the time), people (9%), and snowfall (8%). Human made sound was audible 13.3% of the time on average. (Aircraft sound was audible 7.1% of the time on average.) Conditions exceeded the BCMP percent audible standard 30% of the time, number of events per day 100% of the time, and maximum SPL 61% of the time. For comparison, data collected in 2007 showed the most commonly heard sounds at this site were wind (audible 70% of the time), precipitation (21%), and people (3%). Aircraft sound was audible 8.35% of the time on average. Conditions

exceeded the BCMP percent audible standard 37% of the time, number of events per day 92% of the time, and maximum SPL 89% of the time. Please see the 2007 Denali Soundscapes Annual Report for the detailed data from the previous sampling.

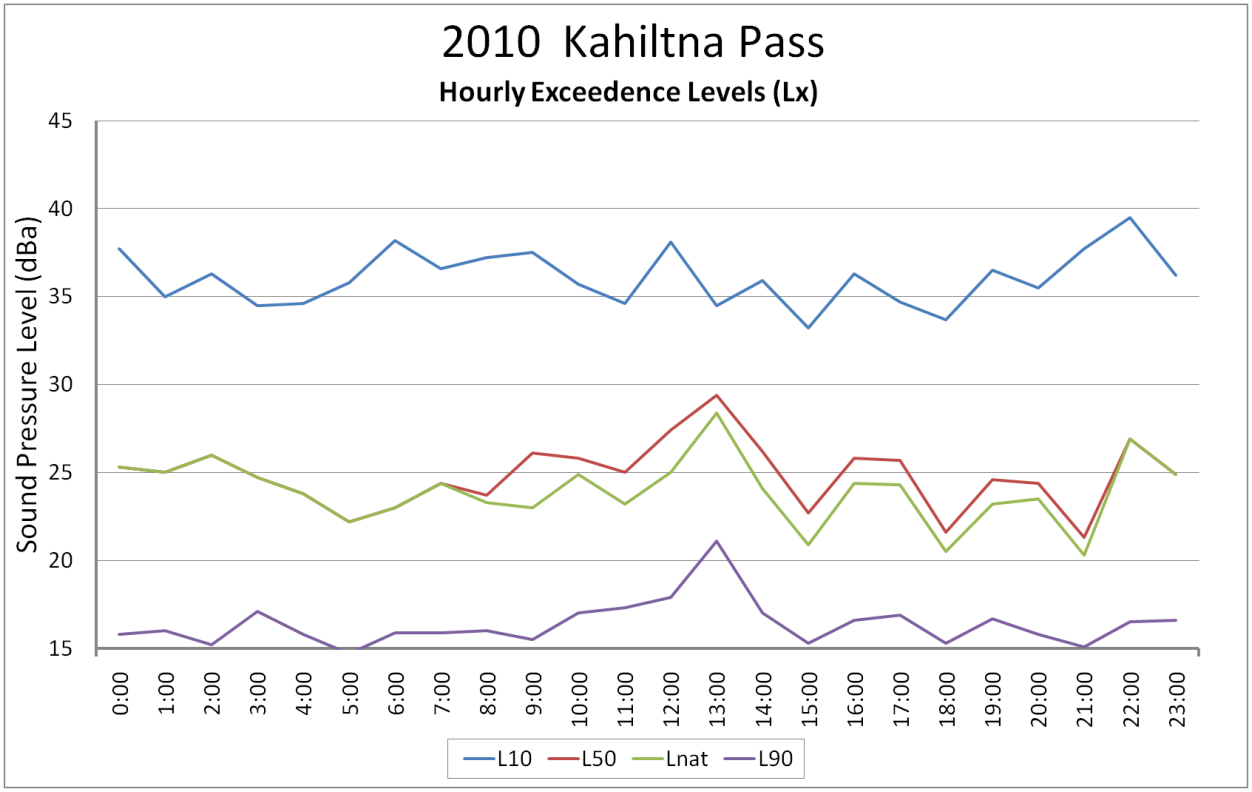


Figure 10. Exceedence levels for Kahiltna Pass.

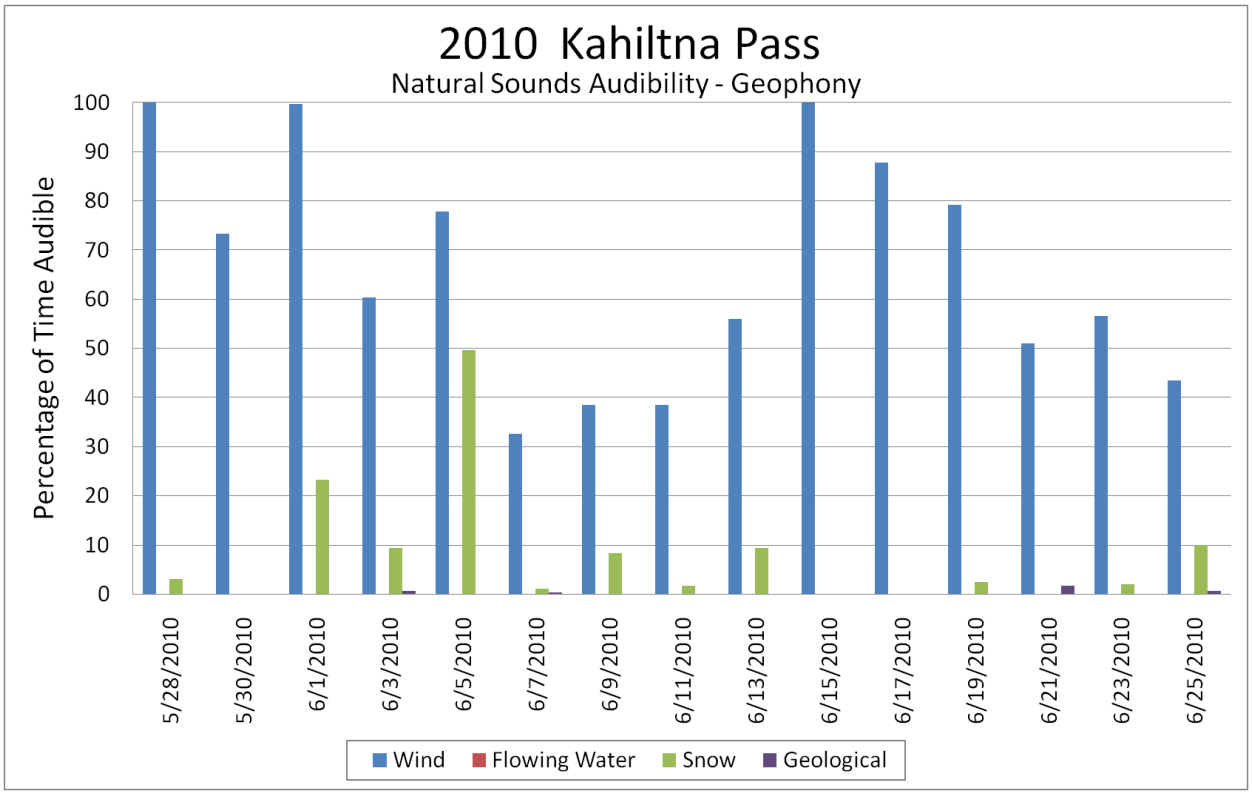


Figure 11. Percentage of time audible for geophonic sounds at Kahiltna Pass.

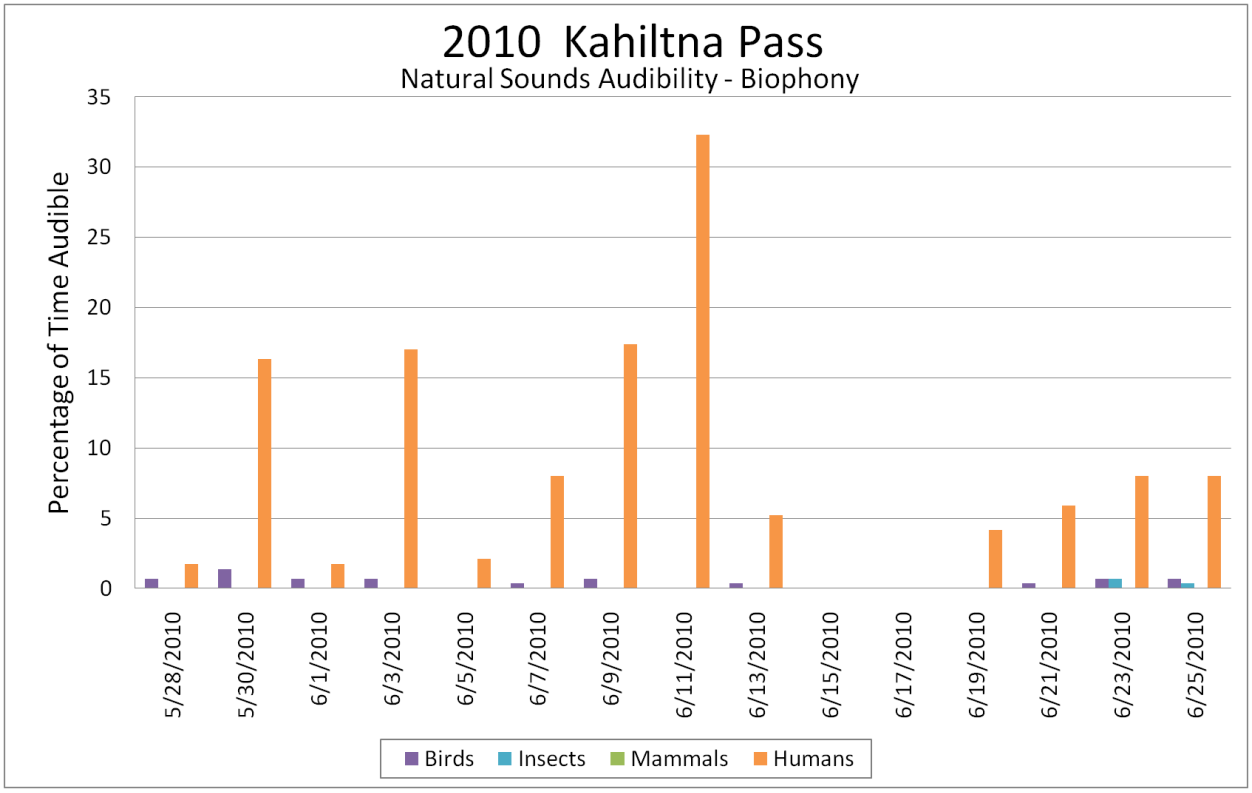


Figure 12. Percentage of time audible for biophonic sounds at Kahiltna Pass.

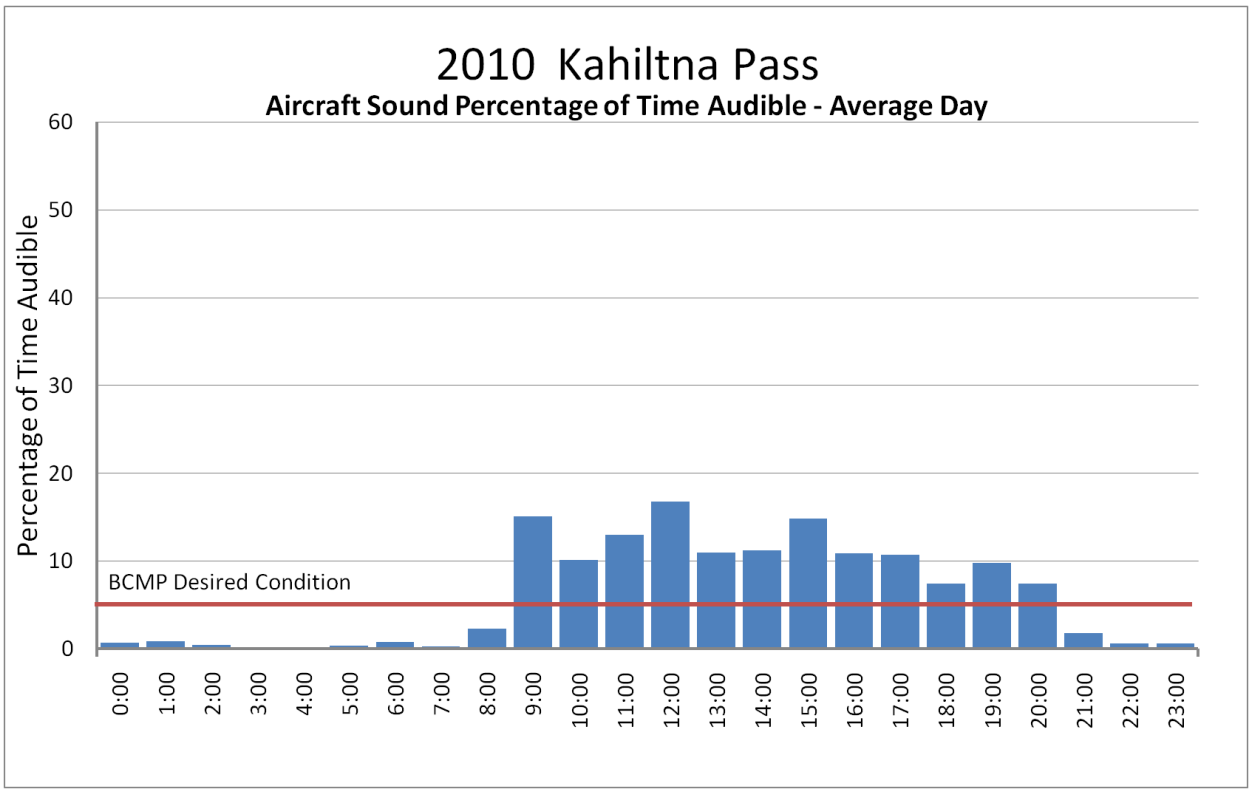


Figure 13. Audibility of aircraft noise for an average day, by hour, at Kahiltna Pass.

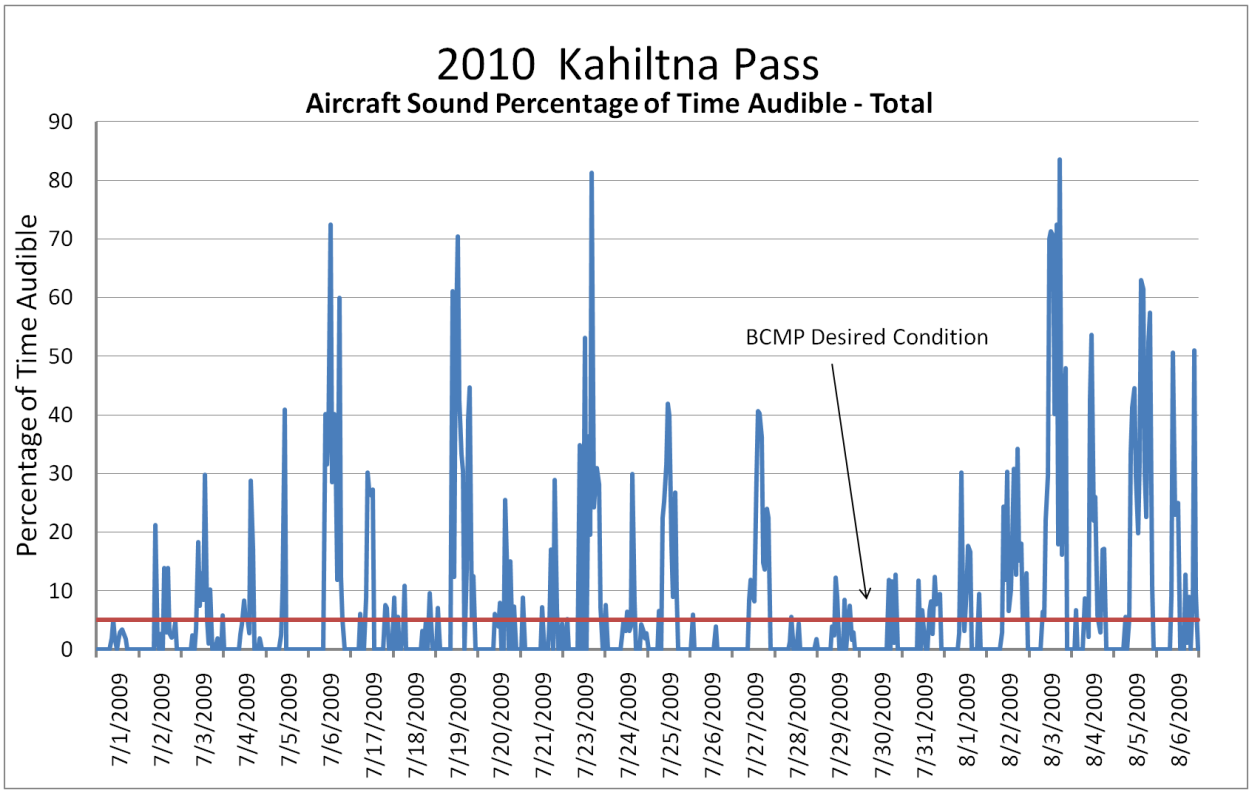


Figure 14. Audibility of aircraft noise at Kahiltna Pass

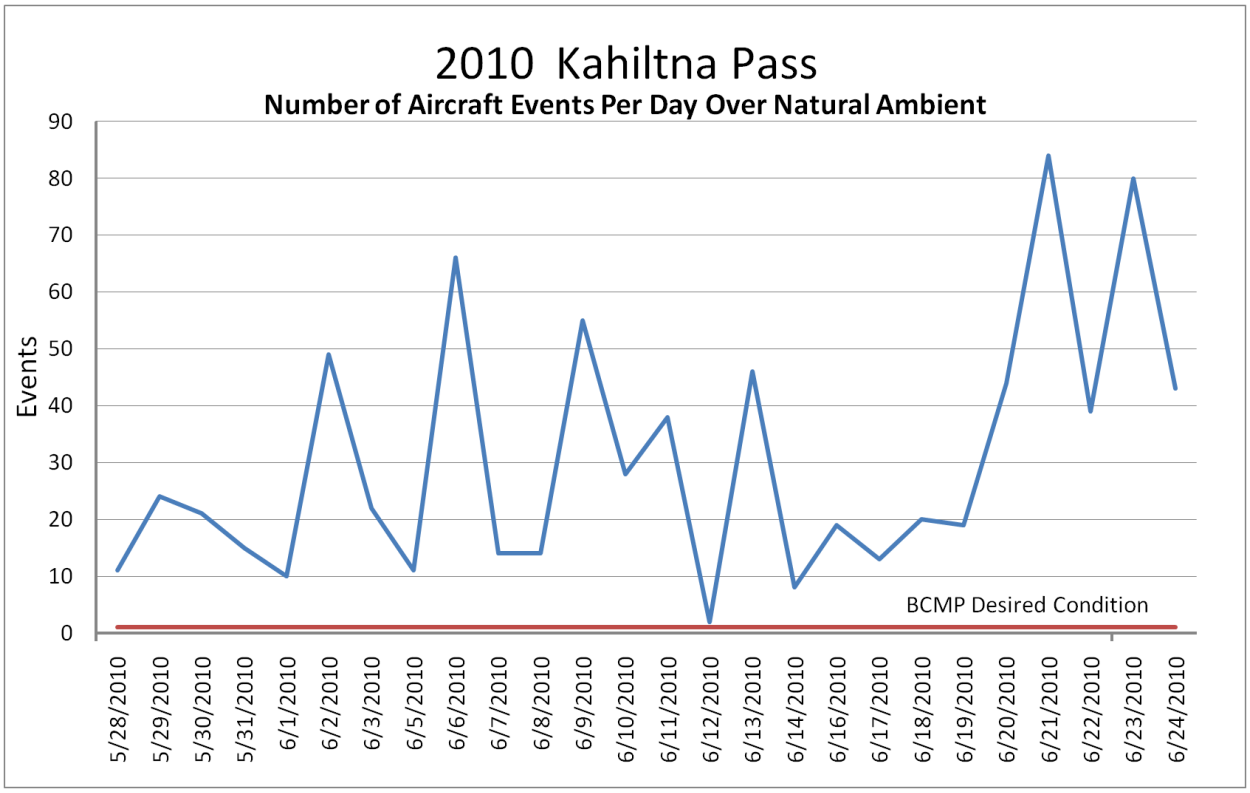


Figure 15. Number of aircraft noise events identified per day at Kahiltna Pass.

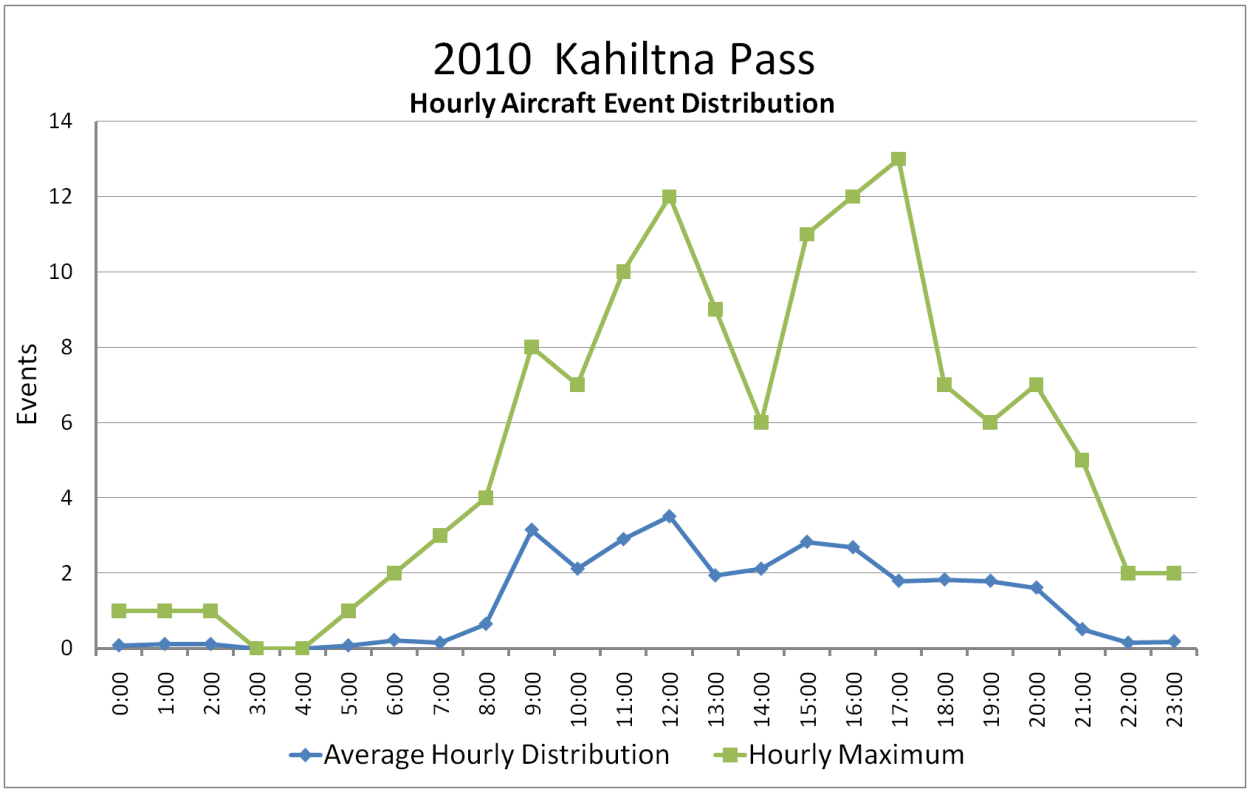


Figure 16. Hourly average and maximum aircraft event distribution at Kahiltna Pass.

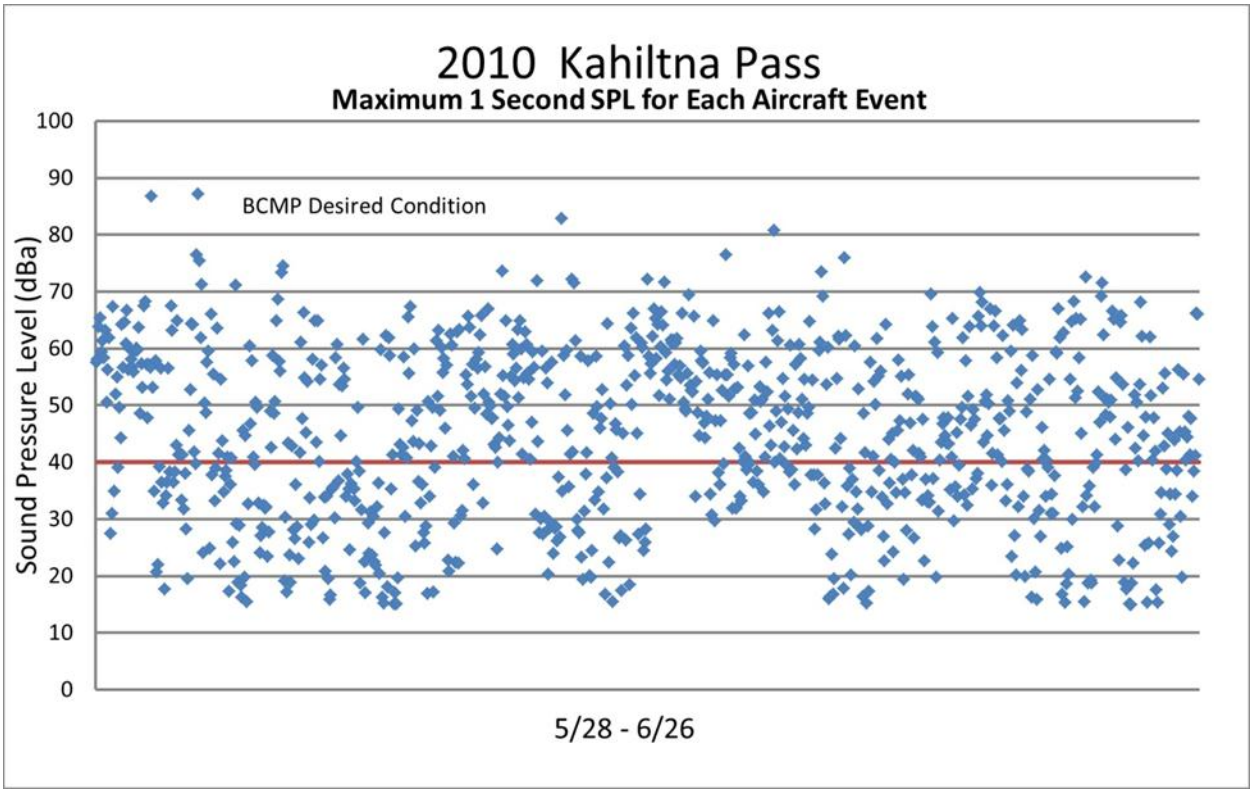
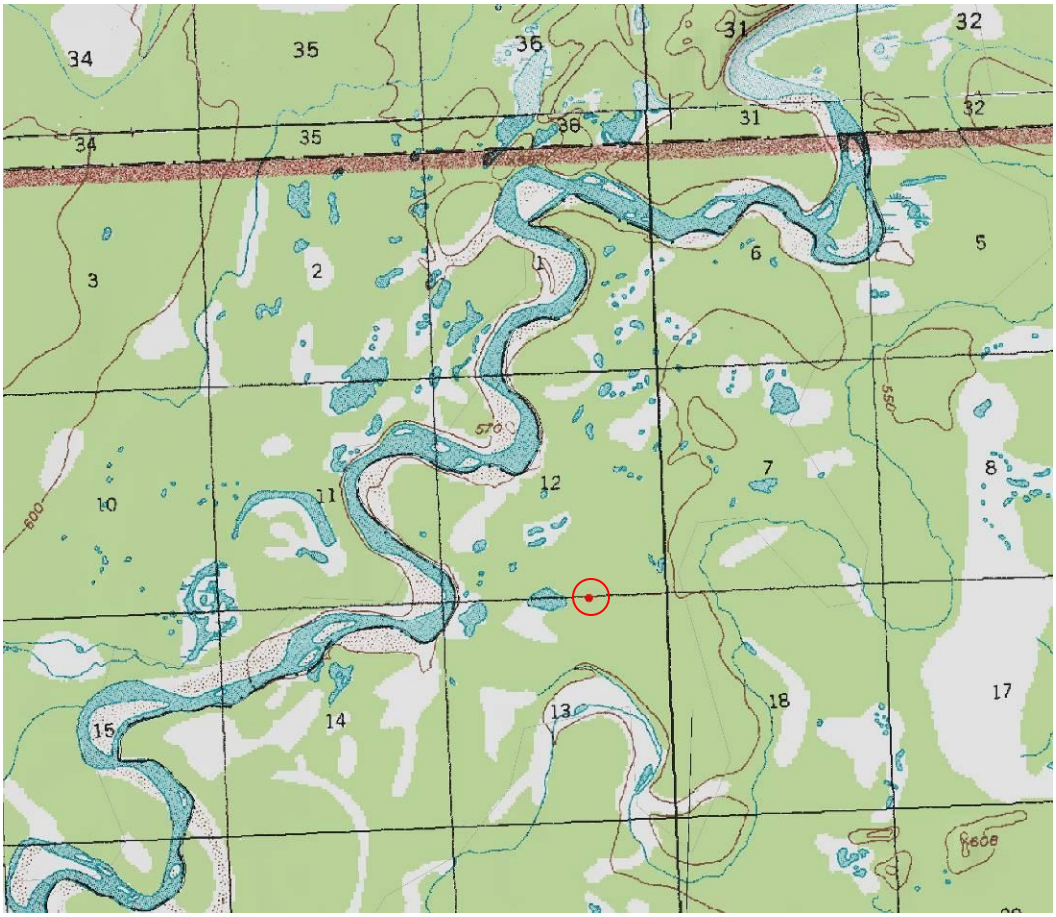


Figure 17. Maximum one-second SPL for each aircraft event identified at Kahiltna Pass.

Lower Kantishna River



Location Description: ~5km south of the northern park boundary, 1km east of the Kantishna River.

Purpose/Project: Location randomly chosen from the LTEM grid as part of the long-term Denali Soundscape inventorying and monitoring sampling plan.

Coordinates: Lat. 63.96405, Long. -151.20627 Elevation: 168 Meters

Time at Location: 06-June-2010 – 10-July-2010

BCMP Management Zone: Low Park Ecoregion: Minchumina Basin Lowlands

Access: Helicopter

Summary: The purpose of the Kantishna River location was to collect data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #249 was stratified as a New Park location and randomly selected from all locations requiring aircraft access.

A steady and polyphonic chorus of bird song was present in the early morning hours, with acoustic entropy reaching an absolute minimum during the mid-afternoon. Insect sound is minimal in the early morning, but tends to increase rapidly around 07:30 - 08:00, then remains part of the baseline soundscape for most of the day, falling off again around 21:00.

An unusual high-frequency component to wind is often heard; this probably comes from air rushing through the dead spruce (from a previous wildfire) that surround the sampling area to the north, south, and east. This results in dry, hollow, and high-frequency (6+ KHz) 'rushing' sounds similar to a distant, fast-moving stream.

The most commonly heard sounds at this site were birds (audible 79% of the time), wind (39%), insects (29%), and rain (15%). Human made sound was audible 4.0% of the time on average. Conditions exceeded the BCMP percent audible standard 27% of the time, number of events per day 100% of the time, and maximum SPL 44% of the time.

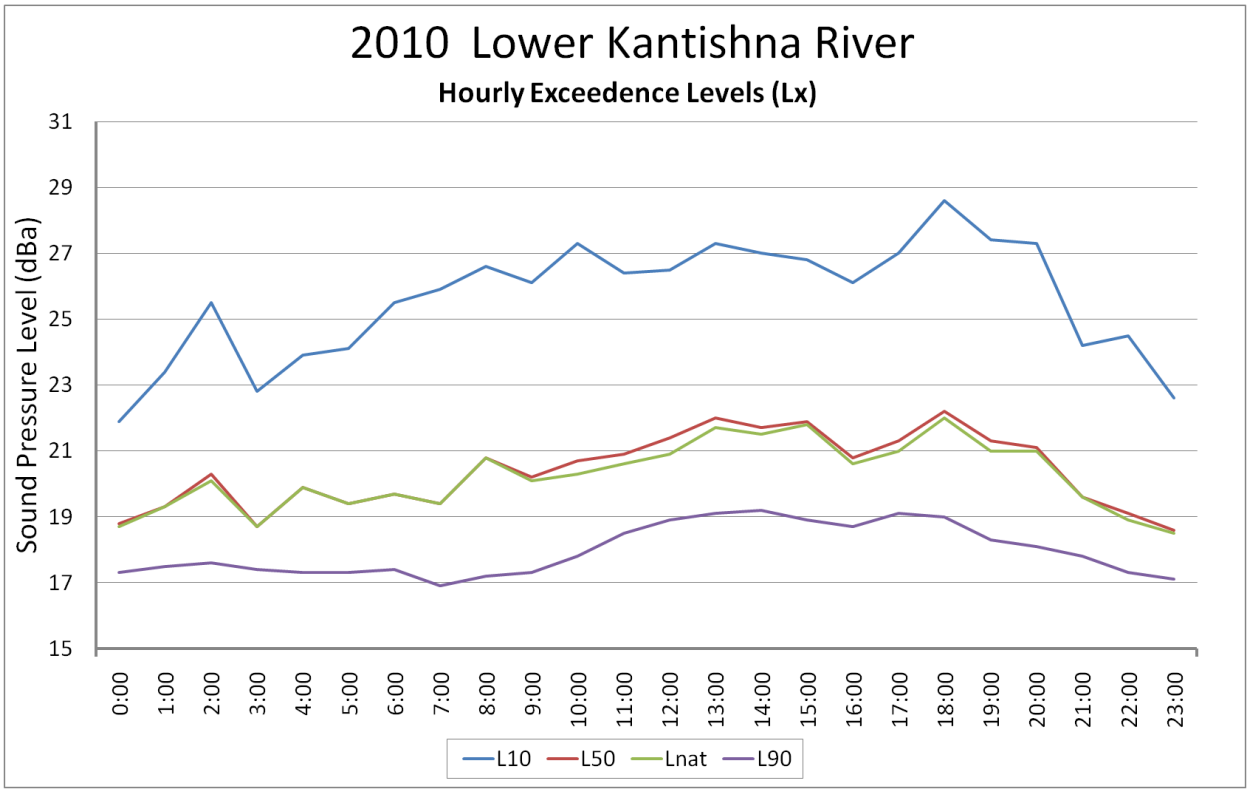


Figure 18. Exceedence levels for Lower Kantishna River.

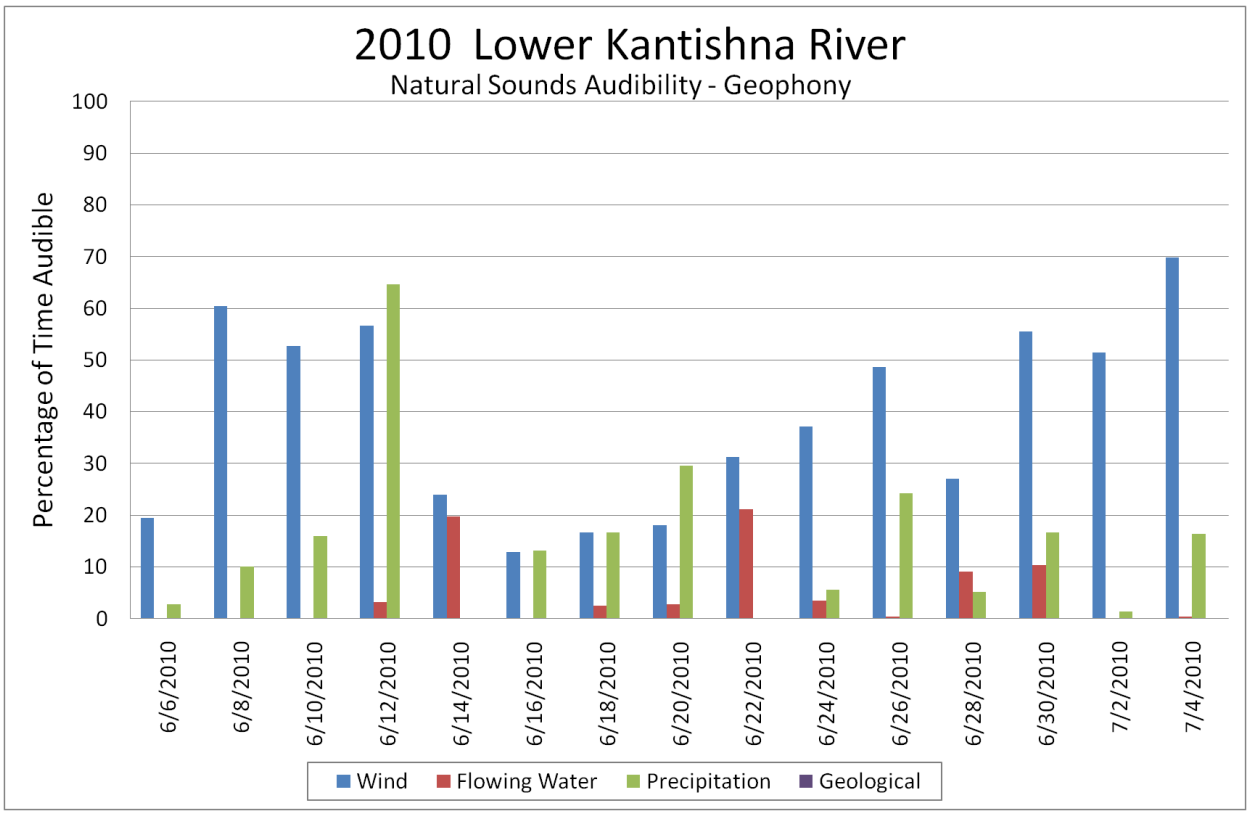


Figure 19. Percentage of time audible for geophonic sounds at Lower Kantishna River.

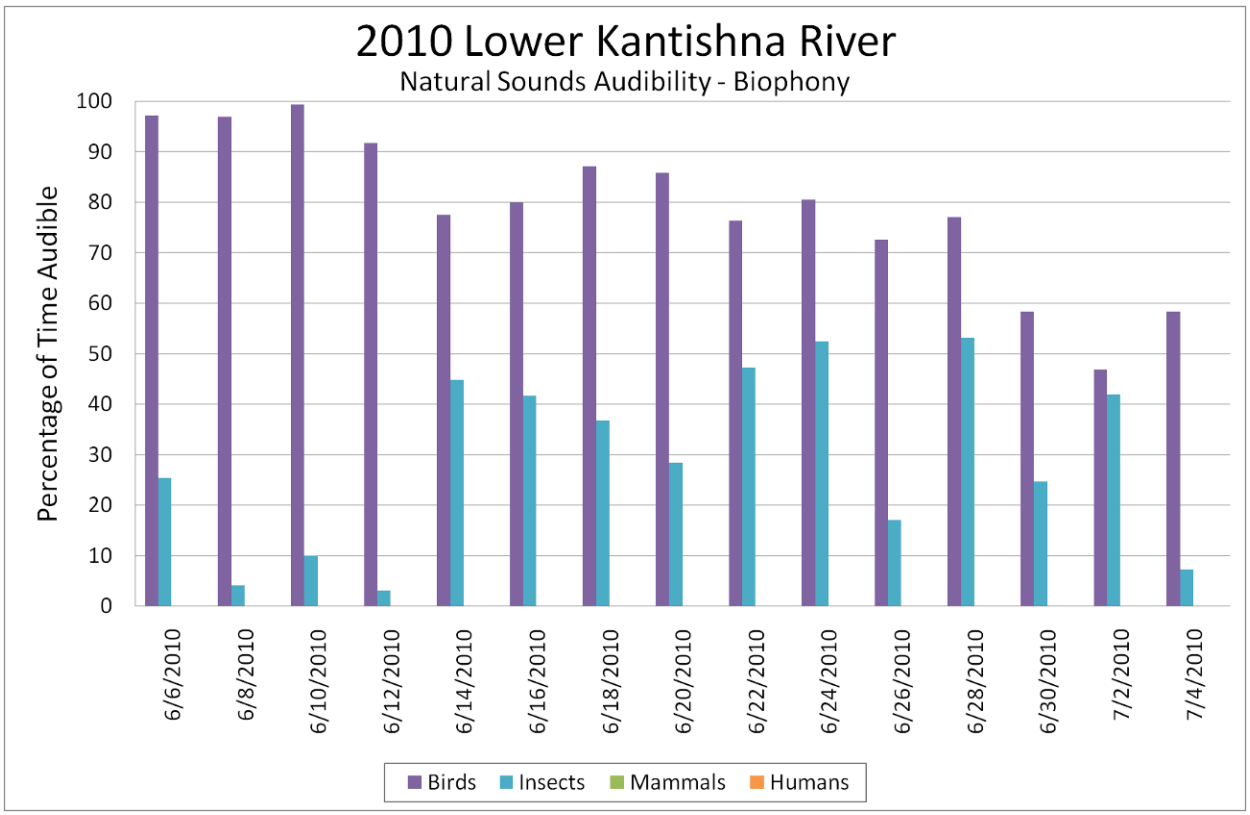


Figure 20. Percentage of time audible for biophonic sounds at Lower Kantishna River.

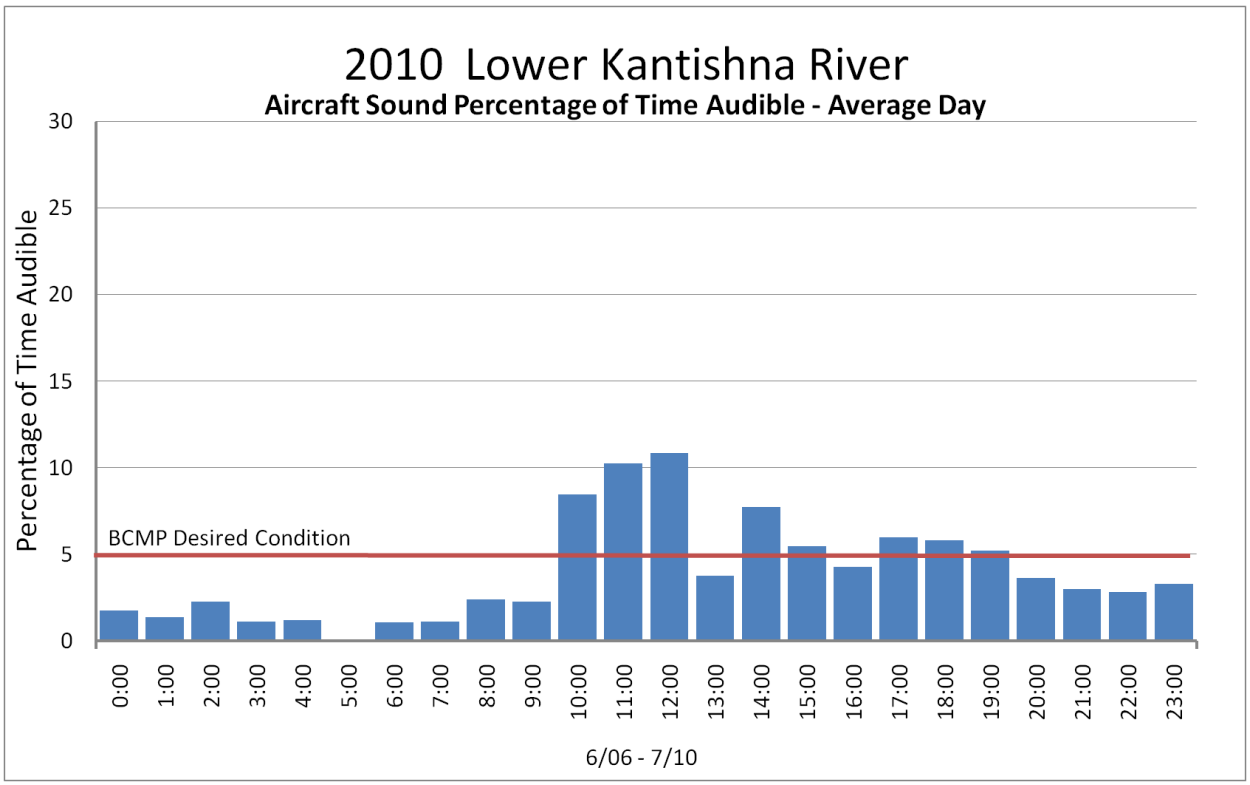


Figure 21. Audibility of aircraft noise for an average day, by hour, at Lower Kantishna River.

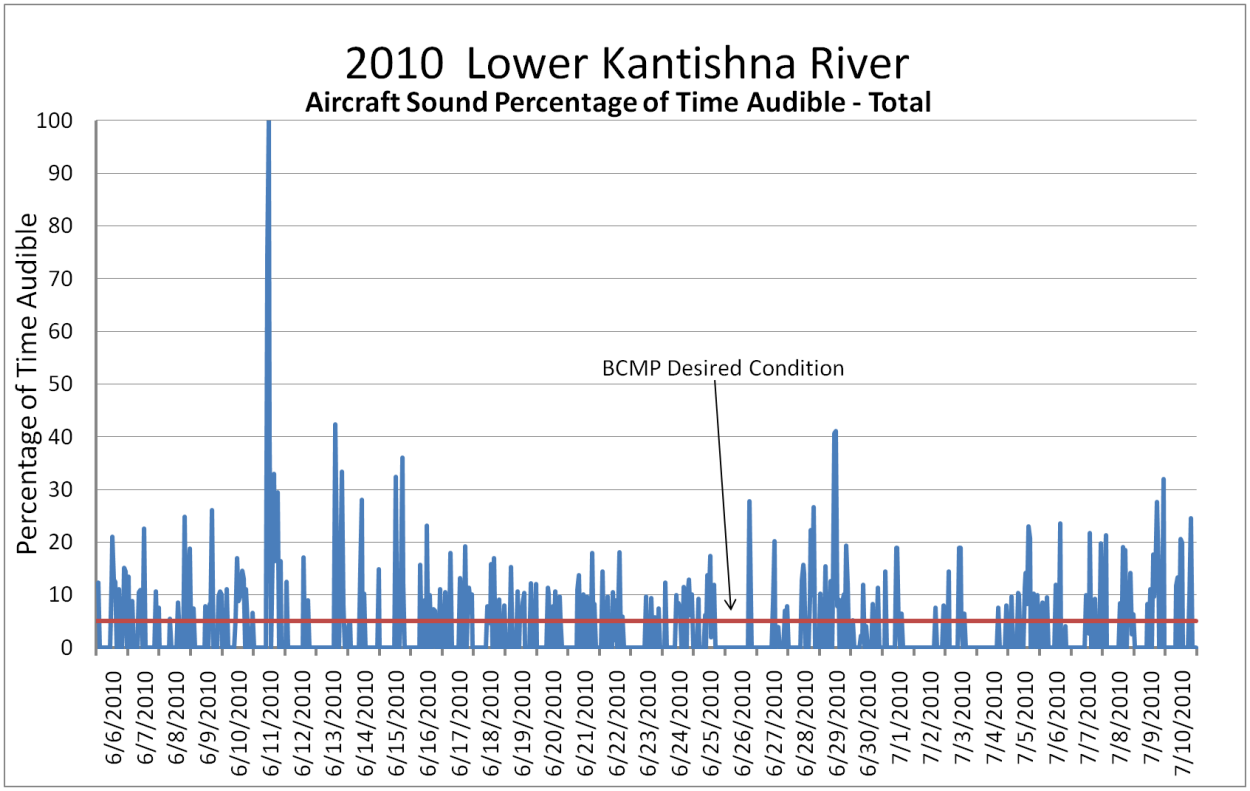


Figure 22. Audibility of aircraft noise at Lower Kantishna River.

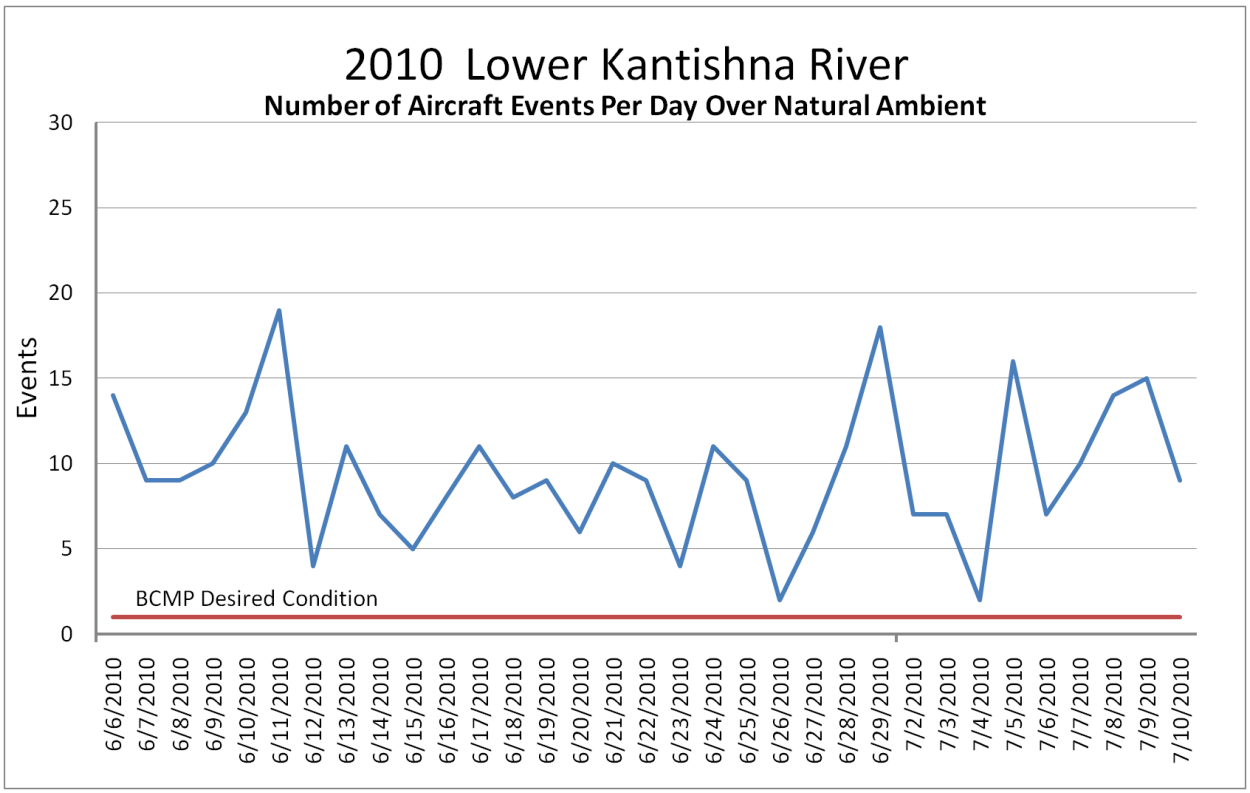


Figure 23. Number of aircraft noise events identified per day at Lower Kantishna River.

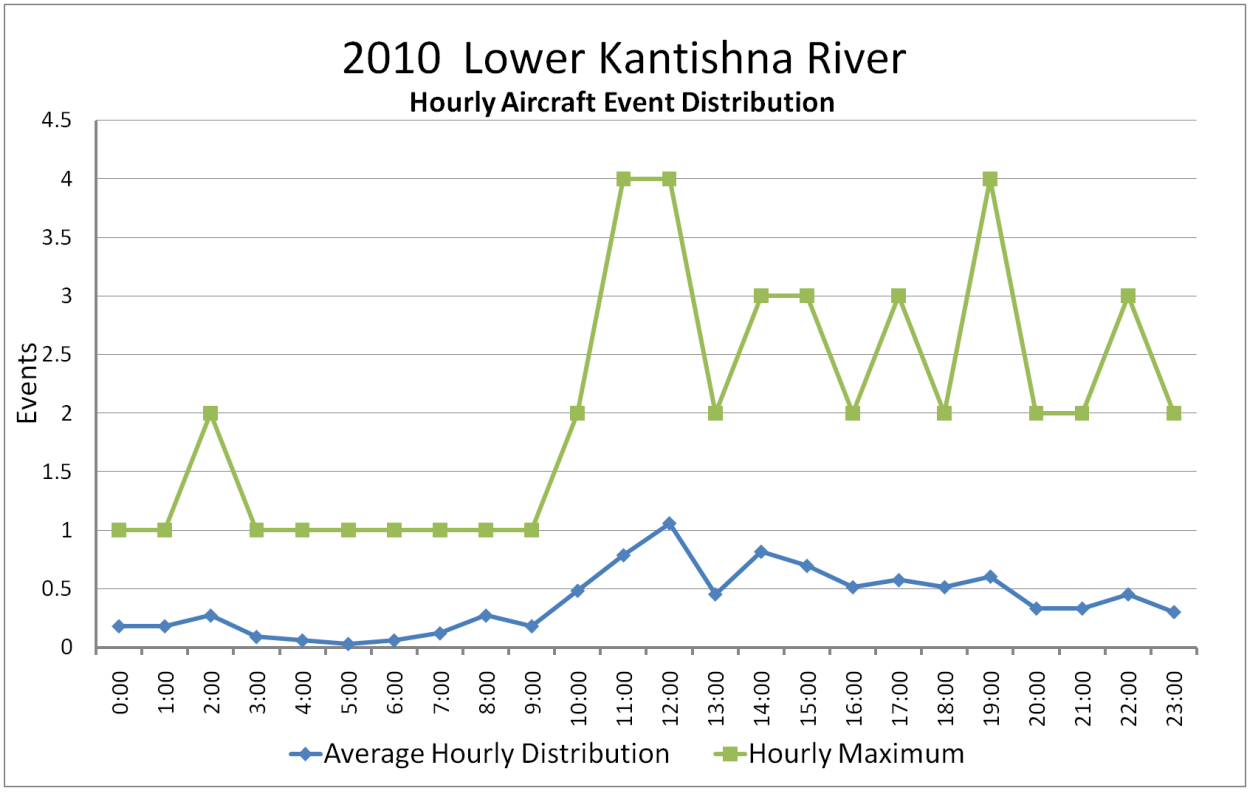


Figure 24. Hourly average and maximum aircraft event distribution at Lower Kantishna River.

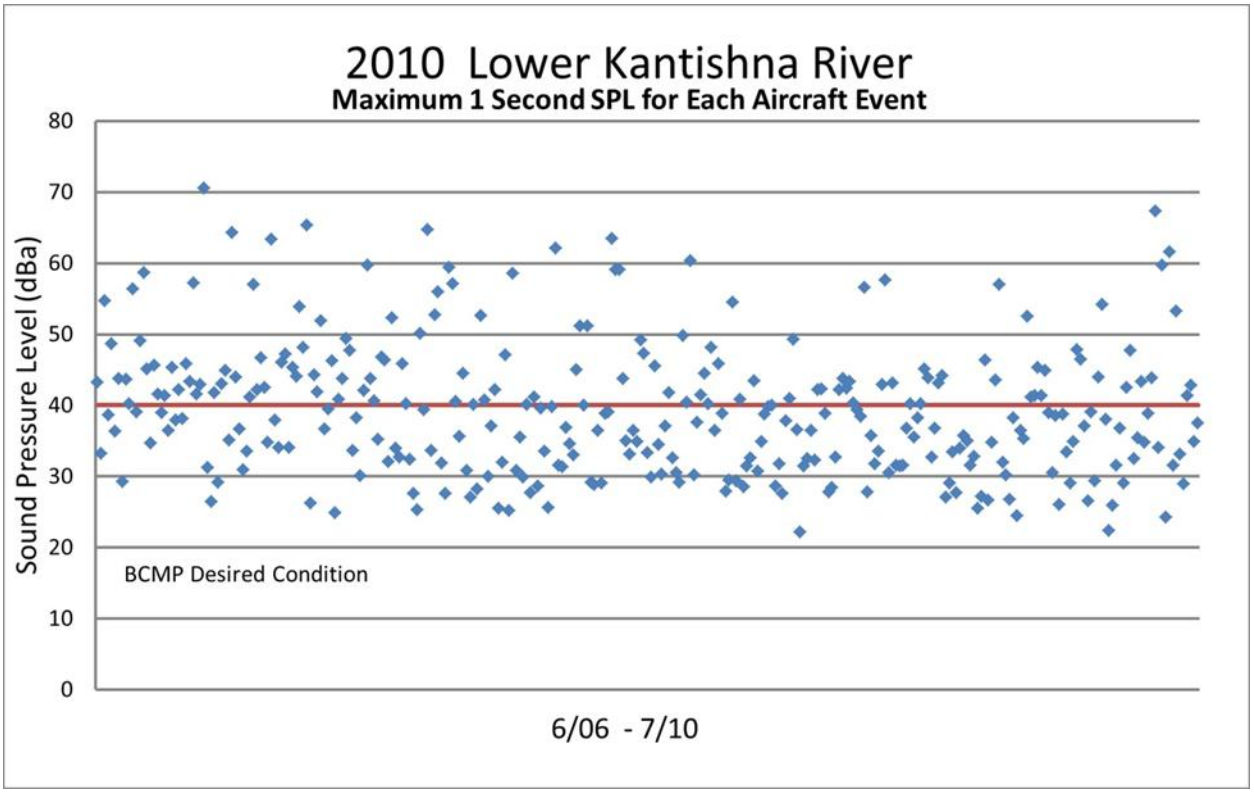
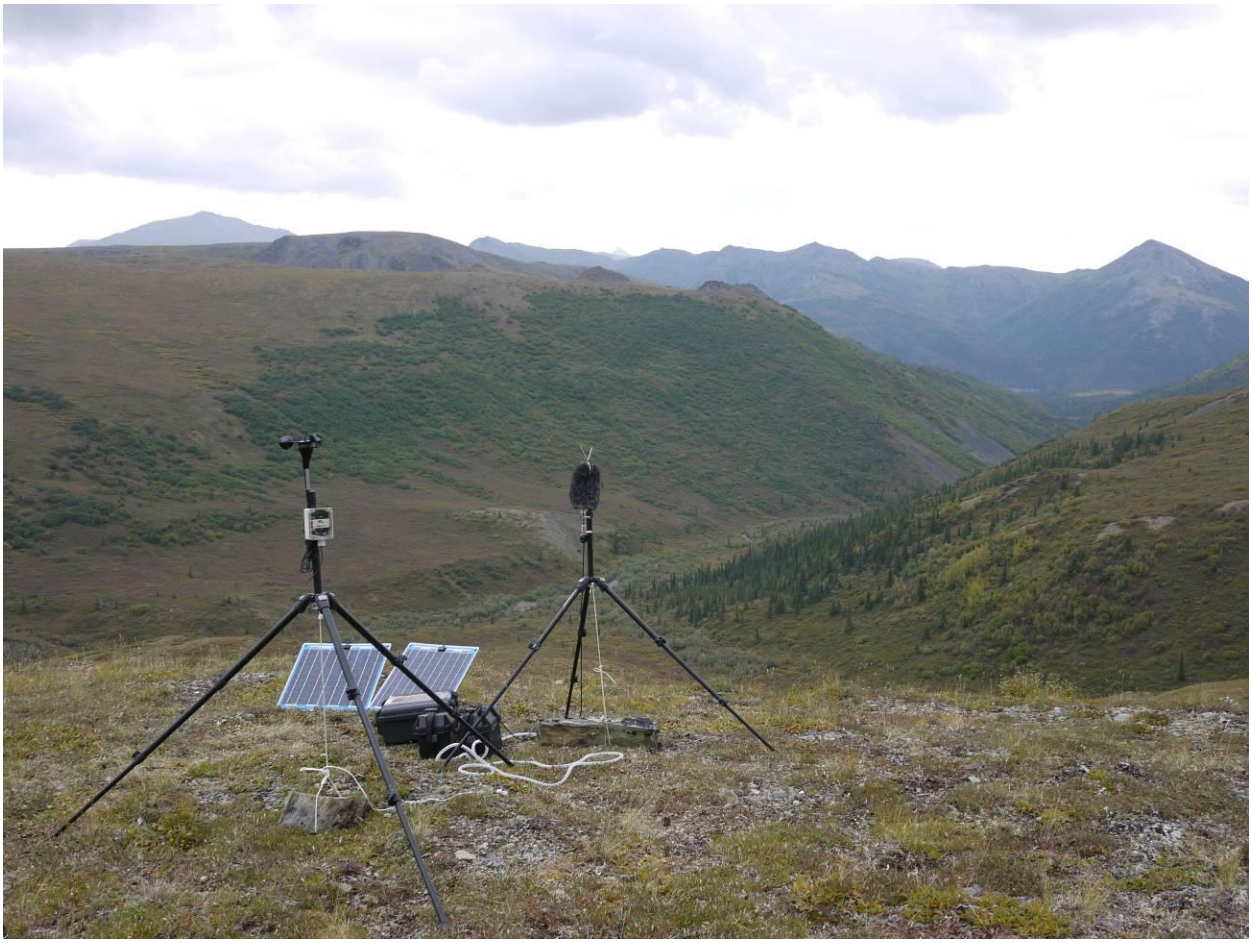


Figure 25. Maximum one-second SPL for each aircraft event identified at Lower Kantishna River.

Myrtle



Location Description: 3.3 Km West of Myrtle Benchmark #4271.

Purpose/Project: Location randomly chosen from the LTEM grid as part of the long-term Denali Soundscape inventorying and monitoring sampling plan.

Coordinates: Lat. 63.59731, Long. -150.40863 Elevation: 947 Meters

Time at Location: 06-August-2010 – 19-Sept-2010

BCMP Management Zone: Medium Park Ecoregion: Alpine Outer Range & Kantishna Hills

Access: Helicopter

Summary: The purpose of the Myrtle location was to collect data at one of the long-term ecological monitoring (LTEM) grid points as outlined in the above sampling plan. LTEM grid point #181 was stratified as a New Park location and randomly selected from all locations requiring aircraft access.

The continuous sound of running water in Clearwater Creek provides the baseline for the soundscape at MYRT. The site is distant enough from the creek (and far enough uphill) that the sound of the water is quite 'thin'. (That is to say, the energy is primarily high-frequency.) Towards the end of the analysis, it became apparent that the soundscape of the MYRT area is

genuinely monophonic during late August and early September. The only sounds that add to the baseline fizz of the creek are scattered showers, a mid-afternoon pulse of wind, or an occasional bird call. One can only speculate as to what the sound pressure levels would be like at a greater distance from the creek, but it is easy to imagine that they could drop quite low during windless periods.

The most commonly heard sounds at this site were flowing water (audible 97% of the time), wind (36%), and rain (13%). Human made sound was audible 3.3% of the time on average. Conditions exceeded the BCMP percent audible standard 6% of the time, number of events per day 0% of the time, and maximum SPL 23% of the time.

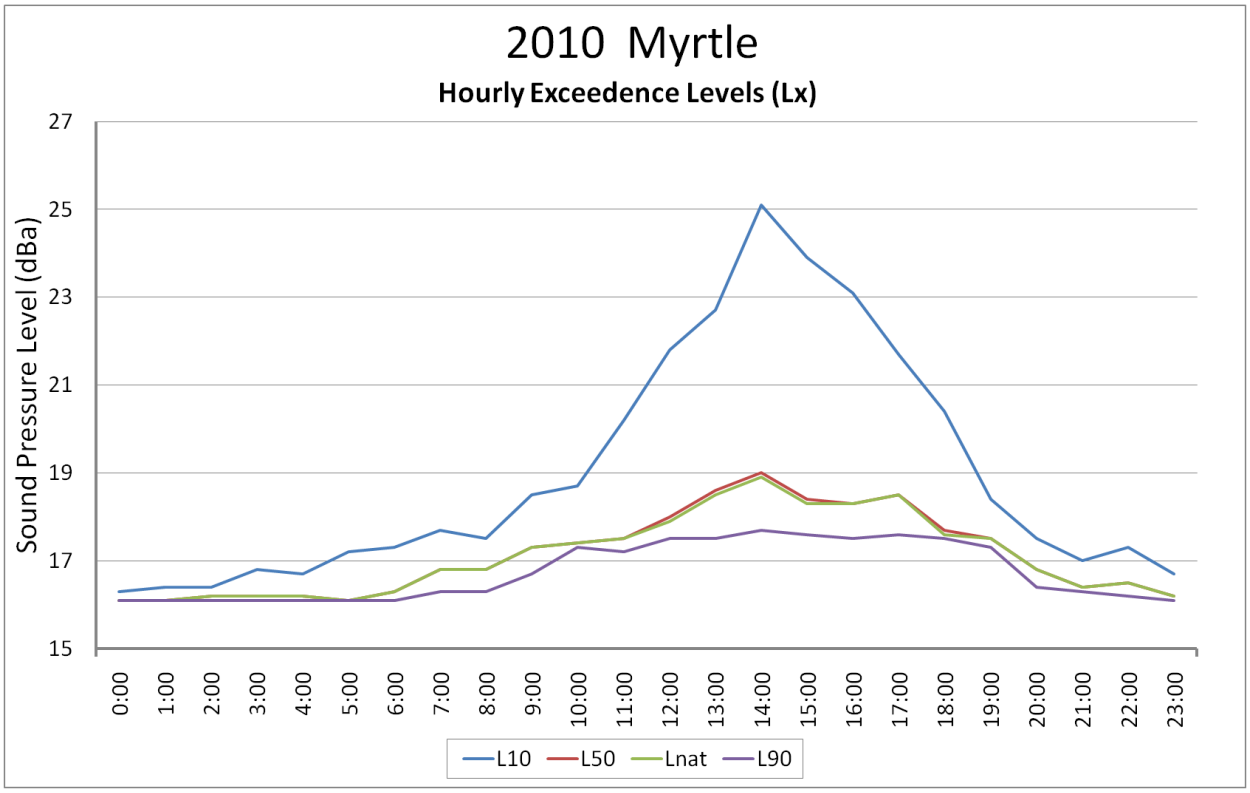


Figure 26. Exceedence levels for Myrtle.

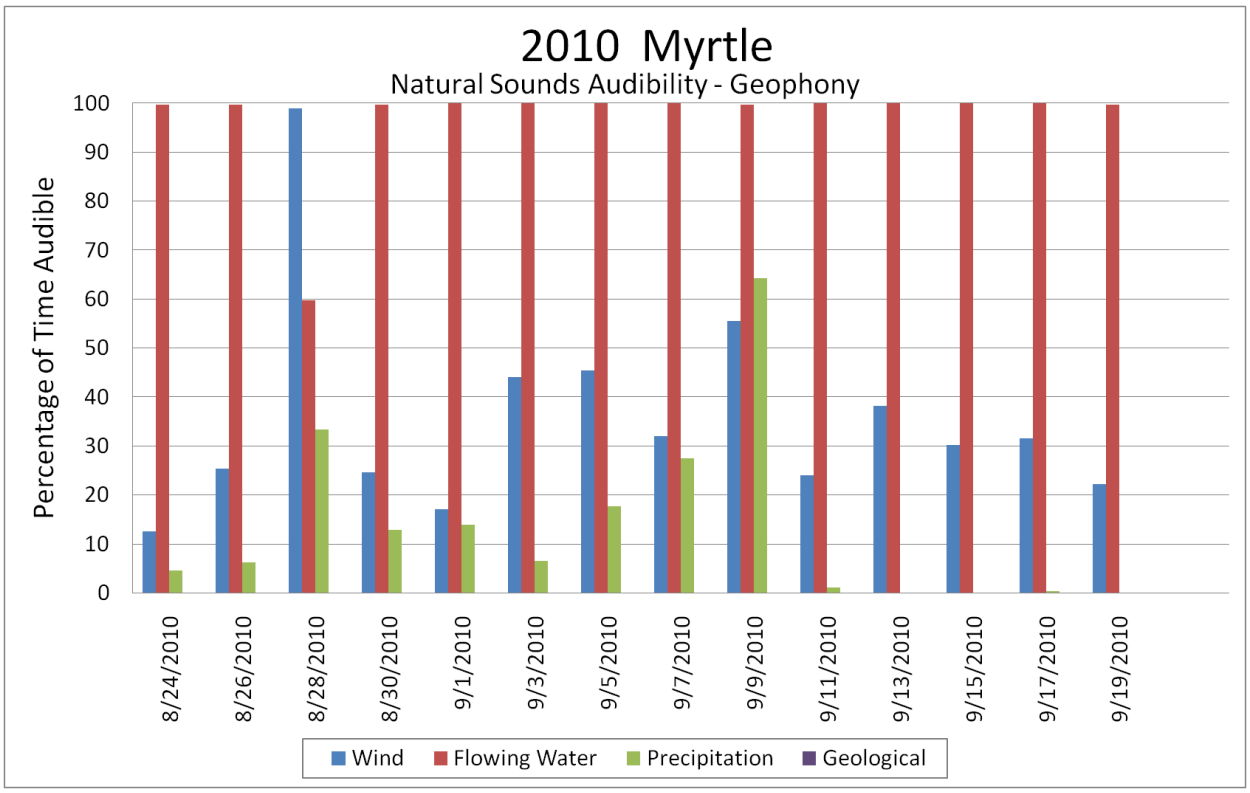


Figure 27. Percentage of time audible for geophonic sounds at Myrtle.

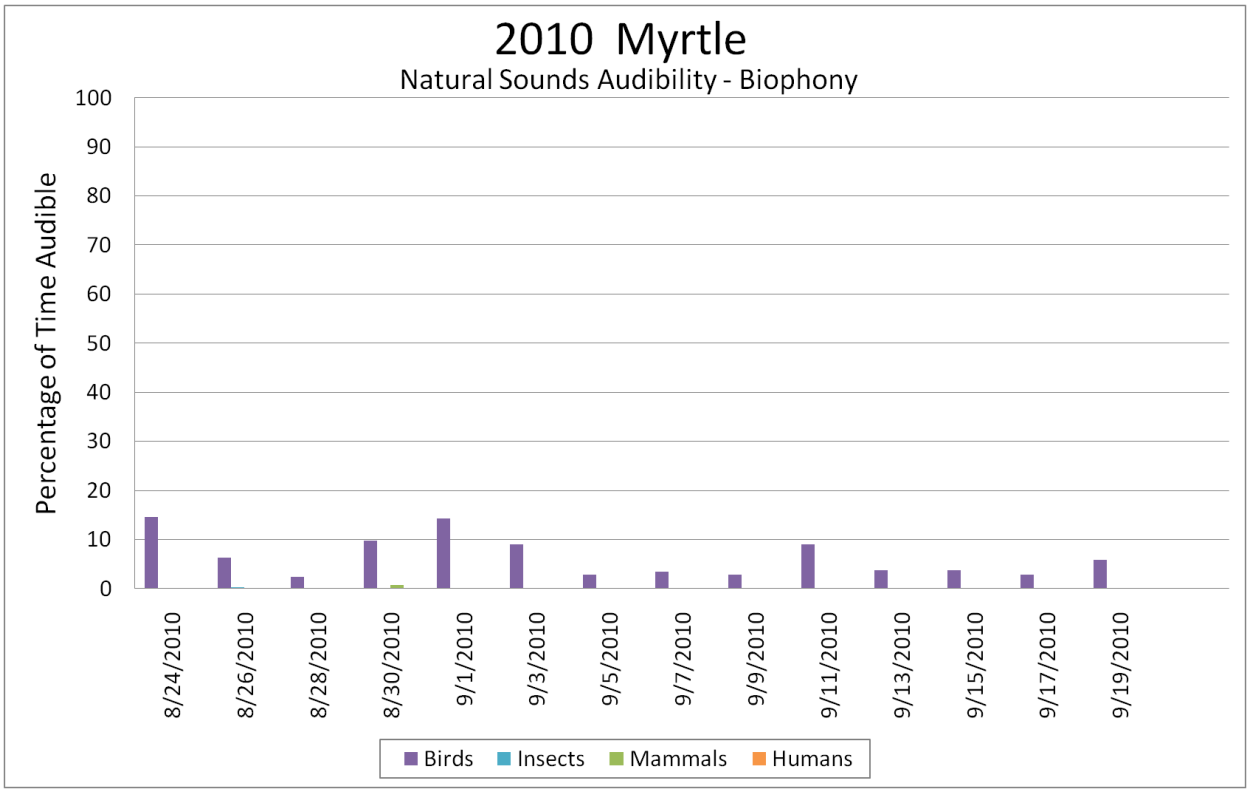


Figure 28. Percentage of time audible for biophonic sounds at Myrtle.

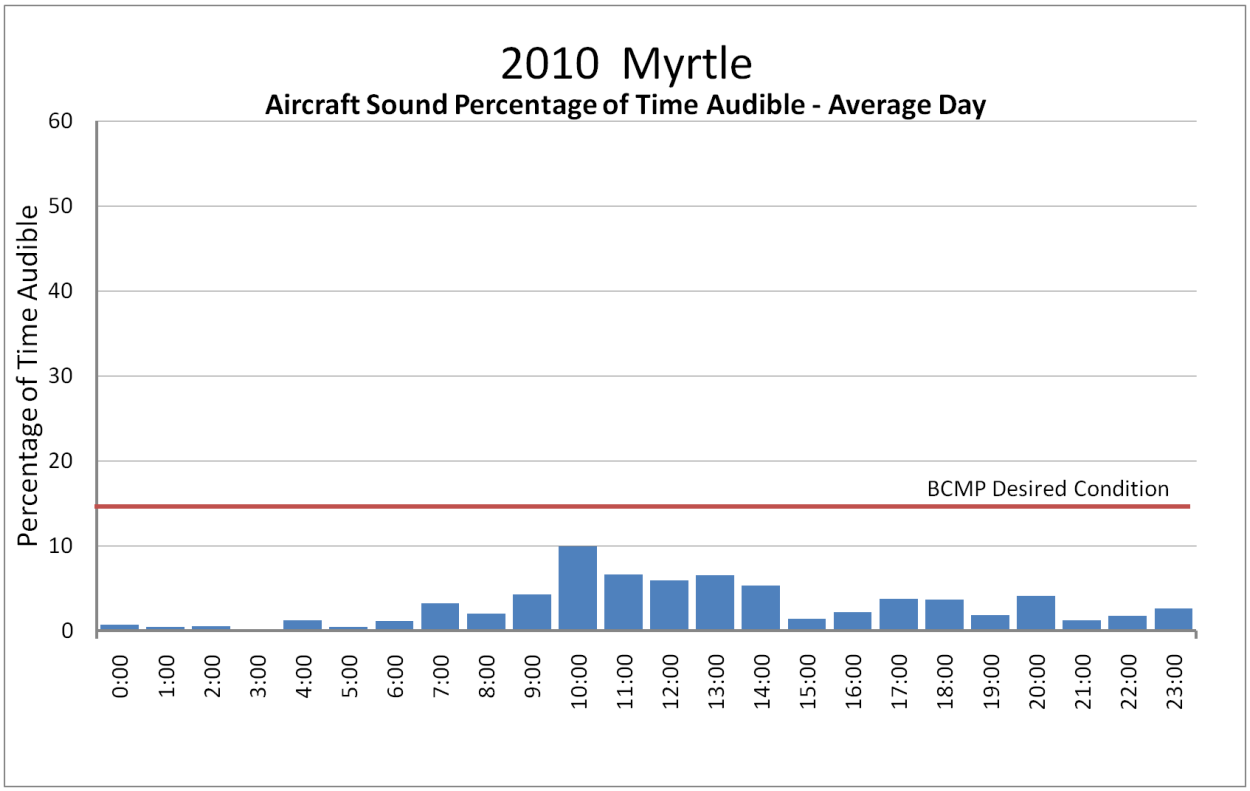


Figure 29. Audibility of aircraft noise for an average day, by hour, at Myrtle.

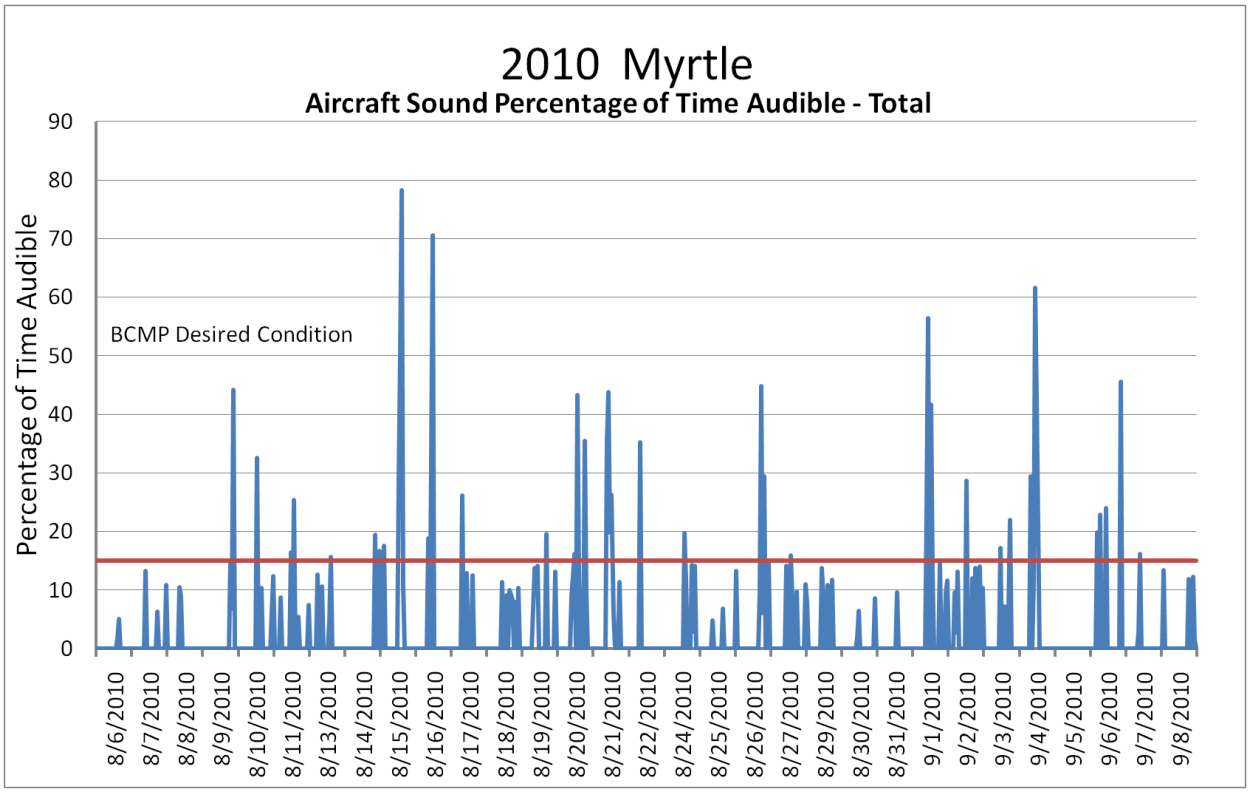


Figure 30. Audibility of aircraft noise at Myrtle.

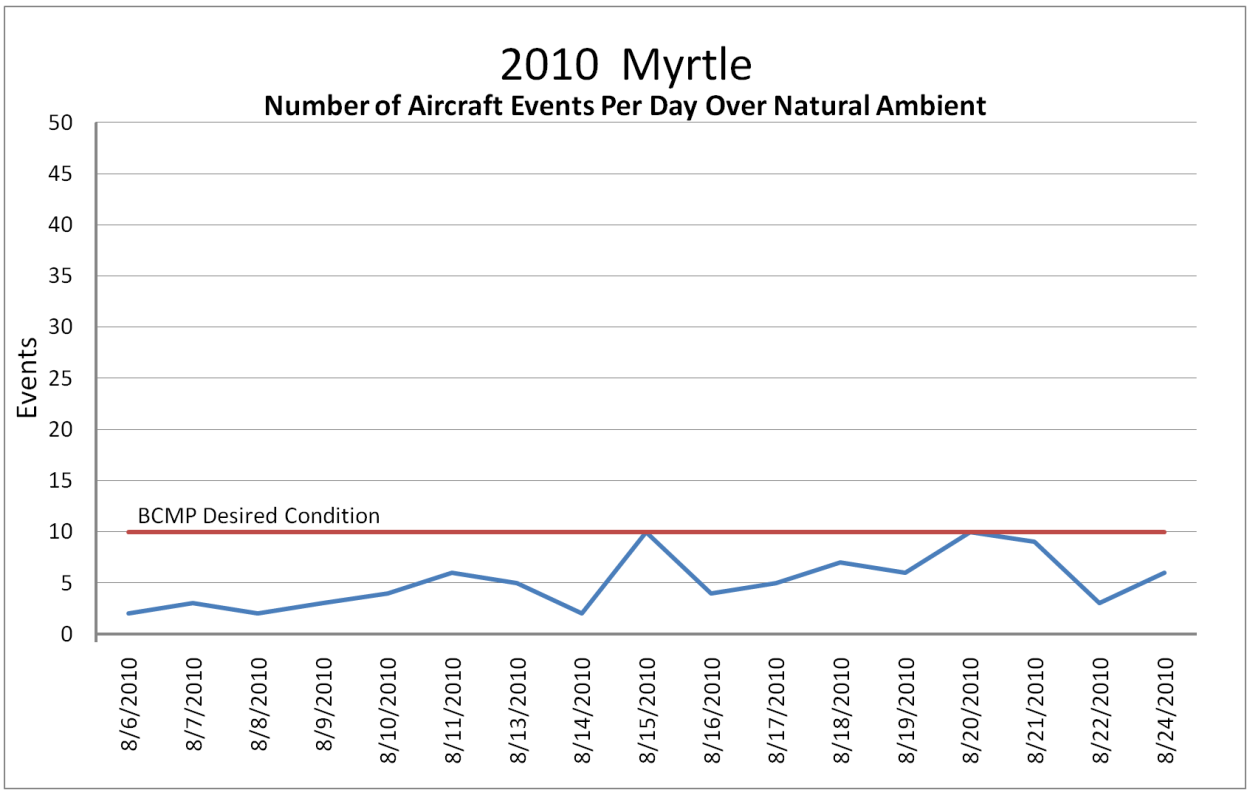


Figure 31. Number of aircraft noise events identified per day at Myrtle.

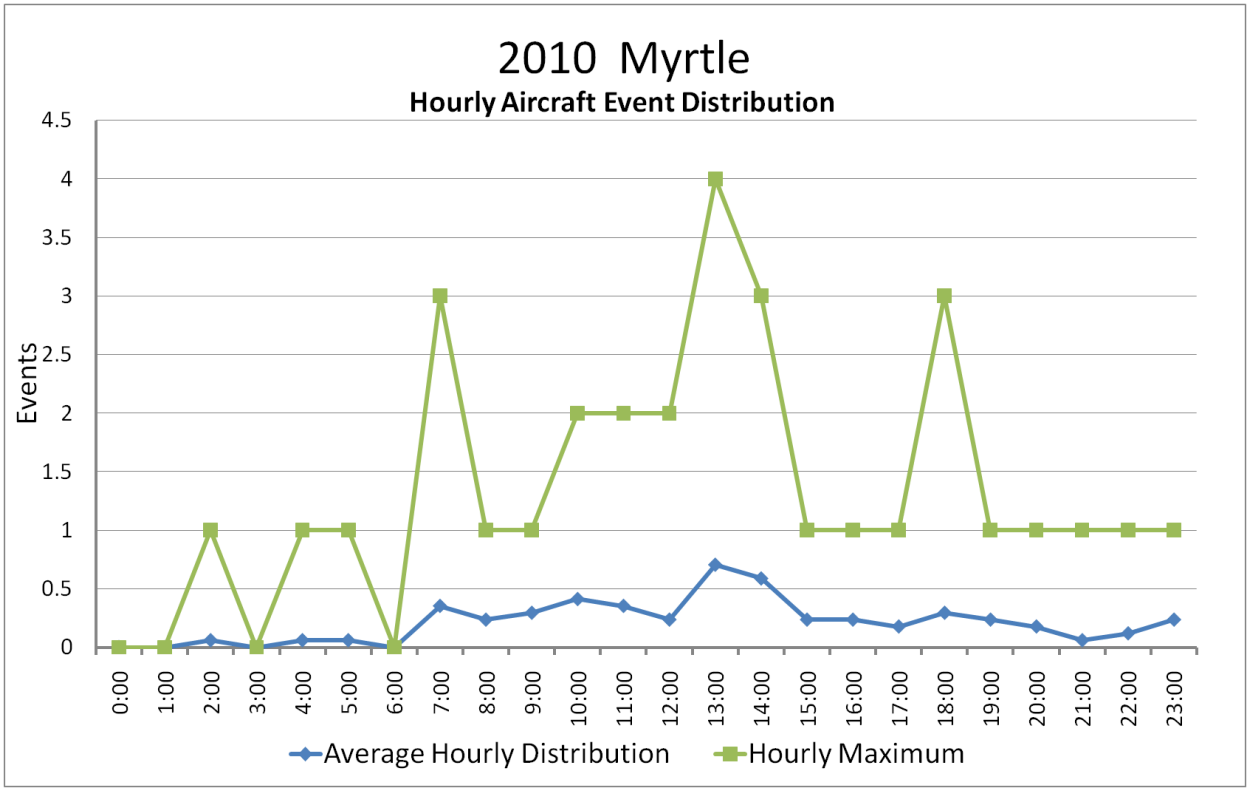


Figure 32. Hourly average and maximum aircraft event distribution at Myrtle.

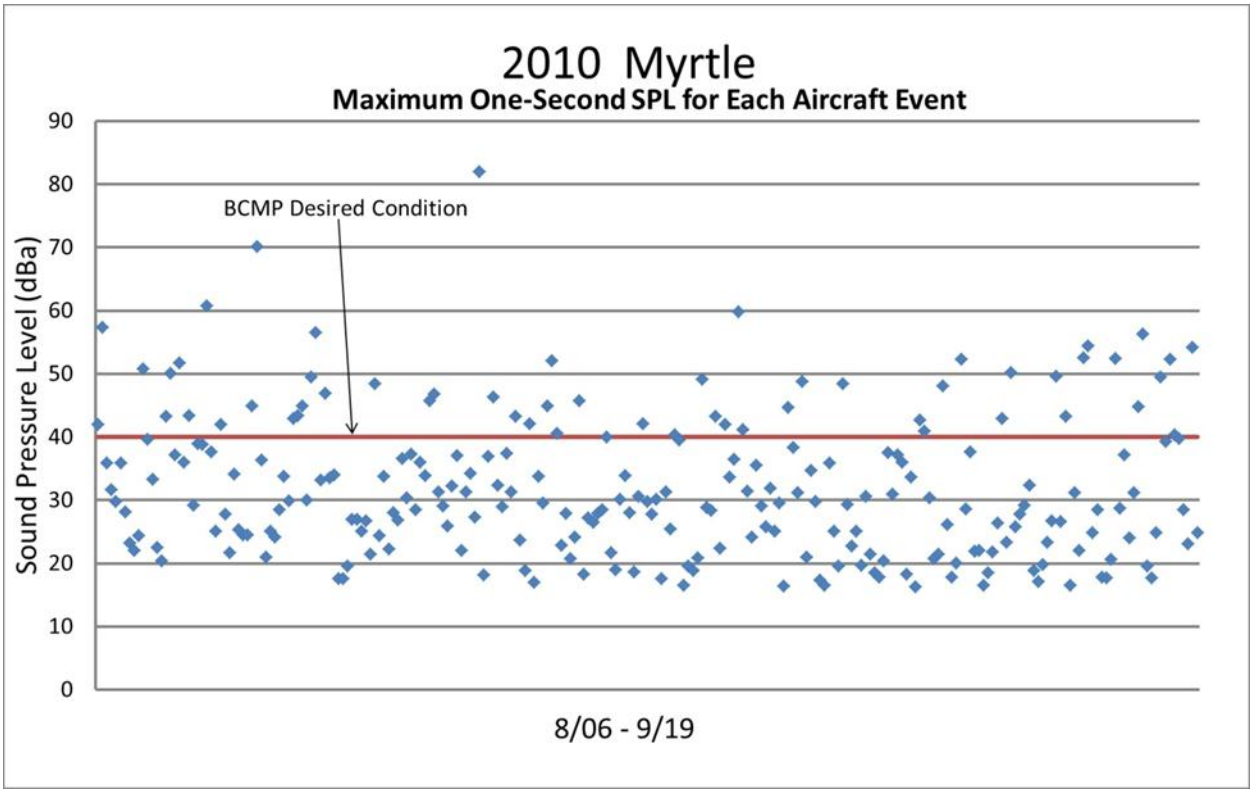


Figure 33. Maximum one-second SPL for each aircraft event identified at Myrtle.

Toe of the Tokositna Glacier

Location Description: On the gravel bar at the Toe of the Tokositna Glacier.

Purpose/Project: Location of interest chosen at the request of park management to assess the impacts from snow machine noise in this area.

Coordinates: Lat. 62.66451, Long. -150.79065 Elevation: 273 Meters

Time at Location: 13-March-2010 – 12-April-2010

BCMP Management Zone: Very High

Park Ecoregion: Lowland Floodplains & Terraces & Fans

Access: Snow Machine

Summary: The purpose of the Toe of the Tokositna Glacier location was to collect data in this common recreational snowmachining area. This site had also been sampled in 2005 and 2001, and offers opportunity for comparison and trend analysis.

The most commonly heard sounds at this site were flowing water (audible 94% of the time), wind (32%), and birds (14%). Human made sound was audible 10.7% of the time on average. Aircraft were audible 5.2% of the time on average. Conditions exceeded the BCMP percent audible standard 1% of the time, number of events per day 0% of the time, and maximum SPL 4% of the time.

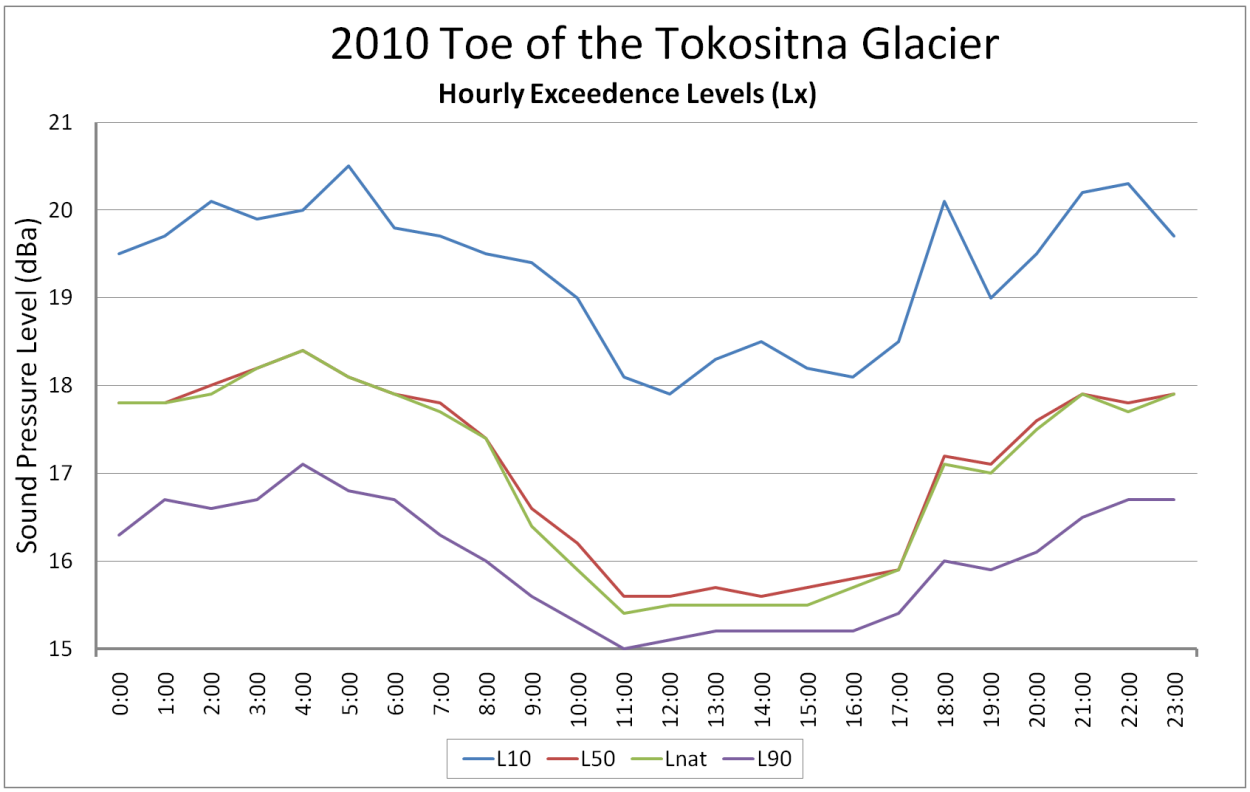


Figure 34. Exceedence levels for Toe of the Tokositna Glacier.

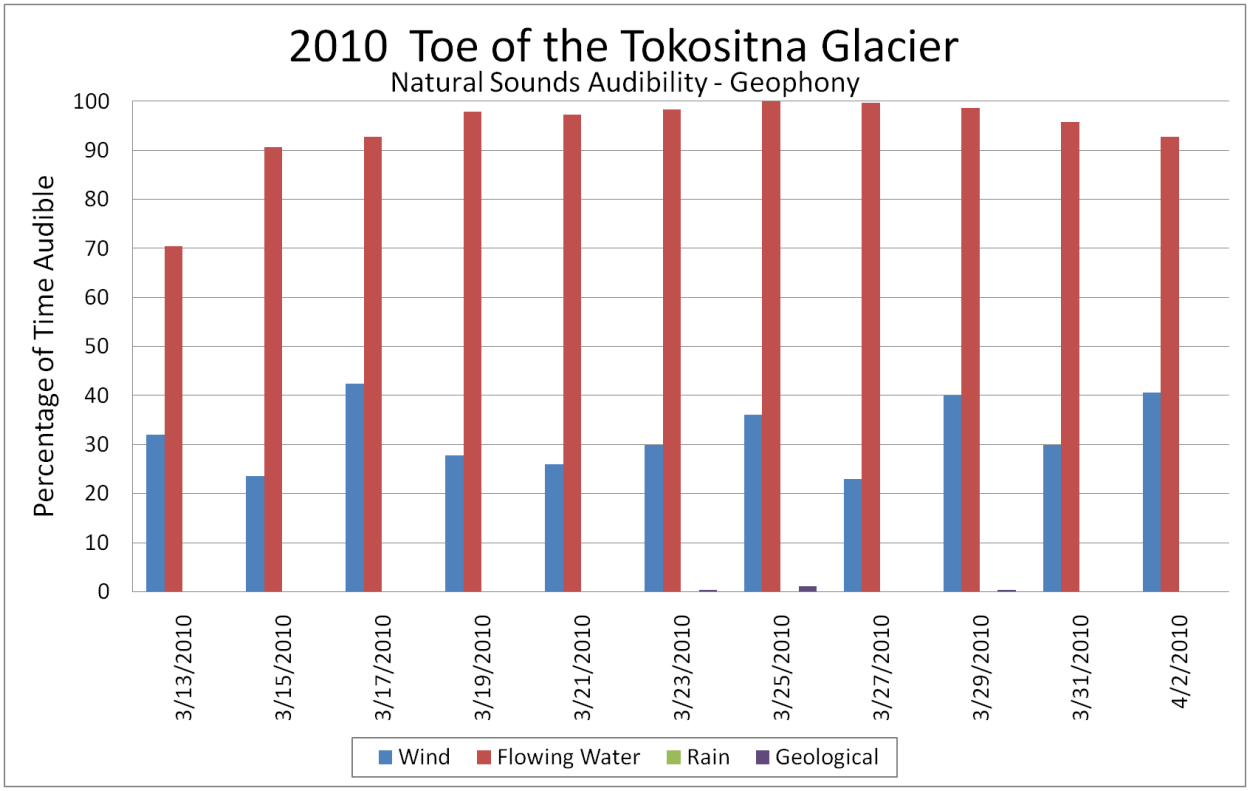


Figure 35. Percentage of time audible for geophonic sounds at Toe of the Tokositna Glacier.

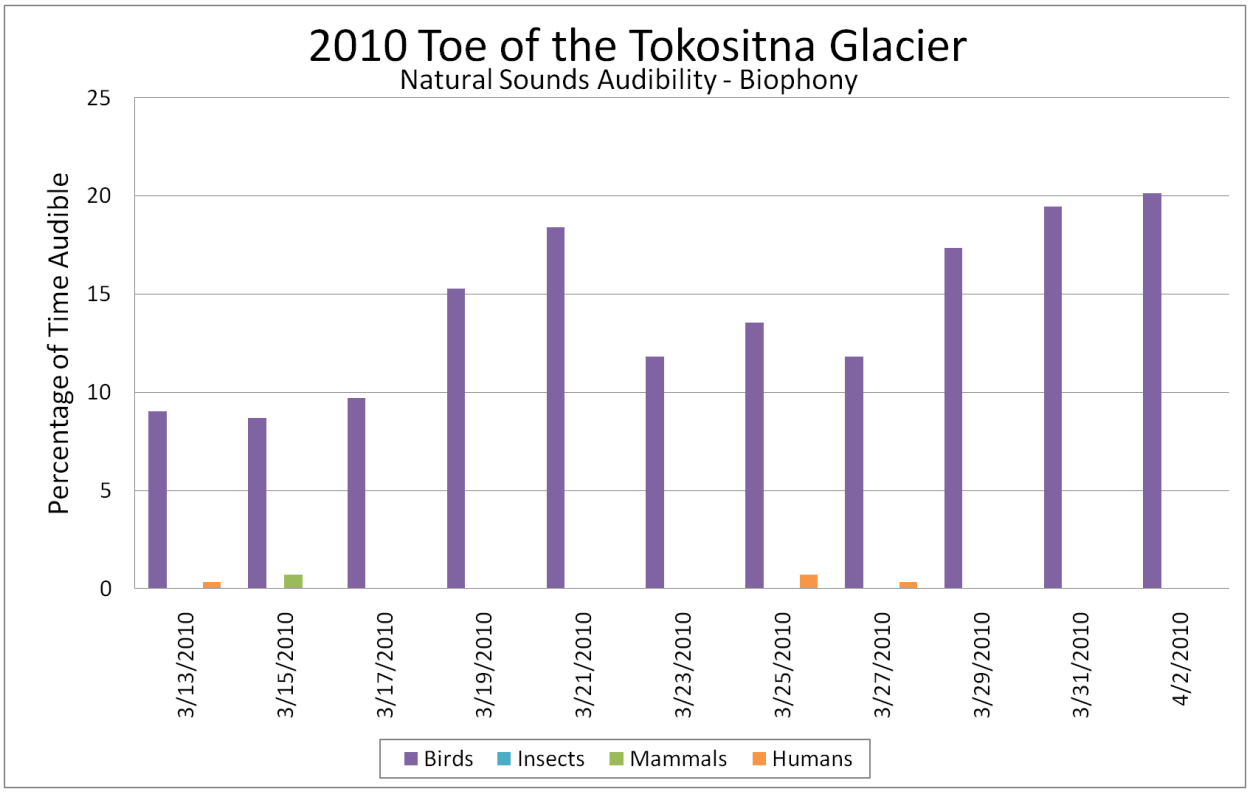


Figure 36. Percentage of time audible for biophonic sounds at Toe of the Tokositna Glacier.

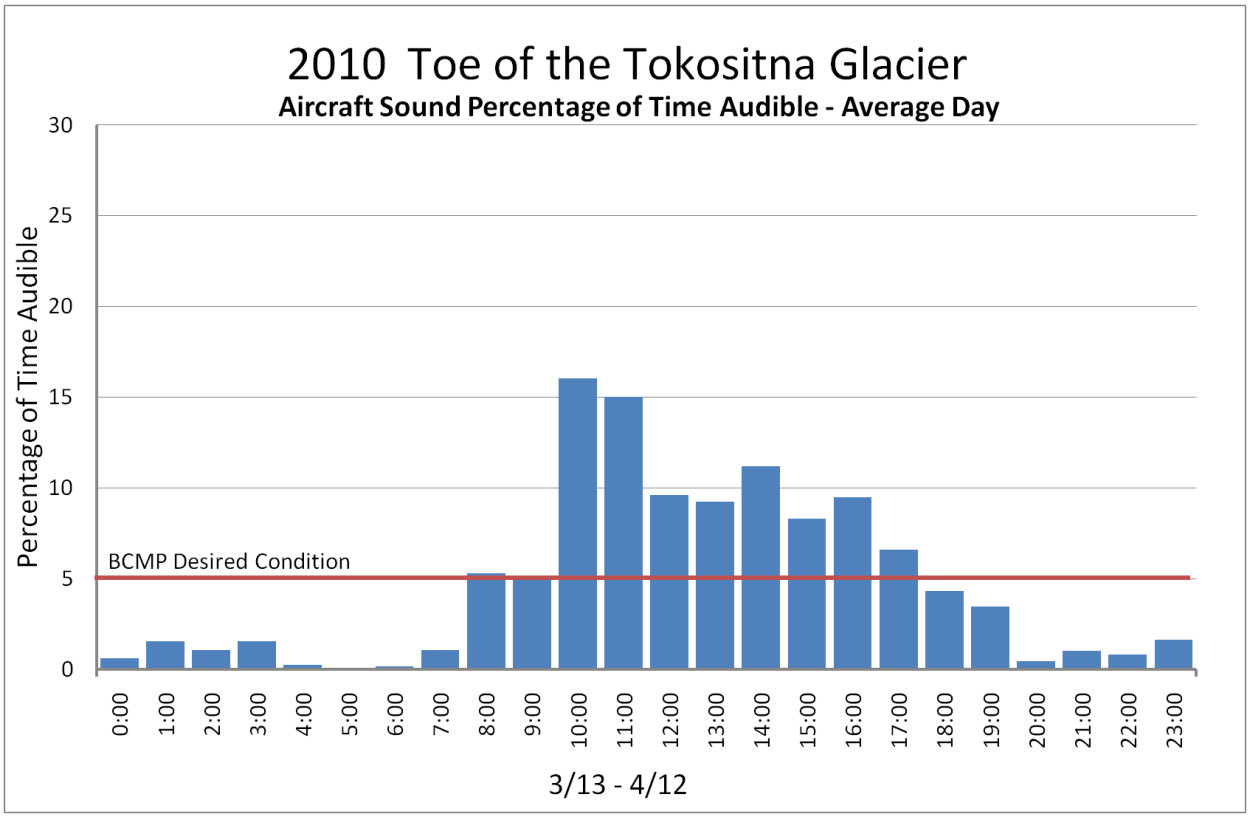


Figure 37. Audibility of aircraft noise for an average day, by hour, at Toe of the Tokositna Glacier.

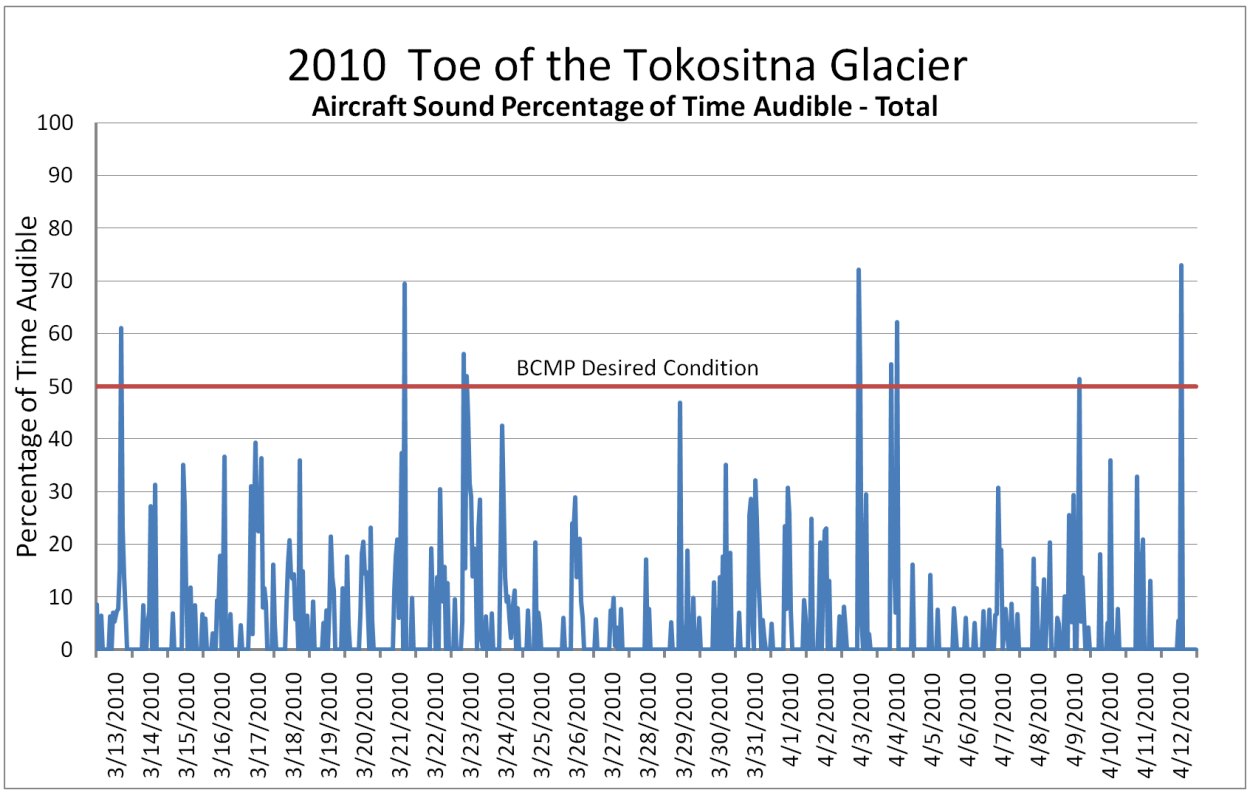


Figure 38. Audibility of aircraft noise at Toe of the Tokositna Glacier.

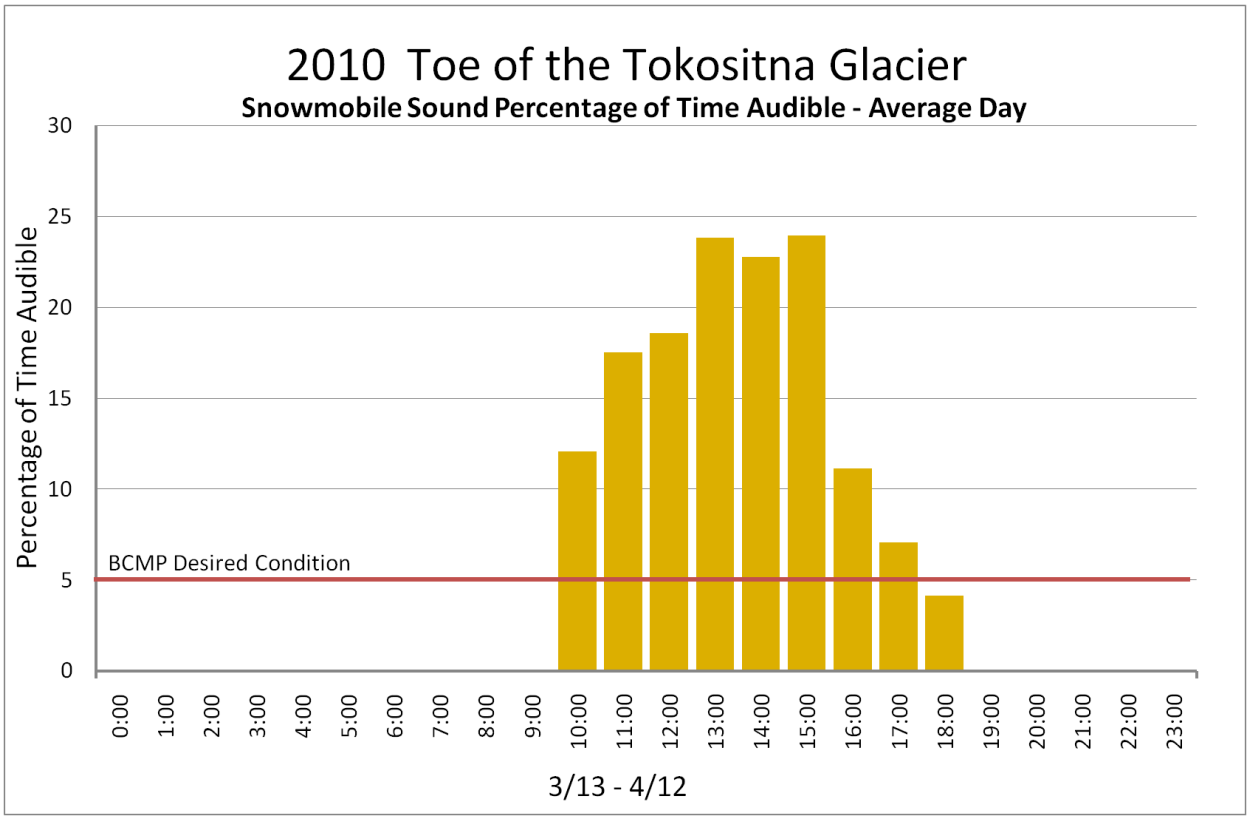


Figure 39. Audibility of snowmobile noise for an average day, by hour, at Toe of the Tokositna Glacier.

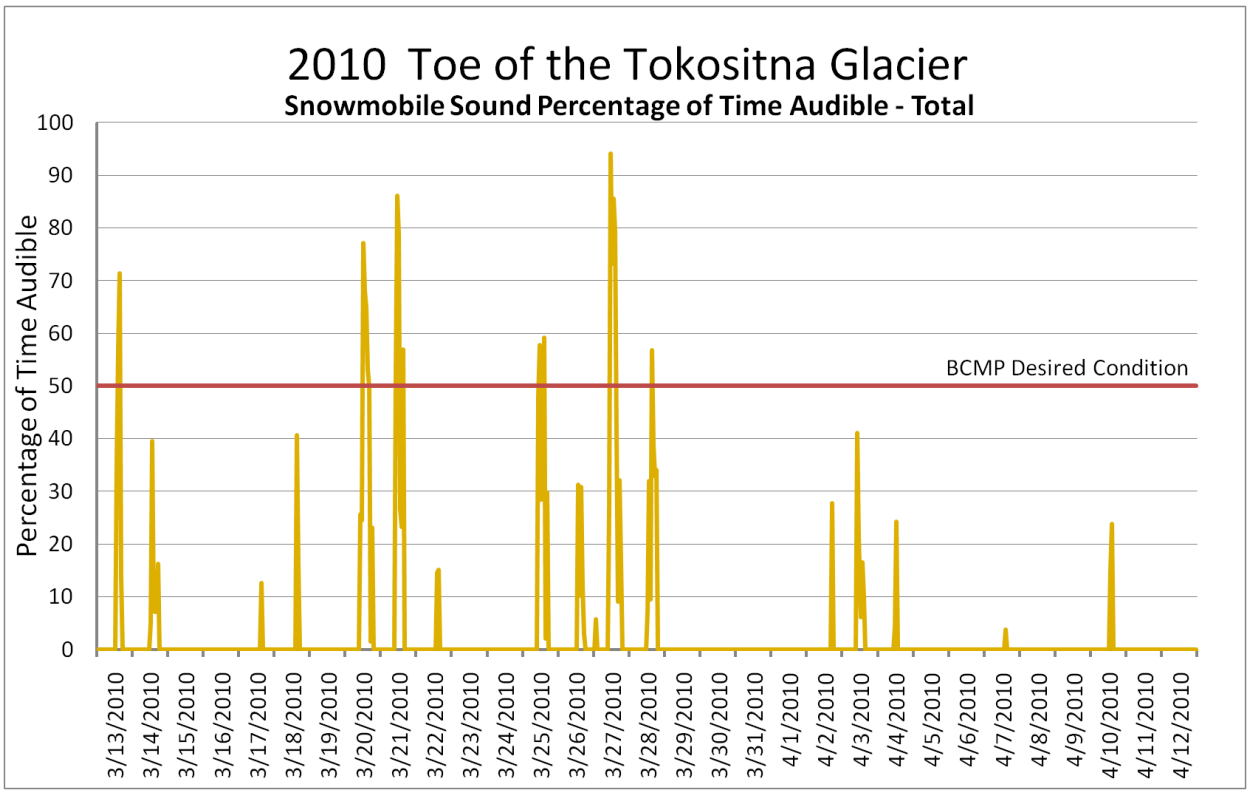


Figure 40. Audibility of snowmobile noise at Toe of the Tokositna Glacier.

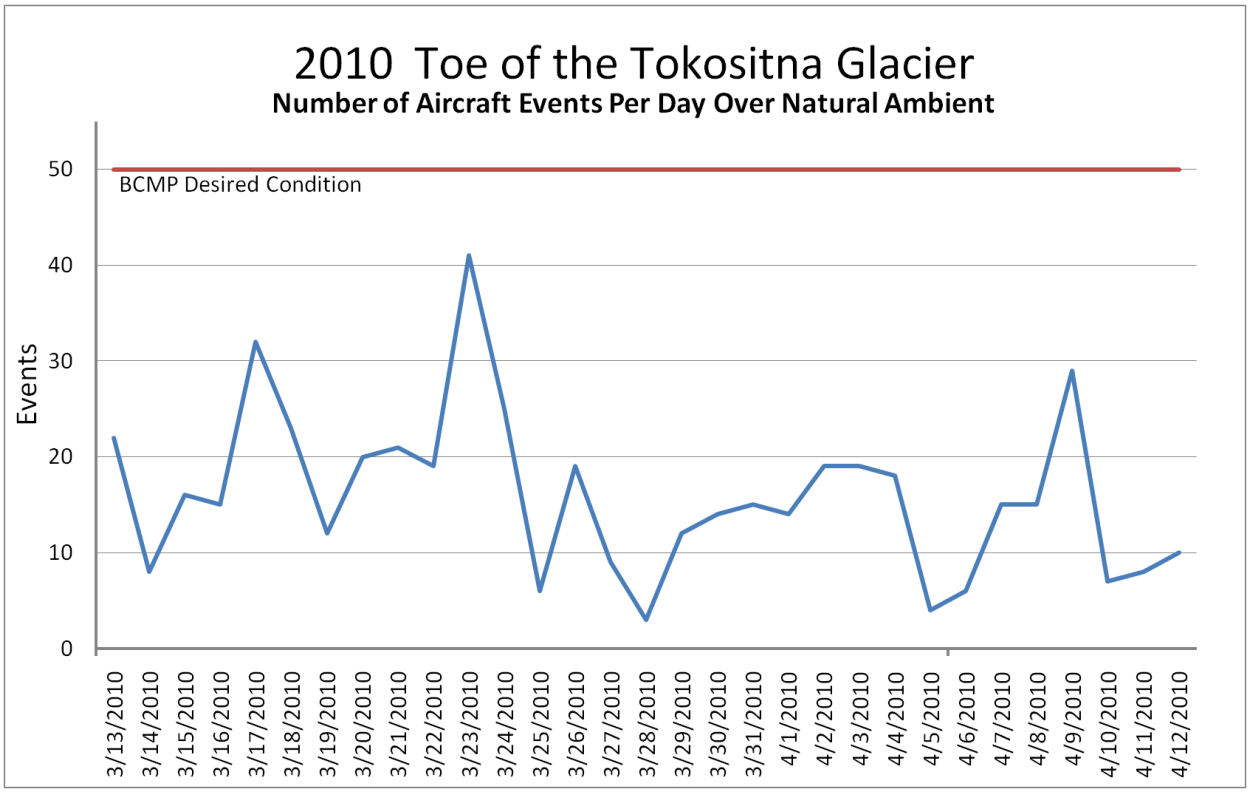


Figure 41. Number of aircraft noise events identified per day at Toe of the Tokositna Glacier.

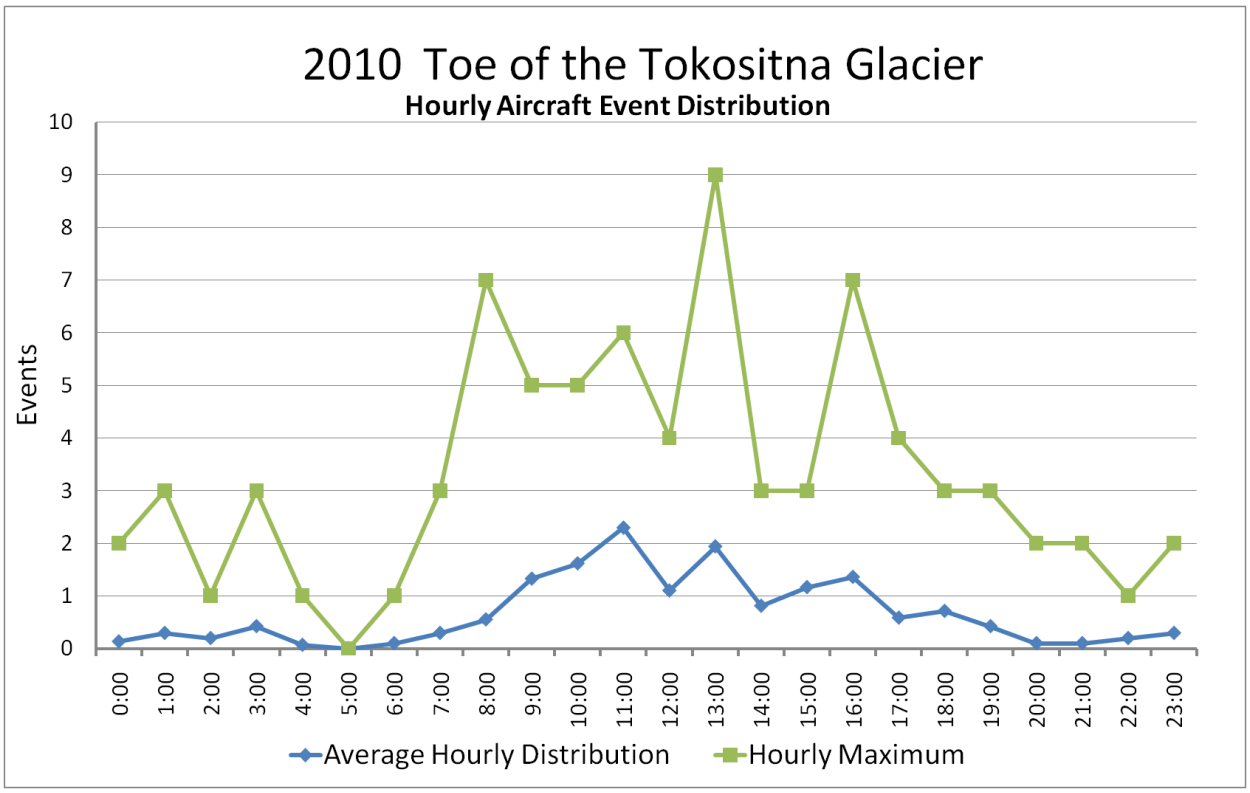


Figure 42. Hourly average and maximum aircraft event distribution at Toe of the Tokositna Glacier.

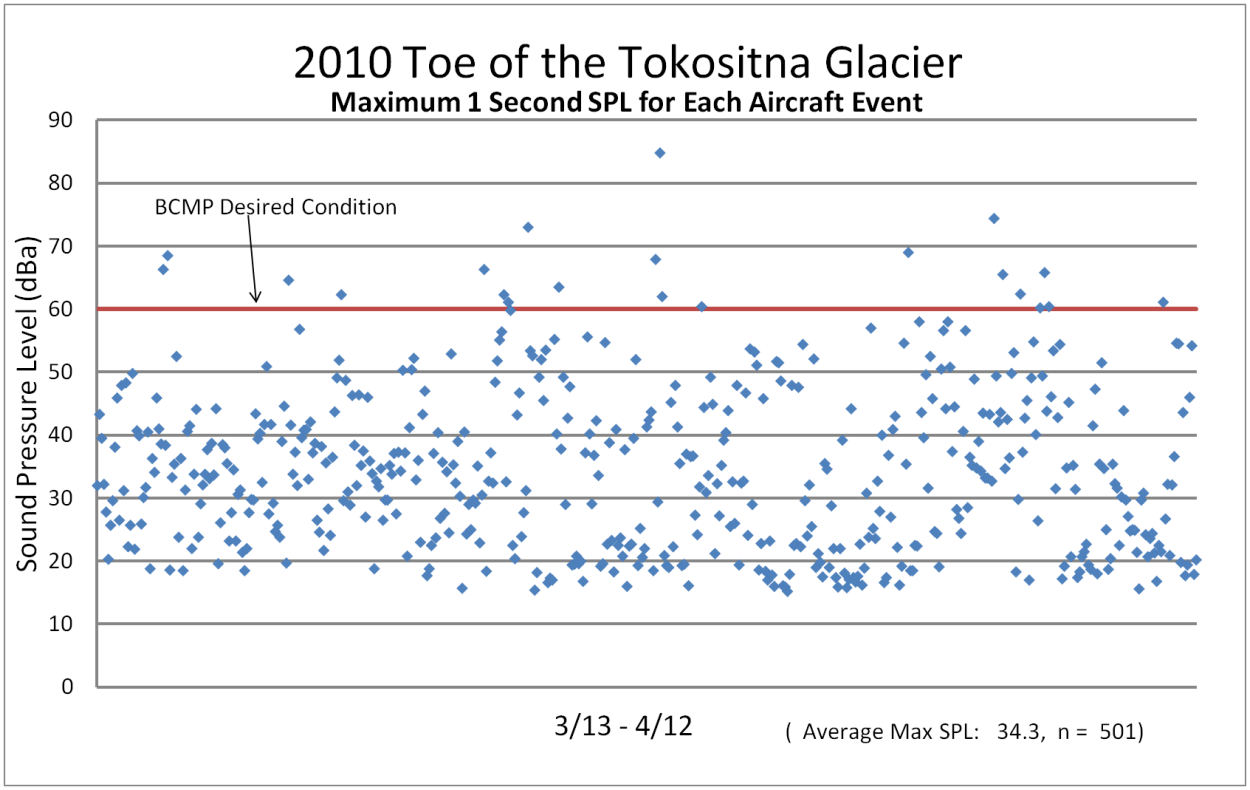


Figure 43. Maximum one-second SPL for each aircraft event identified at Toe of the Tokositna Glacier.

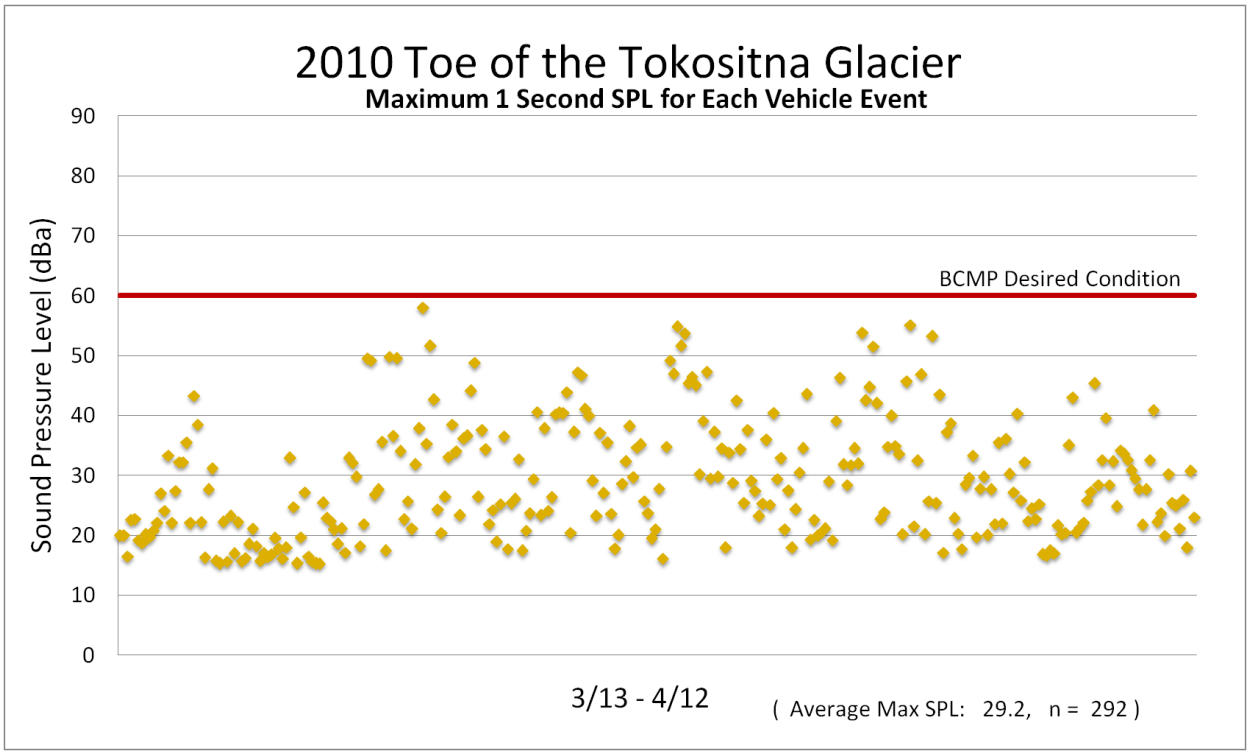
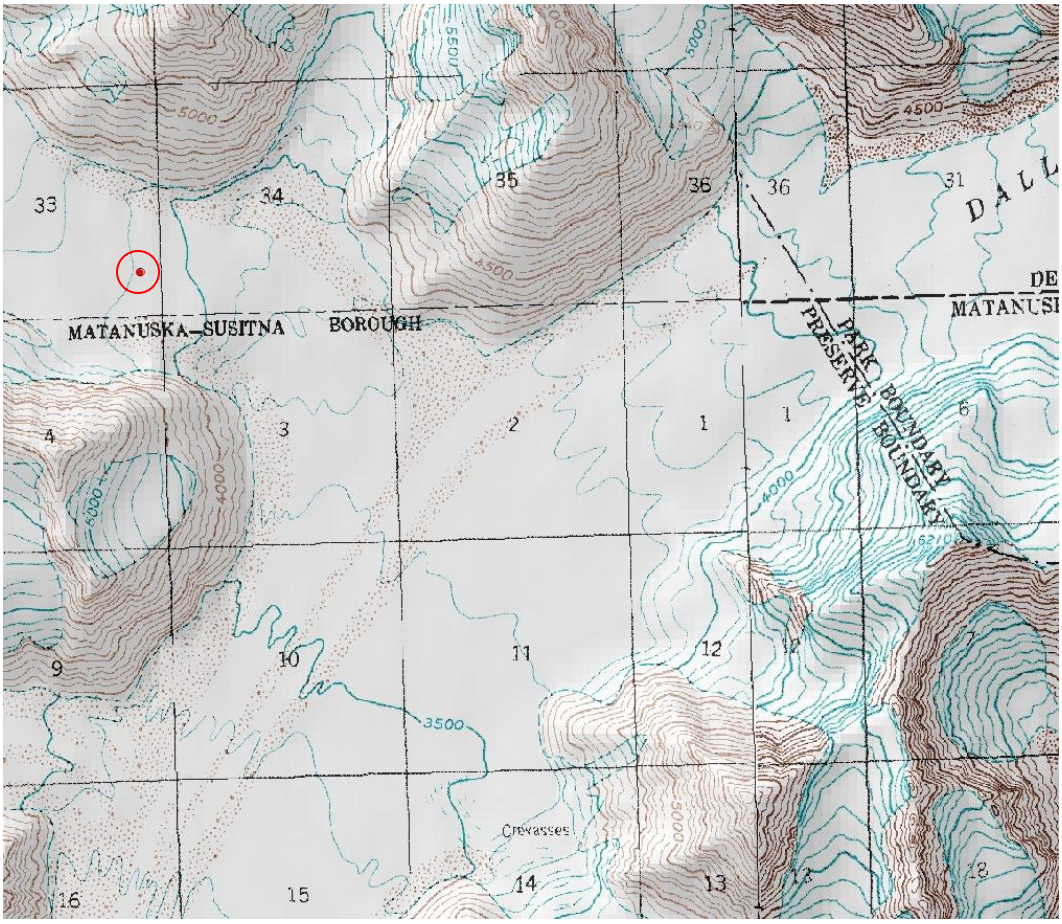


Figure 44. Maximum one-second SPL for each snowmobile event identified at Toe of the Tokositna Glacier.

Upper Dall Glacier



Location Description: Upper Dall Glacier, 0.3 KM North of the Mat-Su Borough boundary, 4.5 KM West of the Park/Preserve boundary.

Purpose/Project: Location randomly chosen from the LTEM grid as part of the long-term Denali Soundscape inventorying and monitoring sampling plan.

Coordinates: Lat. 62.72931, Long. -152.08225 Elevation: 1241 Meters

Time at Location: 02-July-2010 – 20-July-2010

BCMP Management Zone: Low Park Ecoregion: Nonvegetated Alpine Mountains

Access: Helicopter

Summary: The purpose of the Upper Dall Glacier location was to collect data at one of the long-term ecological monitoring (LTEM) grid points as outlined in the above sampling plan. LTEM grid point #42 was stratified as a New Park location and randomly selected from all locations requiring aircraft access.

The Upper Dall Glacier is typified by continuous broadband geophonic sound with individual event excitations occurring on a micro time scale. (Water, ice, trickling rocks, and wind.) Discrete sound events that do occur are infrequent and heterogeneous. These sounds, such as bird calls, rockslides and avalanches, vary widely in terms of texture and spatial

distribution. Human sound is exemplified by aircraft overflights, a majority of which seem to be high-altitude jets. These events are relatively infrequent when considered in terms of the Park as a whole.

The most commonly heard sounds at this site were flowing water (audible 72.1% of the time), wind (60%), and rain (11%). Human made sound was audible 1.2% of the time on average. Conditions exceeded the BCMP percent audible standard 9% of the time, number of events per day 67% of the time, and maximum SPL 60% of the time.

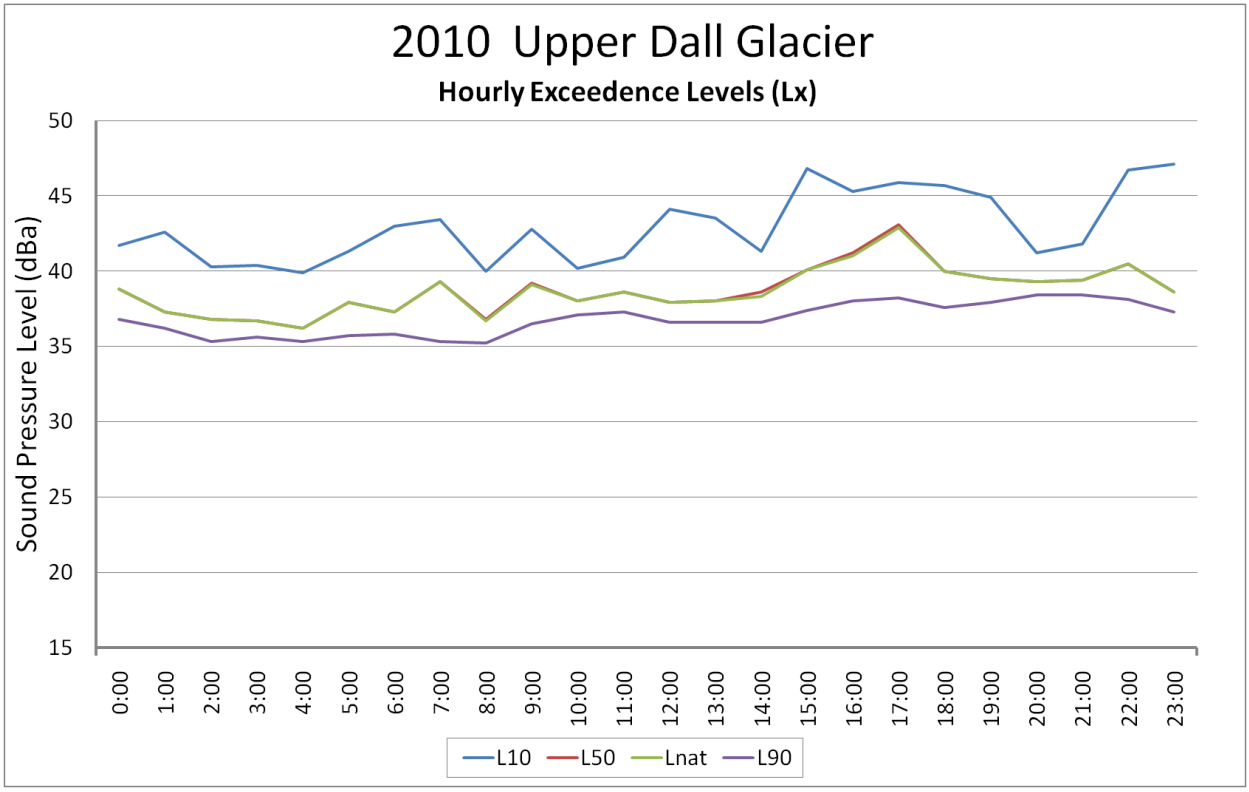


Figure 45. Exceedence levels for Upper Dall Glacier.

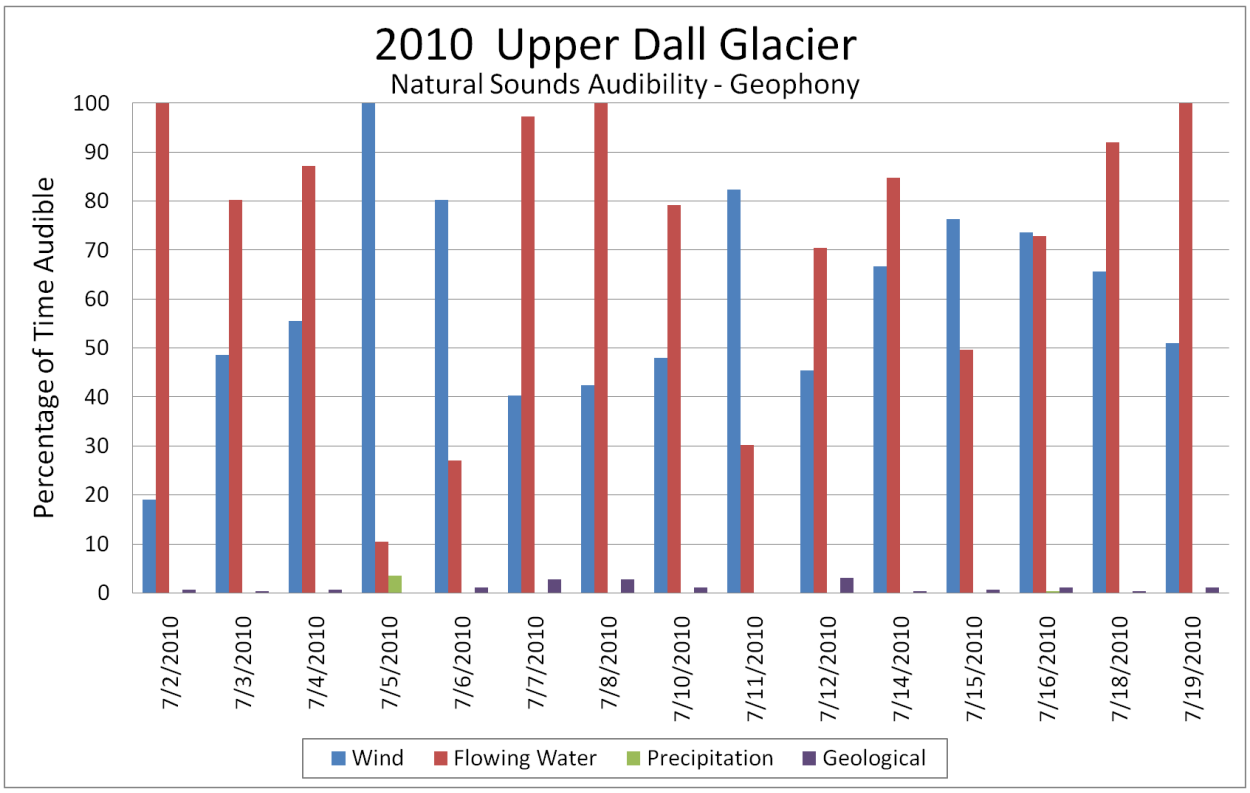


Figure 46. Percentage of time audible for geophonic sounds at Upper Dall Glacier.

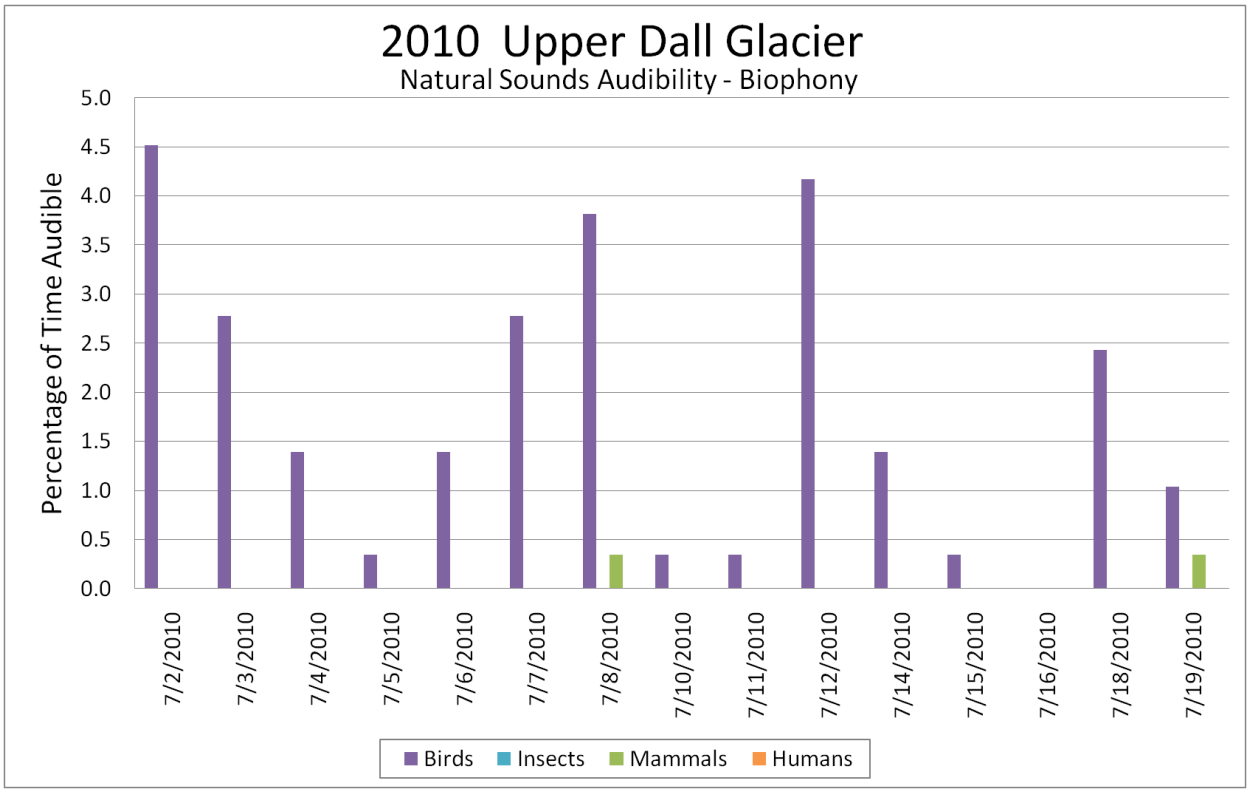


Figure 47. Percentage of time audible for biophonic sounds at Upper Dall Glacier.

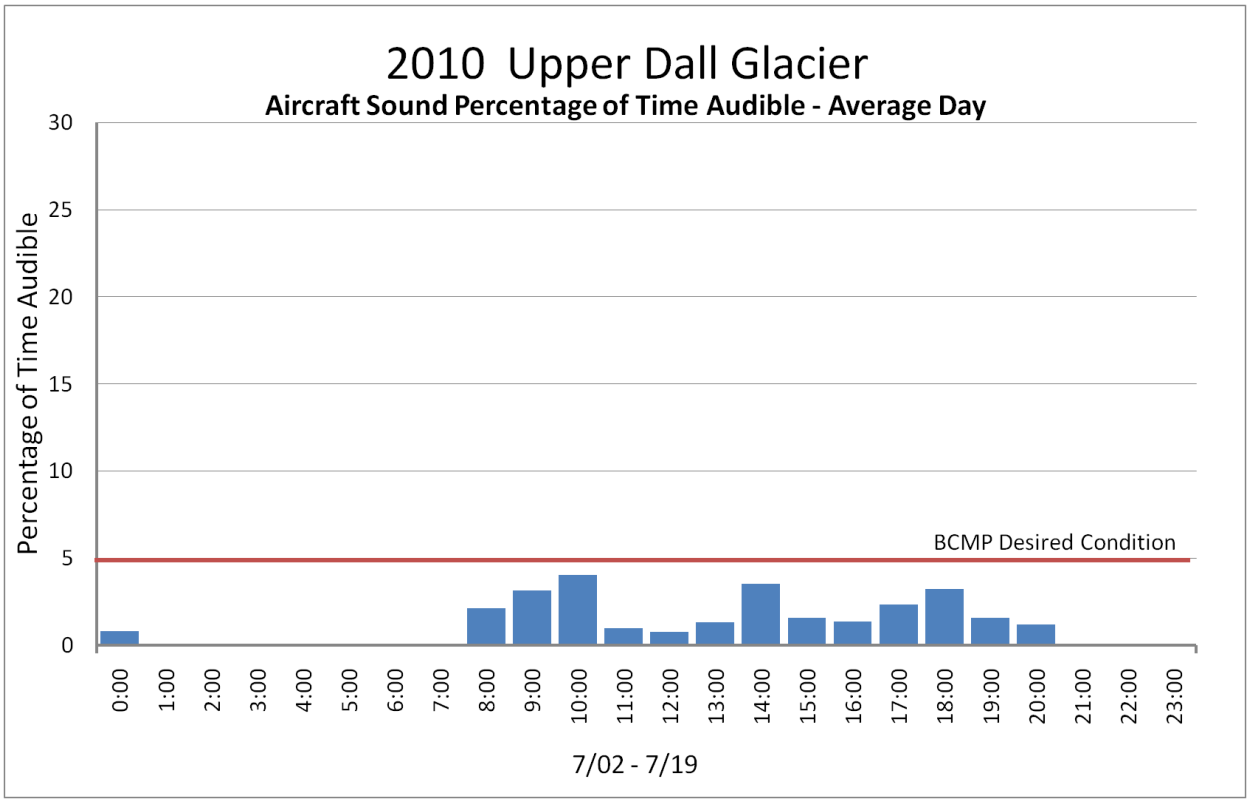


Figure 48. Audibility of aircraft noise for an average day, by hour, at Upper Dall Glacier.

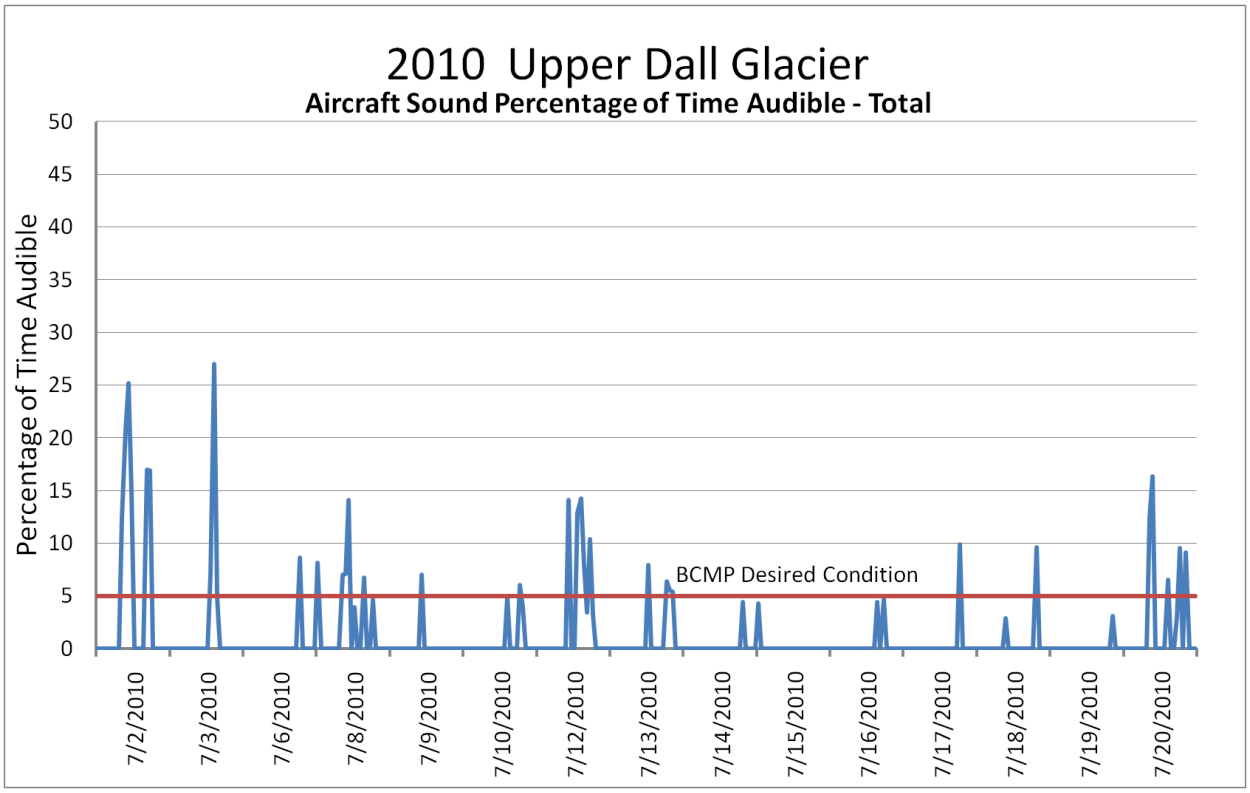


Figure 49. Audibility of aircraft noise at Upper Dall Glacier.

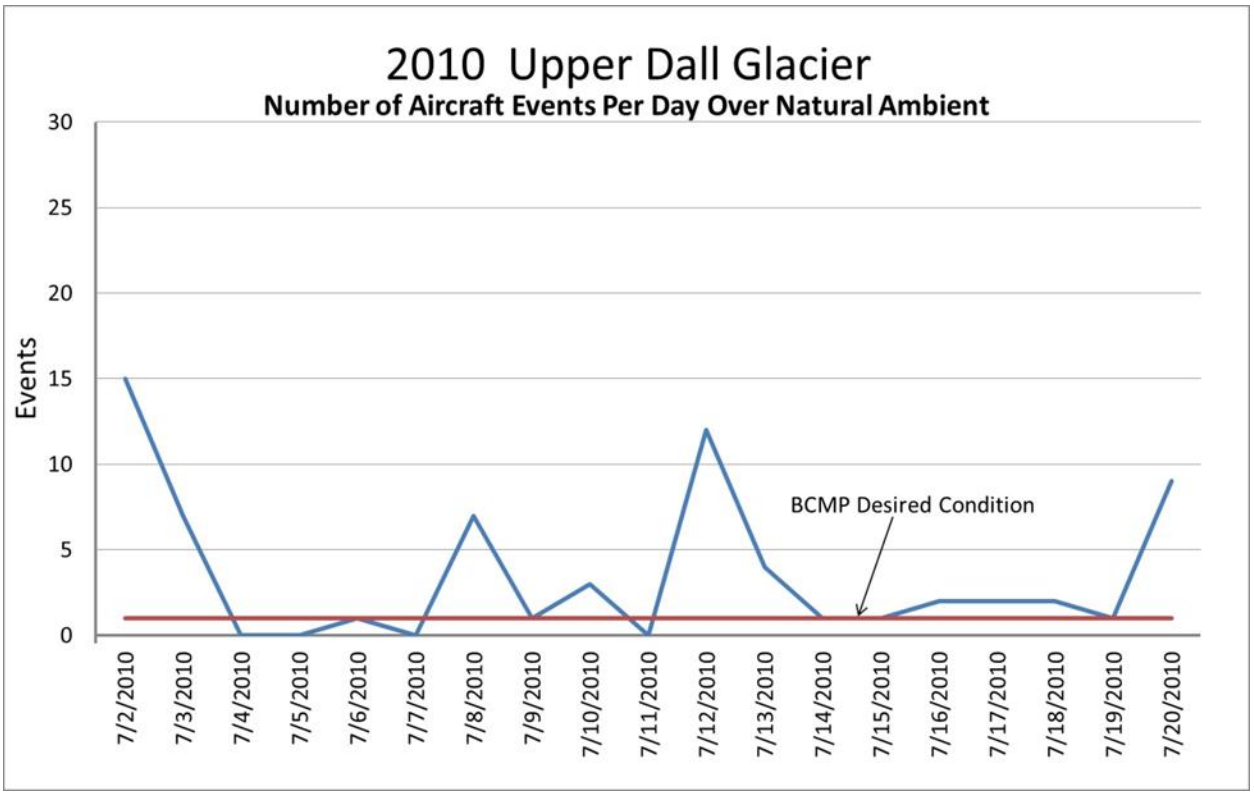


Figure 50. Number of aircraft noise events identified per day at Upper Dall Glacier.

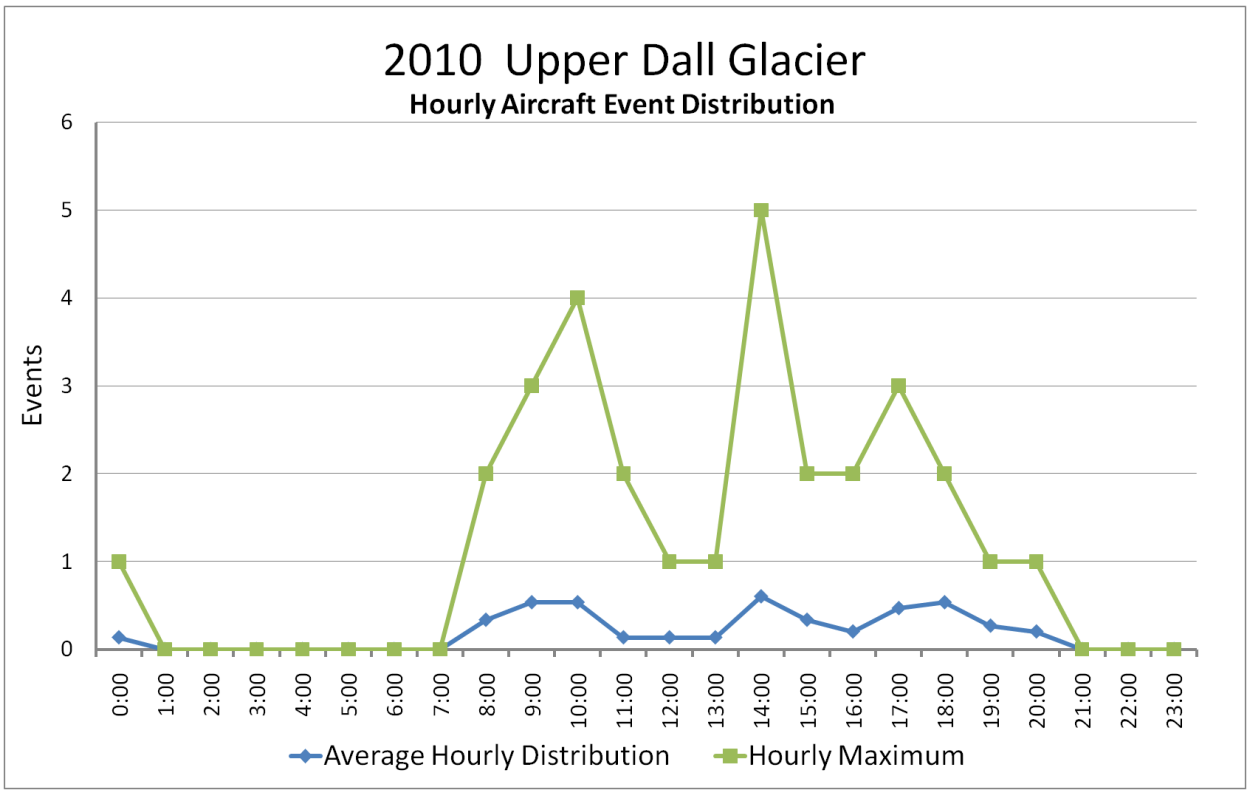


Figure 51. Hourly average and maximum aircraft event distribution at Upper Dall Glacier.

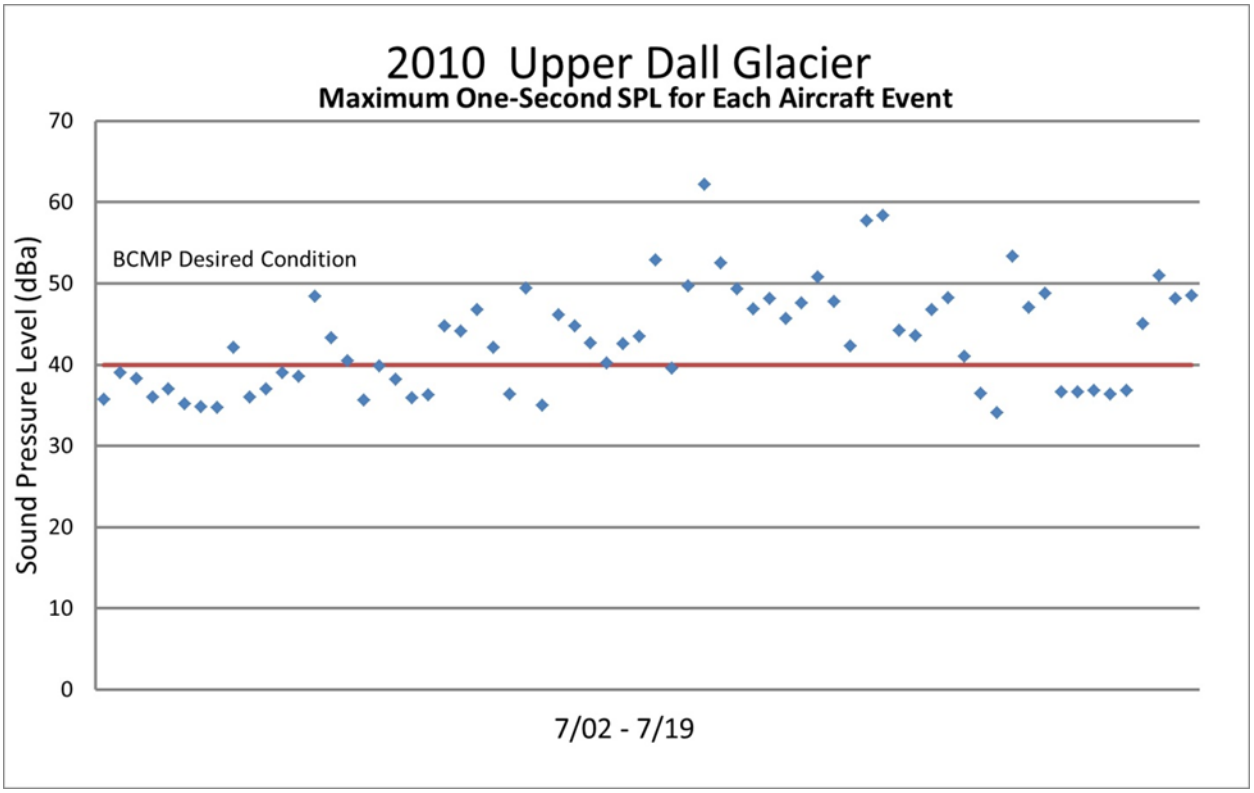
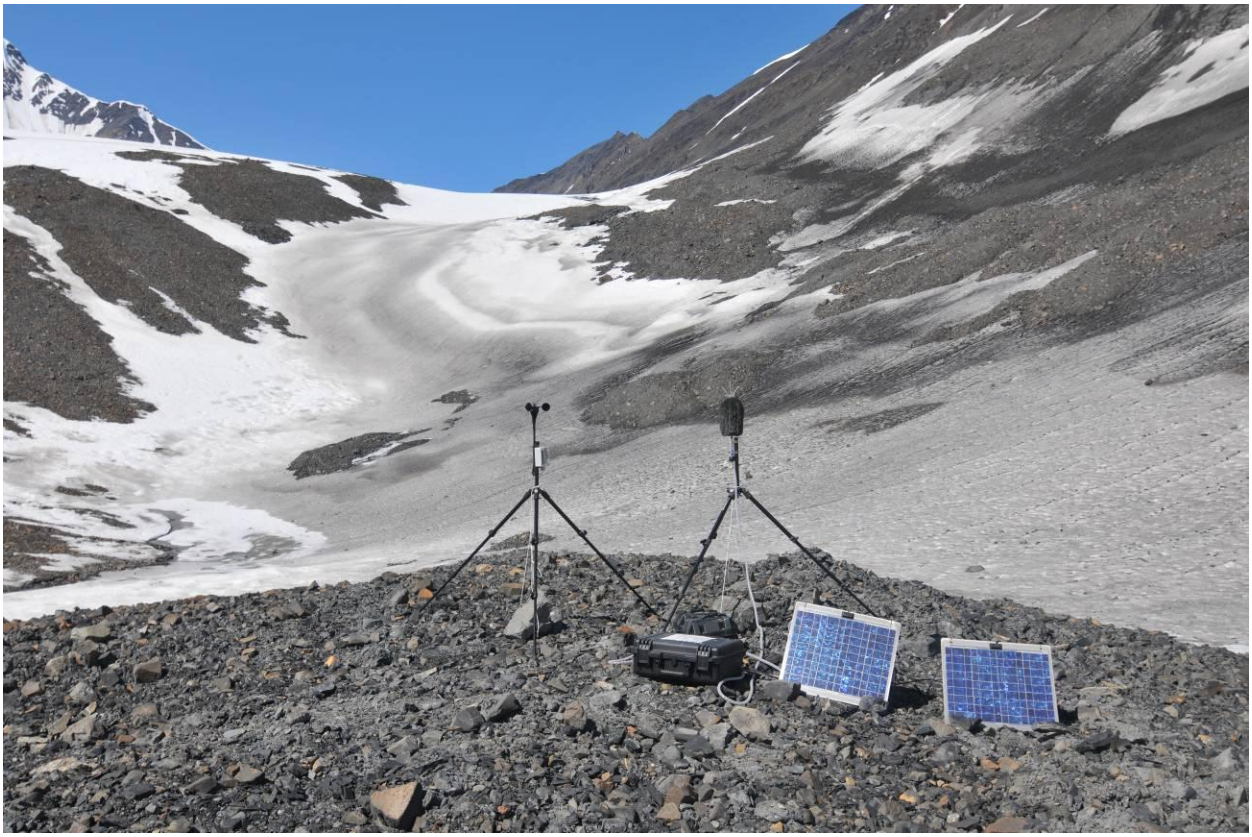


Figure 52. Maximum one-second SPL for each aircraft event identified at Upper Dall Glacier.

Upper Ohio Glacier



Location Description: Icefield between the Ohio Creek tributary glaciers and the Upper West Fork Chulitna Glacier, 1.3 KM North of the wilderness boundary.

Purpose/Project: Location randomly chosen from the LTEM grid as part of the long-term Denali Soundscape inventorying and monitoring sampling plan.

Coordinates: Lat. 63.22536, Long. -150.02376 Elevation: 1504 Meters

Time at Location: 29-May-2010 – 30-June-2010

BCMP Management Zone: Low Park Ecoregion: Nonvegetated Alpine Mountains

Access: Helicopter

Summary: The purpose of the Upper Ohio Glacier location was to collect data at one of the long-term ecological monitoring (LTEM) grid points as outlined in the above sampling plan. LTEM grid point #103 was stratified as an Old Park location (designated wilderness) and randomly selected from all locations requiring aircraft access.

The most commonly heard sounds at this site were flowing water (audible 98% of the time), wind (52%), and mass movement (6%). Human made sound was audible 1.6% of the time on average. Conditions exceeded the BCMP percent audible standard 1% of the time, number of events per day 93% of the time, and maximum SPL 65% of the time.

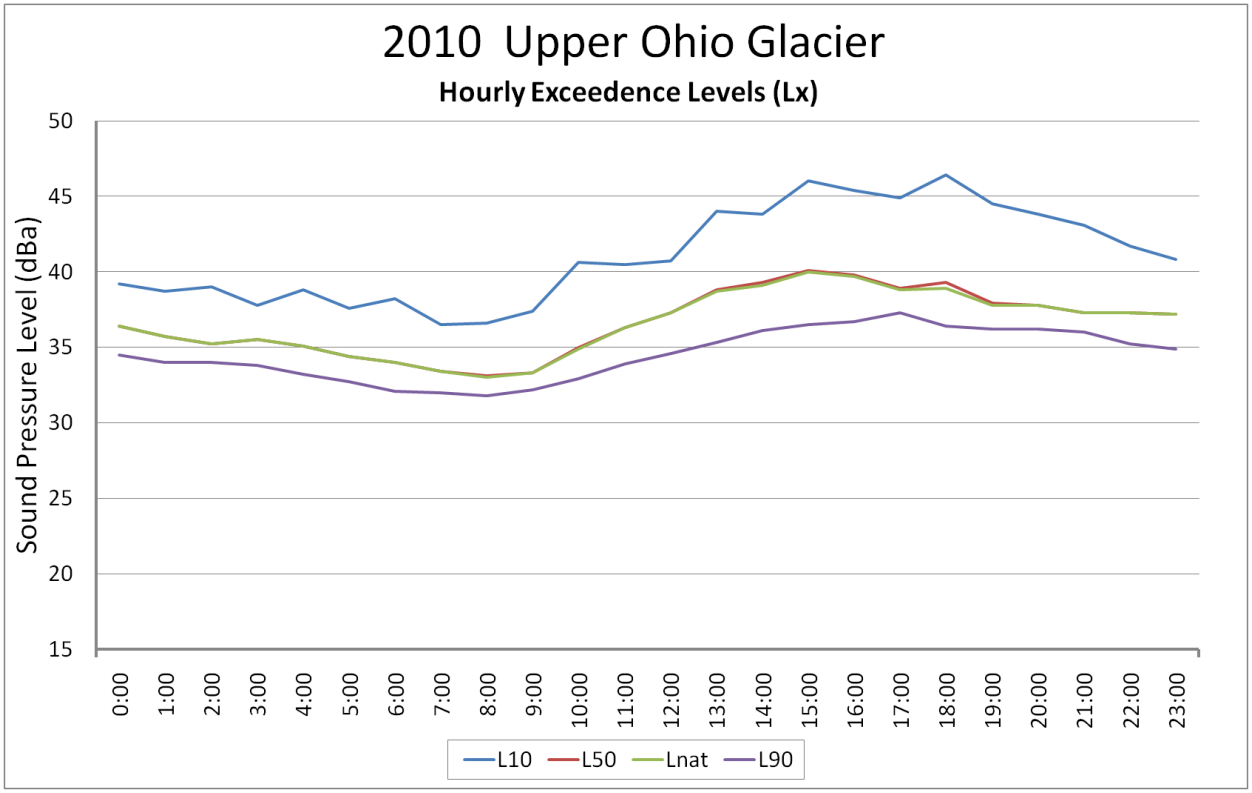


Figure 53. Exceedence levels for Upper Ohio Glacier.

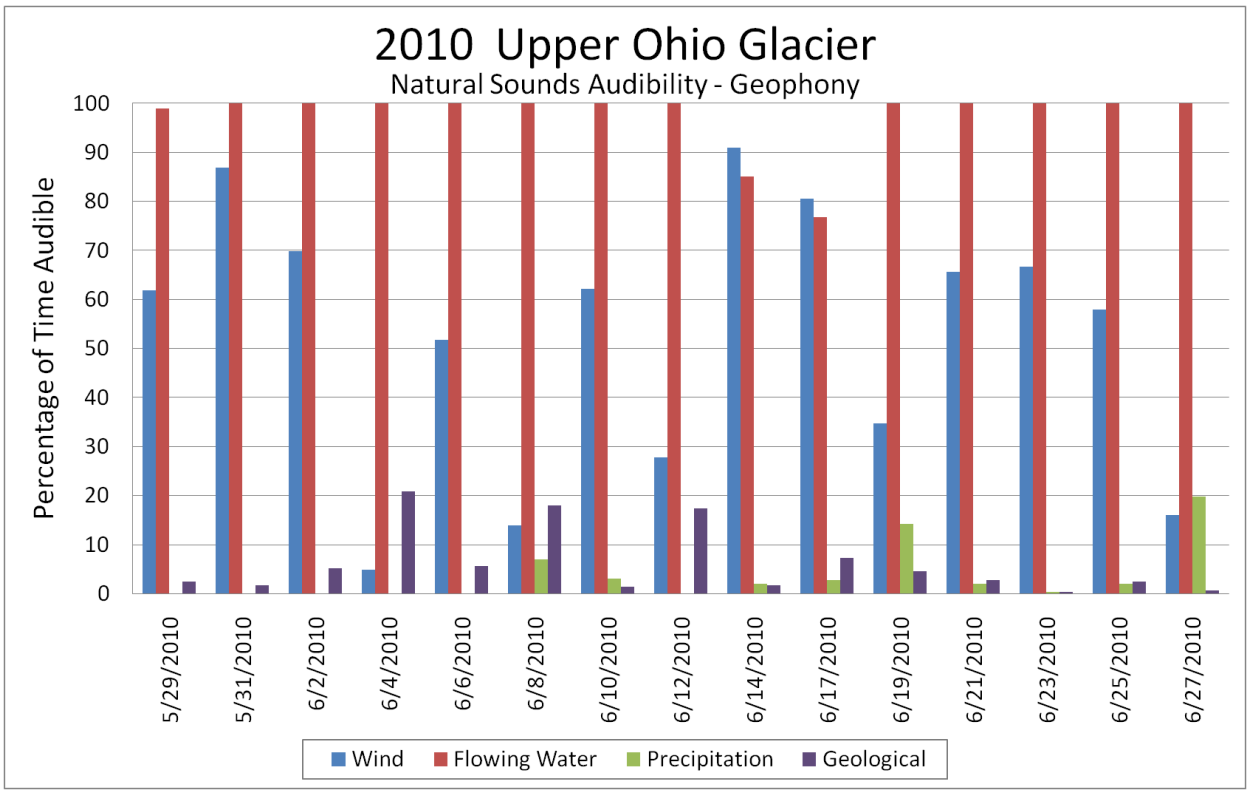


Figure 54. Percentage of time audible for geophonic sounds at Upper Ohio Glacier.

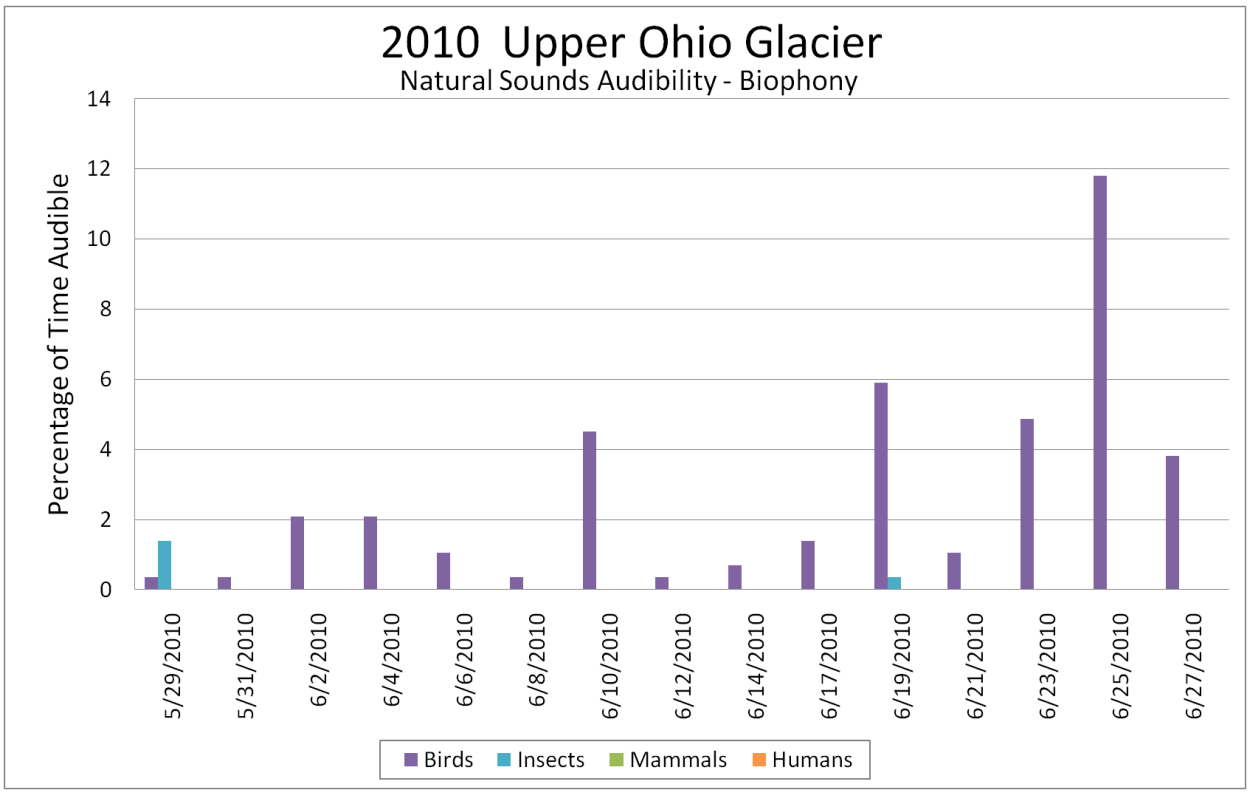


Figure 55. Percentage of time audible for biophonic sounds at Upper Ohio Glacier.

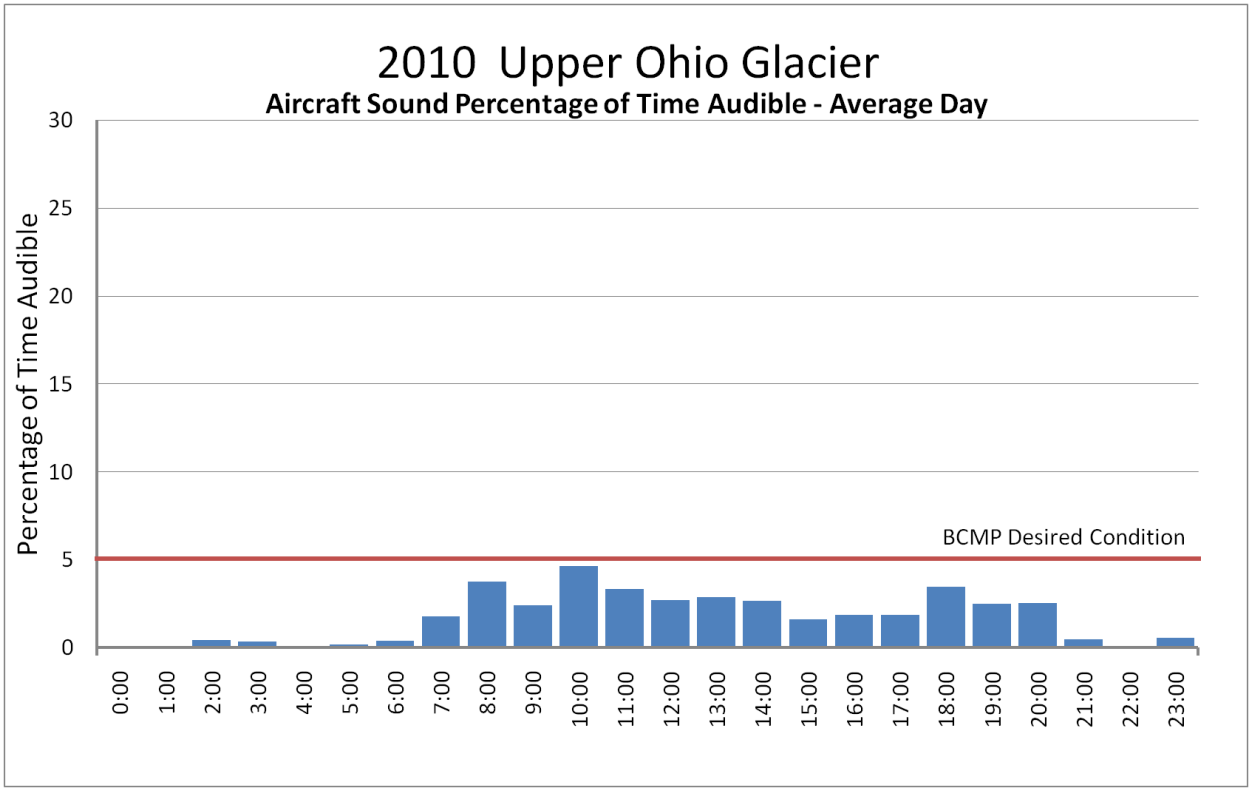


Figure 56. Audibility of aircraft noise for an average day, by hour, at Upper Ohio Glacier.

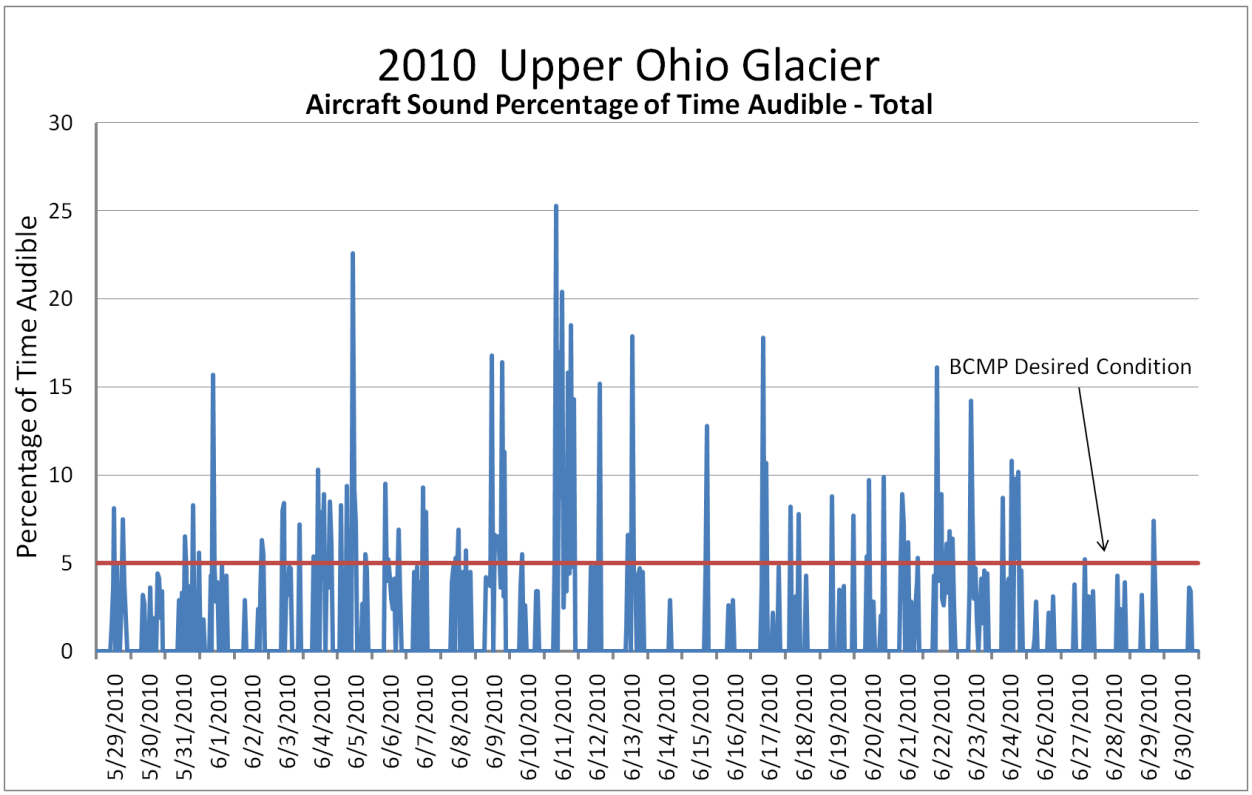


Figure 57. Audibility of aircraft noise at Upper Ohio Glacier.

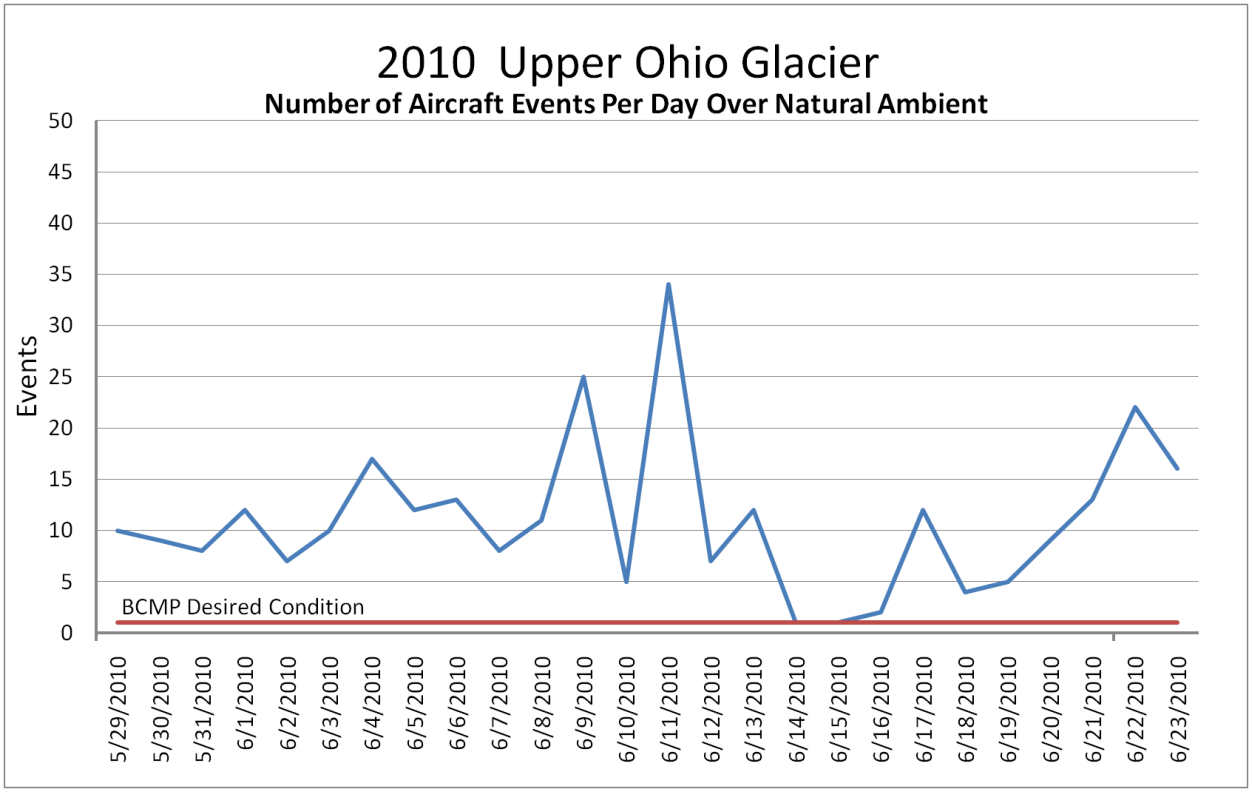


Figure 58. Number of aircraft noise events identified per day at Upper Ohio Glacier.

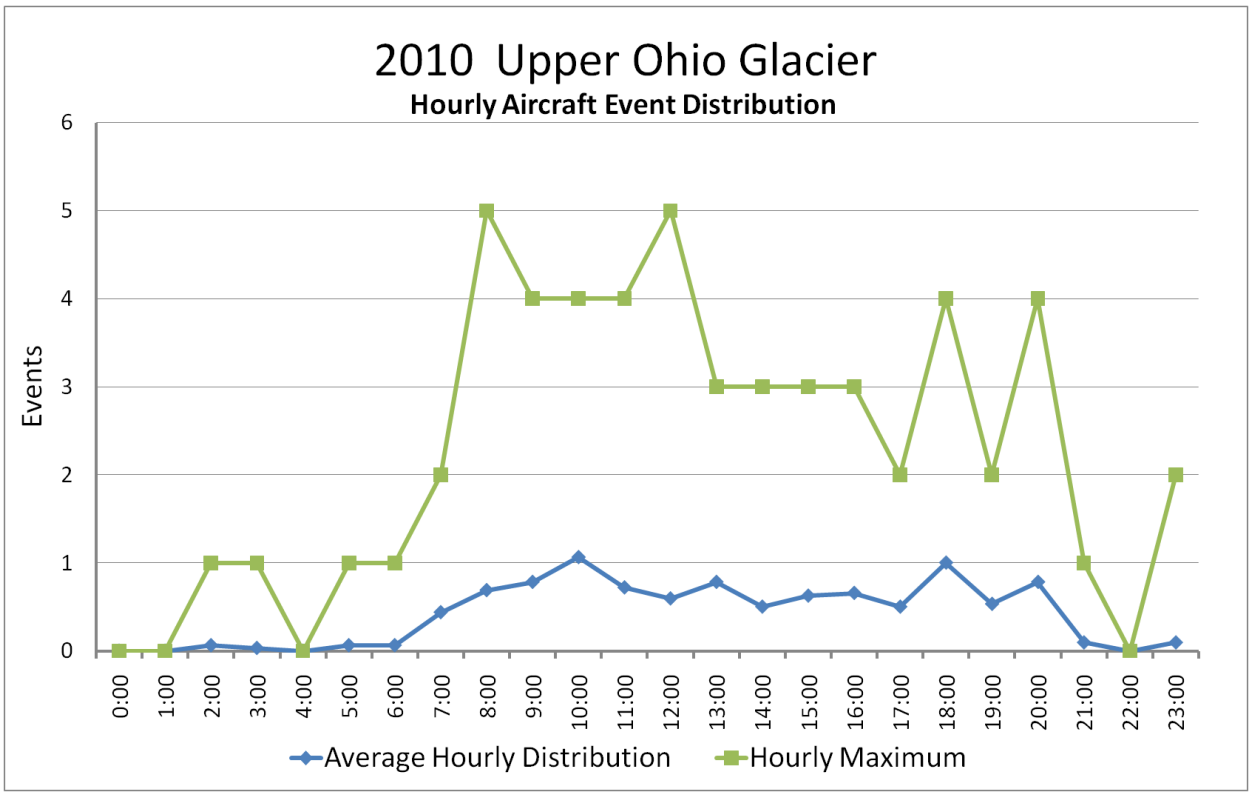


Figure 59. Hourly average and maximum for aircraft events at Upper Ohio Glacier.

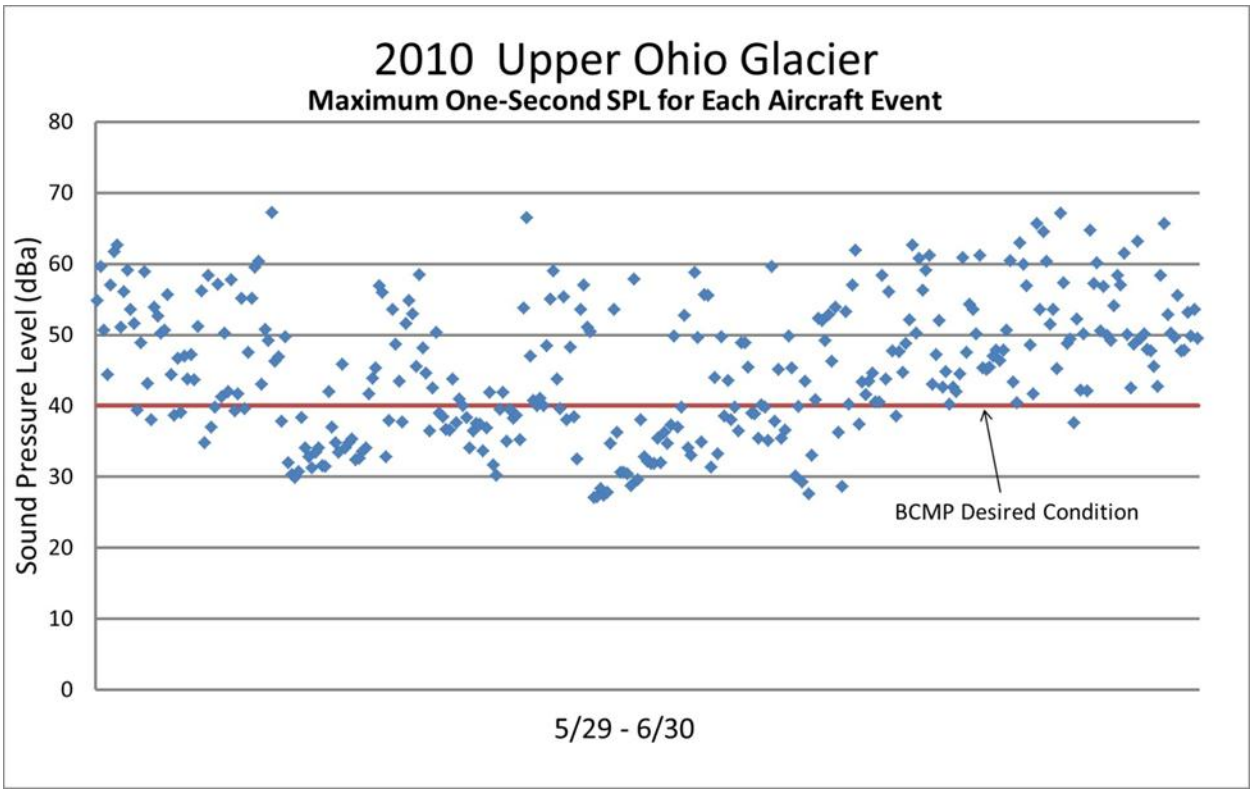
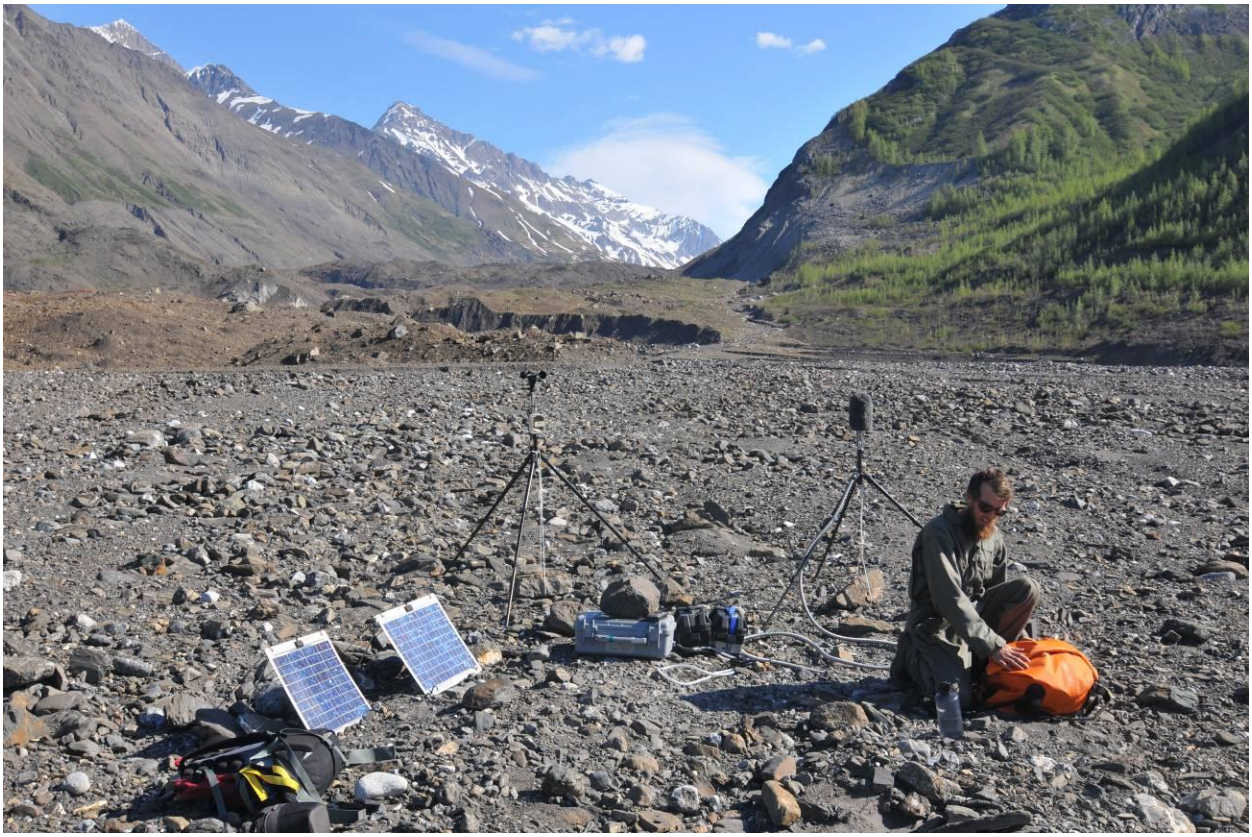


Figure 60. Maximum one-second SPL for each aircraft event identified at Upper Ohio Glacier.

Upper West Fork Yentna River



Location Description: Toe of an un-named glacier, flowing in from the North, to the headwaters of the West Fork of the Yentna River.

Purpose/Project: Location randomly chosen from the LTEM grid as part of the long-term Denali Soundscape inventorying and monitoring sampling plan.

Coordinates: Lat. 62.54351, Long. - 152.47501 Elevation: 343 Meters

Time at Location: 10-June-2010 – 13-July-2010

BCMP Management Zone: Low Park Ecoregion: Lowland Floodplains & Terraces & Fans

Access: Helicopter

Summary: The purpose of the Upper West Fork Yentna River location was to collect acoustic data at one of the long-term ecological monitoring (LTEM) grid points, as outlined in the above sampling plan. LTEM grid point #24 was stratified as a New Park location and randomly selected from all locations requiring aircraft access.

The steady, fast-moving output of water from the glacial toe creates a high-amplitude broadband ambience at this site. The river's masking properties are powerful - making it difficult to hear most sounds. Even wind was challenging to distinguish from the lower roiling frequencies of water at some times.

The most commonly heard sounds at this site were flowing water (audible 99% of the time), wind (59%), and birds (9%). Human made sound was audible 1.1% of the time on average. Conditions exceeded the BCMP percent audible standard 9% of the time and the number of events per day 100% of the time.

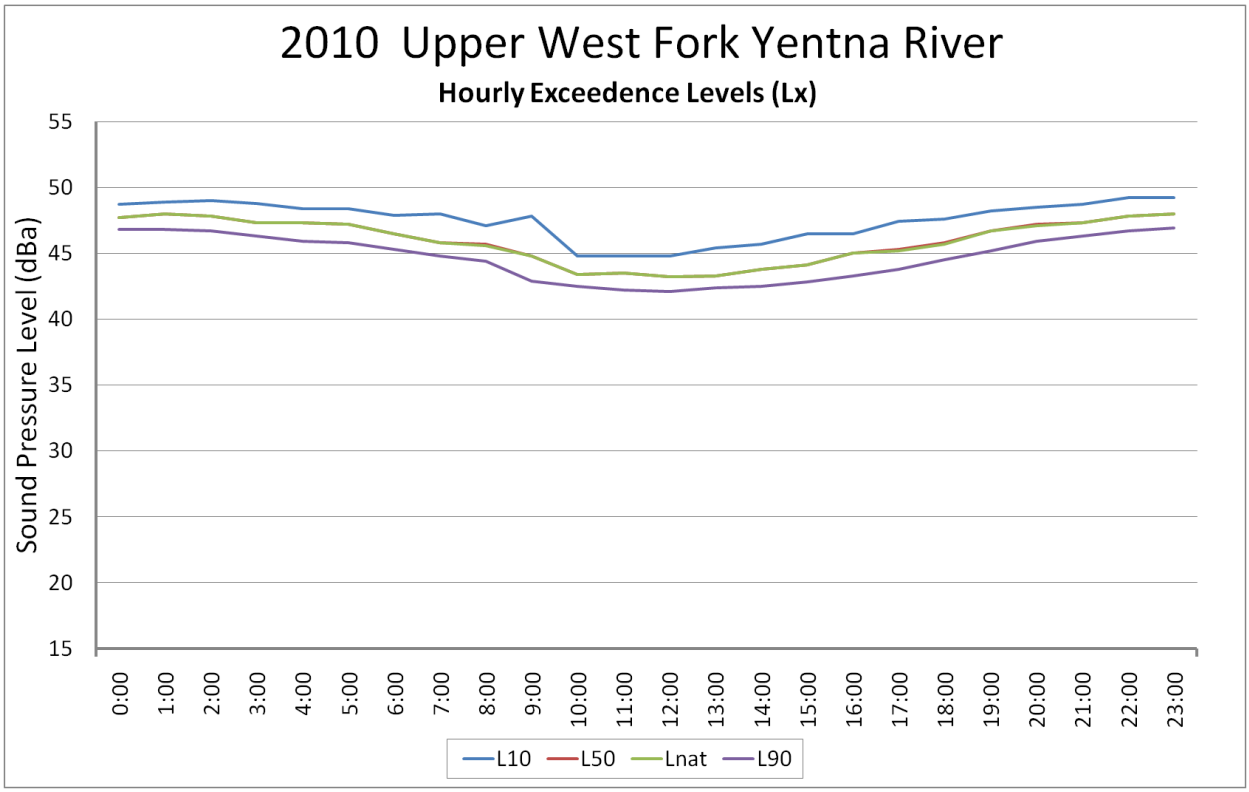


Figure 61. Exceedence levels for Upper West Fork Yentna River.

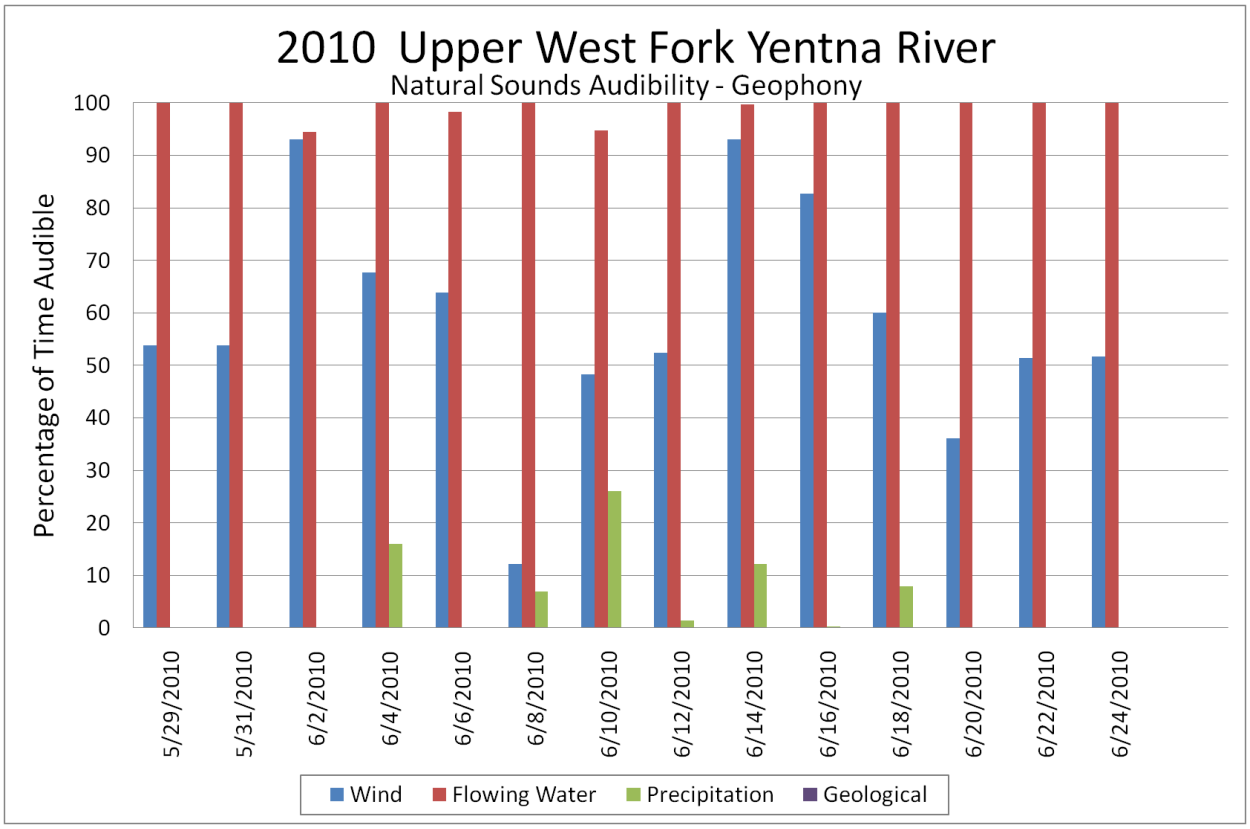


Figure 62. Percentage of time audible for geophonic sounds at Upper West Fork Yentna River.

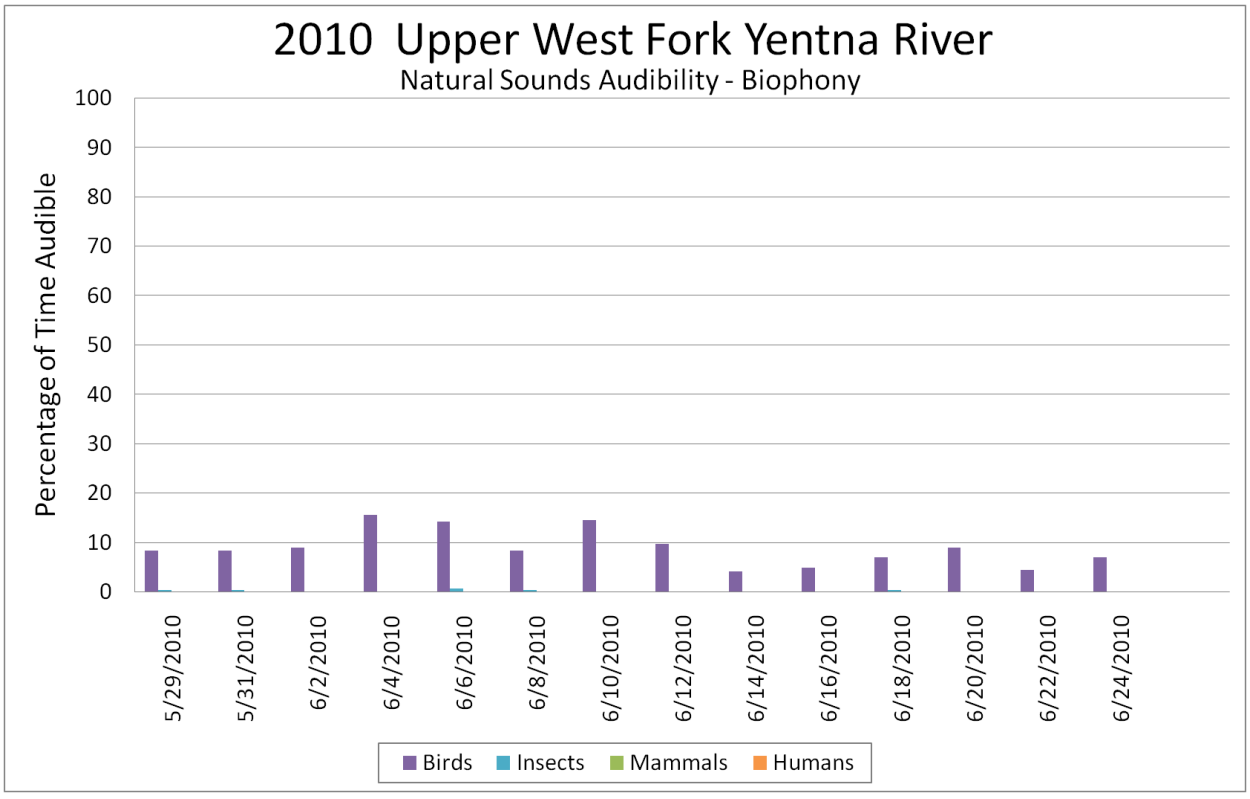


Figure 63. Percentage of time audible for biophonic sounds at Upper West Fork Yentna River.

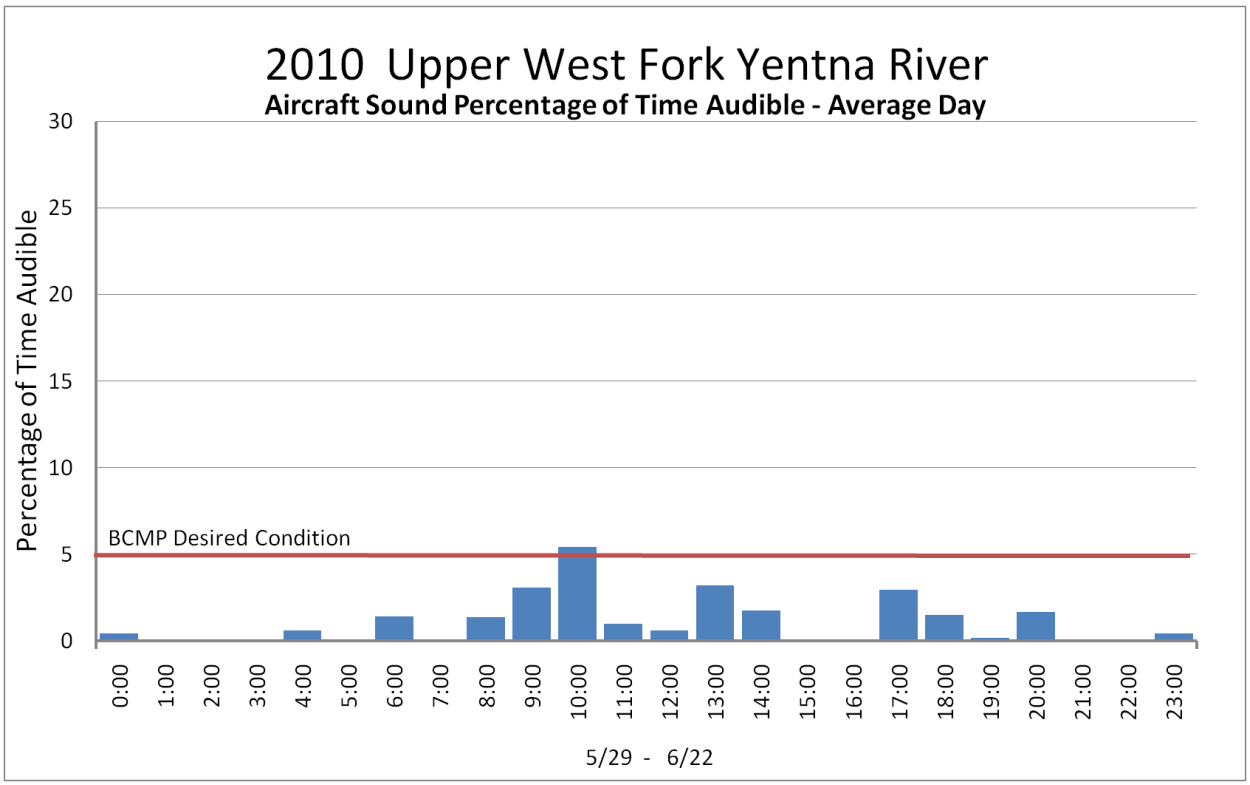


Figure 64. Audibility of aircraft noise for an average day, by hour, at Upper West Fork Yentna River.

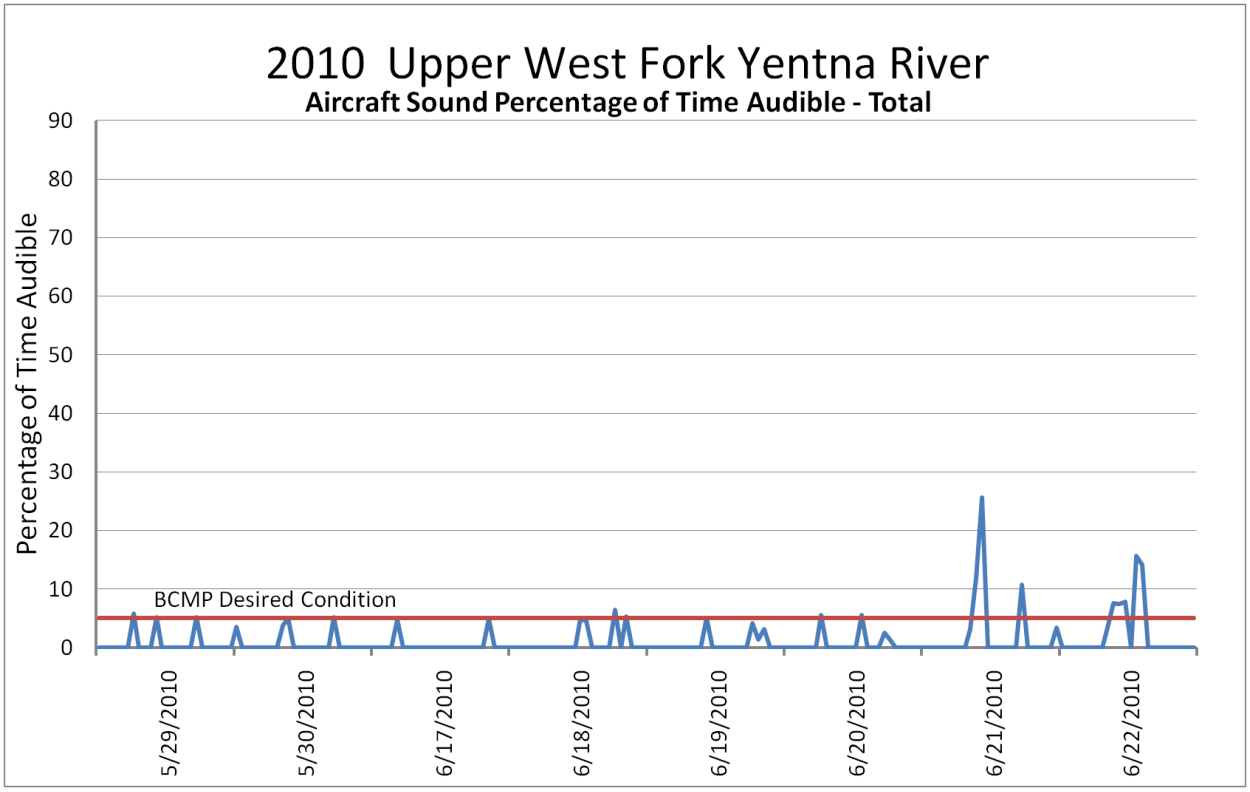


Figure 65. Audibility of aircraft noise at Upper West Fork Yentna River.

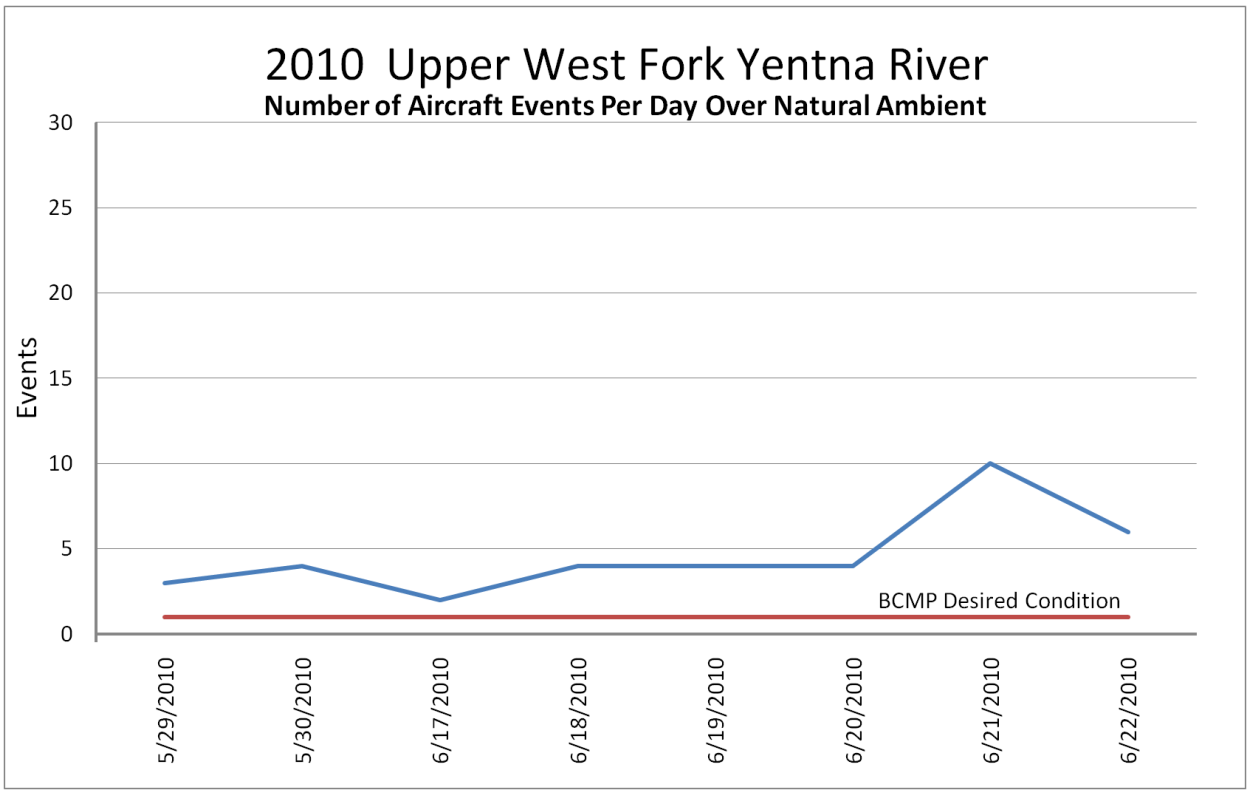


Figure 66. Number of aircraft noise events identified per day at Upper West Fork Yentna River.

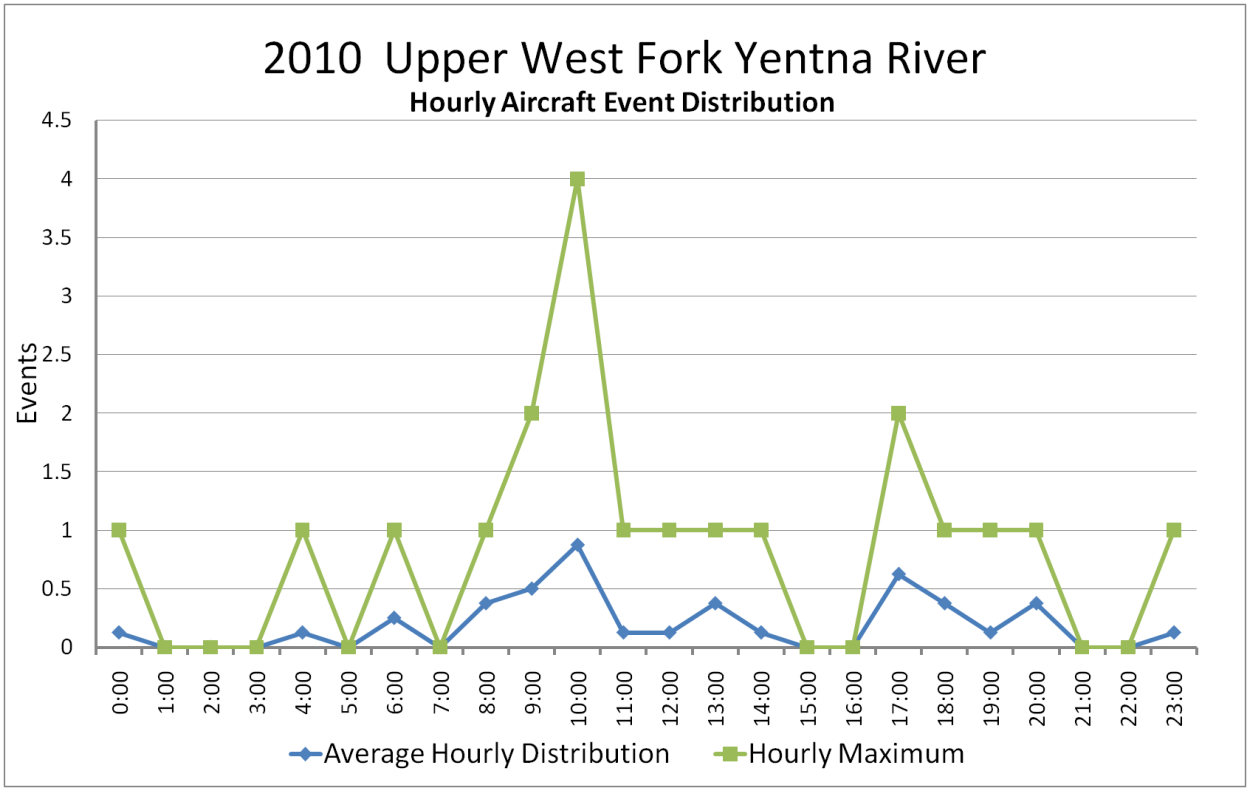


Figure 67. Hourly average and maximum aircraft event distribution at Upper West Fork Yentna River.

West Buttress

Location Description: ~100 meters to the east of 14,000' base camp.

Purpose/Project: Location chosen on the request of the Denali Overflight Advisory Committee to provide an objective measurement of conditions on the upper West Buttress climbing route.

Coordinates: Lat. 63.06929, Long. - 151.07126 Elevation: 4345 Meters

Time at Location: 11-August-2010 – 07-Sept-2010

BCMP Management Zone: Low Park Ecoregion: Nonvegetated Alpine Mountains

Access: Helicopter

Summary: The purpose of the West Buttress location was to collect acoustic data near the 14,000ft base camp on the West Buttress climbing route of Mt. McKinley. This is a busy area where a constant stream of climbers are acclimating, sleeping, climbing technical sections, and recovering during their descent. Park management and the Overflights Advisory Committee members were interested in learning what the acoustic impacts from aircraft overflights were at this location.

The predominant sound of 14,000ft camp is conversation. During the climbing season, days are long and conversations can be heard steadily from 06:00 to 23:00. They vary in quality; from early morning mutterings to roaring comedic tales of adventure. It is not uncommon to hear climbers shouting to their comrades from across 14-Camp or cheering upon the return of

successful groups from the summit. Other sounds of the respiratory tract, especially coughing and nose-blowing, are also frequently heard. In the absence of company sometimes people will whistle.

Another common human sound source is the sound of camp stoves - they are typically running to melt snow into usable water. Sometimes they operate for two or three hours at a time, sometimes for a mere 15 minutes. The sound of a stove is relatively narrow-band but is largely continuous over its duration. It creates a steady masking source that underlays both conversation and stillness. (Poor weather typically dampens conversation, and it is during these days that stoves can be heard operating without conversation.)

Aircraft traffic represents a common iterative sound source in the environment. Both fixed-wing propeller and jet aircraft are well represented. The NPS also maintains an unimproved helipad for the frequent visits from rescue and support helicopters. During wind-free periods, the natural ambient level is quite low and therefore the maximum sound pressure level of an aircraft overflight can seem impressively loud in relative terms.

The most commonly heard sounds at this site were people talking/moving (audible 36% of the time), wind (35%), and campstoves (21%). Human made sound was audible 54.4% of the time on average. Aircraft sound was audible 7.5% of the time on average. Conditions exceeded the BCMP percent audible standard 34% of the time and the number of events per day 100% of the time.

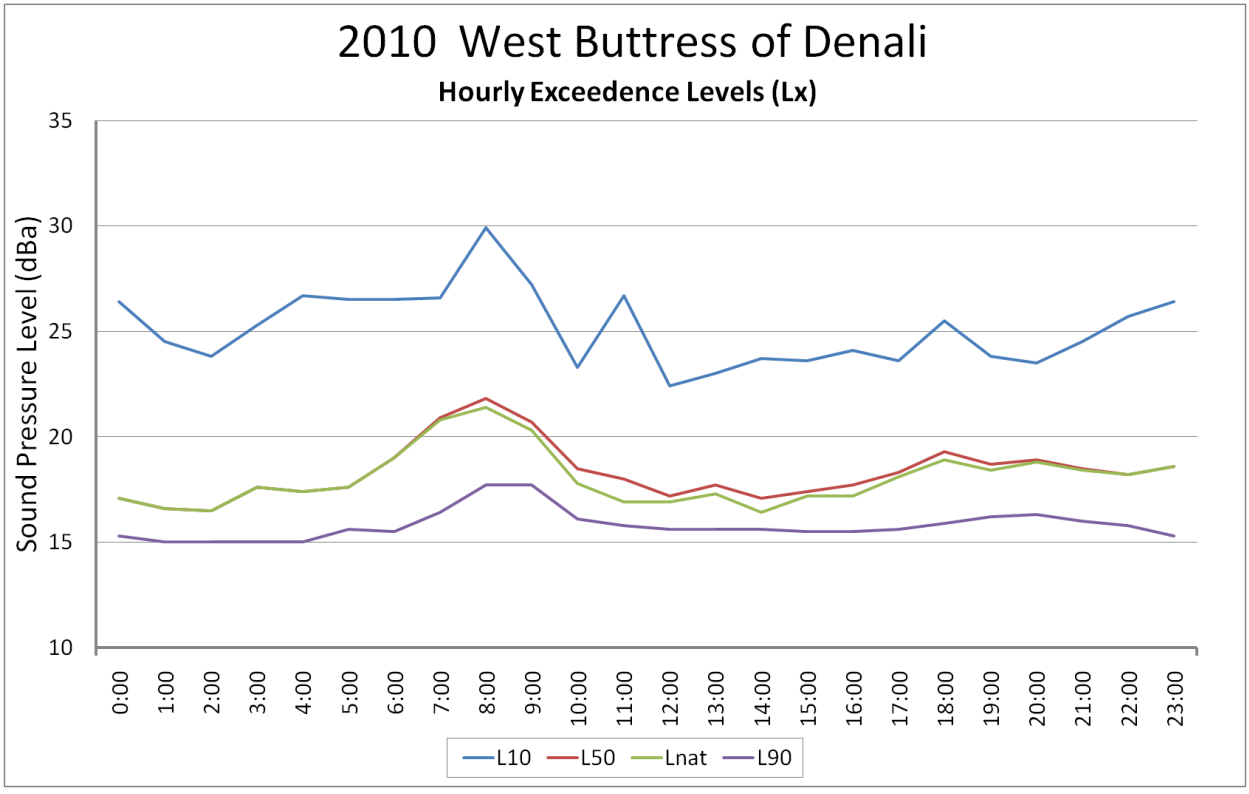


Figure 68. Exceedence levels for West Buttress.

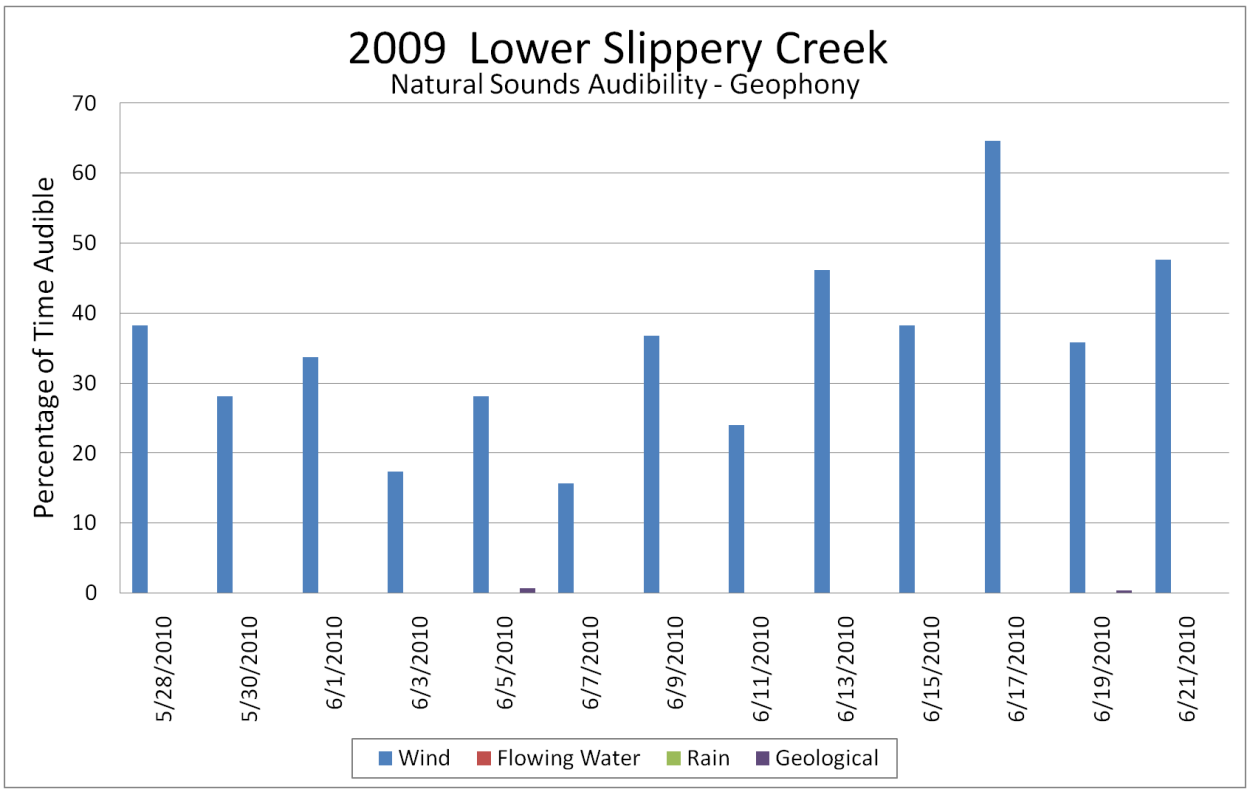


Figure 69. Percentage of time audible for geophonic sounds at West Buttress.

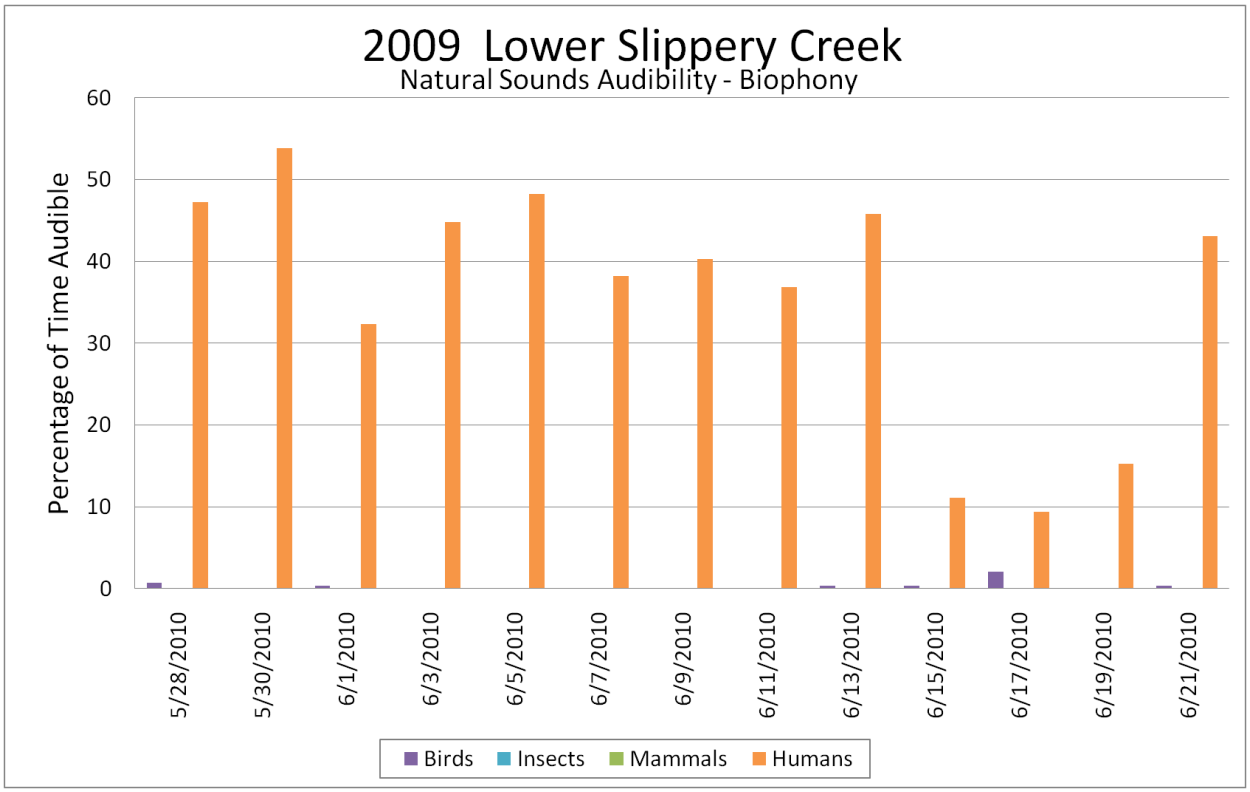


Figure 70. Percentage of time audible for biophonic sounds at West Buttress.

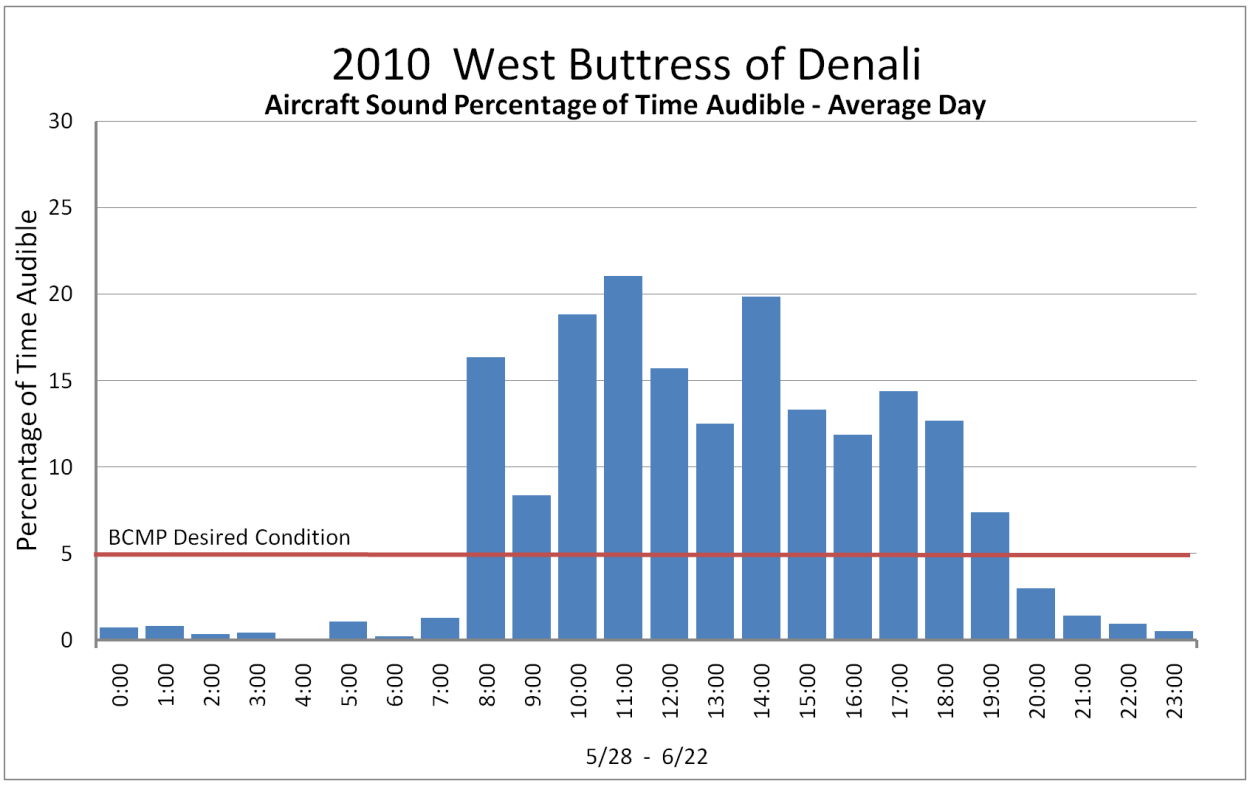


Figure 71. Audibility of aircraft noise for an average day, by hour, at West Buttress.

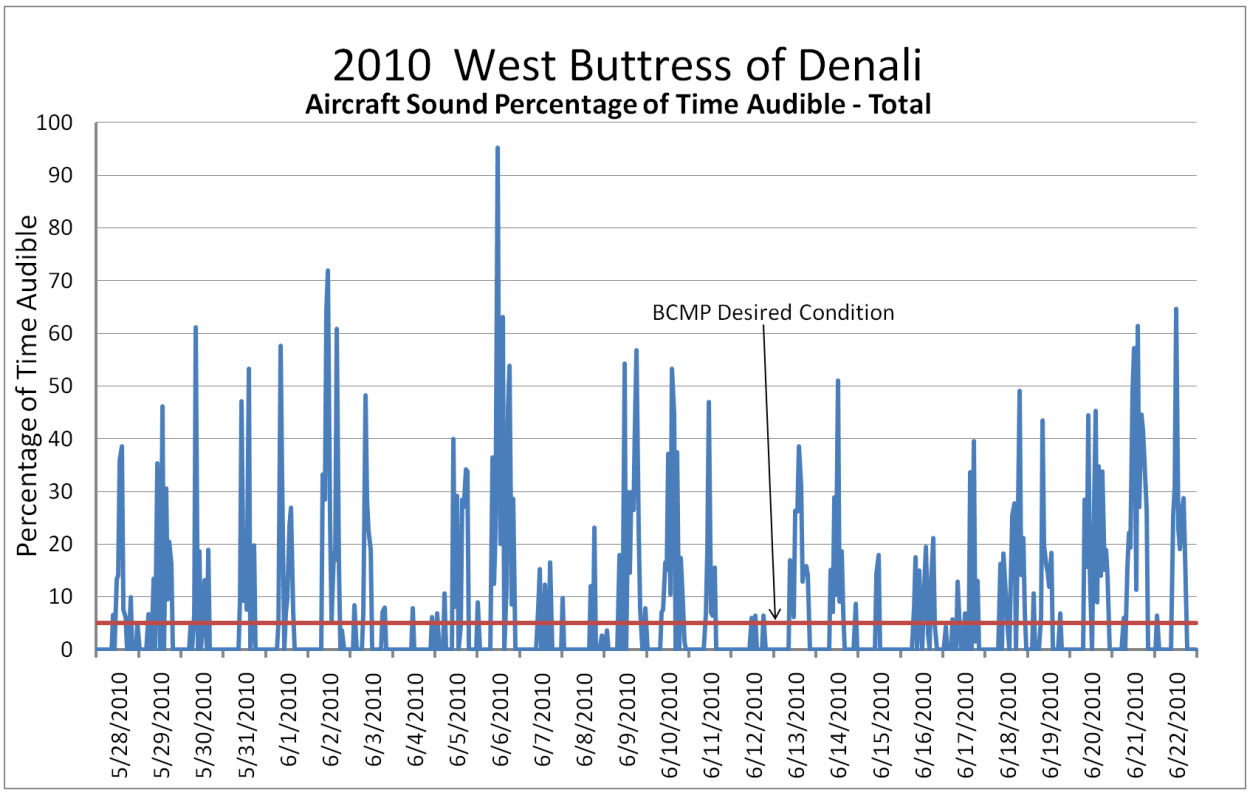


Figure 72. Audibility of aircraft noise at West Buttress.

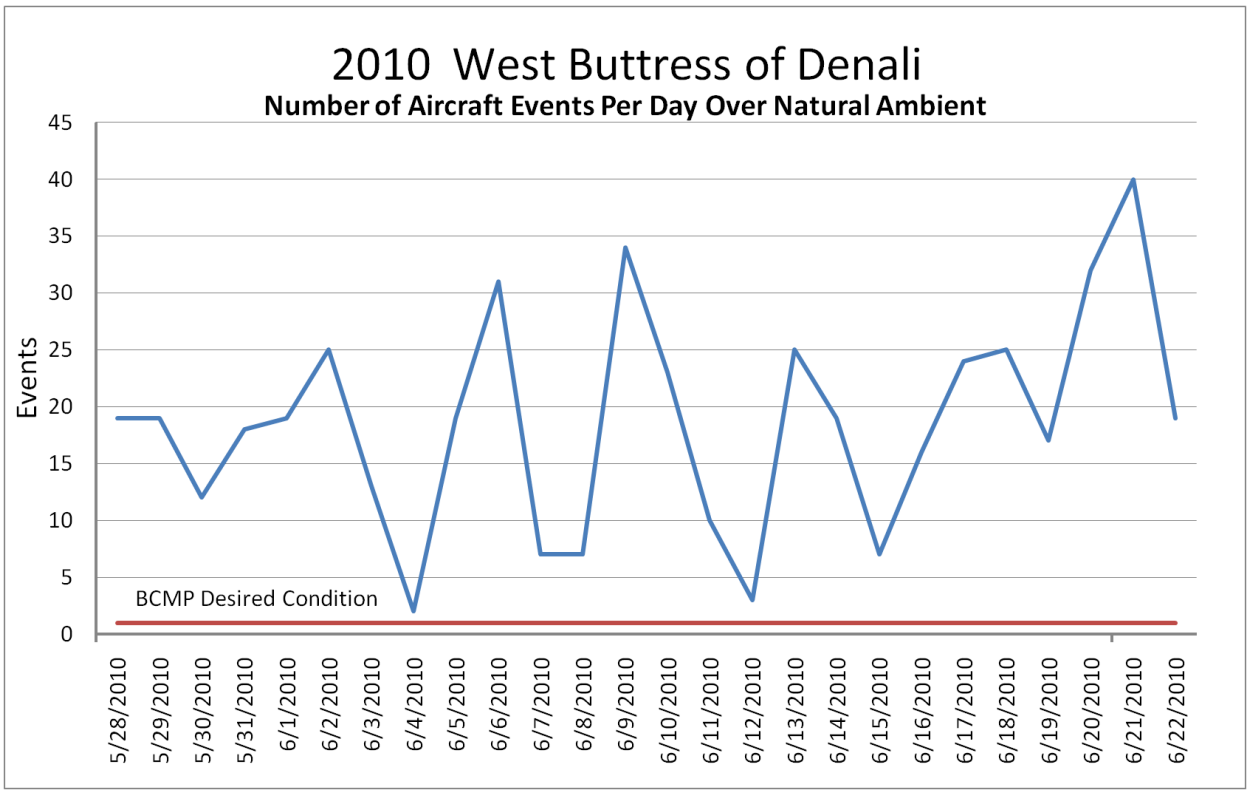


Figure 73. Number of aircraft noise events identified per day at West Buttress.

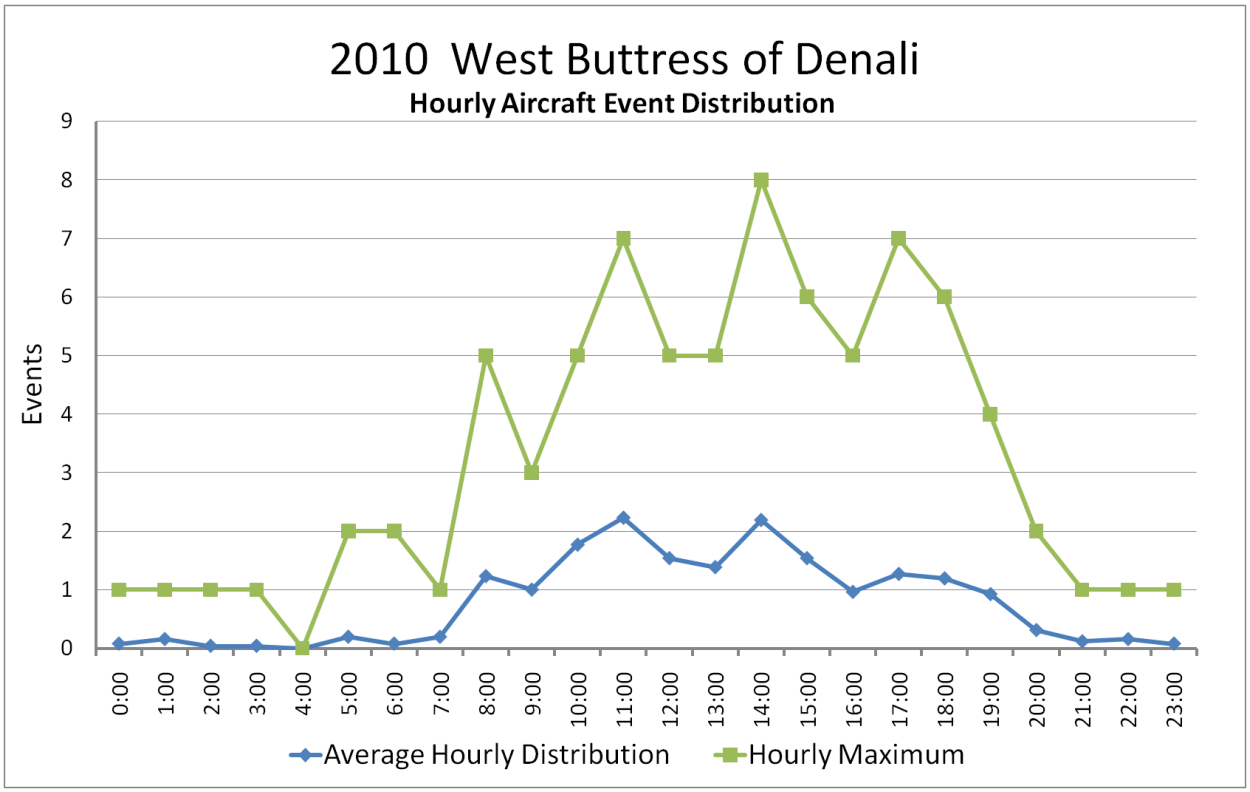


Figure 74. Hourly average and maximum aircraft event distribution at West Buttress.

Conclusion

The goal of the fifth year of the Denali Soundscape Inventory is to measure baseline natural sound conditions and current overflight data at an additional ten sites in Denali National Park and Preserve. It builds on previous work conducted 2001-2009, which collected similar data at other locations.

Acoustic monitoring systems collected detailed records of ambient sound pressure levels. The existing ambient (L_{50}) level is the median sound level, and is the composite of all sounds at a site, both human-caused and natural. Overall, the acoustic conditions of these 2010 sites varied. The Myrtle site experienced the lowest ambient and natural ambient sound levels, as well as relatively low levels of aircraft activity. Of the flights which occurred at Myrtle during the measurement period, the average maximum sound pressure level for an event was the lowest measured thus far in Denali. All sites exhibited some level of exceedence of the Denali Backcountry Management Plan standards as shown in Table 4. These findings have been added to the parkwide backcountry management plan compliance maps which can be found in Appendix B.

Table 4. Percentage of samples exceeding BCMP sound standards.

Site Name	Hourly Motorized Noise Audiblity	Motorized Noise Events/Day	Motorized Max SPL (dBA)
Beaver Lake	21	96	71
Kahiltna Pass	30	100	61
Lower Kantishna River	27	100	44
Myrtle	6	0	23
Tokositna Toe [1]	1	0	4
Upper Dall Glacier	9	67	60
Upper Ohio Glacier	11	93	65
Upper West Fork Yentna	9	100	*
West Buttress	34	100	*

[1] : Winter season site.

*: Collection of SPL data was unsuccessful. This precludes calculation of BCMP Max SPL metrics.

As it stands today, Denali National Park and Preserve has one of the most extensive acoustical monitoring datasets in the National Park system. The data included in this report may be used to inform a Soundscape Management Plan, General Management Plan, Resource Stewardship Strategy, Natural Resource Conditions Assessment, other park plans, or NEPA documents that include soundscapes.

References

American National Standards Institute (ANSI). 1992. Quantities and procedures for description and measurement of environmental sound. Part 2: Measurement of long-term, wide-area sound. Accredited Standards Committee S12, Noise. Acoustical Society of America, New York, NY.

American National Standards Institute (ANSI). 1968. Audiometer Standard 3.6.

Ambrose, S., and S. Burson, S. 2004. Soundscape Studies in National Parks. George Wright Forum 21(1): 29-38

Dunholter, P.A., V. Mestre, R. Harris, and L. Cohn. 1989. Methodology for the measurement of and analysis of aircraft sound levels within national parks. Unpublished report to National Park Service, Contract No. CX 8000-7-0028. Mestre Greve Associates, Newport Beach, CA.

Hults, C. 2005. Denali National Park and Preserve Soundscape Annual Report 2005. National Park Service Internal Document.

Lee, Cynthia, et. al. 2006. Baseline Ambient Sound Levels in Haleakalā National Park. Cambridge, MA: John A. Volpe National Transportation Systems Center Acoustics Facility.

National Park Service. 1916. Organic Act (16 U.S.C 1 2 3 and 4).

National Park Service. 1978. Redwood Act (92 STAT. 163).

National Park Service. 2000. Director's Order #47. Soundscape Preservation and Noise Management.

National Park Service. 2006a. Management Policy 4.9: Soundscape Management.

National Park Service. 2006b. Management Policy 8.2.3: Use of Motorized Equipment.

National Park Service. 2006c. Denali National Park and Preserve Final Backcountry Management Plan, Environmental Impact Statement. National Park Service.

National Park Service. 2008. Haleakalā National Park Acoustic Monitoring Report. Natural Resource Report NPS/NRPC NRTR—2008/001. National Park Service, Fort Collins, CO.

Withers, J. and C. Hults. 2006. Denali National Park and Preserve Soundscape Annual Report 2006. National Park Service Internal Document.

Withers, J. and Betchkal, D. 2010. Denali National Park and Preserve Soundscape Annual Report 2009. National Park Service Internal Document.

Withers, J. 2009. Denali National Park and Preserve Soundscape Annual Report 2008. National Park Service Internal Document.

Withers, J. 2008. Denali National Park and Preserve Soundscape Annual Report 2007. National Park Service Internal Document.

Appendix A. Glossary of Acoustic Terms

Acoustical 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.

Decibel (dB)
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.

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 (Hz)
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.

L_{eq}
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.

L_x
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, L_{50} is the level exceeded 50% of the time (it is also referred to as existing ambient).

L_{nat}
An estimate of what the acoustical 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.

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

Soundscape
Human perception of the acoustical environment.

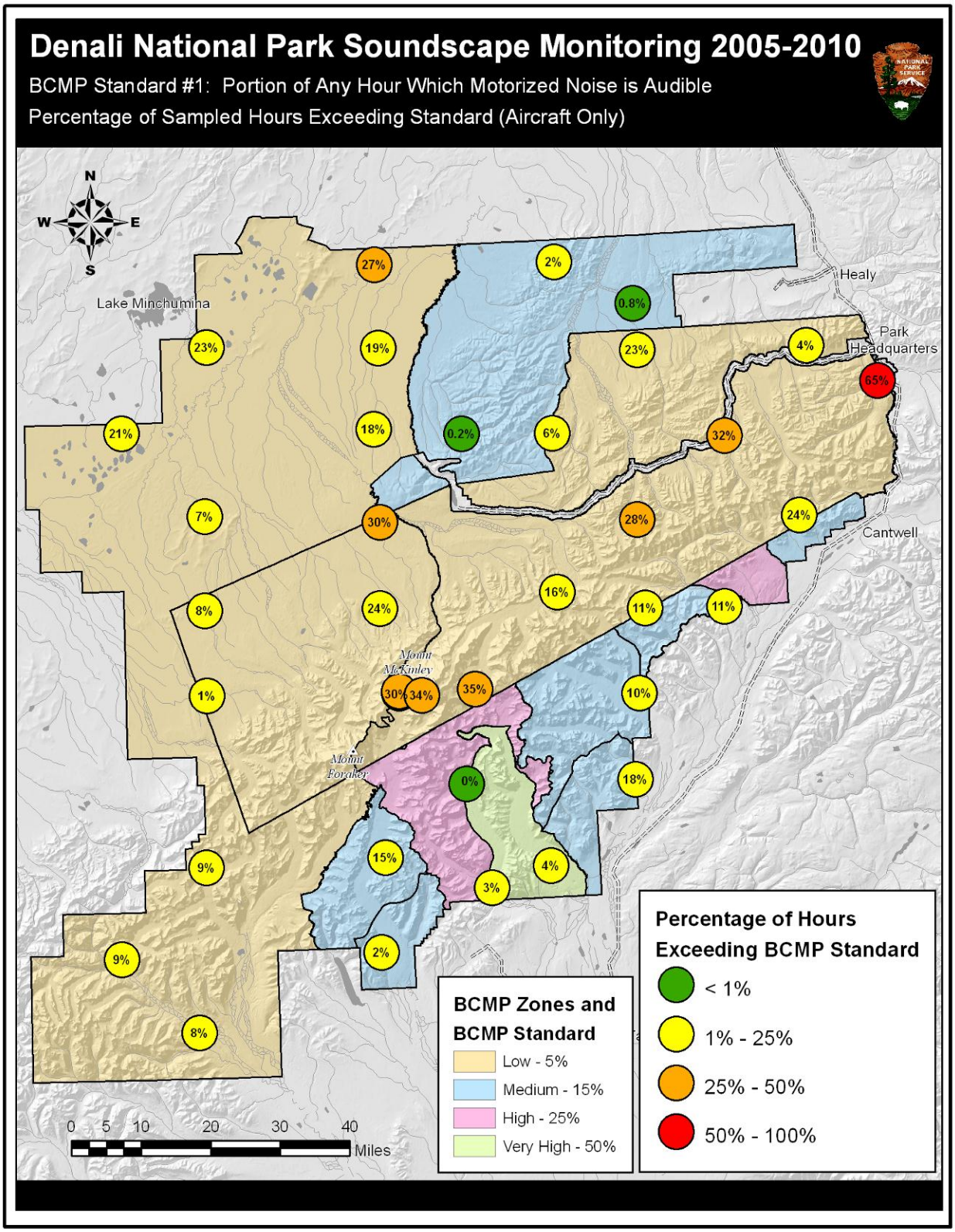
Sound Pressure
The difference between instantaneous pressure and local barometric pressure. Measured in Pascals (Pa), Newtons per square meter, which is the metric equivalent of pounds per square inch.

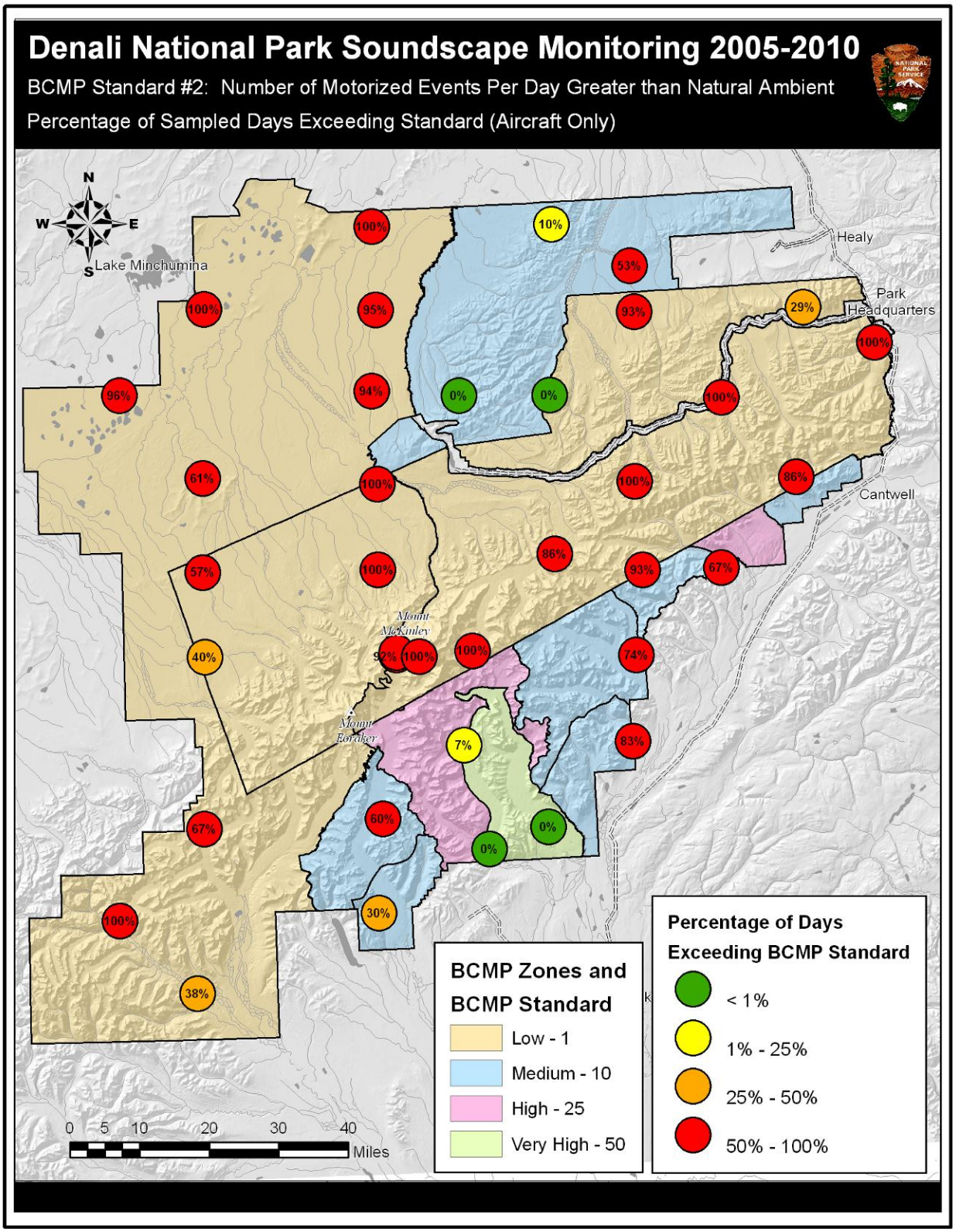
Sound Pressure Level (SPL)
A calibrated measure of sound level, expressed in decibels, and referred to an atmospheric standard of 20 micro Pascals.

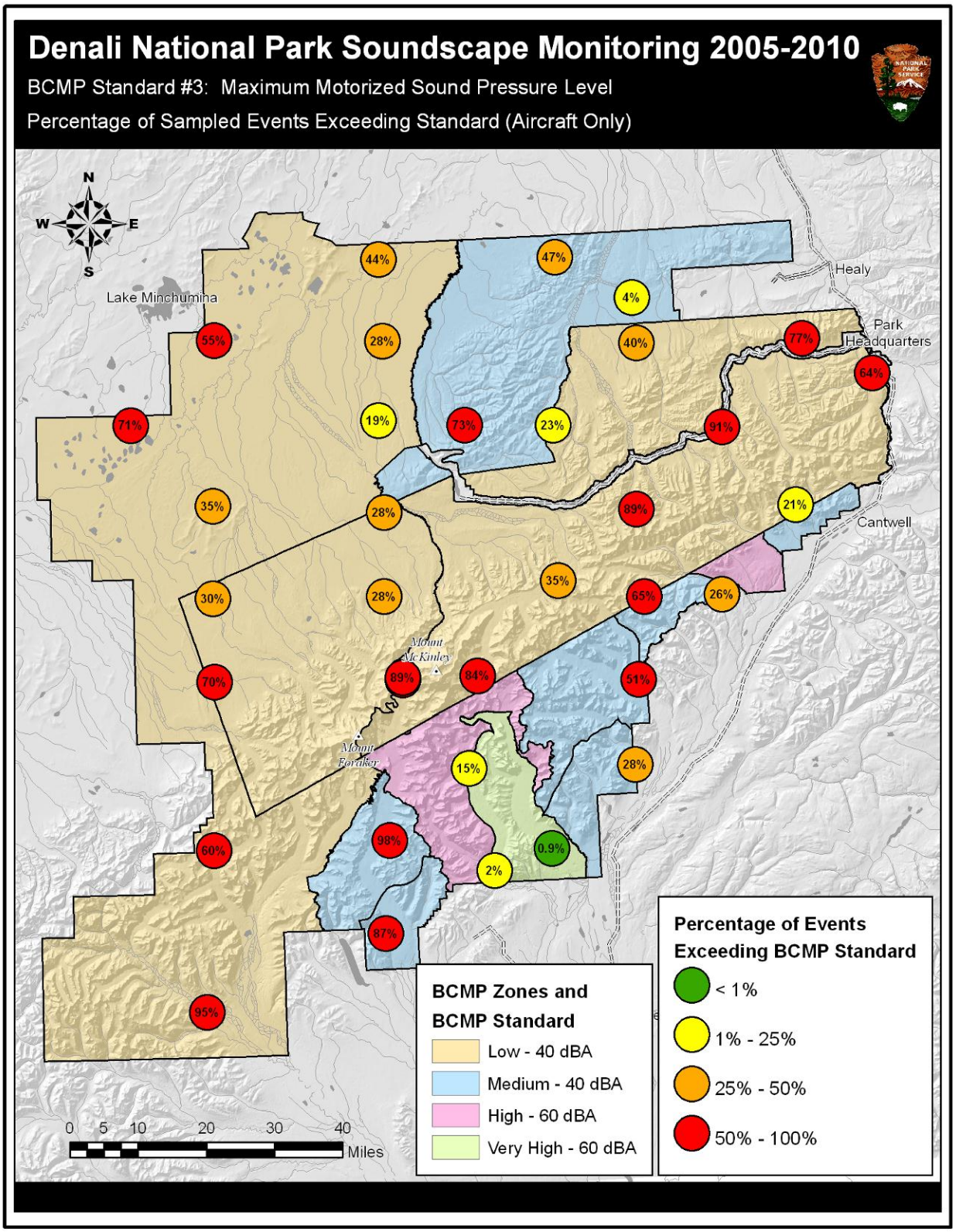
Time Audible
The amount of time that a sound source is audible to a human with normal hearing.

Appendix B. BCMP Exceedence Maps

The following three maps are compiled to provide a parkwide look at the acoustic measurements made to date, and indicate the current level compliance with BCMP acoustic standards. There is one map for each BCMP standard, and each sampling point is annotated with the percentage of time that standard was exceeded during the measurement period. Data from previous years is from Hults 2005, Withers and Hults 2006, and Withers 2009.

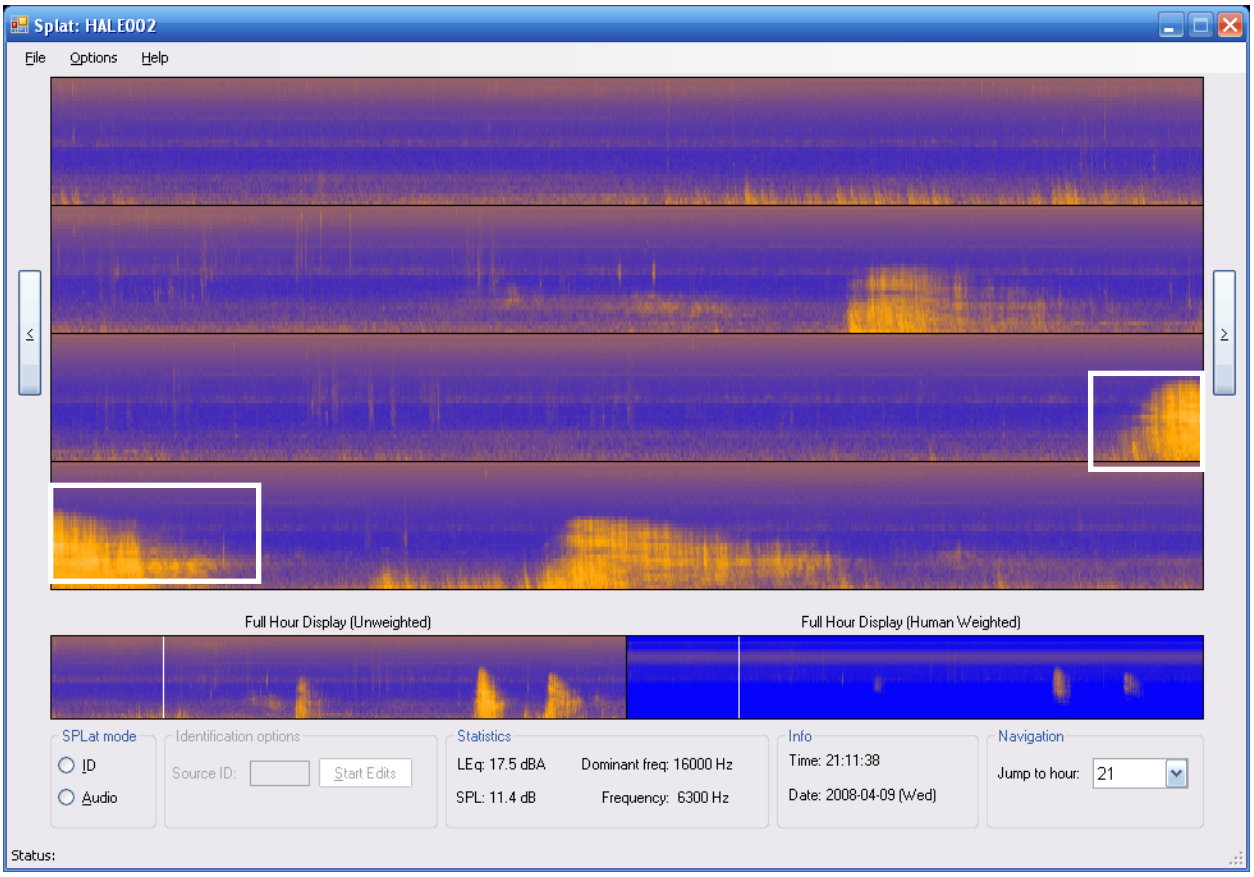

Denali National Park Soundscape Monitoring 2005-2010
BCMP Standard #1: Portion of Any Hour Which Motorized Noise is Audible
Percentage of Sampled Hours Exceeding Standard (Aircraft Only)
N
W
E
S
Lake Minchumina
Healy
Park Headquarters
Cantwell
Mount McKinley
Mount Foraker
27%
2%
0.8%
23%
19%
23%
4%
65%
21%
18%
0.2%
6%
32%
7%
30%
28%
24%
8%
24%
16%
11%
11%
1%
30%
34%
35%
10%
0%
18%
15%
4%
9%
3%
9%
2%
8%
0 5 10 20 30 40
Miles
BCMP Zones and BCMP Standard
Low - 5%
Medium - 15%
High - 25%
Very High - 50%
Percentage of Hours Exceeding BCMP Standard
< 1%
1% - 25%
25% - 50%
50% - 100%


Denali National Park Soundscape Monitoring 2005-2010
BCMP Standard #2: Number of Motorized Events Per Day Greater than Natural Ambient
Percentage of Sampled Days Exceeding Standard (Aircraft Only)
N
W
E
S
Lake Minchumina
Healy
Park Headquarters
Cantwell
Mount McKinley
Mount Foraker
100%
10%
53%
100%
95%
93%
29%
100%
96%
94%
0%
0%
100%
61%
100%
100%
86%
57%
100%
86%
93%
67%
40%
92%
100%
100%
74%
7%
83%
67%
60%
0%
0%
100%
30%
38%
0 5 10 20 30 40
Miles
BCMP Zones and BCMP Standard
Low - 1
Medium - 10
High - 25
Very High - 50
Percentage of Days Exceeding BCMP Standard
< 1%
1% - 25%
25% - 50%
50% - 100%


Denali National Park Soundscape Monitoring 2005-2010
BCMP Standard #3: Maximum Motorized Sound Pressure Level
Percentage of Sampled Events Exceeding Standard (Aircraft Only)
N
W
E
S
Lake Minchumina
Healy
Park Headquarters
Cantwell
Mount McKinley
Mount Foraker
44%
47%
4%
55%
28%
40%
77%
64%
71%
19%
73%
23%
91%
35%
28%
89%
21%
30%
28%
35%
65%
26%
70%
89%
84%
51%
15%
28%
98%
0.9%
2%
60%
87%
95%
0 5 10 20 30 40
Miles
BCMP Zones and BCMP Standard
Low - 40 dBA
Medium - 40 dBA
High - 60 dBA
Very High - 60 dBA
Percentage of Events Exceeding BCMP Standard
< 1%
1% - 25%
25% - 50%
50% - 100%

Appendix C. Analyzing audio with visual tools

Sound pressure levels (SPL) from one hour at an acoustic monitoring site at Haleakala National Park are shown below (Lee, 2006). One hour of SPL data is displayed over four rows. Each row shows SPL values from low frequency (12.5 Hz, bottom of line) to high frequency (20 kHz, top of line). Values are represented with a color scale, where dark blue is quiet and yellow/white is loud. Thus, individual events stand out against the blue background, appearing as yellow areas.



Acoustic events can be visually identified (by drawing a box around the event) and annotated. For each identified event, time, duration, maximum SPL, and spectral information are cataloged. For example, the white boxes above mark the occurrence of a high altitude jet overflight. Two other jet events are also visible.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 184/119672, January 2013

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov