



North Cascades National Park Service Complex

Acoustic Monitoring in Wilderness 2008

Natural Resource Report NPS/NRPC/NRTR—2008/001



ON THE COVER

(Taken from Hannegan Peak Trail, North Cascades National Park Service Complex)
NPS Photo

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Acoustic Monitoring in Wilderness 2008

Natural Resource Report NPS/NRPC/NRTR—2008/001

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Contents

	Page
Contents	iii
Tables	1
Figures.....	1
Executive Summary	2
Study Area	3
Methods.....	8
Results.....	10
Conclusion	16
Literature Cited	16
Appendix A. Glossary of Acoustic Terms.....	17

Tables

	Page
Table 1. Percent time above metrics for three wilderness sites.	2
Table 2. Site locations.....	5
Table 3. Summary of on-site audible sound sources for NOCA004 (High Bridge Trail) n=6.....	10
Table 4. Summary of on-site audible sound sources at NOCA006 (Cascade Pass) n=5.....	11
Table 5. Summary of on-site audible sound sources at NOCA007 (Boundary Camp) n=3.....	12
Table 6. Summary of off-site audible sound sources at NOCA004.	13
Table 7. Summary of off-site audible sound sources at NOCA006.	13
Table 8. Summary of off-site audible sound sources at NOCA007.	13

Figures

Figure 1. NOCA004, High Bridge Trail below Coon Lake.....	5
Figure 2. NOCA006, Cascade Pass on Mix Up Arm Trail near observation platform.	6
Figure 3. NOCA007, Boundary Camp on Copper Ridge Trail.	6
Figure 4. Locations of wilderness acoustic monitoring sites.....	7
Figure 5. Median hourly exceedence metrics at NOCA004 in dBA	14
Figure 6. Median hourly exceedence metrics at NOCA006 in dBA	15
Figure 7. Median hourly exceedence metrics at NOCA007 in dBA.	15

Executive Summary

In the summer of 2008, three acoustic monitoring systems were deployed in wilderness areas of North Cascades National Park Service Complex (NOCA). The purpose of this monitoring effort was to characterize current existing sound levels and estimate natural ambient sound levels in these areas, as well as identify audible sound sources. This data will be used to inform an upcoming wilderness management project.

In determining the current conditions of an acoustic environment, it is important to examine how often sound pressure levels exceed certain thresholds. XTable 1 reports the percent of time that measured levels were above four key thresholds. The first, 35 dBA is designed to address the health effects of sleep interruption. Recent studies suggest that sound events as low as 35 dB can have adverse effects on blood pressure while sleeping (Haralabidis, 2008). The second threshold addresses the World Health Organization's recommendations that noise levels inside bedrooms remain below 45 dBA (Berglund et al., 1999). The third threshold, 52 dBA, is based on the EPA's speech interference threshold for speaking in a raised voice to an audience at 10 meters. This threshold addresses the effects of sound on interpretive presentations in parks. The final threshold, 60 dBA, provides a basis for estimating impacts on normal voice communications at 1 meter. Hikers and visitors viewing scenic vistas in the park would likely be conducting such conversations.

Table 1. Percent time above metrics for three wilderness sites

Site Name	% Exceedence nighttime (7pm - 6:59 am)				% Exceedence daytime (7am - 6:59 pm)			
	35 dBA	45 dBA	53 dBA	60 dBA	35 dBA	45 dBA	53 dBA	60 dBA
High Bridge Trail	98.25	2.17	0.12	0.00	76.22	3.02	0.25	0.00
Cascade Pass	52.82	1.86	0.10	0.00	51.64	1.24	0.28	0.03
Boundary Camp	0.52	0.12	0.01	0.00	1.89	0.13	0.01	0.00

XTable 2 shows results from eight days of off-site listening analysis for each site. Overall, this study found that human-caused sounds are heard relatively infrequently in the NOCA wilderness. However, the natural ambient levels in the park are inherently high due to the presence of flowing water and wind.

Table 2. Mean percent time audible for extrinsic sounds and aircraft sounds

Site Location	Mean % time audible		Median A-Weighted Existing Ambient		Median A-weighted Natural Ambient	
	Extrinsic sounds	Aircraft sounds	Day	Night	Day	Night
High Bridge Trail	12.6	11.7	36.3	36.8	35.8	36.7
Cascade Pass	16.3	15.6	35.1	35.3	34.6	35.2
Boundary Camp	8.4	8.3	29.8	30.2	29.7	30.2

Introduction

A 1998 survey of the American public revealed that 72 percent of respondents thought that providing opportunities to experience natural quiet and the sounds of nature was a very important reason for having national parks, while another 23 percent thought that it was somewhat important (Haas Wakefield 1998). In another survey specific to park visitors, 91 percent of respondents considered enjoyment of natural quiet and the sounds of nature as compelling reasons for visiting national parks (McDonald et. al 1995). Acoustic monitoring provides a scientific basis for assessing the current status of acoustic resources, identifying trends in resource conditions, quantifying impacts from other actions, assessing consistency with park management objectives and standards, and informing management decisions regarding desired future conditions.

National Park Service Natural Sounds Program

The NPS Natural Sounds Program (NSP) Office was established in 2000 to help parks manage sounds in a way that balances access to the park with the expectations of park visitors and the protection of park resources. The NSP addresses acoustical issues raised by Congress, NPS Management Policies, and NPS Directors Orders. An important element of this mission is working with the Federal Aviation Administration (FAA) to implement the National Parks Air Tour Management Act. Congress mandated that FAA and NPS jointly develop Air Tour Management Plans (ATMPs) for more than 106 parks where commercial air tours operate. The program also provides technical assistance to parks in the form of acoustic monitoring, data processing, park planning support, and comparative analyses of acoustic environments throughout the national park system.

Soundscape Planning Authorities

The National Park Service 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." 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."

Direction for management of natural soundscapes¹ 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

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.

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 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).

Study Area

Three acoustic monitoring stations were deployed in the summer of 2008. These sites were selected because they represent many of the vegetation zones in the park and span different elevations.

Table 3. Site locations

Site	Site Name	Vegetation	Elevation (m)	Latitude	Longitude
NOCA004	High Bridge Trail	Douglas Fir	396	48.3829	-120.83544
NOCA006	Cascade Pass	Subalpine	1677	48.46709	-121.05992
NOCA007	Boundary Camp	Silver Fir	1434	48.89004	-121.52149



Figure 1. NOCA004, High Bridge Trail below Coon Lake.



Figure 2. NOCA006, Cascade Pass on Mix Up Arm Trail near observation platform.



Figure 3. NOCA007, Boundary Camp on Copper Ridge Trail.



Acoustic Monitoring Sites

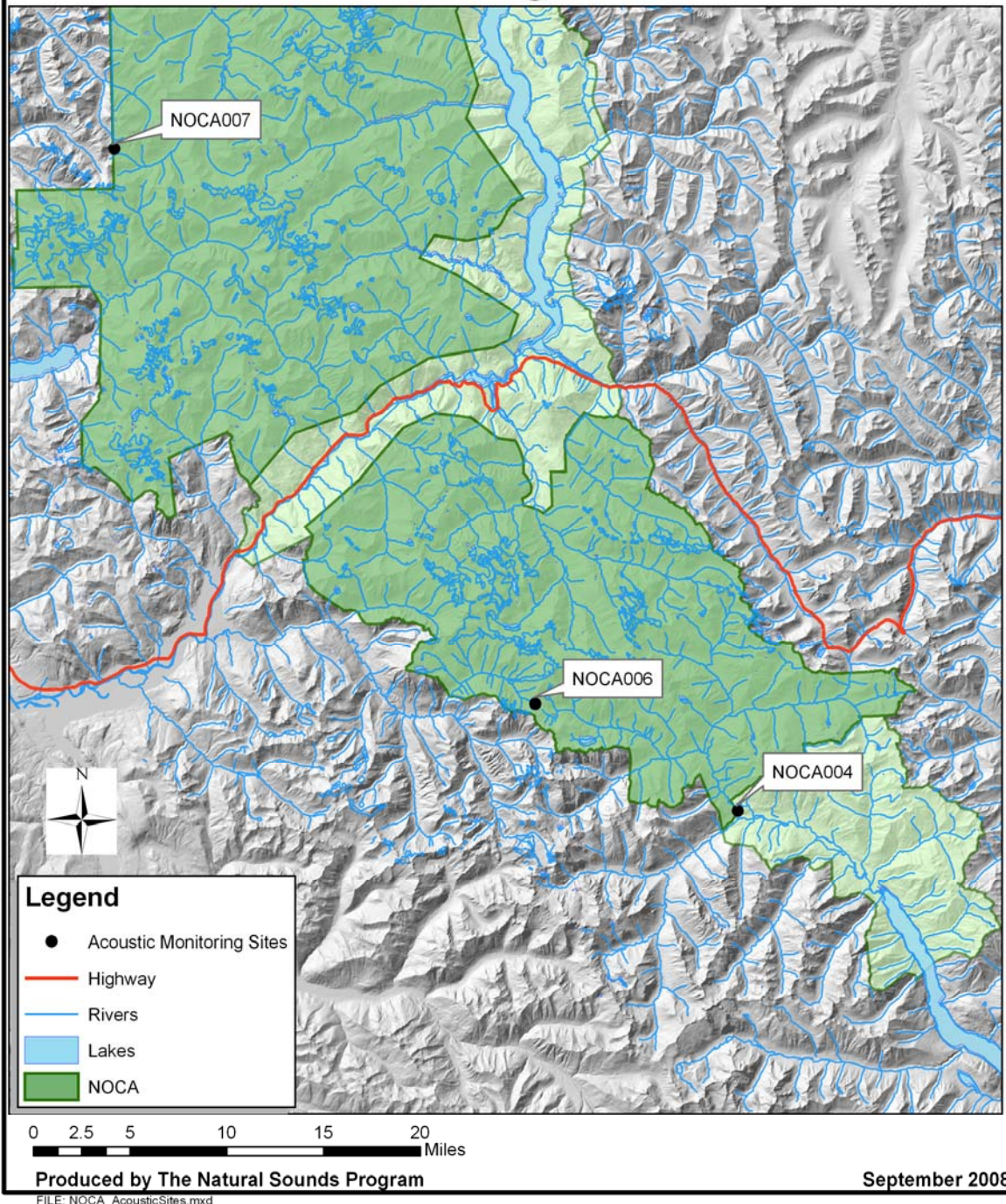


Figure 4. Locations of wilderness acoustic monitoring sites.

Methods

Automatic Monitoring

Larson Davis 831 sound level meters (SLM) were employed over the thirty day monitoring periods at NOCA. 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
- Ten 12 V lantern cell batteries
- Anemometer
- MP3 recorder
- 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

Off-Site Listening

For each day of monitoring, Natural Sounds Program (NSP) staff visually analyzed a subset of SPL samples (eight days) in order to identify durations of audible sound sources. Audio samples were employed to confirm identification. The total percent time extrinsic sounds were audible was then used to calculate the natural ambient sound level for each hour. Bose Quiet Comfort Noise Canceling headphones were used for off-site audio playback to minimize limitations imposed by the office acoustic environment.

On-Site Listening

On-site listening is the practice of placing an observer near the acoustic monitoring station with a handheld PDA. 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 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 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 during sound-level data collection at NOCA. As recommended by NSP protocol (NPS

2005), 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 Personal Digital Assistant (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.

Calculation of Metrics

The current status of the acoustic environment can be characterized by spectral measurements, durations, and overall sound levels (intensities). The NSP uses descriptive figures and metrics to interpret these characteristics. Two fundamental descriptors are existing and natural ambient sound levels. Existing ambient (L_{50}) is characterized by spectra (in dB) drawn from uncensored data, and encompasses all sound sources. Natural ambient (L_{nat}) is an estimate that attempts to remove the sound energy attributed to all extrinsic or anthropogenic noises from the existing ambient.

To calculate L_{nat} , the NSP does the following:

- Calculate the percentage of all samples containing extrinsic sounds for each hour of the day (P_H).
- Use P_H to complete this formula for every hour: $x = \frac{1 - P_H}{2} + P_H$
- Example: if extrinsic sounds are audible 50% of the time ($P_H = 0.5$), then x_H is 0.75.
- Enter hourly x_H values into a database of all octave band information.
- Exclude SPL samples with local measured wind speed over 5 m/s.
- Compute L_{nat} (the sound level that is exceeded 100* x_H percent of the time).

To see the results of these calculations, please see XFigure 5, XFigure 6, and XFigure 7 in the results section.

Results

Onsite Listening

XTable 4, XTable 5, and XTable 6 below display the 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, reports the maximum event length among the sessions for each sound source. Likewise, mean event and min event columns report the mean and minimum length of events. SD reports the standard deviation among event lengths, and count reports the number of times that each sound source was audible. 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 this location.

Table 4. Summary of on-site audible sound sources for NOCA004 (High Bridge Trail) n=6.

Sound Source	PA	Max	Mean Event	Min Event	SD Event	Count
Flowing Water	99	3,599	1,529	48	1,438	14
Bird	96	3,598	765	1	1,178	27
Wind	48	1,738	215	12	351	48
Jet	20	453	103	14	82	42
Insect	5	122	26	1	34	43
Aircraft	2	153	41	4	47	9
Chipmunk	1	113	113	113	1	
People, Walking	0	65	65	65	1	
Amphibian	0	15	6	3	6	4
Motor	0	12	7	2	7	2
Natural Other	0	6	4	1	3	3
Animal (Natural)	0	9	9	9	1	
Natural Unknown	0	2	2	2	0	3
All Aircraft	21.5					
All Non-natural Sources	21.9					
All Natural Sources	99.9					
Noise Free Interval		1,078	296	6	278	57

Table 5. Summary of on-site audible sound sources at NOCA006 (Cascade Pass) n=5.

Sound Source	PA	Max	Mean Event	Min Event	SD Event	Count
Rain/Fog Drip	94	3,560	1,256	42	1,171	11
Wind	77	3,594	666	1	933	17
Flowing Water	58	3,534	2,153	287	1,428	4
Bird	18	344	54	0	63	50
Mammal	15	535	52	1	91	44
Jet	13	252	110	19	70	18
People, Walking	4	127	78	26	42	7
People, Voices	4	81	31	8	21	17
Thunder	2	94	74	49	23	3
Insect	0	13	5	1	4	14
Non-natural Unknown	0	71	71	71	1	
Avalanche / Rockslide	0	12	12	12	1	
All Aircraft	13.4					
All Non-natural Sources	19.2					
All Natural Sources	99.6					
Noise Free Interval		1,809	340	2	421	35

Table 6. Summary of on-site audible sound sources at NOCA007 (Boundary Camp) n=3.

Sound Source	PA	Max	Mean Event	Min Event	SD Event	Count
Flowing Water	100	3,598	2,696	365	1,563	4
Bird	94	3,599	778	18	1,137	13
Insect	12	263	55	1	68	23
Jet	9	199	102	11	63	10
Mammal	7	238	101	19	95	7
Squirrel	3	171	27	3	53	11
Wind	1	91	53	28	34	3
People, Walking	1	156	156	156	1	
People, Voices	0	11	11	11	1	
Avalanche / Rockslide	0	6	6	6	1	
Amphibian	0	1	1	1	1	
All Aircraft	9.4					
All Non-natural Sources	10.9					
All Natural Sources	99.9					
Noise Free Interval		1,241	741	10	448	13

Off-Site Listening

Audibility

XTable 7, XTable 8, and XTable 9 show the percent time that certain sound sources were audible based on eight days of visual analysis. Military jets were audible at all sites, but infrequently. Overall, aircraft were most frequently heard at NOCA006, Cascade Pass. The only audible extrinsic noise sources besides aircraft were people walking or talking.

Table 7. Summary of off-site audible sound sources at NOCA004.

Sound Source	24 h	07-18h	19h-06h	08-15h	16-07h	Events
Jet	7.8	10.9	4.7	13.3	5.1	32.9
Military Jet	0.3	0.5	0.0	0.8	0.0	1.0
Propeller	3.7	6.2	1.2	6.5	2.3	14.9
Helicopter	1.1	2.1	0.0	0.0	1.6	2.0
Voices	1.5	2.8	0.2	3.6	0.4	5.3
Total Aircraft	11.7	17.4	5.9	19.8	7.6	48.1
Total People	1.5	2.8	0.2	3.6	0.4	5.3
Total Non-Natural	12.6	19.2	6.0	22.2	7.8	52.1

Table 8. Summary of off-site audible sound sources at NOCA006.

Sound Source	24 h	07-18h	19h-06h	08-15h	16-07h	Events
Jet	11.9	18.3	5.5	22.9	6.4	43.4
Military Jet	0.1	0.2	0.0	0.3	0.0	1.0
Propeller	3.7	5.8	1.6	6.7	2.2	13.0
Helicopter	0.5	0.9	0.0	0.0	0.7	2.0
Voices	1.1	2.1	0.0	2.2	0.5	3.8
Footsteps	0.3	0.6	0.0	0.9	0.0	2.0
Total Aircraft	15.6	24.2	7.1	29.4	8.7	56.8
Total People	1.1	2.1	0.0	2.2	0.5	4.2
Total Non-Natural	16.3	25.4	7.1	30.7	9.1	59.9

Table 9. Summary of off-site audible sound sources at NOCA007.

Sound Source	24 h	07-18h	19h-06h	08-15h	16-07h	Events
Jet	6.7	9.1	4.5	11.0	4.6	25.1
Military Jet	0.1	0.0	0.2	0.0	0.1	1.0
Propeller	1.6	2.4	0.8	2.7	1.1	5.4
Voices	0.3	0.6	0.0	0.8	0.0	1.0
Total Aircraft	8.3	11.4	5.2	13.6	5.7	30.6
Total People	0.3	0.6	0.0	0.8	0.0	1.0
Total Non-Natural	8.4	11.6	5.2	13.9	5.7	31.0

Metrics

In order to determine the effect extrinsic noise audibility has on the acoustic environment, it is useful to examine the median hourly exceedence metrics. XFigure 5, XFigure 6, and XFigure 7 show existing ambient levels and natural ambient levels. The existing ambient (or median) level for each hour is marked by the upper limit of the gray boxes while natural ambient levels (L_{nat}) are marked by the lower limit of the gray boxes. The height of the 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 30 day monitoring periods. As is evident in the figures, human caused sounds raise the natural ambient levels more during the daytime hours than at night. However, even when the contribution of human-caused sounds is removed to produce ambient levels at these backcountry locations, the natural ambient levels are relatively high. The onsite listening results (see XTable 4, XTable 5, and XTable 6) provide a clue for why this might be. Flowing water and wind are frequently audible. Their presence is the likely cause for high natural ambient levels.

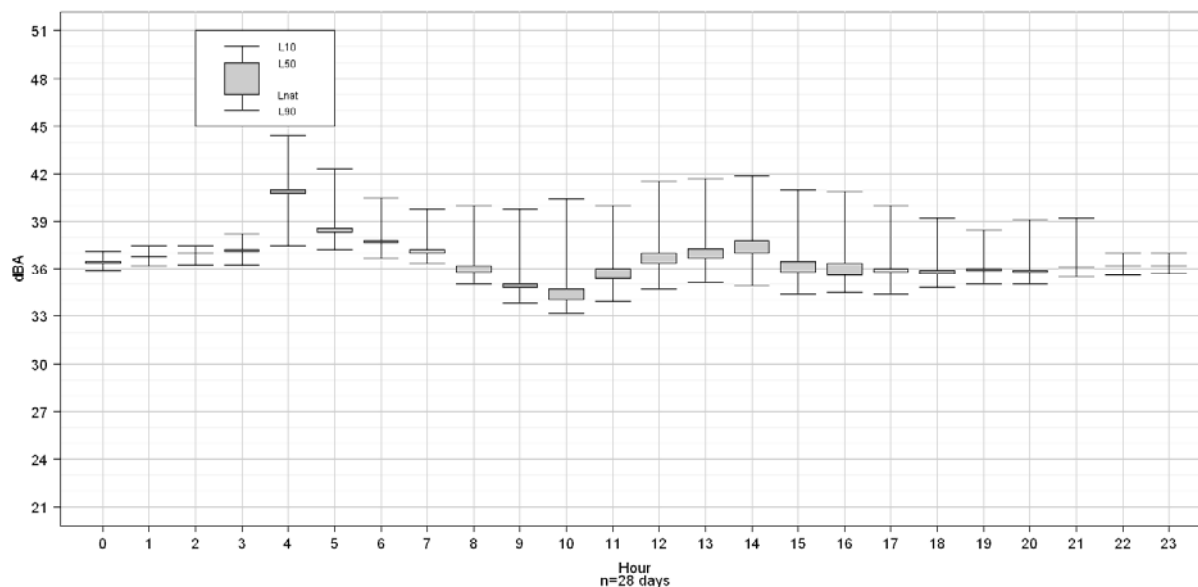


Figure 5. Median hourly exceedence metrics at NOCA004 in dBA

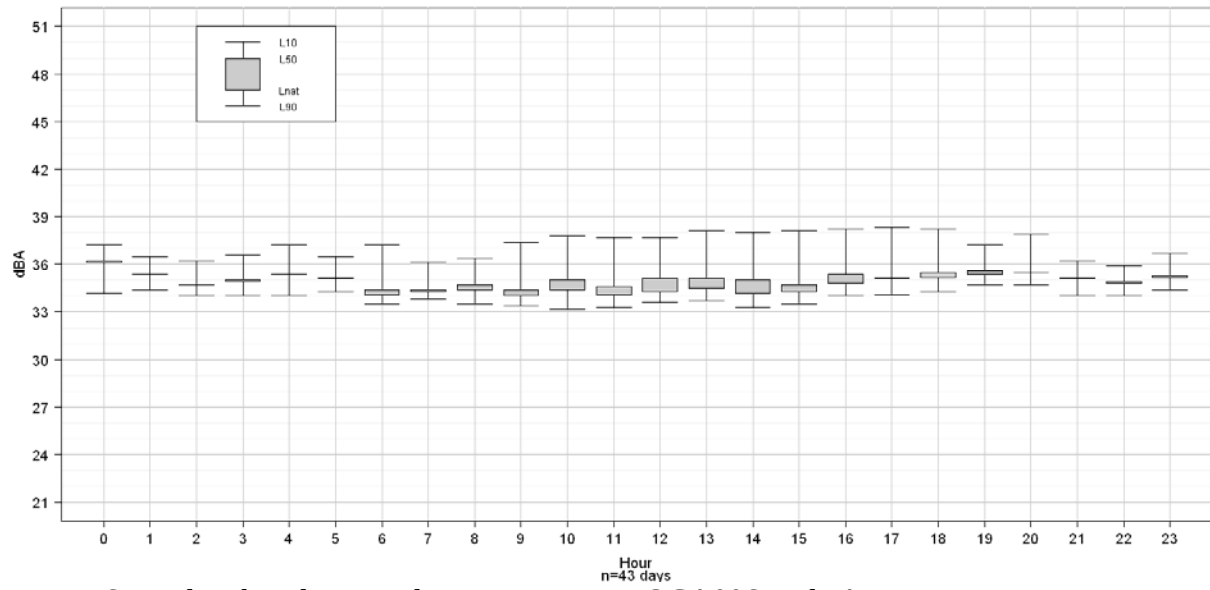


Figure 6. Median hourly exceedence metrics at NOCA006 in dBA

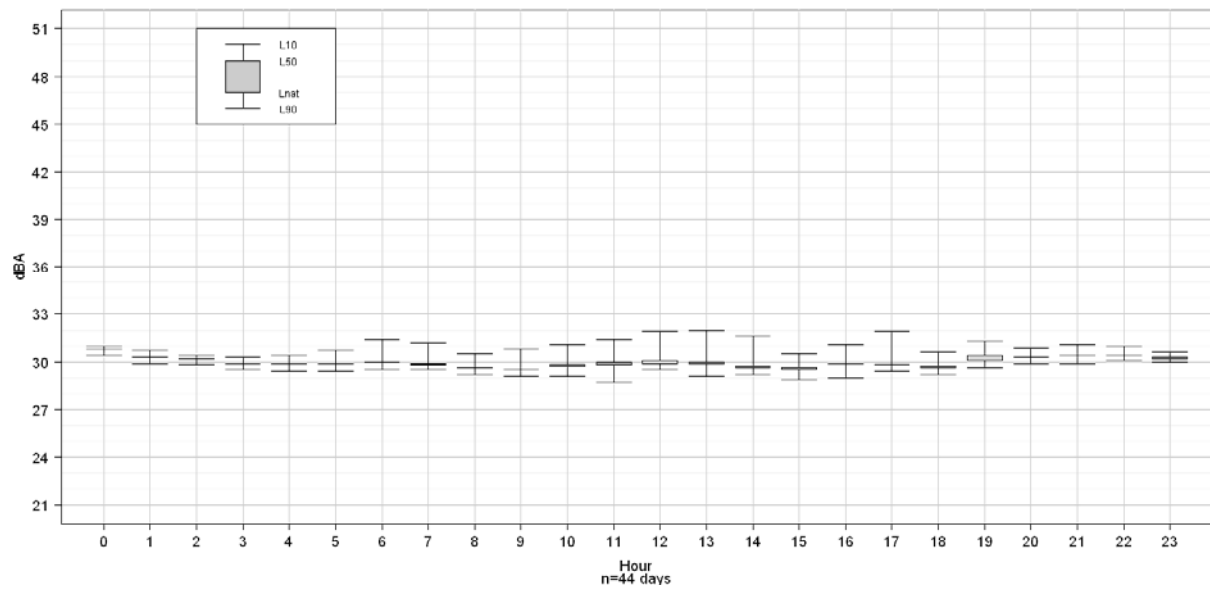


Figure 7. Median hourly exceedence metrics at NOCA007 in dBA.

Conclusion

During analysis, NSP staff discovered recordings of numerous species such as pikas and hummingbirds at Cascade Pass, and chipmunks at Boundary Camp. NSP staff also collected recordings of rock fall at Cascade Pass. These, along with wind and flowing water, are just a few of the many natural sounds which join to create the acoustic environment in North Cascades National Park Service Complex.

Acoustic monitoring in these wilderness areas not only allows us to gain insight into biologic (or geologic) activity, but also allows us to determine the prevalence of extrinsic noise, and perhaps estimate its effects. This study found wilderness areas of NOCA to be moderately impacted by extrinsic noise. Anthropogenic sounds were audible between 8 and 16 percent of the time at the three wilderness sites. From 2006 – 2008, four additional sites were monitored in various locations along Ross Lake. The percent time audible for these “frontcountry sites” ranged from 18 – 36. When compared to the frontcountry sites, the relative solitude of these wilderness areas becomes apparent.

Literature Cited

- Berglund, B., Lindvall, T. and Schwela, D.H (Eds.). 1999. HWO. Guidelines for community noise. World Health Organization, Geneva.
- Haralabidis Alexandros S., et. al. 2008. “Acute effects of night-time noise exposure on blood pressure in populations living near airports” European Heart Journal Advance Access. Published online February 12, 2008.
- National Park Service. 2005. Acoustic and Soundscape Studies in National Parks: Draft. Fort Collins, CO: NPS Natural Sounds Program.
- National Park Service. 2006a. Management Policy 4.9: Soundscape Management.
- National Park Service. 2006b. Management Policy 8.2.3: Use of Motorized Equipment.

Glossary of Acoustical 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

A logarithmic measure of acoustic or electrical signals. The formula for computing decibels is: $10(\log_{10}(\text{sound level}/\text{reference sound level}))$. 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). $\text{Frequency} = \text{Speed of Sound} / \text{Wavelength}$.

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.

 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.

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 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 an animal with normal hearing.

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