



Olympic National Park

Acoustic Monitoring Report 2021

Natural Resource Report NPS/NRSS/NSNSD/NRR—2021/2313



ON THE COVER

The clashing of antlers resounds through Olympic National Park valleys in the autumn, as Roosevelt elk battle for dominance
Image credit Jon Preston, NPS.

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Ashley R. Pipkin

National Park Service
Natural Sounds and Night Skies Division
1201 Oakridge Drive, Suite 100
Fort Collins, Colorado 80525

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Executive Summary

Olympic National Park (OLYM) has been collecting acoustic data to monitor the soundscape since 2010. A previous acoustic report (Lee & Macdonald 2016) provides park managers with initial winter acoustic baseline conditions. This report includes analysis of six sites throughout OLYM over four periods, summer 2010, winter 2010–2011, summer 2011 and winter 2011–2012. This additional baseline data provides information about the park acoustic environment and can be used to understand future changes and their potential to disturb park resources and values.

In each deployment, sound pressure level (SPL) is measured continuously every second by a calibrated, Type 1, Larson Davis 831 sound level meter. In this document, “sound pressure level” refers to broadband (12.5 Hz–20 kHz), A-weighted, 1-second time averaged sound level ($L_{Aeq, 1s}$), hereafter referred to as “sound level.” Sound levels are measured on a logarithmic scale relative to the reference sound pressure for atmospheric sources, 20 μ Pa. The logarithmic scale is a useful way to express the wide range of sound pressures perceived by the human ear. Sound levels are reported in decibels (dB). A-weighting is applied to sound levels to account for the response of the human ear (Harris, 1998). To approximate human hearing sensitivity, A-weighting discounts sounds below 1 kHz and above 6 kHz. Table 1 provides examples of sound levels measured in parks and common sound sources for general reference.

Table 1. Sound level examples.

Park Sound Sources	Common Sound Sources	Sound Level dB*
Volcano crater (Haleakalā National Park)	Human breathing at 3m	10
Leaves rustling (Canyonlands National Park)	Whispering	20
Crickets at 5m (Zion National Park)	Residential area at night	40
Conversation at 5m (Whitman Mission National Historic Site)	Busy restaurant	60
Cruiser motorcycle at 15m (Blue Ridge Parkway)	Curbside of busy street	80
Thunder (Arches National Park)	Jackhammer at 2 m	100
Military jet at 100m AGL (Charley Rivers National Preserve)	Train horn at 1 m	120

* dB re 20 μ Pa A-weighted broadband (12.5 Hz–20 kHz), sound level measured over the duration of the event ($L_{Aeq, event}$)

After data collection was complete, trained technicians calculated how often noise sources were audible. For the purposes of this document, we will refer to “noise” as any human-caused sound that masks or degrades natural sounds (Lynch et al. 2011). See Methods section for protocol details, equipment specifications, and metric calculations. Table 2 displays time audible values for each of these noise sources during the monitoring period, as well as measured sound levels. Median existing (LA_{50}) and natural ambient (LA_{nat}) sound levels are also reported for daytime (7:00–19:00) and nighttime (19:00–7:00).

Table 2. Existing and natural ambient sound levels as well as mean percent time audible for aircraft, vehicles, watercraft, non-natural unknown noise sources, and all extrinsic noise sources combined are shown. These four sources of noise were chosen because they are the most common for one or more of the sites at OLYM.

Site Name and ID	Season	Mean percent time audible noise (in 24-hour time period) ^a					Median Existing Ambient (L ₅₀) in dBA ^b		Median Natural Ambient (L _{nat}) in dBA	
		All Extrinsic	Aircraft	Vehicles	Watercraft	Non-natural unknown	Day ^c	Night ^c	Day	Night
Hoh River Tr. OLYM001	Summer 2010	10.8	7.5	0	0	2.8	33.7	32.5	33.5	32.5
	Winter 2011	4.4	2.6	0	0	1.7	38.0	38.6	37.9	38.6
	Summer 2011	8.6	5.3	0	0	3.3	34.2	32.2	34.0	32.2
Third Beach Tr. OLYM002	Summer 2010	49.7	11.5	11.2	0	24.5	32.7	29.5	30.1	27.7
	Summer 2011	33.1	8.8	1.9	0	19.7	30.8	29.5	28.7	28.2
	Winter 2012	14.7	1.0	0.1	0.6	12.7	32.6	35.7	32.3	35.6
Hurricane Ridge OLYM003	Winter 2011	28.8	11.8	4.3	0	3.8	23.1	23.0	20.7	22.7
	Summer 2011	62.0	15.3	30.5	0	22.8	27.0	19.8	23.7	17.7
Pyramid Mt Tr. OLYM004	Winter 2011	51.3	3.3	47.7	0	0.5	36.9	36.1	35.9	35.8
	Summer 2011	66.0	4.9	61.0	0.1	1.0	34.0	31.1	31.6	30.4
Lake Ozette OLYM005	Summer 2010	21.6	6.4	0	8.0	6.1	24.4	19.7	23.0	19.4
	Summer 2011	25.0	6.9	0	6.0	10.5	25.6	21.2	23.7	20.8
North Fork Skokomish River Tr. OLYM007	Summer 2011	5.5	3.4	0	0	1.3	41.8	41.5	41.8	41.5

In determining the current conditions of an acoustical environment, it is informative to examine how often sound levels exceed certain values. Table 3 reports the percent of time that measured levels at OLYM are above four key values. The first value, 35 dB, 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 et al. 2008). This level or below is the desired background sound level in classrooms (ANSI S12.60-2002). The second value addresses the World Health Organization’s recommendations that noise levels inside bedrooms remain below 45 dB (Berglund et al. 1999). The third value, 52 dB, is based on the EPA’s speech interference level for speaking in a raised voice to an audience at 10 meters (EPA 1974). This value addresses the effects of sound on interpretive presentations in parks. The final value, 60 dB, provides a basis for estimating speech interference on normal voice communications to an audience at 1 meter. Visitors viewing scenic areas in the park would likely be conducting such conversations.

Table 3. Documented effects of different sound levels on humans and wildlife.

Sound level dB	Metric Symbol	Relevance and citation
35	L _{Aeq,1s}	In quiet settings, outdoor sound levels exceeding 35 dB degrades the experience in outdoor performance venues (ANSI 12.9 part 5); blood pressure increases in sleeping humans (Haralabidis et al., 2008); maximum acceptable background noise level conducive to learning inside classrooms (ANSI Standard S12.60).
40	L _{Aeq} *	Wildlife responses to noise in terrestrial environments have been documented at noise levels as low as 40 dB (Shannon et al. 2016).
45	L _{Aeq,1s}	World Health Organization’s recommendation for maximum noise levels inside bedrooms to avoid sleep disturbance. (Berglund, Lindvall, and Schwela, 1999).
52	L _{Aeq,1s}	Speech interference for interpretive programs (U.S. Environmental Protection Agency, 1974).
60	L _{Aeq,1s}	Speech interruption for normal conversation (U.S. Environmental Protection Agency, 1974)

Sound levels are typically measured over narrow frequency bands (typically in one-third octave bands between 12.5 Hz–20 kHz) because these smaller bands closely represent how humans distinguish between frequencies of sound. In this study, we examine how often sound levels exceeded these key values in two frequency ranges. The bottom value in each split-cell of Table 4 uses the full frequency range (12.5 Hz–20 kHz) collected, whereas the top value only contains low frequency sound (20–1,250 Hz). Most motorized human-caused noise is confined to the truncated, lower-frequency range, while many natural sounds, including insects and birds, are higher in pitch (frequency). Therefore, the truncated range (20–1,250 Hz) is more appropriate for identifying impacts from anthropogenic noise in parks (Acoustical Society of America 2014).

Table 4. Time above metrics at Olympic National Park.

Season	Site Location and ID	Frequency (Hz)	% Time above sound level: 0700 to 1900 (Day)				% Time above sound level: 1900 to 0700 (Night)			
			35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
Summer 2010	Hoh R. Tr. OLYM001	20–1,250	27.74	0.31	0.04	0.00	1.13	0.01	0.00	0.00
	Hoh R. Tr. OLYM001	12.5–20,000	37.68	0.74	0.08	0.00	10.30	0.18	0.00	0.00
Winter 2010	Hoh R. Tr. OLYM001	20–1,250	100.00	0.31	0.01	0.00	100.00	0.05	0.00	0.00
	Hoh R. Tr. OLYM001	12.5–20,000	100.00	0.85	0.03	0.00	100.00	0.80	0.00	0.00
Summer 2011	Hoh R. Tr. OLYM001	20–1,250	27.74	0.26	0.04	0.00	0.69	0.00	0.00	0.00
	Hoh R. Tr. OLYM001	12.5–20,000	45.22	1.09	0.16	0.01	5.35	0.18	0.00	0.00
Summer 2010	Third Beach Tr. OLYM002	20–1,250	16.53	0.91	0.06	0.00	1.73	0.13	0.00	0.00
	Third Beach Tr. OLYM002	12.5–20,000	37.69	5.33	0.62	0.10	14.76	1.16	0.08	0.01
Summer 2011	Third Beach Tr. OLYM002	20–1,250	11.33	1.15	0.24	0.01	1.74	0.07	0.00	0.00
	Third Beach Tr. OLYM002	12.5–20,000	32.29	4.66	0.45	0.03	15.10	2.18	0.18	0.00
Winter 2011	Third Beach Tr. OLYM002	20–1,250	25.95	0.63	0.15	0.00	53.28	0.19	0.01	0.00
	Third Beach Tr. OLYM002	12.5–20,000	28.09	1.01	0.19	0.01	60.14	0.78	0.04	0.00

Table 4 (continued). Time above metrics at Olympic National Park.

Season	Site Location and ID	Frequency (Hz)	% Time above sound level: 0700 to 1900 (Day)				% Time above sound level: 1900 to 0700 (Night)			
			35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
Winter 2010	Hurricane Ridge OLYM003	20–1,250	5.19	0.68	0.14	0.01	2.49	0.26	0.00	0.00
	Hurricane Ridge OLYM003	12.5–20,000	5.51	0.76	0.15	0.01	5.07	0.34	0.01	0.00
Summer 2011	Hurricane Ridge OLYM003	20–1,250	12.95	1.53	0.20	0.03	1.91	0.21	0.02	0.00
	Hurricane Ridge OLYM003	12.5–20,000	14.68	1.84	0.23	0.04	2.17	0.23	0.02	0.00
Winter 2010	Pyramid Mt. Tr. OLYM004	20–1,250	56.45	2.47	0.85	0.10	47.40	0.70	0.18	0.00
	Pyramid Mt. Tr. OLYM004	12.5–20,000	98.05	3.27	1.02	0.21	86.31	0.94	0.19	0.00
Summer 2011	Pyramid Mt. Tr. OLYM004	20–1,250	28.40	2.00	0.62	0.15	6.94	0.28	0.01	0.00
	Pyramid Mt. Tr. OLYM004	12.5–20,000	37.68	2.92	0.74	0.15	14.96	0.37	0.06	0.00
Summer 2010	Lake Ozette OLYM005	20–1,250	4.26	0.24	0.01	0.00	0.21	0.00	0.00	0.00
	Lake Ozette OLYM005	12.5–20,000	6.66	0.51	0.04	0.00	0.54	0.04	0.00	0.00

Table 4 (continued). Time above metrics at Olympic National Park.

Season	Site Location and ID	Frequency (Hz)	% Time above sound level: 0700 to 1900 (Day)				% Time above sound level: 1900 to 0700 (Night)			
			35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
Summer 2011	Lake Ozette OLYM005	20–1,250	7.52	0.42	0.06	0.00	0.22	0.00	0.00	0.00
	Lake Ozette OLYM005	12.5–20,000	10.33	0.59	0.07	0.00	0.44	0.02	0.00	0.00
Summer 2011	North Fork Skokomish River Tr. OLYM007	20–1,250	100.00	0.34	0.04	0.00	100.00	0.03	0.00	0.00
	North Fork Skokomish River Tr. OLYM007	12.5–20,000	100.00	1.34	0.13	0.00	100.00	0.36	0.00	0.00

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Glossary of Acoustical Terms

Table 5. Acoustical terms and definitions.

Term	Definition
Acoustic Environment	A combination of all the physical sound resources within a given area. This includes natural sounds and cultural sounds, and non-natural human-caused sounds. The acoustic environment of a park can be divided into two main categories: intrinsic and extrinsic.
Acoustic Resources	Includes both natural sounds (i.e., wind, water, and wildlife) and cultural and historic sounds (i.e., tribal ceremonies, quiet reverence, and battle reenactments).
Amplitude	The relative strength of a sound wave described in decibels (dB). The amplitude of a sound wave determines its loudness or volume.
Air Tour Management Plan (ATMP)	A plan that the FAA and the NPS create to assure that air tours over NPS units have minimal impacts on park resources.
Audibility	The ability of animals with normal hearing, including humans, to hear a given sound. It can vary depending upon pitch and volume of the sound and by an individual animal's hearing ability.
Decibel (dB)	A unit of sound energy. Every 10 dB increase represents a tenfold increase in energy. Therefore, a 20 dB increase represents a hundredfold increase in energy. When sound levels are adjusted for human hearing they are expressed as dB (A) and reflect a decrease in energy at the lowest end of audible spectrum.
Existing Ambient	This is the LA ₅₀ at a site, or the median current acoustic condition.
Extrinsic Sound	Any sounds not forming an essential part of the park unit, or a sound originating from outside the park boundary. This could include voices, radio music, or jets flying thousands of feet above the park.
Frequency	Related to the pitch of a sound, it is defined as the number of times per second that the wave of sound repeats itself and is expressed in terms of hertz (Hz). Sound levels are often adjusted ("weighted") to match the hearing abilities of a given animal. In other words, different species of animals and humans are capable of hearing (or not hearing) at different frequencies. Humans with normal hearing can hear sounds between 20 Hz and 20,000 Hz, and as low as 0 dB at 1,000 Hz. Bats, on the other hand, can hear sounds between 20 Hz and 200,000 Hz.
Hertz (Hz)	A unit of measurement that describes frequency. Humans can hear between 20 Hz and 20,000 Hz.
Intrinsic Sound	Belongs to a park by the park's very nature, based on its purposes, values, and establishing legislation. Intrinsic sounds can include natural, cultural, and historic sounds that contribute to the acoustical environment of the park.
LA ₅₀ (Median Existing) LA ₉₀	Metrics used to describe sound pressure levels (L), in decibels, exceeded 50 and 90 percent of the time, respectively. Put another way, half the time the measured levels of sound are greater than the LA ₅₀ value, while 90 percent of the time the measured levels are higher than the LA ₉₀ value.
L _{dn}	Day-Night Average Sound Level. Average equivalent sound level over a 24-hour period, with a 10 dB increase added for sound levels between 10 p.m. and 7 a.m.

Table 5 (continued). Acoustical terms and definitions.

Term	Definition
L_{eq}	Energy Equivalent Sound Level. The sound energy level averaged over the measurement period.
LA_{nat} (Natural Ambient Sound Level)	The natural sound conditions (i.e., sound level) in parks, which exist in the absence of any human-produced noise.
Noise	Any human-caused sound that masks or degrades natural sounds (Lynch et al. 2011).
Noise Free Interval (NFI)	The length of a continuous period of time during which no human-caused sounds are audible.
Octave Band	A frequency band that spans one octave.
Percent Time Above Natural Ambient	The amount of time that various sound sources are above the natural ambient sound pressure levels in a given area. It is most commonly used to measure the amount of time that human-caused sounds are above natural ambient levels.
Pitch	Conceptual measure of frequency.
Sound Pressure Level (SPL)	Minute change in atmospheric pressure due to passage of sound that can be detected by microphones.
Sound vs. Noise	The NSNSD differentiates between the use of <i>sound</i> and <i>noise</i> since these definitions have been used inconsistently in the literature. Although <i>noise</i> is sometimes incorrectly used as a synonym for sound, it is in fact sound that is undesired or extraneous to an environment. Humans perceive <i>sound</i> as an auditory sensation created by pressure variations that move through a medium such as water or air and are measured in terms of amplitude and frequency (Harris 1998; Templeton 1997).
Soundscape	The human perception of physical sound resources.
Time Audible (%)	The amount of time that various sound sources are audible to humans with normal hearing. A sound may be above natural ambient sound pressure levels, but still not audible. Similarly, some sounds that are below the natural ambient can be audible. Percent Time Audible is useful because of its simplicity. It is a measure that correlates well with visitor complaints of excessive noise and annoyance. Most noise sources are audible to humans at lower levels than virtually all wildlife species. Therefore, percent time audible is a protective proxy for wildlife. These data can be collected either by a trained observer (on-site listening) or by making high-quality digital recordings for later playback (off-site listening).

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). Acoustical monitoring provides a scientific basis for assessing the status of these valued 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 acoustic conditions.

National Park Service Natural Sounds and Night Skies Division

The Natural Sounds and Night Skies Division (NSNSD) helps parks manage sounds in a way that protects park resources and the visitor experience. The NSNSD addresses acoustical issues raised by Congress, NPS Management Policies, and NPS Director's Orders. The NSNSD works to protect, maintain, or restore acoustical environments throughout the National Park System. Its goal is to provide coordination, guidance, and a consistent approach to soundscape protection with respect to park resources and visitor use. The program also provides technical assistance to parks in the form of acoustical monitoring, data processing, park planning support, and comparative analyses of acoustical environments.

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 found 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

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.

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 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 acoustical 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).

The National Parks Air Tour Management Act (NPATMA) was passed as Public Law 106-181 on April 5, 2000 to manage commercial air tour operations for each unit of the National Park System, or abutting tribal land, where such operations occur or are proposed. The Act required the Federal Aviation Administration (FAA), in cooperation with the NPS, to develop an Air Tour Management Plan (ATMP) for each unit of the National Park Service with proposed air tours. ATMPs should provide acceptable and effective measures to mitigate or prevent significant adverse impacts, if any, of commercial air tour operations upon natural and cultural resources and visitor experiences.

The Natural Soundscape of Olympic National Park

Olympic National Park is a haven for diversity, with glacier-draped mountains and subalpine meadows giving way to lowland ancient forests and a sweep of wild Pacific Ocean coastline. This breadth of biological and physical landscapes holds visual values, but also possesses critical values discovered in the park's soundscape, the incredibly rich entirety of its natural acoustic environment.

The natural soundscape of the park conveys oral narratives of its significant stories: the bugling of the park's iconic species, Roosevelt elk, and the crashing together of their antlers during the rut; the whistle of the endemic Olympic marmot warning of threatening predators; or the four-note calls of the park's last Northern spotted owls. Everywhere is the sound of water in Olympic: droplets sprinkling onto evergreen branches, rain pouring through the forest canopy, overflowing rumbling streams racing into roaring rivers, and waterfalls plunging over vertical cliffs. Natural sounds found in park wilderness can elicit tranquility for those seeking stillness away from civilization: the calm of a quiet subalpine lake, the soft echo of a varied thrush in the deep forest, the trill of a winter wren, the gentle stepping of black-tailed deer. Natural sounds found here can also provoke fear: the scream of a cougar, the roaring of a wildfire, and the howling of storm-driven winds. Olympic's natural soundscape can beat with repetition: drumming of ruffed grouse wings, tree hammering by pileated woodpeckers, bird-like chirping of chipmunks, and whirring mosquitoes. The sounds that meet us at the sea speak of the coast's wildness: the high-pitched peal of the bald eagle, the bark of sea lions, the spouting of air and water from a grey whale's blowhole, and the crash of high surf against sand and boulder beaches.

An acoustic environment undisrupted by human-caused noise enriches our personal experience of the wild. Yet its value is inestimable to its residents and essential to their livelihood. A protected soundscape allows wildlife to communicate more effectively, to establish their territories, to accomplish courtship and mating, and to avoid predators. Olympic National Park's natural soundscape is a resource in and of itself for which the National Park Service is its steward, to protect and preserve unimpaired for this and future generations. Acoustical monitoring provides a quantifiable representation of the park's natural soundscape, to help us understand more concretely what it is that the park's mission calls us to protect and preserve. This Olympic National Park Acoustic Monitoring Report presents data from six soundscape monitoring sites in the park, from the coast to the park's high country, during winters and summers, providing a baseline of this unique acoustical environment.

Study Area

Acoustical monitoring sites were deployed over four monitoring periods during the summers of 2010 and 2011 and the winters of 2010–2011 and 2011–2012 (Table 6). Sites were chosen within diverse habitats across the park with different management designations, spanning a gradient of elevations and climatic conditions. The park has a diversity of environments: the Pacific Ocean coastline where OLYM002 and OLYM005 are located; the westside temperate rainforest where OLYM001 is; the subalpine fir community where OLYM003 is; and the western hemlock and Douglas fir forests that include the other two sites. OLYM was established as a national park in 1938. In 1988, Congress designated 95% of the park as the Olympic Wilderness, renamed the Daniel J. Evans Wilderness in 2017. All the sites are within federally designated wilderness except for OLYM003 and OLYM004. See Appendix A for site photos.

Table 6. Olympic acoustical monitoring sites and locations.

Site ID	Site Name	Dates Deployed	Vegetation	Elevation (m)	Latitude	Longitude
OLYM001	Hoh River Trail	6/10/2010–7/16/2010; 12/8/2010–01/18/2011; 7/8/2011–8/9/2011	Sitka Spruce Zone	226	47.86627	–123.9146
OLYM002	Third Beach Trail	6/9/2010–7/13/2010; 6/1/2011–7/1/2011; 12/1/2011–12/31/2011	Sitka Spruce Zone – Coast	80	47.88517	–124.59748
OLYM003	Hurricane Ridge	1/20/2011–2/28/2011; 8/17/2011–9/27/2011	Subalpine Fir Zone	1570	47.96968	–123.50123
OLYM004	Pyramid Mt Trail	1/28/2011–2/28/2011; 6/22/2011–7/23/2011	Douglas Fir Zone	395	48.0696	–123.84014
OLYM005	Lake Ozette	7/19/2010–8/24/2010; 7/27/2011–8/31/2011	Sitka Spruce Zone – Coast	36	48.11472	–124.65189
OLYM007	North Fork Skokomish River Trail	7/12/2011–8/16/2011	Western Hemlock Zone	277	47.525142	–123.339283

A map of OLYM is presented in Figure 1. The map shows both the coastal and interior portions of OLYM and the six acoustic monitoring locations analyzed in this report. All federally designated wilderness areas, for the park and national forest, are also shown on the map. Major roads throughout

the park are also included in Figure 1 and provide context for when a park visitor would be likely to hear road noise and approximate if the site is in the frontcountry or more remote.

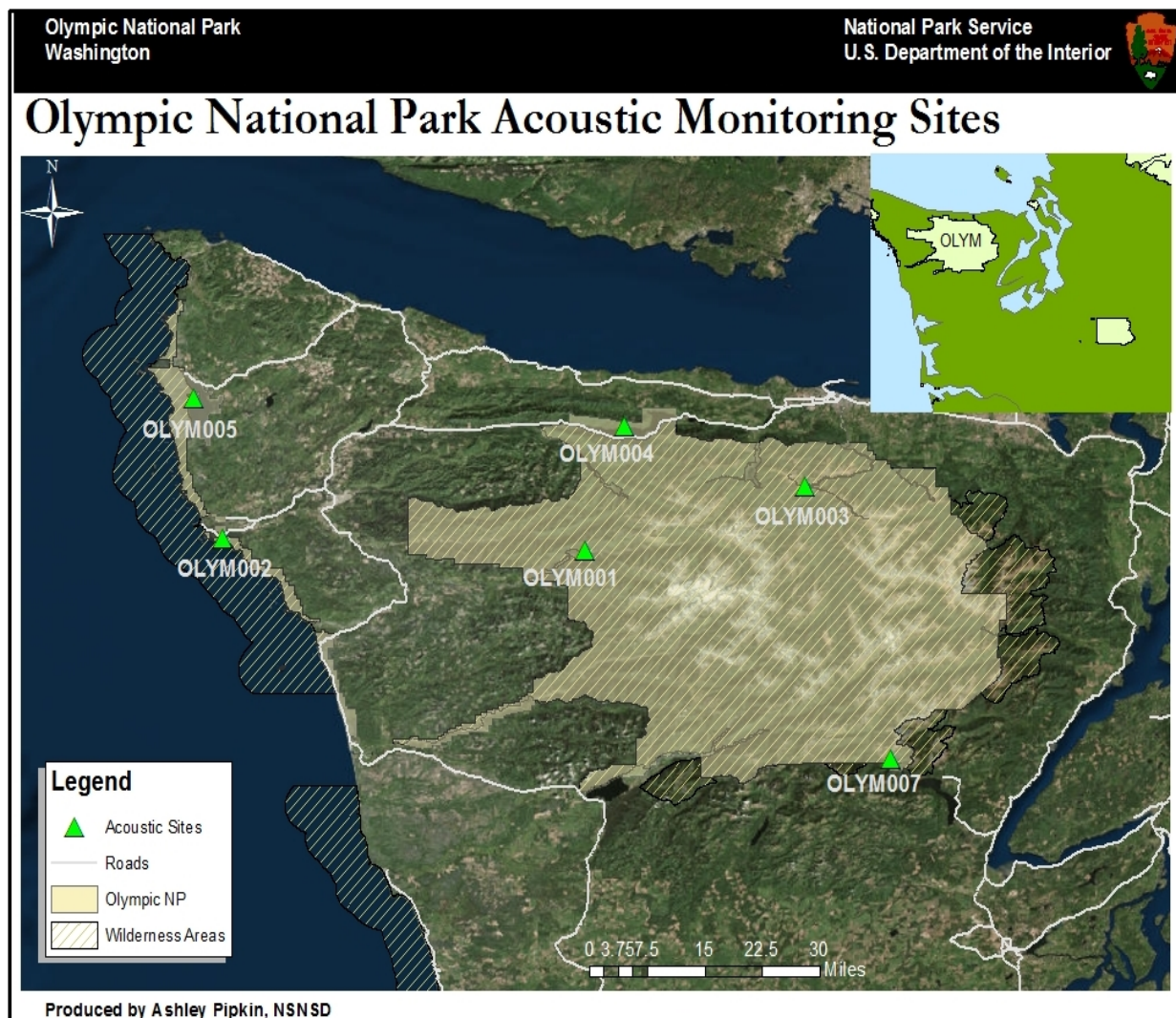


Figure 1. Location of acoustic monitoring sites at Olympic National Park analyzed in this report.

Methods

Automatic Monitoring

A Larson Davis 831 sound level meter (SLM) was deployed at each site over the monitoring periods at OLYM. The Larson Davis SLM is a hardware-based, real-time analyzer which continuously records one second SPL and 1/3 octave band data. This Larson Davis-based site met American National Standards Institute (ANSI) Type 1 standards. The sound level meter provided the information needed to calculate metrics described below in [Calculation of Metrics](#).

The sampling stations consisted of:

- Microphone with environmental shroud
- Preamplifier
- 12 V alkaline battery packs
- Anemometer (wind speed and direction)
- Relative humidity and temperature sensor
- MP3 recorder

The sampling stations collected:

- A-weighted 1 second time averaged sound level (LAeq, 1s) in dB re 20 µPa
- Continuous digital audio recordings
- One-third octave band data every second ranging from 12.5 Hz–20,000 Hz
- Continuous meteorological data for wind speed, relative humidity, and temperature.

Calculation of Metrics

The status of the acoustical environment can be characterized by measurement across the audible spectrum, including frequency bands from 20 Hz to 20,000 Hz. Spectral measurements, durations, and overall sound levels (intensities) can characterize the status of the acoustical environment. The NSNSD uses descriptive figures and metrics to interpret these characteristics. Two fundamental metrics are existing ambient (LA₅₀) and natural ambient (LA_{nat}) sound levels. These are both examples of exceedance levels, where each L_x value refers to the SPL that is exceeded x% of the time. The LA₅₀ represents the median SPL and is comprised of spectra (in dB) drawn from a full dataset (removing data with wind speed > 5m/s to eliminate error from microphone distortion). The natural ambient (LA_{nat}) is an estimate of what the ambient level for a site would be if all extrinsic (anthropogenic sources) were removed. Unlike the existing ambient, the natural ambient is comprised of spectra drawn from a subset of the original data.

For a given hour (or other specified time period), LA_{nat} is calculated to be the decibel level exceeded x percent of the time, where x is defined by equation (1):

$$x = \frac{100 - P_H}{2} + P_H \quad (1)$$

P_H is the percentage of samples containing extrinsic or anthropogenic noise for the hour. For example, if human caused sounds are present 30% of the hour, $x = 65$, and the LA_{nat} is equal to the L_{65} , or the level exceeded 65% of the time. To summarize and display these data, the median of the hourly LA_{nat} values for the daytime hours (0700–1900) and the median of the hourly LA_{nat} values for the nighttime (1900–0700) are displayed in Figures 2–14 in the results section. Additionally, this figure separates the data into 33 one-third octave bands.

Off-Site Listening

Auditory analysis was used to calculate the audibility of sound sources at OLYM. Trained technicians at Colorado State University analyzed a subset of .mp3 samples (10 seconds every two minutes for eight days of audio) to identify durations of audible sound sources. Staff used the total percent time extrinsic sounds were audible to calculate the natural ambient sound level for each hour (see Equation 1 below for more information). Bose Quiet Comfort Noise Canceling headphones were used for off-site audio playback to minimize limitations imposed by the office acoustic environment.

Results

Off-Site Data Analysis

Metrics

To determine the effect that noise audibility has on the acoustical environment, it is useful to examine the median hourly percentile metrics. The sound levels for 33 one-third octave band frequencies over the day and night periods are shown in Figures 2–14. High frequency sounds (such as a cricket chirping) and low frequency sounds (such as flowing water) often occur simultaneously, so the frequency spectrum is split into 33 smaller ranges, each encompassing one-third of an octave. These smaller bands closely represent how humans distinguish between frequencies of sound. For each one-third octave band, sound level ($L_{eq, 1s}$) was recorded once per second for the duration of the monitoring periods.

Examining the sound energy in each one-third octave band (combined with digital audio recordings) allows acoustic technicians to determine what types of sounds are contributing to the overall sound levels at a site. The shaded area of the graphs represents sound levels outside of the typical range of human hearing. The percentile sound levels (L_x) are also shown for each one-third octave band. They represent the sound levels exceeded x percent of the time. For example, LA_{90} is the sound level that has been exceeded 90% of the time, and only the quietest 10% of the samples can be found below this point. On the other hand, the LA_{10} is the sound level that has been exceeded 10% of the time, and 90% of the measurements are quieter than the LA_{10} . The bold portion of the column represents the difference between LA_{50} and LA_{nat} . The height of this bold portion is a measure of the contribution of anthropogenic noise to the existing sound levels at this site. The size of this portion of the column is directly related to the percent time that human caused sounds are audible. When bold portions of the column do not appear the natural and existing sound levels are either very close or are equal.

LA_{nat} and LA_{50} are bordered above by LA_{10} and below by LA_{90} , which essentially marks the median (LA_{50}), near maximum (LA_{10}), and near minimum (LA_{90}) sound levels over the monitoring period. This bar shows 80% of the sound levels recorded, excluding the extremes. The typical frequency levels for transportation, conversation, and songbirds are presented on the figure as examples for interpretation of the data. These ranges are estimates and are not vehicle-, species-, or habitat-specific.

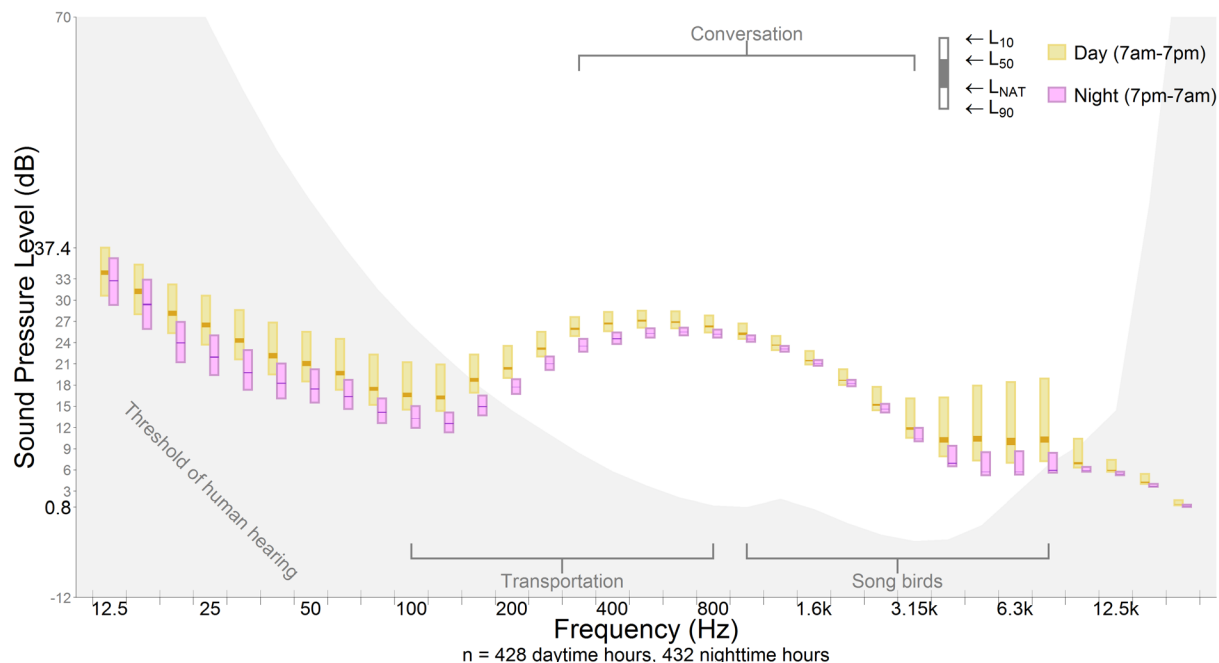


Figure 2. Day and night sound level for 33 one-third octave bands at OLYM001 in the summer of 2010.

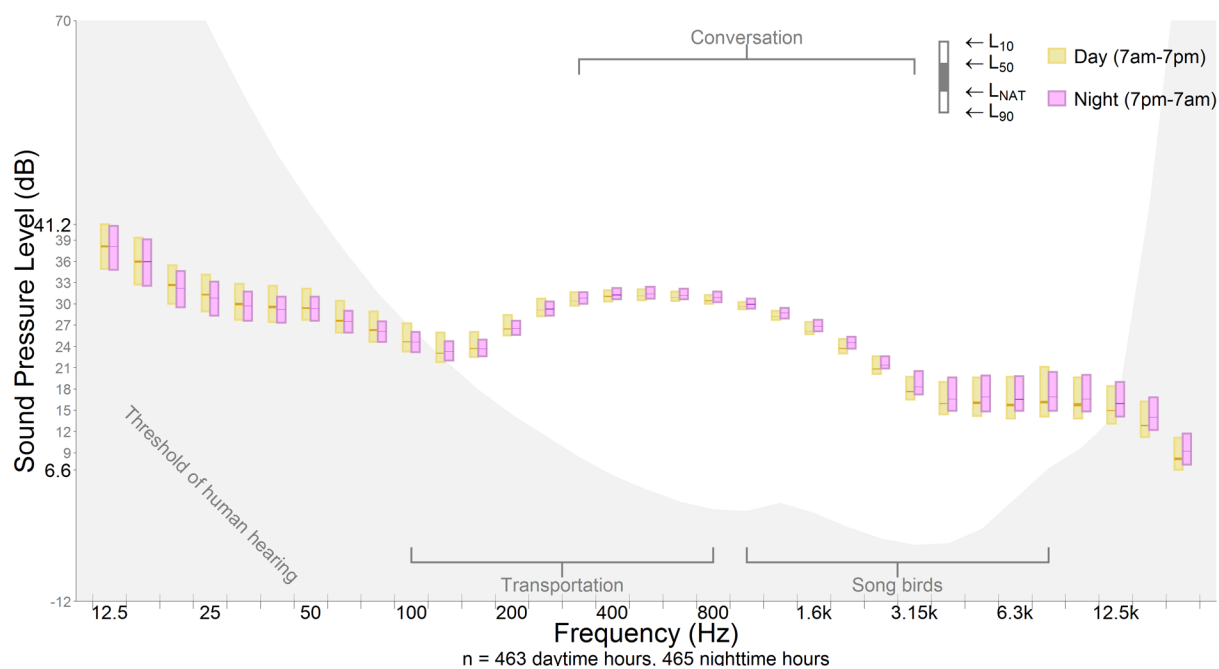


Figure 3. Day and night sound level for 33 one-third octave bands at OLYM001 in the winter of 2010–2011.

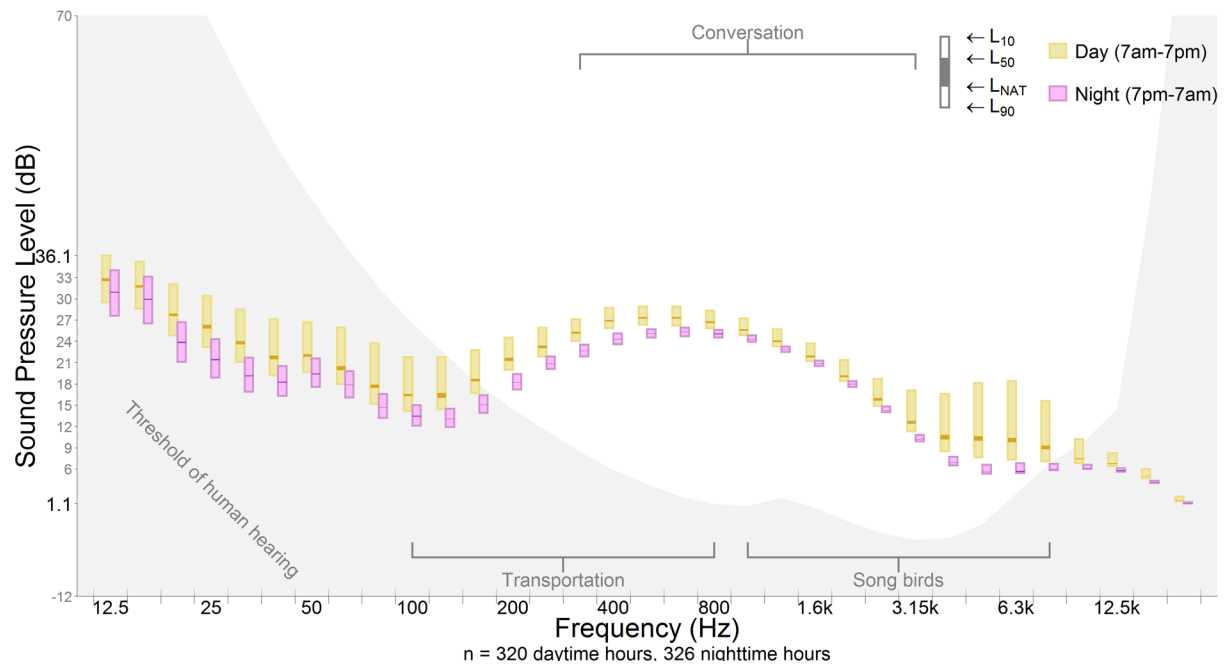


Figure 4. Day and night sound level for 33 one-third octave bands at OLYM001 in the summer of 2011.

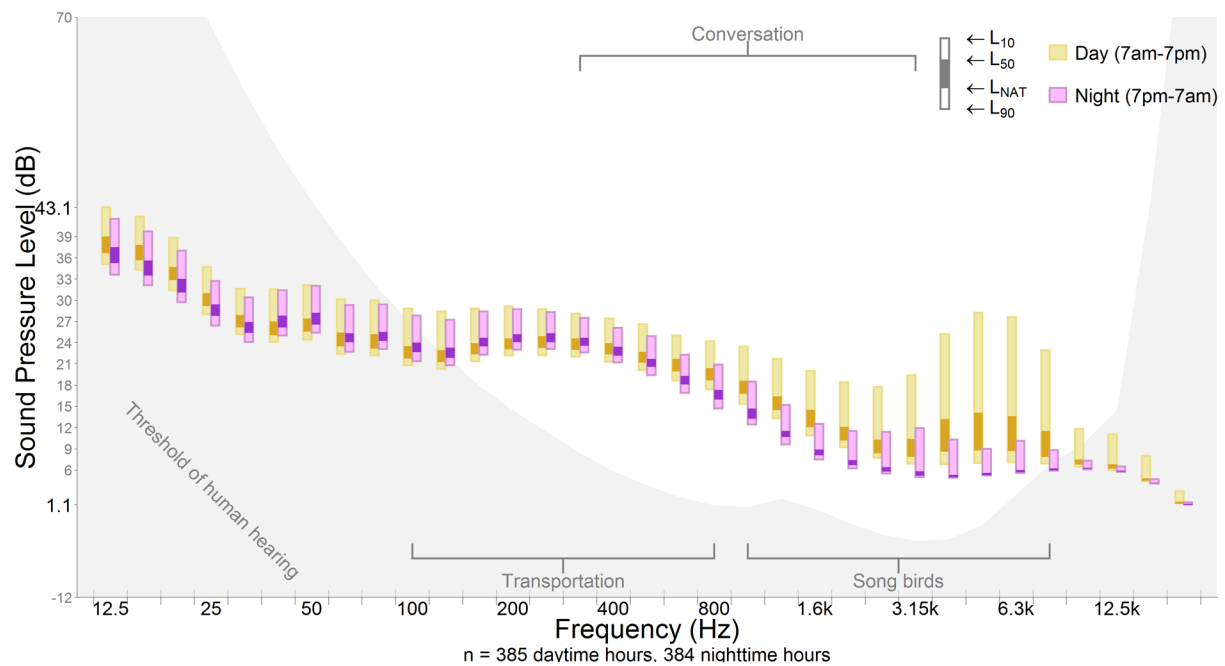


Figure 5. Day and night sound level for 33 one-third octave bands at OLYM002 in the summer of 2010.

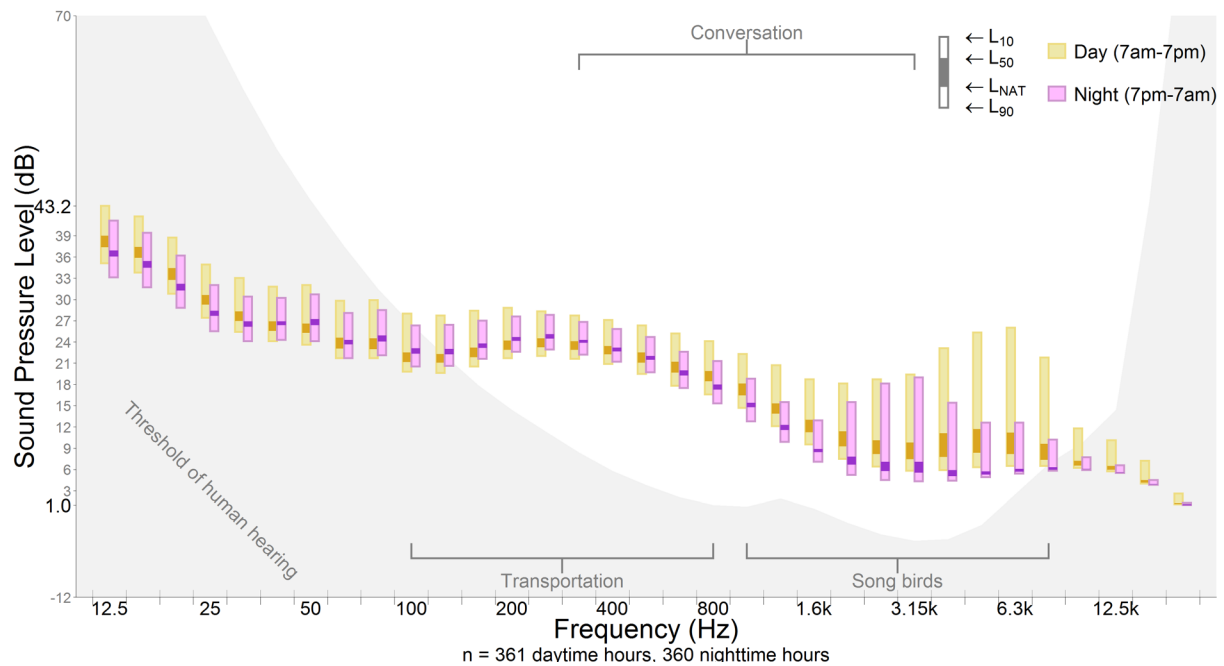


Figure 6. Day and night sound level for 33 one-third octave bands at OLYM002 in the summer of 2011.

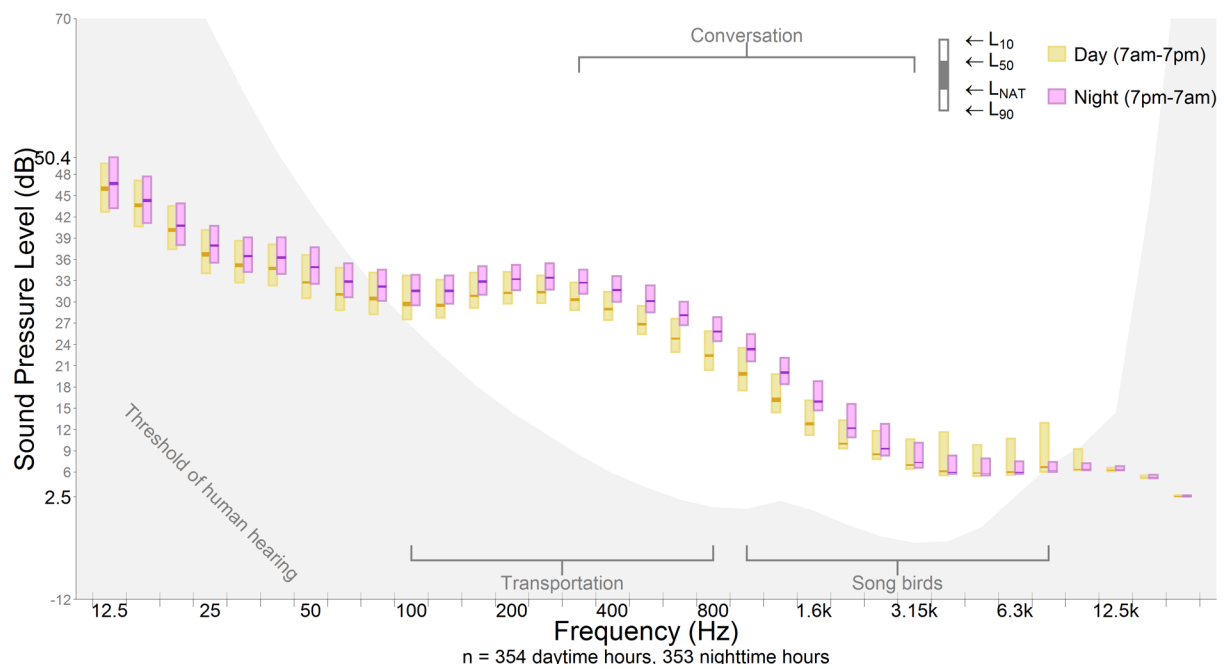


Figure 7. Day and night sound level for 33 one-third octave bands at OLYM002 in the winter of 2011–2012.

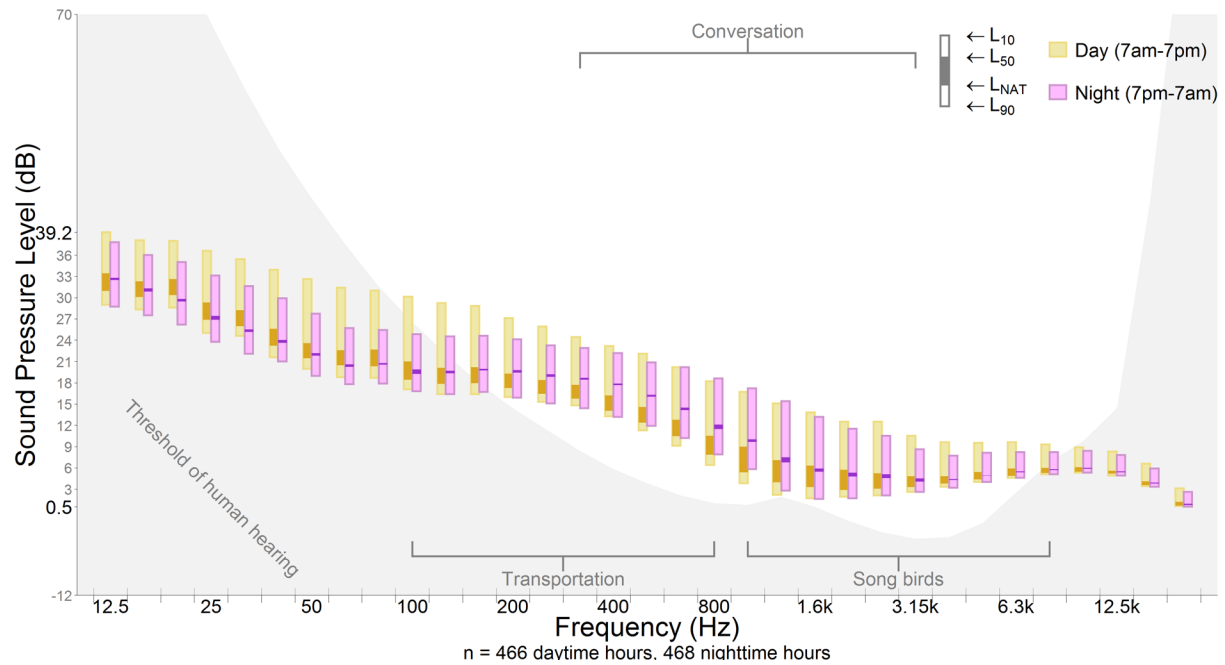


Figure 8. Day and night sound level for 33 one-third octave bands at OLYM003 in the winter of 2010–2011.

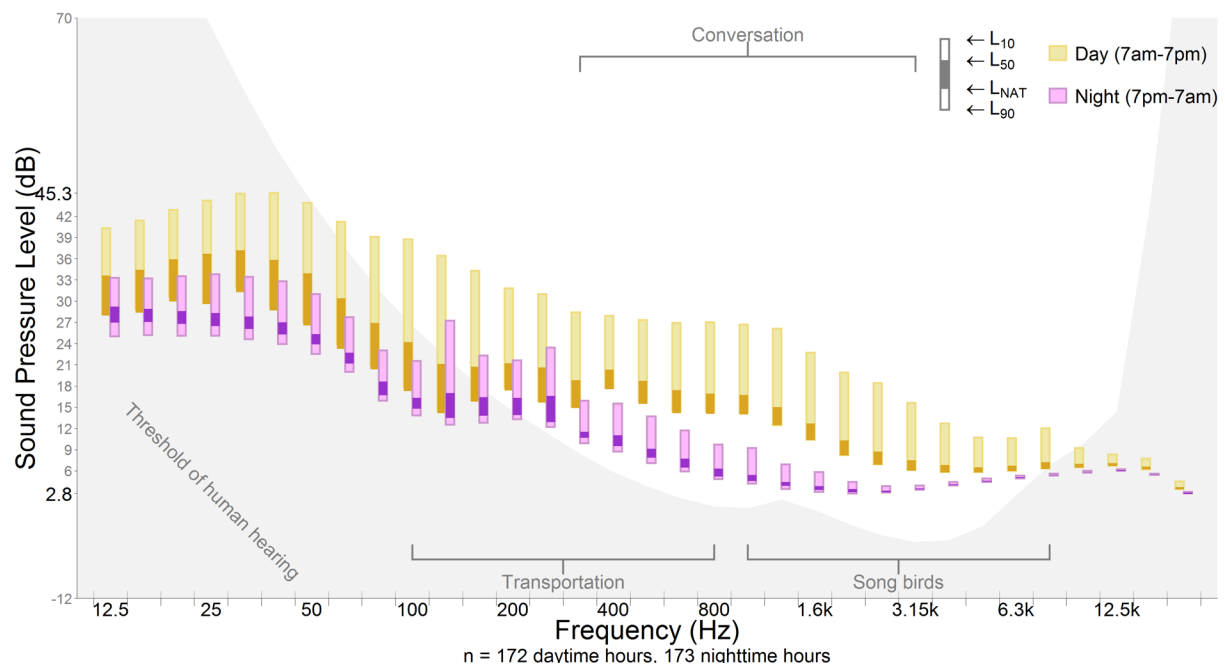


Figure 9. Day and night sound level for 33 one-third octave bands at OLYM003 in the summer of 2011.

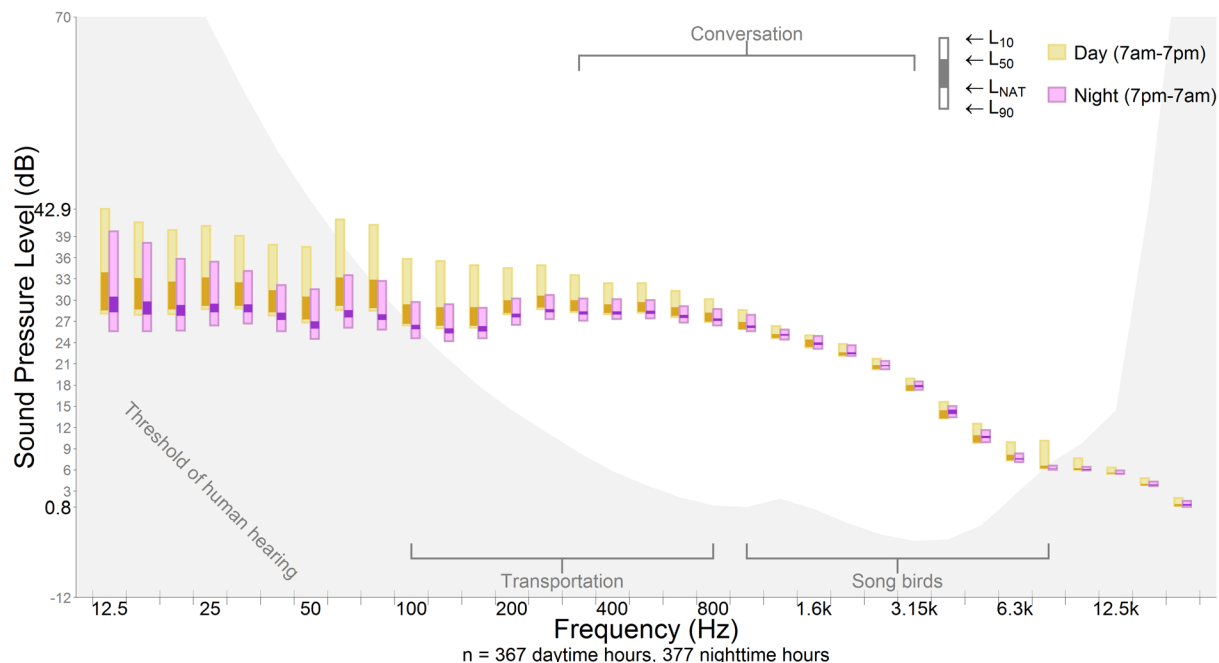


Figure 10. Day and night sound level for 33 one-third octave bands at OLYM004 in the winter of 2010–2011.

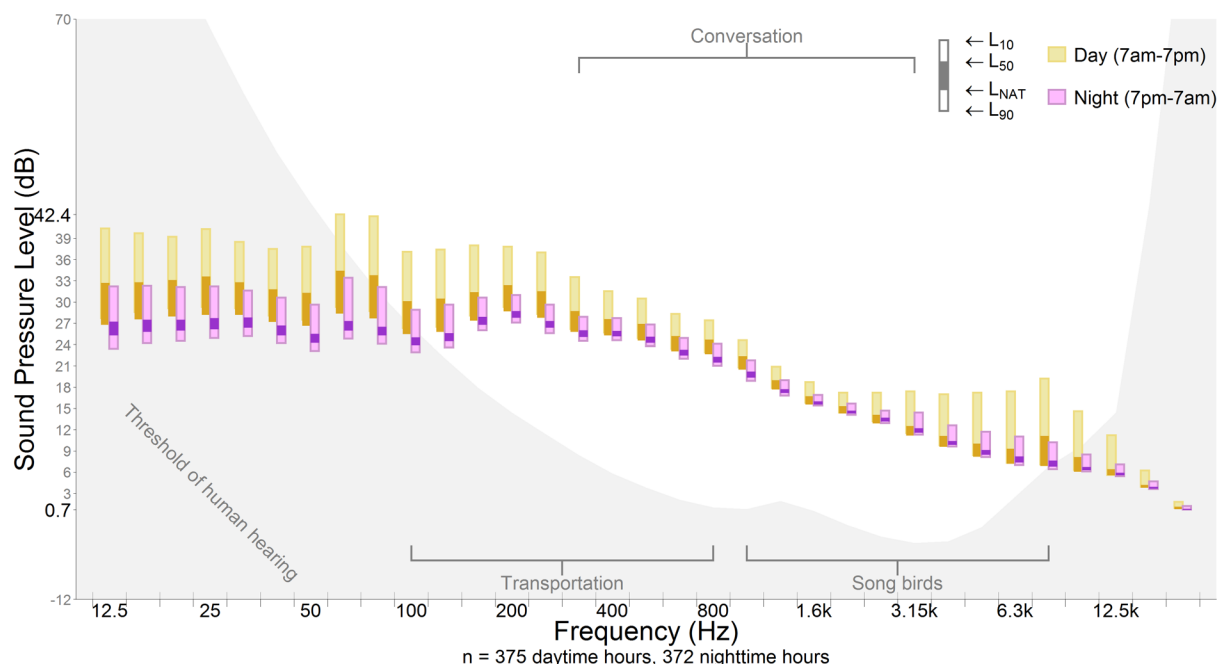


Figure 11. Day and night sound level for 33 one-third octave bands at OLYM004 in the summer of 2011.

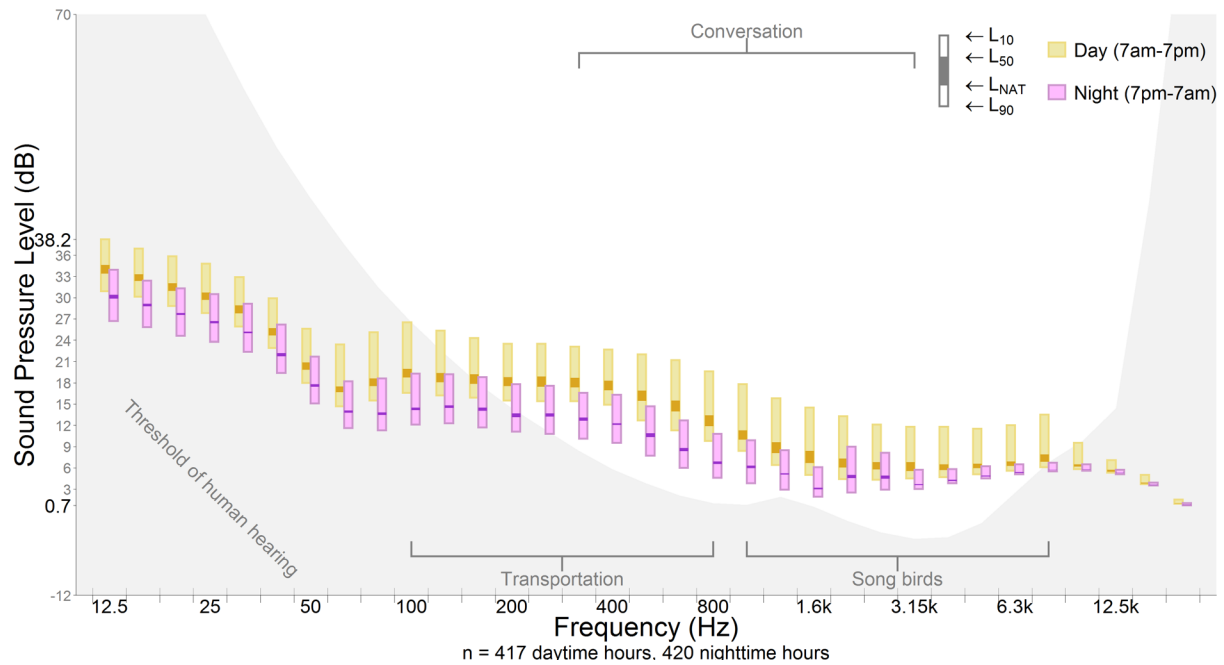


Figure 12. Day and night sound level for 33 one-third octave bands at OLYM005 in the summer of 2010.

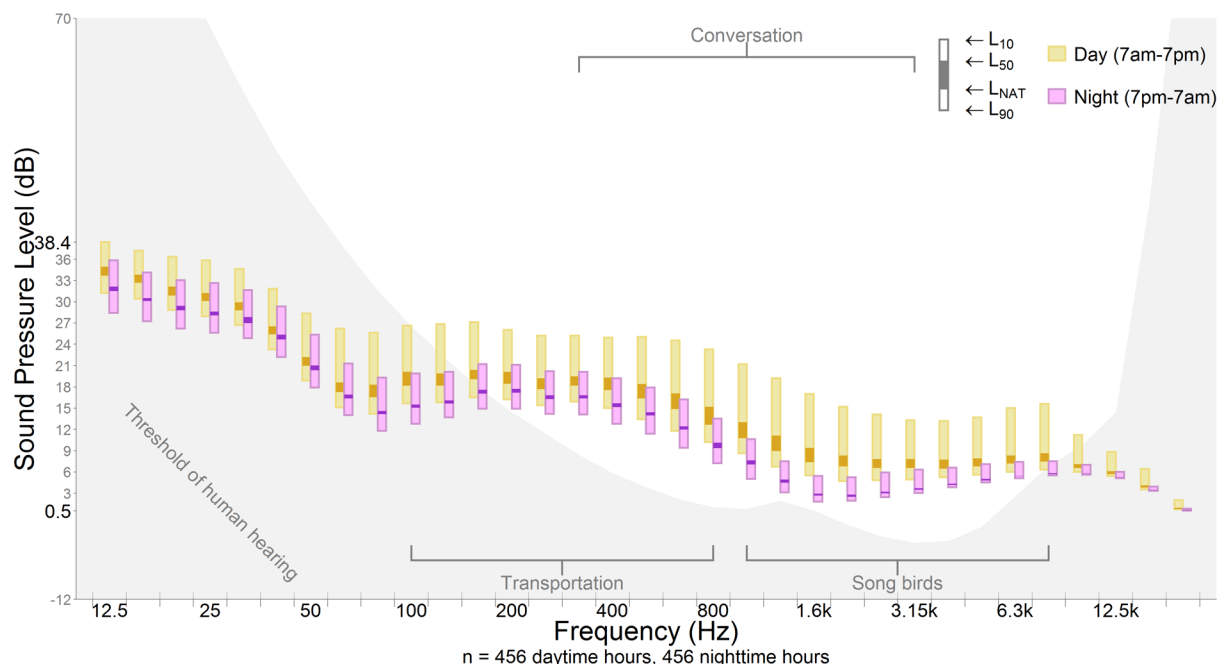


Figure 13. Day and night sound level for 33 one-third octave bands at OLYM005 in the summer of 2011.

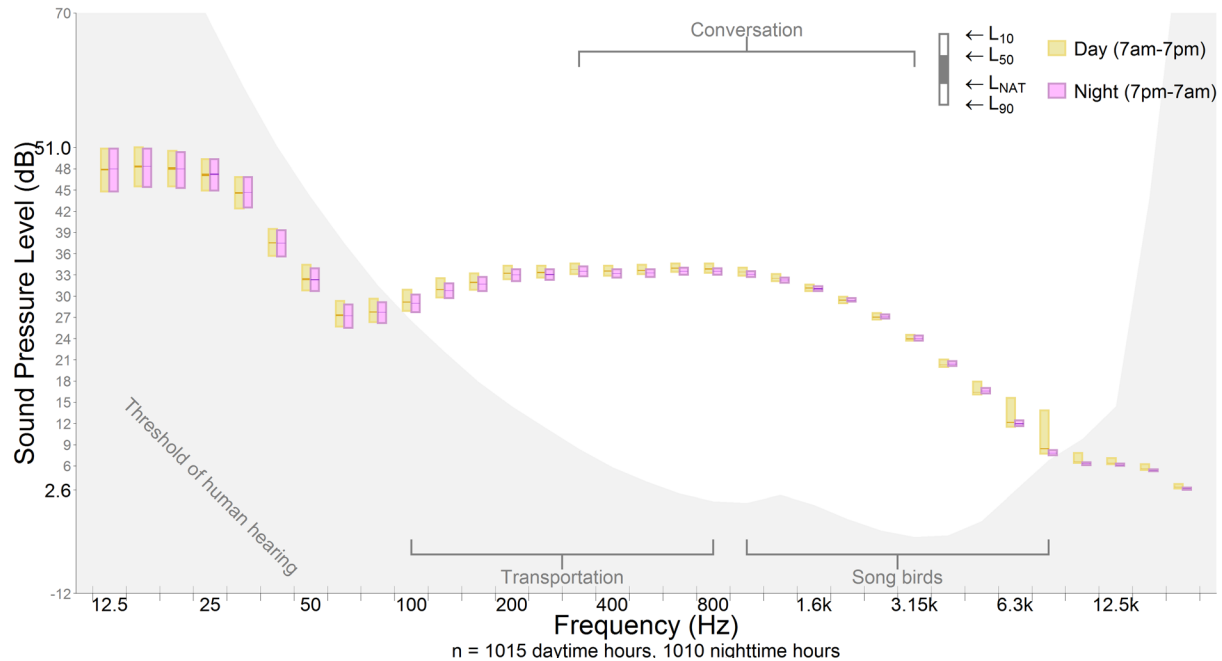


Figure 14. Day and night sound level for 33 one-third octave bands at OLYM007 in the summer of 2011.

Tables 7–10 report the A-weighted percentile sound levels (LA90, LAnat, LA50, and LA10) for the acoustical monitoring sites in OLYM. Values are A-weighted in accordance with ANSI/ASA S3/SC1.100-2014. These values are calculated from the hourly broadband (12.5 Hz–20 kHz) A-weighted 1-second time averaged sound levels ($L_{Aeq, 1s}$). The top value in each cell focuses on the lower frequencies (20–1,250 Hz) affected by transportation noise and in these sites may also include low frequency natural sounds like flowing water. The bottom value shows the full frequency range measured at each location. Most human-caused noise is confined to a lower frequency range, while many loud natural sounds, including insects and birds, are higher in pitch. Therefore, the truncated range is more appropriate for identifying noise levels in parks (Acoustical Society of America 2014). As described above, percentile sound levels (LA_x) represent the sound level exceeded x percent of time during the given measurement period. For instance, in Table 7 for OLYM001 the daytime LA_{90} is 32.8 dB. LA_{90} is exceeded 90% of the time, and only the quietest 10% of the samples are below this point. On the other hand, the LA_{10} for the same period at this site is 36.7 dB. This level is exceeded 10% of the time, and 90% of the measurements are quieter than the LA_{10} .

Table 7. Exceedance levels for existing conditions at OLYM in the summer of 2010.

Site	Frequency (Hz)	Percentile levels ($L_{Aeq, 12hr}$): 0700 to 1900 hours (Day)				Percentile levels ($L_{Aeq, 12hr}$): 1900 to 0700 hours (Night)			
		LA_{90}	LA_{nat}	LA_{50}	LA_{10}	LA_{90}	LA_{nat}	LA_{50}	LA_{10}
OLYM001 Hoh River Trail	20–1,250	31.8	32.5	32.7	34.4	31	31.4	31.4	31.8
	12.5–20,000	32.8	33.5	33.7	36.7	32.1	32.5	32.5	33.3
OLYM002 Third Beach Trail	20–1,250	26.1	27.3	28.9	33.7	24.9	25.9	27.0	30.4
	12.5–20,000	28.4	30.1	32.7	40.1	26.5	27.7	29.5	33.5
OLYM005 Lake Ozette	20–1,250	19.0	21.4	22.6	27.9	14.0	16.3	16.6	20.6
	12.5–20,000	21.0	23.0	24.4	30.5	17.7	19.4	19.7	23.4

Table 8. Exceedance levels for existing conditions at OLYM in the winter of 2010–2011.

Site	Frequency (Hz)	Percentile levels ($L_{Aeq, 12hr}$): 0700 to 1900 hours (Day)				Percentile levels ($L_{Aeq, 12hr}$): 1900 to 0700 hours (Night)			
		LA_{90}	LA_{nat}	LA_{50}	LA_{10}	LA_{90}	LA_{nat}	LA_{50}	LA_{10}
OLYM001 Hoh River Trail	20–1,250	36.5	36.8	36.8	37.8	36.8	37.2	37.2	38.0
	12.5–20,000	37.5	37.9	38.0	39.3	38.2	38.6	38.6	39.5
OLYM003 Hurricane Ridge	20–1,250	17.6	18.5	21.0	29.7	18.0	21.5	21.6	27.4
	12.5–20,000	19.6	20.7	23.1	31.1	19.8	22.7	23.0	28.9
OLYM004 Pyramid Mt Trail	20–1,250	34.2	34.4	35.6	39.0	33.7	34.3	34.6	36.0
	12.5–20,000	35.8	35.9	36.9	39.8	35.4	35.8	36.1	37.6

Table 9. Exceedance levels for existing conditions at OLYM in the summer of 2011.

Site	Frequency (Hz)	Percentile levels ($L_{Aeq, 12hr}$): 0700 to 1900 hours (Day)				Percentile levels ($L_{Aeq, 12hr}$): 1900 to 0700 hours (Night)			
		LA_{90}	LA_{nat}	LA_{50}	LA_{10}	LA_{90}	LA_{nat}	LA_{50}	LA_{10}
OLYM001 Hoh River Trail	20–1,250	32.1	32.9	33.1	34.8	30.8	31.2	31.2	31.5
	12.5–20,000	33.2	34.0	34.2	36.8	31.8	32.2	32.2	32.8
OLYM002 Third Beach Trail	20–1,250	25.2	26.9	28.3	32.8	24.9	26.5	27.1	29.9
	12.5–20,000	26.9	28.7	30.8	39.3	26.2	28.2	29.5	34.2
OLYM003 Hurricane Ridge	20–1,250	22.7	22.4	25.9	36.4	14.3	15.1	18.0	22.3
	12.5–20,000	24.0	23.7	27.0	37.1	17.3	17.7	19.8	23.0
OLYM004 Pyramid Mt Trail	20–1,250	30.9	30.6	33.1	37.3	29.0	29.5	30.3	32.0
	12.5–20,000	31.9	31.6	34.0	38.3	30.1	30.4	31.1	33.4
OLYM005 Lake Ozette	20–1,250	19.01	21.6	23.6	31.0	16.9	19.1	19.7	23.0
	12.5–20,000	21.2	23.7	25.6	32.6	19.0	20.8	21.2	24.3

Table 9 (continued). Exceedance levels for existing conditions at OLYM in the summer of 2011.

Site	Frequency (Hz)	Percentile levels ($L_{Aeq, 12hr}$): 0700 to 1900 hours (Day)				Percentile levels ($L_{Aeq, 12hr}$): 1900 to 0700 hours (Night)			
		LA_{90}	LA_{nat}	LA_{50}	LA_{10}	LA_{90}	LA_{nat}	LA_{50}	LA_{10}
OLYM007 North Fork Skokomish River Trail	20–1,250	40.1	40.4	40.4	40.9	39.8	40.0	40.1	40.3
	12.5–20,000	41.5	41.8	41.8	42.3	41.3	41.5	41.5	41.7

Table 10. Exceedance levels for existing conditions at OLYM002 in the winter of 2011–2012.

Site	Frequency (Hz)	Percentile levels ($L_{Aeq, 12hr}$): 1900 to 0700 hours (Night)				Percentile levels ($L_{Aeq, 12hr}$): 0700 to 1900 hours (Day)			
		LA_{90}	LA_{nat}	LA_{50}	LA_{10}	LA_{90}	LA_{nat}	LA_{50}	LA_{10}
OLYM002 Third Beach Trail	20–1,250	30.7	31.9	32.3	35.1	33.7	35.2	35.3	37.0
	12.5–20,000	31.0	32.3	32.6	35.3	34.3	35.6	35.7	37.4

Tables 11–14 report the percent of time that measured levels are above four key values during the monitoring period (daytime and nighttime). The top value in each cell focuses on the lower frequencies (20–1,250 Hz) affected by transportation noise and the bottom value shows the full frequency range measured at each location. Most motorized human-caused noise is confined to the truncated, lower-frequency range, while many natural sounds, including insects and birds, are higher in pitch. Therefore, the truncated range (20–1,250 Hz) is more appropriate for identifying impacts from anthropogenic noise in parks (Acoustical Society of America 2014). The first, 35 dB ($LA_{eq,1s}$), 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 in sleeping humans (Haralabidis et al. 2008). This background sound level recommended for listening comprehension in classrooms is also 35 dB (ANSI S12.60-2002). The second value addresses the World Health Organization’s recommendations that noise levels inside bedrooms remain below 45 dB ($LA_{eq,1s}$) (Berglund et al. 1999). The third value, 52 dB ($LA_{eq,1s}$), is based on the EPA’s speech interference threshold for speaking in a raised voice to an audience at 10 meters (EPA 1974). This threshold addresses the effects of sound on interpretive presentations in parks. The final value, 60 dB ($LA_{eq,1s}$), provides a basis for estimating impacts on normal voice communications at 1 meter. Visitors viewing scenic areas in the park would likely be conducting such conversations.

Increased sound levels may also have wide ranging effects on wildlife such as reduced predatory success (Mason 2015), changes in vocal communication, or increased vigilance by keystone species (Shannon et al. 2014). In a review of literature addressing the effects of noise on wildlife published

between 1990 and 2013, wildlife responses to noise were observed beginning at 40 dB ($LA_{eq, *}$).² Of the papers reviewed, 20% showed impacts to terrestrial wildlife at or below noise levels of 50 dB ($LA_{eq, 1s}$) (Shannon et al. 2016). Wildlife response to noise is found to be highly variable between taxonomic groups. With respect to the effects of noise on species of park interest, there is evidence that wildlife can suffer adverse behavioral and physiological changes from noise and other human disturbances but our ability to translate that evidence into quantitative estimates of impact by species and noise stimulus is presently limited (Shannon et al. 2014).

Table 11. Time above metrics for existing conditions in Olympic National Park in the summer 2010.

Site ID	Frequency (Hz)	Time above sound level (% of daytime hours, 07:00 to 19:00)				Time above sound level (% of nighttime hours, 19:00 to 07:00)			
		35 dB*	45 dB*	52 dB*	60 dB*	35 dB*	45 dB*	52 dB*	60 dB*
OLYM001 Hoh River Trail	20–1,250	27.74	0.31	0.04	0.00	1.13	0.01	0.00	0.00
	12.5–20,000	37.68	0.74	0.08	0.00	10.30	0.18	0.00	0.00
OLYM002 Third Beach Trail	20–1,250	16.53	0.91	0.06	0.00	1.73	0.13	0.00	0.00
	12.5–20,000	37.69	5.33	0.62	0.10	14.76	1.16	0.08	0.01
OLYM005 Lake Ozette	20–1,250	4.26	0.24	0.01	0.00	0.21	0.00	0.00	0.00
	12.5–20,000	6.66	0.51	0.04	0.00	0.54	0.04	0.00	0.00

* dB re 20 μ Pa

Table 12. Time above metrics for existing conditions in Olympic National Park in the winter 2010–2011.

Site ID	Frequency (Hz)	Time above sound level (% of daytime hours, 07:00 to 19:00)				Time above sound level (% of nighttime hours, 19:00 to 07:00)			
		35 dB*	45 dB*	52 dB*	60 dB*	35 dB*	45 dB*	52 dB*	60 dB*
OLYM001 Hoh River Trail	20–1,250	100.00	0.31	0.01	0.00	100.00	0.05	0.00	0.00
	12.5–20,000	100.00	0.85	0.03	0.00	100.00	0.80	0.00	0.00
OLYM003 Hurricane Ridge	20–1,250	5.19	0.68	0.14	0.01	2.49	0.26	0.00	0.00
	12.5–20,000	5.51	0.76	0.15	0.01	5.07	0.34	0.01	0.00
OLYM004 Pyramid Mt Trail	20–1,250	56.45	2.47	0.85	0.10	47.40	0.70	0.18	0.00
	12.5–20,000	98.05	3.27	1.02	0.21	86.31	0.94	0.19	0.00

* dB re 20 μ Pa

² This metric is a composite of multiple metrics with varying time averaging metrics.

Table 13. Time above metrics for existing conditions in Olympic National Park in the summer 2011.

Site ID	Frequency (Hz)	Time above sound level (% of daytime hours, 07:00 to 19:00)				Time above sound level (% of nighttime hours, 19:00 to 07:00)			
		35 dB*	45 dB*	52 dB*	60 dB*	35 dB*	45 dB*	52 dB*	60 dB*
OLYM001 Hoh River Trail	20–1,250	27.74	0.26	0.04	0.00	0.69	0.00	0.00	0.00
	12.5–20,000	45.22	1.09	0.16	0.01	5.35	0.18	0.00	0.00
OLYM002 Third Beach Trail	20–1,250	11.33	1.15	0.24	0.01	1.74	0.07	0.00	0.00
	12.5–20,000	32.29	4.66	0.45	0.03	15.10	2.18	0.18	0.00
OLYM003 Hurricane Ridge	20–1,250	12.95	1.53	0.20	0.03	1.91	0.21	0.02	0.00
	12.5–20,000	14.68	1.84	0.23	0.04	2.17	0.23	0.02	0.00
OLYM004 Pyramid Mt Trail	20–1,250	28.40	2.00	0.62	0.15	6.94	0.28	0.01	0.00
	12.5–20,000	37.68	2.92	0.74	0.15	14.96	0.37	0.06	0.00
OLYM005 Lake Ozette	20–1,250	7.52	0.42	0.06	0.00	0.22	0.00	0.00	0.00
	12.5–20,000	10.33	0.59	0.07	0.00	0.44	0.02	0.00	0.00
OLYM007 North Fork Skokomish River Trail	20–1,250	100.00	0.34	0.04	0.00	100.00	0.03	0.00	0.00
	12.5–20,000	100.00	1.34	0.13	0.00	100.00	0.36	0.00	0.00

* dB re 20 µPa

Table 14. Time above metrics for existing conditions in Olympic National Park in the winter 2011–2012.

Site ID	Frequency (Hz)	Time above sound level (% of daytime hours, 07:00 to 19:00)				Time above sound level (% of nighttime hours, 19:00 to 07:00)			
		35 dB*	45 dB*	35 dB*	45 dB*	35 dB*	45 dB*	35 dB*	45 dB*
OLYM002 Third Beach Trail	20–1,250	25.95	0.63	0.15	0.00	53.28	0.19	0.01	0.00
	12.5–20,000	28.09	1.01	0.19	0.01	60.14	0.78	0.04	0.00

* dB re 20 µPa

Audibility of noise sources

Identifying the percentage of time a noise source is audible is an important step in understanding the acoustic environment. Tables 15–27 show the mean percentage of time that natural and non-natural sound sources were audible by hour. These results represent the audibility of noise sources over a 24-hour day, averaged over 8 days. Non-natural sound sources are not highlighted and natural sound sources or artifacts that do not create noise are denoted by an asterisk (*) and highlighted in gray. Acoustic artifacts are caused by the presence of the acoustic equipment or staff in the field, therefore do not contribute to an increase in the acoustic environment calculation. When looking at Tables 15–27 many of the sound sources may seem redundant, for example “military jet” and “jet.” Noise sources characterized as something specific like military jet refer to a specific source when it could be defined by the listener. If a listener heard a jet, but could not determine if it was a military jet or a commercial jet they would choose the general “jet” option.

Table 15. Mean hourly time audible (%) for each sound source during summer 2010 at OLYM001. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Aircraft	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0.4	0	0	0	0	0	0	0
Jet	0	0	0.4	1.2	0.8	0	0.4	0.4	2.9	3.8	3.3	2.1	1.2	1.7	3.3	1.7	0.8	5	0.4	0.8	0.8	0	2.1	0
Military Jet	0.8	0	0	3.8	2.1	1.7	0.4	0.8	2.9	8.3	15	10.4	16.3	9.6	15	7.5	12.1	4.2	5	7.5	1.7	2.5	7.9	2.9
Prop Plane	0	0	0	0	0	0	0	0	1.7	0.4	1.7	4.2	1.2	0.4	0.8	2.5	0.8	0.8	0.8	0	0.8	0	0	0
Vehicles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0
Non-Natural Unknown	1.2	0	0.4	0	3.3	3.8	2.1	4.2	5	6.2	5.8	4.6	4.2	4.2	3.3	2.1	3.8	5	3.3	2.1	1.7	0	0.8	0
Wind*	0	0	0	8.7	0	0	0	0	0	0	0	1.7	7.1	14.6	25.4	33.3	48.3	36.2	27.9	6.7	3.8	1.2	0.4	2.1
Water*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0.4	0.4	0
Rain, Fog Drip*	12.5	8.7	2.5	12.5	12.1	2.5	12.5	7.9	0	2.1	5.4	0	3.3	7.5	2.9	12.5	2.5	2.1	0	1.2	1.7	8.3	12.5	12.5
Flowing Water*	100	100	100	100	100	100	100	100	100	95.4	93.3	100	100	100	87.9	87.5	87.5	87.1	87.5	87.1	87.5	87.1	86.7	87.5
Mammals*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0
Squirrel*	0	0	0	0	0	0	1.2	1.2	5.8	5.8	2.9	1.7	1.2	0.4	0	0.4	4.2	0	4.2	0	6.7	9.6	0	0
Birds*	5	1.7	4.2	6.7	60.4	100	100	100	100	100	100	100	99.2	94.6	76.2	66.7	73.8	77.9	80	81.7	79.2	50	4.2	5.8
Insects*	4.2	0	0	0	0	2.5	2.1	2.5	6.7	11.7	8.3	9.6	10.4	9.2	6.7	5	2.1	7.1	9.6	10	7.1	1.2	0.8	0
Animals*	0	0	0	0	0	0	0	1.7	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Other*	0	0.4	0.4	0.8	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0.4	0.4	0.8	0.8	0	0	0
Natural Unknown*	0.4	0.8	0.4	0.4	0	1.2	0.8	0	0	0.4	2.1	0	0.8	2.1	0.8	0.4	0.4	2.5	0.4	0.4	1.7	2.1	0.8	0.4
Static*	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0
Field Personnel*	0	0	0	0	0	0	0	0	0	0	1.2	4.2	0	1.7	0.8	0.4	0	0	0	0	0	0	0	0
Unknown*	0.4	0.8	0	0.4	3.8	19.2	24.2	22.9	24.2	25	25.4	21.2	13.8	9.6	2.5	2.9	1.2	1.7	1.7	7.1	10	12.5	0	0

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 16. Mean hourly time audible (%) for each sound source during winter 2010–2011 at OLYM001. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Aircraft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0.8	0	0	0
Jet	0	0	2.1	0	0	0	0	0	0.8	2.1	0.4	0.8	1.2	2.5	0	0.4	1.2	0.4	1.7	0	0.8	0.4	0	0
Commercial Jet	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0
Military Jet	0	0	0	1.2	0	0	0	1.2	1.7	1.7	4.2	4.2	5	9.6	3.8	1.7	0.8	0	2.1	0	0.4	0.4	0	0.8
Prop Plane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	3.3	0	0	0	0	0	0	0
Non-Natural Unknown	0	0	0	0	0	0	0	0.8	4.2	4.6	7.5	5	6.7	7.5	1.7	0.4	0	0.8	0.4	0.4	0	0	1.2	0
Wind*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4
Rain, Fog Drip*	75	75	75	75	75	75	75	75	75	75	75	74.6	75	75	75	75	75	74.6	64.6	62.5	63.8	62.5	65.8	74.2
Flowing Water*	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.1	62.5	62.5	62.5	62.5	62.1	62.1	62.5	62.5	62.5	62.1	62.5
Mammal*	0	0	0	0	0	0	0	0	0	0.4	2.9	1.7	0.4	0	0	0	0	0	0	0	0	0	0	0
Squirrel*	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.4	0.4	0	0	0	0	0	0	0	0	0
Bird*	0	0	0	0.4	0	0	0	7.1	35	18.3	26.2	31.7	21.2	39.6	31.7	37.9	19.2	0.4	0	0	0.8	0	0	0
Animals*	0	0	0	0	0	0	0	0	0	0	8.7	3.8	5	5.8	5.8	5	0	0	0	0	0.8	0	0.8	0
Natural Other*	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0.4	0	0.4	0	0	0	0	0	0
Natural Unknown*	1.7	2.1	1.7	1.7	5	3.8	3.3	4.2	13.8	10.4	7.5	11.7	12.5	12.1	12.9	7.5	6.7	1.2	4.6	1.7	2.5	3.3	3.3	2.5
Unknown*	0	0.4	0	0	0	0.4	0	0.4	0	0	0	0.4	0.4	0	0	0.4	0	0	0.8	0	0	0	0	0

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 17. Mean hourly time audible (%) for each sound source during summer 2011 at OLYM001. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Aircraft	0	0	0	0	0	0	0	0	0	0	0.8	0	0.4	0.8	0	0	0	0	0	0	0	0	0	0
Jet	0	0	0	1.7	0.4	1.7	0	1.2	4.6	6.2	8.3	5	7.9	12.9	1.2	2.5	0.8	1.7	2.1	1.7	1.2	0	0	0
Military jet	0	0	0	0	0	1.2	0.4	0.8	2.1	5	1.2	3.8	0.4	2.5	0	0	2.1	0.4	2.1	1.7	0	6.2	4.6	8.3
Prop Plane	0	0	0	0	0	0	0	0	0.4	3.3	2.1	2.1	2.5	1.7	1.2	0.8	1.7	0	0.4	2.1	0.4	0	0	0
Helicopter	0	0	0	0	0	0	0	0	0	0.4	0.4	0	0	0	0	0	0	0	0	0	0.4	0	0	0
Voices	0	0	0	0	0	0	0	0	0	0	0	0.4	0.4	0	0	0.4	0	0	0.4	0	0	0	0	0
Non-natural Unknown	0	0.4	0	0.4	0.8	0.4	1.2	0.8	0.8	4.2	5.8	6.2	9.2	5.8	6.2	8.3	9.6	6.2	1.7	3.8	2.1	0	2.1	2.1
Wind*	0	0	0	0	0	4.6	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind-Induced Nat*	30.4	30.4	31.7	33.7	38.3	11.3	10	12.9	7.9	5.8	5.4	4.2	12.9	40.8	47.9	57.5	52.5	40.8	22.9	15.4	15.4	21.7	22.5	23.7
Rain, fog Drip*	25	25	25	25	25	25	25	25	27.9	34.2	26.2	28.3	25	22.9	25	25	25	25	25.4	25	25	25	25	25
Flowing Water*	100	98.3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99.6	100	100	100	100	100
Thunder*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
Mammal*	0	0	0	0	0	1.7	3.8	2.1	0.8	2.5	3.3	2.1	0.8	0.4	0.4	0	0.4	1.2	0.8	0.4	0	0	0	0
Squirrel*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0.4	5.4	0	0	0	0
Bird*	0	1.7	0	1.7	4.2	85.4	98.3	99.6	97.1	97.9	96.2	96.7	93.3	82.1	60.4	62.9	56.3	70.8	60.8	60.8	49.2	8.7	1.2	1.2
Insect*	0	0	0	0	0	0.4	2.9	7.5	3.8	9.2	5.4	10.8	9.6	5	4.6	2.1	3.8	2.1	5.4	3.8	1.2	0	0	0
Animal*	0	0.4	0.8	0.4	0	2.1	0	0.4	0.4	1.2	0.8	0	0	0	1.7	0.8	1.2	0	3.3	7.9	0	0	0.4	2.5
Natural Other*	0	0	0	0	0	0	0	0	0.4	0	0	0	0.4	0	0	0	0.4	0	1.2	0	0	0	0	0
Natural Unknown*	0	0	0	0.4	0	0	0.4	0	0	2.5	0.4	0.4	0.8	0	0	0	3.8	0.8	0.4	0.4	0.4	0	0	0
Unknown*	2.5	0	0	0	0	0.8	1.7	0.4	0.8	0	1.2	2.1	3.3	0.8	4.6	6.7	2.1	3.8	2.1	1.7	6.7	2.5	0	0

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 18. Mean hourly time audible (%) for each sound source during summer 2010 at OLYM002. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Aircraft	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0
Jet	1.7	0.8	0	4.2	6.7	3.3	0.8	2.1	2.5	5	4.2	11.7	6.7	9.2	7.5	10	7.9	6.2	7.5	8.7	10	9.6	5	8.3
Military Jet	0	0	0	0	0	0	0	0	0	0	2.5	3.8	1.2	0	8.7	2.5	0	1.2	2.1	5.4	0	0.8	1.7	0
Prop Plane	0.4	0	0	0	0.8	3.3	0	0.8	2.9	1.7	2.1	2.5	3.3	1.2	6.7	2.9	2.5	6.7	2.9	1.2	1.7	5.8	1.7	6.7
Helicopter	0	0.4	0	0	0	0	0	0	0	1.2	0	8.3	8.3	0	5.4	7.1	5.8	0.8	7.5	0.8	0.4	0.4	0	0.4
Vehicle	0	2.1	1.7	3.3	2.5	3.8	5.4	7.1	10.4	16.3	7.1	2.5	6.2	5.4	9.2	10.4	12.5	14.2	8.3	7.1	14.2	12.9	11.3	2.5
Automobile	1.7	0.4	0.4	2.1	2.5	5	4.6	1.2	1.2	1.7	1.7	4.2	4.6	6.2	4.6	2.5	2.1	5	7.9	2.5	5.4	5	7.9	2.1
Horn Alarm	0	0	0	0	0	0	0	0.4	0	0.4	1.7	0	0	0	0	0	0	0.4	0	0.4	0	0.4	0	0
Motorcycle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.8	0	0	0	0	1.2	0	0
Truck	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0.8	0.4	0	0	0	0	0.8	3.8	0	0	0
People	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Voices	0	0	0	0	0	0	0	0.8	2.5	8.3	9.2	15	9.6	9.2	15.4	9.6	17.5	24.6	12.5	10.4	7.1	0.4	0.8	0
Walking	0	0	0	0	0	0	0.4	0.4	0	0.8	2.5	1.2	2.5	0.4	3.3	2.9	2.9	5.4	1.7	2.9	1.2	0	0	0
Gunshot	0	1.7	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0.4	0	0.4	1.7	1.2	2.5	3.3	7.1	0
Dog	0.4	0	0	0	0	0	0.4	0	0	0	0.4	0	0.4	0	0	0	0.4	0	0	0.4	0.4	0.8	1.2	2.5
Non-Nat Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.4	0.8	7.1	10.8	3.8
Non-Nat Unknown	28.7	17.1	27.1	25	32.5	31.2	34.6	24.6	24.6	27.5	20	11.3	15.8	17.9	18.8	17.9	23.7	25	14.6	25.4	35.4	31.2	25.4	31.7
Wind*	0	0.4	0	2.1	0.4	1.7	0.8	1.7	2.5	3.3	4.6	7.5	5	14.2	11.3	27.1	22.5	6.2	8.3	2.1	1.7	3.3	2.9	0.8
Wind-Induced Nat*	10	6.2	3.3	1.2	4.6	1.7	5.4	4.2	5	4.2	0.4	0	1.7	0.8	0	0.4	6.7	3.8	9.6	3.8	5.8	9.6	7.9	12.5
Water*	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0
Rain, Fog Drip*	8.3	10.8	20	32.1	30.8	25.4	23.7	12.9	25.4	28.3	25	24.6	16.7	17.5	12.9	17.9	7.9	10	5.4	9.6	10.4	7.1	14.2	12.5
Flowing Water*	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0
Waves*	100	99.6	100	99.6	99.2	99.2	99.2	100	100	95.4	79.6	82.5	90	90.4	85	94.6	98.7	96.2	96.2	92.5	94.2	99.6	96.7	97.5

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 18 (continued). Mean hourly time audible (%) for each sound source during summer 2010 at OLYM002. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Thunder*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.4
Mammal*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0.8	0	0	0	0	0	0	0	0
Squirrel*	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bird*	5.4	3.8	6.2	4.2	44.6	97.5	99.2	97.9	100	97.5	91.2	92.9	89.2	92.9	80.8	85.8	77.9	82.5	77.5	75	75.8	52.9	5	4.6
Insect*	0.4	0	0	0	0	0.8	0.4	1.2	2.5	4.2	5	7.1	3.8	4.6	6.7	7.9	3.8	2.1	5.4	4.6	2.1	0.8	0	0
Animal*	1.7	2.1	2.1	2.1	0.8	1.2	5.4	3.3	1.2	0	5	4.2	2.5	4.6	4.2	1.2	3.3	2.9	4.2	2.1	0	1.2	2.1	1.2
Natural Other*	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0
Natural Unknown*	14.6	21.7	15	11.7	9.6	2.1	8.3	6.7	6.2	5.4	5.4	3.8	7.5	9.6	9.6	12.5	3.3	1.2	2.1	4.2	4.6	5.8	7.9	11.3

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 19. Mean hourly time audible (%) for each sound source during summer 2011 at OLYM002. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Jet	0	0	0.4	1.7	5	1.7	0	2.5	12.5	9.6	5.8	12.9	10.8	4.2	8.7	10	7.1	11.7	5	8.3	9.2	7.1	11.3	6.2
Military Jet	0	0.4	0	0	0	0	0	0	1.2	0	3.3	3.8	3.8	5.8	0	5.4	0	0	3.8	3.8	0.4	0.8	2.9	0
Prop Plane	0	0	0	0	0	0	0	0	0	0.8	1.7	1.7	5.4	4.6	0.8	2.1	0	0	1.7	0	0	0	0	0
Helicopter	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	1.2	0	0	0	0	0	0	0	0
Vehicle	2.9	2.5	0	0	2.5	1.7	2.1	3.3	2.5	3.3	2.1	3.8	0.8	2.1	1.2	1.7	0	0	0.8	2.9	3.3	2.1	2.5	0.4
Alarm Horn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0.4	0
Brakes	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
Grounds Care	0	0	0	0	0	0	0	0	0	0	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0
People	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Voices	0	0	0	0	0	0	0.4	0.8	0.8	2.1	5.4	8.3	5	8.3	7.5	6.2	6.7	7.5	5.8	2.5	1.7	0	0	0
Walking	0	0	0	0	0	0	0	0.8	1.2	5	4.2	8.3	5.8	6.2	9.2	6.7	5	4.6	5.8	2.5	1.2	0	0	0
Portable Audio	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0.4	0	0	0	0	0	0	0	0
Dog	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	2.1	2.1	0	0
Non-Natural Unknown	13.8	20.8	14.6	19.6	14.6	15	33.3	30.8	31.2	24.2	29.6	18.8	23.7	20	12.5	15.8	14.2	23.3	26.2	24.6	11.3	13.8	14.6	8.3
Wind*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	3.3	1.7	0	0	0	0	0	0	0
Wind Induced Natural*	27.5	25.8	27.9	25.4	14.2	2.9	3.3	8.3	5.4	7.1	11.7	16.3	25.8	27.5	29.6	39.2	37.5	26.2	17.5	6.7	8.3	12.1	27.9	30.8
Rain, Fog Drip*	12.5	21.2	28.7	29.2	26.2	31.7	37.5	37.9	37.5	37.5	37.5	37.5	32.1	23.3	17.5	22.5	16.7	14.6	20.4	25	15.8	12.5	23.7	25
Waves*	100	91.7	87.1	87.1	87.5	87.5	87.5	86.2	86.2	86.7	81.7	84.6	84.6	87.1	86.2	78.3	82.1	87.9	92.9	96.2	95.4	97.9	98.3	99.6
Mammal*	0	0.4	0	0	0	2.1	3.8	5.8	1.2	4.6	5.4	6.2	8.3	7.9	7.5	2.5	3.3	5	0.4	0.8	0.4	1.2	0	2.1
Squirrel*	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0
Bird*	1.7	0.8	2.5	0.8	51.3	99.6	97.5	95.8	92.9	96.2	94.2	98.3	97.1	90.4	83.7	83.3	71.3	83.7	80.8	83.7	84.2	60.8	2.1	0.8
Insect*	0.4	0	0	0	0	2.9	6.2	10.8	12.1	23.7	19.2	21.2	10	14.6	7.1	7.5	11.3	13.3	13.8	14.6	15.8	5	0	0
Animal*	0.8	0.8	0.8	0	0.4	0	0	0	0	0.8	0	0	0	0.4	0	0	0	0	0	0.4	0.4	0	0	0.4
Natural Other*	11.3	10.8	6.2	3.3	0.8	0	2.5	0	0.8	2.1	2.5	3.3	5.4	7.1	12.1	10.8	9.6	2.9	1.2	4.2	3.3	4.2	1.7	1.7
Natural Unknown*	0	0	0.4	0	0	0.4	1.2	1.2	1.2	1.2	1.2	0.4	0.8	0	0.4	0.8	0	0.4	0	0	0	0.4	0	0

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 20. Mean hourly time audible (%) for each sound source during winter 2011–2012 at OLYM002. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Jet	0	0	0	0	0.8	0	0	0	0	0.4	2.5	2.5	3.3	2.1	2.5	2.1	0.4	1.7	0.8	0.4	0	0	0	0
Military Jet	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0.4	0.8	0	0	0	0	0	0	0	0	0
Prop Plane	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.8	0	0.4	0	0	0	0	0	0	0	0
Helicopter	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0
Vehicle	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0.4	0.4	0	0	0	0	0
Watercraft	0	0.4	0	0	0	0	0	0	0	0	0	1.7	0.8	3.3	3.8	1.2	2.9	0.4	0	0	0	0	0	0.4
Voices	0	0	0	0	0	0	0	0	0	0	0.8	1.2	1.2	2.1	0.4	1.2	0.4	0	0	0	0	0	0.4	0
Walking	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0.8	0.4	0.4	0.4	0	0	0	0.4	0	0	0
Dog	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0.4	0.4	0	0	0	0	0
Non-Natural Unknown	10.8	15.4	10.4	12.5	12.5	16.7	20.4	25.4	15	14.2	14.6	12.9	15	11.7	12.1	5.8	8.3	12.9	13.3	11.7	7.5	7.5	5.4	11.7
Wind*	0	0	0	0	0	0	0	0	0	0	2.1	2.5	3.8	3.8	3.8	4.2	5.8	1.2	3.3	2.9	1.2	0.8	0.4	0
Wind-induced Nat*	0.8	9.6	17.1	7.9	8.7	7.5	10	7.9	13.3	15.8	14.2	14.2	15.8	25.4	22.1	22.1	17.1	16.7	18.8	9.2	18.8	14.6	10.4	2.9
Rain, fog Drip*	62.5	62.5	61.7	62.5	62.5	62.5	62.1	60	52.5	50	49.6	43.8	37.1	27.9	25	25	25	27.1	32.9	36.2	35.8	37.5	38.3	42.1
Waves*	100	100	100	100	99.6	100	100	100	100	100	100	100	99.6	99.6	100	100	99.6	100	100	100	100	100	100	99.6
Mammal*	0	0	0	0	0	0	0	1.2	2.5	0.4	0.4	0.8	1.2	2.1	1.2	0	0.4	0	0	0	0	0	0	0
Bird*	0	0	0	0	0.4	0.8	1.2	7.1	37.9	27.9	38.8	38.3	32.5	30.8	35.4	25.4	12.1	0	0.4	0.4	0	0.4	0.8	0.4
Animal*	0	0	0	0.4	0	0	1.7	0.8	1.2	5.8	8.3	6.2	6.7	3.8	7.1	8.3	2.9	0.4	0.8	0.4	1.7	0.4	1.2	0.4
Natural Unknown*	0	0	0	0	0	0.4	0	3.8	2.1	3.8	7.1	7.9	5.4	1.7	4.6	5.4	3.8	6.7	2.9	0.4	0.4	0.8	0.4	0.4

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 21. Mean hourly time audible (%) for each sound source during winter 2010–2011 at OLYM003. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Jet	2.5	2.5	4.2	2.9	1.2	5.4	13.8	12.1	12.5	15	10	15.4	20.8	34.2	20	17.1	11.7	13.3	10	20.4	6.2	13.3	8.7	2.9
Prop Plane	0	0	0	0	0.4	1.2	0	0	0	0	2.1	1.2	0	0	0.8	0.8	1.7	0	0	1.7	0	0	0.4	0
Helicopter	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0.8
Vehicles	0	0	0	0	0	2.1	1.7	13.8	14.6	16.7	9.6	9.6	4.2	3.3	9.6	8.7	3.8	1.2	0	0.4	0	0	0	0
Alarm, Horn	0	0	0	0	0	0	0.8	6.2	0	0	0	0.8	0.4	0	0	0	0	0	0	0	0	0	0	0
Auto Door	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0.4	0	0.4	0	0	0	0	0	0	0
People	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Voices	0	0	0	0	0	0	0	0	0.8	5.8	30.4	37.5	42.1	49.6	46.3	37.5	13.8	1.2	0	0	0	0	0	0
Walking	0	0	0	0	0	0	0.4	0	0	1.7	19.2	28.3	19.2	22.9	22.9	18.3	9.2	0.4	0	0.8	0.4	0	0	0
Non-Nat Other	0	0	0	0	0	0	0	0	0	0	0	1.2	1.2	0.4	0	0	0.8	0	0	0	0	0	0	0
Non-Nat Unknown	2.1	0	0	0	0.8	3.3	4.6	11.7	9.6	10.4	9.6	12.5	2.5	4.2	1.7	3.8	3.3	5.8	2.5	3.3	0	0	0.4	0
Wind*	14.2	4.6	5.4	7.5	9.6	9.2	10	4.2	1.7	1.7	0.8	2.9	7.9	5.4	7.1	8.3	4.6	4.6	0.4	3.3	5	5.4	3.8	2.5
Wind-induced Nat*	73.3	80.8	87.1	86.2	87.9	81.7	86.7	86.2	85.8	77.1	77.1	80	75	65	65.8	83.7	85.4	92.5	90.8	80.4	83.7	84.6	87.5	76.2
Rain, Fog Drip*	33.7	32.1	47.5	47.1	62.9	47.9	55.4	48.3	35.4	44.2	28.7	27.9	30.4	22.5	24.2	26.2	30	32.5	39.6	37.1	32.5	40.4	41.3	32.9
Birds*	2.1	3.3	9.2	9.2	2.9	1.2	0	6.7	10	19.6	16.3	12.9	17.5	9.6	12.1	9.2	5.8	2.5	0	0	0	0	0	0
Natural Other*	0.4	0.4	7.9	1.2	8.3	4.2	0.4	2.1	11.3	1.7	1.2	0	1.7	2.1	1.2	2.9	5.8	8.3	9.6	9.6	6.2	0	0.8	0
Natural Unknown*	0	3.8	0	0	0	0	0	0.8	0	0.4	0	1.2	0.8	0	0.4	0.8	0	0	0	0	0	0.4	0	0
Artifacts*	0	0	0	0	0.4	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind Distortion*	1.7	0.4	0.4	0.4	0.4	0	0	0	0	0	0	0.4	0.8	1.7	1.2	2.9	1.7	0.4	0	0	0	0.4	0	0
Unknown*	6.2	5	1.2	3.8	2.9	2.1	0.8	0.4	0	0	0.4	0.4	0	0	0	0.4	1.2	0.4	0.4	1.7	2.9	0.8	4.6	5.4

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 22. Mean hourly time audible (%) for each sound source during summer 2011 at OLYM003. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Jet	5.4	0	5.8	2.1	1.7	1.2	14.2	17.9	16.7	15.4	35.8	27.5	12.9	18.3	25	21.2	22.5	9.6	11.7	17.5	18.8	26.7	5	5.8
Prop Plane	0	0	0	0	0	0	0	4.2	1.7	2.1	2.5	2.9	1.2	2.1	4.2	2.1	0.4	1.7	0.4	3.3	0	0	0	0
Vehicle	2.9	0.4	0	0	0	2.1	3.8	8.7	15	37.1	44.6	53.3	64.2	59.6	54.2	38.3	48.8	50.4	37.5	31.2	27.5	6.7	10	2.9
Alarm, Horn	0	0	0	0	0	0	0	0	0	0.4	0.4	0.4	0	0.4	0.8	0	0	0	0.8	0.4	0	0	0	0
Auto Door	0	0	0	0	0	0.4	2.5	2.9	6.7	15.8	12.9	14.6	16.7	12.9	5.4	7.1	9.6	14.2	18.8	11.7	12.5	6.2	7.9	0
People	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.4	0.4	0	0.4	0.4	0	0	0
Voices	0	0	0	0	0	0	0.4	0.8	0.4	0.4	2.9	5.8	5	9.2	9.6	10.4	8.7	6.2	3.8	5.4	9.2	22.1	10	0
Walking	0	0	0	0	0	0	0	0	0	0.4	1.2	1.7	0.8	2.1	0.4	1.2	2.5	2.5	0	2.5	2.9	0.4	0.4	0
Dog	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0.4	0.4	0	0.4	0	0
Non-Natural Unknown	40.4	41.7	21.2	23.3	26.7	16.7	17.9	15.4	10	11.3	2.9	3.8	3.3	3.3	14.2	45	23.3	28.7	32.1	30.4	30.4	29.2	36.2	40
Wind*	0	0	0	0	0.8	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0.4	0
Wind-induced Nat*	18.3	9.6	11.3	13.3	15	13.8	12.1	12.1	12.9	12.9	12.9	12.5	12.5	15	15.8	14.2	17.5	15	8.3	3.3	1.2	9.6	10.8	11.3
Rain, fog Drip*	0	0	0	0	0	0	0	0	1.2	12.1	4.6	9.2	8.7	11.7	12.1	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Flowing Water*	100	100	100	100	100	100	99.6	100	99.6	97.9	100	98.7	100	99.6	99.6	98.7	98.7	99.6	99.6	97.9	100	98.3	99.2	99.6
Mammal*	0	0	0	0	0	0	1.7	3.3	1.7	6.2	10	1.7	4.2	4.6	0.4	0.4	1.2	7.9	8.3	4.2	0	0	0	0
Bird*	2.5	5	4.2	1.7	2.9	5.8	52.9	68.8	58.3	52.1	54.2	48.3	46.3	48.8	39.2	32.1	39.2	40	37.5	47.9	20.4	2.9	2.1	2.1
Insect*	0	0.4	0	0	0	4.2	68.8	75	82.1	78.7	68.8	68.3	61.7	57.9	58.3	53.8	52.5	52.5	55	52.1	25.8	0	0	0
Animal*	0	0	0.4	0	0.8	0.8	4.2	3.3	4.6	1.2	0.8	1.2	0.8	0.8	0.4	0.8	2.1	0.8	3.8	2.9	6.7	1.7	0	0.8
Natural Unknown*	0	0.4	0.8	0.4	0	2.1	1.7	0.4	0.4	0	1.2	0.4	0.8	0	0	0	0.4	0.4	0	0.4	0.4	0.8	1.7	0.8

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 23. Mean hourly time audible (%) for each sound source during winter 2010–2011 at OLYM004. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Jet	0	2.5	0.4	0.4	0.8	0	2.5	2.1	2.1	4.6	6.2	3.8	5.8	10.4	7.1	1.7	0.8	2.9	3.3	5	0.4	3.8	1.7	0.4
Military Jet	0	0	0	0	0	0	0	0	0.8	0	0	0	1.2	2.5	0	0	0	0	0	0	0	0	0	0
Prop Plane	0	0	0	0	0	0	0	0	0.8	0	0	0	1.2	0.8	0	0.8	0	0.8	0	0.4	0.4	0	0	0
Helicopter	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0.4	0.4	0	0	0	0	0	0	0	0
Vehicle	11.3	7.1	12.9	27.1	26.2	48.3	59.2	62.1	64.6	62.5	65.4	74.6	65	65	72.5	70.8	67.5	60	60.4	53.3	39.6	25.4	17.5	13.3
Automobile	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brakes	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0
Motorcycle	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Truck	0	0	0	0	0	1.7	2.1	1.7	1.2	0	2.1	0	0.8	0.8	0	1.2	0	0	0	0	0	0	0	0
Watercraft	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0
Voices	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0.4	0	0	0	0	0	0	0	0	0	0
Walking	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0
Non-natural Unknown	2.5	0.4	1.2	0	0	1.2	0	1.2	0.4	1.7	0.4	0	0.4	0.8	0.4	0	0	1.2	0	0	0.4	0.4	0	0
Wind*	0.4	0	0	0	0.4	0	0	0	1.7	0.4	2.5	0.8	0.4	0	0	1.7	5.8	4.2	1.2	3.3	4.2	1.2	2.9	2.1
Wind-induced Nat*	1.7	0	2.5	2.1	3.8	4.2	10	7.1	9.6	15.4	14.2	13.3	32.1	17.9	25.8	36.2	45.4	27.9	30	28.3	35.4	26.2	20.4	11.3
Rain, fog Drip*	27.5	27.1	25	25	25	27.1	28.7	21.7	25.4	20.4	18.8	11.3	24.6	31.2	37.1	23.7	45	42.5	31.2	30.4	32.5	17.5	14.6	14.6
Flowing Water*	100	100	100	100	100	100	100	99.6	100	99.6	100	100	100	100	100	100	99.6	100	100	100	100	91.2	87.5	87.5
Bird*	0	0	0	0	0	0	0.4	18.8	22.9	13.8	22.1	17.1	10	13.8	10.4	10.8	9.2	4.6	0	0	0	0	0	0
Animal*	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0
Natural Other*	0.4	0	0	0.4	0.4	0	0	0	0.4	1.2	3.3	10.4	0.4	0.4	0.4	0	0.8	0	0	0	0	0.8	2.5	0.4
Natural Unknown*	0	0	0	0	0	0	1.2	0	0	0.8	0.4	0.4	0	0	0.4	0	0.4	0	0.4	0	0.4	0	0	0.4

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 24. Mean hourly time audible (%) for each sound source during summer 2011 at OLYM004. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Jet	0.8	0	2.5	5	0.4	0.4	0.8	0.8	5	5	8.7	5	4.6	12.9	9.6	8.7	7.5	2.5	5	7.1	5.4	3.3	4.6	0.8
Prop	0	0	0	0	0	0	0	0	1.2	1.7	0	0	2.9	0	0.4	0	0	0	0	0	0.4	0	0	0
Helicopter	0	0	0	0	0	0	0	0	0	0.8	0	0.8	0	0	0	0	0.8	0	0	1.7	0	0	0	0
Vehicle	27.9	15.8	27.9	37.9	44.6	59.6	76.2	77.5	74.6	72.1	81.7	85.8	84.6	82.5	84.2	87.5	82.5	70.8	73.3	59.6	54.6	42.5	30.8	28.3
Alarm, Horn	0	0	0	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0
Brakes	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0
Truck	0	0	0	0	0	0	0	0	0	0.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0
Watercraft	0	0	0	0	0	0	0	0	0	0.4	0	0.4	0.4	1.2	0	0	0	0	0	0	0	0	0	0
Voices	0	0	0	0	0	0	0	0	0	0.8	2.5	2.9	3.3	8.3	2.9	0.8	1.2	0.4	0	0	0	0	0	0
Walking	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0.8	0	0	0	0	0	0	0	0	0	0
Dog	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0
Non-natural Unknown	1.7	1.7	0	0	0.4	0.4	1.2	0.8	0.4	3.3	0	0.8	3.3	3.3	0.8	0.4	1.2	0.8	1.2	0.4	0.4	0.4	1.2	0
Wind*	0	0.8	0.4	0	0	0	0	0	0	0	0.4	1.2	0.4	1.2	1.7	0	0	0.8	0.4	0	0	0.4	0.8	0.4
Wind-induced Nat*	14.2	14.2	14.2	15	19.6	11.7	5.8	5	4.6	8.3	12.5	14.6	12.9	12.5	11.3	12.1	18.3	8.3	6.2	8.7	9.2	12.5	10.4	12.1
Rain, fog Drip*	75	75	75	75	77.1	58.8	60.4	42.9	36.2	35.8	30.8	27.1	30.8	29.2	27.1	37.1	40	39.2	38.3	49.2	50.8	48.3	77.9	77.9
Flowing Water*	100	100	100	100	100	100	100	100	98.7	99.6	99.2	99.6	100	98.7	99.2	100	96.7	100	99.2	97.9	99.2	99.6	98.7	99.6
Thunder*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0
Mammal*	0	0	0	0	0	0	0	0	0	0	0.4	0	0.4	0	0	0	0	0	0	0	0	0	0	0
Bird*	0	0	0	0	30.8	96.2	87.5	83.3	83.7	82.9	82.5	89.2	77.9	81.2	71.7	61.3	47.9	52.9	47.9	62.9	53.8	21.7	0	0
Insect*	0	0	0	0	0	0.8	2.1	0.8	5.8	6.2	4.6	9.2	12.1	10	9.2	4.2	2.1	4.6	2.5	1.2	0	0	0	0
Animal*	0	0	0.4	0.4	0	0	0.4	0.8	1.7	0.4	0.4	0	0.4	2.1	0.4	0	0.4	0.4	0.4	0.8	0	2.5	0	0
Natural Other*	0.4	0	0	0	0	0	0.4	0	0.4	0	0	0	0	0	0.4	0	0	0	0	0	0.4	0.8	0	0.4
Natural Unknown*	0	0	0	0	0	0	0	0	0.4	0.8	0.8	0	2.5	0.4	1.2	1.7	0.8	0.8	0.8	0.8	0.4	2.9	0	0.4

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 25. Mean hourly time audible (%) for each sound source during summer 2010 at OLYM005. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Aircraft	4.6	0.8	0.4	7.1	11.7	5.8	0.8	1.2	6.2	6.7	8.3	5.4	4.2	8.7	5.4	14.6	2.5	8.7	8.7	12.9	6.2	8.3	3.3	5.8
Prop Plane	0	0	0	0	0	0	0	0	0	0	0	0	0.4	1.7	0	0	0	0	0	0	0	0	0	0
Helicopter	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	1.7	0	0	0
Automobile	0	0	0	0	0	0.4	7.1	10.8	12.1	12.5	15.8	20	25	15.8	20.8	17.1	12.1	18.3	2.1	0.8	0.8	0	0	0
Watercraft	0	0	0	0	0	0	0	0	0	0	2.5	5	7.1	2.9	0	2.9	10.8	8.7	4.6	2.5	0.4	0.4	0	0
Voices	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0
Non-natural Unknown	0.4	0.4	1.7	0	4.6	4.2	16.7	10	15	17.5	12.1	7.1	7.1	4.6	7.1	5.8	2.1	10.8	7.9	3.3	3.3	2.5	0.8	1.7
Wind*	0	0	0	0	0	0	0	0	0	0.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind Induced Natural*	29.2	34.2	31.7	16.7	20	29.6	6.7	3.3	10	15.8	16.7	18.3	22.9	34.6	36.2	30	33.3	24.2	25.4	20.4	15	13.8	19.6	20.8
Rain, fog Drip*	60	58.3	60	62.1	54.2	54.6	51.7	50	43.8	42.9	28.3	29.6	34.6	38.3	40.4	39.2	32.5	30	35	26.2	28.7	32.1	35.8	37.9
Waves*	98.7	100	100	99.2	99.6	100	100	100	99.2	99.6	99.6	99.6	92.9	94.6	100	97.9	99.6	100	100	99.6	99.6	100	100	99.6
Mammal*	0	0	0	0	0	0	2.9	4.6	1.7	0	1.2	0.8	0	0	0	0.4	0	0.8	3.3	0.8	1.7	0	0	0
Birds*	3.8	0	0	0.8	0	16.7	72.9	82.9	79.2	75.8	76.7	77.9	69.6	53.8	53.8	52.9	53.8	46.3	55.8	48.8	24.6	2.9	0	0
Amphibians*	42.9	27.1	13.3	8.3	3.3	3.8	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	2.9	51.7	66.3	59.6
Insects*	0	0	0	0	0	2.5	18.3	9.6	5.4	8.3	9.2	7.1	4.6	2.9	4.6	6.2	2.5	5.8	4.6	5	8.3	1.2	0	0
Animals*	0.8	0.4	0.4	0	0	1.7	1.7	0.4	0.4	2.5	5	1.2	3.3	1.2	0	0.4	0	3.8	0	1.2	0.4	0.8	1.7	3.3
Natural Other*	0.4	0	0	0	0.8	0	1.7	2.1	0.4	0	0.8	0	0	0	0	0	0	0	0.8	0.8	0.4	0.4	0.4	0.4
Natural Unknown*	1.2	0.4	0	0	0	0.4	0.8	2.9	0.8	0.4	0.4	2.9	1.2	0	0	0.4	0	0	1.7	0	2.5	0.4	4.2	5.8
Artifacts*	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0.4	0	0
Unknown*	0	0	1.2	0.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 26. Mean hourly time audible (%) for each sound source during summer 2011 at OLYM005. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Jet	5	2.1	2.1	0.4	11.7	4.6	1.2	2.5	10.8	5.8	16.7	7.5	6.7	9.2	5.4	5.8	2.5	3.8	8.3	15.4	6.7	3.8	6.2	8.7
Prop	0	0	0	0	0	0	0	0	0.4	1.7	0	0.8	0	0	0	2.1	0.8	2.5	0	0	1.7	0	0	0
Helicopter	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0.8	0.8	0	0	0	0	0	0	0
Vehicle	0	0	0	0	0	0	2.5	11.3	8.7	12.1	7.1	9.2	13.3	9.6	15	9.2	9.2	13.8	10	3.8	2.9	3.3	0	0.8
People	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0.4	0	0	0
Voices	0	0	0	0	0	0	0	0	0	4.6	3.3	6.2	3.3	4.6	3.3	0.4	3.8	2.1	6.2	6.7	8.3	1.2	0	0
Dog	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0.4	0	0	0	0	0	0	0	0	0	0
Non-natural Other	0.4	1.2	0	0	0	0	0	0	0	1.7	0.4	0	0	0	0	0	0.4	0.4	0	0	0	0	0	0
Non-natural Unknown	2.1	1.2	2.1	5.8	10.8	9.2	24.6	32.5	16.3	9.6	9.2	6.2	13.8	13.8	12.9	9.2	3.8	15.4	8.3	9.6	11.7	4.2	7.9	12.1
Rain, Fog Drip*	40.8	39.6	41.3	52.1	48.8	44.6	37.1	37.1	37.5	37.9	43.3	51.7	48.8	62.5	65	55	43.8	36.7	36.2	37.1	36.7	51.3	57.1	52.1
Waves*	100	100	100	100	99.6	99.6	100	100	100	100	98.7	99.6	100	99.2	100	100	99.6	99.6	100	99.6	100	100	96.2	100
Mammals*	0	0	0	0	0	0	5	5	4.2	5	3.8	2.1	2.9	1.2	0	0.4	0	1.2	0.8	0.4	1.2	0.4	0	0
Birds*	0.4	1.2	0.4	0.4	0.8	30.4	91.7	93.7	94.2	90.4	88.7	73.3	71.3	60	41.3	39.6	48.8	27.9	35.4	34.6	17.1	2.1	0.4	0.4
Amphibians*	54.2	35.4	9.6	3.3	3.3	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25.4	53.8	42.1
Insects*	0	0	0	0	0	4.2	45.4	39.2	47.5	36.7	30.8	17.5	30.8	21.2	5	3.8	4.2	2.9	6.7	10.8	5.8	0.8	0	0
Animals*	0.8	1.2	0	0.8	0	0.8	0	5	2.1	0.4	0	0.4	0	0	0	0.4	0	1.7	2.5	0.8	1.2	0.4	0.8	0
Natural Other*	0	0	2.1	0	0	1.7	0	0	0.4	0.4	0.4	0	0	0	0	0	0.8	0	0	0	0	0.8	0	0
Wind-induced Nat*	3.8	5.4	6.7	7.1	1.7	4.2	1.2	0	0.4	5.8	11.3	10.8	14.2	41.3	52.1	57.9	50.4	36.2	17.9	5.4	1.7	5.8	2.9	9.6
Natural Unknown*	0	0	0.4	0	0.8	0	0.8	0.4	0	0	0	1.2	0.4	0	0	0	0	0	0	0.8	0	0	0	0
Artifacts*	0	0	0	0	0	0	0	0	0.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown*	2.5	2.5	0.4	1.2	0.4	0.4	0	2.5	3.8	1.2	0.4	0	0	0	0	0.4	0	0	0.4	0.4	0.4	1.7	0	0

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Table 27. Mean hourly time audible (%) for each sound source during summer 2011 at OLYM007. N=8 days off-site sound source analysis.

Sound Source	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
Jet	0	0	0	0	0	1.7	2.5	1.7	1.7	2.5	4.6	7.9	6.7	9.2	5.8	2.1	7.9	5.8	3.8	3.8	0	3.8	1.7	0.8
Military jet	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0.4	0	0	0	0	0	0	0	0	0
Prop Plane	0	0	0	0	0	0	0	0	0	0.4	1.7	0	0.8	0.8	0	0	0.4	0.8	0	0.4	0.4	0	0	0
Voices	0	0	0	0	0	0	0	0	0.8	0.4	0.4	2.1	2.5	2.5	2.9	1.7	1.7	2.5	0.8	1.2	0.4	0	0	0
Walking	0	0	0	0	0	0	0	0	0.8	0	0.4	0.8	1.7	0	2.1	0	0.4	0	0.4	0.8	0.4	0	0	0
Non-natural Unknown	0	0	0	0	0	0	0.8	0	0.4	0	6.7	0.4	4.2	6.7	5	2.5	0.8	2.1	0.8	0.8	0	0.4	0	0
Wind*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0
Wind-induced Nat*	0	0	0	0	0	0.4	0	0	0	0	1.2	0	0.8	8.3	5.8	3.8	1.2	2.1	2.9	0.8	0	0	0.4	0.4
Rain, fog Drip*	10.4	4.2	5	5.4	4.2	0.4	0.4	0	0	0	0.8	1.2	0	0	0	0	0	0.4	10.8	9.6	3.8	12.5	12.5	12.5
Flowing water*	99.6	100	100	100	99.6	99.6	100	100	100	100	100	100	100	100	99.2	98.7	100	100	99.6	100	100	100	100	100
Waves*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	1.2	0	0	0	0	0	0	0	0
Mammals*	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Squirrel*	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bird*	0	0	0	0	4.2	87.5	96.7	85	77.9	78.7	74.2	66.7	65.8	50.4	57.5	52.9	47.1	32.1	42.1	42.5	40	2.5	0	0
Insect*	0	0	0	0	0	0	0	0	0	0	0.8	0.4	0	0.4	1.2	0.8	0	0	0	0	0	0	0	0
Animals*	0	0	0	0	0	0	0	0.4	1.2	0.8	0	1.7	0.4	0.8	0.8	0.8	1.7	1.7	0	0.4	0.4	0.4	0	0.4
Natural Other*	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Unknown*	0	0	0	0	0	0	0	0	0.4	0	0	0.4	0.4	0	1.7	0.8	1.7	1.7	0	0	0	0	0	0
Field Personnel*	0	0	0	0	0	0	0	0	0	0	0	2.5	2.5	0	0	0	0	0	0	0	0	0	0	0
Unknown*	0.4	0	0	0	0	0	0	0	0	1.2	0.8	0	0	0.4	0	0	0	0	0	0	0	0	1.2	0

* Natural sound sources or artifacts that do not contribute to noise, also shown highlighted in gray.

Figures 15–27 also show hourly audibility results. These graphs show overall noise audibility for each hour and display how much the two most common motorized noise sources contribute to that audibility. The results show that aircraft is a major contributor of daytime noise at all sites, while vehicles and watercraft are also common sources of noise. The categories of noise sources represented in these figures refer to all types of aircraft and not one specific type, so in these plots, aircraft includes all jets, military jets, propeller planes and helicopters heard at a site. The same principle applies to vehicles too.

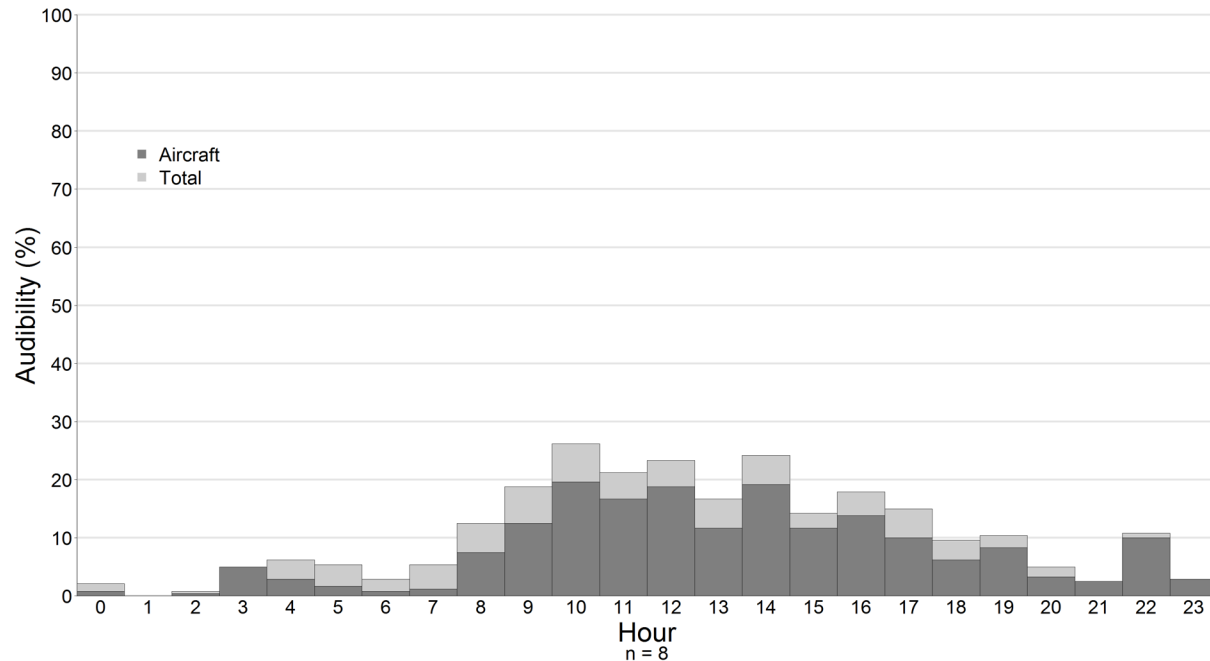


Figure 15. Hourly aircraft audibility and overall noise audibility at OLYM001 during the summer of 2010.

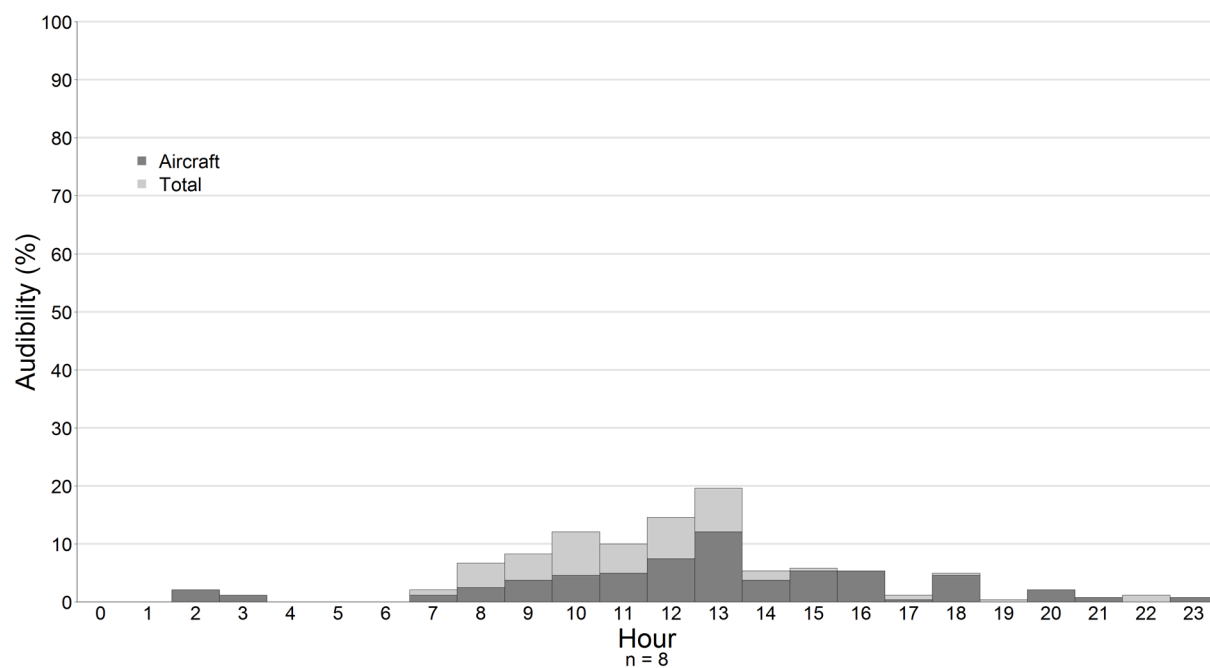


Figure 16. Comparison of hourly aircraft audibility and overall noise audibility at OLYM001 during the winter of 2010–2011.

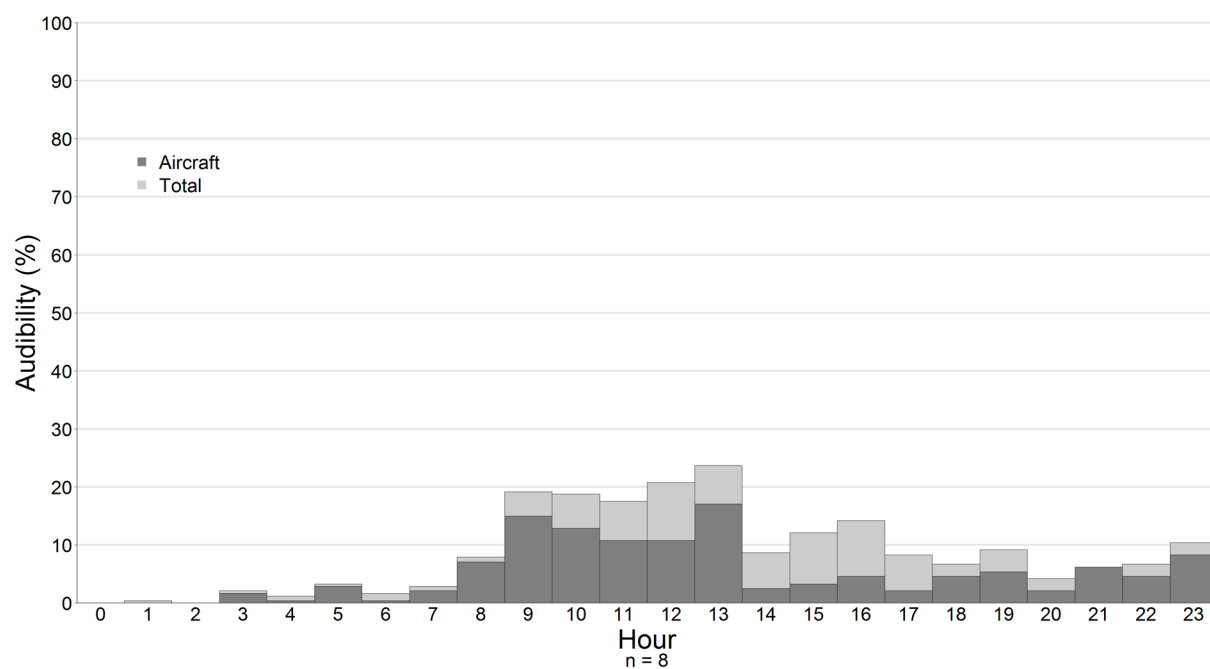


Figure 17. Comparison of hourly aircraft audibility and overall noise audibility at OLYM001 during the summer of 2011.

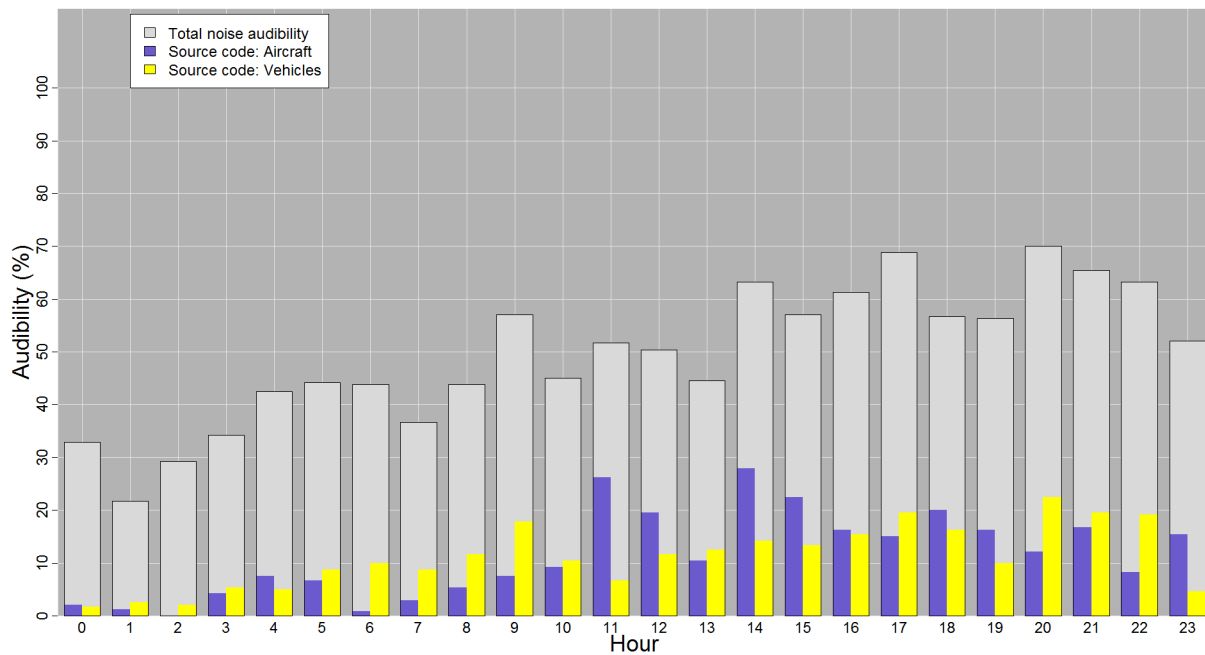


Figure 18. Comparison of hourly aircraft and vehicle audibility and overall noise audibility at OLYM002 during the summer of 2010.

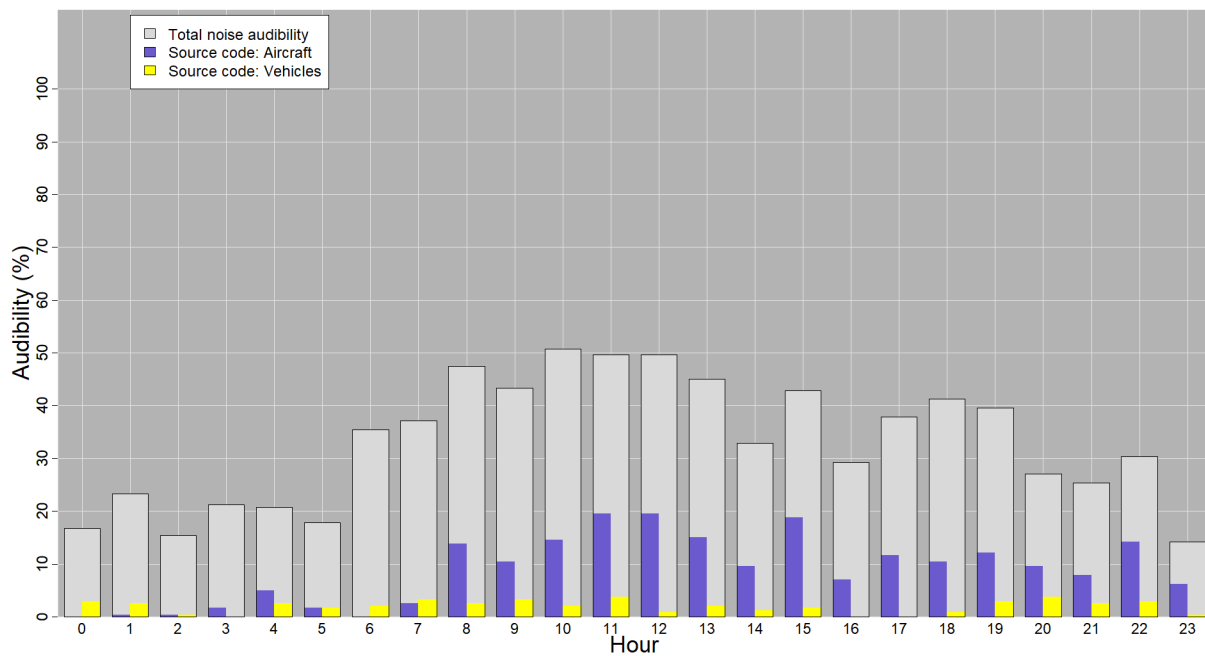


Figure 19. Comparison of hourly aircraft and vehicle audibility and overall noise audibility at OLYM002 during the summer of 2011.

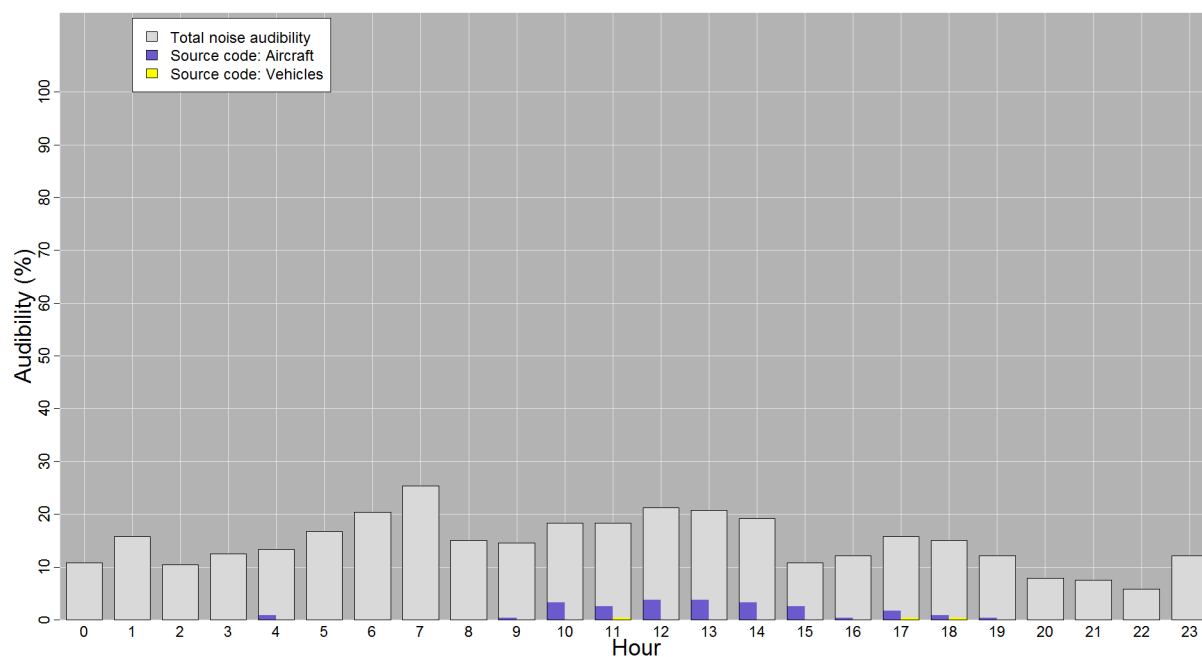


Figure 20. Comparison of hourly aircraft and vehicle audibility and overall noise audibility at OLYM002 during the winter of 2011–2012.

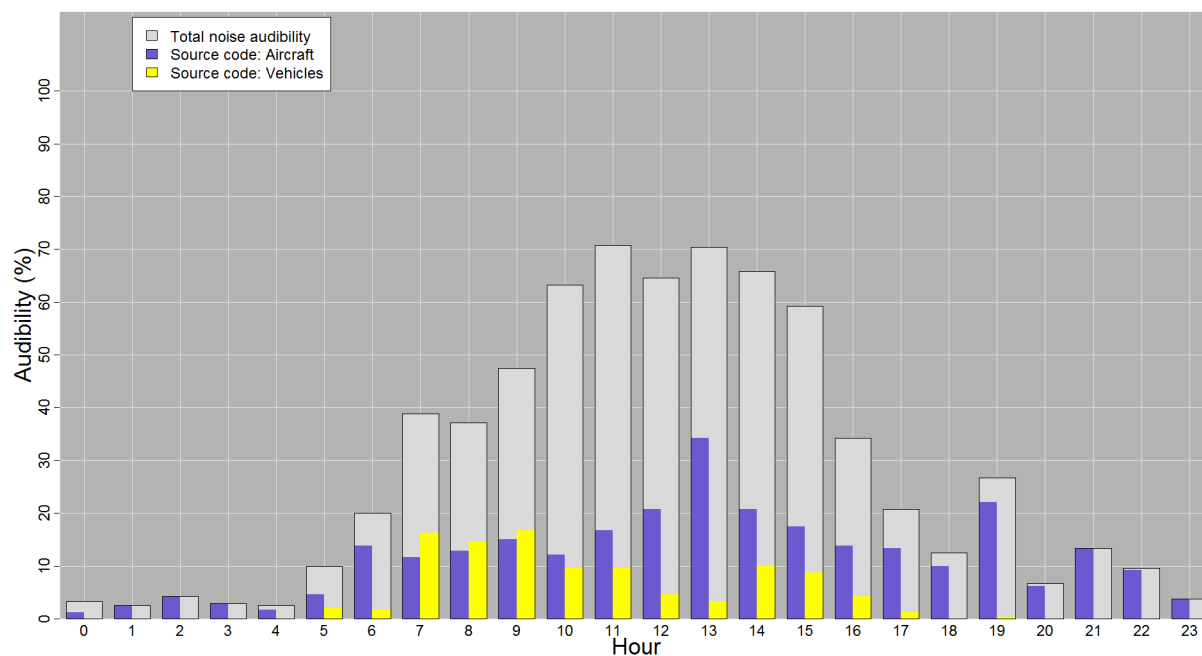


Figure 21. Comparison of hourly aircraft and vehicle audibility and overall noise audibility at OLYM003 during the winter of 2010–2011.

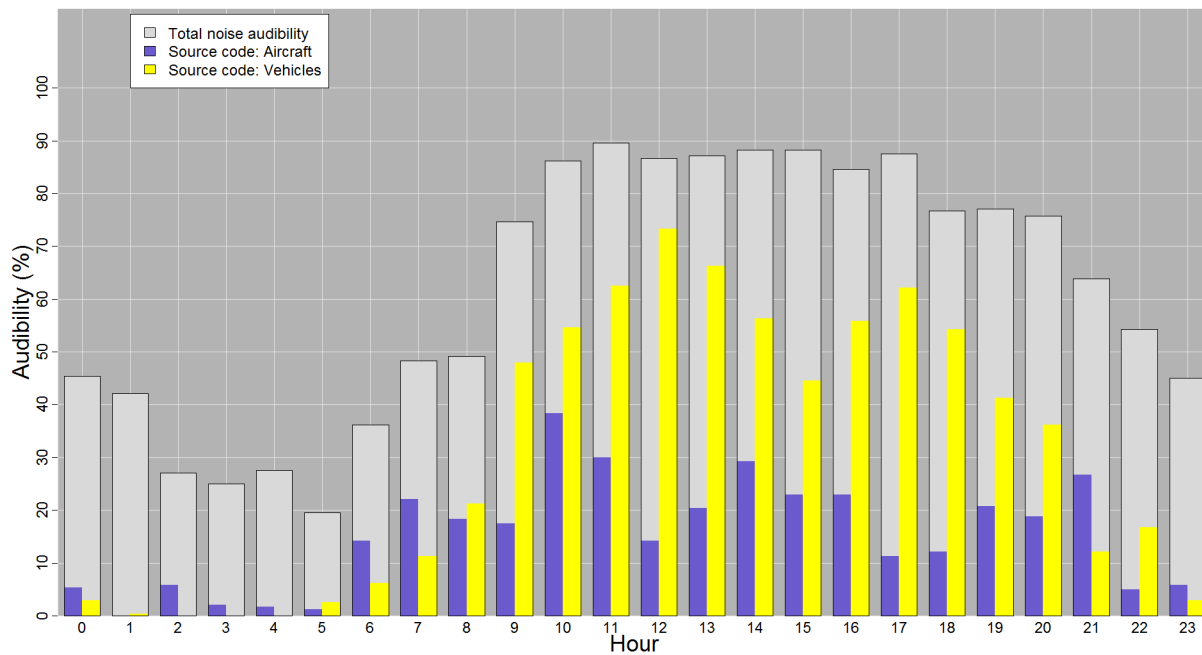


Figure 22. Comparison of hourly aircraft and vehicle audibility and overall noise audibility at OLYM003 during the summer of 2011.

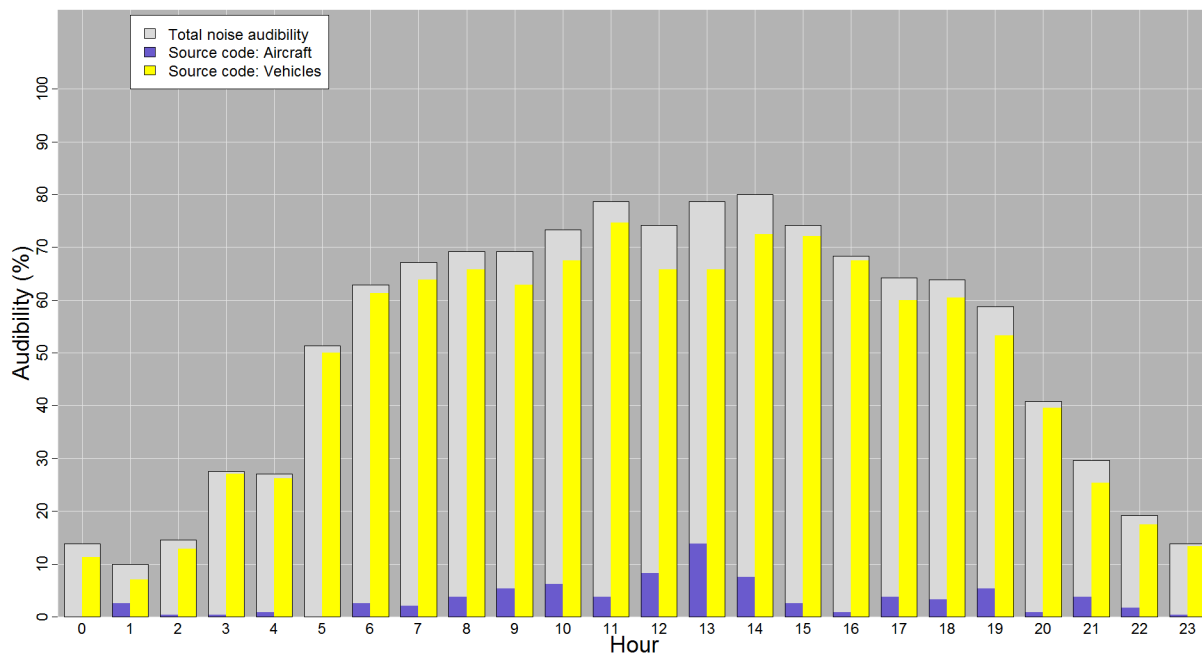


Figure 23. Comparison of hourly aircraft and vehicle audibility and overall noise audibility at OLYM004 during the winter of 2010–2011.

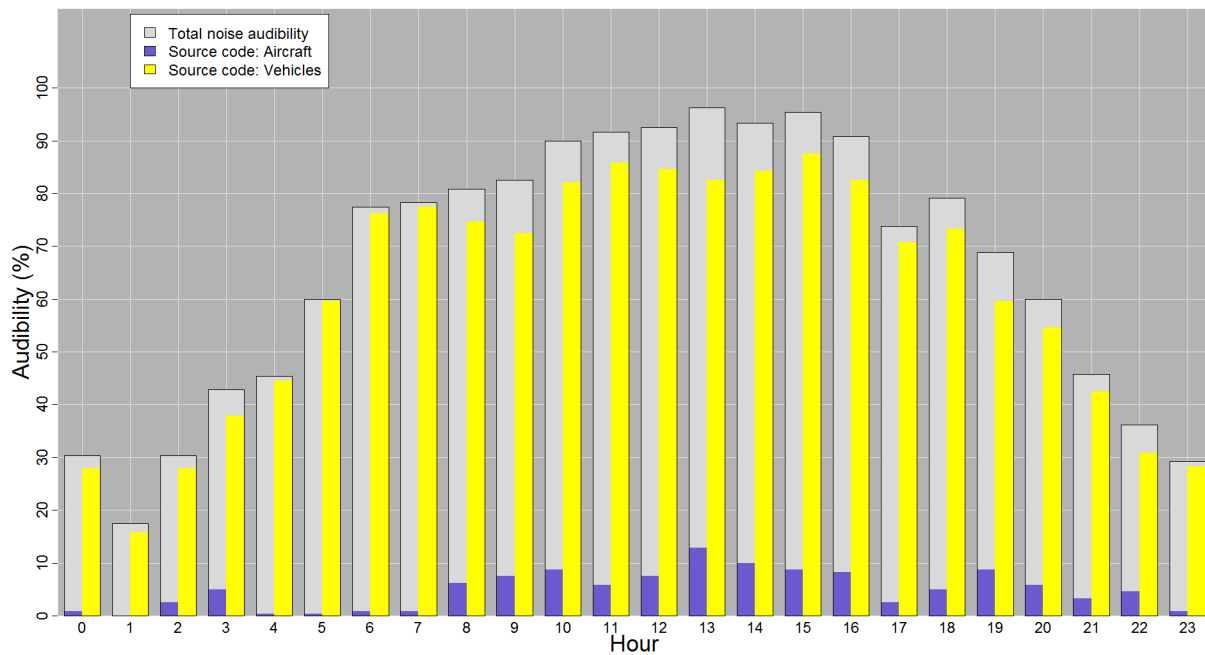


Figure 24. Comparison of hourly aircraft and vehicle audibility and overall noise audibility at OLYM004 during the summer of 2011.

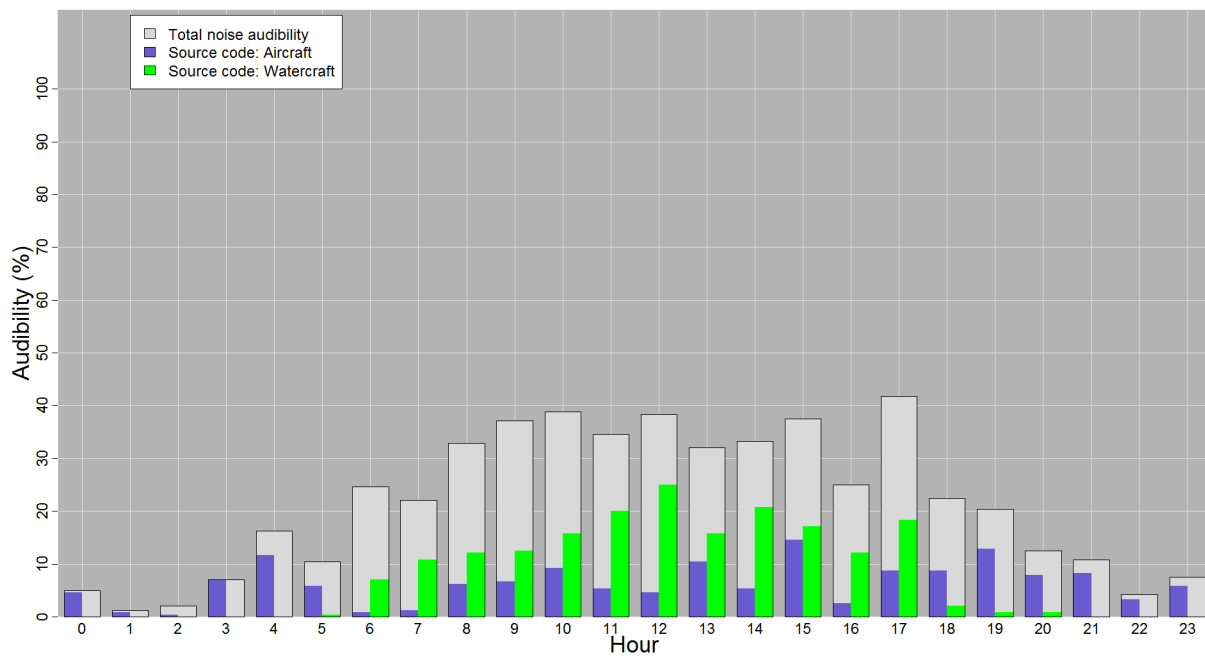


Figure 25. Comparison of hourly aircraft and watercraft audibility and overall noise audibility at OLYM005 during the summer of 2010.

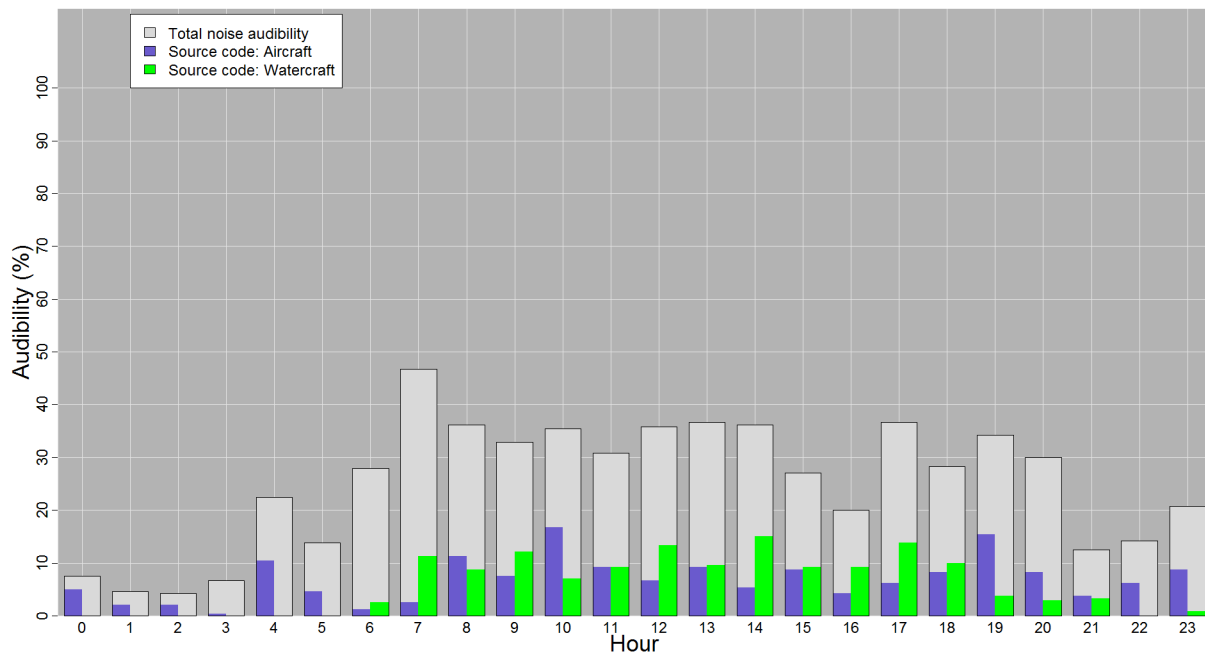


Figure 26. Comparison of hourly aircraft and watercraft audibility and overall noise audibility at OLYM005 during the summer of 2011.

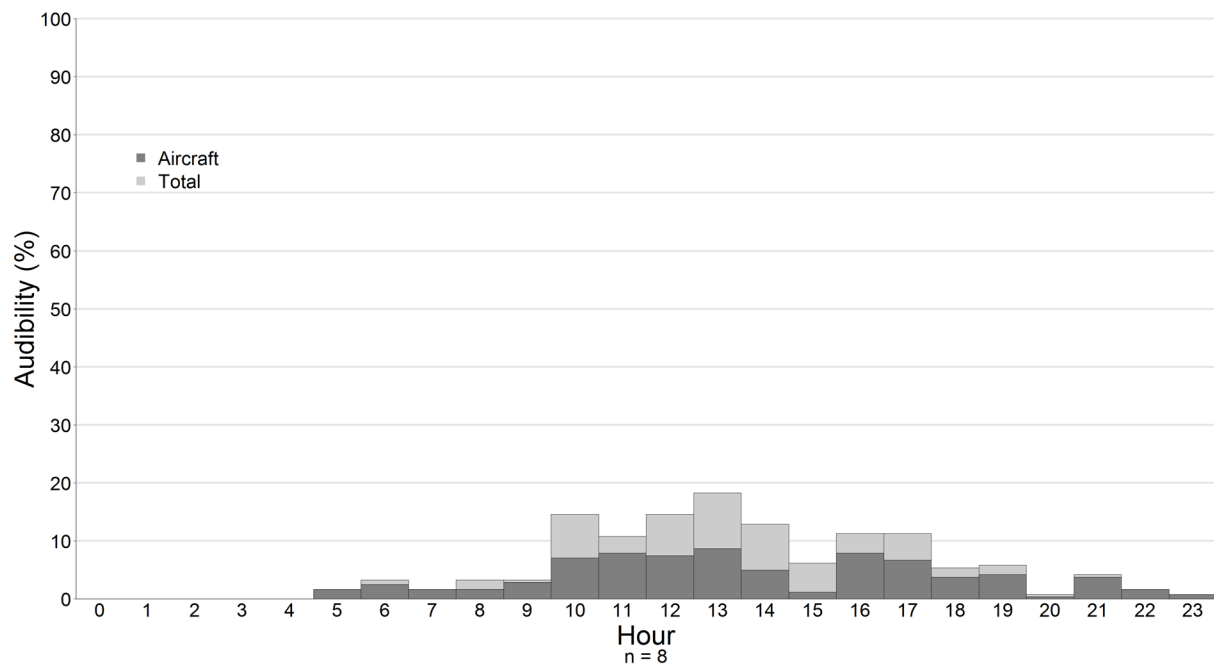


Figure 27. Hourly aircraft audibility and overall noise audibility at OLYM007 during the summer of 2011.

Discussion

The purpose of this study is to assess the condition of the acoustic environment at OLYM. OLYM is world renowned as having one of the most pristine acoustic environments in the country. Monitoring results describe existing and natural ambient sound levels within the park, which provides baseline information for the protection of resources. Sound sources are also included in the report and provide specific information about what wildlife and people would hear at OLYM. Continuous audio recordings, sound level data, and meteorological data were collected from six sites during four time periods. This is currently the only Natural Resource Report published that includes acoustic analysis of summer data at OLYM. Lee and MacDonald, 2016 describes acoustic conditions at many of these same sites for the winter of 2009–2010 (Appendix C).

The Hoh River Trail site (OLYM001) is in the temperate rainforest within wilderness. Data were collected and analyzed during two years over two seasons in the winter and summer of 2010 and 2011. This report discusses three of those time periods. All three periods have a relatively similar acoustic structure (Figures 2–4) suggesting limited seasonal variation between winter and summer in the Hoh. The most notable seasonal difference is the presence of the dawn chorus in summer which is less prominent in winter. The difference between the natural ambient (LA_{nat}) and the ambient (LA_{50}) during these three time periods is very low, not exceeding 0.2 dB (Tables 6–8). Noise audibility averaged over the course of a 24-hour day, is lowest in the winter at 4.4%. Over the three periods, the summer of 2010 has the highest noise audibility at 10.8 % (Table 2). While the winter period for this site has steady rain that fills the acoustic environment, the summers have more activity from wildlife, especially birds. While this site is dominated by natural sounds, noise is heard during most hours (Figures 15–17). Aircraft is the most prevalent noise source heard at OLYM001. Hikers talking along the nearby trail are audible at the site. The non-natural unknown sound recorded here consists of an unidentifiable low rumble. Noise impacts at the Hoh River Trail are low, natural sounds dominate the landscape.

At the Third Beach Trail site, OLYM002, data were collected and analyzed during four periods over the course of two calendar years. The winter 2010 data were analyzed in a previous report (Lee & Macdonald 2010). The summer of 2010, summer of 2011, and winter of 2011–2012 are reported here. The Third Beach Trail site is located within a coastal spruce forest near the ocean within designated wilderness. A road and a frequently used trail are nearby. This site is impacted by higher levels of anthropogenic noise than OLYM001. This site has the second highest audibility from anthropogenic noise after Pyramid Mountain Trail, discussed below. Audibility over a 24-hour period peaked at 49.7% during the summer of 2010 and dipped to 14.7% during the winter (Table 2). Spectral signatures are similar across the three periods analyzed in this report indicating limited seasonal variation. There is less variation between LA_{90} to LA_{10} in winter than summer for most octave bands (Figures 5–7). Noise impacts are higher in the summer than winter. The dawn chorus is clearly distinct during the summertime for both periods (Figure 5, 6). In the winter, noise increased the daytime ambient by only 0.4 dB while in the summer it increased daytime ambient by 2.6 dB (2010) and 2.1 dB (2011). While an increase of 2.6 dB may seem small it can reduce the listening area by 45% for wildlife and visitors (Barber et al. 2010). Noise increased ambient sound

levels here less during nighttime, regardless of season (Tables 6, 7, 9). There are many noise sources at this site, especially in summer (Tables 17–19). Aircraft is the most frequent disruption to the natural soundscape. Vehicles and some low non-natural unknown sound sources are also audible. Watercraft noise is only heard in winter and is dominated by foghorns. This may have been foghorns operated by the US Coast Guard on shore instead of watercraft, but it is a challenge to distinguish at this site. Foghorns are used to communicate with boaters in thick fog and represent an important way in which humans use sound to navigate and communicate in this environment. The audible sounds of people walking along the trail are also very common, an indicator that people often visit this trail and would have an opportunity to enjoy the natural soundscape.

At the Hurricane Ridge site, OLYM003, data were collected and analyzed during three periods. The winter of 2010–11 and the summer of 2011 are discussed in this report. While acoustic recording instruments were at Hurricane Ridge for 41 days in the summer, only 14 days were suitable for acoustic analysis due to high winds ($> 5\text{ m/s}$) that create microphone distortion leading to poor data quality. Between all sites the spectral signatures at Hurricane Ridge varied the most between winter and summer (Figures 8, 9). This indicates strong seasonal variability in the environment. This is the highest elevation site, over 1,000 m higher than the other five sites. The summer has more sound level variation between day and night than winter (Table 2). This site, during summer, has more variation between the LA_{90} and the LA_{10} in the low frequencies, indicating high impacts from transportation noise (Figure 9). While audibility is not the highest here, OLYM003 has higher noise impacts to the ambient acoustic environment than any of the other sites. The high noise impacts are primarily a result of this naturally quiet environment being in close proximity to a road. In naturally quiet environments, like some alpine landscapes, even low audibility can have a big impact on the soundscape because often sources of noise are much louder than the ambient acoustic conditions. During daytime the natural ambient acoustic environment increases in summer by 3.3 dB and 2.4 dB in the winter (Table 2). These increases in sound level reduce the listening area for wildlife on average by 53.2% and 42.5% respectively (Barber et.al, 2010). The audibility of noise during summer sampling reached 62%, and in the winter noise audibility is 28.8% (Table 2). In the winter, the dominant noise source is aircraft. In the summer, vehicles surpassed aircraft in noise audibility. Hurricane Ridge, despite intrusions from anthropogenic noise, has the lowest ambient sound level in winter of any site in this report.

At the Pyramid Mt. Trail acoustic monitoring station, OLYM004, data were collected and analyzed for three periods. This report contains the analysis for both the summer of 2010 and the winter of 2010–2011. This area has a similar acoustic environment between summer and winter. Pyramid Mt. Trail is the only acoustic site that has higher impacts from vehicles than aircraft for both seasons. The audibility of vehicles is high for all hours of the day (Table 23, 24). Nearby Hwy 101 within the park is a common place for visitors to take scenic drives. Logging trucks and road noise are common along Highway 101. The summer dawn chorus occurs (Table 24) but is less prominent in the acoustic structure than in other forested locations (Figure 11). This site has the highest overall percentage of time above 60 dB, the threshold for speech interference during normal conversation (U.S. Environmental Protection Agency, 1974) (Table 12, 13). In comparison to other locations there are small differences in audible noise between winter and summer with noise being audible 51.3%

and 68% respectively. While this site has higher audibility of noise sources than the other five it has lower increases in overall sound level from anthropogenic sources than OLYM003. This is because a nearby stream dominates much of the acoustic energy at this site, masking some of the anthropogenic noise. In the summer of 2011, there is an increase of 2.4 dB added to the daytime LA_{nat} and during the winter there is an increase of 1 dB (Table 2).

At the Lake Ozette acoustic site, OLYM005, data were collected and analyzed during three periods, both the summer 2010 and the summer of 2011 data are reported here. Winter 2010 data is in a previous report (Lee & Macdonald 2010). Like the Third Beach site, OLYM005 is near the ocean in a coastal spruce forest, and within designated wilderness. The spectral structure for these two periods are nearly identical from year to year denoting minimal changes to the acoustic environment within this period (Figure 12 & 13). Noise increases to the ambient acoustic environment are very similar from year to year; 1.4 dB in summer 2010 and 1.9 dB in summer 2011 for daytime and 0.3 dB and 0.4 dB for nighttime. This site has the lowest ambient and natural ambient sound levels (Table 2). A visitor to this site could expect to hear noise on average 24% of the day (averaged across both monitoring periods). Lake Ozette has the most audibility from watercraft, at its peak watercraft would have been heard 25% of the noon hour (on average) during the summer of 2010 (Table 25). Overall a visitor to Lake Ozette could expect to encounter a natural serene acoustic environment with occasional noise interruptions.

At the North Fork Skokomish River Trail site, OLYM007, data were collected during the summer of 2011. This site is in the far southeast corner of the park in designated wilderness, and is within the Western Hemlock Zone, on a boulder-strewn hillside. This site has very little impacts from outside noise, and minimal differences between exceedance metrics. This is the most naturally energetic site from those sampled in this report with a daytime ambient of 41.8 dB (Table 9). Sound levels are likely so high because of the natural sound of flowing water that may have masked other natural sounds and noise (Table 27). Due to the naturally loud conditions at the site, noise events are heard infrequently. Visitors can expect to hear mostly sounds of flowing water with noise intrusions occurring only 6.7% of the day. Aircraft is the most audible noise source at this site. Bird song, which occurs in a higher frequency range than flowing water, is still audible and abundant (Table 27). Any visitors or wildlife at this site should expect a natural soundscape filled with the sounds of flowing water.

This acoustic analysis shows that the natural ambient sound level is higher during the day than night at all sites in the summer. During winter the natural ambient sound level is higher during the nighttime than the daytime at three of four sites with winter data (Table 2). In general, the dawn chorus and bird song dominate the natural soundscape during the summer months and in the winter the sounds of flowing water and rain are a persistent part of the intrinsic acoustic environment. Despite relatively low impacts to ambient conditions, noise is often audible during daytime hours at OLYM.

Vehicles and watercraft are commonly heard at sites depending on their proximity to the road or navigable water. Aircraft noise at OLYM is also common across all sites but most frequently on Hurricane Ridge. Across all sites, aircraft is more audible in summer than winter. The two sites

outside of federally designated wilderness, OLYM003 and OLYM004 have high levels of motorized noise. OLYM004, across Lake Crescent from Highway 101, has the highest levels of audibility from vehicles. OLYM005, on Lake Ozette, has higher audibility from motorized watercraft than any of the other sites (Table 2). While wilderness areas often experience less noise from ground or water-based transportation, noise from aircraft are common. In addition to the frequent air traffic flying to and from commercial and military airports, there is also a special use airspace designated above the park. OLYM002 and OLYM005 are directly under the Olympic B Military Operating Area and OLYM001 is on the border of this airspace. There is also a U.S. Area Navigation (RNAV) route (T263) that goes through the center of the park and is marked on the aeronautical chart. This RNAV route is oriented north to south and is very close to both OLYM003 and OLYM007 (Appendix D).

Ambient sound levels are low at Olympic National Park; noise is present but did not dominate the acoustic environment. In fact, the ambient sound level during the monitoring period is considerably lower than most residential areas and maintains its natural characteristics. For comparison, a comprehensive 1982 study of noise levels in residential areas found that nearly 87% of US residents were exposed to day-night sound levels (L_{dn}) over 55 dB, and an additional 53% were exposed to L_{dn} over 60 dB (EPA 1982). For comparison the lowest L_{dn} is 37.7 dB at Hurricane Ridge in the winter. The highest L_{dn} is 58.1 dB at OLYM007 and most of the energy at this site is from natural sounds (Table 29). Note that noise levels have increased nationally with population growth since the EPA study (Suter 1991; Barber et al. 2010).

Olympic National Park is a unique landscape of high national significance. Maintaining a natural acoustic environment is a fundamental resource and value at OLYM (National Park Service, 2017). In addition to noise impacting the acoustic resource in the park, noise also degrades habitat for wildlife, another important park resource (Proppe et al. 2013; Shannon et al. 2016). Visitors to OLYM may hear noise near the monitoring sites throughout the year. Noise has the potential to affect a visitor's experience in parks by causing annoyance (Rapoza et al. 2015), reducing the perceived scenic beauty (Weinzimmer et al. 2014), or simply by limiting opportunities for solitude. Four of the acoustic sites are within the Daniel J. Evans Wilderness. Noise experienced in wilderness diminishes the opportunity for solitude and primitive recreation, an important wilderness characteristic. This report provides park managers with baseline acoustic information at OLYM to better understand the impacts to the acoustic environment and to support the protection of park resources and visitor experiences for future generations.

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Appendix A: Site Photographs

Figures 28–33 show photographs of each of the acoustic monitoring sites reported in this document.



Figure 28. Site photograph of Hoh Rain Forest, OLYM001, acoustical monitoring site during the summer deployment.

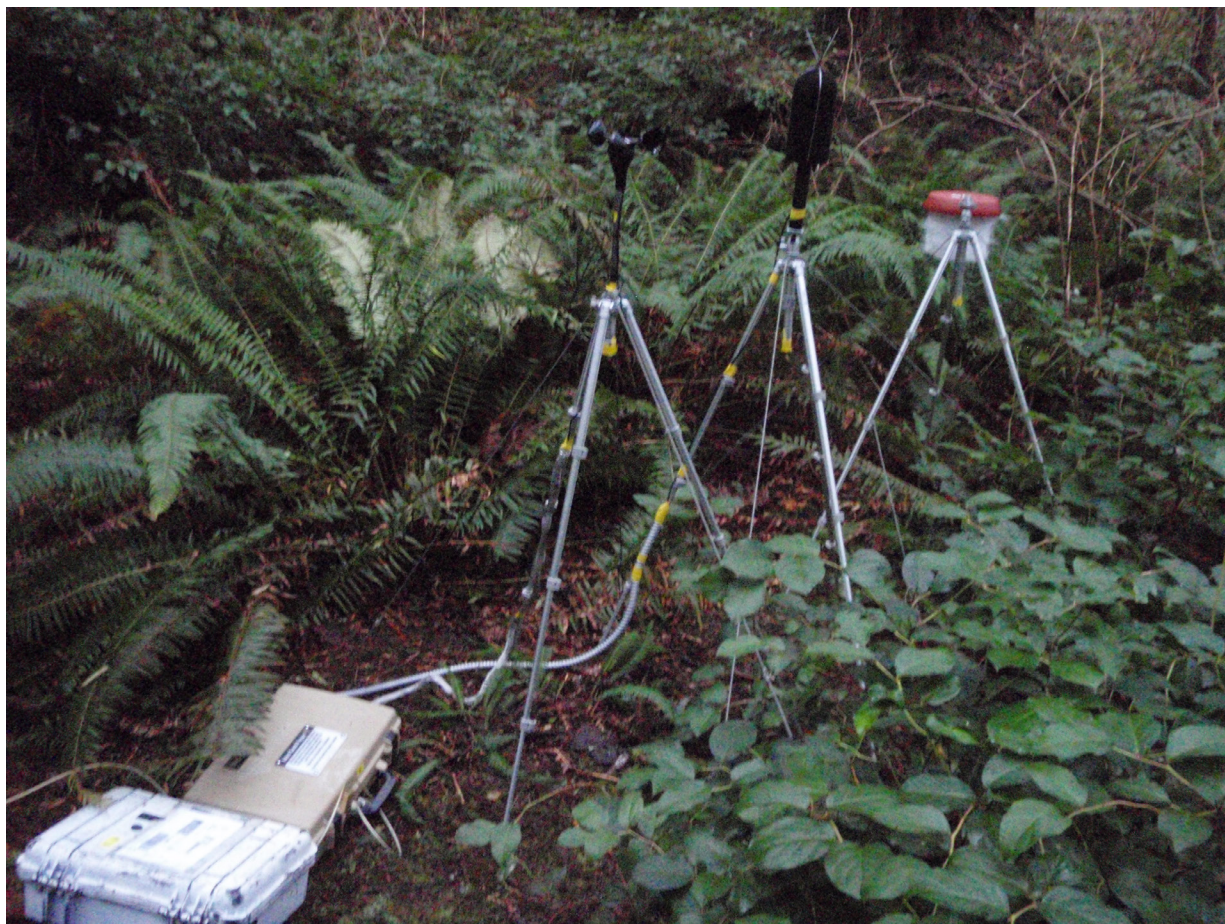


Figure 29. Site photograph of Third Beach, OLYM002, acoustical monitoring site during the summer deployment.



Figure 30. Site photograph of Hurricane Ridge, OLYM003, acoustical monitoring site during the winter deployment.



Figure 31. Site photograph of Pyramid Mountain Trail, OLYM004, acoustical monitoring site during the summer deployment.



Figure 32. Site photograph of Lake Ozette, OLYM005, acoustical monitoring site during the summer deployment.



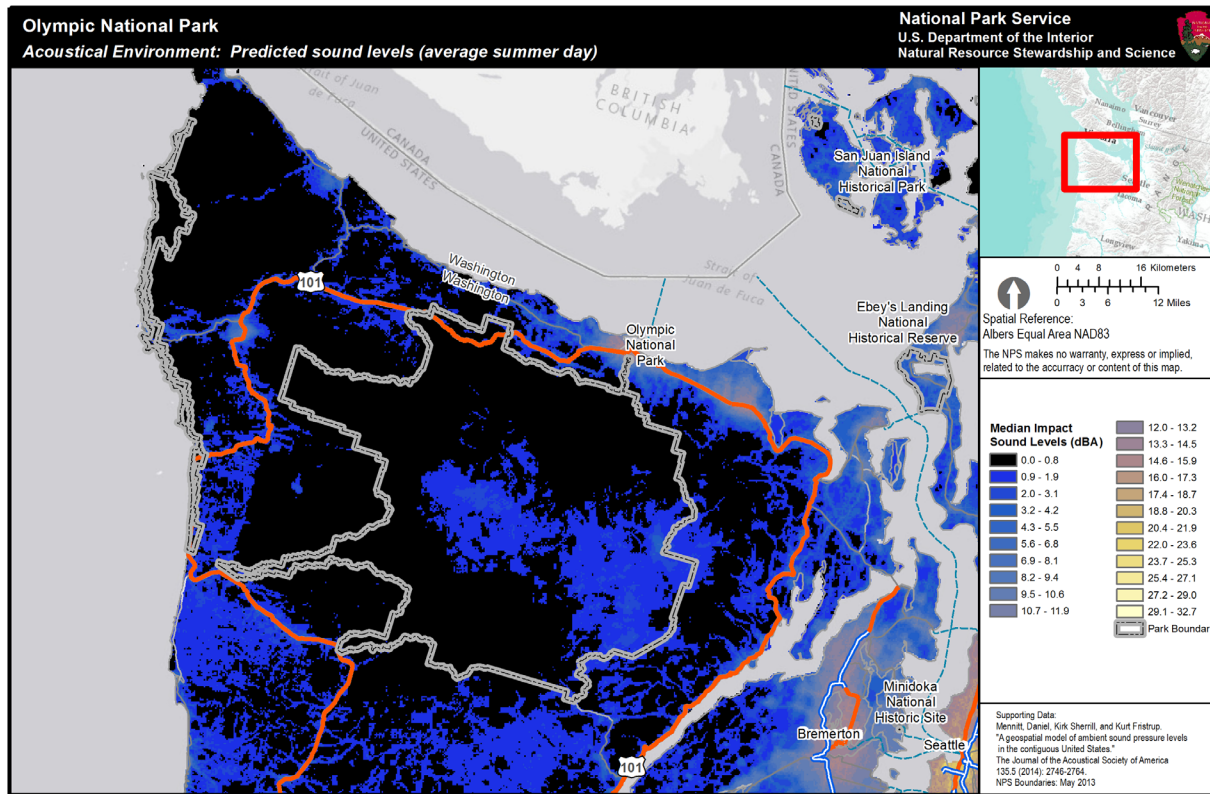
Figure 33. Site photograph of North Fork Skokomish site OLYM007 acoustical monitoring site during the summer deployment.

Appendix B: Geospatial Modeling

NSNSD developed a geospatial sound level model (Mennitt et al. 2014) that predicts the median sound level (LA_{50}) using measurements made in hundreds of national park sites as well as 109 explanatory variables such as location, climate, land cover, hydrology, wind speed, and proximity to noise sources such as roads, railroads, and airports.

The model predicts summer daytime sound levels anywhere in the U.S. and estimates the amount that noise increases sound levels above natural levels. When on the ground data cannot be collected, we use modeled data to predict conditions. This model is used to predict the difference between the existing ambient and natural ambient sound level at OLYM (Figure 9), on an average summer day. Within the park, the median level of noise added to the environment is 0.0 dB and the mean is 0.3 dB. Impacts range from 0.0 dB–12.9 dB across the park. All 6 sites in this report have the lowest modeled impacts, meaning that the model estimated that the amount of noise added to the acoustic environment would increase sound levels 0.0–0.8 dB. The actual acoustic data collected in the park ranges from impacts of 3.3 dB at OLYM003 to 0.0 at OLYM007. The model slightly underestimates the amount of noise added to the environment at OLYM002, OLYM003, OLYM004, and OLYM005 based on the acoustic data collected. Data from this report will go into the geospatial model to improve prediction capabilities.

Each pixel in the graphic shown in Figure 34 represents 270 meters. For reference in translating added anthropogenic noise into functional effects (for human visitors and resident wildlife), an increase in background sound level of 3 dB produces an approximate decrease in listening area of 50%. In other words, by raising the sound level by 3 dB, the ability of listeners to hear the sounds around them is effectively cut in half. Furthermore, an increase of 7 dB leads to an approximate decrease in listening area of 80%, and an increase of 10 dB decreases listening area by approximately 90%. The modeled results of 0.0 dB over the entire park would not alter the listening area.



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Figure 34. Modeled median increases in sound level in the area immediately surrounding OLYM and the nearby region (inset). Map of predicted increased sound levels in the park for an average summer day. The color scale indicates how much noise increases the ambient sound level (in A-weighted decibels, or dB), with 270-meter resolution. Black or dark blue colors indicate low impact while yellow or white colors indicate greater impact. Note that this graphic may not reflect recent localized changes such as new access roads or development. The mean anthropogenic increase in acoustic energy is 0.0 dB within the park boundary.

Appendix C: Additional Metrics

The metrics in table 28 are not a part of the standard protocol for assessing soundscapes in national parks, but they are often referred to in the scientific literature (Lynch 2011). They are presented here as additional information and for reference when reviewing other acoustic reports. The LA_{EQ} (24hr) is the average sound pressure level averaged over the monitoring period of the 24-hour day. For comparison the L_{50} is the median sound pressure level. The LA_{DN} is very similar but has a 10 dB increase artificially added to the nighttime environment. The LA_{EQ} (15hr) is also an average like the LA_{EQ} (24hr) but only uses average sound pressure levels from 7:00–22:00 for daytime. While the LA_{EQ} (9hr) uses average sound pressure levels from nighttime from 22:00–7:00.

Table 28. Additional acoustic metrics for reference.

Season	Site ID	LA_{DN}	LA_{eq} (24hr)	LA_{eq} (15hr)	LA_{eq} (9hr)
Summer 2010	OLYM001	41.6	36.1	36.7	34.9
Winter 2011	OLYM001	48	41.5	41.4	41.6
Summer 2011	OLYM001	42.6	37.9	38.9	35.5
Summer 2010	OLYM002	44.4	39.6	40.5	37.4
Summer 2011	OLYM002	46.9	40.8	41.1	40.4
Winter 2012	OLYM002	51.5	45.4	45.6	44.9
Winter 2011	OLYM003	43.3	37.8	38.5	36.5
Summer 2011	OLYM003	37.7	35.5	37.2	28.4
Winter 2011	OLYM004	49.6	44.2	44.8	42.8
Summer 2011	OLYM004	43.8	40.3	41.7	35.9
Summer 2010	OLYM005	38.2	34.5	35.8	30.5
Summer 2011	OLYM005	45.5	42.6	44.2	37.1
Summer 2011	OLYM007	58.1	51.7	51.8	51.7

This report often references winter data reported by Lee and MacDonald 2016. Most of the data collection methods, analysis and sites were the same in Lee and MacDonald as they are in this report. The only percentile level metrics ($L_{Aeq, 12hr}$) reported in Lee and MacDonald that were also reported here were the L_{nat} , L_{90} and L_{50} . The L_{nat} was only reported for daytime and the L_{10} was not reported in Lee and MacDonald. Table 29 includes acoustic data reported here next to data from winter 2010 at OLYM, as reported in Lee and MacDonald. Table 29 reports percentile metrics for comparison with the winter data. Winter 2010 data is highlighted in gray. Summer 2010, Winter 2011, Summer 2011, and Winter 2012 data are not highlighted.

Table 29. Percentile metrics reported from Lee and MacDonald 2010 next to the same metrics in this report.

Site	Season	Percentile levels 0700 to 1900 hours (Day)			Percentile levels 1900 to 0700 hours (Night)	
		LA ₉₀	LA ₅₀	LA _{nat}	LA ₉₀	LA ₅₀
OLYM001	Winter 2010*	32.9	34.5	34.1	32.4	34.0
OLYM001	Summer 2010	32.8	33.7	33.5	32.1	32.5
OLYM001	Winter 2011	37.5	38.0	37.9	38.2	38.6
OLYM001	Summer 2011	33.2	34.2	34.0	31.8	32.2
OLYM002	Winter 2010*	26.7	36.7	35.6	30.5	36.7
OLYM002	Summer 2010	28.4	32.7	30.1	26.5	29.5
OLYM002	Summer 2011	26.9	30.8	28.7	26.2	29.5
OLYM002	Winter 2012	31.0	32.6	32.3	34.3	35.7
OLYM003	Winter 2010*	15.4	24.4	23.1	14.7	21.8
OLYM003	Winter 2011	19.6	23.1	20.7	19.8	23.0
OLYM003	Summer 2011	24.0	27.0	23.7	17.3	19.8
OLYM004	Winter 2010*	31.5	35.1	32.3	28.6	32.4
OLYM004	Winter 2011	35.8	36.9	35.9	35.4	36.1
OLYM004	Summer 2011	31.9	34.0	31.6	30.1	31.1
OLYM005	Winter 2010*	21.7	32.4	31.4	22.1	33.8
OLYM005	Summer 2010	21.0	24.4	23.0	17.7	19.7
OLYM005	Summer 2011	21.2	25.6	23.7	19.0	21.2
OLYM007	Summer 2011	41.5	41.8	41.8	41.3	41.5

* Winter 2010 data is highlighted in gray

Appendix D: Maps of Airspace

This section includes maps of airspace over OLYM. Figure 35 highlights the Olympic Military Operating Area (MOA). This airspace includes MOA section A&B which is functionally used as one block. The altitude range for the Olympic MOA airspace begins at 6,000 ft above mean sea level (MSL) and extends to an upper limit of 18,000 ft MSL. The 6,000 ft MSL floor of the airspace is straightforward for most of the MOA, but in the eastern part of the MOA the terrain can rise several thousand feet above sea level, approaching the floor of the airspace. To account for this, a further restriction requires that aircraft operating over land in the Olympic MOAs maintain an altitude of at least 1,200 ft above ground level. This 1,200 ft restriction would only affect terrain located at the eastern edge of the MOAs, where elevations could exceed 4,800 ft. MSL (United States Department of the Navy, 2019).

Figure 36 shows the Federal Aviation Administration Seattle Sectional Aeronautical Chart, 96th edition. The park boundary is on this map along with various airspaces as well as aircraft routes and information for pilots flying over the park. The park boundary is marked as noise-sensitive area. Noise sensitive areas should follow the Advisory Circular: Visual Flight Rules (VFR) Flight Near Noise-Sensitive Areas (AC91-36dD). AC91-36D states that “Pilots operating noise producing aircraft over noise-sensitive areas should make every effort to fly not less than 2,000 feet above ground level (AGL), weather permitting” Furthermore, “The intent of the 2,000 feet AGL recommendation is to reduce potential interference with wildlife and complaints of noise disturbances caused by low flying aircraft over noise-sensitive areas.”



Figure 35. The Olympic Military Operating Area (A&B) over Olympic National Park.

FAA Sectional Aeronautical Chart Seattle 96th Edition



Figure 36. The Federal Aviation Administration Seattle Sectional Aeronautical Chart, 96th edition.



Figure 37. Backpackers enjoying the quiet peace of the Dosewallips River, Olympic National Park. Photo credit: Ruth Scott/NPS

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.

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National Park Service
U.S. Department of the Interior



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1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525