



Glacier Bay National Park and Preserve

Acoustical Monitoring 2011

Natural Resource Technical Report NPS/NRSS/NRTR—2012/XXX



ON THE COVER

Glacier Bay National Park and Preserve
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Natural Resource Technical Report NPS/NRSS/NRTR—2012/XXX

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Executive Summary

In 2011, five digital audio recorders were deployed by park staff in Glacier Bay National Park and Preserve. The recorders continuously documented audible sounds for between 18 and 25 days in .mp3 format. In addition, park staff collected on-site audibility data at numerous sites (using handheld personal digital assistants) for a total of 1,110 minutes. The purpose of these monitoring efforts was to collect information about the audibility of anthropogenic sounds in the bay area, particularly jets, propeller aircraft, and watercraft, as well as the length of noise free intervals. This information will guide the park as it undertakes the complex task of managing its acoustical environment.

This document will refer to “noise” as any human-caused sound that masks or degrades natural sounds (Lynch et al. 2011). Principle sources of noise at the park include motorized watercraft and aircraft (both jet and propeller). Table 1 displays percent time audible values for each of these common noise sources during the monitoring period as well as total audibility of noise at each site. For sites where total audibility exceeds the sum of the propeller, jet, and watercraft audibility, other noise sources (such as generators) were intermittently audible. A number of biologic sounds were found to be present during the monitoring period. Though rain, waves, and wind were particularly prominent sounds, humpback whales (*Megaptera novaeangliae*) were present at a number of sites, as were common loons (*Gavia immer*), song birds, and waterfowl. Percent time audible metrics were calculated by a trained technician after monitoring was complete using a visual analysis method. See Methods section for protocol details and equipment specifications.

Table 1. Mean percent time audible (based on offsite analysis of audio recordings) for all extrinsic sounds, jets, propellers, and watercraft

Site ID	Site Description	Mean percent time audible of noise sources			
		All noise	Jet	Propeller	Watercraft
GLBAHUTCH	Hutchins Bay	15.6	2.5	2.2	8.9
GLBAMCLEOD	Pt. McLeod	5.7	3.8	0.6	1.2
GLBAMOUSE	Blue Mouse Cove	9.5	0.7	0.3	6.8
GLBAMUIR	Upper Muir	2.3	1.9	0.2	0.2
GLBARENDU	Rendu	37.9	2.6	1.8	33.8

It is clear from the results in Table 1 that the sites receive varying levels of noise intrusions, and that some noise sources are more prevalent in certain areas. It is the intent of this report to elucidate these differences in a way that will help the park protect its unique acoustical resources. The findings of this pilot study may also serve to inform the design of long-term acoustical monitoring efforts in the park.

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 current status of acoustic resources, identifying trends in resource conditions, quantifying impacts from other actions, assessing consistency with park management objectives and standards, and informing management decisions regarding desired future conditions.

National Park Service Natural Sounds and Night Skies Division

The Natural Sounds and Night Skies Division (NSNSD) helps parks manage sounds in a way that balances access to the park with the expectations of park visitors and the protection of park resources. The 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 represented in 2006 Management Policy 4.9:

The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts. Using appropriate management planning, superintendents will identify what levels and types of unnatural sound constitute acceptable impacts on park natural soundscapes. The frequencies, magnitudes, and durations of acceptable levels of unnatural sound will vary throughout a park, being generally greater in developed areas. In and adjacent to parks, the Service will monitor

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.

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).

Study Area

Glacier Bay National Park and Preserve is a large wilderness park, encompassing a pristine set of terrestrial and marine ecosystems within its 3.3 million acre boundaries. While a subset of visitors explore the park from the cockpit of a kayak, the vast majority of park visitors experience its wonders from the decks of large cruise ships (or other motorized vessels), or from above on a flightseeing tour (via propeller aircraft). This has the effect of introducing a significant amount of anthropogenic noise into the ecosystem. The addition of noise to the park's acoustical environment is a concern for both terrestrial and marine wildlife.

To quantify the degree to which anthropogenic sounds were audible across the (terrestrial) landscape, the park deployed five digital audio recorders during the summer (August-September) of 2011. The recorders were left in place for 18-25 days at the sites shown in Table 2. The photo in Figure 1 is representative of site setup in GLBA. Sites consisted of a Roland R05 digital audio recorder inside a weatherproofing "hat," mounted on a tripod.

Table 2. Site Locations

Site ID	Site Name	Dates		Vegetation	Elevation	Latitude	Longitude
		Deployed					
GLBAHUTCH	Hutchins Bay	8/24/2011 - 9/14/2011		alder/spruce forest	< 3m above high tide	58.534600	-135.853100
GLBAMCLEOD	Pt. McLeod	8/19/2011 - 9/11/2011		alder/ willow thicket	< 7m above high tide	58.915200	-136.110820
GLBAMOUSE	Blue Mouse Cove	8/24/2011 - 9/10/2011		Bare/alder/ willow	~10 m	58.795660	-136.490728
GLBAMUIR	Upper Muir	8/19/2011 - 9/12/2011		alder/ willow thicket	~ 4m above high tide	59.051200	-136.269540
GLBARENDU	Rendu	8/03/2011 - 8/26/2011		Bare/alder/ willow	~ 5 m	58.889960	-136.630350



Figure 1. An example of the type of digital audio recording systems deployed in GLBA.



GLBA Acoustical Monitoring Sites 2011



Produced by E Lynch, Natural Sounds and Night Skies Division, May 2012

FILE: Un00d.mxd

Figure 2. Map of onsite listening locations (triangle) and recorder locations (circle) in GLBA

Methods

Monitoring period

The variability of sound pressure levels over time and space in national parks is still not well understood. Each additional dataset gathered provides insight into natural variability. The monitoring period used for collection of these data is based on a preliminary statistical study that evaluated long-term datasets from Bryce Canyon National Park and Arches National Park. It was determined that a 25 day monitoring period in either winter or summer months would limit sound pressure level uncertainty to <3 dB (Iyer 2005). It is widely accepted that this is the threshold at which the average, healthy, human ear can detect noise level changes, when actively engaged in listening (Hendriks 1998). In addition to this study, logic dictates that a 25 day monitoring period would be sufficient to capture the inevitable variation in weather patterns in national parks. Thus, for continuity, park staff attempted to record sounds at each site for 25 days. Battery power truncated the monitoring period at some of the monitoring sites, but because the purpose of this monitoring effort was to determine noise source audibility (and not absolute sound pressure levels); the shorter monitoring periods are still entirely useful datasets.

Automatic Monitoring

In 2005, the NPS drafted protocols for acoustic studies in national parks, in cooperation with staff from the Volpe National Transportation Systems Center². When these acoustical monitoring protocols were developed, the amount of power it took to run recording devices and storage limitations of these devices were such that continuous recordings could not be made. As an alternative, recordings were made every 2 minutes for 10 seconds. This sampling scheme was designed to ensure that events of interest (namely aircraft and vehicles) would be recorded. Since that time, audio recorders have become much smaller and now require far less power. In addition, storage devices with larger capacities have become readily available. Therefore, continuous audio recordings were collected during the 2011 monitoring period at GLBA. Five digital audio recorders were employed over the 18-25 day monitoring period. The recorders were model R05, produced by Roland (<http://www.rolandus.com/>). They were chosen for their high quality stereo recording capabilities, compact design, and low power consumption. Each recorder was mounted under a weatherproofing shield to protect the microphones from wind and moisture. The recorders were powered by rechargeable external batteries.

Calculating noise audibility: visual analysis

The 2005 acoustical monitoring protocol also dictates that during the recommended 25-day monitoring period, investigators should conduct several hours of observer logging or recording playback (typically 16 hours per site) to determine the audible sources of noise. Continuous recording has offered us the convenience of conducting these listening sessions in the office instead of in the field. Thus, Natural Sounds and Night Skies Division (NSNSD) staff listen to a subset of the audio data, using the 10 seconds per 2 minutes sampling scheme. When placed end-to-end, these 10 second samples constitute 2 hours of audio recordings. To reach an equivalent 16 hours of observer logging, NSNSD listens to 8 days of sub-sampled audio.

At sites where anthropogenic noise occurs infrequently, as in the case of GLBA sites, NSNSD staff can further accelerate source identification using daily spectrograms generated from sound

² National Park Service. 2005. Acoustic and Soundscape Studies in National Parks DRAFT.

pressure level data. Spectrograms are plots which display sound level as a function of time and frequency. Because most anthropogenic sounds possess recognizable sound signatures, staff can quickly examine many samples within the measurement period, noting duration, frequency span, maximum level, and sound exposure level (SEL) of each noise event. For events with less distinctive sound signatures, corresponding audio files are played back through noise canceling headphones. Days are randomly selected for analysis if they do not contain significant weather events (rain or wind) that might preclude source identification. When all events have been identified, NSNSD software calculates the total percent time anthropogenic sounds were audible by averaging the 8 replications to produce a single hourly percent time audible for each of the 24 hours of the day. To learn more about visual analysis techniques, see Appendix A: Visual analysis. All of the GLBA sites were analyzed using this visual technique. Eight days of continuous data was analyzed per site. All anthropogenic noise sources were identified, categorized, and annotated. A complete, site-by-site summary of results is provided in the following section.

Onsite listening

Onsite listening is the practice of placing an observer near at a particular point in the park with a handheld personal digital assistant (PDA). The observer listens for a designated period of time, and identifies all sound sources and their durations. Sessions lasted between 15 minutes and 1 hour. Onsite listening takes full advantage of human binaural hearing capabilities, and closely matches the experience of park visitors. Logistic constraints prevent comprehensive sampling by this technique, but selective samples of onsite listening provide a basis for relating the results of off-site listening to the probable auditory perception of events by park visitors and wildlife. Onsite listening sessions are also an excellent screening tool for parks initiating acoustical environment studies. They produce an extensive inventory of sound sources, require little equipment or training, and can help educate park staff and volunteers.

Numerous periods of onsite listening were conducted by park staff in order to discern the type, timing, and duration of audible sound sources. Both natural and non-natural sounds were tracked during these sessions, but for simplicity, only non-natural noise event results will be reported. These on-site listening sessions provided the basis for the calculation of metrics including the period of time between noise events (average noise free interval [NFI]), percent time each sound source was audible, and maximum, minimum, and mean length (in seconds) of sound source events. The results of these on-site listening sessions are summarized below, and detailed report files are included in the appendices section.

Results

Off-Site Data Analysis

Eight days of continuous audio data were analyzed per site, and each occurrence of anthropogenic noise was documented. From these data, mean hourly percent time audible was calculated. Table 3 provides a quick snapshot of mean percent time audible results, averaged over all hours, while the figures below address audibility on a much finer (hourly) scale. The figures below report the total percent time audible for *all* noise sources, compared to certain noise sources of interest (jet, propeller, and watercraft). The light gray bars represent the total percent time audible for all noise sources while the dark gray bars show percent time audible for the individual sources of interest (jet, propeller, and watercraft). These results are also presented in tabular format in Appendix B. Mean hourly percent time audible for sources of interest.

It is interesting to note overall audibility of anthropogenic noise sources between sites, as well as the degree to which the three sources of interest contribute to overall noise audibility. For instance, noise is infrequently audible at GLBAMUIR and GLBAMCLEOD, but when noise is audible, it is more often than not jet aircraft. Conversely, GLBAHUTCH, GLBAMOUSE, and GLBARENDU are far more affected by watercraft noise intrusions. At all sites, propeller aircraft events contributed the least to overall noise audibility. Jets were the most consistently audible source across all sites, which is logical because their sound footprint is the largest, and is therefore the most likely to blanket large parts of the park. The timing of these anthropogenic events is also an essential component of analysis. A quick survey of the hours that are most affected by noise reveals that early morning hours seem to be the quietest in almost all cases. See the figures below for detailed hourly audibility results of jets, propeller aircraft, and watercraft.

Table 3. Mean percent time that noise sources were audible, averaged over all hours of the day

Site ID	Site Description	Mean percent time audible of noise sources across all hours			
		All noise	Jet	Propeller	Watercraft
GLBAHUTCH	Hutchins Bay	15.6	2.5	2.2	8.9
GLBAMCLEOD	Pt. McLeod	5.7	3.8	0.6	1.2
GLBAMOUSE	Blue Mouse Cove	9.5	0.7	0.3	6.8
GLBAMUIR	Upper Muir	2.3	1.9	0.2	0.2
GLBARENDU	Rendu	37.9	2.6	1.8	33.8

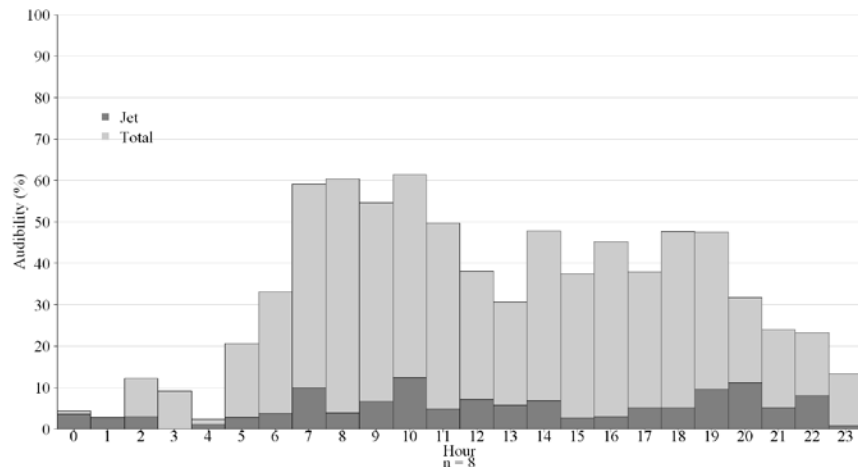


Figure 3. Mean hourly percent time audible for jets and all anthropogenic sources at GLBAHUTCH

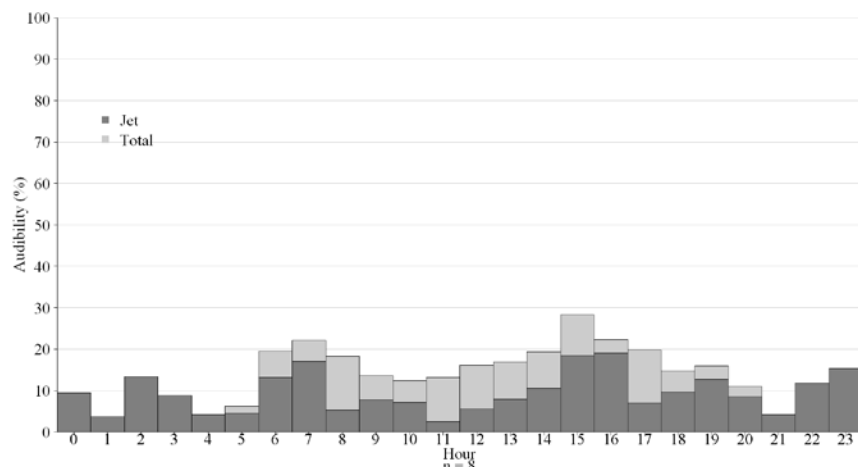


Figure 4. Mean hourly percent time audible for jets and all anthropogenic sources at GLBAMCLEOD

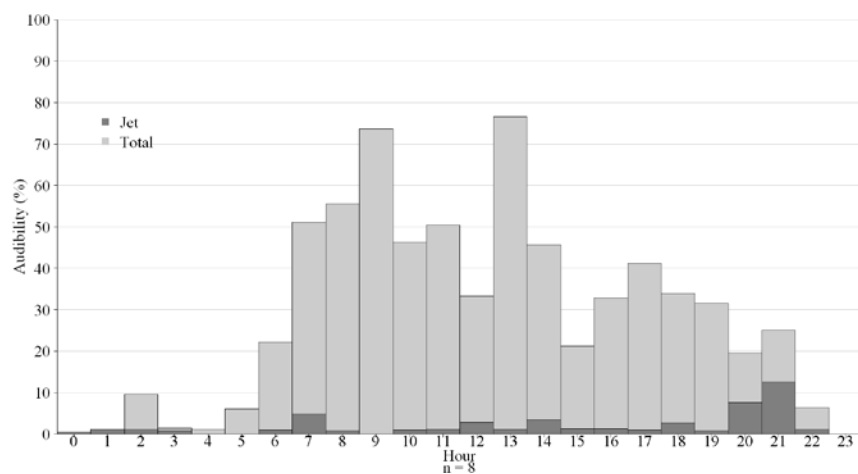


Figure 5. Mean hourly percent time audible for jets and all anthropogenic sources at GLBAMOUSE

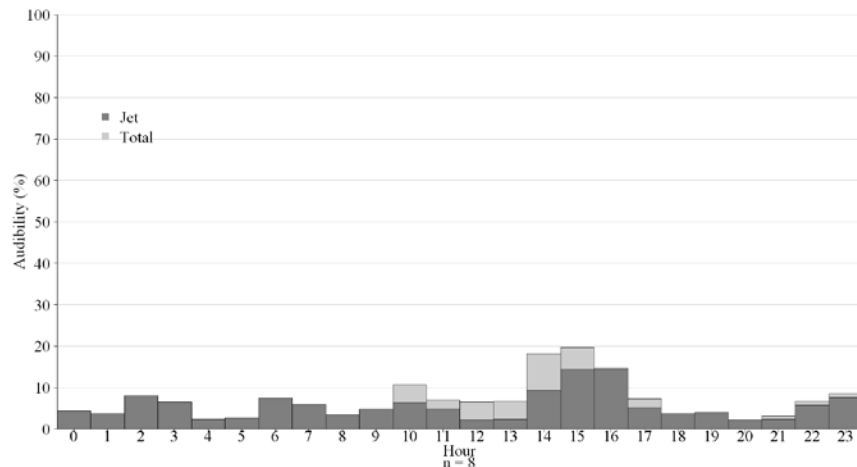


Figure 6. Mean hourly percent time audible for jets and all anthropogenic sources at GLBAMUIR

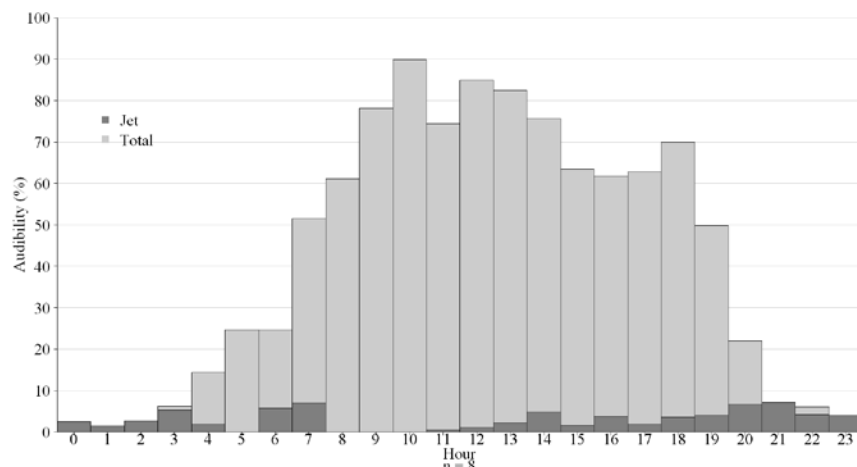


Figure 7. Mean hourly percent time audible for jets and all anthropogenic sources at GLBARENDU

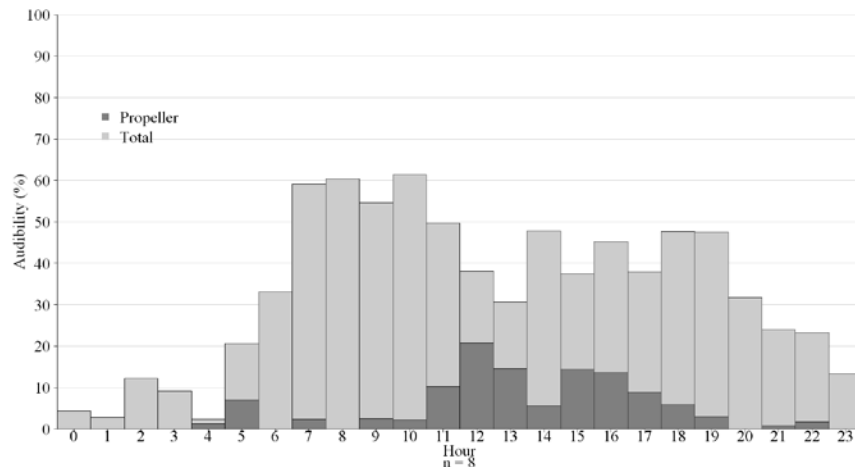


Figure 8. Mean hourly percent time audible for propeller aircraft and all anthropogenic sources at GLBAHUTCH

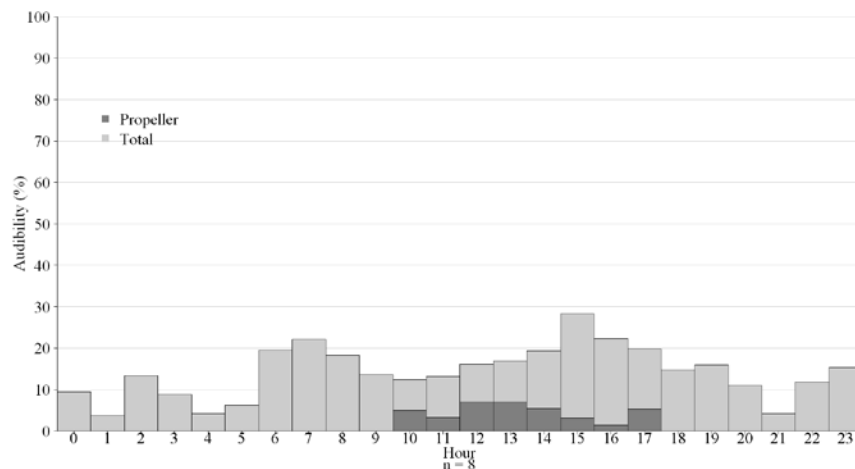


Figure 9. Mean hourly percent time audible for propeller aircraft and all anthropogenic sources at GLBAMCLEOD

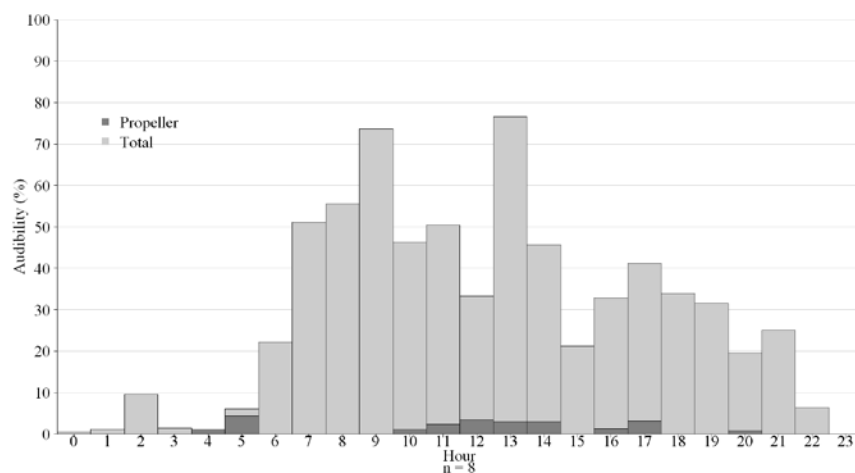


Figure 10. Mean hourly percent time audible for propeller aircraft and all anthropogenic sources at GLBAMOUSE

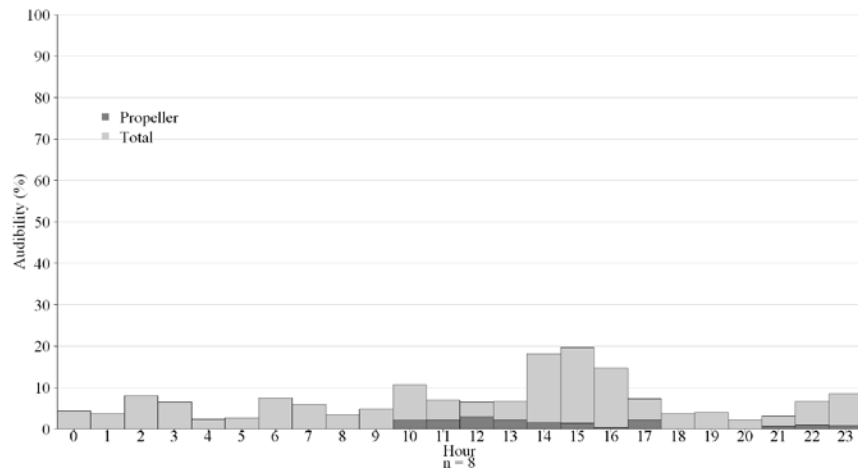


Figure 11. Mean hourly percent time audible for propeller aircraft and all anthropogenic sources at GLBAMUIR

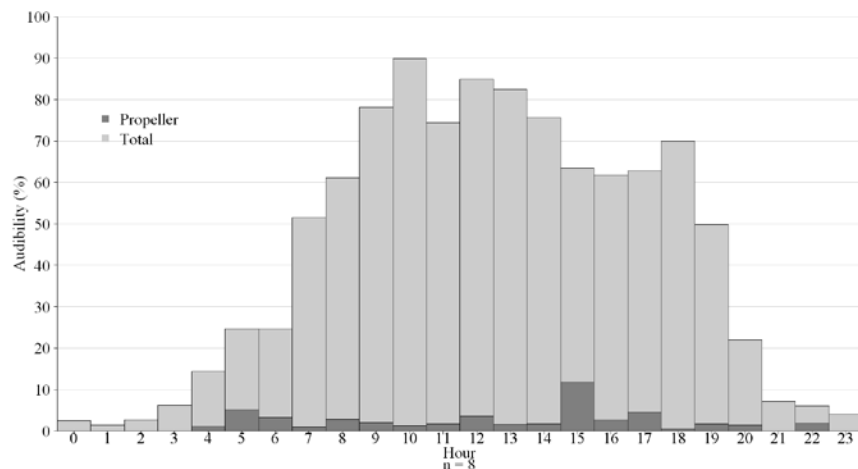


Figure 12. Mean hourly percent time audible for propeller aircraft and all anthropogenic sources at GLBARENDU

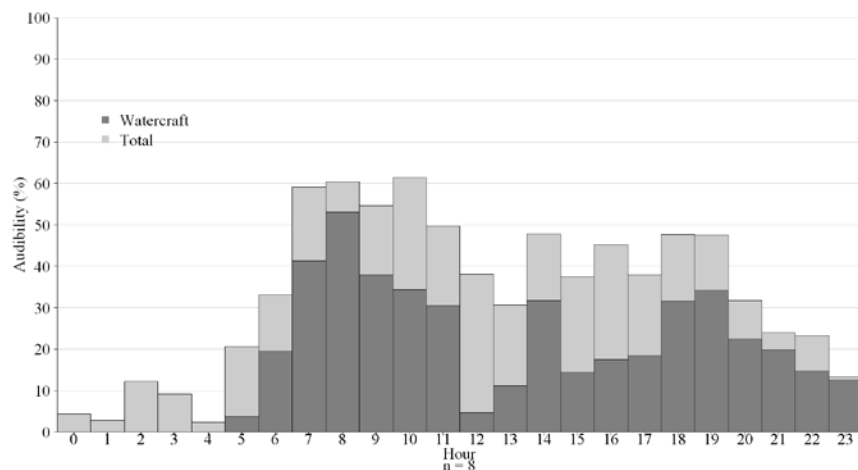


Figure 13. Mean hourly percent time audible for watercraft and all anthropogenic sources at GLBAHUTCH

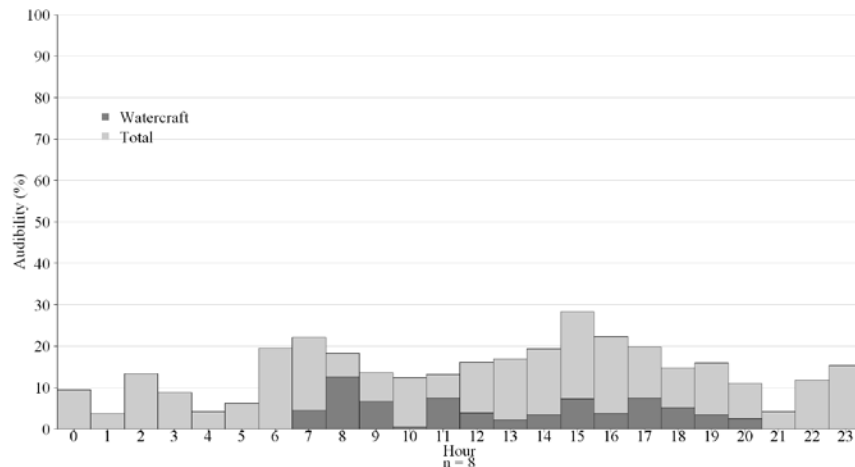


Figure 14. Mean hourly percent time audible for watercraft and all anthropogenic sources at GLBAMCLEOD

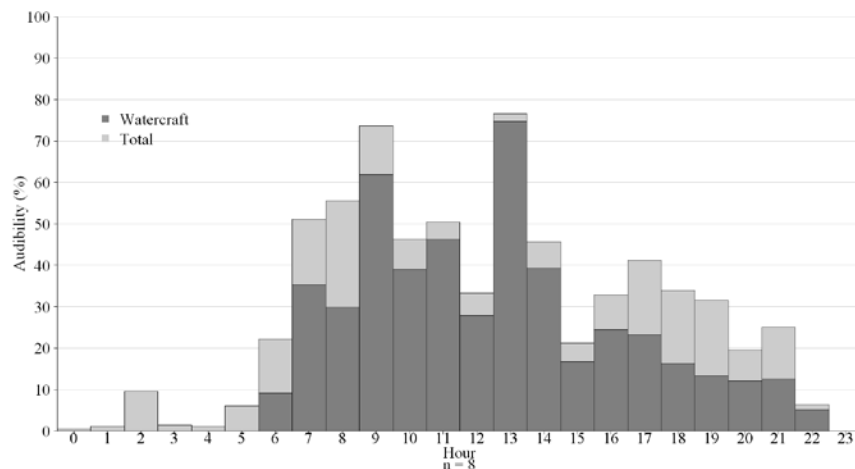


Figure 15. Mean hourly percent time audible for watercraft and all anthropogenic sources at GLBAMOUSE

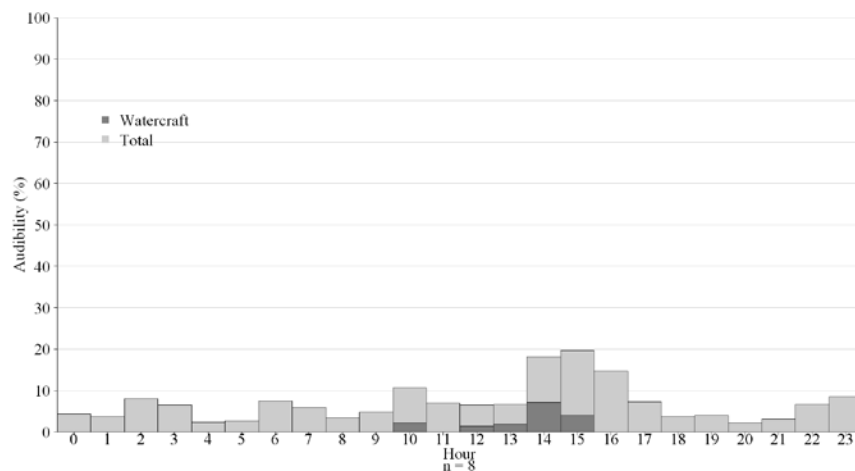


Figure 16. Mean hourly percent time audible for watercraft and all anthropogenic sources at GLBAMUIR

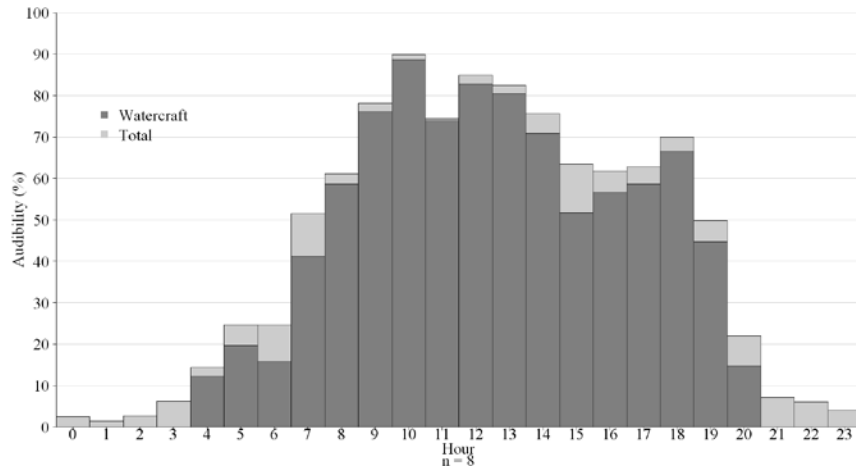


Figure 17. Mean hourly percent time audible for watercraft and all anthropogenic sources at GLBARENDU

The figures above reveal information about when noise sources were audible, and how long they were audible for. The inverse of this audibility metric is noise free interval, which is defined as the period of time *between* noise events. One might translate the term “noise free interval” as the typical length of time one could sit at the five monitoring sites without hearing anthropogenic noise. It is an essential metric because it describes the degree of solitude one can experience at a given acoustical monitoring site. The table below reports mean noise free interval length for all sites and all hours.

Table 4. Mean noise free interval length in mm:ss for all sites, all hours

	GLBAHUTCH	GLBAMCLEOD	GLBAMOUSE	GLBAMUIR	GLBARENDU
00h	19:44	17:22	37:36	15:11	27:24
01h	40:37	15:54	49:56	27:16	34:31
02h	16:33	7:27	31:46	9:50	20:41
03h	20:32	13:08	20:07	13:59	14:45
04h	34:37	15:00	19:24	15:52	13:26
05h	3:51	22:02	15:41	21:17	4:20
06h	2:45	5:27	4:16	10:31	6:39
07h	1:34	6:54	2:03	17:08	1:02
08h	1:53	14:22	0:42	22:33	1:35
09h	1:04	3:13	0:24	14:27	0:24
10h	1:37	15:35	1:07	11:43	0:35
11h	1:49	22:12	2:06	16:56	1:05
12h	2:17	5:42	1:09	14:04	0:16
13h	3:25	3:53	0:41	16:29	0:42
14h	2:48	6:34	5:15	5:58	0:57
15h	5:25	3:48	3:03	5:07	1:39
16h	2:01	5:37	3:55	4:33	1:29
17h	3:46	4:18	3:56	10:37	1:19
18h	2:00	7:34	2:54	16:57	0:54
19h	1:18	9:44	14:08	19:10	1:53
20h	5:05	16:23	12:46	23:26	12:13
21h	7:00	30:49	3:09	14:49	14:06
22h	5:49	4:56	55:27	11:03	13:23
23h	10:47	8:59	60:00	13:34	14:56

A few interesting patterns emerge in the table above. The early morning and late evening hours were the most likely to demonstrate the longest noise free intervals. Conversely, the shortest noise free intervals occurred during daytime hours (presumably because human activity was greatest at these times). However, a few evening hours did not exhibit long noise free intervals. The evening silence was often punctuated by jet aircraft at GLBAMCLEOD, GLBAMUIR, and GLBARENDU, and long term motor sounds (such as those produced by distant watercraft or generators) were audible during the evening hours at GLBAHUTCH. Sites with regular cruise ship passby events (such as GLBARENDU) exhibited very short noise free intervals for some hours (such as just 0:04 for the noon hour).

On-site audibility sessions

Nearly 75 on-site audibility sessions of varying length were logged over the course of the summer by park staff. To best demonstrate trends in noise source audibility the sessions were stratified by 12 geographic locations (Sebree area, Reid Inlet, Russell Island, Johns Hopkins Inlet, Johns Hopkins Inlet Entrance, Blue Mouse Cove, Upper East Arm, Muir Inlet, Gloomy Knob, Queen Inlet, and Rendu) 4 times of day (morning, midday, evening, and night), and 3 months (June, July, and August). While both natural and non-natural sources were logged during these sessions, audibility results below are limited to noise sources like jet, propeller, helicopter, generator, watercraft, and all noise sources. Table 5 shows the number of minutes logged at each site. Because they span fewer minutes of the day, onsite listening results may differ from offsite results. However, they are still valuable to the acoustical monitoring effort because they provide visual confirmation of sound sources that may have been difficult to identify using sound alone.

Table 5. Number of minutes logged in each geographic area and corresponding session numbers

Site	Sebree	Reid	Russel	JH Inlet	JH Entrance	Blue Mouse	Upper EastArm	Muir	Gloomy	Queen	Rendu	Link
Duration (min)	105	253	45	30	137	165	60	75	60	60	60	60
Session numbers	73, 74	81.1, 82.1, 83.1	82, 83, 84	85, 89	90, 91, 93, 125, 126	99, 100, 101, 102, 103, 104, 106	114, 115, 121	116, 117, 118, 120	122	123	124	110

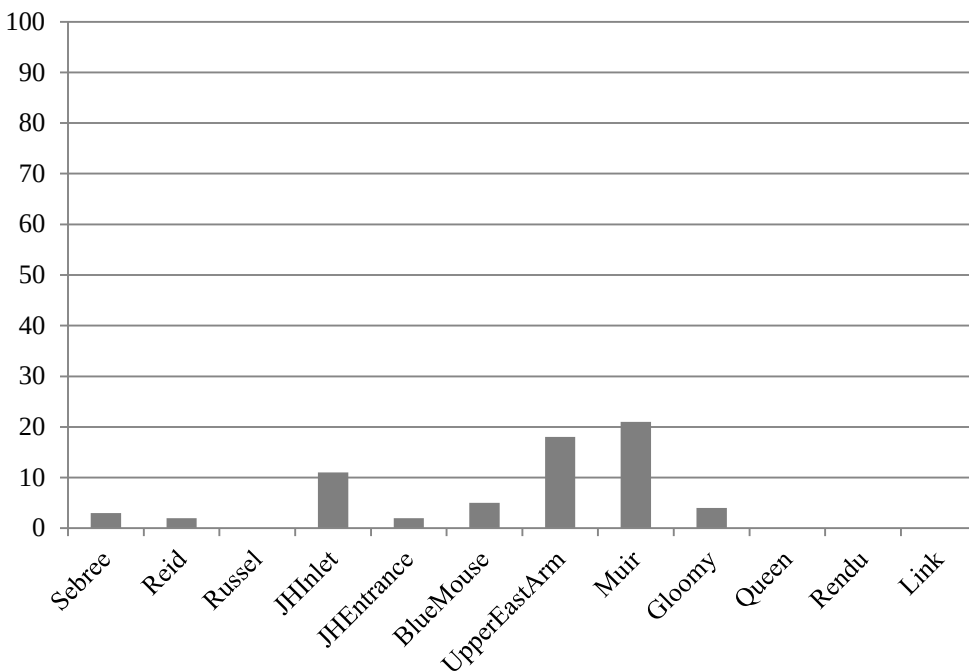


Figure 18. Jet audibility for 12 listening locations

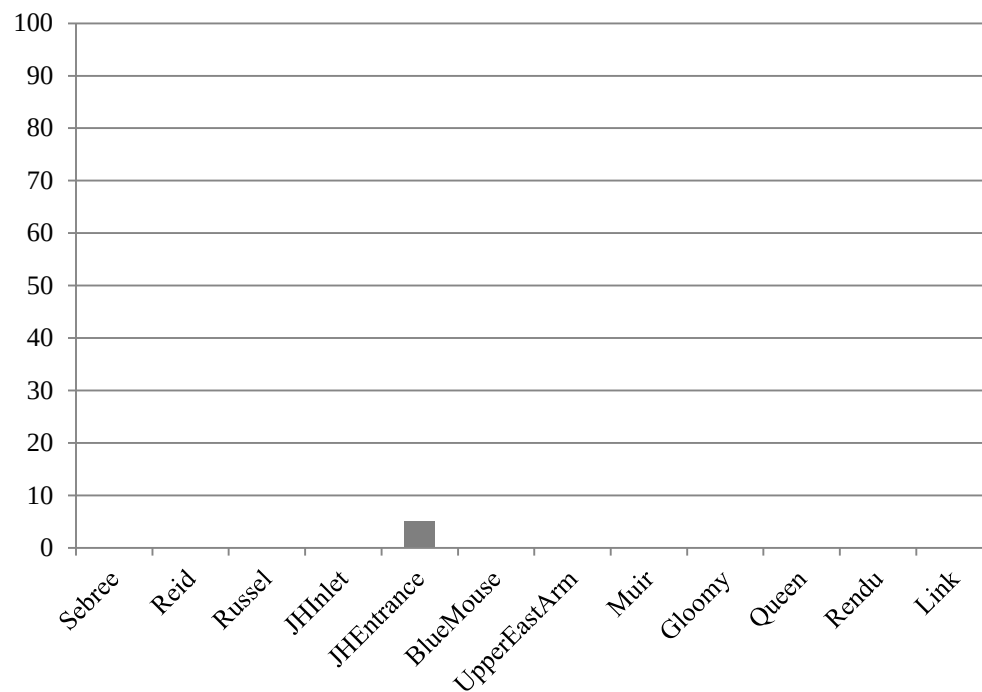


Figure 19. Helicopter audibility for 12 listening locations

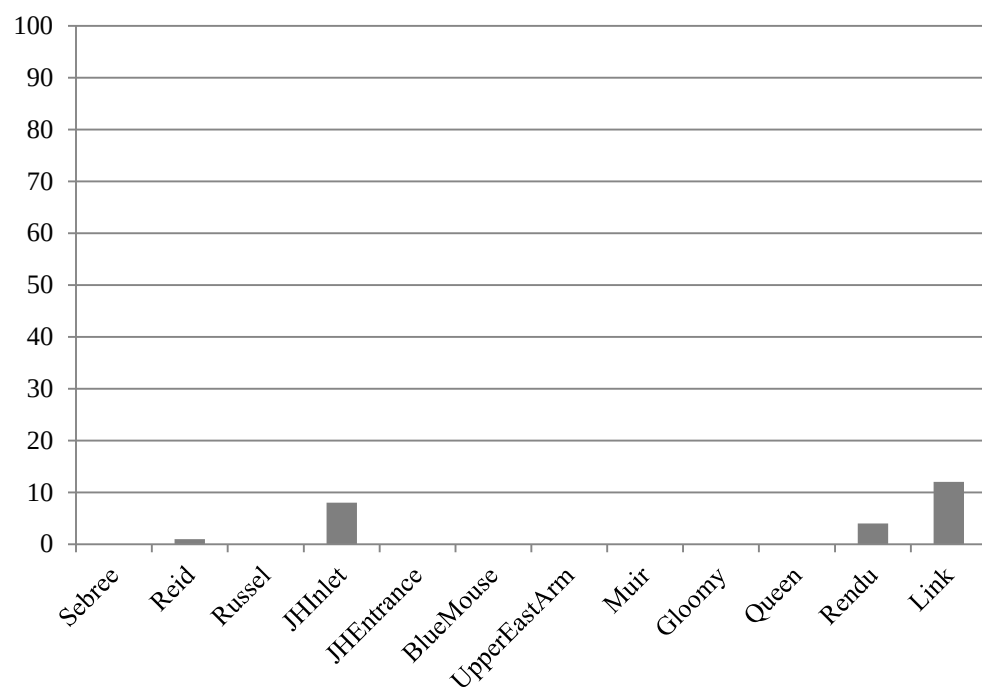


Figure 20. Propeller audibility for 12 listening locations

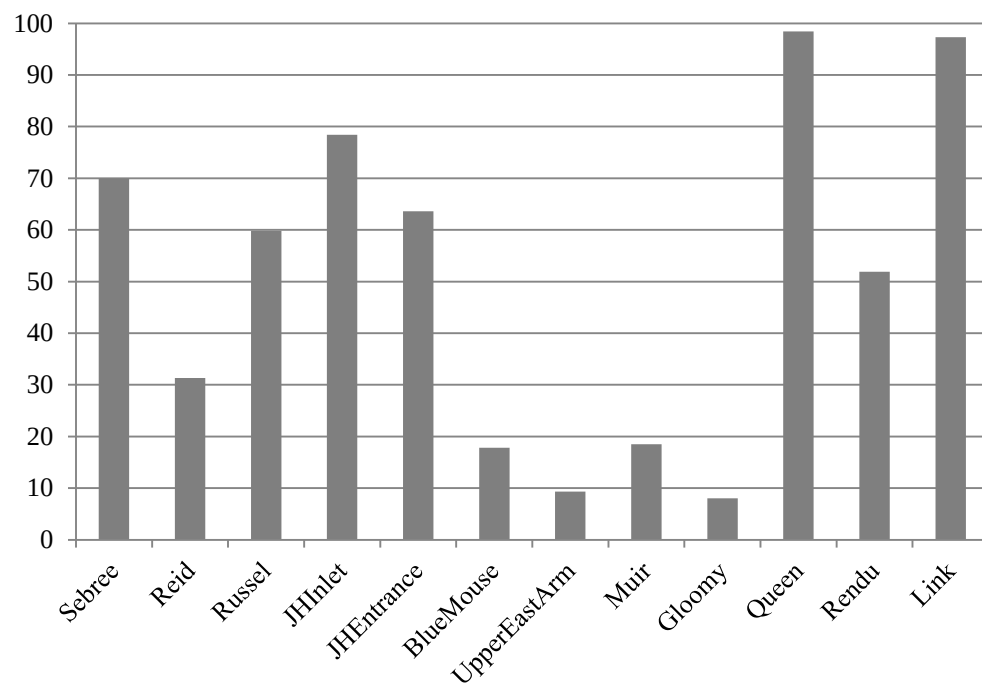


Figure 21. Watercraft audibility for 12 listening locations

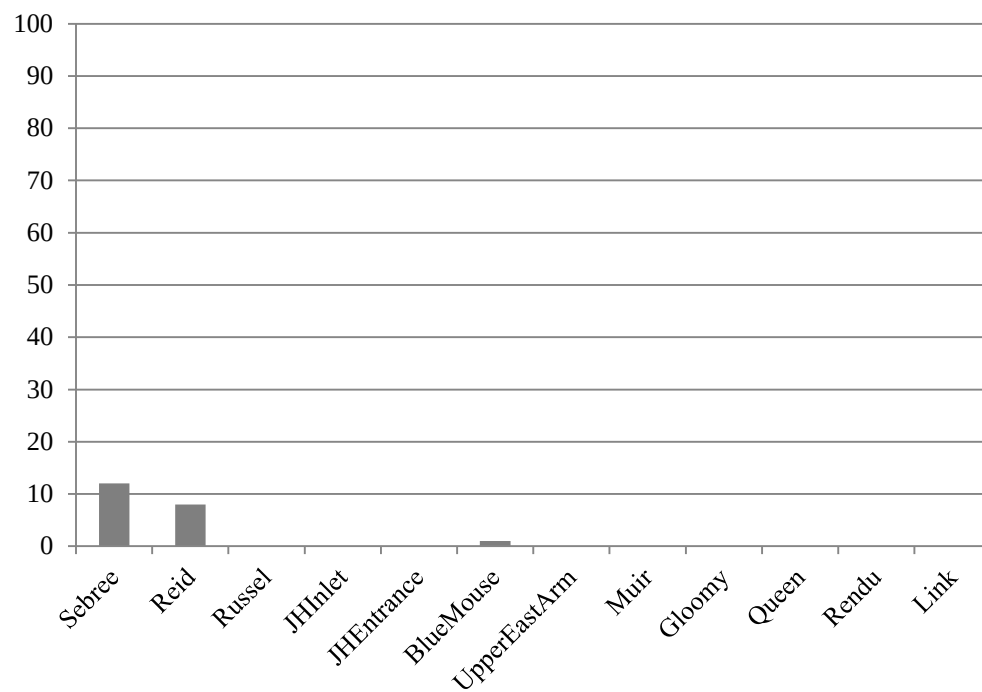


Figure 22. Generator audibility for 12 listening locations

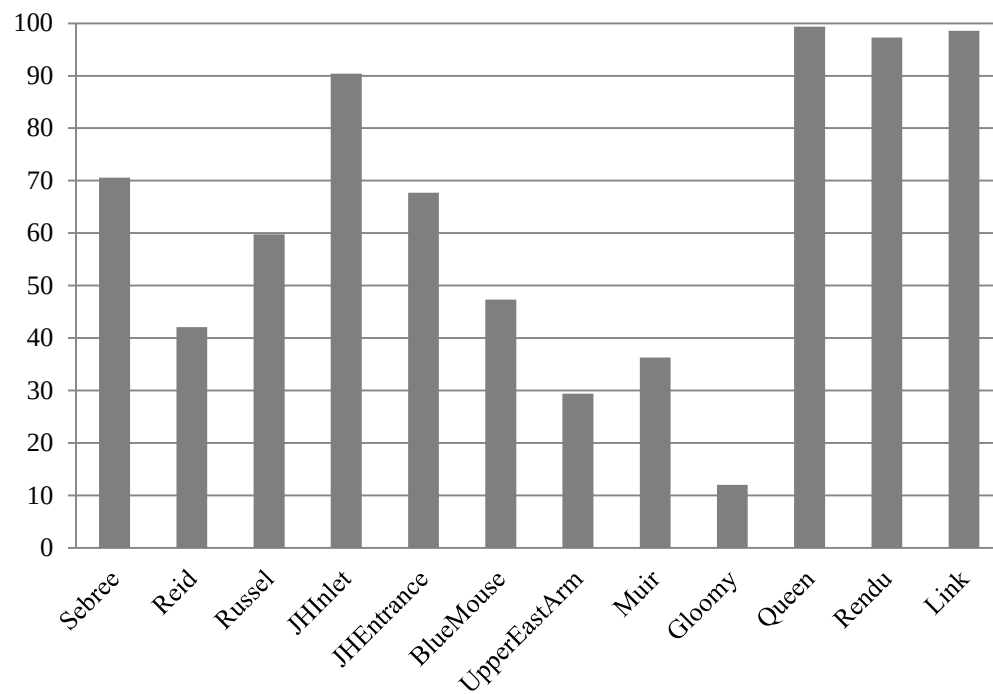


Figure 23. Audibility for all noise sources at 12 listening locations

As mentioned above, the onsite listening sessions were also analyzed by time of day. Table 6 shows the number of minutes logged by time of day, and Figure 24 plots the audibility of noise sources in each of four time categories (morning, midday, evening, and night).

Table 6. Minutes of onsite listening conducted by time of day

Time Periods	Morning	Midday	Evening	Night
Duration (min)	185	917	308	165

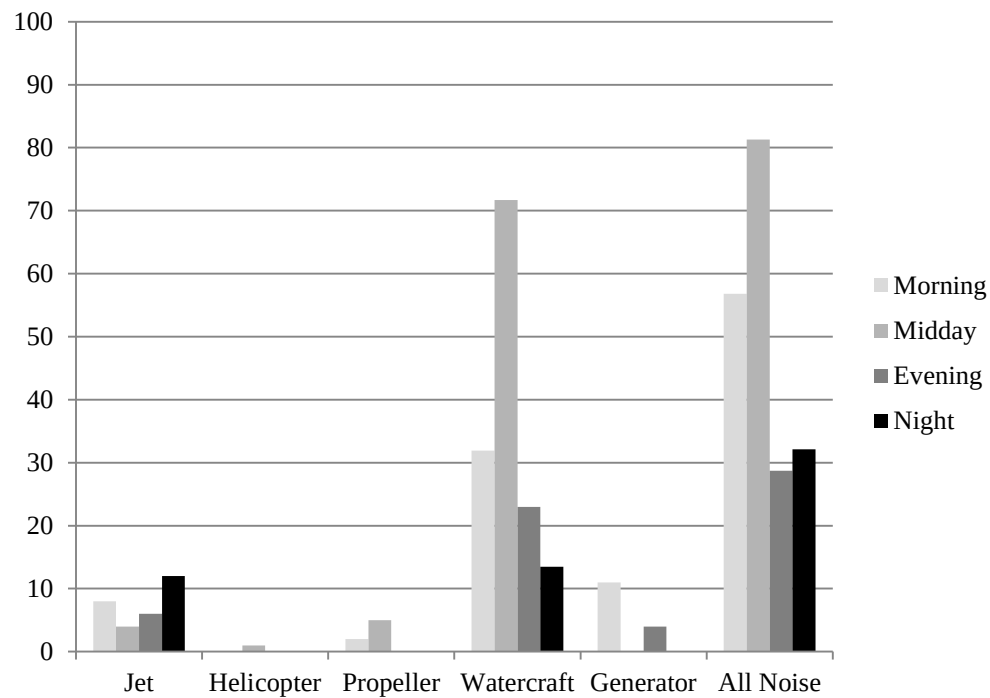


Figure 24. Audibility of noise sources by time of day

Finally, on site listening sessions were separated by the month in which they occurred. Table 7 shows how many minutes of onsite listening happened by month and Figure 25 plots the audibility of noise sources by month.

Table 7. Minutes of onsite listening conducted by month

Months	June	July	August
Duration (min)	525	300	520

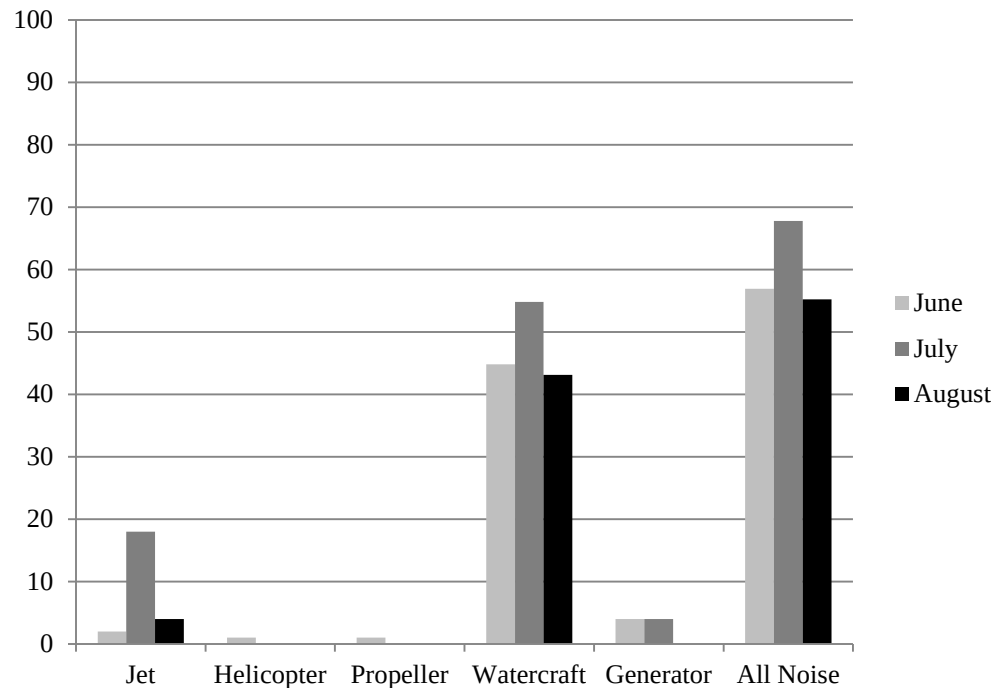


Figure 25. Audibility of noise sources by month

Table 8. Mean noise free interval in minutes, based on onsite listening efforts

	Mean Noise Free Interval (minutes)				
Sebree	4:25	Morning	4:26	June	4:02
Reid	3:15	Midday	1:53	July	2:06
Russell	4:31	Evening	3:40	August	3:02
JHInlet	0:35	Night	6:36		
JHEntrance	5:31				
BlueMouse	2:35				
UpperEastArm	2:29				
Muir	3:11				
Gloomy	17:36				
Queen	0:10				
Rendu	1:36				
Link	0:49				

Discussion

The purpose of this study was twofold: to characterize the existing acoustical environment at five sites in Glacier Bay National Park and Preserve, and to provide concrete information about the audibility of certain noise sources of interest (namely, jets, propellers, and watercraft) in these places. Monitoring results were intended to give the park baseline information as well as inform management decisions. Continuous .mp3 audio data was gathered from five sites in the park for approximately twenty days each. Eight days from each site were selected for detailed audibility analysis. Each noise event was categorized and its duration was recorded. These results were then summarized to provide mean hourly audibility of noise for all sites.

Great variability in noise source audibility was noted across all sites during offsite analysis, and a number of patterns appeared. As a whole, propeller aircraft events were audible infrequently at the selected sites. Jet aircraft were a consistent source of noise across all sites. That is to say, jets were audible about the same amount of time at all sites. This is a familiar phenomenon in national parks. High altitude jets are a ubiquitous noise source and a single overflight can produce a sizeable noise footprint on the landscape below (Barber et al. 2010). Watercraft had the widest variability in audibility from site to site during the monitoring period, ranging from less than 1 percent time audible at Muir Inlet (GLBAMUIR), to almost thirty-four percent time audible at Rendu (GLBARENDU). Still, there were many instances at all sites when only natural sounds were audible. These noise-free intervals tended to be in the early morning and late evening (when humans were less active), but they were also interspersed among the midday hours. In general, onsite audibility mirrored offsite patterns of temporal and geographic noise source audibility, but shorter listening periods did result in slight variability in audibility.

Many natural sounds were recorded during this monitoring effort in addition to the aforementioned noise sources. Rain storms approached, waves crashed on the beach, sea gulls called overhead, humpback whales bubble fed just off shore, and loons wailed from across the water. These are just a handful of the natural sound resources that contribute to the unique acoustical environment of Glacier Bay National Park and Preserve. These sounds (and the continuous acoustical monitoring data) will be stored in the Natural Sounds and Night Skies archive, and will always be available to the park upon request.

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Glossary of Acoustical Terms

Acoustical Environment

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

Amplitude

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

Audibility

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

dBA

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

Decibel

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

Diel

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

Extrinsic Sound

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

Frequency

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

Hearing Range (frequency)

By convention, an average, healthy, young person is said to hear frequencies from approximately 20Hz to 20000 Hz.

Hertz

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

Human-Caused Sound

Noise. Any sound that is attributable to a human source.

Intrinsic sound

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

Listening Horizon

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

 L_{eq}

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

 L_x

A metric used to describe acoustic data. It represents the level of sound exceeded x percent of the time during the given measurement period.

Masking

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

Noise-Free Interval

The period of time between noise events (not silence).

Noise

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

Off-site Listening

The systematic identification of sound sources using digital recordings previously collected in the field.

Sound Level Floor (Noise Floor)

The lowest amplitude measurable by sound monitoring equipment.

Appendix A: Visual analysis

The Natural Sounds and Night Skies Division uses visual analysis to identify the type and duration of noise sources. Figure 17 shows one hour of sound pressure level data in the form of a spectrogram. A white box has been drawn around the single commercial jet event that occurred during this hour.

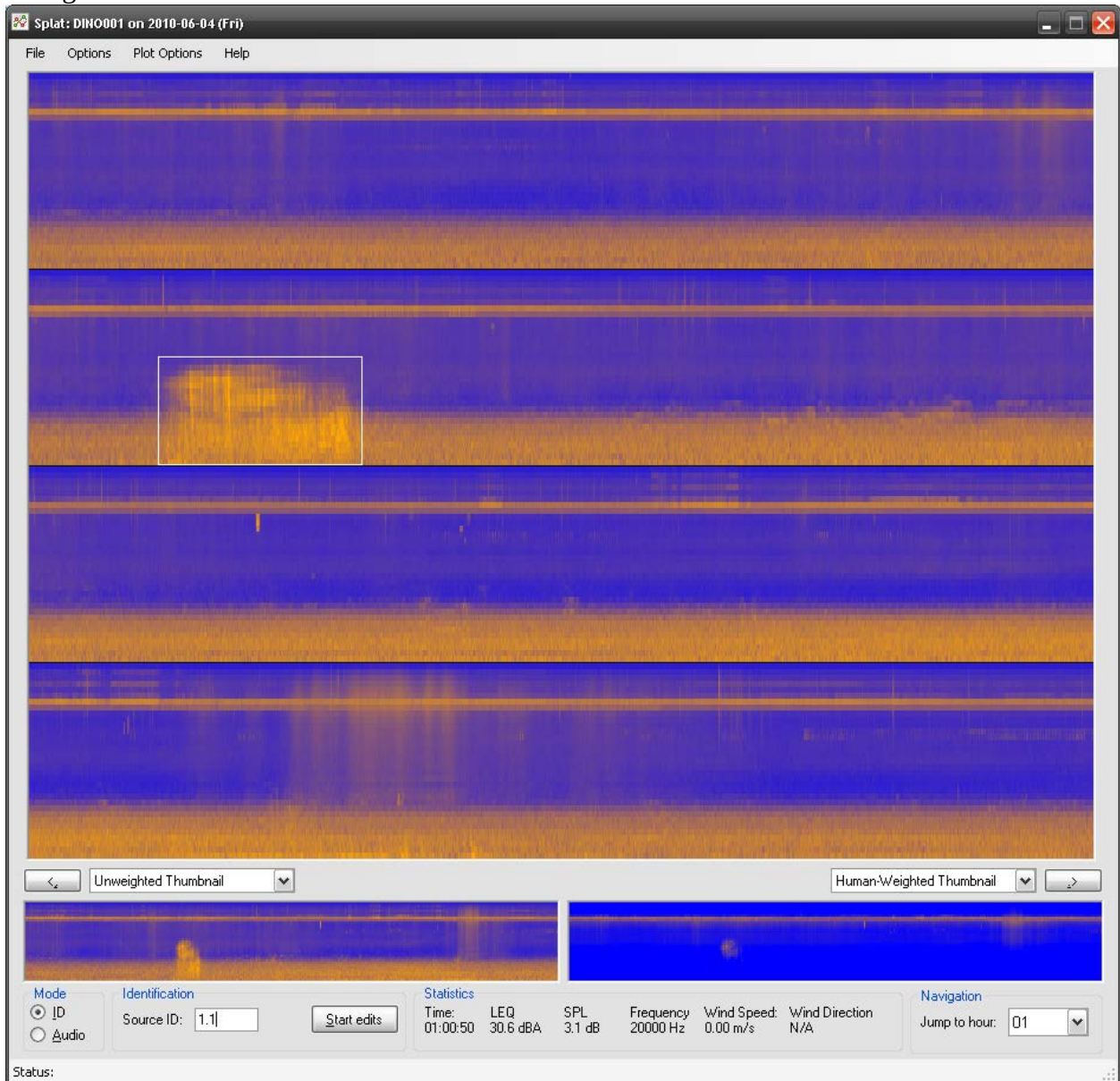


Figure 26. A demonstration of visual noise source analysis, using Sound Pressure Level Annotation Tool (SPLAT).

Appendix B. Mean hourly percent time audible for sources of interest

For each of the five sites, eight days of continuous audio was analyzed for noise audibility. Then, the results from these eight replications were averaged to produce a single mean percent time audible for each hour.

Table 9. Mean hourly percent time audible at GLBAHUTCH

Hour	All sources	Jet	Propeller	Watercraft
0	4.3	3.6	0.0	0.0
1	2.8	2.8	0.0	0.0
2	12.2	2.9	0.0	0.0
3	9.1	0.0	0.0	0.0
4	2.4	1.1	1.3	0.0
5	20.6	2.8	7.0	3.8
6	33.1	3.8	0.0	19.4
7	59.1	10.0	2.4	41.3
8	60.4	3.9	0.0	53.1
9	54.6	6.6	2.5	37.9
10	61.3	12.4	2.3	34.4
11	49.7	4.9	10.2	30.6
12	38.1	7.2	20.7	4.6
13	30.7	5.7	14.6	11.2
14	47.8	6.8	5.6	31.7
15	37.5	2.7	14.3	14.3
16	45.2	3.0	13.6	17.5
17	38.0	5.1	8.9	18.4
18	47.6	5.1	5.8	31.6
19	47.5	9.5	3.0	34.1
20	31.8	11.2	0.0	22.4
21	23.9	5.2	0.7	19.9
22	23.3	8.0	1.7	14.7
23	13.3	0.8	0.0	12.5

Table 10. Mean hourly percent time audible at GLBAMCLEOD

Hour	All sources	Jet	Propeller	Watercraft
0	9.4	9.4	0.0	0.0
1	3.7	3.7	0.0	0.0
2	13.3	13.3	0.0	0.0
3	8.8	8.8	0.0	0.0
4	4.2	4.2	0.0	0.0
5	6.2	4.5	0.0	0.0
6	19.5	13.1	0.0	0.0
7	22.1	17.0	0.0	4.4
8	18.3	5.3	0.0	12.6
9	13.6	7.8	0.0	6.6
10	12.4	7.1	5.0	0.5
11	13.1	2.5	3.2	7.5
12	16.1	5.5	6.9	3.9
13	16.9	7.9	6.9	2.3
14	19.3	10.5	5.4	3.5
15	28.3	18.5	3.1	7.3
16	22.3	19.0	1.4	3.8
17	19.8	7.0	5.3	7.5
18	14.7	9.6	0.0	5.2
19	16.0	12.7	0.0	3.4
20	11.0	8.4	0.0	2.5
21	4.2	4.2	0.0	0.0
22	11.8	11.8	0.0	0.0
23	15.3	15.3	0.0	0.0

Table 11. Mean hourly percent time audible at GLBAMOUSE

Hour	All sources	Jet	Propeller	Watercraft
0	0.4	0.4	0.0	0.0
1	1.2	1.2	0.0	0.0
2	9.5	1.1	0.0	0.0
3	1.4	0.8	0.0	0.0
4	1.1	0.0	1.0	0.0
5	6.1	0.0	4.3	0.0
6	22.2	0.9	0.0	9.1
7	51.1	4.7	0.0	35.3
8	55.5	0.7	0.0	29.8
9	73.6	0.0	0.0	61.9
10	46.2	0.9	1.0	39.0
11	50.4	1.2	2.4	46.2
12	33.3	2.8	3.4	27.8
13	76.6	1.2	3.0	74.7
14	45.7	3.4	3.0	39.3
15	21.2	1.3	0.0	16.7
16	32.8	1.3	1.3	24.5
17	41.2	0.9	3.1	23.3
18	33.9	2.7	0.0	16.3
19	31.5	0.7	0.0	13.3
20	19.5	7.6	0.7	12.0
21	25.0	12.5	0.0	12.5
22	6.3	1.0	0.0	5.2
23	0.0	0.0	0.0	0.0

Table 12. Mean hourly percent time audible at GLBAMUIR

Hour	All sources	Jet	Propeller	Watercraft
0	4.3	4.3	0.0	0.0
1	3.7	3.7	0.0	0.0
2	8.0	8.0	0.0	0.0
3	6.5	6.5	0.0	0.0
4	2.4	2.4	0.0	0.0
5	2.7	2.7	0.0	0.0
6	7.5	7.5	0.0	0.0
7	5.9	5.9	0.0	0.0
8	3.5	3.5	0.0	0.0
9	4.8	4.8	0.0	0.0
10	10.6	6.4	2.1	2.2
11	6.9	4.7	2.2	0.0
12	6.5	2.3	2.9	1.4
13	6.6	2.4	2.3	1.9
14	18.1	9.3	1.5	7.2
15	19.7	14.3	1.4	4.0
16	14.7	14.4	0.3	0.0
17	7.3	5.1	2.2	0.0
18	3.7	3.7	0.0	0.0
19	4.0	4.0	0.0	0.0
20	2.2	2.2	0.0	0.0
21	3.1	2.4	0.6	0.0
22	6.6	5.7	0.9	0.0
23	8.4	7.6	0.8	0.0

Table 13. Mean hourly percent time audible at GLBARENDU

Hour	All sources	Jet	Propeller	Watercraft
0	2.5	2.5	0.0	0.0
1	1.4	1.0	0.0	0.0
2	2.7	2.7	0.0	0.0
3	6.2	5.3	0.0	0.0
4	14.3	1.8	1.0	12.2
5	24.7	0.0	5.1	19.7
6	24.6	5.7	3.2	15.7
7	51.4	7.0	0.9	41.2
8	61.1	0.0	2.8	58.6
9	78.1	0.0	2.0	76.1
10	89.9	0.0	1.3	88.7
11	74.4	0.5	1.7	73.9
12	84.9	1.1	3.6	82.8
13	82.5	2.3	1.6	80.5
14	75.6	4.7	1.7	70.8
15	63.4	1.6	11.7	51.7
16	61.8	3.8	2.6	56.6
17	62.8	1.8	4.5	58.6
18	69.9	3.6	0.5	66.5
19	49.8	4.0	1.7	44.7
20	22.0	6.6	1.4	14.8
21	7.2	7.2	0.0	0.0
22	6.1	4.2	1.8	0.0
23	4.0	4.0	0.0	0.0

Appendix C. Detailed onsite listening results

The following reports show detailed results of onsite listening sessions, grouped by location, time of day, and month.

Sebree

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	3.0	206	206	206		1
3	Watercraft	14.0	883	883	883		1
3.1	Outboard	49.0	894	618	154	368	5
3.11	Outboard, 2-stroke	14.0	886	886	886		1
3.6	Non-Motorized Craft	0.0	19	19	19		1
3.7	Sail Boat	9.0	586	586	586		1
6.1	Generator	12.0	740	740	740		1
8	People	6.0	406	406	406		1
19	Non-natural Other	0.0	5	5	5		1
19.1	Wind-induced Non-natural	21.0	726	672	618	76	2
21	Wind	14.0	858	858	858		1
22	Water	71.0	897	890	878	8	5
24	Mammal	0.0	22	22	22		1
24.2	Chipmunk	0.0	11	10	8	2	2
24.5	Other Animal	2.0	45	19	5	19	6
25	Bird	82.0	899	370	6	410	14
25.1	Raven	6.0	269	136	16	127	3
28	Insect	39.0	897	70	3	150	35
39	Natural Other	8.0	475	475	475		1
39.1	Natural Other	27.0	882	857	832	35	2
G0100	All Aircraft	3.3					
G0300	All Watercraft	70.3					
G2000	All Non-natural Sources	70.6					
G4000	All Natural Sources	99.6					
NFI	Noise Free Interval	29.4	900	265	6	434	7

Reid Inlet

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	2.0	83	31	1	30	12
1.2	Aircraft, Propeller	1.0	112	25	5	39	7
3	Watercraft	20.0	2,719	372	1	949	8
3.1	Outboard	7.0	1,117	1,117	1,117		1
3.11	Outboard, 2-stroke	3.0	231	91	3	102	5
3.12	Outboard, 4-stroke	5.0	387	106	13	133	7
3.7	Sail Boat	2.0	170	166	163	5	2
3.8	Boat Wake (on shore)	3.0	368	237	106	185	2
6.1	Generator	8.0	570	414	275	148	3
8	People	0.0	4	2	1	1	7
8.1	People, Voices	0.0	27	7	0	9	8
8.2	People, Walking	1.0	39	21	2	17	5
19.1	Wind-induced Non-natural	5.0	483	413	343	99	2
21	Wind	38.0	3,592	276	1	794	21
22	Water	71.0	3,588	1,343	44	1,430	8
22.2	Flowing Water	64.0	3,587	747	31	935	13
24.5	Other Animal	0.0	3	3	3		1
25	Bird	83.0	1,266	116	0	226	109
28	Insect	17.0	606	15	0	65	168
39.1	Natural Other	22.0	2,877	418	16	995	8
99	Unknown	0.0	14	8	1	9	2
G0100	All Aircraft	3.6					
G0300	All Watercraft	31.3					
G2000	All Non-natural Sources	42.1					
G4000	All Natural Sources	94.0					
NFI	Noise Free Interval	57.8	1,300	195	1	312	45

Russell Island

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
3	Watercraft	60.0	897	538	106	401	3
22	Water	66.0	895	894	894	1	2
22.1	Rain/Fog Drip	65.0	896	884	871	18	2
24.5	Other Animal	1.0	21	16	12	6	2
25	Bird	70.0	890	172	0	262	11
G0300	All Watercraft	59.8					
G2000	All Non-natural Sources	59.8					
G4000	All Natural Sources	99.4					
NFI	Noise Free Interval	40.2	900	271	1	428	4

Johns Hopkins Inlet

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	11.0	103	98	94	6	2
1.2	Aircraft, Propeller	8.0	144	144	144		1
3	Watercraft	29.0	520	520	520		1
3.11	Outboard, 2-stroke	50.0	891	891	891		1
22	Water	99.0	895	894	894	1	2
22.1	Rain/Fog Drip	49.0	878	878	878		1
22.2	Flowing Water	89.0	895	802	710	131	2
25	Bird	68.0	896	307	60	394	4
G0100	All Aircraft	18.9					
G0300	All Watercraft	78.4					
G2000	All Non-natural Sources	90.4					
G4000	All Natural Sources	99.5					
NFI	Noise Free Interval	9.6	138	35	3	58	5

Johns Hopkins Inlet Entrance

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	2.0	197	197	197		1
1.3	Helicopter	5.0	234	144	33	102	3
3	Watercraft	62.0	3,562	1,704	657	1,613	3
3.1	Outboard	44.0	3,587	3,587	3,587		1
3.12	Outboard, 4-stroke	5.0	339	208	77	185	2
3.6	Non-Motorized Craft	1.0	87	87	87		1
3.7	Sail Boat	0.0	30	30	30		1
3.8	Boat Wake (on shore)	2.0	114	66	18	68	2
19.1	Wind-induced Non-natural	15.0	450	242	91	155	5
21	Wind	24.0	2,008	2,008	2,008		1
21.1	Wind, Light	27.0	1,449	560	91	610	4
22	Water	76.0	3,565	1,564	896	1,334	4
24.5	Other Animal	1.0	42	14	2	16	6
25	Bird	70.0	3,595	637	0	1,169	9
25.1	Raven	4.0	254	110	12	127	3
28	Insect	70.0	3,518	717	70	1,162	8
39	Natural Other	1.0	38	23	8	21	2
39.1	Natural Other	4.0	343	343	343		1
40	Natural Unknown	6.0	428	114	6	209	4
G0100	All Aircraft	7.6					
G0300	All Watercraft	63.6					
G2000	All Non-natural Sources	67.7					
G4000	All Natural Sources	90.8					
NFI	Noise Free Interval	32.3	1,005	331	1	417	8

Blue Mouse Cove

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	5.0	120	36	2	40	14
3	Watercraft	15.0	896	300	4	370	5
3.1	Outboard	3.0	344	344	344		1
3.11	Outboard, 2-stroke	0.0	43	43	43		1
6	Motor	0.0	22	22	22		1
6.1	Generator	1.0	79	79	79		1
19	Non-natural Other	44.0	897	732	216	269	6
19.1	Wind-induced Non-natural	1.0	31	6	0	8	18
21	Wind	21.0	899	175	2	338	12
21.1	Wind, Light	20.0	885	71	0	190	28
22	Water	52.0	897	426	2	425	12
22.1	Rain/Fog Drip	81.0	896	668	3	349	12
22.2	Flowing Water	25.0	854	492	1	431	5
24	Mammal	0.0	6	2	1	2	4
24.5	Other Animal	1.0	12	2	0	2	60
25	Bird	63.0	898	79	0	190	79
25.1	Raven	1.0	62	14	1	24	6
28	Insect	4.0	380	110	2	181	4
29	Animal (Natural)	0.0	2	2	2		1
39	Natural Other	0.0	2	2	2	0	4
39.1	Natural Other	36.0	893	108	2	253	33
40	Natural Unknown	0.0	20	3	0	6	12
41.5	Field Personnel	2.0	56	11	0	17	14
99	Unknown	0.0	4	4	4		1
G0100	All Aircraft	5.2					
G0300	All Watercraft	17.8					
G2000	All Non-natural Sources	47.3					
G4000	All Natural Sources	98.7					
G4100	All Artifacts	1.6					
NFI	Noise Free Interval	51.7	861	155	1	212	33

Link Island

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.2	Aircraft, Propeller	12.0	365	215	65	212	2
3	Watercraft	97.0	1,985	1,751	1,517	331	2
21.1	Wind, Light	10.0	367	367	367		1
22	Water	100.0	3,598	3,598	3,598		1
24.5	Other Animal	100.0	3,590	3,590	3,590		1
25	Bird	100.0	3,600	3,600	3,600		1
25.1	Raven	20.0	111	56	12	38	13
27	Amphibian	3.0	88	24	5	36	5
28	Insect	0.0	3	3	2	1	3
39	Natural Other	100.0	3,595	3,595	3,595		1
40	Natural Unknown	0.0	7	6	5	1	2
G0100	All Aircraft	11.9					
G0300	All Watercraft	97.3					
G2000	All Non-natural Sources	98.6					
G4000	All Natural Sources	100.0					
NFI	Noise Free Interval	1.4	49	49	49		1

Upper East Arm

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	18.0	371	132	20	142	5
3	Watercraft	9.0	124	84	40	34	4
8	People	3.0	41	15	3	14	8
21	Wind	25.0	896	896	896		1
22	Water	99.0	897	889	880	7	4
22.1	Rain/Fog Drip	14.0	497	497	497		1
22.2	Flowing Water	25.0	895	895	895		1
24.5	Other Animal	0.0	1	1	1		1
25	Bird	100.0	899	898	898	1	4
28	Insect	45.0	897	321	26	366	5
39	Natural Other	2.0	83	83	83		1
39.1	Natural Other	8.0	131	101	79	27	3
40	Natural Unknown	4.0	119	53	4	59	3
G0100	All Aircraft	18.4					
G0300	All Watercraft	9.3					
G2000	All Non-natural Sources	29.4					
G4000	All Natural Sources	99.8					
NFI	Noise Free Interval	70.6	900	149	3	274	17

Muir Inlet

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	21.0	162	73	15	42	13
3	Watercraft	19.0	834	834	834		1
22	Water	80.0	897	895	892	2	4
22.2	Flowing Water	100.0	898	896	894	1	5
25	Bird	75.0	899	483	73	349	7
28	Insect	38.0	515	188	62	141	9
39.1	Natural Other	6.0	99	71	21	35	4
G0100	All Aircraft	21.0					
G0300	All Watercraft	18.5					
G2000	All Non-natural Sources	36.3					
G4000	All Natural Sources	99.8					
NFI	Noise Free Interval	63.7	782	191	5	254	15

Gloomy Knob

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	4.0	145	145	145		1
3.1	Outboard	8.0	287	287	287		1
21	Wind	89.0	3,193	3,193	3,193		1
21.1	Wind, Light	94.0	3,400	3,400	3,400		1
22	Water	100.0	3,583	3,583	3,583		1
24.5	Other Animal	0.0	4	4	4		1
25	Bird	33.0	579	43	1	112	27
28	Insect	0.0	4	4	3	1	2
39.1	Natural Other	100.0	3,585	3,585	3,585		1
G0100	All Aircraft	4.0					
G0300	All Watercraft	8.0					
G2000	All Non-natural Sources	12.0					
G4000	All Natural Sources	99.6					
NFI	Noise Free Interval	88.0	1,880	1,056	35	938	3

Queen Inlet

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
3	Watercraft	1.0	45	45	45		1
3.1	Outboard	95.0	1,966	1,143	696	714	3
3.12	Outboard, 4-stroke	0.0	7	7	7		1
3.8	Boat Wake (on shore)	5.0	163	163	163		1
8.4	Portable Audio Devices	1.0	42	42	42		1
19	Non-natural Other	54.0	1,550	964	377	829	2
21.1	Wind, Light	16.0	594	594	594		1
22	Water	100.0	3,597	3,597	3,597		1
22.2	Flowing Water	99.0	3,565	3,565	3,565		1
25	Bird	50.0	481	127	6	128	14
28	Insect	2.0	16	7	2	4	9
G0300	All Watercraft	98.4					
G2000	All Non-natural Sources	99.4					
G4000	All Natural Sources	99.9					
NFI	Noise Free Interval	0.6	19	10	1	13	2

Mouth of Rendu

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.2	Aircraft, Propeller	4.0	140	140	140		1
3	Watercraft	50.0	816	302	23	298	6
3.8	Boat Wake (on shore)	2.0	57	57	57		1
19.1	Wind-induced Non-natural	97.0	3,480	3,480	3,480		1
21	Wind	100.0	3,591	3,591	3,591		1
21.1	Wind, Light	2.0	81	81	81		1
21.2	Wind, Heavy	27.0	975	975	975		1
22	Water	100.0	3,598	3,598	3,598		1
25	Bird	33.0	206	74	7	67	16
39.1	Natural Other	96.0	3,470	3,470	3,470		1
G0100	All Aircraft	3.9					
G0300	All Watercraft	51.9					
G2000	All Non-natural Sources	97.3					
G4000	All Natural Sources	99.9					
NFI	Noise Free Interval	2.7	96	96	96		1

June

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	2.0	197	51	1	59	14
1.2	Aircraft, Propeller	1.0	140	40	5	54	8
1.3	Helicopter	1.0	234	144	33	102	3
3	Watercraft	27.0	3,562	525	1	1,055	16
3.1	Outboard	27.0	3,587	1,403	287	1,210	6
3.11	Outboard, 2-stroke	1.0	231	91	3	102	5
3.12	Outboard, 4-stroke	4.0	387	117	7	137	10
3.6	Non-Motorized Craft	0.0	87	87	87		1
3.7	Sail Boat	1.0	170	121	30	79	3
3.8	Boat Wake (on shore)	3.0	368	138	18	123	6
6.1	Generator	4.0	570	414	275	148	3
8	People	0.0	4	2	1	1	7
8.1	People, Voices	0.0	27	7	0	9	8
8.2	People, Walking	0.0	39	21	2	17	5
8.4	Portable Audio Devices	0.0	42	42	42		1
19	Non-natural Other	6.0	1,550	964	377	829	2
19.1	Wind-induced Non-natural	18.0	3,480	690	91	1,137	8
21	Wind	46.0	3,592	608	1	1,188	24
21.1	Wind, Light	20.0	3,400	902	81	1,197	7
21.2	Wind, Heavy	3.0	975	975	975		1
22	Water	80.0	3,598	2,091	44	1,588	12
22.2	Flowing Water	42.0	3,587	949	31	1,172	14
24.5	Other Animal	0.0	7	4	2	2	6
25	Bird	65.0	3,595	122	0	333	167
25.1	Raven	1.0	254	110	12	127	3
28	Insect	23.0	3,518	40	0	274	183
39.1	Natural Other	34.0	3,585	977	16	1,512	11
40	Natural Unknown	1.0	428	114	6	209	4
99	Unknown	0.0	14	8	1	9	2
G0100	All Aircraft	4.6					
G0300	All Watercraft	44.8					
G2000	All Non-natural Sources	56.9					
G4000	All Natural Sources	94.7					
NFI	Noise Free Interval	43.1	1,880	242	1	406	56

July

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	18.0	388	109	15	96	29
1.2	Aircraft, Propeller	0.0	3	3	3		1
3	Watercraft	35.0	898	526	20	407	12
3.1	Outboard	17.0	894	618	154	368	5
3.11	Outboard, 2-stroke	5.0	886	886	886		1
3.12	Outboard, 4-stroke	5.0	880	880	880		1
3.6	Non-Motorized Craft	0.0	19	19	19		1
3.7	Sail Boat	3.0	586	586	586		1
6.1	Generator	4.0	740	740	740		1
8	People	3.0	406	59	3	131	9
19	Non-natural Other	0.0	5	5	5		1
19.1	Wind-induced Non-natural	17.0	891	767	618	121	4
21	Wind	19.0	898	872	837	30	4
21.1	Wind, Light	5.0	893	893	893		1
22	Water	69.0	897	891	878	6	14
22.1	Rain/Fog Drip	3.0	497	497	497		1
22.2	Flowing Water	39.0	898	882	787	38	8
24	Mammal	0.0	22	22	22		1
24.2	Chipmunk	0.0	11	10	8	2	2
24.5	Other Animal	1.0	45	12	1	15	17
25	Bird	94.0	899	732	0	310	23
25.1	Raven	2.0	269	136	16	127	3
28	Insect	33.0	897	95	1	175	63
39	Natural Other	7.0	714	424	83	319	3
39.1	Natural Other	27.0	895	410	21	404	12
40	Natural Unknown	1.0	119	43	3	47	5
G0100	All Aircraft	17.5					
G0300	All Watercraft	54.8					
G2000	All Non-natural Sources	67.8					
G4000	All Natural Sources	99.7					
NFI	Noise Free Interval	32.2	900	126	2	229	46

August

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	4.0	167	53	2	47	26
1.2	Aircraft, Propeller	0.0	144	144	144		1
3	Watercraft	39.0	1,783	647	4	526	19
3.1	Outboard	1.0	344	178	13	234	2
3.11	Outboard, 2-stroke	3.0	891	467	43	600	2
3.12	Outboard, 4-stroke	1.0	259	198	138	86	2
3.6	Non-Motorized Craft	0.0	8	8	8		1
3.7	Sail Boat	0.0	14	14	14		1
6	Motor	0.0	22	13	4	13	2
6.1	Generator	0.0	79	79	79		1
8	People	0.0	6	4	1	3	3
8.4	Portable Audio Devices	0.0	77	26	1	35	4
19	Non-natural Other	25.0	1,786	775	5	571	10
19.1	Wind-induced Non-natural	0.0	31	6	0	8	18
20	Non-natural Unknown	0.0	5	5	5		1
21	Wind	7.0	899	175	2	338	12
21.1	Wind, Light	23.0	1,789	208	0	443	35
22	Water	80.0	1,800	752	2	440	33
22.1	Rain/Fog Drip	56.0	897	734	3	295	24
22.2	Flowing Water	33.0	899	739	1	310	14
24	Mammal	0.0	6	2	1	2	4
24.5	Other Animal	1.0	44	4	0	8	71
25	Bird	71.0	1,803	125	0	268	177
25.1	Raven	0.0	62	14	1	24	6
28	Insect	6.0	494	102	1	151	18
29	Animal (Natural)	0.0	2	2	2		1
30.1	Avalanche / Rockslide	1.0	41	18	0	12	14
39	Natural Other	32.0	895	548	2	432	18
39.1	Natural Other	22.0	1,788	196	2	440	35
40	Natural Unknown	0.0	20	3	0	6	12
41.5	Field Personnel	1.0	56	7	0	10	48
99	Unknown	0.0	4	2	1	2	2
G0100	All Aircraft	4.9					

G0300	All Watercraft	43.1					
G2000	All Non-natural Sources	55.2					
G4000	All Natural Sources	97.5					
G4100	All Artifacts	1.0					
NFI	Noise Free Interval	44.3	900	182	1	261	76

Morning

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	8.0	267	127	55	75	7
1.2	Aircraft, Propeller	2.0	112	25	5	39	7
3	Watercraft	24.0	896	240	1	368	11
3.1	Outboard	8.0	894	894	894		1
6.1	Generator	11.0	570	414	275	148	3
19	Non-natural Other	8.0	875	875	875		1
19.1	Wind-induced Non-natural	1.0	31	10	1	11	7
21	Wind	2.0	75	30	1	29	8
21.1	Wind, Light	3.0	108	27	0	33	12
22	Water	48.0	897	894	891	3	6
22.1	Rain/Fog Drip	15.0	896	538	84	415	3
22.2	Flowing Water	47.0	897	574	31	391	9
24.5	Elk	0.0	31	12	2	16	3
25	Bird	85.0	899	304	0	380	31
28	Insect	3.0	106	13	0	26	30
30.1	Avalanche / Rockslide	1.0	41	20	0	14	7
39	Natural Other	8.0	893	893	893		1
39.1	Natural Other	6.0	193	75	10	58	9
40	Natural Unknown	0.0	20	20	20		1
41.5	Field Personnel	0.0	7	7	7		1
G0100	All Aircraft	9.6					
G0300	All Watercraft	31.9					
G2000	All Non-natural Sources	56.8					
G4000	All Natural Sources	97.0					
G4100	All Artifacts	0.1					
NFI	Noise Free Interval	43.2	908	266	1	367	18

Midday

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	4.0	236	77	11	58	29
1.2	Aircraft, Propeller	5.0	365	161	12	109	17
1.3	Helicopter	1.0	234	144	33	102	3
2.1	Automobile (car, van, light	1.0	109	55	13	39	7
3	Watercraft	66.0	3,566	840	4	979	43
3.1	Outboard	16.0	3,587	1,288	13	1,169	7
3.11	Outboard, 2-stroke	4.0	891	285	3	381	8
3.12	Outboard, 4-stroke	4.0	880	244	7	277	8
3.6	Non-Motorized Craft	0.0	87	59	8	44	3
3.7	Sail Boat	1.0	170	94	14	84	4
3.8	Boat Wake (on shore)	2.0	368	85	15	100	12
6	Motor	6.0	2,802	323	4	876	10
8	People	1.0	141	23	1	38	17
8.1	People, Voices	0.0	68	37	12	29	3
8.2	People, Walking	0.0	89	64	40	35	2
8.4	Portable Audio Devices	0.0	77	24	1	28	7
9.1	Dog	0.0	1	1	1		1
11	Construction	2.0	184	45	4	49	20
19	Non-natural Other	16.0	2,319	888	4	881	10
19.1	Wind-induced Non-natural	18.0	3,480	721	91	923	14
20	Non-natural Unknown	0.0	5	5	5		1
21	Wind	32.0	3,592	1,448	13	1,241	12
21.1	Wind, Light	23.0	2,563	614	3	698	21
21.2	Wind, Heavy	2.0	975	975	975		1
22	Water	73.0	3,598	1,256	2	1,135	32
22.1	Rain/Fog Drip	26.0	2,326	723	3	499	20
22.2	Flowing Water	39.0	3,587	1,552	1	1,295	14
24	Mammal	0.0	22	22	22		1
24.2	Chipmunk	0.0	13	8	3	3	10
24.5	Other Animal	7.0	3,590	80	0	507	50
25	Bird	73.0	3,600	172	0	415	235
25.1	Raven	3.0	269	50	1	67	32

27	Amphibian	0.0	88	24	5	36	5
28	Insect	18.0	3,518	65	0	301	155
39	Natural Other	28.0	3,595	1,039	83	873	15
39.1	Natural Other	32.0	3,470	981	21	1,062	18
40	Natural Unknown	1.0	428	49	1	118	13
41.5	Field Personnel	1.0	87	12	1	19	53
99	Unknown	1.0	377	104	1	133	7
G0100	All Aircraft	9.7					
G0200	All Road Vehicles	0.7					
G0300	All Watercraft	71.7					
G2000	All Non-natural Sources	81.3					
G4000	All Natural Sources	96.0					
G4100	All Artifacts	1.2					
NFI	Noise Free Interval	18.4	1,005	113	1	195	90

Evening

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	6.0	206	48	1	53	22
1.2	Aircraft, Propeller	0.0	3	3	3		1
3	Watercraft	8.0	886	372	66	377	4
3.1	Outboard	11.0	892	392	154	288	5
3.12	Outboard, 4-stroke	3.0	387	99	13	161	5
3.6	Non-Motorized Craft	0.0	19	19	19		1
3.7	Sail Boat	3.0	586	586	586		1
6.1	Generator	4.0	740	740	740		1
8	People	2.0	406	83	1	181	5
8.1	People, Voices	0.0	27	7	0	9	8
8.2	People, Walking	1.0	39	21	2	17	5
19	Non-natural Other	5.0	864	434	5	607	2
19.1	Wind-induced Non-natural	8.0	833	184	1	339	8
21	Wind	24.0	3,193	340	2	892	13
21.1	Wind, Light	24.0	3,400	748	3	1,344	6
22	Water	81.0	3,588	1,006	7	1,113	15
22.1	Rain/Fog Drip	14.0	891	885	877	7	3
22.2	Flowing Water	28.0	899	585	40	397	9
24.5	Elk	1.0	27	4	0	5	40
25	Bird	75.0	899	104	0	214	134
28	Insect	22.0	897	49	0	149	81
39	Natural Other	5.0	895	225	2	447	4
39.1	Natural Other	34.0	3,585	319	3	830	20
40	Natural Unknown	0.0	2	1	0	1	7
41.5	Field Personnel	0.0	3	2	1	1	3
99	Unknown	0.0	1	1	1		1
G0100	All Aircraft	5.7					
G0300	All Watercraft	23.0					
G2000	All Non-natural Sources	28.7					
G4000	All Natural Sources	96.8					
G4100	All Artifacts	0.0					
NFI	Noise Free Interval	71.3	1,880	220	1	381	60

Night

Sound ID	Sound Source Description	PA	Max Event	Mean Event	Min Event	SD Event	Count
1.1	Jet	12.0	388	117	2	146	10
3	Watercraft	13.0	678	668	657	15	2
8	People	0.0	3	3	3		1
19	Non-natural Other	9.0	651	434	216	308	2
19.1	Wind-induced Non-natural	0.0	8	3	0	3	5
21	Wind	12.0	896	153	2	307	8
21.1	Wind, Light	0.0	9	5	1	3	7
22	Water	81.0	898	891	877	8	9
22.1	Rain/Fog Drip	17.0	871	862	854	12	2
22.2	Flowing Water	45.0	899	895	890	4	5
24.5	Other Animal	1.0	42	23	3	20	3
25	Bird	56.0	899	110	0	215	50
28	Insect	15.0	494	28	0	77	53
30.1	Avalanche / Rockslide	1.0	24	15	3	10	7
39	Natural Other	10.0	895	314	8	504	3
39.1	Natural Other	7.0	157	53	2	56	14
40	Natural Unknown	1.0	50	26	3	33	2
41.5	Field Personnel	0.0	3	1	0	2	3
G0100	All Aircraft	11.9					
G0300	All Watercraft	13.5					
G2000	All Non-natural Sources	32.1					
G4000	All Natural Sources	99.2					
G4100	All Artifacts	0.0					
NFI	Noise Free Interval	67.9	900	396	4	377	17

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



Natural Resource Stewardship and Science

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