National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Golden Gate National Recreation Area

Acoustical Monitoring 2007/2008

Natural Resource Technical Report NPS/NRSS/NRTR—2013/711

ON THE COVER
Golden Gate Bridge, taken at GGNRA in 2009
Volpe Center Photo

Golden Gate National Recreation Area

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Prepared For:

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Natural Sounds and Night Skies Division
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Environmental Measurement and Modeling Division, RVT-41

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In 2007, the Natural Sounds Program (NPS) received a technical assistance request to collect baseline acoustical data at Golden Gate National Recreation Area (GGNRA). During the summer (June – September 2007) and winter (January – February 2008), six sites were deployed for approximately 30 days each. The baseline data collected during this period will help park managers and planners estimate the effects of future noise impacts and will help to inform future park planning objectives such as creating soundscape management plans, as well as the development of an Air Tour Management Plan (ATMP), which provides for the regulation of commercial air tours. The sound sources of concern at GGNRA include developments near park boundaries, air tours, commercial and private aircraft activities, and requests for special use permits for noisy activities. This document summarizes the results of the noise measurement study.</td></tr>
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Executive Summary

In 2007, the NPS Natural Sounds and Night Skies Division received a technical assistance request to collect baseline acoustical data at Golden Gate National Recreation Area (GGNRA). During June-July 2007 and January-February 2008, six acoustical monitoring systems were deployed in Golden Gate National Recreation Area (GGNRA) by NPS personnel. The purpose of this monitoring effort was to characterize existing sound levels and estimate natural ambient sound levels in these areas, as well as identify audible sound sources. This report provides a summary of results of these measurements, representing GGNRA's summer and winter seasons, respectively.

In determining the current conditions of an acoustical environment, the NPS examines how often sound pressure levels exceed certain decibel values that relate to human health and speech. The NPS uses these values for making comparisons, but should not be construed as thresholds of impact. Table 1 and Table 2 report the percent of time that measured levels were above four decibels values at each of the GGNRA measurement locations for summer and winter seasons, respectively. The first decibel value, 35 dBA, addresses the health effects of sleep interruption (Haralabidis et al. 2008). The second value addresses the World Health Organization's recommendations that noise levels inside bedrooms remain below 45 dBA (Berglund at al. 1999). The third value, 52 dBA, is based on the Environmental Protection Agency's (EPA 1974) speech interference threshold for speaking in a raised voice to an audience at 10 meters. This value addresses the effects of sound on interpretive presentations in parks. The final value, 60 dBA, provides a basis for estimating impacts on normal voice communications at 1 m (3 ft). Hikers and visitors viewing scenic vistas in the park would likely be conducting such conversations.

Table 1. Percent Time Above Metrics for summer season

Site ID	Site Name	% Time above sound level: 7 am to 7 pm				% Time above sound level: 7 pm to 7 am			
		35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
GOGA001	Alcatraz West	100.0	99.6	75.6	12.8	99.9	74.9	37.4	8.0
GOGA002	Banducci West Drainage	79.1	23.0	2.3	0.1	28.6	4.2	0.6	0.0
GOGA003	Bonita Point	99.7	49.3	7.7	0.6	94.1	27.8	2.4	0.1
GOGA004	Alcatraz Water Tower	100.0	98.1	45.4	8.3	99.8	65.9	25.4	5.2
GOGA005	Crissy Marsh Field	100.0	100.0	95.0	5.3	100.0	85.1	38.7	1.0
GOGA006	Milagra Ridge	99.9	67.1	7.7	1.0	94.0	34.5	3.3	0.4

Table 2. Percent Time Above Metrics for winter season

Site ID	Site Name	% Time above sound level: 7 am to 7 pm				% Time above sound level: 7 pm to 7 am			
		35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
GOGA001	Alcatraz West	99.6	57.3	14.7	2.3	85.9	21.9	5.2	0.4
GOGA002	Banducci West Drainage	85.3	20.1	3.4	0.1	49.1	11.4	2.7	0.0
GOGA003	Bonita Point	100.0	82.4	21.0	1.5	100.0	80.8	17.4	1.6
GOGA004	Alcatraz Water Tower	100.0	73.8	19.2	3.8	91.5	31.5	8.8	0.5
GOGA005	Crissy Marsh Field	100.0	99.9	75.9	4.9	100.0	88.1	35.9	0.9
GOGA006	Milagra Ridge	99.9	71.7	17.5	2.1	87.3	35.1	9.0	1.2

Table 3 though Table 4 summarize the acoustic observer log data (office listening and in-situ logging combined) for summer and winter measurements, respectively. These results provide an indication of the amount of time that certain sources are present at each site. The in-situ logging is performed during visits to the site itself; office listening is performed in the office using audio files that were collected at each site.

Table 3. Summary of acoustic observer log data (in situ and office listening combined) for all sites for the summer season

Site ID	Site Name	% Time Audible			
		Fixed-Wing Aircraft and Helicopter Sounds	Other Aircraft Sounds	Other Human Sounds	Natural Sounds
GOGA001	Alcatraz West	7.1	4.8	83.9	4.2
GOGA002	Banducci West Drainage	5.2	10.4	72.2	12.2
GOGA003	Bonita Point	9.7	15.4	33.0	41.9
GOGA004	Alcatraz Water Tower	12.3	18.3	65.8	3.6
GOGA005	Crissy Marsh Field	5.7	4.2	90.0	0.2
GOGA006	Milagra Ridge	2.3	45.7	33.2	18.8

Table 4. Summary of acoustic observer log data (in situ and office listening combined) for all sites for the winter season

Site ID	Site Name	% Time Audible			
		Fixed-Wing Aircraft and Helicopter Sounds	Other Aircraft Sounds	Other Human Sounds	Natural Sounds
GOGA001	Alcatraz West	10.3	14.1	73.5	2.3
GOGA002	Banducci West Drainage	6.9	15.3	63.5	13.8
GOGA003	Bonita Point	8.3	10.9	16.7	64.2
GOGA004	Alcatraz Water Tower	6.1	13.0	70.2	10.6
GOGA005	Crissy Marsh Field	8.1	7.3	84.6	0.1
GOGA006	Milagra Ridge	1.2	53.0	33.4	12.4

1. Introduction

An important part of the National Park Service (NPS) mission is to preserve and/or restore the natural resources of the parks, including the natural soundscapes associated with units of the national park system. The collection of ambient sound level data provides valuable information about a park's acoustic conditions for use in developing soundscape management plans.

Ambient data are also required to establish a baseline from which noise impacts can be assessed. The National Parks Air Tour Management Act of 2000 provides for the regulation of commercial air tour operations over units of the national park system through air tour management plans (ATMPs). The objective of the ATMPs is to develop acceptable and effective measures to mitigate or prevent significant adverse impacts, if any, of commercial air tour operations upon the natural and cultural resources of and visitor experiences in national park units as well as tribal lands (those included in or abutting a national park).

The U.S. Department of Transportation, Research and Innovative Technology Administration, John A. Volpe National Transportation Systems Center (Volpe Center) is supporting the Federal Aviation Administration (FAA), Western-Pacific Region (AWP) and NPS, Natural Sounds and Night Skies Division in the development of ATMPs.

Ambient data were collected by NPS personnel in Golden Gate National Recreation Area (GGNRA) during June-July 2007 and January-February 2008. A map of the areas managed by GGNRA is shown in Figure 1. The purpose of this report is to provide a summary of the results of these measurements and will be used to represent GGNRA's summer and winter seasons, respectively.

Figure 1. Map of Areas Managed by GGNRA*

* http://www.nps.gov/goga/planyourvisit/maps.htm

2. Study Area

Six acoustical monitoring systems were deployed during June-July 2007 and January-February 2008. These sites were selected based on discussions between NPS and GGNRA personnel and are shown in Table 5.

Table 5. Measurement site locations

Site ID	Site Name	# Days of Data (Summer/ Winter)	NLCD* Classification	Summer Coordinates (latitude/longitude in decimal degrees)	Winter Coordinates (latitude/longitude in decimal degrees)	Elevation (m)
GOGA001	Alcatraz West	34 days / 29 days	Developed	37.82685° / 122.42410°	37.82688° / 122.42397°	21 m (69 ft)
GOGA002	Banducci West Drainage	32 days / 28 days	Shrubland	37.86586° / 122.57967°	37.86584° / 122.57973°	15 m (49 ft)
GOGA003	Bonita Point	15 days / 31 days	Shrubland	37.82178° / 122.52847°	37.82172° / 122.52841°	39 m (128 ft)
GOGA004	Alcatraz Water Tower	34 days / 18 days	Developed	37.82768° / 122.42316°	37.82758° / 122.42358°	24 m (79 ft)
GOGA005	Crissy Marsh Field	32 days / 28 days	Developed	37.80444° / 122.45506°	37.80440° / 122.45509°	-1 m (-3 ft)
GOGA006	Milagra Ridge	24 days / 30 days	Shrubland	37.63660° / 122.47310°	37.63670° / 122.47355°	209 m (686 ft)

* With the goal of potentially facilitating future data transferability between parks, all baseline acoustic data collected for the ATMP program have been organized/classified in accordance with the National Land Cover Database (NLCD). Developed by the U.S. Geological Survey (USGS), the NLCD is the only nationally consistent land cover data set in existence and is comprised of twenty-one NLCD subclass categories for the entire U.S. (Vogelmann, J.E., S.M. Howard, L. Yang, C.R. Larson, B.K. Wylie, N. Van Driel, Completion of the 1990s National Land Cover Data Set for the Conterminous United States from Landsat Thematic Mapper Data and Ancillary Data Sources, Photogrammetric Engineering and Remote Sensing, 67:650-652, 2001.)

3. Methods

3.1 Automatic Monitoring

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

Each Larson Davis sampling station at GGNRA consisted of:

- Microphone with environmental shroud
- Preamplifier
- Multiple 12V NiMH rechargeable battery packs
- Anemometer
- MP3 recorder
- Meteorological data logger
- Photo voltaic panels

Each acoustic sampling station collected:

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

3.2 Source Identification/Observer Logging

In characterizing natural and non-natural acoustic conditions in a park, knowledge of the intensity, duration, and distribution of the sound sources is essential. Thus, during sound-level data collection, FAA and NPS have agreed that periods of observer logging "*in situ*" (i.e., on site and in real-time) and/or post measurements using high-quality digital recordings will be conducted in order to discern the type, timing, and duration of different sound sources. *In situ* observer logging takes full advantage of human binaural hearing capabilities, allows identification of sound source origin, simultaneous sound sources, and directionality, and closely matches the experience of park visitors. Off-site audio playback observer logging allows for sampling periodically throughout the entire measurement period (e.g., 10 seconds every 2 minutes) and repeated playback of the recordings (e.g. when the sound is difficult to identify). Bose Quiet Comfort Noise Canceling headphones were used for off-site audio playback to minimize limitations imposed by the office acoustic environment.

3.3 Calculation of Sound Level Descriptors

All sound-level data were analyzed in terms of the following metrics (refer to the Terminology section for definitions):

- L_{Aeq}: The equivalent sound level determined by the logarithmic average of sound levels of a specific time period;

- L_{50}: A statistical descriptor describing the sound level exceeded 50 percent of a specific time period (i.e., the median); and
- L_{90}: A statistical descriptor describing the sound level exceeded 90 percent of a specific time period and only the quietest 10 percent of the sample can be found below this point.

For each descriptor, both the broadband A-weighted sound level is determined and its associated ⅓-octave band un-weighted spectrum from 12.5 to 20,000 Hz. The process of computing the un-weighted one-third octave-band spectrum is virtually identical to the process for computing the broadband A-weighted sound level descriptors. The only difference is that the sound-level value is computed for un-weighted frequency-based sound levels rather than for broadband A-weighted sound levels. Specifically, the un-weighted sound level is computed individually for each ⅓-octave-band. The 33 un-weighted one-third octave-band sound levels (12.5 to 20,000 Hz) define the un-weighted sound level spectrum. This method of constructing the sound level spectrum means it is not an actual measured ⅓-octave band spectrum associated with a particular measurement sample, but a composite spectrum using the computed descriptor for each ⅓-octave-band.

3.4 Definitions of Ambient

The following four types of "ambient" characterizations are generally used and considered sufficient by the FAA and NPS in environmental analyses related to transportation noise (Fleming et al. 1998, Fleming et al. 1999, Plotkin 2002):

- *Existing Ambient:* The composite, all-inclusive sound associated with a given environment, excluding only the analysis system's electrical noise (i.e., aircraft-related sounds are included);
- *Existing Ambient Without Source of Interest:* The composite, all-inclusive sound associated with a given environment, excluding the analysis system's electrical noise and the sound source of interest, in this case, commercial air tour aircraft;[*]
- *Existing Ambient Without All Aircraft* (for use in assessing cumulative impacts): The composite, all-inclusive sound associated with a given environment, excluding the analysis system's electrical noise and the sounds produced by the sound source of interest, in this case, all types of aircraft (i.e. commercial air tours, commercial jets, general aviation aircraft, military aircraft, and agricultural operations);[†] and
- *Natural Ambient:* The natural sound conditions found in a study area, including all sounds of nature (i.e., wind, streams, wildlife, etc.), and excluding all human and mechanical sounds.

If one considers the three sound level descriptors presented in Section 3.3 and the four types of ambient characterizations above, twelve ambient descriptors could potentially be computed as shown in Table 6.

[*] Pending additional input from the FAA, all fixed-wing aircraft and helicopters were conservatively considered as an air tours and not general aviation (i.e., the "other aircraft" category) because of specific routes of the air tour operators were not known at the time of the measurements. The effect to ambient descriptors was typically less than 1 dBA as can be seen in the differences between the "Existing Ambient Without Air Tours" and the "Existing Ambient Without All Aircraft".

[†] The definition of Existing Ambient Without All Aircraft used in this report is consistent with FAA's historical approach for cumulative impact analysis.

Table 6. Matrix of twelve potential ambient descriptors

Metric	Ambient Type			
	Existing	Existing Without Air Tours	Existing Without All Aircraft	Natural
L_{Aeq}	1	4	7	10
L_{50}	2	5	8	11
L_{90}	3	6	9	12

From the above twelve potential ambient descriptors, only the first three can be readily computed. The computation of ambient types other than Existing Ambient is more challenging because different sound sources often overlap in both frequency and amplitude; there is currently no practical method to separate out acoustic energy of different sound sources (i.e., human-caused sounds imbedded with natural sounds). The two ambient descriptors agreed upon for use in ATMP analyses are:

- Existing Ambient Without Source of Interest ($L_{Existw/oTours}$) – Descriptor 5 from the table above; and
- Natural Ambient (L_{Nat})– Descriptor 11 from the table above.

3.5 Calculation of Ambients

From the twelve potential ambient descriptors in Table 6, only the first three can be readily computed. The computation of ambient types other than Existing Ambient is more challenging because different sound sources often overlap in both frequency and amplitude; there is currently no practical method to separate out acoustic energy of different sound sources (i.e., human-caused sounds imbedded with natural sounds). Using the data in the acoustic observer logs, different characterizations of ambient can be *estimated* from the sound level data. This method was developed by performing a detailed data analyses conducted by the Volpe Center, working closely with the NPS, in comparing several approaches of estimating of the Natural Ambient and is comprised of the following steps (Rapoza et al. 2008):

1. From the short-term in situ and off-site logging, determine the percent time human-caused sounds are audible.
2. Sort, high-to-low, the A-weighted level data, derived from the short-term, one-second, one-third octave-band data (regardless of acoustic state), and remove the loudest percentage (determined from the percent time audible of human-caused sounds in the short-term observer logs) of sound-level data. For example, if from Step 1 above, it is determined that at a particular site, the percent time audible of all human-caused sounds is 40 percent, then the loudest 40 percent of the A-weighted level data is removed. The L_{50} computed from the remaining data is the estimated A-weighted natural ambient. This L_{50}, computed from the remaining data, can be mathematically expressed as an L_x of the entire dataset as follows (%TA is the percent of time human-caused sounds are audible in the short-term observer logs):

$$L_x = \frac{100 - \%TA}{2} + \%TA$$

For example, if non-natural sounds are audible for 40% of the time, L0 to L40 corresponds to the loudest (generally non-natural) sounds, and L_{40} to L_{100} corresponds to the quietest (generally natural) sounds. The median of L_{40} to L_{100} data is L_{70}. Therefore, the A-weighted decibel value at L_{70}, the sound level exceeded 70 percent of the time, would be used for the entire dataset to characterize the natural ambient sound level.

3. The associated one-third octave-band un-weighted spectrum from 12.5 to 20,000 Hz is constructed similarly, except the L_{50} is computed from the remaining data for each one-third octave-band. As with the Volpe method, it is not an actual measured one-third octave-band spectrum associated with a particular measurement sample, but rather a composite spectrum derived from the L_x for each one-third octave-band.

This method for estimating the natural ambient is conceptually straightforward – as percent time audible approaches 0 percent, the Lx approaches L_{50}; as it approaches 100 percent, the L_x approaches L_{100}. A concern with this approach is that loud natural sounds, such as thunder, could be removed from the data before calculating natural ambient sound levels, and the resulting calculated natural ambient sound levels could be an under-estimate of natural ambient sound levels. Although this is a valid concern, such events are rare relative to the entire measurement period (>25 days). Therefore, removing these data should not likely have a significant impact on calculations of natural ambient sound levels. This method also eliminates the possibility of having an estimated natural ambient level that exceeds the existing ambient level.

Based on the concept of the above method, the computation of the other ambient types (Existing Without Sound Source of Interest using the percentage of time sounds from the source of interest, e.g., air tour aircraft, are audible from short-term in situ and off-site observer logging, and Existing Ambient Without All Aircraft using the percentage of time all aircraft are audible from the observer logging) is a similar process.

4. Results

This section summarizes the results of the study. Included is an overall summary of the final, ambient sound levels for each measurement site, Time Above analysis, temporal trends, and the acoustic observer data logged at each measurement site.

4.1 Summary Results

The following figures and tables are presented to show overall site-to-site comparisons:

- Figure 2 and Figure 3: A plot of the overall daytime[*] L_{50} sound level computed for each site with all days included for the summer and winter seasons, respectively (a few points of interest outside the parks are also shown for comparison purposes only). The figure also shows a dark line above and below each plotting symbol, which indicate the 95% confidence interval on the results[†];
- Table 7 and Table 8 present a tabular summary of daytime, nighttime and computed ambients for summer and winter seasons, respectively; and
- Table 9, Table 10, and Figure 4 through Figure 7 present the associated spectral data for the ambient data.

[*] For most parks, the majority of air tour operations occur during the day, the NPS and FAA have agreed that the impact assessment will be conducted using ambient sound levels during the time that the air tour operations occur. Accordingly, all ATMP analyses are based on daytime ambient data. In general, daytime refers to the time period of 7 am to 7 pm unless otherwise specified by the NPS and FAA.

[†] The confidence interval is a measure of how certain one is of the value shown. The length of each of the dark lines indicate the day-to-day variability of the measurement for a particular site - the longer the line, the larger the day-to-day variability.

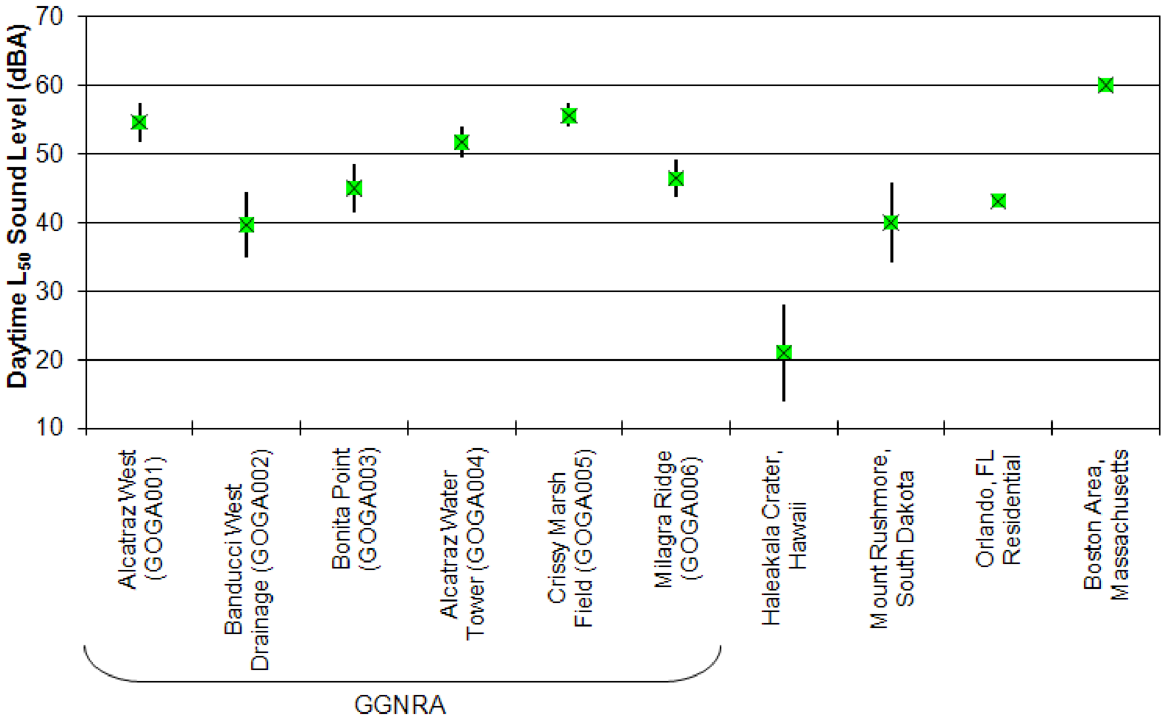

Figure 2. Comparison of overall daytime L_{50} sound levels for all sites for the summer season.*

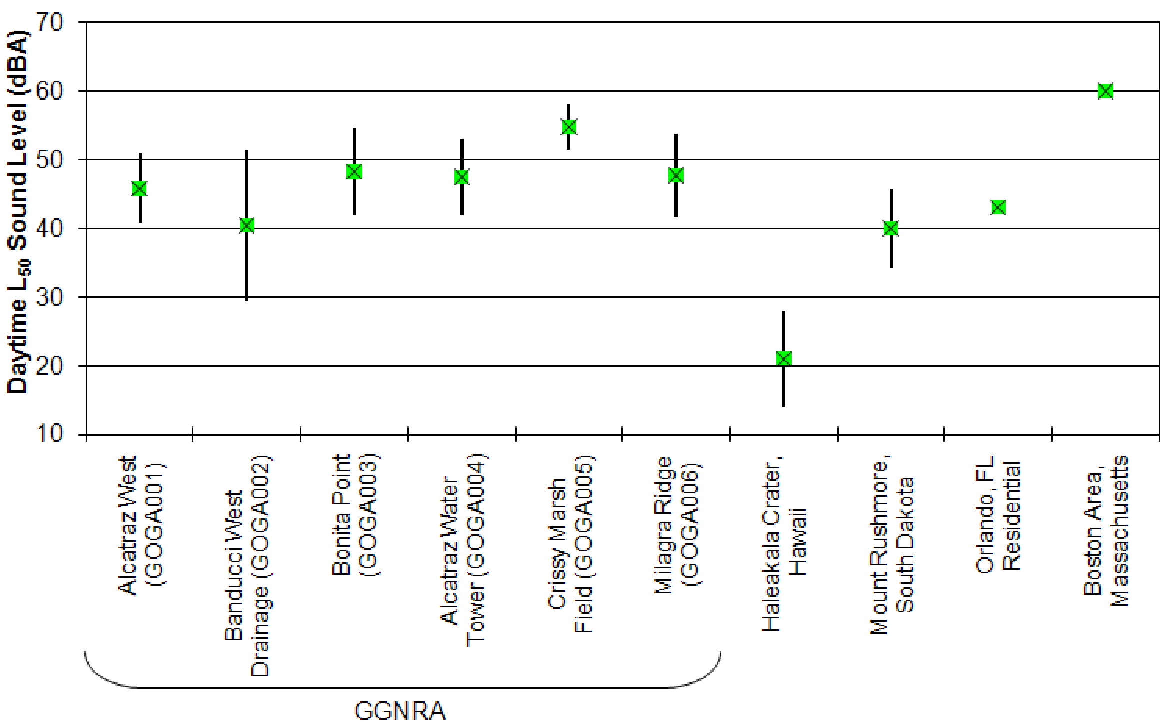

Figure 3. Comparison of overall daytime L_{50} sound levels for all sites for the winter season.*

* Confidence intervals for Orlando and Boston are not shown due to the limited amount of data represented (2 days and 1 week, respectively). Ambient data at ATMP parks, such as Golden Gate, are typically measured for at least 25 days.

Table 7. Summary of summer ambient sound level data[*]

Site ID	Site Name	Total # Days	Existing Ambient						Existing Ambient Without Air Tours[†] (Daytime Data 7 am to 7 pm)	Existing Ambient Without All Aircraft (Daytime Data 7 am to 7 pm)	Natural Ambient (Daytime Data 7 am to 7 pm)
			Daytime Data Only: 7 am to 7 pm			Nighttime Data Only: 7 pm to 7 am					
			L_{Aeq} (dBA)	L_{50} (dBA)	L_{90} (dBA)	L_{Aeq} (dBA)	L_{50} (dBA)	L_{90} (dBA)	L_{50} (dBA)	L_{50} (dBA)	L_{50} (dBA)
GOGA001	Alcatraz West	34	58.4	54.6	49.7	56.2	49.8	41.5	54.2	54.1	49.7
GOGA002	Banducci West Drainage	32	44.9	39.6	32.5	38.6	28.7	20.1	39.2	38.4	32.5
GOGA003	Bonita Point	15	48.8	45.0	40.5	45.5	42.7	36.3	44.5	43.8	42.2
GOGA004	Alcatraz Water Tower	34	58.4	51.7	47.6	56.4	47.5	40.7	51.1	50.5	47.6
GOGA005	Crissy Marsh Field	32	57.1	55.6	52.9	52.7	50.6	44.1	55.5	55.3	52.9
GOGA006	Milagra Ridge	24	49.5	46.4	42.5	46.8	43.1	36.5	46.3	44.4	42.5

[*] As stated earlier, two ambient maps were agreed upon for use in ATMP analyses: the Existing Ambient Without Air Tours (L_{50}) and the Natural Ambient (L_{50}).
[†] Pending additional input from the FAA, all fixed-wing aircraft and helicopters were conservatively considered as an air tours and not general aviation (i.e., the "other aircraft" category) because of specific routes of the air tour operators were not known at the time of the measurements. The effect to ambient descriptors was typically less than 1 dBA as can be seen in the differences between the "Existing Ambient Without Air Tours" and the "Existing Ambient Without All Aircraft".

Table 8. Summary of winter ambient sound level data*

Site ID	Site Name	Total # Days	Existing Ambient						Existing Ambient Without Air Tours† (Daytime Data 7 am to 7 pm)	Existing Ambient Without All Aircraft (Daytime Data 7 am to 7 pm)	Natural Ambient (Daytime Data 7 am to 7 pm)
			Daytime Data Only: 7 am to 7 pm			Nighttime Data Only: 7 pm to 7 am					
			L_{Aeq} (dBA)	L_{50} (dBA)	L_{90} (dBA)	L_{Aeq} (dBA)	L_{50} (dBA)	L_{90} (dBA)	L_{50} (dBA)	L_{50} (dBA)	L_{50} (dBA)
GOGA001	Alcatraz West	29	52.1	45.8	40.4	46.6	40.0	34.1	45.3	44.5	40.4
GOGA002	Banducci West Drainage	28	46.0	40.4	34.0	43.0	34.9	27.3	40.0	39.0	34.0
GOGA003	Bonita Point	31	52.0	48.3	43.9	51.9	48.0	43.7	47.8	47.3	46.6
GOGA004	Alcatraz Water Tower	18	53.9	47.5	42.7	48.3	42.7	35.4	47.2	46.5	42.7
GOGA005	Crissy Marsh Field	28	56.1	54.8	50.1	52.6	50.6	44.7	54.5	54.1	50.1
GOGA006	Milagra Ridge	30	51.9	47.7	42.1	49.6	42.5	34.3	47.5	44.3	42.1

* As stated earlier, two ambient maps were agreed upon for use in ATMP analyses: the Existing Ambient Without Air Tours (L_{50}) and the Natural Ambient (L_{50}).
† Pending additional input from the FAA, all fixed-wing aircraft and helicopters were conservatively considered as an air tours and not general aviation (i.e., the "other aircraft" category) because of specific routes of the air tour operators were not known at the time of the measurements. The effect to ambient descriptors was typically less than 1 dBA as can be seen in the differences between the "Existing Ambient Without Air Tours" and the "Existing Ambient Without All Aircraft".

Table 9. Summary of measured, daytime (7 am to 7 pm), ambient sound level spectral data for the summer season.*

Frequency (Hz)	Existing Ambient Without Air Tours L_{50} (dB)						Natural Ambient L_{50} (dB)					
	GGNRA 001	GGNRA 002	GGNRA 003	GGNRA 004	GGNRA 005	GGNRA 006	GOGA 001	GOGA 002	GGNRA 003	GGNRA 004	GGNRA 005	GGNRA 006
12.5	57.8	42.9	51.9	57.2	57.5	55.1	54.0	39.1	49.7	54.0	53.9	48.9
16	57.0	43.6	51.8	56.8	58.4	55.0	53.7	40.1	50.0	53.7	55.4	50.2
20	55.6	43.1	51.5	55.8	58.4	54.7	52.9	39.9	49.9	53.0	55.6	50.4
25	54.7	43.4	51.8	55.6	59.2	54.4	52.0	40.2	50.4	53.3	56.7	50.7
31	54.2	43.1	52.3	57.6	60.3	53.9	51.7	40.0	50.8	55.1	58.0	50.9
40	53.5	42.4	53.3	56.6	60.7	53.2	51.2	39.1	51.7	54.4	58.7	50.5
50	52.9	40.2	52.4	55.1	61.1	54.2	50.8	37.1	51.1	52.9	59.1	51.5
63	52.2	38.0	51.4	55.3	61.2	54.6	50.0	35.1	50.1	53.2	59.0	52.2
80	51.7	36.8	49.9	52.4	60.2	52.2	49.6	34.1	48.4	50.5	58.0	49.7
100	51.4	34.5	47.4	50.3	58.2	49.6	49.1	31.5	46.0	48.3	55.8	47.1
125	48.7	31.9	44.6	49.6	54.5	47.2	46.6	28.3	43.4	47.7	52.3	44.6
160	45.3	30.1	41.6	47.6	50.3	43.4	43.5	26.8	40.2	45.6	48.3	40.4
200	43.1	30.4	39.1	44.7	47.5	40.4	41.3	26.9	37.9	42.7	45.3	37.1
250	42.2	30.7	37.7	43.3	45.5	39.2	40.3	27.1	36.3	41.3	43.4	36.5
315	41.8	30.0	36.8	41.2	43.7	39.3	39.8	26.1	35.4	39.0	41.8	36.6
400	40.5	29.5	35.7	40.4	44.0	38.9	38.5	25.8	34.7	37.8	41.8	36.7
500	41.5	29.3	35.1	38.6	44.4	38.3	39.3	25.0	33.6	36.6	42.7	36.1
630	41.8	28.6	34.7	38.2	45.2	38.1	39.7	24.6	33.5	36.2	43.6	36.0
800	43.0	29.5	34.1	39.3	46.6	38.0	40.7	24.4	32.7	36.2	45.0	35.7
1000	46.0	29.0	33.4	42.3	46.6	36.9	42.6	23.7	32.0	39.5	44.9	34.5
1250	45.6	26.8	32.6	40.9	45.6	34.8	42.3	21.4	31.1	37.6	43.6	32.4
1600	41.0	24.4	31.2	36.7	44.3	32.1	38.8	19.4	29.7	32.9	42.2	29.5
2000	38.7	22.0	29.6	34.0	41.2	29.4	36.2	17.1	28.0	31.3	38.9	26.1
2500	41.0	20.4	27.9	39.0	37.3	26.7	35.9	16.3	26.1	35.0	34.6	23.1
3150	39.1	20.1	26.0	36.7	32.4	24.5	33.7	15.6	23.8	32.7	29.8	20.8
4000	33.9	18.1	23.0	31.5	29.6	22.8	30.4	13.6	20.7	28.4	25.6	18.9
5000	30.8	16.7	19.9	26.5	27.1	21.6	27.4	12.1	17.6	23.8	22.8	17.7
6300	27.9	14.8	17.0	22.1	24.0	20.2	24.1	11.1	14.8	19.7	19.3	16.6
8000	26.1	14.3	14.2	19.6	23.2	19.4	21.9	11.1	12.6	17.0	17.3	16.7
10000	24.3	13.9	11.9	17.3	22.6	18.7	20.0	11.6	11.3	14.7	16.8	16.3
12500	22.3	13.8	11.3	15.2	20.9	16.9	17.7	12.3	11.2	12.6	15.9	14.3
16000	20.1	13.8	11.8	12.3	19.3	15.9	15.4	12.8	11.7	10.5	14.9	13.9
20000	15.0	13.8	12.1	9.3	17.8	14.4	10.7	13.3	12.0	8.6	16.1	13.0

* As discussed in Section 3.5, the spectral data associated with the L_{50} exceedence level is constructed by determining the L_{50} from each one-third octave-band; therefore, it is not an actual measured one-third octave-band spectrum associated with a particular measurement sample.

Table 10. Summary of measured, daytime (7 am to 7 pm), ambient sound level spectral data for the winter season*

Frequency (Hz)	Existing Ambient Without Air Tours L_{50} (dB)						Natural Ambient L_{50} (dB)					
	GGNRA 001	GGNRA 002	GGNRA 003	GGNRA 004	GGNRA 005	GGNRA 006	GOGA 001	GOGA 002	GGNRA 003	GGNRA 004	GGNRA 005	GGNRA 006
12.5	52.0	41.4	55.2	54.7	56.2	50.2	48.6	37.6	54.0	51.1	52.6	45.7
16	51.8	41.9	54.2	55.4	56.8	50.9	48.7	38.4	53.2	52.3	53.7	46.8
20	50.8	42.1	53.5	54.7	56.8	51.4	48.0	38.5	52.5	51.6	53.9	47.4
25	50.8	43.2	52.8	51.3	57.8	52.4	48.1	39.5	51.8	48.7	55.2	48.5
31	51.4	43.4	52.8	51.9	59.2	52.8	49.0	39.9	51.8	49.3	56.7	49.1
40	51.0	43.1	52.8	55.8	60.3	52.4	48.5	39.4	52.0	53.0	57.7	48.9
50	50.3	41.8	52.5	54.1	61.0	52.1	47.8	38.0	51.5	51.7	58.5	48.4
63	50.1	40.0	51.9	56.3	60.7	52.4	47.6	35.8	51.0	53.0	58.4	48.8
80	48.1	37.9	50.1	53.4	59.3	52.5	45.6	34.0	49.3	50.9	57.0	49.1
100	47.1	34.5	47.6	51.3	57.5	48.6	44.2	31.0	46.8	48.6	55.2	45.7
125	46.1	31.7	45.1	49.2	54.7	45.8	43.8	27.8	44.4	46.2	52.4	42.4
160	42.7	28.8	42.9	46.2	50.0	42.1	39.9	25.5	41.9	42.9	47.9	37.7
200	38.5	28.8	41.0	43.5	47.2	39.9	36.0	25.6	40.1	40.3	45.1	34.6
250	36.2	29.0	40.6	40.7	45.2	40.3	33.4	25.5	39.7	37.5	43.0	35.5
315	34.5	29.0	39.5	38.5	43.3	39.6	32.1	24.9	38.6	35.6	41.2	35.5
400	34.0	29.6	40.4	37.0	42.8	39.2	31.7	25.3	39.4	34.4	40.4	36.2
500	34.5	30.3	39.4	37.0	44.1	39.4	32.4	25.9	38.6	34.5	42.0	36.4
630	35.8	30.2	39.6	36.4	45.3	39.2	33.2	25.3	38.9	33.6	43.3	36.5
800	34.4	30.2	38.6	36.0	46.5	39.7	31.6	25.5	37.9	32.4	44.6	37.2
1000	35.0	30.0	38.0	35.4	46.4	38.4	31.5	25.5	37.2	31.6	44.2	35.8
1250	34.3	28.5	37.3	33.6	45.1	35.2	29.9	24.0	36.4	30.0	43.1	32.3
1600	28.4	26.6	35.7	31.1	42.8	30.7	25.2	23.4	34.8	27.9	40.6	28.1
2000	27.0	24.8	34.6	29.1	39.0	27.0	22.9	22.6	33.6	26.5	36.6	24.0
2500	26.6	23.2	32.8	28.7	33.8	21.5	21.6	21.7	31.8	24.1	31.7	18.8
3150	24.3	22.1	30.4	26.4	29.0	18.1	18.9	20.5	29.2	21.4	26.5	14.7
4000	21.5	20.3	27.4	23.3	25.6	16.8	17.0	19.0	26.1	17.9	22.8	11.6
5000	19.1	19.0	23.9	18.4	24.0	15.8	15.8	18.0	22.6	14.5	20.6	10.2
6300	17.6	18.1	19.9	15.2	21.0	13.0	16.0	17.5	18.7	12.8	17.9	9.1
8000	17.4	17.7	15.5	14.0	19.0	11.4	16.5	17.4	14.6	12.4	16.8	8.5
10000	17.7	17.8	12.4	13.7	18.2	10.6	17.2	17.6	12.0	12.7	17.0	8.6
12500	18.4	18.3	12.2	14.0	18.2	10.3	18.2	18.2	12.1	13.4	17.6	8.7
16000	19.2	19.1	13.5	15.4	18.7	9.6	19.0	19.0	13.4	15.0	18.4	8.4
20000	20.6	20.7	15.6	16.7	20.2	8.5	20.4	20.7	15.5	16.6	20.0	8.2

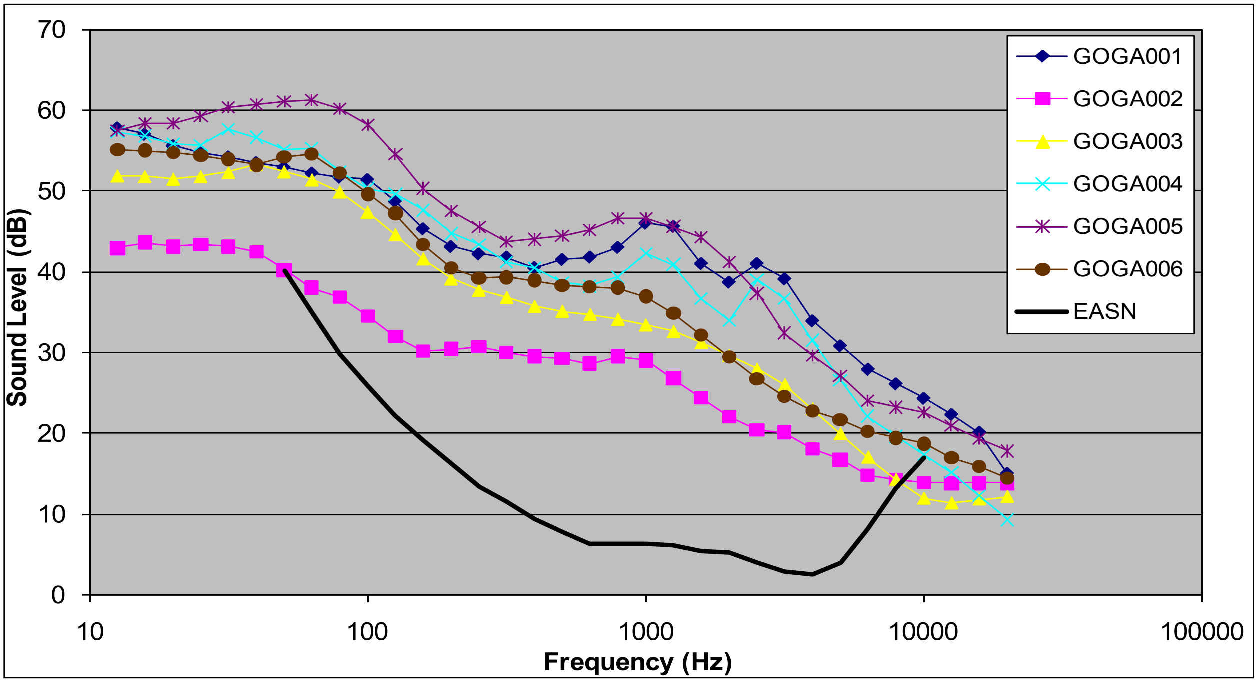

Figure 4. Spectral data for the Existing Ambient Without Air Tours (L_{50}) for each site for the summer season*

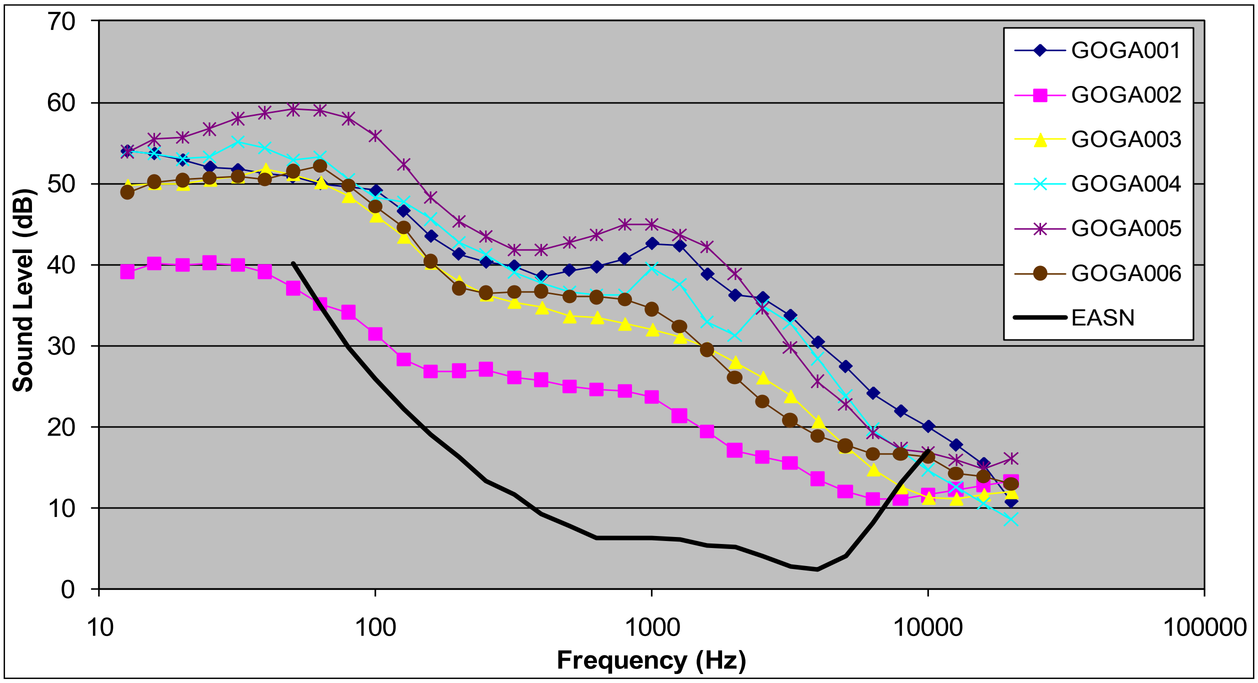

Figure 5. Spectral data for the Natural Ambient (L_{50}) determined for each site for the summer season*

* Also shown in each figure is the Equivalent Auditory System Noise (EASN), which represents the threshold of human hearing for use in modeling audibility using one-third octave-band data.

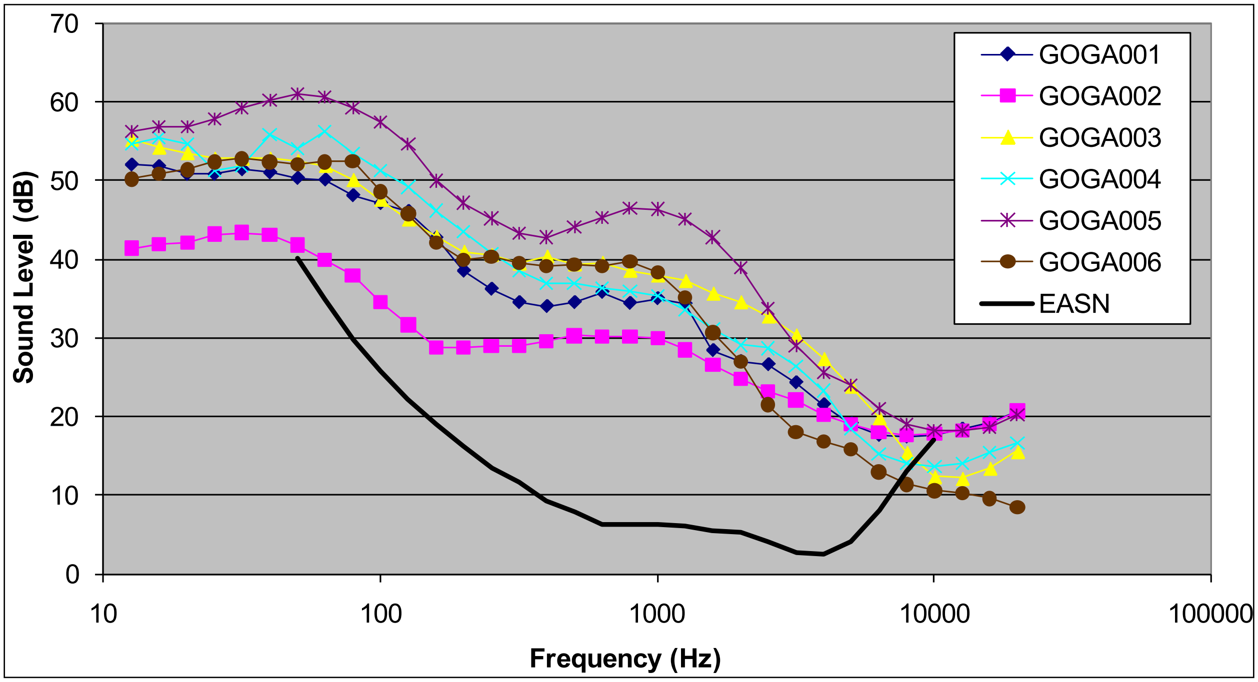

Figure 6. Spectral data for the Existing Ambient Without Air Tours (L_{50}) for each site for the winter season*

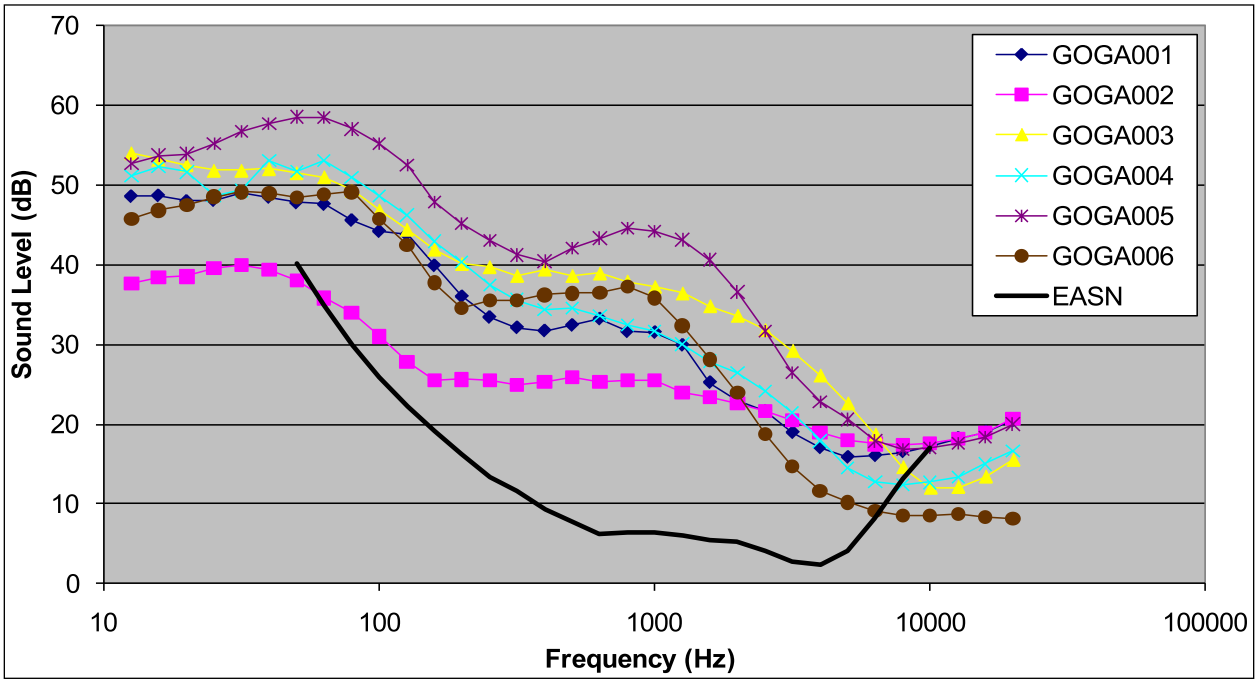

Figure 7. Spectral data for the Natural Ambient (L_{50}) determined for each site for the summer season*

* Also shown in each figure is the Equivalent Auditory System Noise (EASN), which represents the threshold of human hearing for use in modeling audibility using one-third octave-band data.

4.2 Time Above Results

The Time Above metric indicates the amount of time that the sound level exceeds specified decibel values. In determining the current conditions of an acoustical environment, the NPS examines how often sound pressure levels exceed certain decibel values that relate to human health and speech. The NPS uses these values for making comparisons, but should not be construed as thresholds of impact. Table 11 and Table 12 report the percent of time that measured levels were above four decibels values at each of the GGNRA measurement locations for summer and winter seasons, respectively. The first decibel value, 35 dBA, addresses the health effects of sleep interruption (Haralabidis et al. 2008). The second value addresses the World Health Organization's recommendations that noise levels inside bedrooms remain below 45 dBA (Berglund et al. 1999). The third value, 52 dBA, is based on the Environmental Protection Agency's (EPA 1974) speech interference threshold for speaking in a raised voice to an audience at 10 meters. This value addresses the effects of sound on interpretive presentations in parks. The final value, 60 dBA, provides a basis for estimating impacts on normal voice communications at 1 m (3 ft). Hikers and visitors viewing scenic vistas in the park would likely be conducting such conversations.

Table 11. Percent Time Above Metrics for summer season

Site ID	Site Name	% Time above sound level: 7 am to 7 pm				% Time above sound level: 7 pm to 7 am			
		35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
GOGA001	Alcatraz West	100.0	99.6	75.6	12.8	99.9	74.9	37.4	8.0
GOGA002	Banducci West Drainage	79.1	23.0	2.3	0.1	28.6	4.2	0.6	0.0
GOGA003	Bonita Point	99.7	49.3	7.7	0.6	94.1	27.8	2.4	0.1
GOGA004	Alcatraz Water Tower	100.0	98.1	45.4	8.3	99.8	65.9	25.4	5.2
GOGA005	Crissy Marsh Field	100.0	100.0	95.0	5.3	100.0	85.1	38.7	1.0
GOGA006	Milagra Ridge	99.9	67.1	7.7	1.0	94.0	34.5	3.3	0.4

Table 12. Percent Time Above Metrics for winter season

Site ID	Site Name	% Time above sound level: 7 am to 7 pm				% Time above sound level: 7 pm to 7 am			
		35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
GOGA001	Alcatraz West	99.6	57.3	14.7	2.3	85.9	21.9	5.2	0.4
GOGA002	Banducci West Drainage	85.3	20.1	3.4	0.1	49.1	11.4	2.7	0.0
GOGA003	Bonita Point	100.0	82.4	21.0	1.5	100.0	80.8	17.4	1.6
GOGA004	Alcatraz Water Tower	100.0	73.8	19.2	3.8	91.5	31.5	8.8	0.5
GOGA005	Crissy Marsh Field	100.0	99.9	75.9	4.9	100.0	88.1	35.9	0.9
GOGA006	Milagra Ridge	99.9	71.7	17.5	2.1	87.3	35.1	9.0	1.2

4.3 Temporal Trends

This section discusses the daily and diurnal trends of the data. Daily trends are shown on a 24-hour basis. Figure 8 and Figure 9 present the daily median Existing Ambient (i.e., the L50 with all sounds included) for the summer and winter seasons, respectively. For the purpose of assessing daily trends in the data, sound level descriptors are computed for each individual hour; then the median from the 24 hours each day is determined. Dips and increases in daily sound levels are usually an indication of passing inclement weather and localized events (e.g., Blue Angel's air show). This data is useful in visually identifying potential anomalies in the data. Data anomalies would then be further examined from data recorded by the sound level meter and/or recorded audio samples.

Diurnal trends are shown on an hourly basis. Sites with a strong daytime diurnal pattern typically indicate the presence of human activity largely influencing the sound levels at those sites. Sites with a nighttime pattern typically indicate the presence of insect activity. Sites with little discernable pattern, e.g., somewhat constant across all hours, typically indicates a constant sound source. Examples of constant sound sources include nearby generators or shoreline surf. This data is also useful in visually identifying potential anomalies in the data.

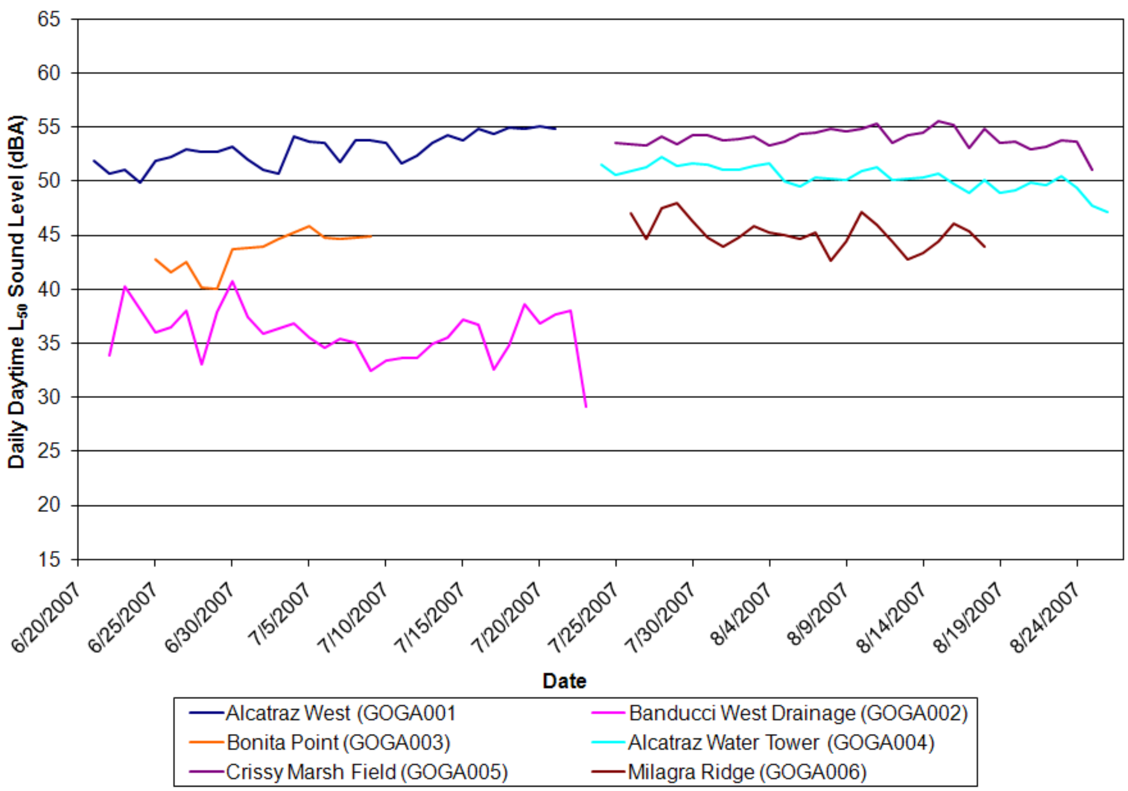

Figure 8. Comparison of daily L_{50} sound levels for all sites for the summer season

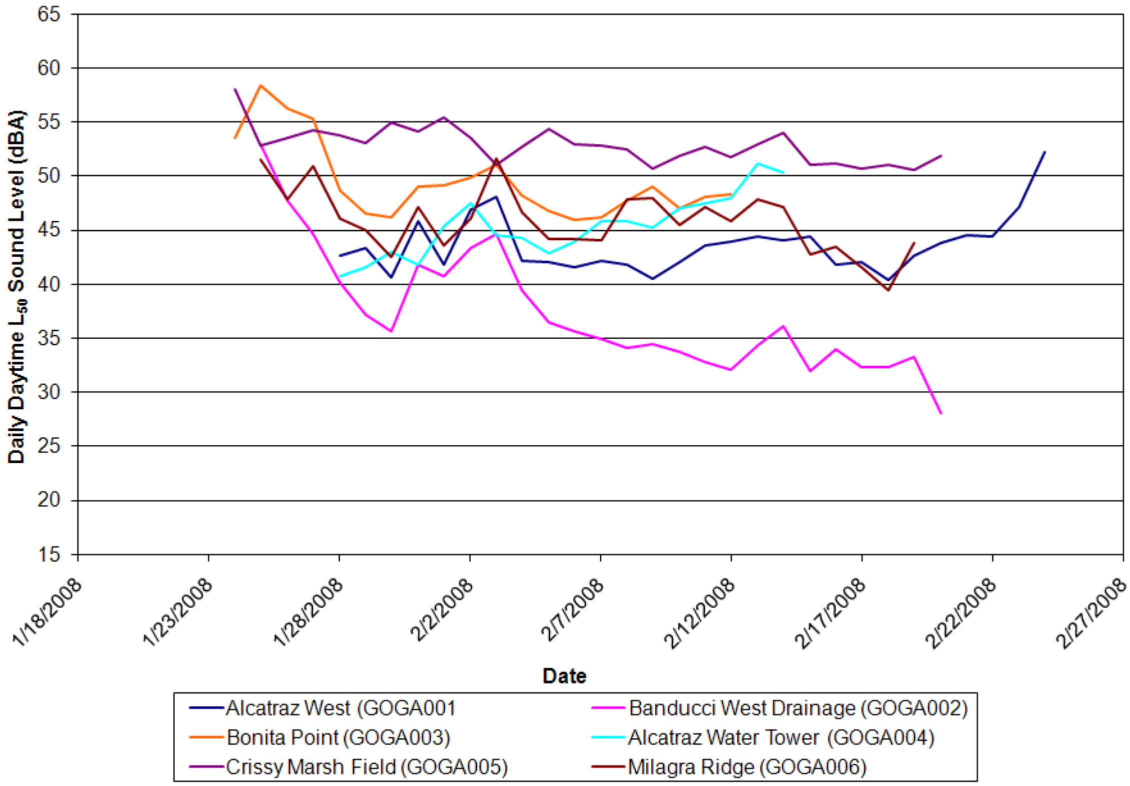

Figure 9. Comparison of daily L_{50} sound levels for all sites for the winter season

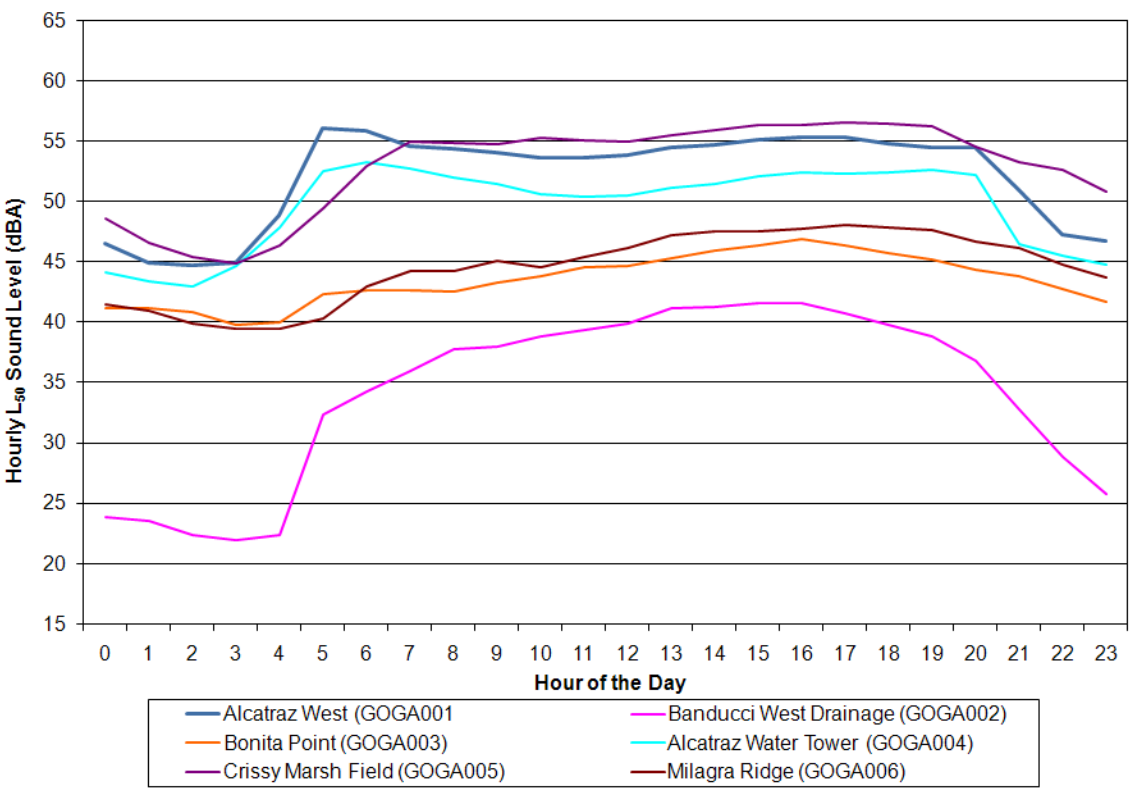

Figure 10. Comparison of hourly L_{50} sound levels for all sites for the summer season

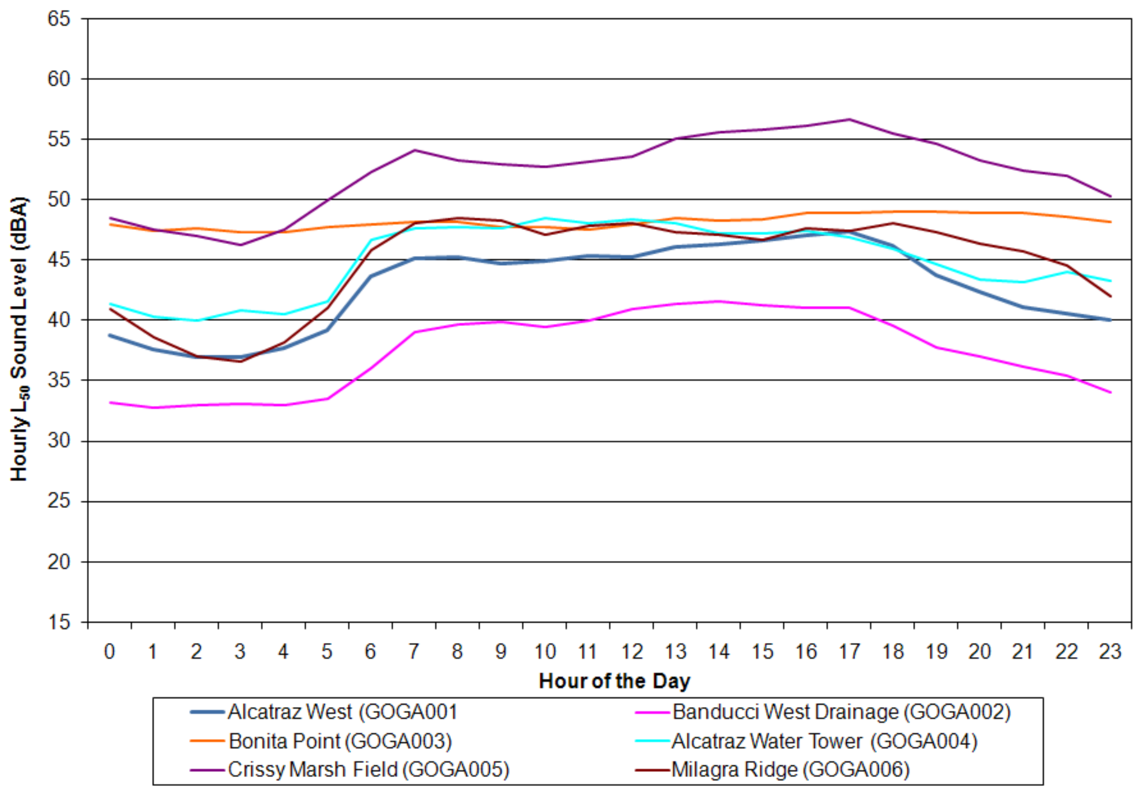

Figure 11. Comparison of hourly L_{50} sound levels for all sites for the winter season

4.4 Acoustic Observer Logging Results

Table 13 though Table 14 summarize the office listening and in-situ logging results for summer and winter measurements, respectively. These results provide an indication of the amount of time that certain sources are present at each site. The in-situ logging occurs live at the site itself and consists of an observer that logs the time and duration of sounds that they hear at the site. Typically a limited amount of in-situ logging is available due to logistics of the measurement and the days that the acoustic team is in the area. The office listening results are from a review of the audio files that were collected at each site. Continuous audio files were collected for the entire measurement and this allows a greater ability to listen and log sound sources for several days and any time period.

Table 13. Summary of acoustic observer log data (in situ and office listening combined) for all sites for the summer season

Site ID	Site Name	# Days of Office Listening Samples	% Time Audible			
			Fixed-Wing Aircraft and Helicopter Sounds	Other Aircraft Sounds	Other Human Sounds	Natural Sounds
GOGA001	Alcatraz West	8	7.1	4.8	83.9	4.2
GOGA002	Banducci West Drainage	8	5.2	10.4	72.2	12.2
GOGA003	Bonita Point	8	9.7	15.4	33.0	41.9

Site ID	Site Name	# Days of Office Listening Samples	% Time Audible			
			Fixed-Wing Aircraft and Helicopter Sounds	Other Aircraft Sounds	Other Human Sounds	Natural Sounds
GOGA004	Alcatraz Water Tower	8	12.0	15.4	67.3	5.4
GOGA005	Crissy Marsh Field	8	5.7	4.2	90.0	0.2
GOGA006	Milagra Ridge	7	2.2	44.9	33.5	19.4

Table 14. Summary of acoustic observer log data (in situ and office listening combined) for all sites for the winter season

Site ID	Site Name	# Days of In-situ Logging	% Time Audible			
			Fixed-Wing Aircraft and Helicopter Sounds	Other Aircraft Sounds	Other Human Sounds	Natural Sounds
GOGA001	Alcatraz West	3	12.1	13.4	73.5	1.1
GOGA002	Banducci West Drainage	3	7.5	14.7	63.5	14.4
GOGA003	Bonita Point	3	8.3	10.9	16.7	64.2
GOGA004	Alcatraz Water Tower	5	6.7	12.2	72.4	8.7
GOGA005	Crissy Marsh Field	3	8.1	7.3	84.6	0.1
GOGA006	Milagra Ridge	3	1.2	58.6	35.0	5.2

5. Ambient Mapping

Using the ambient data measured at each site, a comprehensive grid of ambient sound levels throughout the park (i.e., an ambient "map") is developed. Ambient maps are useful to: (1) graphically characterize the ambient environment throughout an entire study area; and (2) to establish baseline, or background values in computer modeling. For ATMPs, the FAA's INM* will be used to model air tour aircraft activities and compute various noise-related descriptors (e.g., percentage of time aircraft sounds are above the ambient) and generate the sound-level contours that will be used in the assessment of potential noise impacts due to air tour operations.

The development of ambient maps is accomplished using Geographic Information System (GIS). In GIS, the following actions are performed:

- Define the input "objects":
    - Define the park boundary in Universal Transverse Mercator (UTM) † coordinates to set the initial grid area boundary. ‡
    - Divide the park into a regular grid of points at a desired spacing using a Digital Elevation Model (DEM), which is a digital representation of a topographic surface typically used in GIS applications. Each point is assigned an elevation value and UTM coordinates from the DEM. For GGNRA, a grid spacing of 500 ft (152.4 m) was used.
    - Define the acoustic zone boundaries in UTM coordinates (see Section 5.1).
    - Define the location of each measurement site.
- Assign a "measured" ambient sound level (and its associated one-third octave-band, unweighted spectrum) computed in Section 4.1, to each acoustic zone.

For development of all ambient maps, except for Natural Ambient, three additional steps are performed:

- Define the location of localized noise sources, primarily vehicles on roads, but may also include trains, waterfalls, and river rapids. The closest distance to each source is calculated and assigned to each grid point.
- Assign an ambient sound level (and its associated one-third octave-band, unweighted spectrum) for each roadway to each grid point using the drop-off rates determined by computer modeling discussed in Section 5.2.
- Compute a combined measured and roadway ambient (and spectra). This is performed by using energy-addition, i.e., sound levels in decibels were converted to energy prior to addition.

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* For ATMPs, the FAA and NPS have agreed to use the INM. The INM is a computer program used by over 700 organizations in over 50 countries to assess changes in noise impact. Requirements for INM use are defined in FAA Order 1050.1E, Environmental Impacts: Policies and Procedures, and Federal Aviation Regulations (FAR) Part 150, Airport Noise Compatibility Planning. In accordance with the results of the Federal Interagency Committee on Aviation Noise (FICAN) review ("Findings and Recommendations on Tools for Modeling Aircraft Noise in National Parks"), INM Version 6.2 is the best-practice modeling methodology currently available for evaluating aircraft noise in national parks and will be the model used for ATMP development.

† The UTM system provides coordinates on a worldwide flat grid for easy manipulation in GIS applications.

‡ Because the ATMP Act applies to all commercial air tour operations within the ½-mile outside the boundary of a national park, the park boundary includes a ½-mile buffer.

The final ambient maps are presented in Section 5.3.

5.1 Define Acoustic Zones and Assignment of Ambient Data

Because it is neither economically nor expeditiously feasible to manually collect noise data under all possible conditions throughout an entire park, areas of like vegetation, topography, elevation, and climate were grouped into "acoustic zones," with the assumption that similar wildlife, physical processes, and other sources of natural sounds occur in similar areas with similar attributes. The primary goal of the site selection process was to identify the minimum number of field-measurement sites, which would allow for characterization of the baseline ambient sound levels throughout the entire park by assigning measured data stratified to these acoustic zones. The following considerations are used in the determination of acoustic zones:

- Vegetation/Land Cover: Sound propagates differently over different types of ground cover and through different types of vegetation. For example, sound propagates more freely over barren environments as compared with grasslands, and less freely through forest type environments. In addition, vegetation is typically dependent upon time-of-year, with foliage being sparser in the winter than other times in the year. Land cover can also affect wildlife activity.
- Climate Conditions: Climate conditions (temperature, humidity, precipitation, wind speed, wind direction, etc.) can also affect ambient sound levels. For example, higher elevation areas typically exhibit higher wind speeds resulting in higher ambient sound levels. Climate is also dependent upon daily and seasonal variations, which can affect ambient sound levels. For example, under conditions of a temperature inversion (temperature increasing with increasing height as in winter and at sundown), sound waves may be heard over larger distances; and winds tend to increase later in the day, and, as such, may be expected to contribute to higher ambient noise levels in the afternoon as compared with the morning.
- Park Resources/Management Zones: Park resources contribute, not only, to the multitude of sounds produced in certain areas of the park, but also to the serenity of other areas in the park. The way in which a park manages its resources can affect how potential impacts may be later assessed. It may also help identify where greater resource protection may be needed.

Based on the above considerations, Figure 12 presents the acoustic zones that were developed and the location of the measurement sites for GGNRA. Because the ATMP Act applies to all commercial air tour operations within the ½-mile outside the boundary of a national park, areas within the ½-mile buffer overlap parts of Point Reyes National Seashore (PORE) and Muir Woods National Monument (MUWO). Ambient data representing the summer and winter seasons within PORE and MUWO were collected in July 2009 and January 2010, respectively, by the Volpe Center. Therefore, ambient data measured for PORE and MUWO were used for those overlapping areas, as well as other similar acoustic zones within close proximity. A data report for PORE and MUWO will be provided separately. Table 15 presents which measurement site data were applied to each acoustic zone.

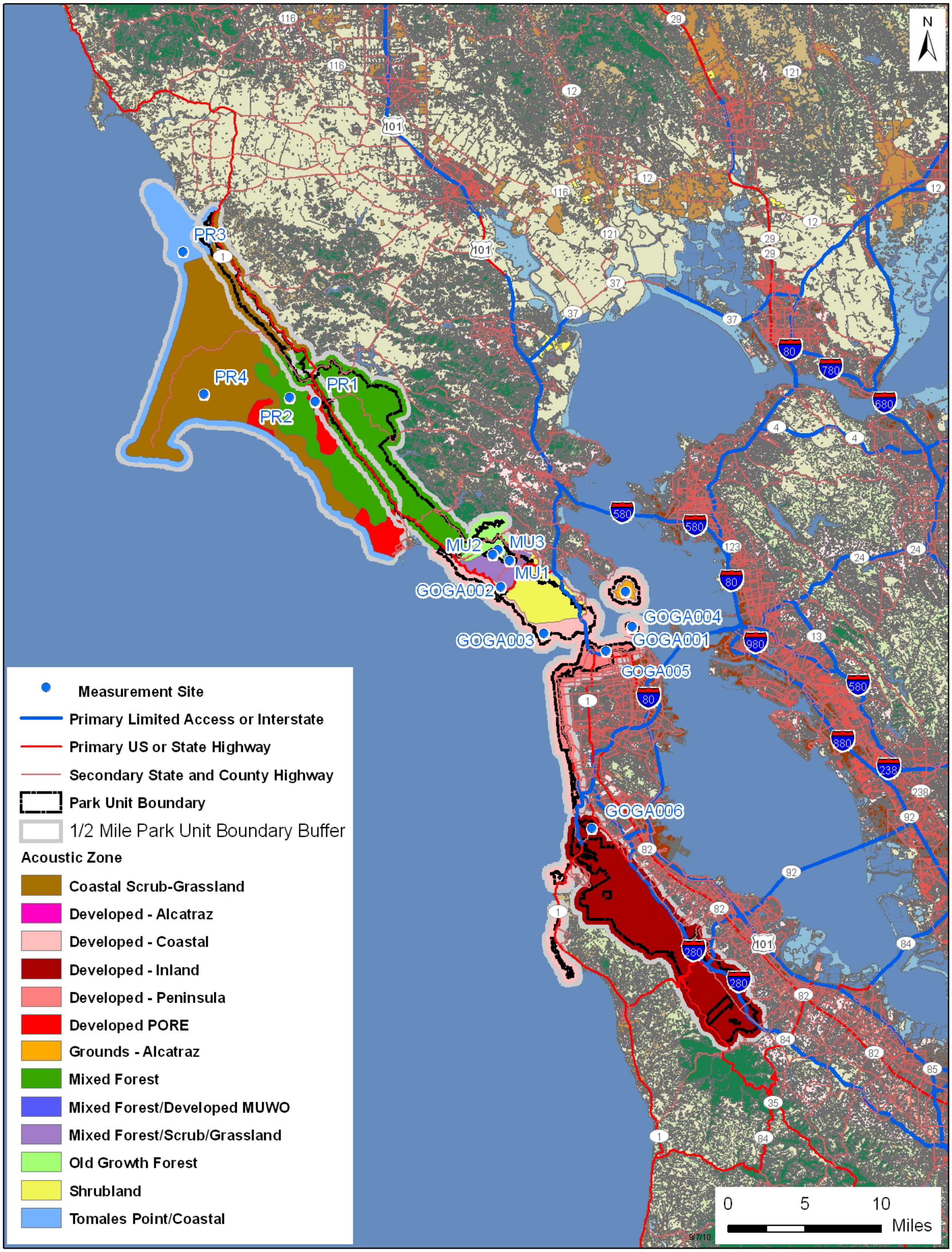

Figure 12. Acoustic zones and measurement sites for GGNRA (with overlapping areas from PORE and MUWO also shown)

Table 15. Assignment of ambient data to acoustic zones

Acoustic Zone	Site ID	Site Name
Developed - Alcatraz	GOGA001	Alcatraz West
Shrubland	GOGA002	Banducci West Drainage
Developed - Coastal	GOGA003	Bonita Point
Grounds - Alcatraz	GOGA004	Alcatraz Water Tower
Grounds - Alcatraz	GOGA004	Alcatraz Water Tower
Developed - Peninsula	GOGA005	Crissy Marsh Field
Developed - Inland	GOGA006	Milagra Ridge
Developed (PORE)	PORE001	Bear Valley Visitor Center
Mixed Forest (PORE)	PORE002	Fire Road Trail
Tomales Point/Coastal (PORE)	PORE003	Tomales Bay Point
Coastal Scrub-Grassland (PORE)	PORE004	Drakes Head Estero
Old Growth Forest (MUWO)	MUWO001	Ben Johnson Trail
Mixed Forest/Scrub/Grassland (MUWO)	MUWO002	Deer Park Fire Trail
Mixed Forest/Developed (MUWO)	MUWO003	Dipsea Trail

5.2 Ambient Mapping of Localized Sound Sources

The contributing effect of localized noise sources, primarily vehicles on roads, but may also include trains, waterfalls, and river rapids, are typically modeled and combined with the measured sound levels to develop a composite, baseline, ambient "map" of a park for all ambient maps, except natural ambient (see Table 16). The combined (measured plus roadway, for example) ambient are computed by using energy-addition, i.e., sound levels in decibels were converted to energy prior to addition. Roadway sound sources were modeled using the Federal Highway Administration's Traffic Noise Model® (TNM) (Lee et al. 2004), where the estimated drop-off rate, reflecting a continuous decrease in sound level as a function of increasing distance from each sound source, was computed. For a non-time-varying source, such as roadway noise, the TNM-computed L_{Aeq} sound level parameters may be conservatively assumed to be equivalent to the L_{50} and L_{90} and, thus, used interchangeably as the "roadway" ambient.

Table 16. Composite ambient maps.

Metric	Ambient Type			
	Existing	Existing Without Air Tours	Existing Without All Aircraft	Natural
L_{50}	Measured + Localized Noise Source(s)	Measured + Localized Noise Source(s)	Measured + Localized Noise Source(s)	Measured

In the vicinity of and within GGNRA, there were a number of roadways. The following general assumptions were made in the modeling:

- Roadway Traffic Volumes – Annual traffic volume on each roadway was determined using data collected by the California Department of Transportation (CALTRANS). The

CALTRANS Traffic Data Branch (http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/index.htm). Where data are available for multiple years, the most current year was chosen. The traffic volume for an average day during the peak summer month (July) and the peak winter month (January) was obtained by using monthly visitation data obtained from the NPS Public Use Statistics Office website (http://www2.nature.nps.gov/stats/) to apportion the CALTRANS annual traffic. Hourly volume is estimated by dividing the month's volume by the number of days in the month (31) and by 12 hours per day, which assumes the majority of traffic for GGNRA occurs between 7 am and 7 pm – typical commute hours.

- Roadway Traffic Mix and Speeds –The traffic mix and speeds on a given roadway were based on two sources: (1) State of California Department of Motor Vehicles (DMV) registered vehicle statistics (http://www.dmv.ca.gov/about/profile/official.pdf ; (2) regulatory provisions in the 2009 Superintendent's Compendium (http://www.nps.gov/goga/parkmgmt/loader.cfm?csModule=security/getfile&pageid=276204); and (3) observations by field personnel during site visits. In some cases, a specific speed limit was determined using Google Maps using the "street view" to view an actual speed limit sign. When multiple speed limit signs showed varying speeds over a single road segment, an average. In some specific cases, notations from the Volpe field notes en route to measurement site locations were used to determine speed limits over various segments. An average speed of 35 mph was assumed as the default within the park when another more specific speed limit could not be determined.
- Ground Impedance – Because much of GGNRA is within an urban environment, a moderately hard acoustical ground impedance was assumed using an effective flow resistivity of 1000 cgs/rayls. For roadways within close proximity to forested areas, sound levels were propagated through a "tree zone" to account for the attenuation effects.

Table 17. Estimated hourly roadway traffic volume and speed for the summer season

Roadway			Estimated Hourly Volume				
#	Name	Average Speed (mph)	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
1	Miller Ave, Mill Valley	30	2,268	49	8	41	84
2	Miller Ave + SR 1	30	2,922	64	10	53	108
3	US 101 North of GG	65	14,218	309	47	256	525
4	Tennessee Valley Road	25	868	0	0	0	46
5	Bridgeway/Alexander Ave, Sausalito	25	3,489	76	12	63	129
6	East Street, Sausalito	30	1,890	41	6	34	70
7	Navy Memorial	15	2,113	46	7	38	78
8	Bunker Road (West)	25	1,207	0	0	0	64
9	Conzelman Road	25	3,193	0	0	0	168
10	Bunker Road (East)	25	1,672	36	6	30	62
11	US101/SR1/GG Bridge	45	18,493	402	61	333	683
12	US 101 South of GG (Doyle Drive)	35	11,689	254	39	210	432
13	Marina Blvd.	25	2,742	60	9	49	101
14	Mason Street	25	3,065	67	10	55	113
15	Presidio Loop	25	2,617	57	9	47	97
16	US 101 (Lombard/Van Ness)	35	7,763	169	26	140	287
17	SR 1 South of GG Bridge	45	16,225	353	54	292	600
18	Great Hwy/Lower Geary Blvd	35	2,161	47	7	39	80

Roadway			Estimated Hourly Volume				
#	Name	Average Speed (mph)	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
19	Central Freeway	55	8,854	193	29	159	327
20	I-80 Bay Bridge	45	22,069	480	73	397	815
21	US101 South of Bay Bridge	65	39,253	854	130	706	1,450
22	I280	65	26,169	569	87	471	967
23	SR 35 NE of Stonestown	35	4,213	92	14	76	156
24	SR 35 S of Stonestown	45	5,234	114	17	94	193
25	SR 1/I-280 Daly City Split	55	13,870	302	46	249	513
26	SR 1 South of Colma	40	6,848	149	23	123	253
27	I-280 South of Colma	65	23,203	505	77	417	857
28	SR 35/I-280 @ San Andreas Lake	65	17,359	378	58	312	641
29	SR 1 near Phleger Estates	45	4,972	108	17	89	184
30	SR 92 near Phleger Estates	35	4,283	93	14	77	158
31	SR 35 near Phleger Estates	35	436	10	1	8	16
32	I-280 near Phleger Estates	65	17,359	378	58	312	641
33	Kings Mountain Road (Phleger Estates) (West)	30	436	10	1	8	16
34	Kings Mountain Road (Phleger Estates) (East)	30	7,502	163	25	135	277
35	SR 84 (Phleger Estates)	35	4,013	87	13	72	148
36	I-380	55	14,306	311	48	257	529
37	Shoreline Highway 1/Tomales-Petaluma Rd	55	282	6	1	5	10
38	Shoreline Highway 1/Marshall-Petaluma Rd	55	379	8	1	7	14
39	Shoreline Highway 1/Point Reyes-Petaluma Rd	55	850	19	3	15	31
40	Shoreline Highway 1/Sir Francis Drake	55	1,551	34	5	28	57
41	Shoreline Highway 1/Bolinas-Fairfax Rd	55	517	11	2	9	19
42	Marshall-Petaluma Road	40	126	3	0	2	5
43	Pierce Point Road L Ranch Road	35	60	1	0	1	2
44	Sir Francis Drake Boulevard/CA-1	35	952	21	3	17	35
45	Sir Francis Drake Boulevard/Park entrance	35	110	2	0	1	4
46	Sir Francis Drake Boulevard/Pierce Point Rd	40	25	1	0	0	1
47	Mount Vision Road	40	4	0	0	0	0
48	Limantour Road	40	22	1	0	0	1
49	Bear Valley Road	40	47	1	0	1	2
50	Point Reyes-Petaluma Road	40	130	3	0	2	5
51	Nicasio Valley Road	40	32	1	0	1	1
52	Lucas Valley Road	40	16	0	0	0	1
53	Horseshoe Hill Road	30	84	2	0	2	3
54	Olema-Bolinas Road	30	167	4	1	3	6
55	Bolinas-Fairfax Road	40	172	4	1	3	6
56	Mesa Road	35	9	0	0	0	0
57	Overlook Drive	35	5	0	0	0	0
58	Elm Road	35	5	0	0	0	0
59	Panoramic Hwy/Stinson Beach	30	999	22	3	18	37
60	Panoramic Hwy/South Junction	30	822	18	3	15	30

Roadway			Estimated Hourly Volume				
#	Name	Average Speed (mph)	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
61	Panoramic Hwy/North	30	493	11	2	9	18
62	Muir Woods Road (Frank Valley), South	35	340	7	1	6	13
63	Muir Woods Road (Frank Valley), North	35	493	11	2	9	18
64	Alice East Wood Road	40	100	2	0	2	4
65	Parallel to Old Mine Trail	40	83	2	0	1	3
66	CA 1	45	999	22	3	18	37
67	Ridge Rd/Ridge Ave	40	200	4	1	4	7
68	Cll De Los Arbores	35	66	1	0	1	2
69	Cll De Dias	35	66	1	0	1	2
70	Cam Del Canyon	35	44	1	0	1	2
71	Conlon Ave	35	132	3	0	2	5

Table 18. Estimated hourly roadway traffic volume and speed for the winter season

Roadway			Estimated Hourly Volume				
#	Name	Average Speed (mph)	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
1	Miller Ave, Mill Valley	30	1,862	41	6	34	69
2	Miller Ave + SR 1	30	2,399	52	8	43	89
3	US 101 North of GG	65	11,673	254	39	210	431
4	Tennessee Valley Road	25	1,633	0	0	0	86
5	Bridgeway/Alexander Ave, Sausalito	25	2,864	62	10	52	106
6	East Street, Sausalito	30	1,551	34	5	28	57
7	Navy Memorial	15	1,273	28	4	23	47
8	Bunker Road (West)	25	1,207	0	0	0	64
9	Conzelman Road	25	3,515	0	0	0	185
10	Bunker Road (East)	25	3,227	70	11	58	119
11	US101/SR1/GG Bridge	45	15,181	330	50	273	561
12	US 101 South of GG (Doyle Drive)	35	9,596	209	32	173	355
13	Marina Blvd.	25	2,573	56	9	46	95
14	Mason Street	25	2,228	49	7	40	82
15	Presidio Loop	25	2,148	47	7	39	79
16	US 101 (Lombard/Van Ness)	35	6,373	139	21	115	236
17	SR 1 South of GG Bridge	45	13,320	290	44	240	492
18	Great Hwy/Lower Geary Blvd	35	1,466	32	5	26	54
19	Central Freeway	55	7,269	158	24	131	269
20	I-80 Bay Bridge	45	18,118	394	60	326	669
21	US101 South of Bay Bridge	65	32,225	701	107	579	1,191
22	I280	65	21,483	467	71	386	794
23	SR 35 NE of Stonestown	35	3,459	75	12	62	128
24	SR 35 S of Stonestown	45	4,297	94	14	77	159
25	SR 1/I-280 Daly City Split	55	11,386	248	38	205	421
26	SR 1 South of Colma	40	5,621	122	19	101	208
27	I-280 South of Colma	65	19,048	414	63	343	704
28	SR 35/I-280 @ San Andreas Lake	65	14,251	310	47	256	527
29	SR 1 near Phleger Estates	45	4,082	89	14	73	151

Roadway			Estimated Hourly Volume				
#	Name	Average Speed (mph)	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
30	SR 92 near Phleger Estates	35	3,516	77	12	63	130
31	SR 35 near Phleger Estates	35	358	8	1	6	13
32	I-280 near Phleger Estates	65	14,251	310	47	256	527
33	Kings Mountain Road (Phleger Estates) (West)	30	358	8	1	6	13
34	Kings Mountain Road (Phleger Estates) (East)	30	6,159	134	20	111	228
35	SR 84 (Phleger Estates)	35	3,294	72	11	59	122
36	I-380	55	11,744	256	39	211	434
37	Shoreline Highway 1/Tomales-Petaluma Rd	55	180	4	1	3	7
38	Shoreline Highway 1/Marshall-Petaluma Rd	55	242	5	1	4	9
39	Shoreline Highway 1/Point Reyes-Petaluma Rd	55	543	12	2	10	20
40	Shoreline Highway 1/Sir Francis Drake	55	992	22	3	18	37
41	Shoreline Highway 1/Bolinas-Fairfax Rd	55	331	7	1	6	12
42	Marshall-Petaluma Road	40	81	2	0	1	3
43	Pierce Point Road L Ranch Road	35	38	1	0	1	1
44	Sir Francis Drake Boulevard/CA-1	35	609	13	2	11	23
45	Sir Francis Drake Boulevard/Park entrance	35	70	2	0	1	3
46	Sir Francis Drake Boulevard/Pierce Point Rd	40	16	0	0	0	1
47	Mount Vision Road	40	3	0	0	0	0
48	Limantour Road	40	14	0	0	0	1
49	Bear Valley Road	40	30	1	0	1	1
50	Point Reyes-Petaluma Road	40	83	2	0	2	3
51	Nicasio Valley Road	40	21	0	0	0	1
52	Lucas Valley Road	40	10	0	0	0	0
53	Horseshoe Hill Road	30	54	1	0	1	2
54	Olema-Bolinas Road	30	107	2	0	2	4
55	Bolinas-Fairfax Road	40	110	2	0	2	4
56	Mesa Road	35	6	0	0	0	0
57	Overlook Drive	35	3	0	0	0	0
58	Elm Road	35	3	0	0	0	0
59	Panoramic Hwy/Stinson Beach	30	467	10	2	8	17
60	Panoramic Hwy/South Junction	35	385	8	1	7	14
61	Panoramic Hwy/North	40	231	5	1	4	9
62	Muir Woods Road (Frank Valley), South	40	159	3	1	1	6
63	Muir Woods Road (Frank Valley), North	45	231	5	1	4	9
64	Alice East Wood Road	35	47	1	0	1	2
65	Parallel to Old Mine Trail	35	39	1	0	1	1
66	CA 1	35	467	10	2	8	17
67	Ridge Rd/Ridge Ave	35	93	2	0	2	3
68	Cll De Los Arbores	40	31	1	0	1	1
69	Cll De Dias	30	31	1	0	1	1

Roadway			Estimated Hourly Volume				
#	Name	Average Speed (mph)	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-cycles
70	Cam Del Canyon	30	21	0	0	0	1
71	Conlon Ave	35	62	1	0	1	2

5.3 Final Ambient Maps

The two ambient maps agreed upon for use in ATMP analyses are:

- Existing Ambient Without Air Tours (i.e., the Source of Interest); and
- Natural Ambient.

Figure 13 through Figure 16 present the four ambient maps for the summer and winter seasons, respectively.

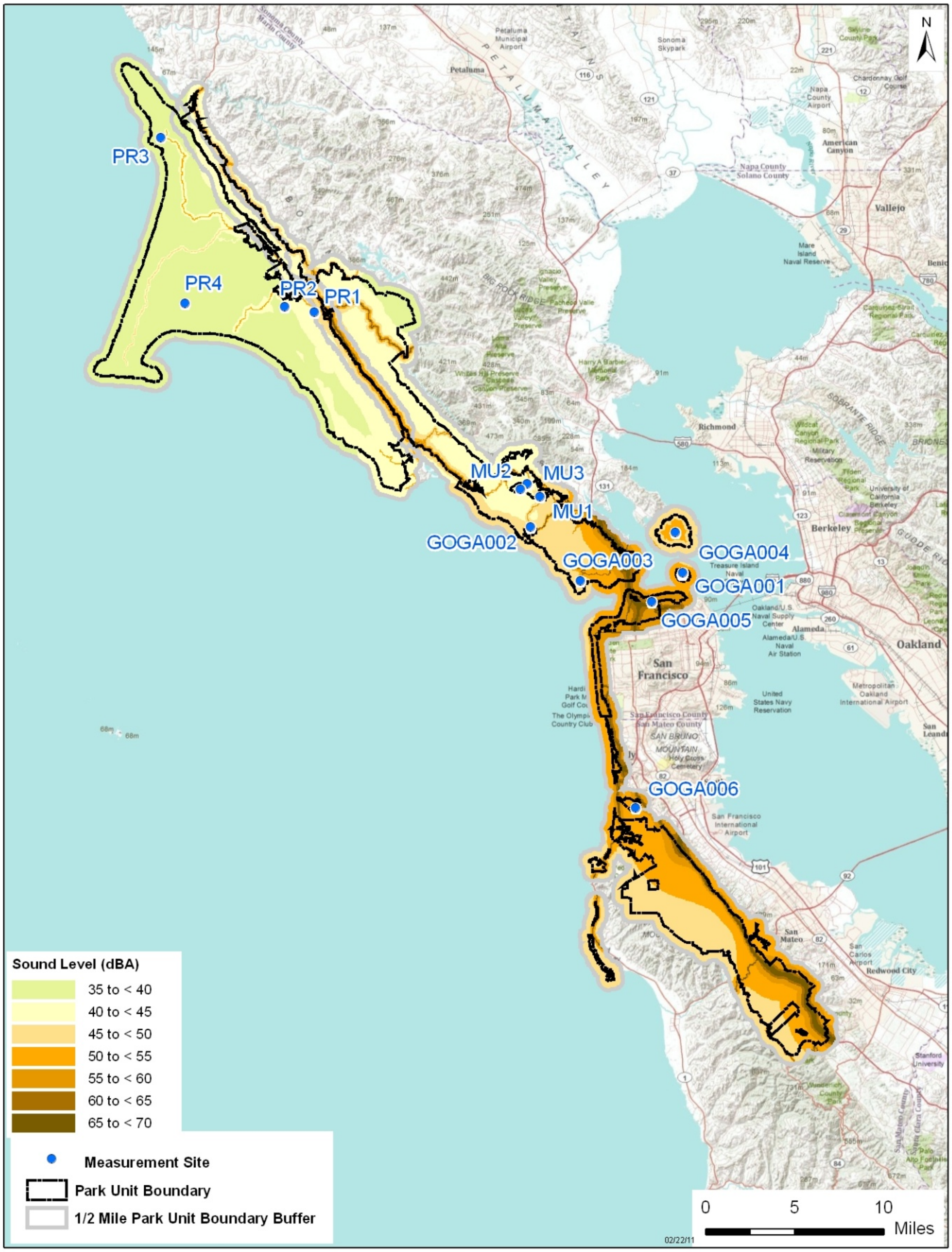

Figure 13. Baseline ambient map: Existing Ambient Without Air Tours (L_{50}) for the summer season

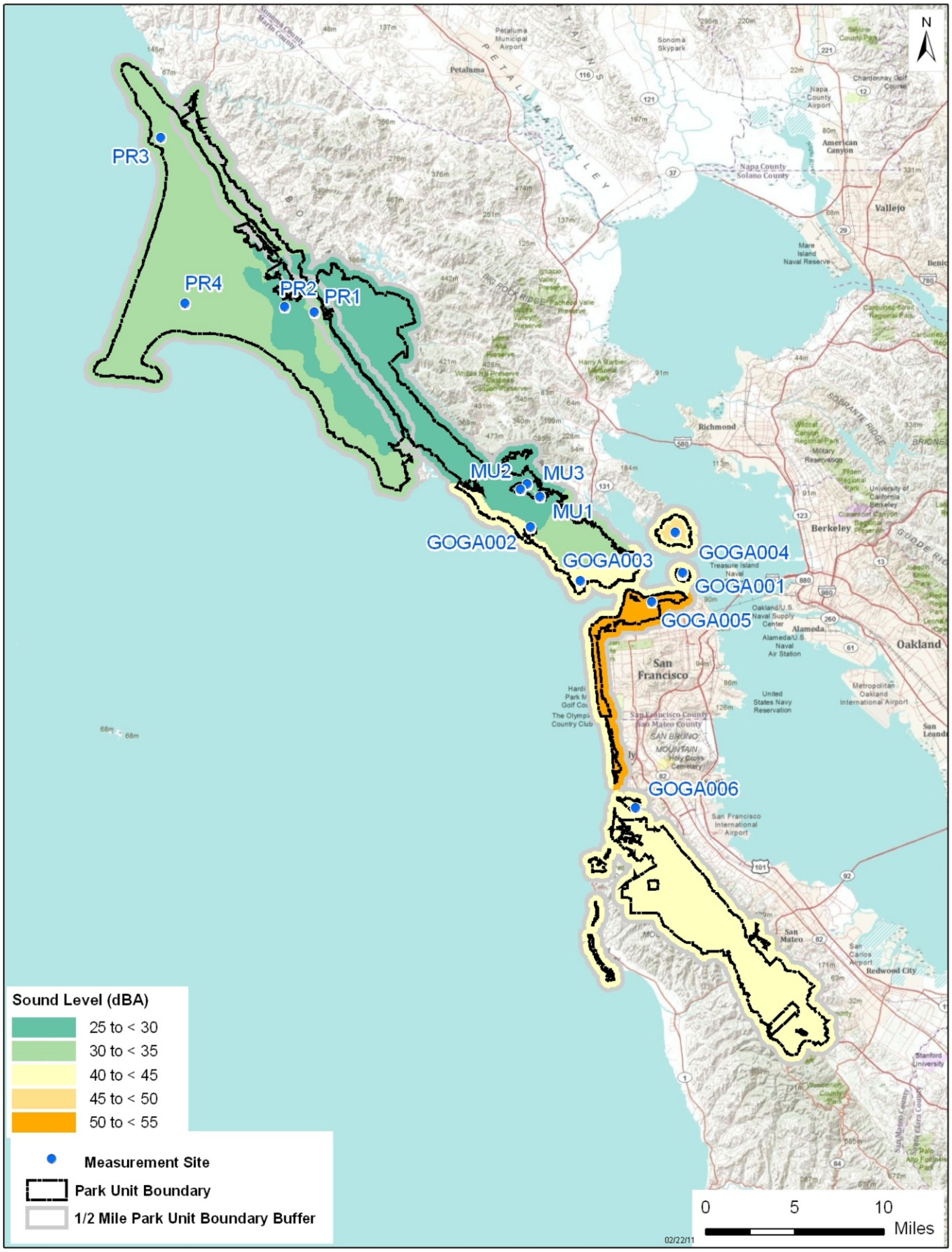

Figure 14. Baseline ambient map: Natural Ambient (L_{50}) for the summer season

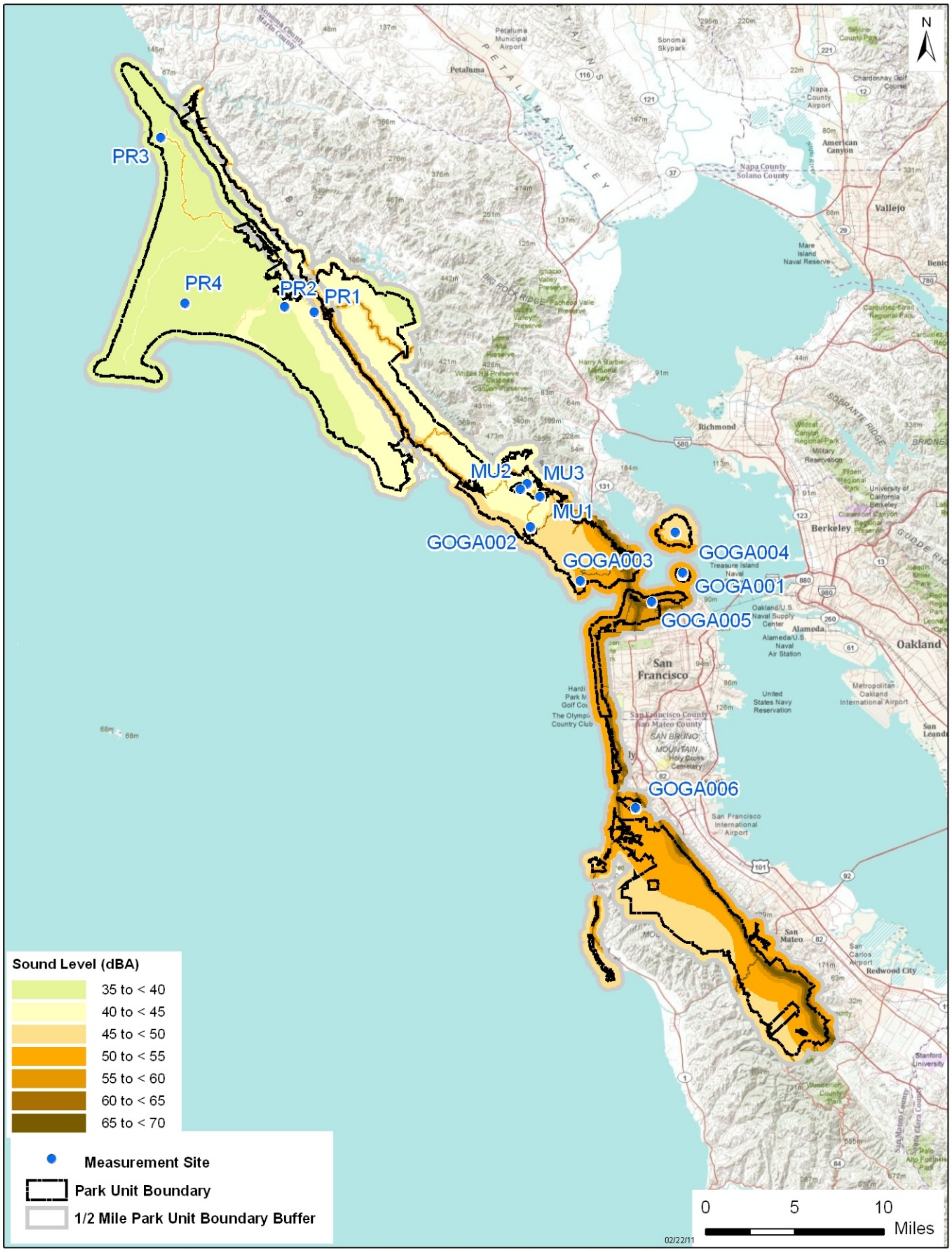

Figure 15. Baseline ambient map: Existing Ambient Without Air Tours (L_{50}) for the winter season

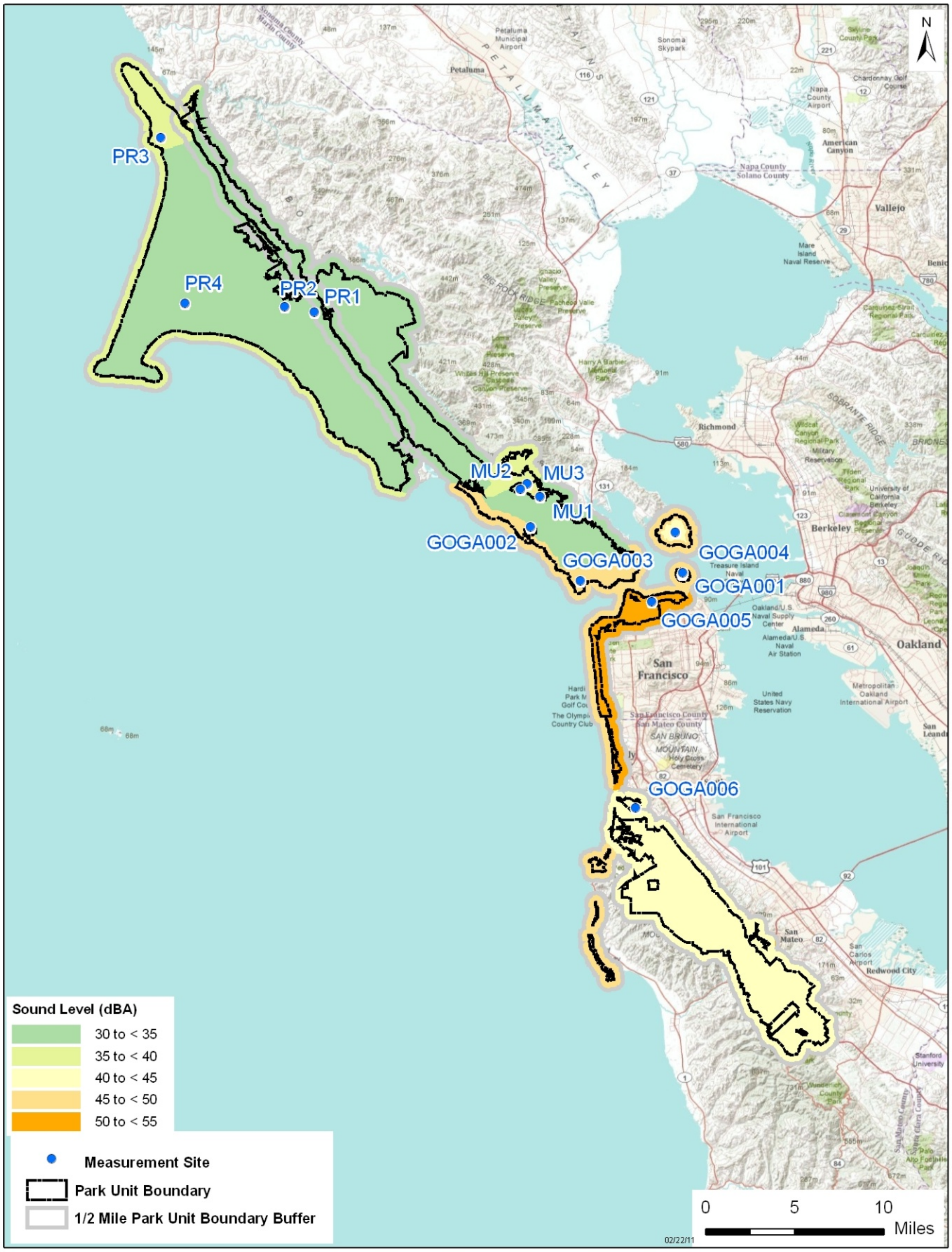

Figure 16. Baseline ambient map: Natural Ambient (L_{50}) for the winter season

6. Data for Individual Sites

This section provides more detailed information for each individual site. For each site, the following are included:

- A photograph of the measurement site and a brief discussion of preliminary observations;
- A pie chart presenting a comparison of types of sound sources that were audible during observer logging;
- A graphic presenting distribution plots of the number of 1-second samples of each sound pressure level measured during daytime and nighttime hours, and daytime/nighttime combined;
- A graphic presenting the daily sound levels using three hourly A-weighted metrics (L_{Aeq}, L_{50}, and L_{90} - refer to Section 3 for definitions), as well as average daily wind speeds over the entire measurement period;
- A graphic presenting the hourly sound levels using three hourly A-weighted metrics (L_{Aeq}, L_{50}, and L_{90} - refer to Section 3 for definitions), as well as average hourly wind speeds over the entire measurement period; and
- A graphic presenting the dB levels for each of 33 one-third octave band frequencies over the day and night periods using three hourly A-weighted metrics (L_{10}, L_{50}, and L_{90}). The L_{10} exceedence level represents the dB exceeded 10 percent of the time and 90 percent of the measurements are quieter than the L_{10}. Refer to Section 3 for definitions of L_{50} and L_{90}. The grayed area represents sound levels outside of the typical range of human hearing.

6.1 Site GOGA001 – Alcatraz West

Figure 17. Photograph of Site GOGA001.

Observations

This site was located on the west side of Alcatraz Island and subject to a wide variety of sounds that included natural (birds and wind), aircraft (jets, fixed-wing, and helicopters), watercraft, waterfront sounds (buoy bell) and visitors. It is a coastal cliff near nesting sites and three meters from a low use trail. The site experienced a general diurnal trend where sound levels rose during the day and diminished in the evening. The site was nearly 10 dB louder (daytime L_{50}) during the summer compared to the winter. The reasons for the louder acoustic conditions in the summer appear to be human activity in and around this area, including fireworks during the fourth of July.

Observer audibility results were similar from summer to winter seasons. Watercraft were audible 60-70% of the time during the summer daytime hours whereas it was only audible 20-30% of the time during the winter. The winter weather and off-peak seasonal activity led to the quieter sound levels in the winter at this location. Vehicle sounds were more audible during winter than summer and this may be due to decreased bird activity in the winter allowing the listener to detect distant sounds. The GOGA001 summer spectra have more acoustic content in the range of 1-5 kHz than during the winter season. This frequency range is typically associated with bird vocalizations.

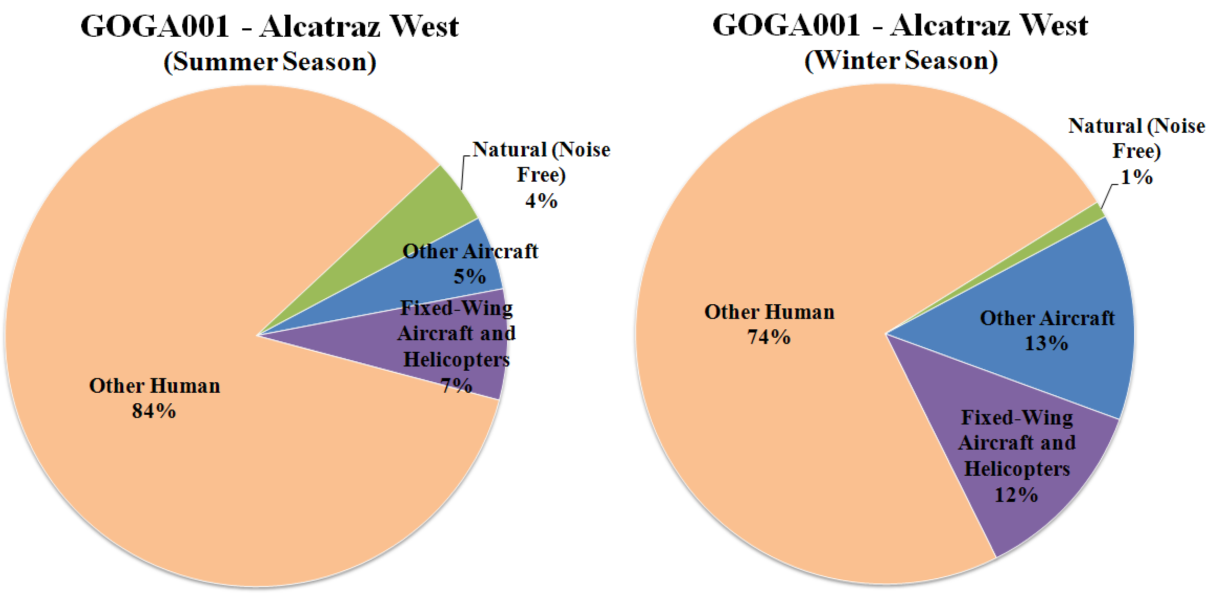

Figure 18. Distribution of sound sources audible (in situ and office listening combined) for Site GOGA001 for summer and winter seasons

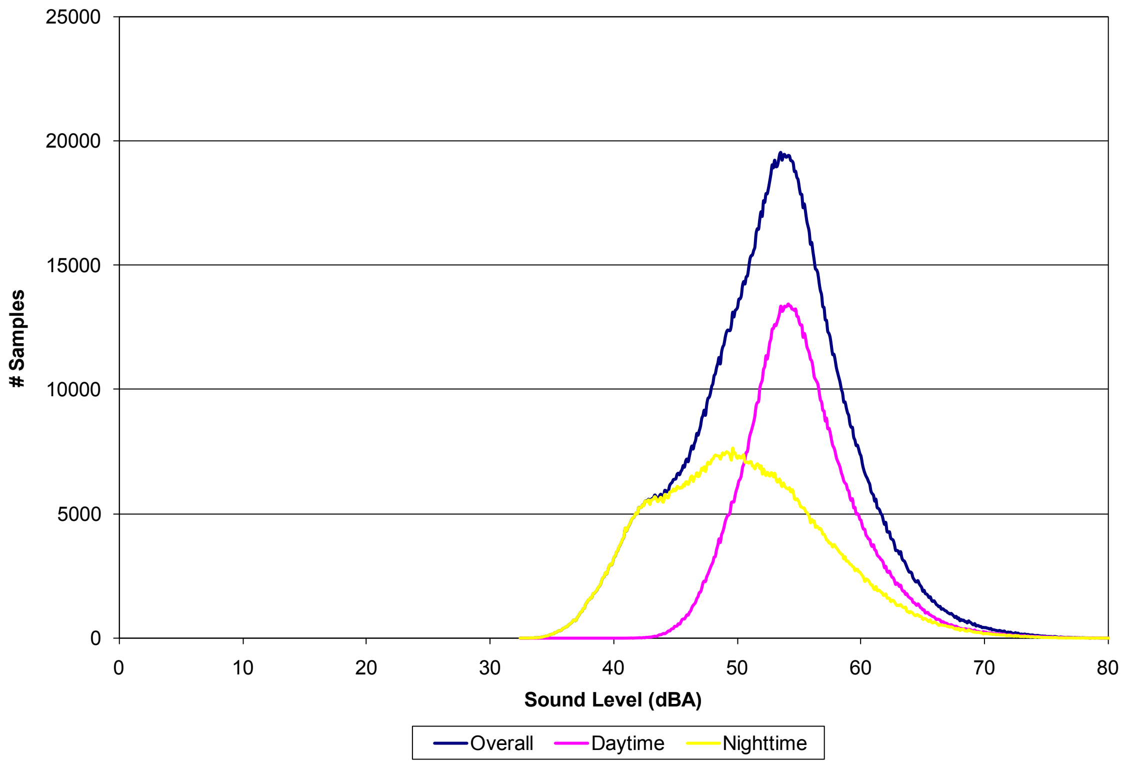

Figure 19. Distribution of data for Site GOGA001 for summer season

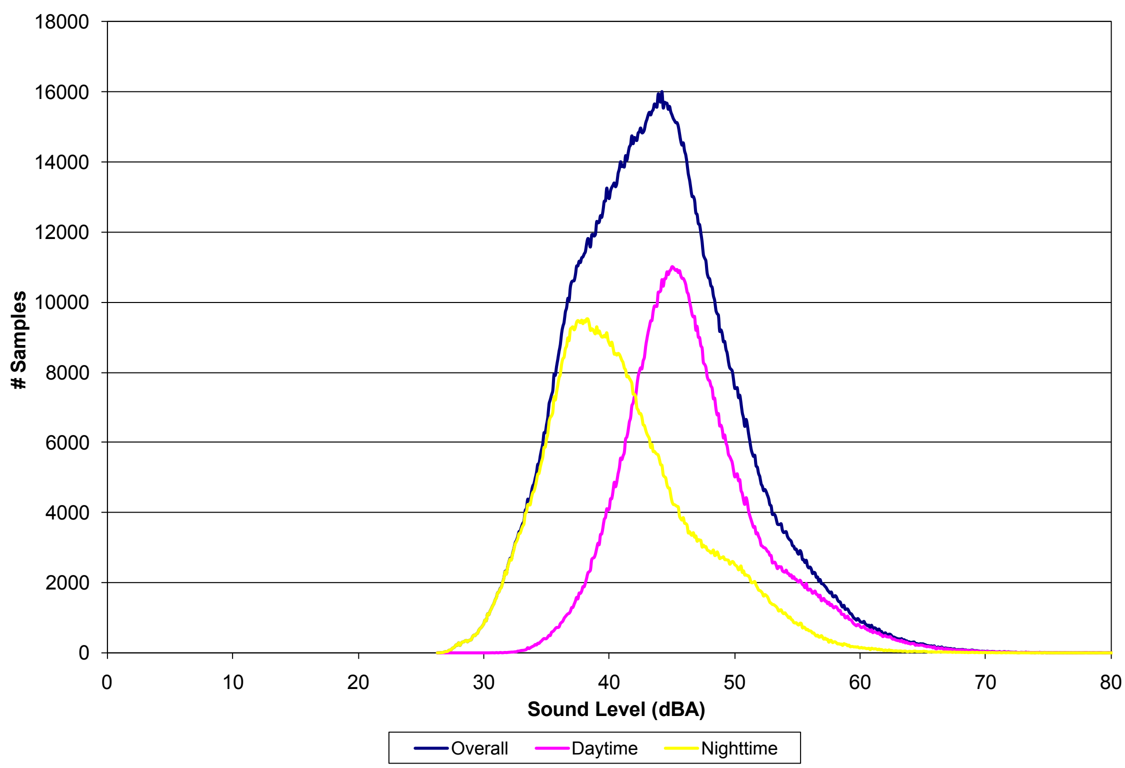

Figure 20. Distribution of data for Site GOGA001 for winter season

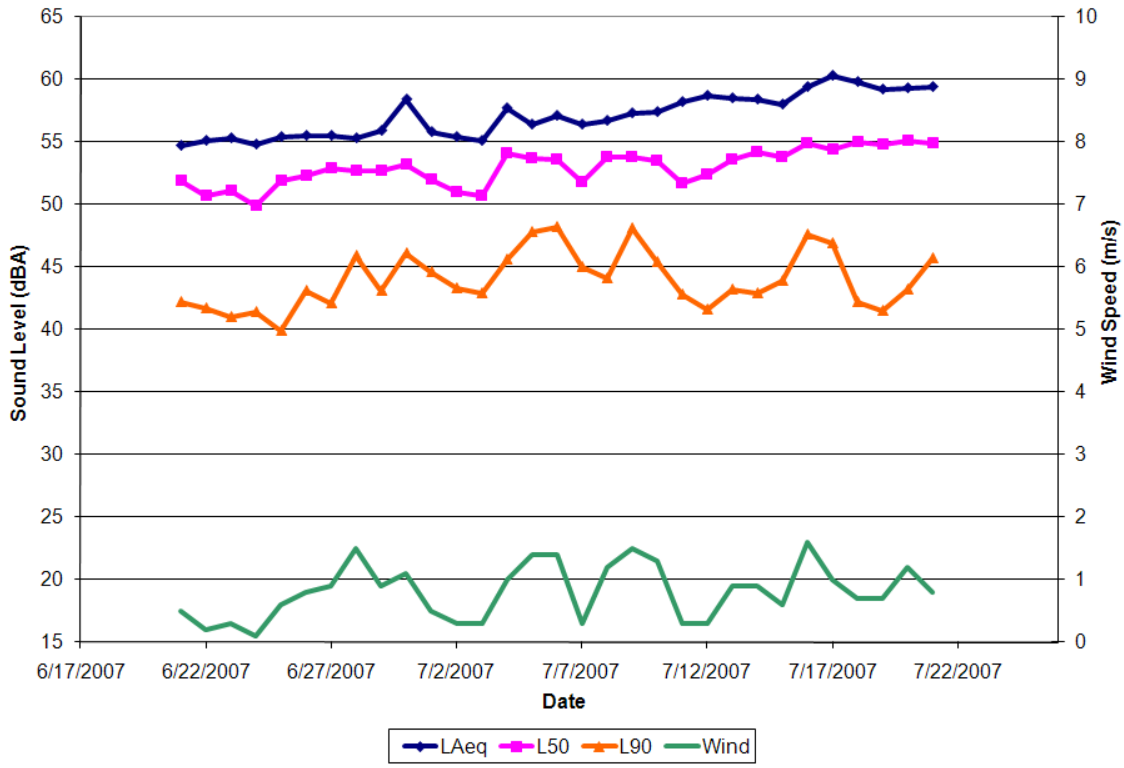

Figure 21. Daily sound levels and wind speeds for Site GOGA001 for summer season

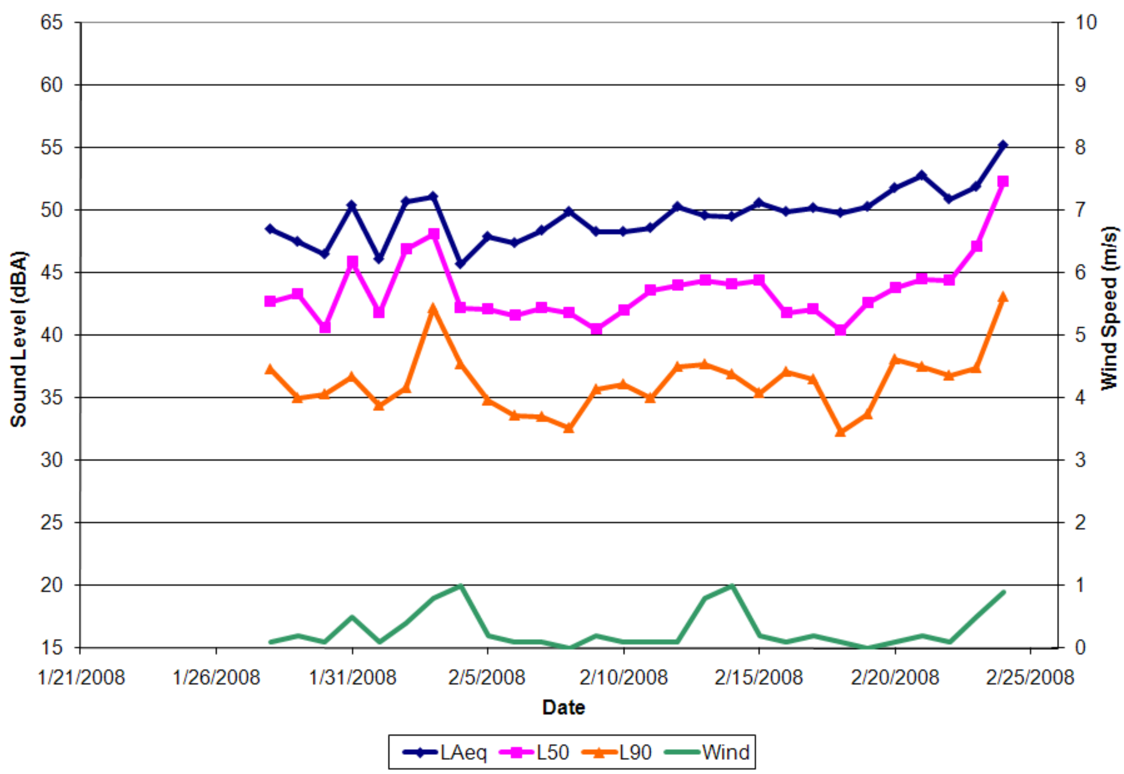

Figure 22. Daily sound levels and wind speeds for Site GOGA001 for winter season

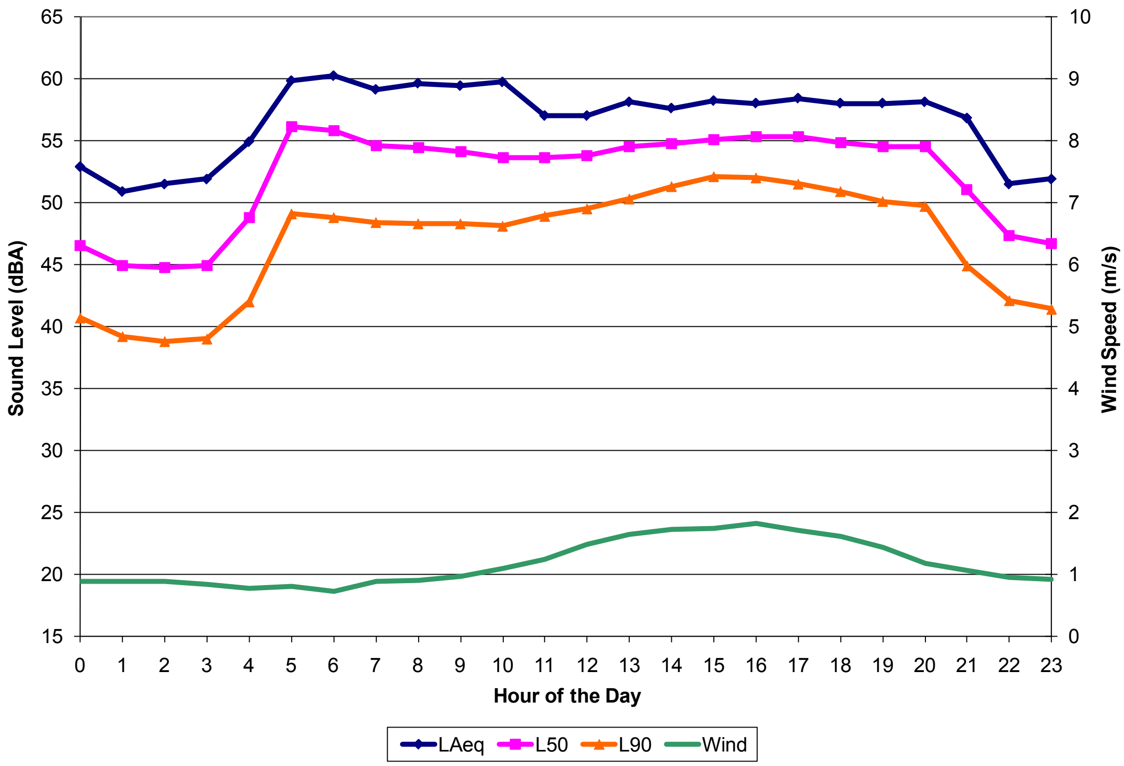

Figure 23. Hourly sound levels and wind speeds for Site GOGA001 for summer season

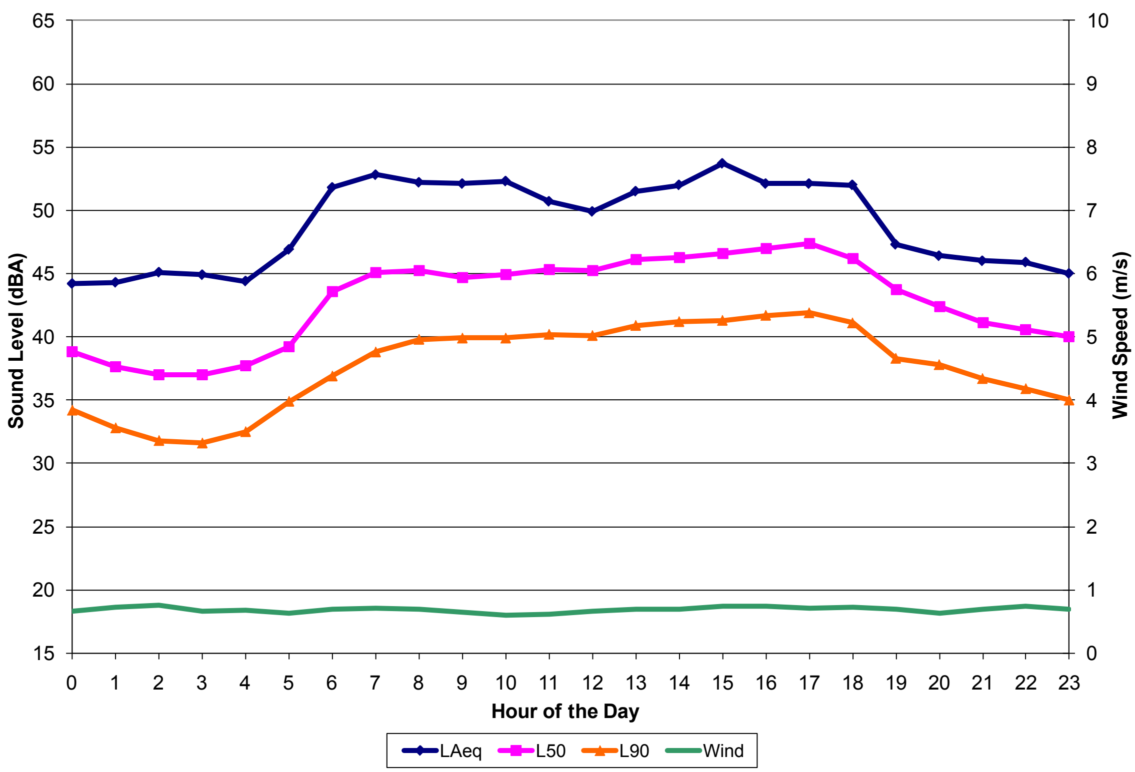

Figure 24. Hourly sound levels and wind speeds for Site GOGA001 for winter season

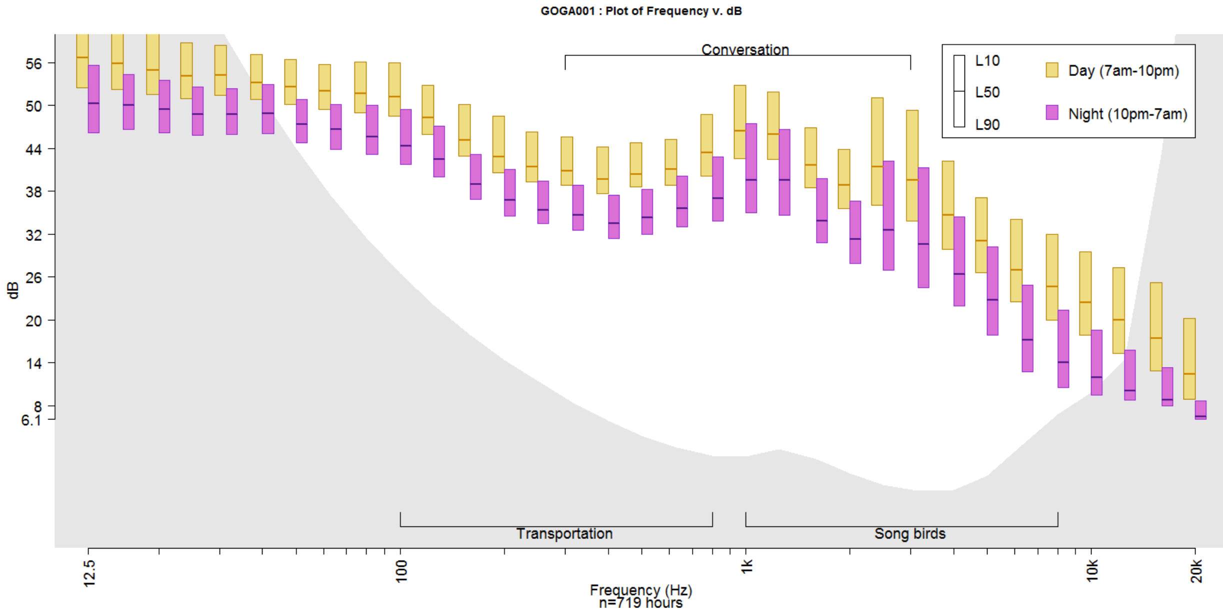

Figure 25. Sound spectrum for GOGA001 for summer season

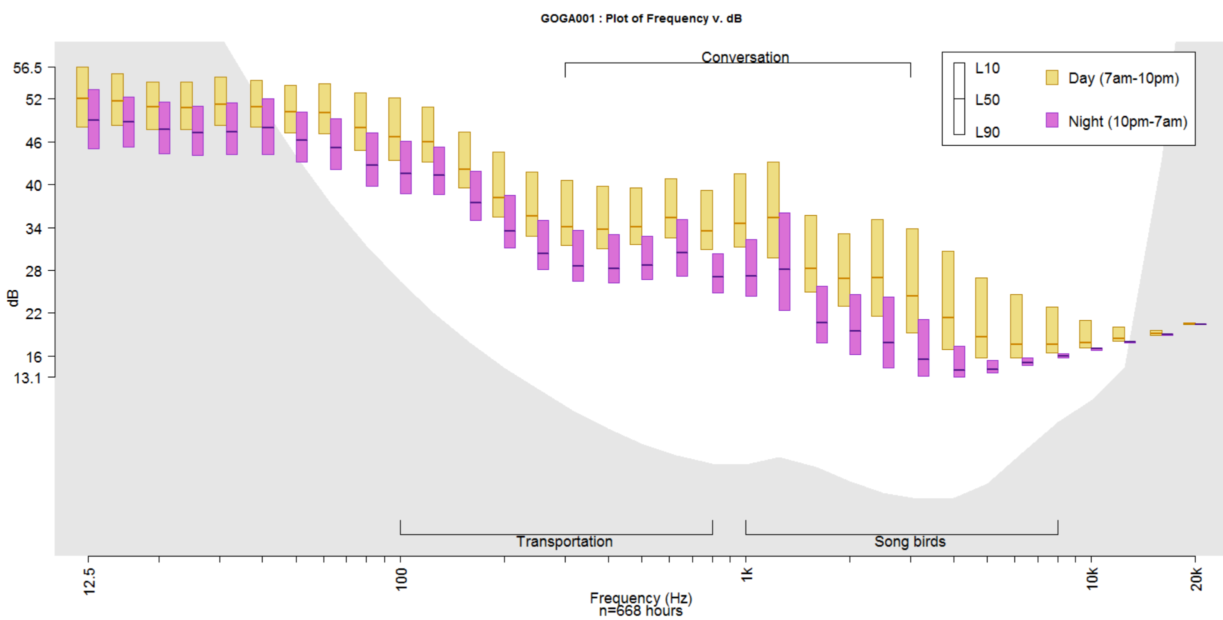

Figure 26. Sound spectrum for GOGA001 for winter season

6.2 Site GOGA002 – Banducci West Drainage

Figure 27. Photograph of Site GOGA002.

Observations

This site was located 70 m (231 ft) from the road into Muir Woods NM (Shoreline Highway) and 238 m (781 ft) from Muir Woods Road. Vehicle sounds were the most common non-natural sounds and could be heard even from a distance late at night and early in the morning. Fog horns were also audible on most days. Aircraft, lawn mowers and other visitor-related sounds were also occasionally heard. Natural sounds included wind, birds, and frogs (in the evening) during the summer. In addition to these sounds, running water and rain were audible during the winter. The seasonal sound levels at this site were consistent (39.6 dBA during the summer and 40.3 dBA during the winter daytime hours).

The site followed a diurnal trend during both seasons, but the summer exhibited a stronger pattern of louder sound levels during the day and quieter sound levels at night. A loud jet event (possibly military) occurred during the winter measurement on 2/16/08 at the 1400 hour and is responsible for the spike in the daily and hourly sound level graph.

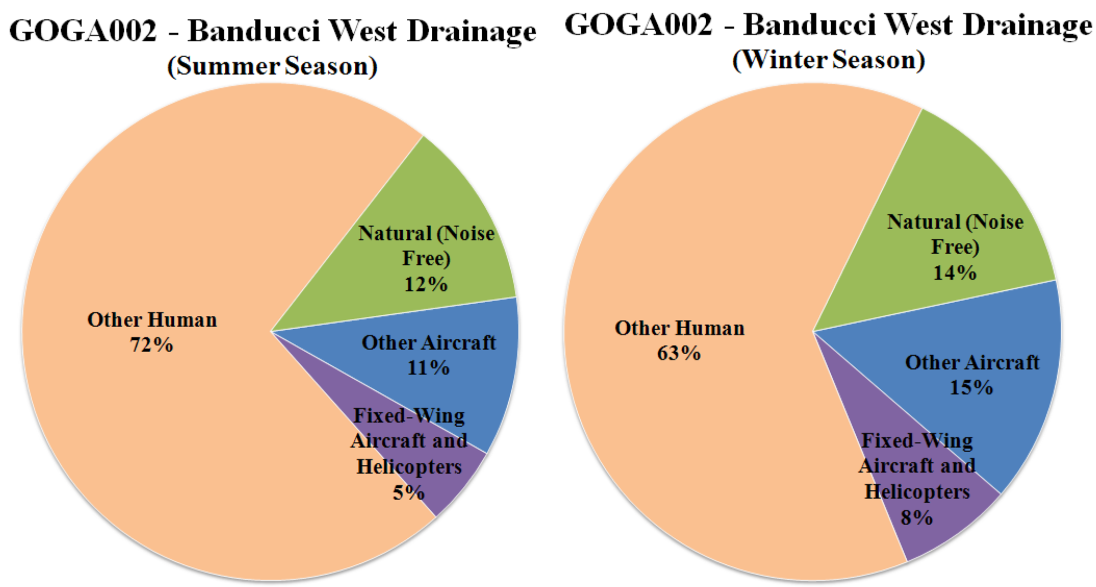

Figure 28. Distribution of sound sources audible (in situ and office listening combined) for Site GOGA002 for summer and winter seasons

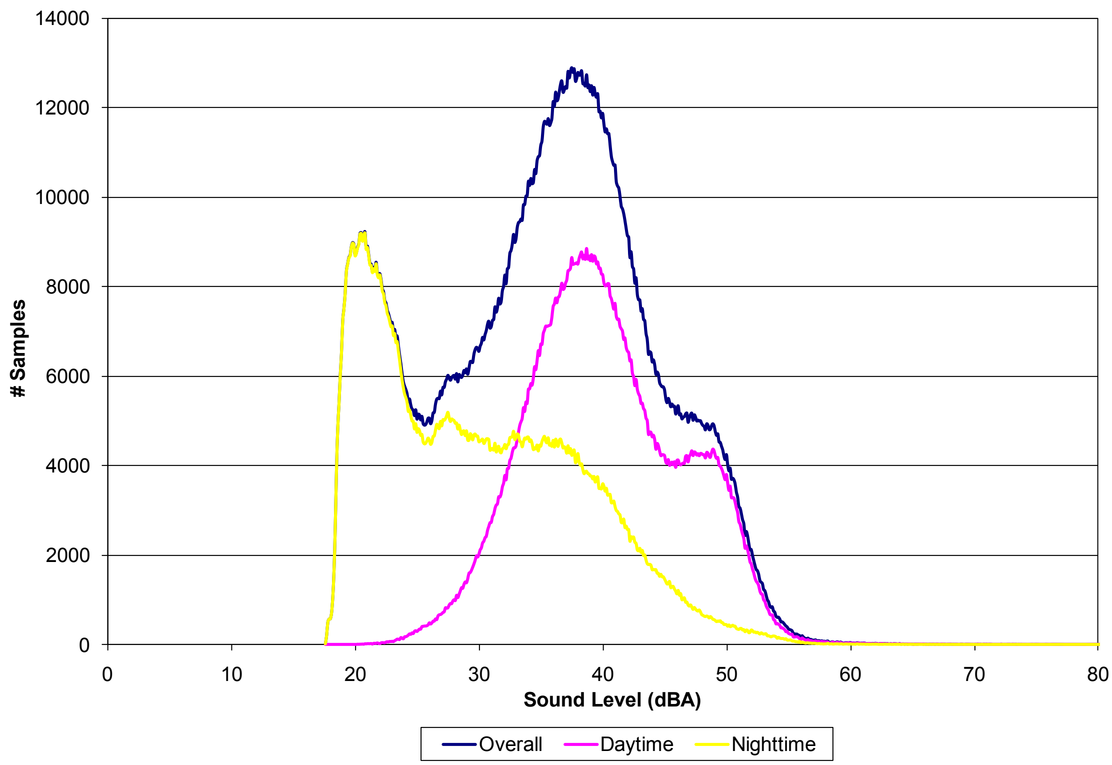

Figure 29. Distribution of data for Site GOGA002 for summer season

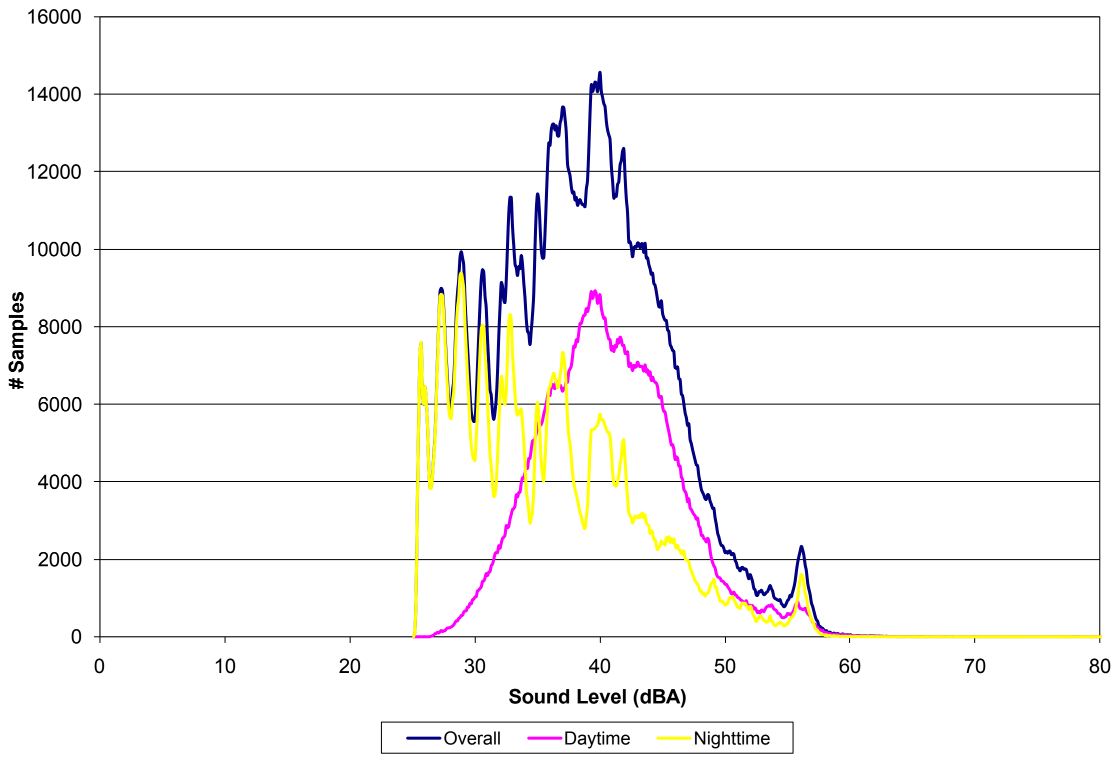

Figure 30. Distribution of data for Site GOGA002 for winter season

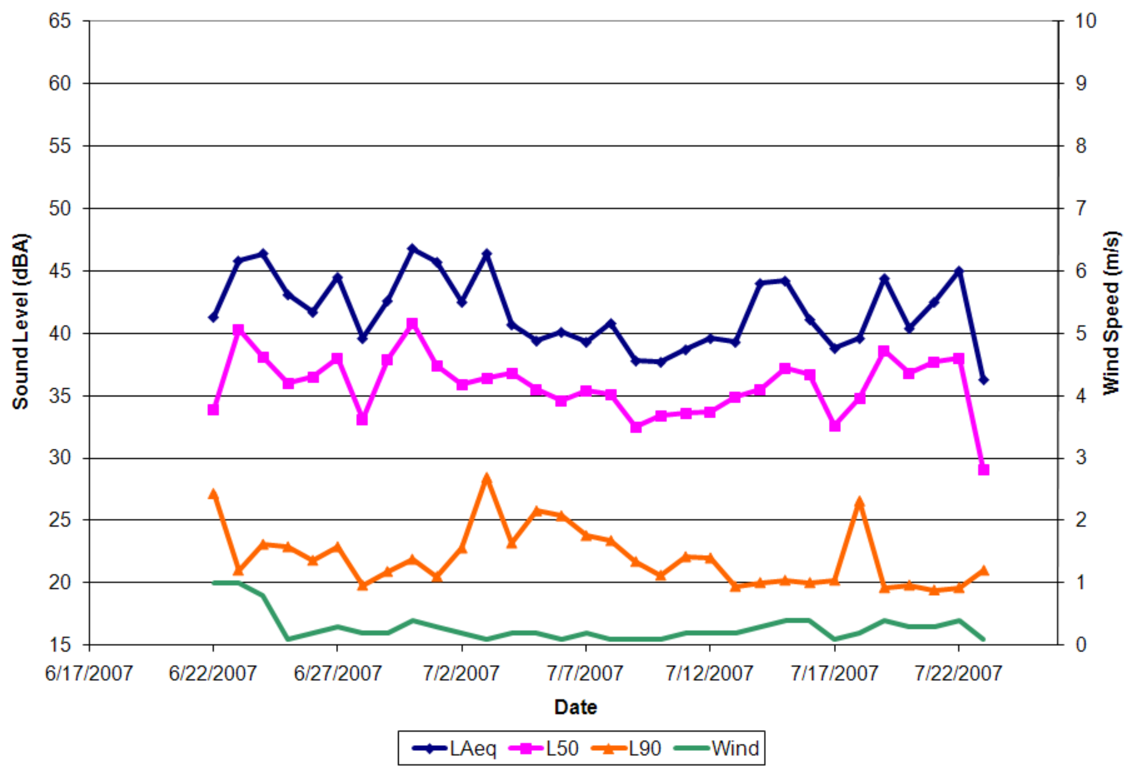

Figure 31. Daily sound levels and wind speeds for Site GOGA002 for summer season

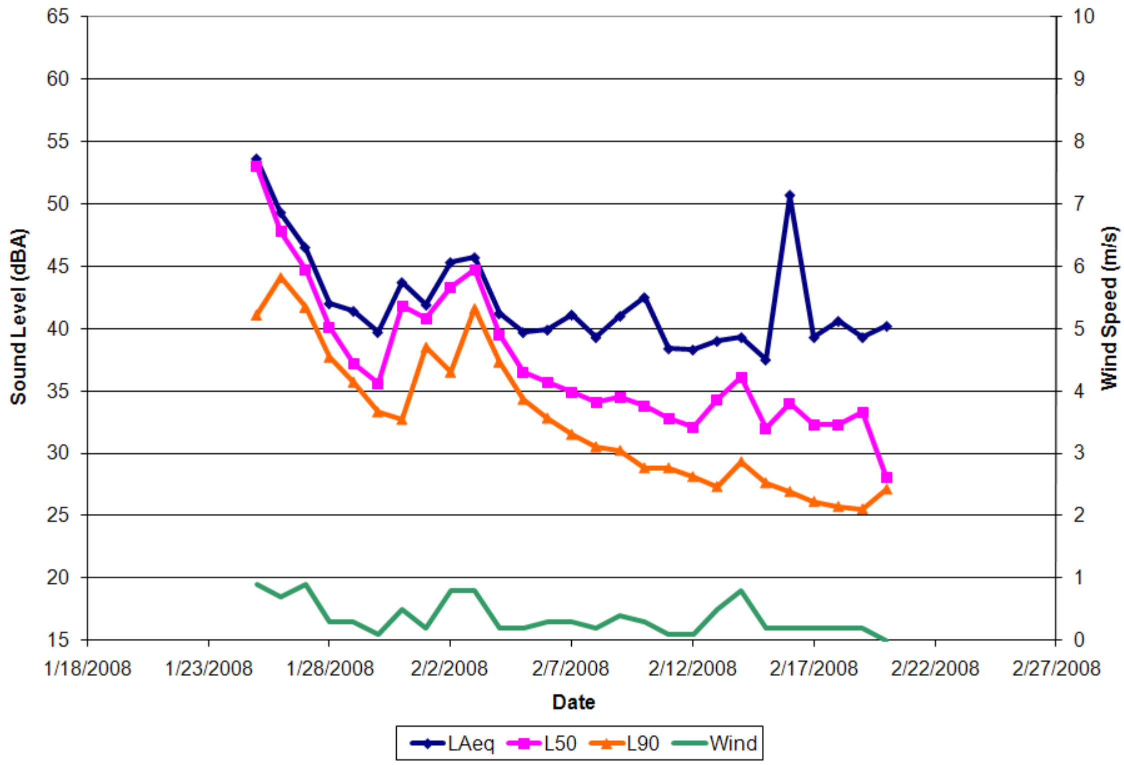

Figure 32. Daily sound levels and wind speeds for Site GOGA002 for winter season

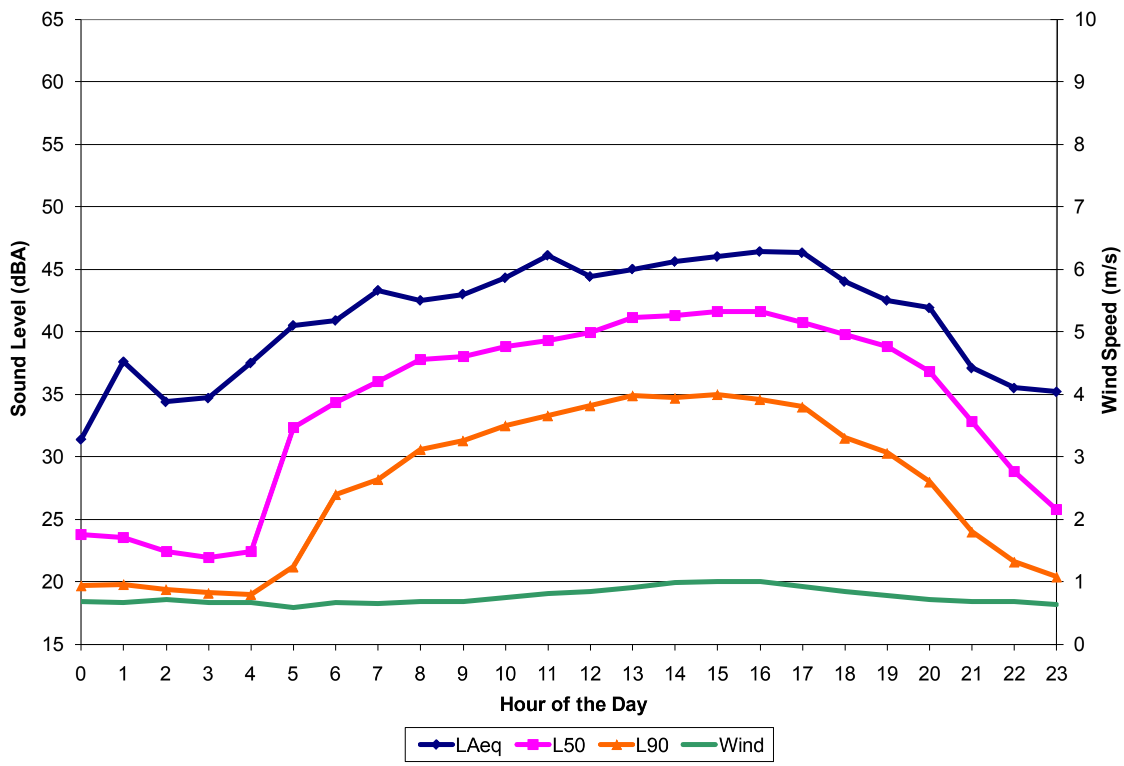

Figure 33. Hourly sound levels and wind speeds for Site GOGA002 for summer season

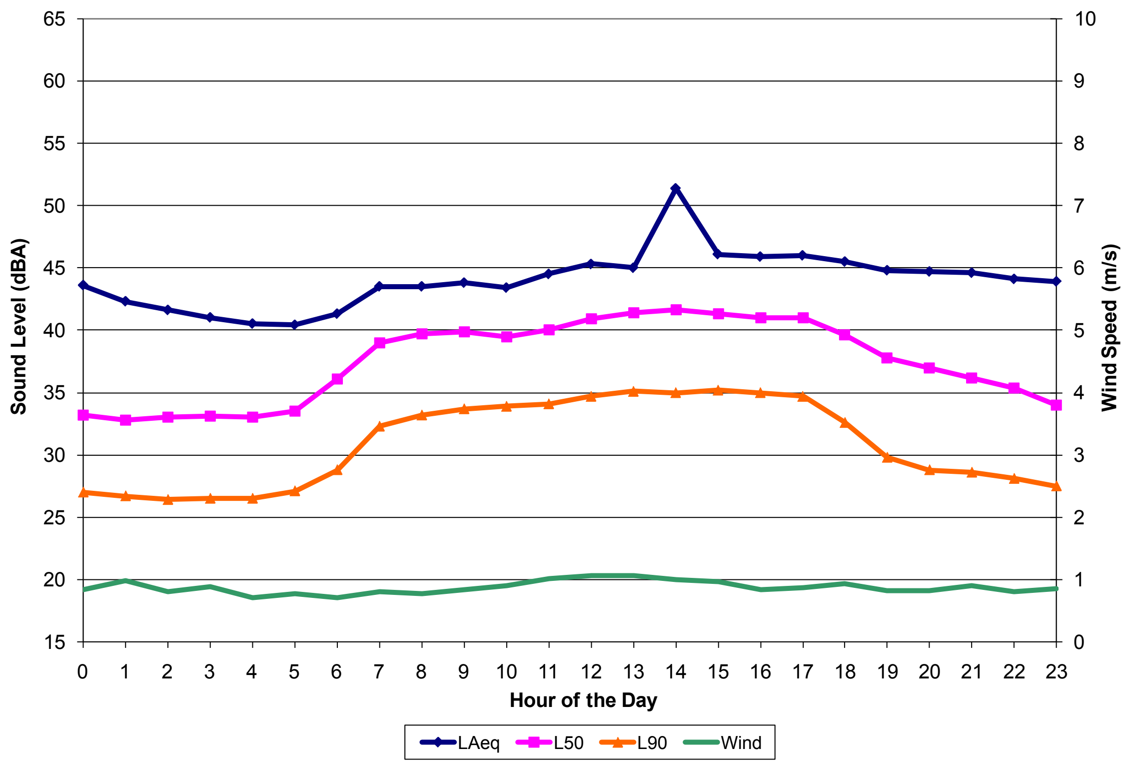

Figure 34. Hourly sound levels and wind speeds for Site GOGA002 for winter season

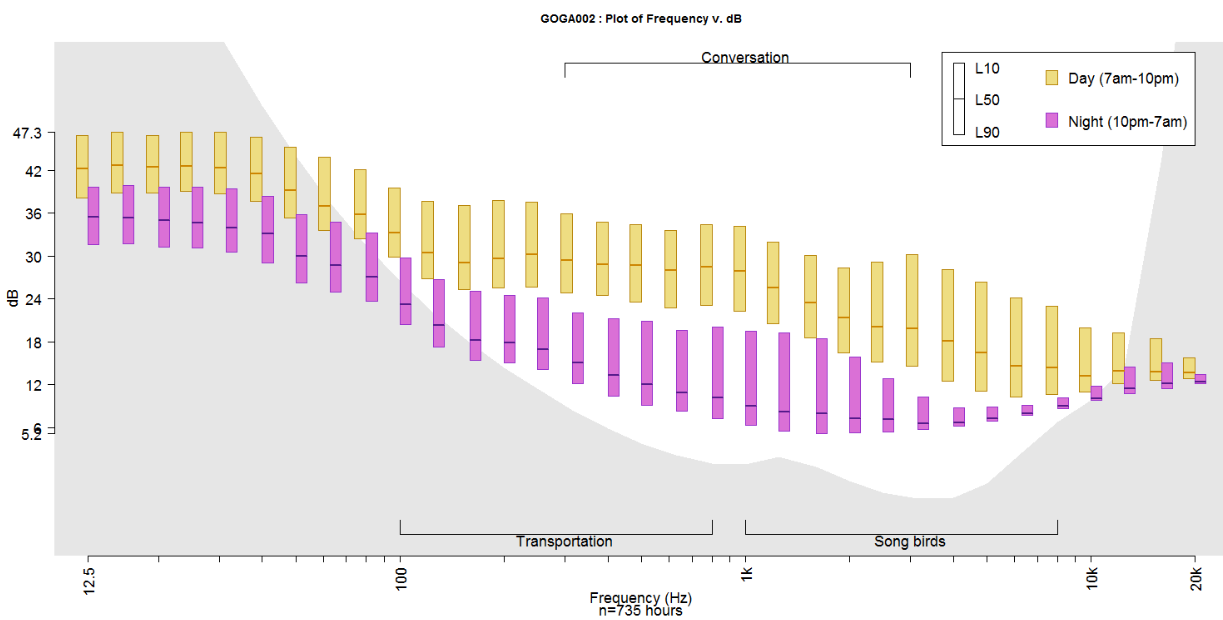

Figure 35. Sound spectrum for GOGA002 for summer season

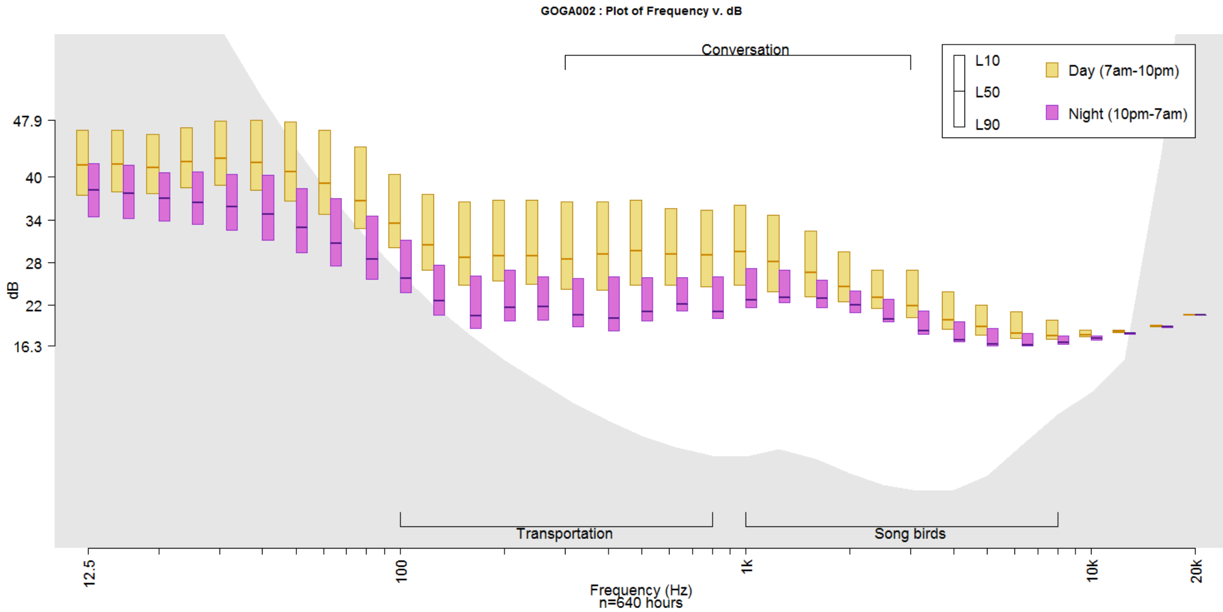

Figure 36. Sound spectrum for GOGA002 for winter season

6.3 Site GOGA003 – Bonita Point

Figure 37. Photograph of Site GOGA003.

Observations

The Bonita Point site was a primarily natural environment, but was subject to occasional watercraft and aircraft sounds for up to 40% of the daytime hours. The site is on a coastal cliff, 50 m (164 ft) from a residential area and 100 m (328 ft) from a trail. The natural sounds audible at this site were surf, birds, and wind during both seasons, with a large increase in rainfall during the winter season. Human sounds included watercraft, jet and fixed-wing aircraft, and sounds related to visitors in the area. The daily L_{50} sound level was approximately 3 dBA higher in the winter than the summer season. A diurnal trend can be seen in the summer season, but not during the winter. Surf and fog horns were audible for much of the day and evening hours for both seasons. Daily sound levels tend to track with wind speed at this site. This was due to wind effects on nearby foliage and was the cause of the consistent and higher sound levels during the winter season.

Observer logs indicated more aircraft in the summer and more noise free periods during the winter. Surf was audible for much of the time during both seasons.

The sound spectra at GOGA003 are similar from summer to winter; the daytime and night time spectra and sound levels are similar, indicating a constant source of sound in the area (surf and wind).

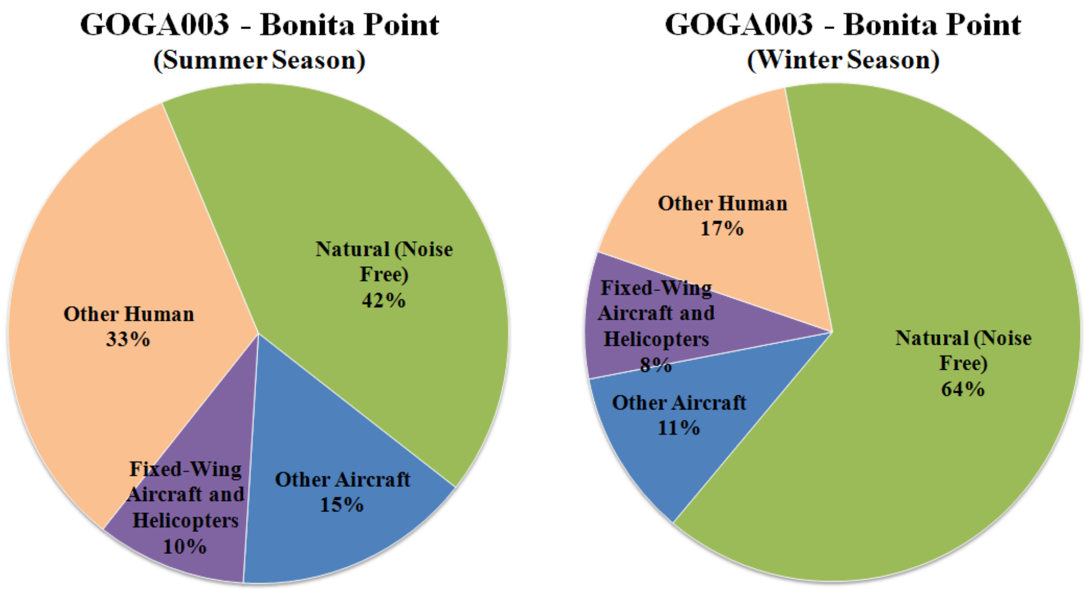

Figure 38. Distribution of sound sources audible (in situ and office listening combined) for Site GOGA003 for summer and winter seasons

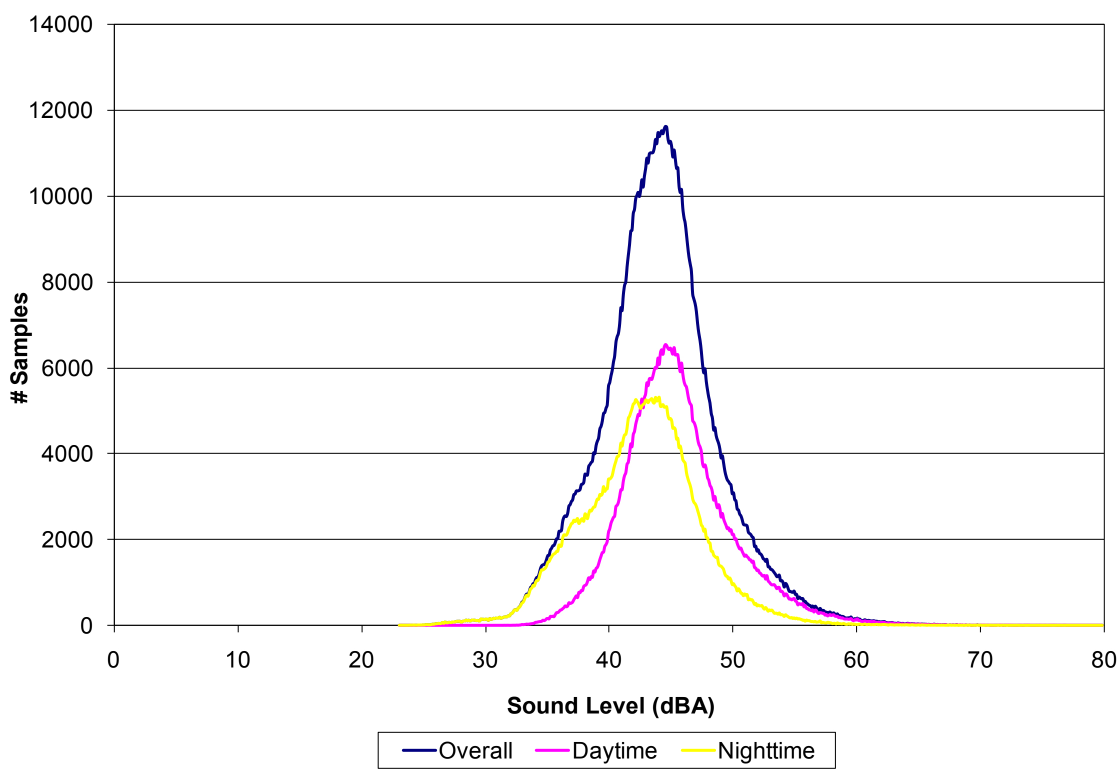

Figure 39. Distribution of data for Site GOGA003 for summer season

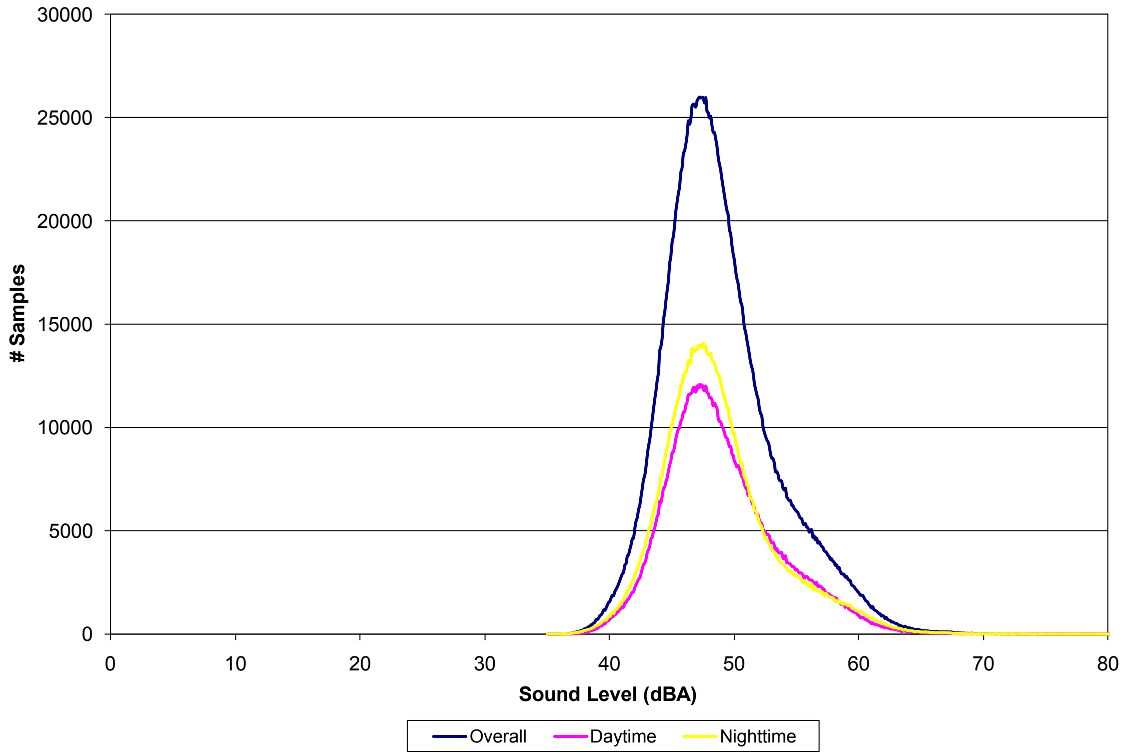

Figure 40. Distribution of data for Site GOGA003 for winter season

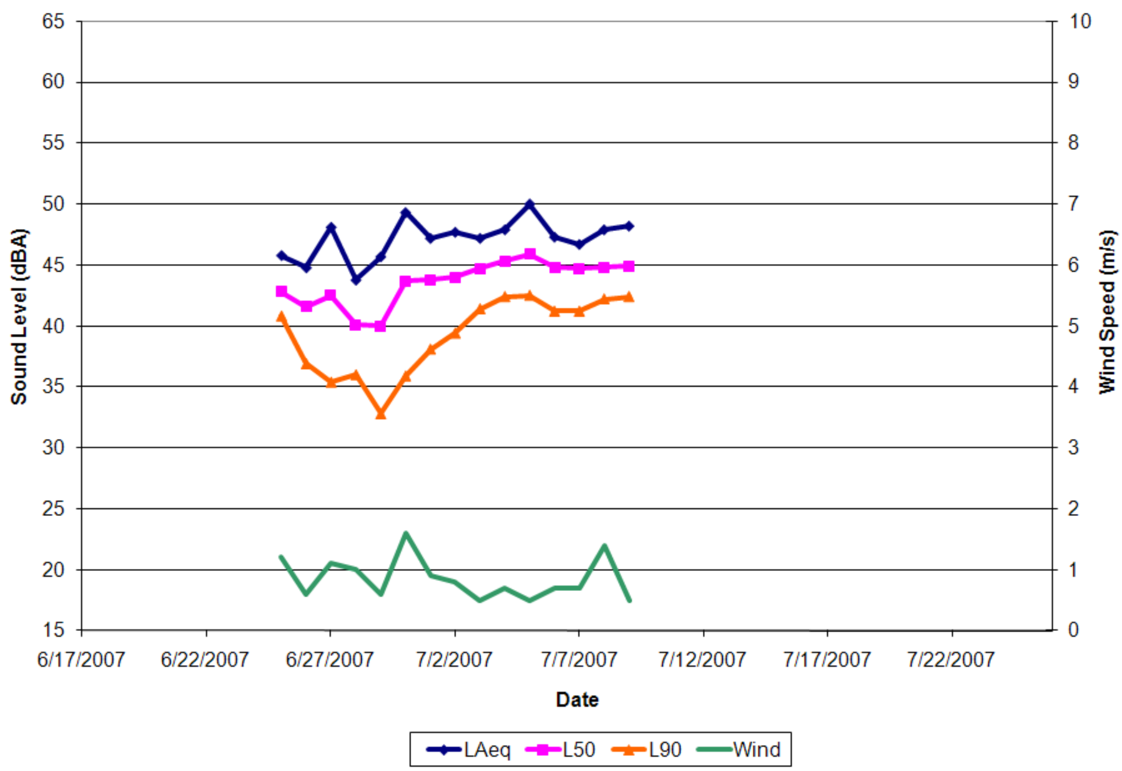

Figure 41. Daily sound levels and wind speeds for Site GOGA003 for summer season

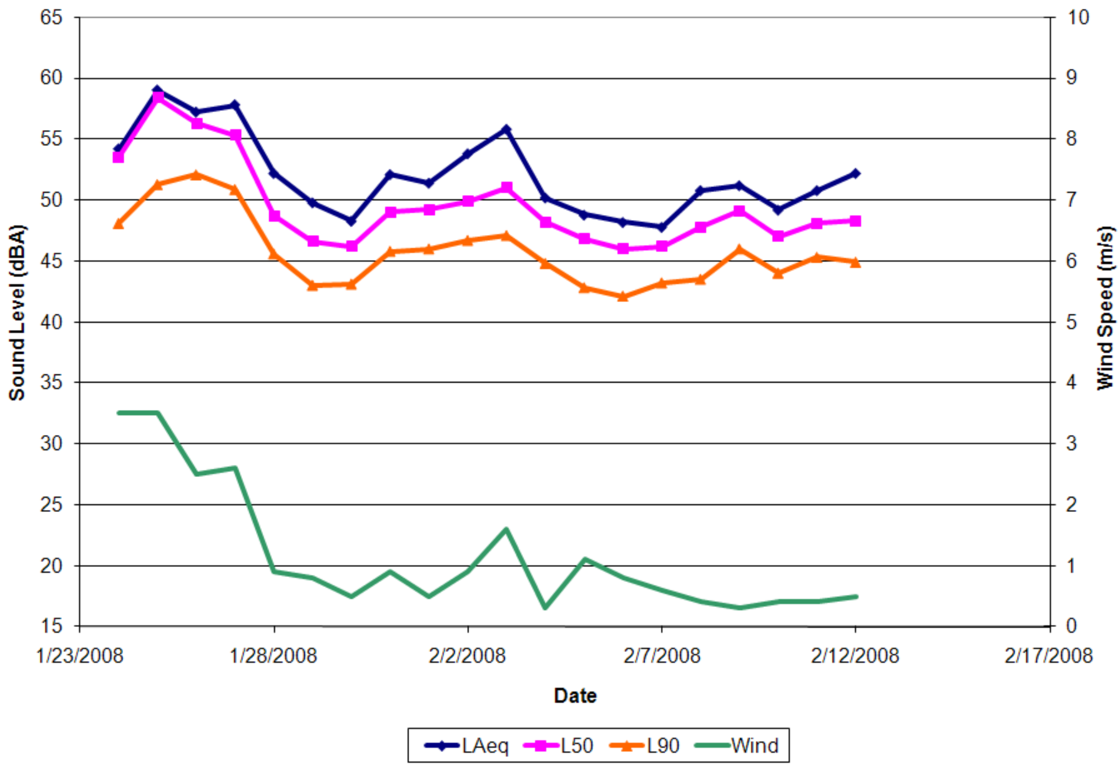

Figure 42. Daily sound levels and wind speeds for Site GOGA003 for winter season

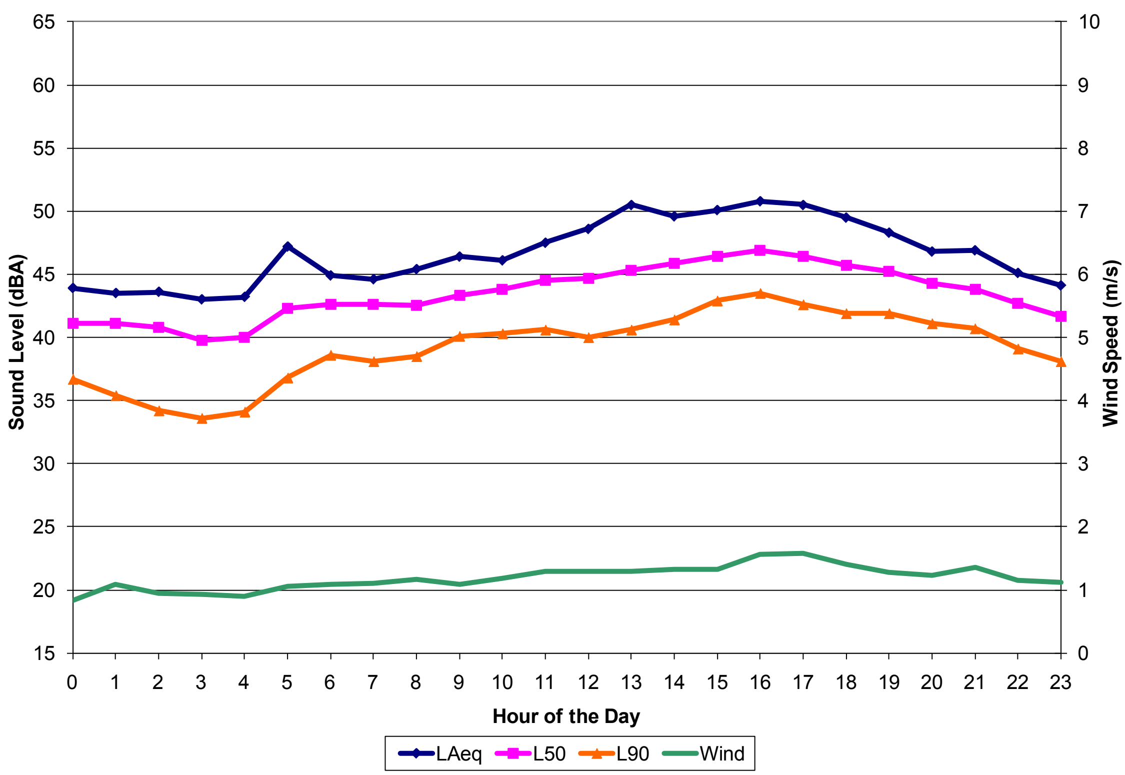

Figure 43. Hourly sound levels and wind speeds for Site GOGA003 for summer season

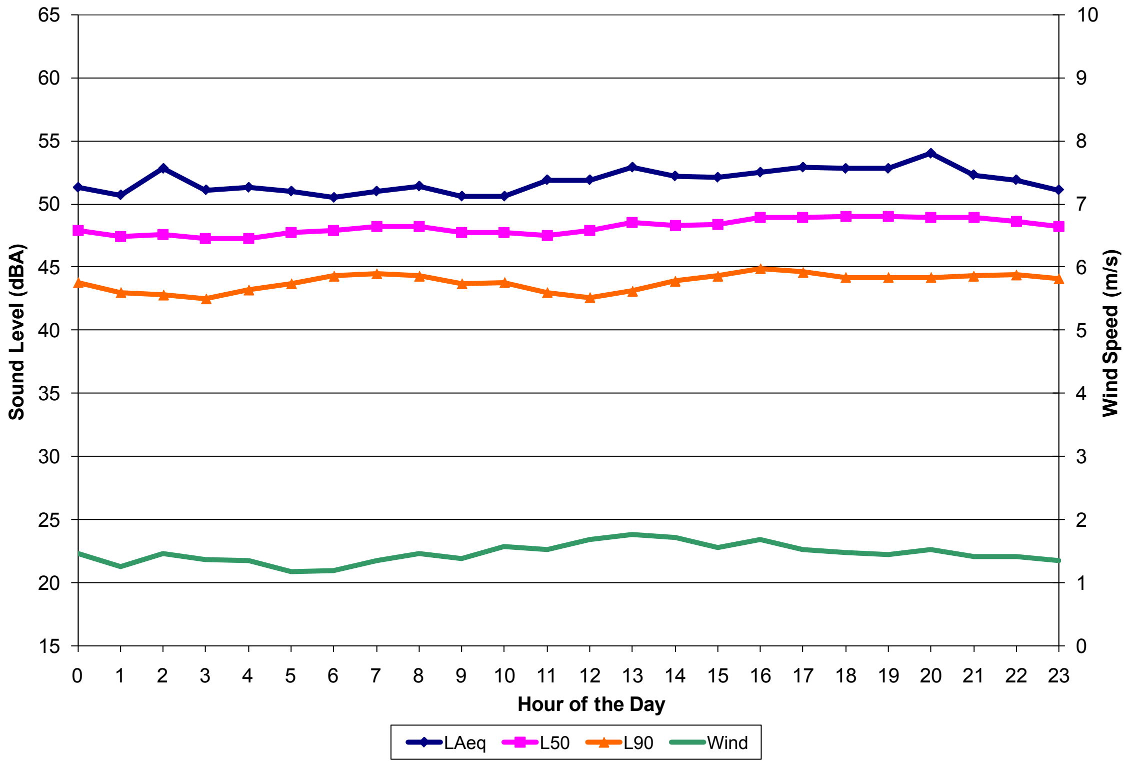

Figure 44. Hourly sound levels and wind speeds for Site GOGA003 for winter season

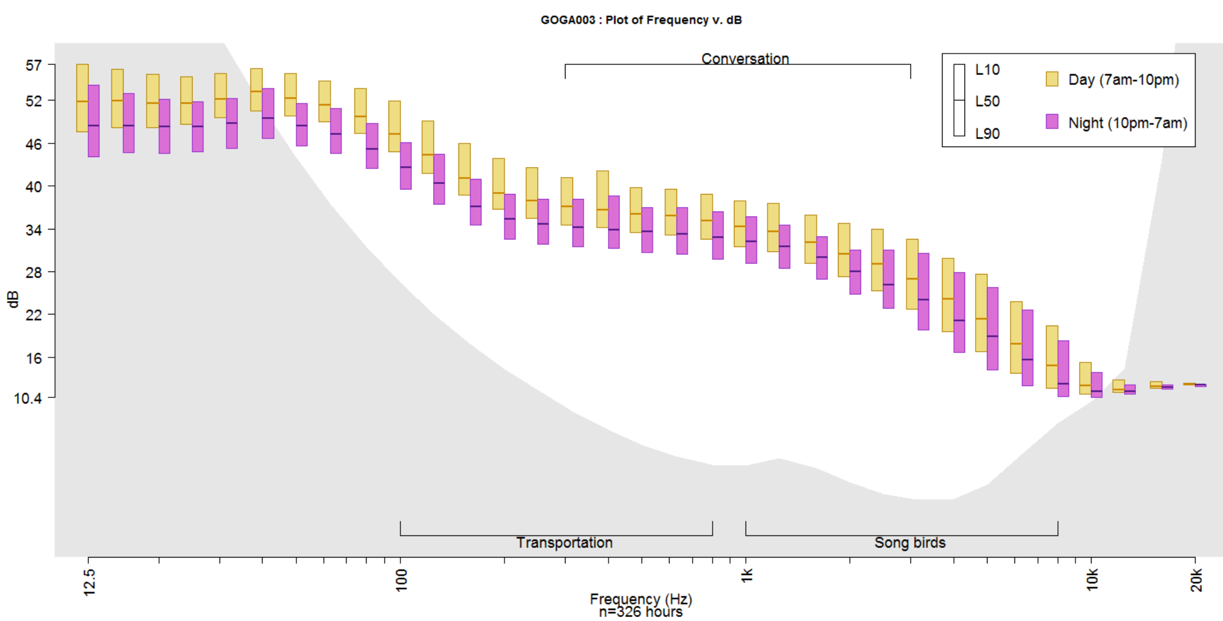

Figure 45. Sound spectrum for GOGA003 for summer season

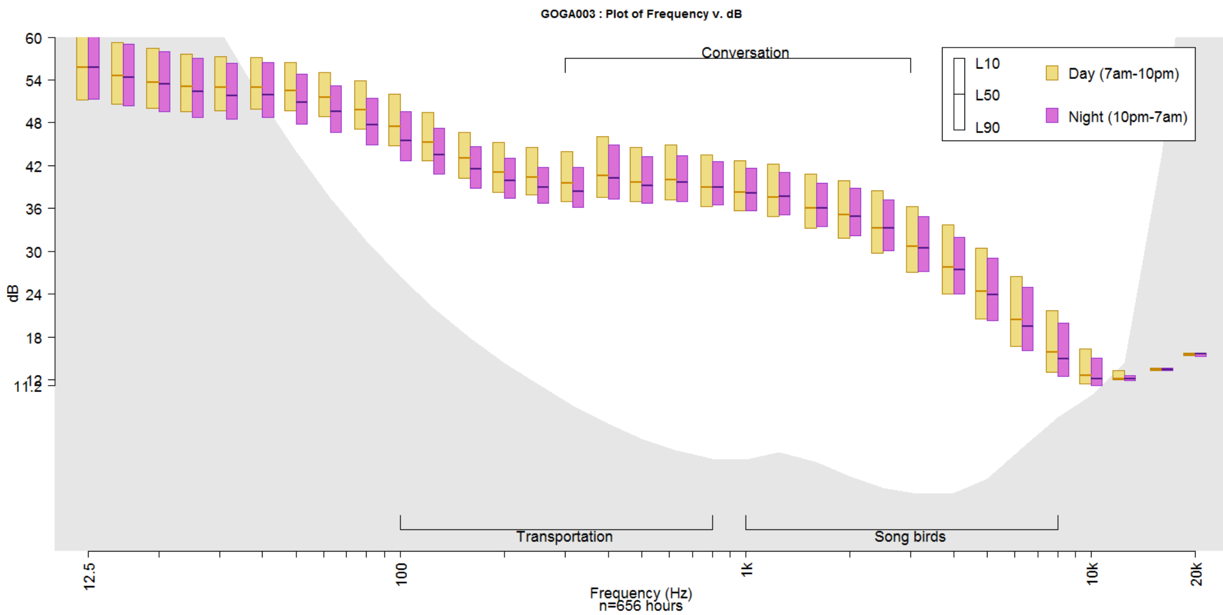

Figure 46. Sound spectrum for GOGA003 for winter season

6.4 Site GOGA004 – Alcatraz Water Tower

Figure 47. Photograph of Site GOGA004.

Observations

This site is located on the east side of Alcatraz Island near the water tower and was subject to a wide variety of sounds that included natural (birds and wind), aircraft (jets, fixed-wing and helicopter), watercraft, waterfront sounds (buoy bell, ship horns), some construction activity on the island, and visitor-related. The site experienced a general diurnal trend during both seasons where sound levels rose during the day and diminished in the evening. The site was approximately 4 dBA louder (daytime L_{50}) during the summer compared to the winter season. The reasons for the louder acoustic conditions in the summer appear to be human activity (visitor and ferries) in and around this area. The summer sound levels were louder than winter even though construction noise was present in the winter season. The summer daily sound levels are very consistent from day to day, whereas winter daily sound levels are more erratic, most likely due to the construction activity near the site in the winter.

More aircraft sounds were audible in the summer than in the winter (30% versus 19%). The types of sounds were fairly consistent, but with more rain during the winter.

The summer spectra for GOGA004 show additional tones in the frequency range of 1 kHz to 5 kHz that are not present in the winter data. These frequency bands are typically associated with birds. There is a 400 Hz tone during the summer season that is related to ship horns in the bay that were much more audible during summer than winter.

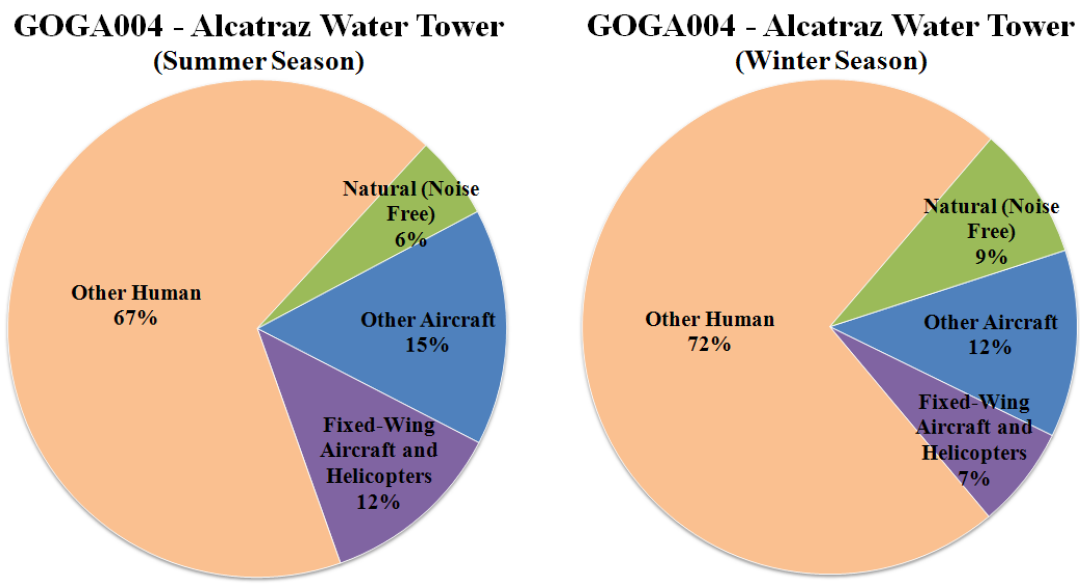

Figure 48. Distribution of sound sources audible (in situ and office listening combined) for Site GOGA004 for summer and winter seasons

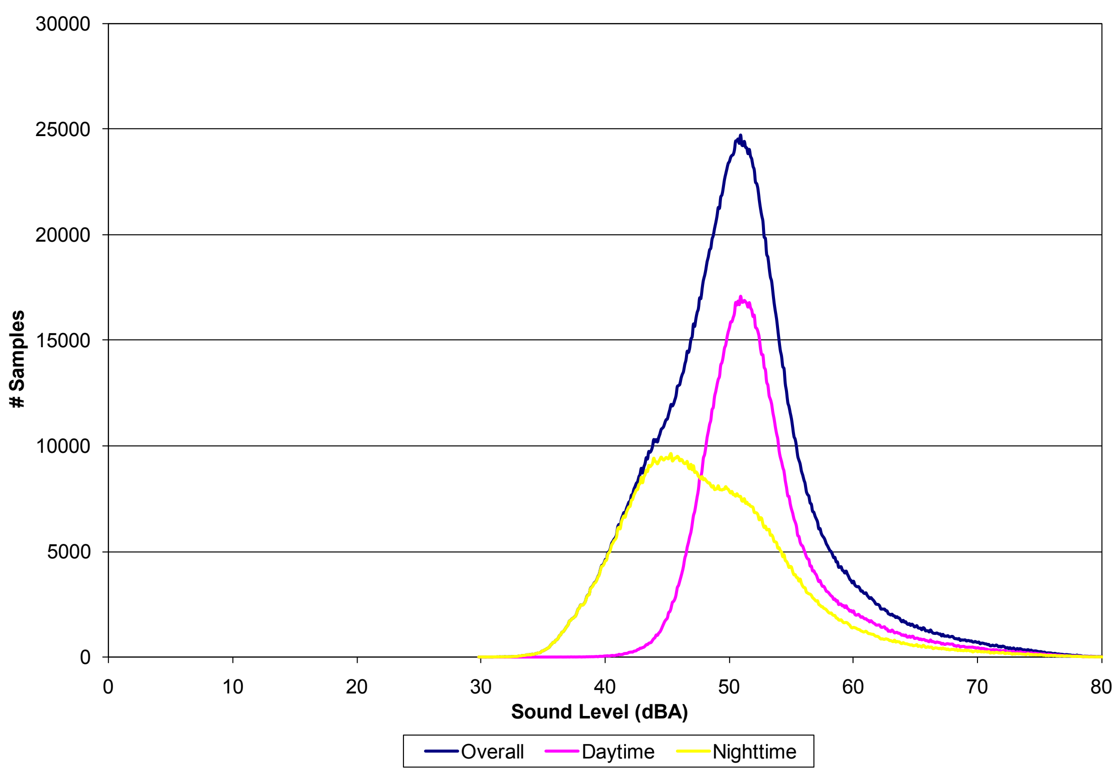

Figure 49. Distribution of data for Site GOGA004 for summer season

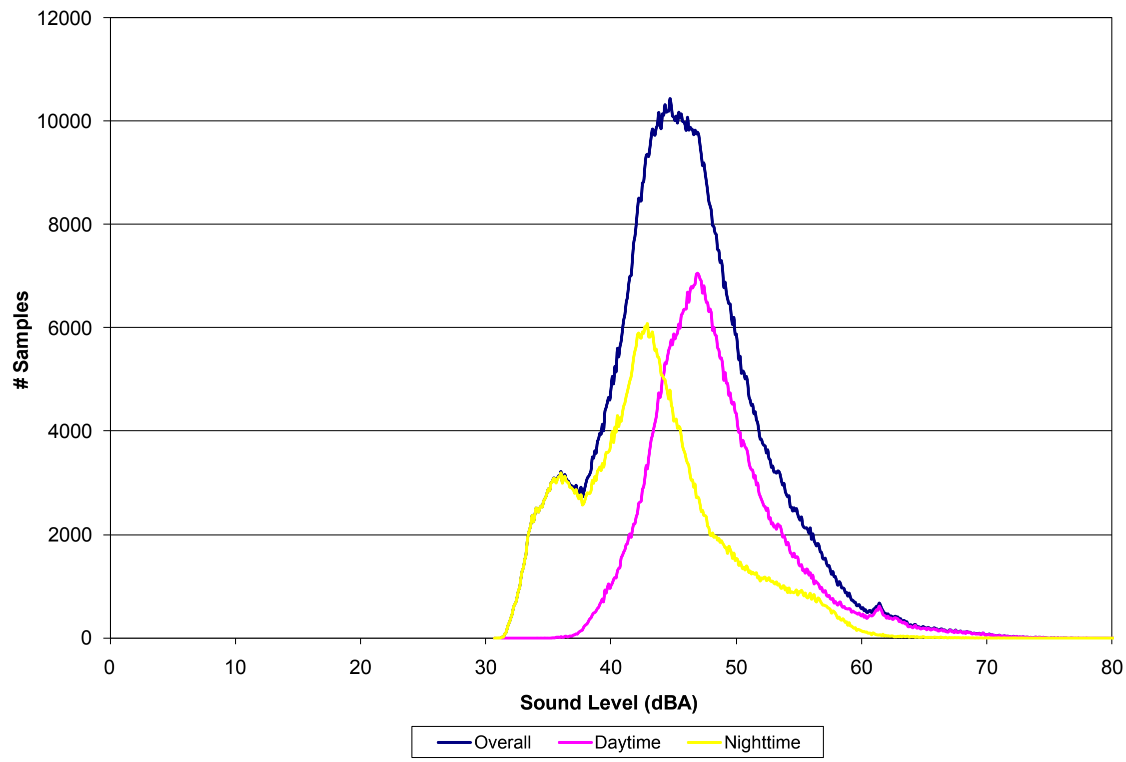

Figure 50. Distribution of data for Site GOGA004 for winter season

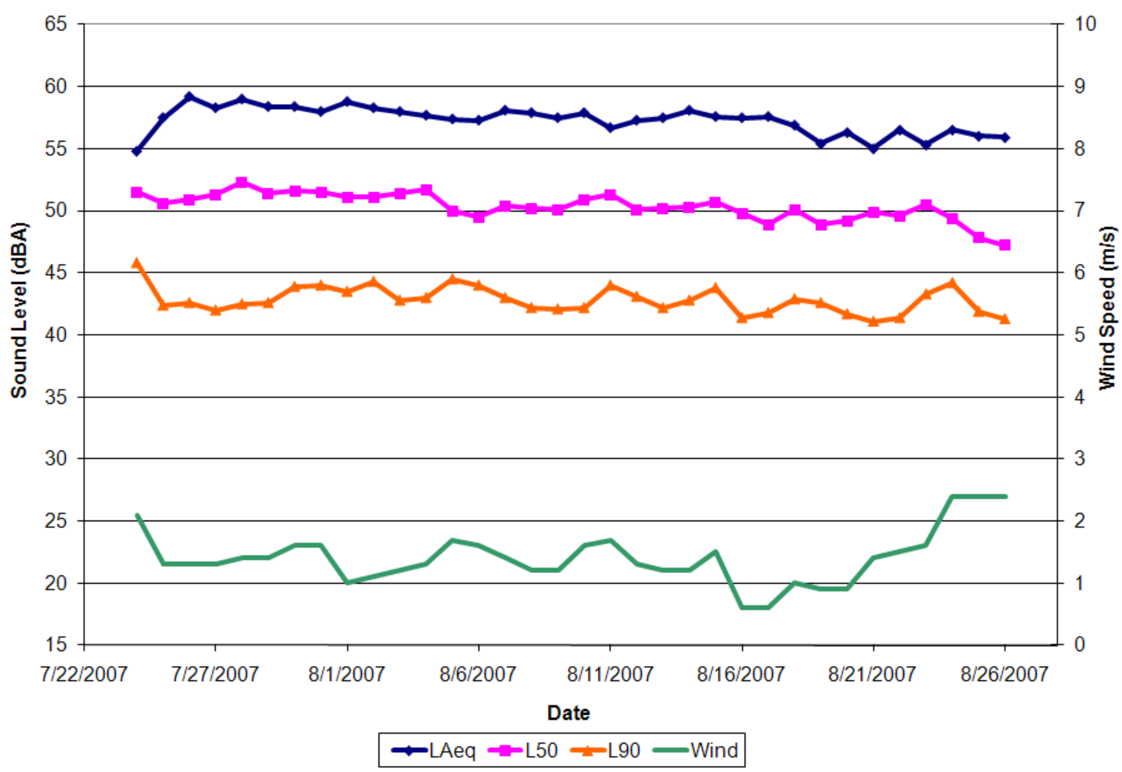

Figure 51. Daily sound levels and wind speeds for Site GOGA004 for summer season

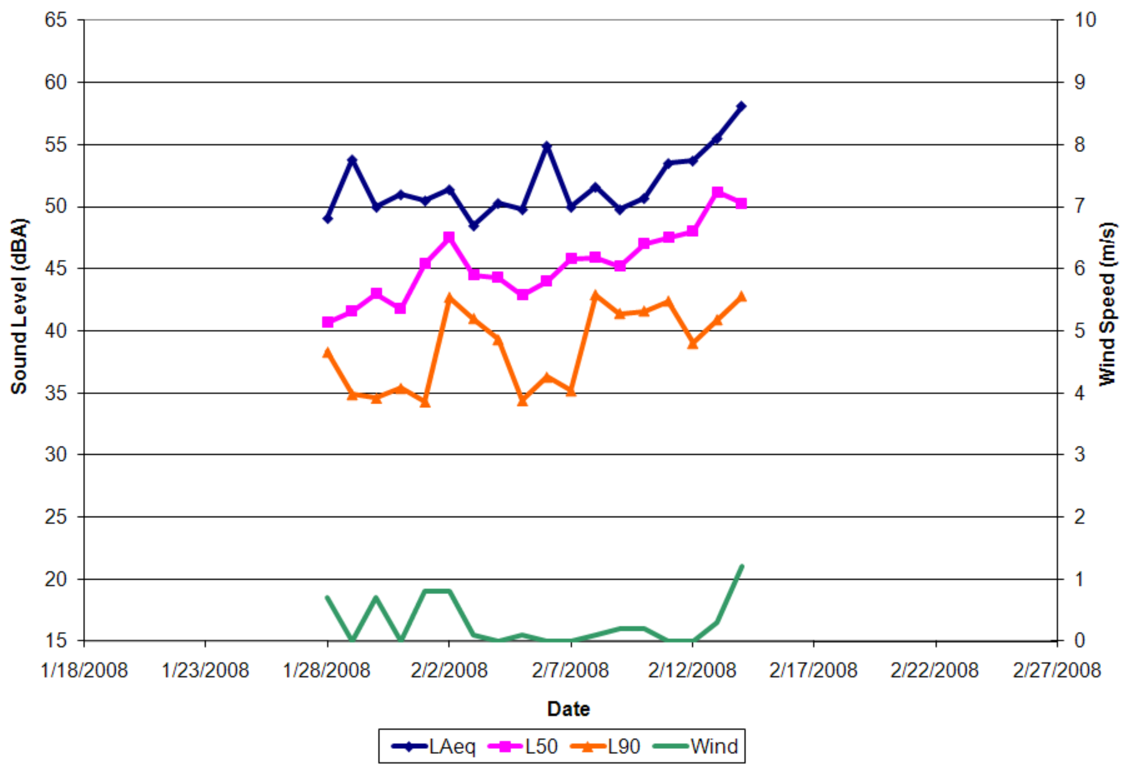

Figure 52. Daily sound levels and wind speeds for Site GOGA004 for winter season

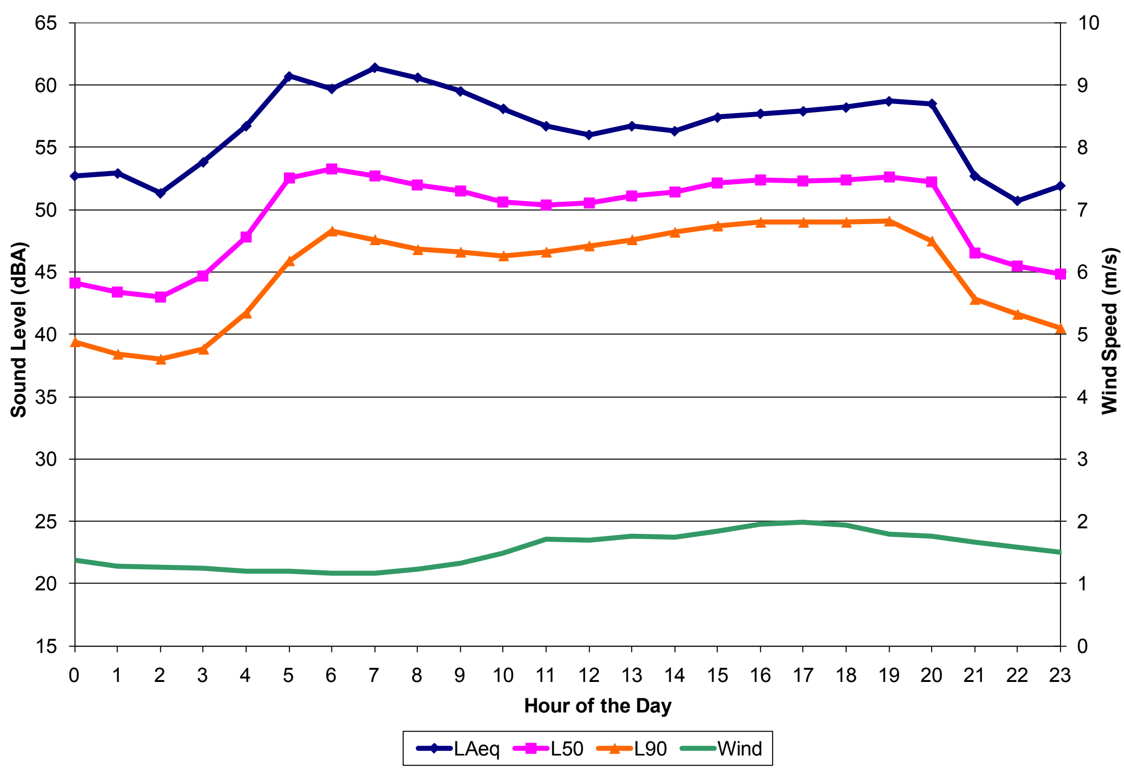

Figure 53. Hourly sound levels and wind speeds for Site GOGA004 for summer season

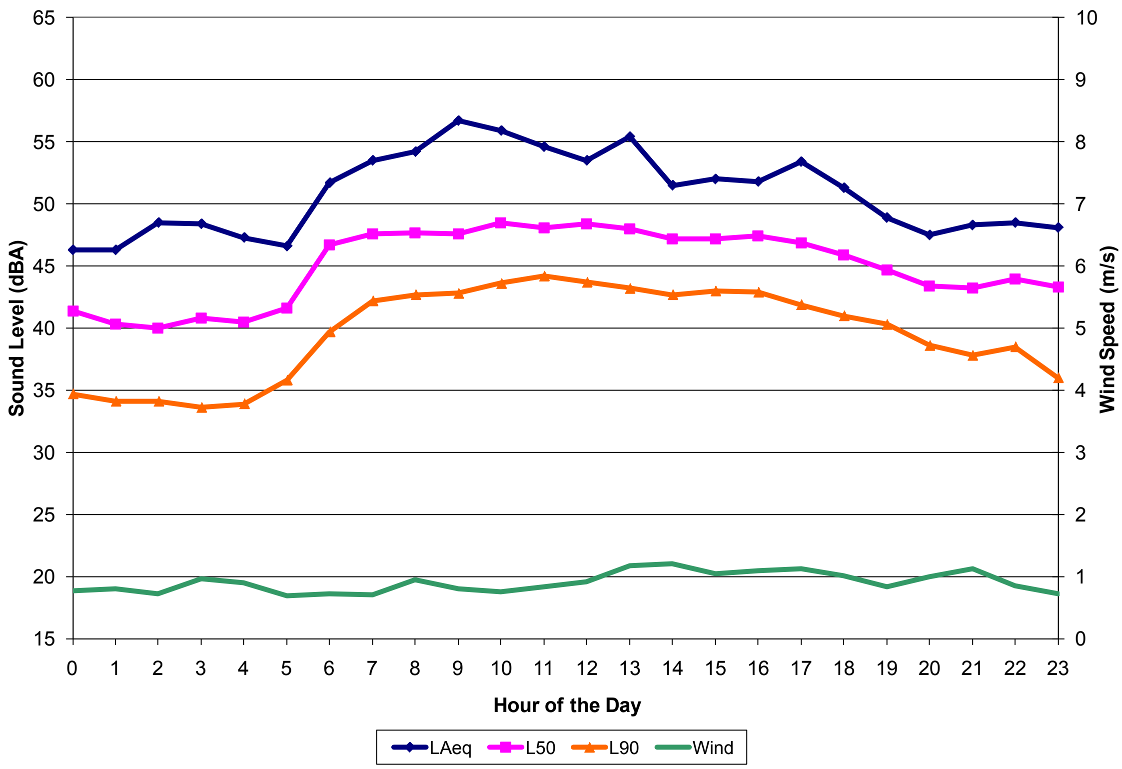

Figure 54. Hourly sound levels and wind speeds for Site GOGA004 for winter season

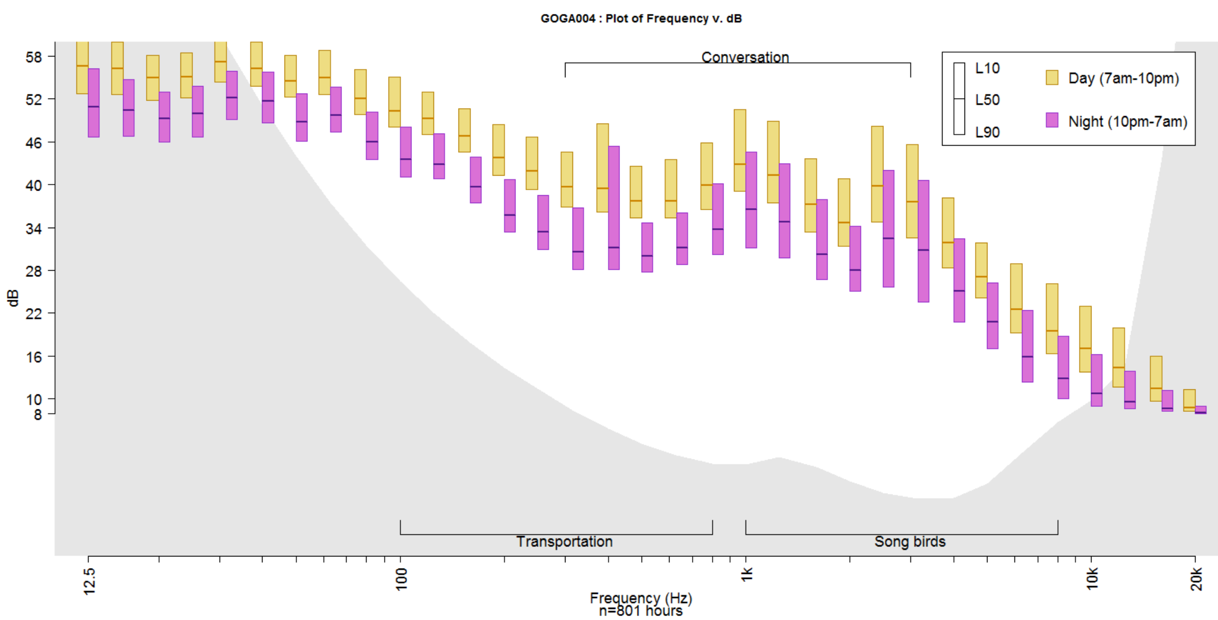

Figure 55. Sound spectrum for GOGA004 for summer season

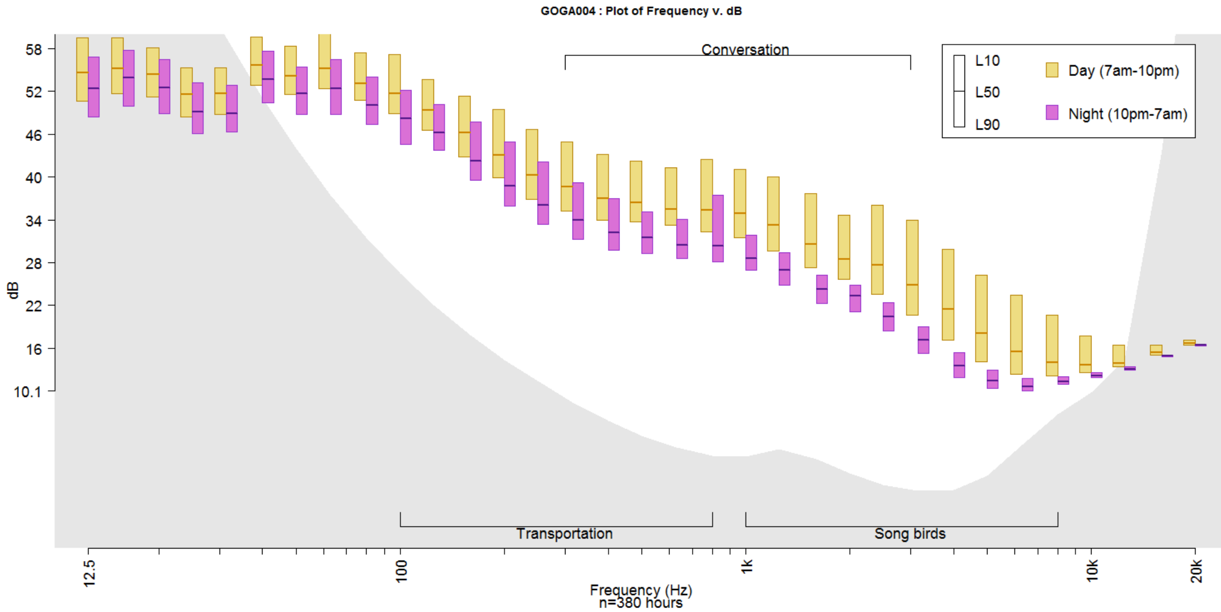

Figure 56. Sound spectrum for GOGA004 for winter season

6.5 Site GOGA005 – Crissy Marsh Field

Figure 57. Photograph of Site GOGA005.

Observations

This site was located approximately 34 m (112 ft) from a well-traveled road (Mason Street) and approximately 109 m (358 ft) from Highway 101, a busy highway. This area is a coastal marsh in the vicinity of an urban area. The acoustic observer logged vehicle sounds in almost all samples every day with very little noise-free daytime periods. Fog horns from the Golden Gate Bridge could be heard on most days. People and dogs could be heard occasionally on the walking/biking path next to Mason Street. Very few aircraft were audible at this location. Wind and birds were the dominant natural sounds.

The sound levels at this site were consistent from season to season (55.4 dBA summer L_{50} and 55.0 dBA winter L_{50}). A diurnal trend was evident for both seasons with louder sound levels during the day and quieter at night. The winter season also exhibited several windy days, whereas the summer season experienced generally light winds.

The sound spectra are very similar from summer to winter seasons for GOGA005. The influence of roadway traffic is the primary reason for this trend. The summer spectra also contain additional content in 7 kHz to 10 kHz range, which is normally due to insect activity.

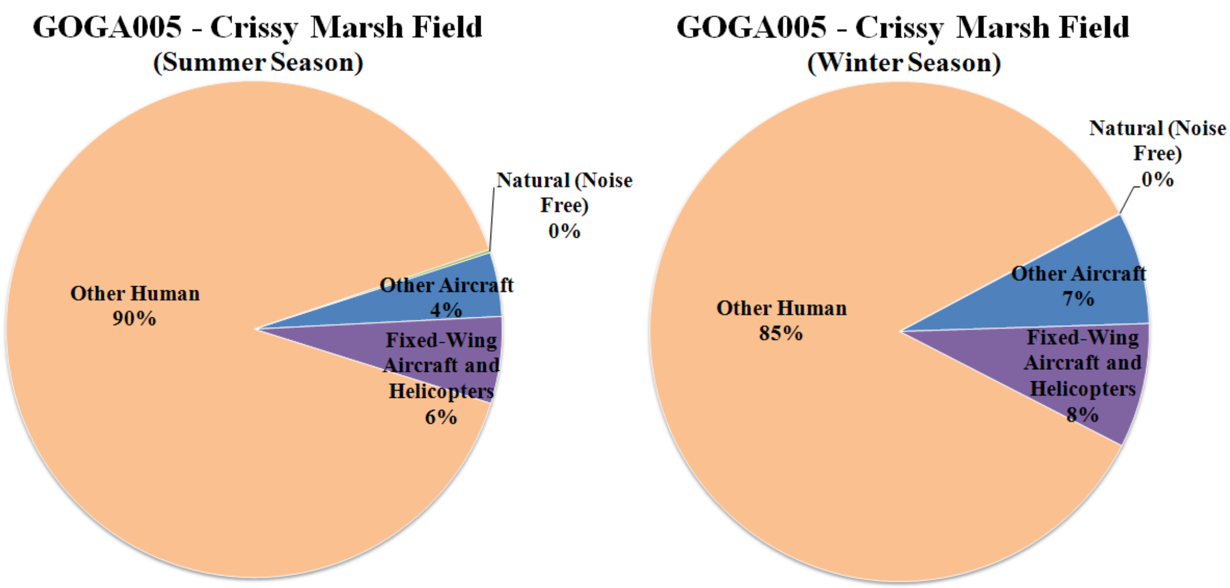

Figure 58. Distribution of sound sources audible (in situ and office listening combined) for Site GOGA005 for summer and winter seasons

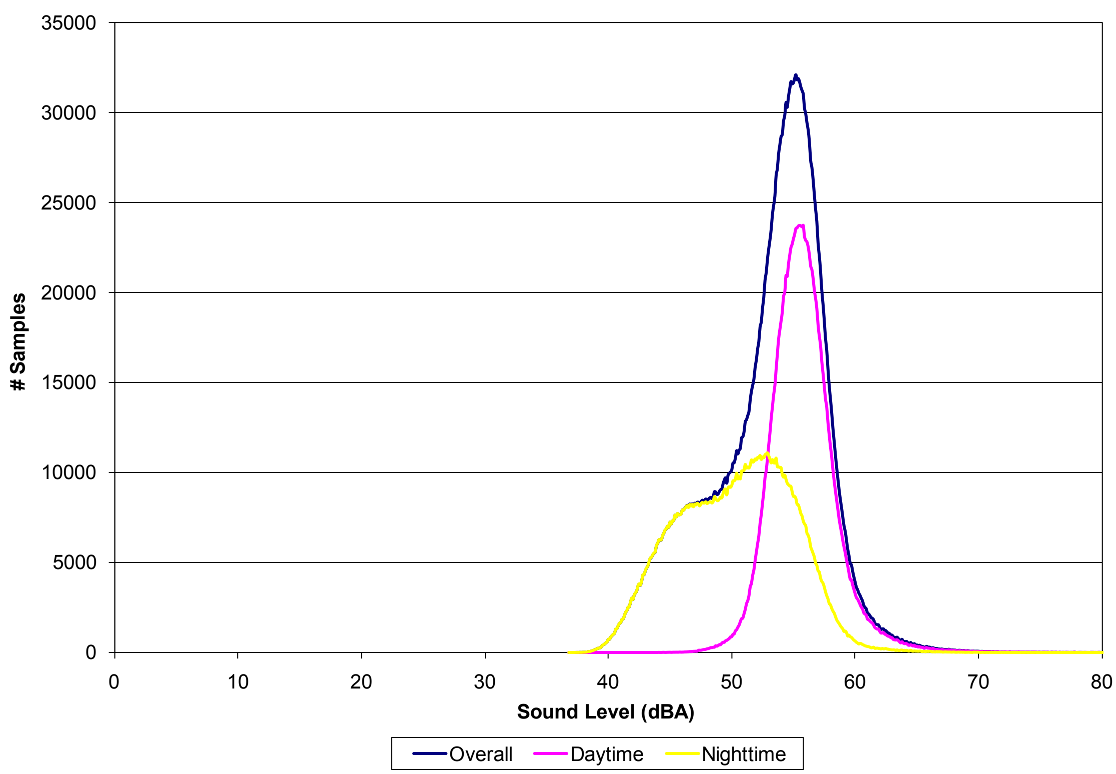

Figure 59. Distribution of data for Site GOGA005 for summer season

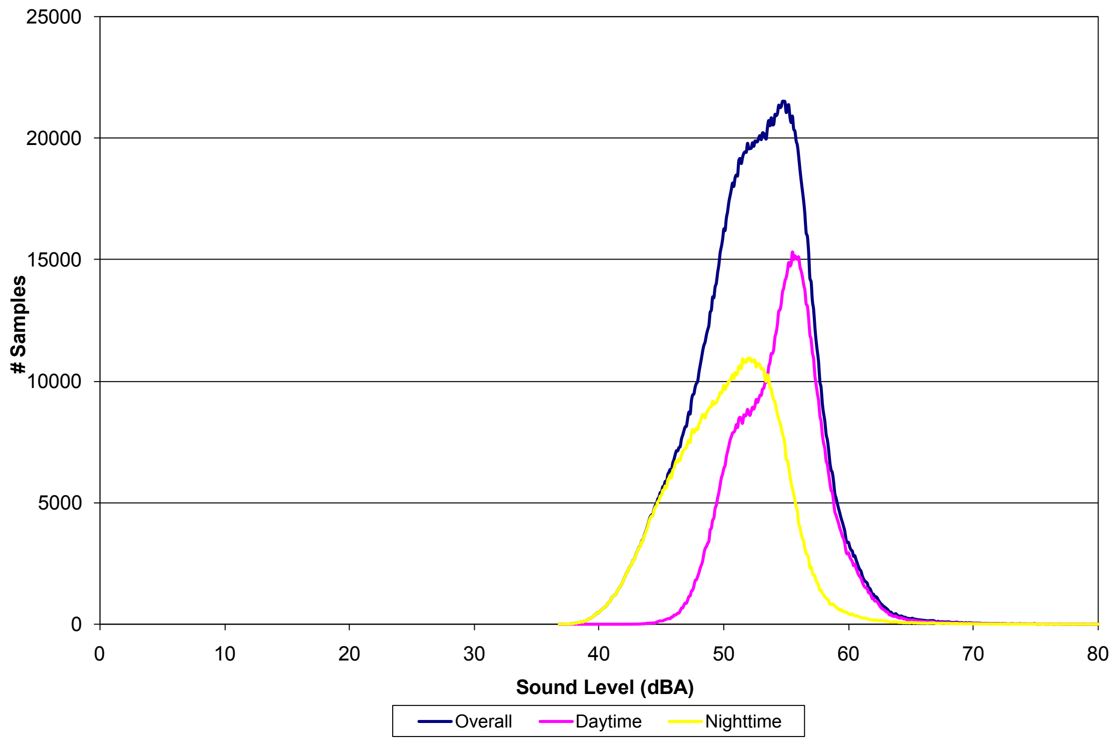

Figure 60. Distribution of data for Site GOGA005 for winter season

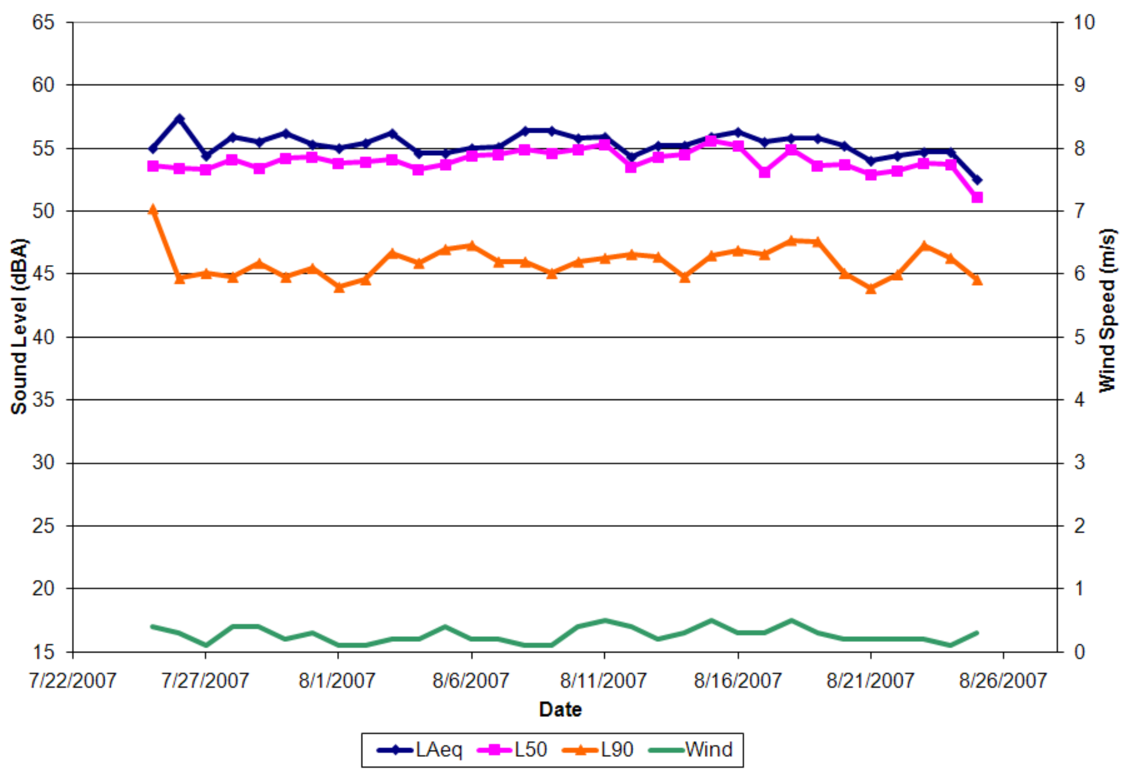

Figure 61. Daily sound levels and wind speeds for Site GOGA005 for summer season

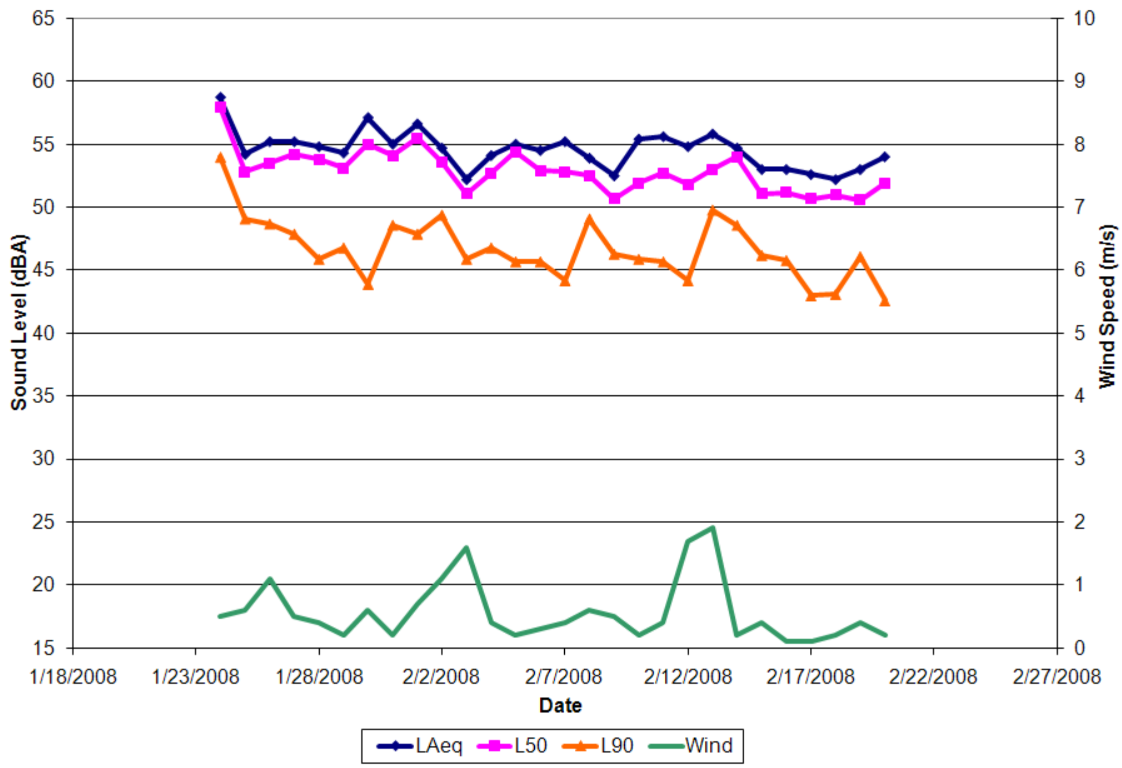

Figure 62. Daily sound levels and wind speeds for Site GOGA005 for winter season

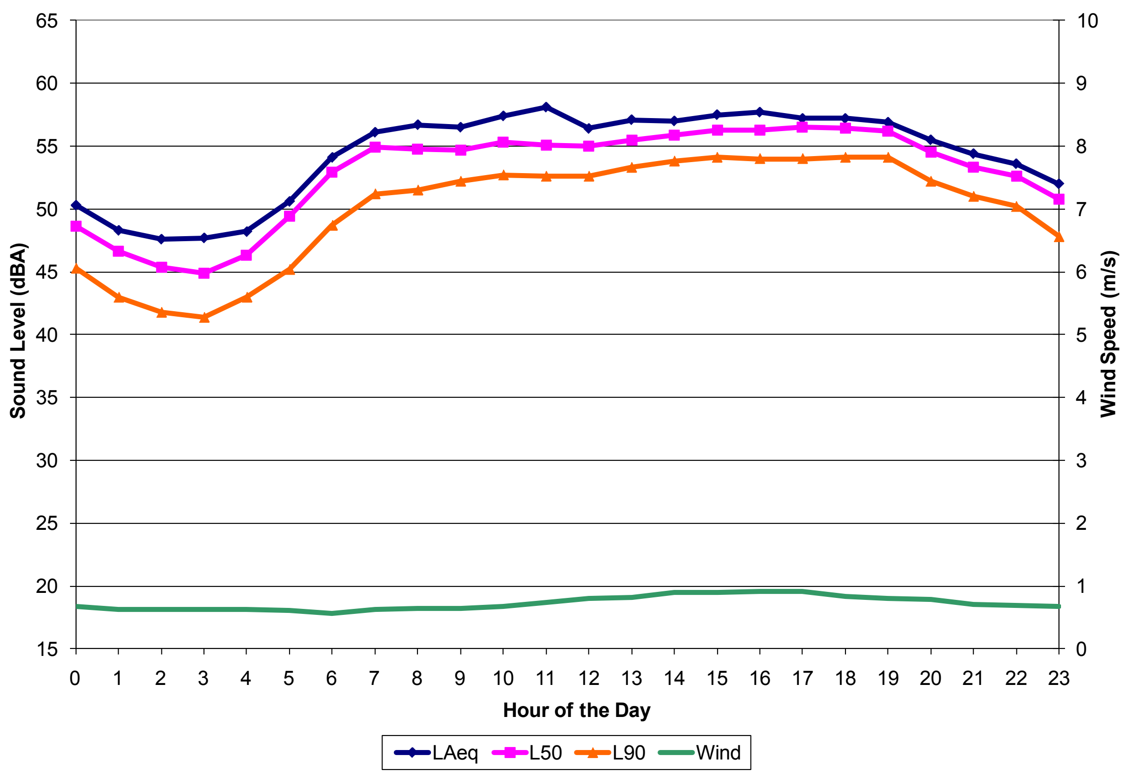

Figure 63. Hourly sound levels and wind speeds for Site GOGA005 for summer season

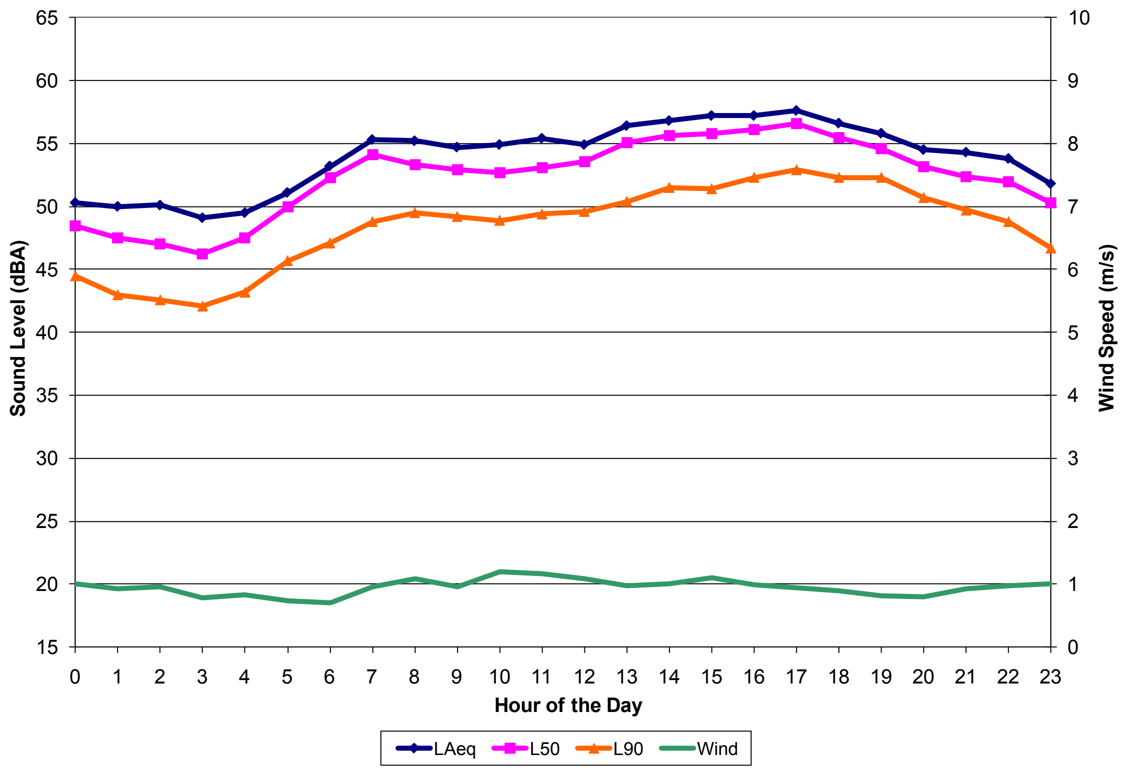

Figure 64. Hourly sound levels and wind speeds for Site GOGA005 for winter season

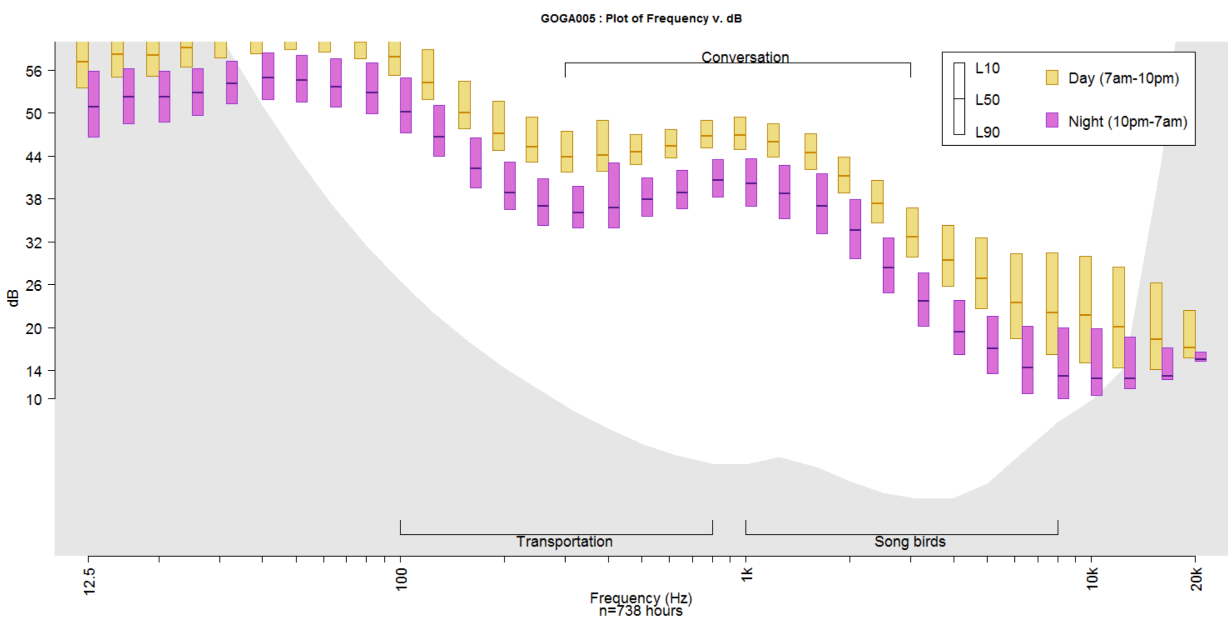

Figure 65. Sound spectrum for GOGA005 for summer season

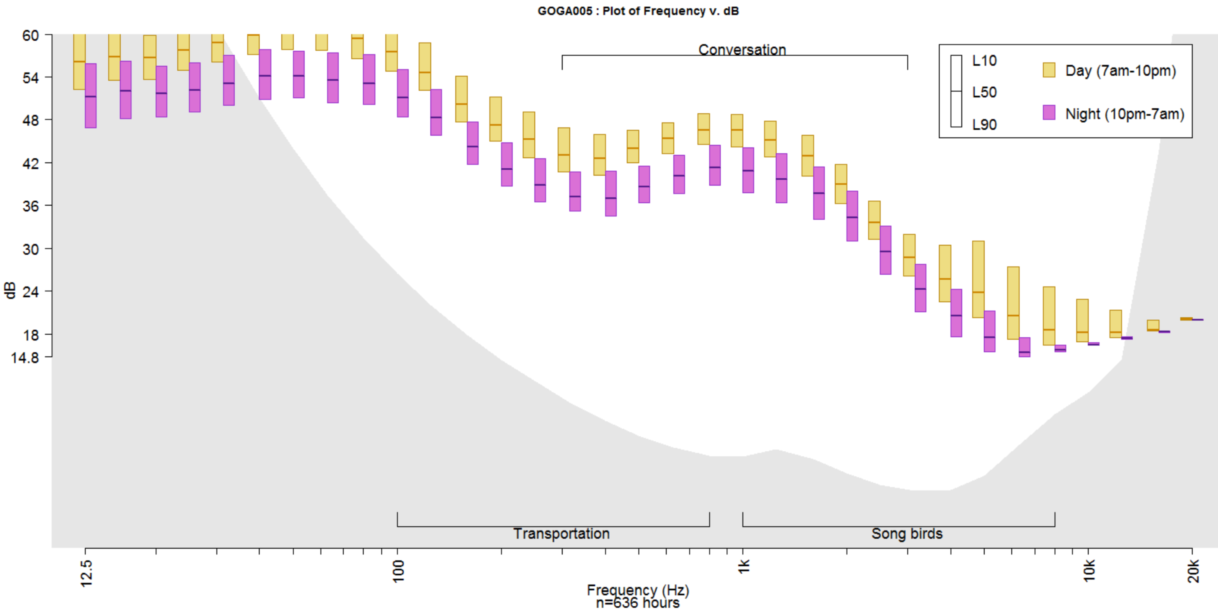

Figure 66. Sound spectrum for GOGA005 for winter season

6.6 Site GOGA006 – Milagra Ridge

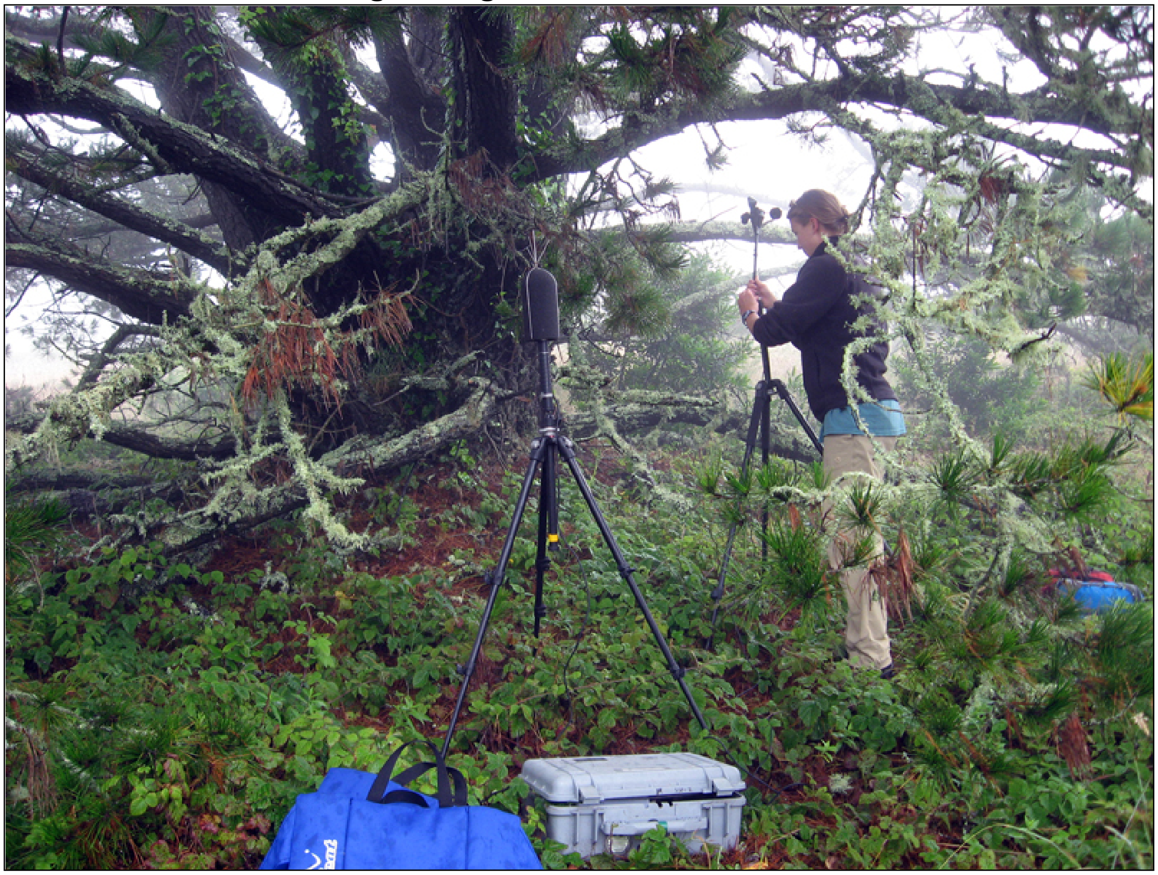

Figure 67. Photograph of Site GOGA006.

Observations

This site is located in an area surrounded by urban residential housing. The site experienced mainly natural sounds including birds and wind related sounds. This area is accessible to the public and is used by people to walk their dogs and other activities. The sound levels were consistent from winter to summer seasons (47.5 dBA and 46.4 dBA L_{50}, respectively). Winds were stronger during the winter season, which have a direct correlation with increasing sound levels. A diurnal trend existed at this site resulting from the human activity in the area.

Audible sources were consistent from summer to winter with a large amount of jet aircraft noise at this site. Aircraft is noticeable in this area, especially jet aircraft. Not surprising, as the site is located on the approach/departure flight path for Runway 29 at San Francisco International Airport. Vehicles were more audible during the winter than summer. Water-related sounds were audible in the summer.

Both summer and winter seasons at GOGA006 contain acoustic contributions in the low to mid frequency ranges which is likely due to jet aircraft activity in the area..

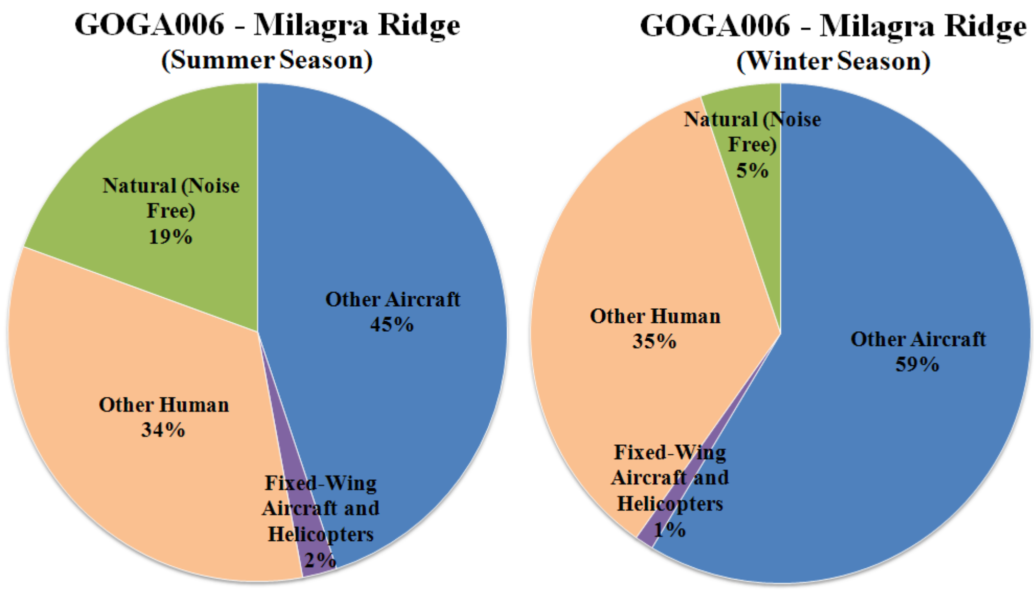

Figure 68. Distribution of sound sources audible (in situ and office listening combined) for Site GOGA006 for summer and winter seasons

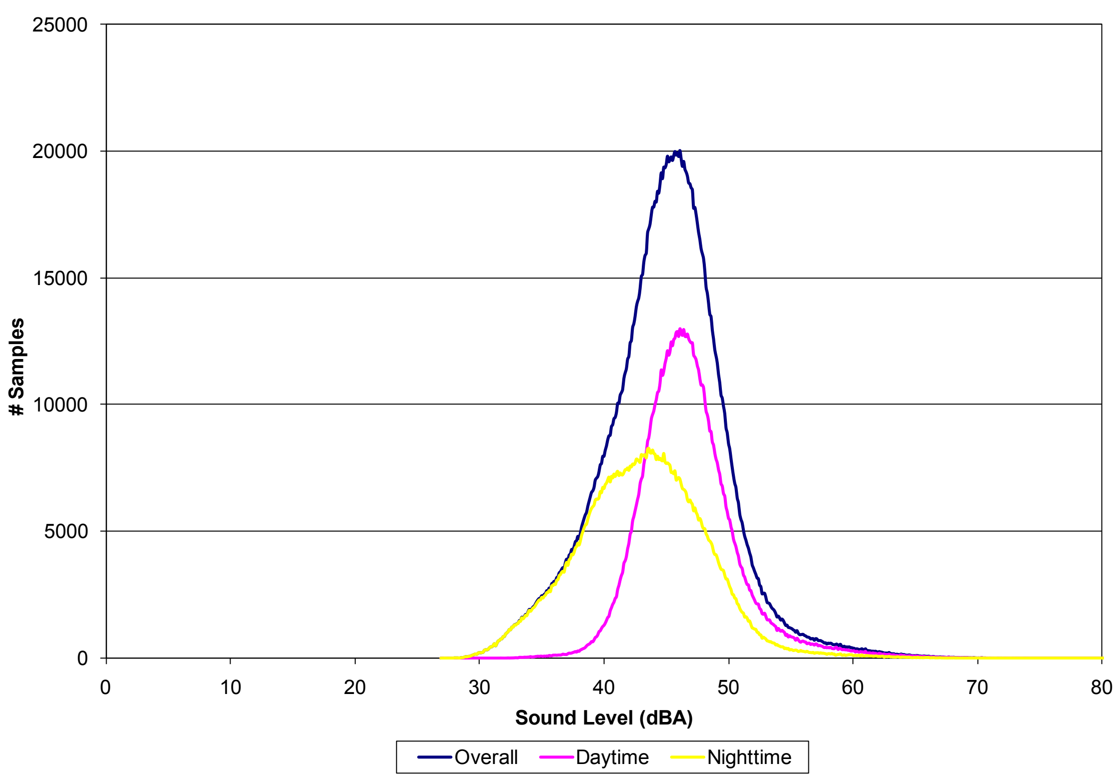

Figure 69. Distribution of data for Site GOGA006 for summer season

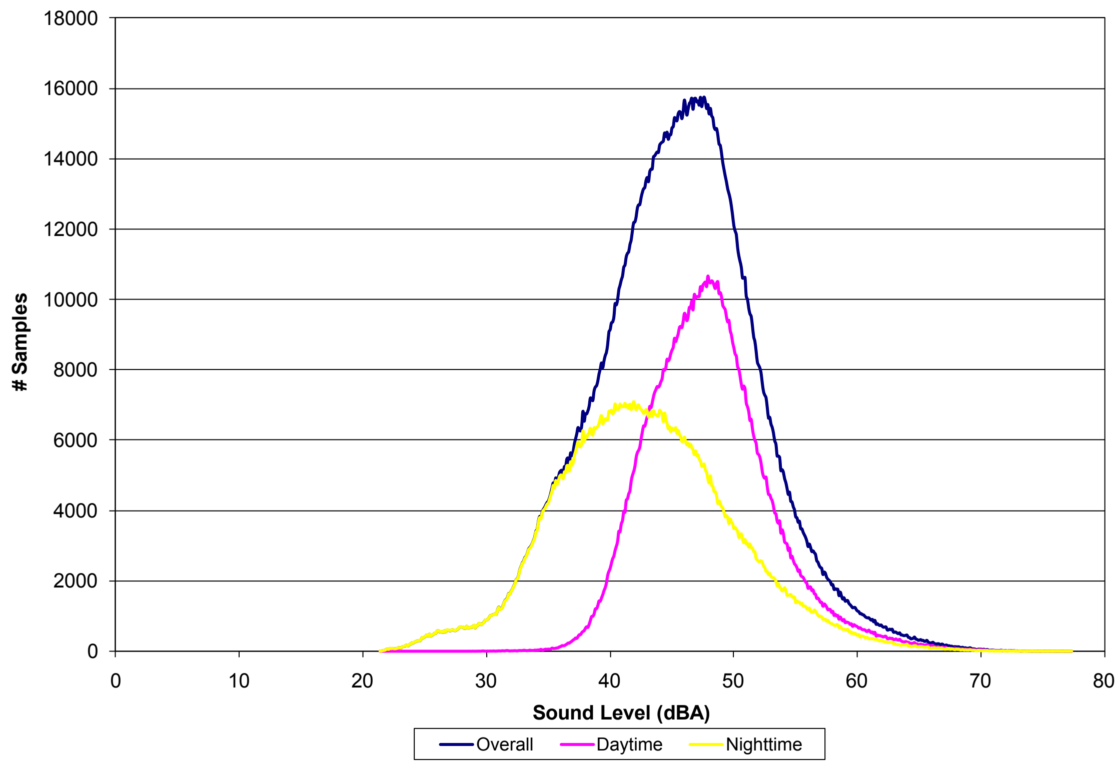

Figure 70. Distribution of data for Site GOGA006 for winter season

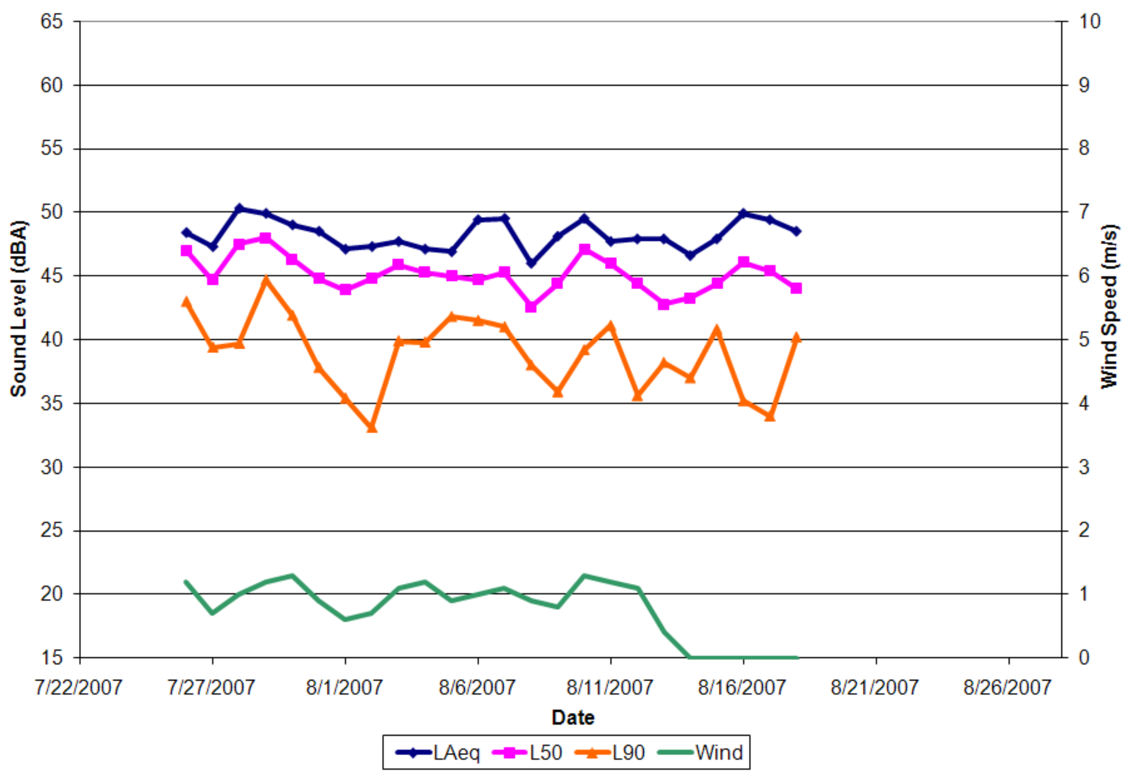

Figure 71. Daily sound levels and wind speeds for Site GOGA006 for summer season

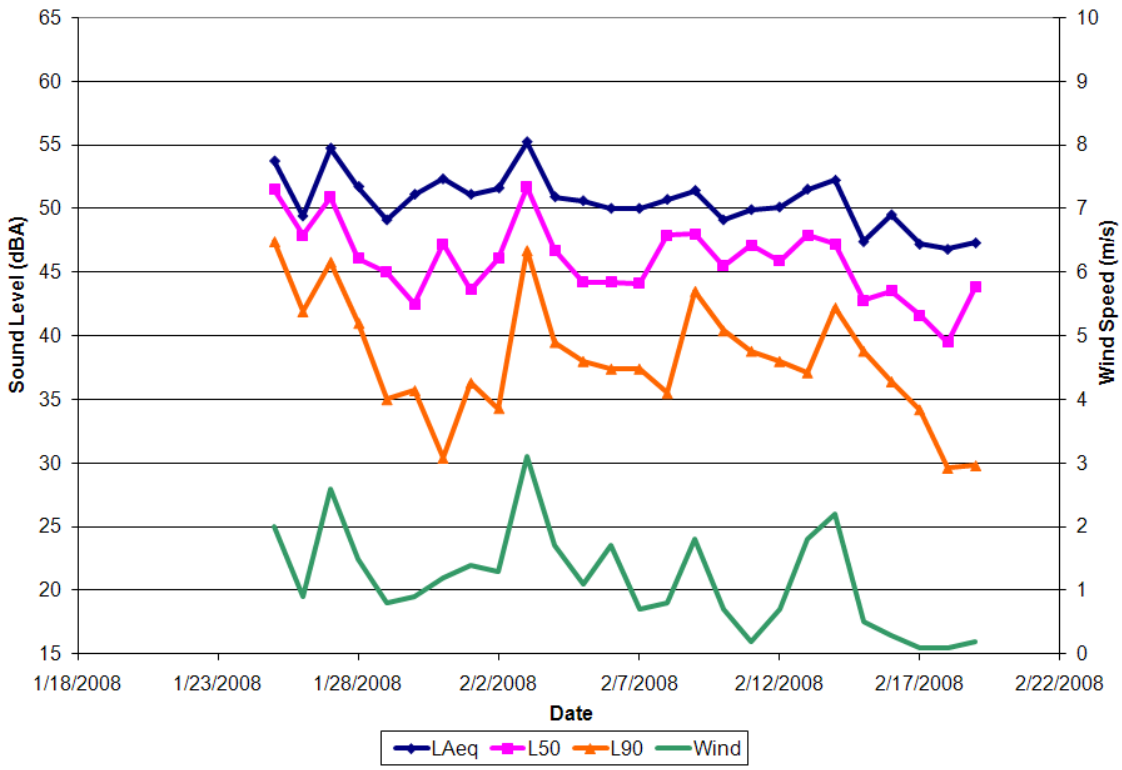

Figure 72. Daily sound levels and wind speeds for Site GOGA006 for winter season

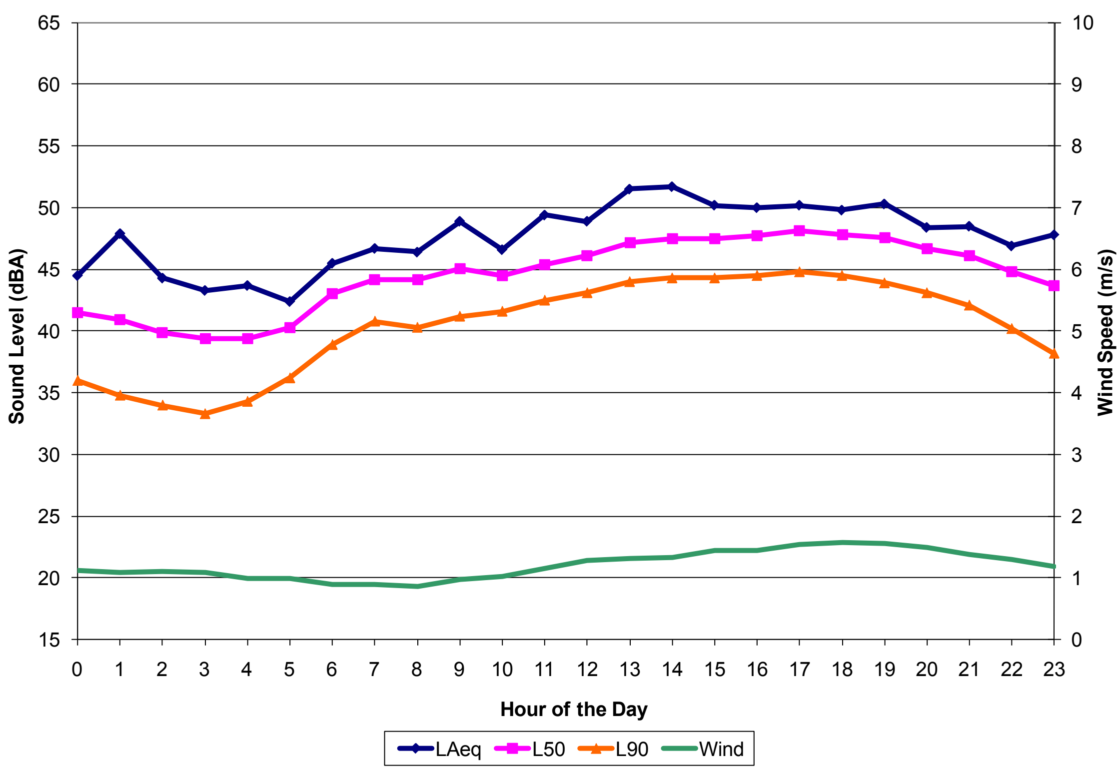

Figure 73. Hourly sound levels and wind speeds for Site GOGA006 for summer season

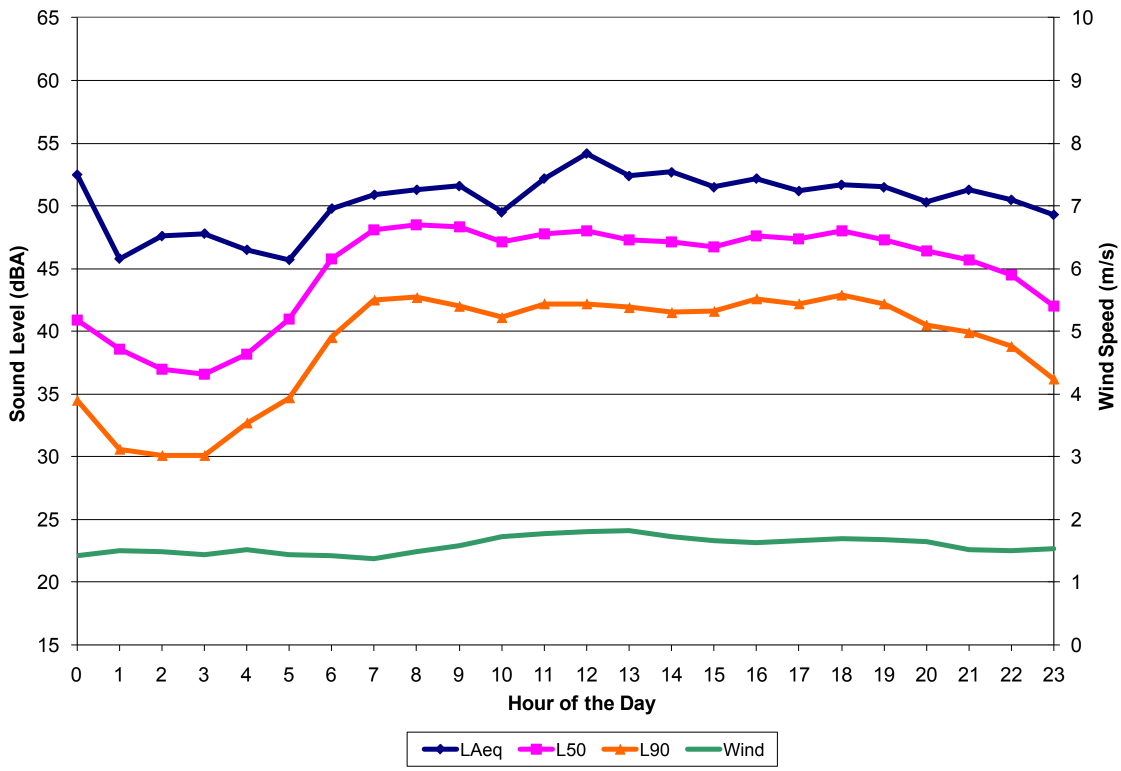

Figure 74. Hourly sound levels and wind speeds for Site GOGA006 for winter season

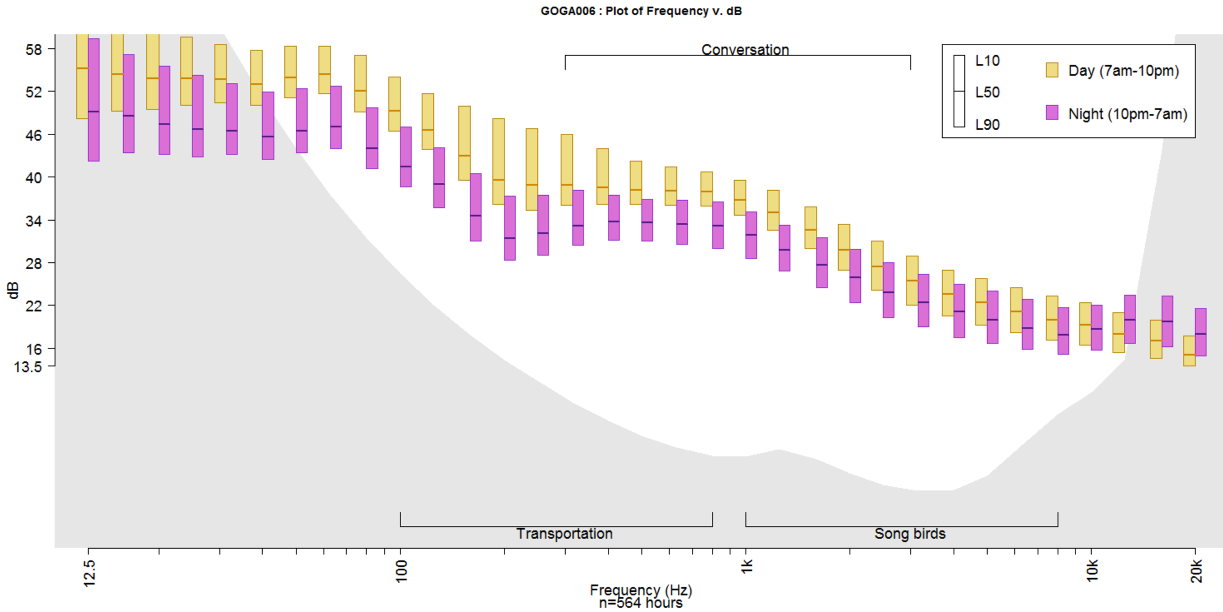

Figure 75. Sound spectrum for GOGA006 for summer season

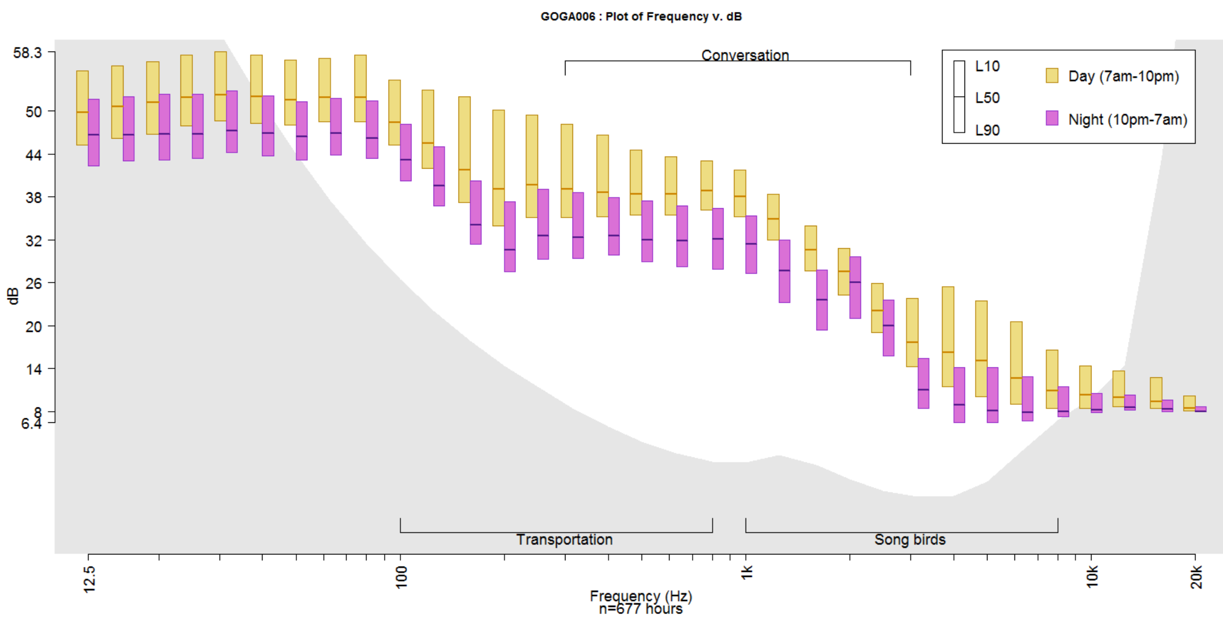

Figure 76. Sound spectrum for GOGA006 for winter season

7. 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: $10(\text{Log}_{10}(\text{sound level/reference sound level}))$. 0 dB represents the lowest sound level that can be perceived by a human with healthy hearing. Conversational speech is about 65 dB.

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

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

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

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

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

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

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.

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NPS 641/120082, March 2013

National Park Service
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