

SiteID	GRCA065	Summary: All reported noise events exceeded the EPA's criterion for speech interference for interpretive programs, and some exceeded the EPA's criterion for interruption of normal conversation.
Description	Tusayan Ruins and Museum	
Latitude	36.01223	
Longitude	-111.8661	

Interpreter Comments and Observations				Cross validation with Acoustic Data	
Date	Time	Describe the Noise Source and Loudness	Initials	L _{max}	Minutes/seconds audible
1/1/2008	1317	<i>Motorcycle interrupted interpretive talk. Had to raise voice. Two visitors complained</i>	<i>Example</i>	<i>n/a</i>	<i>n/a</i>
3/17/09	3:30 pm	Helicopter out of corridor near museum. Very loud	EH	57.2 dBA	6 min, 20 sec
5/4/09	08:05am	Helicopter out of corridor over museum- East direction	LC	56.3 dBA	4 min
7/8/09	11:50 am	Very loud copter	BG	---	---
7/7/09	5:40 pm	Helicopter over ruins- May have been park movie crew returning to the airport	LC	---	---
7/8/09	7:45 am	Filming park movie all day at Pinal Point	LC	---	---
**	*	Most days helicopters are close and loud during programs	LC	---	---
7/9/09	3:45 pm	Loud Helicopter	LC	---	---
8/2/09	1:45 pm	A military jet flew over, very loud – SE to NE direction of travel	AT	---	---
8/13/09	3:50 pm	A plane heading east over museum	LC	---	---
8/31/09	11:00 am	A plane heading east overhead	LC	59.8 dBA	2 min, 18 sec
9/14/09	2:40 pm	A plane went back and forth (3times) west to east	LC	<u>Pass over 1</u> 66.0 dBA <u>Pass over 2</u> 72.7 dBA <u>Pass over 3</u> 72.1 dBA	7 min total
10/07/09	9:35 am	A plane went toward east right over office	LC	69.8 dBA	6 min
10/11/09	11:00 am	2 loud flyovers (military) during program, visitors complained	BG	<u>Jet 1</u> 65.1 dBA <u>Jet 2</u> 77.2 dBA	<u>Jet 1</u> 1 min, 5 sec <u>Jet 2</u> 1 min, 15 sec
10/14/09	11:30 am	Plane out of corridor over Tusayan Museum during Ranger Program	LC	61.8 dBA	1 min, 5 sec

Data & Metrics

Sound pressure level (SPL) measurements were taken, along with digital audio recordings. The equipment makes 33 SPL measurements for a set of frequency bands that span the range of human hearing (12.5 - 20,000 Hz). These 33 measurements approximate the capacity of human listeners to independently sense signals in different parts of the audible spectrum. The SPL is measured in decibels (dB), a logarithmic scale where 0 dB represents the threshold of human hearing. Microphone measurements can be adjusted according to a weighted scale (A-weighting) such that they resemble the response of the human ear (Harris, 1998, p. 116).

The logarithmic dB scale can be difficult to interpret, and the functional effect of a seemingly small change in SPL can be greater than anticipated. When noise interferes with hearing natural sounds, the noise is said to *mask* the natural sounds, and this affects the extent of the listening area. For example, if the ambient SPL is 30 dB, and transportation noise raises the ambient to 33 dB (a 3 dB increase), the listening area for humans (and many birds and mammals) would be reduced by 50%. Increasing the ambient SPL an additional 3 dB (to 36 dB) would reduce the listening area by half again, to 25% of the initial area. Note however, that changes in SPL do not proportionately translate to changes in perceived loudness. The rate of change of loudness is complex and dependent on the stimulus itself (SPL, frequency, bandwidth, duration, background, etc.). At a minimum, each 10 dB increase in SPL causes a doubling of perceived loudness (Crocker, 1997, p.1481). Table 1 presents park sound sources and common sound sources with their corresponding A-weighted decibel values (dBA).

Table 1. Sound pressure level examples

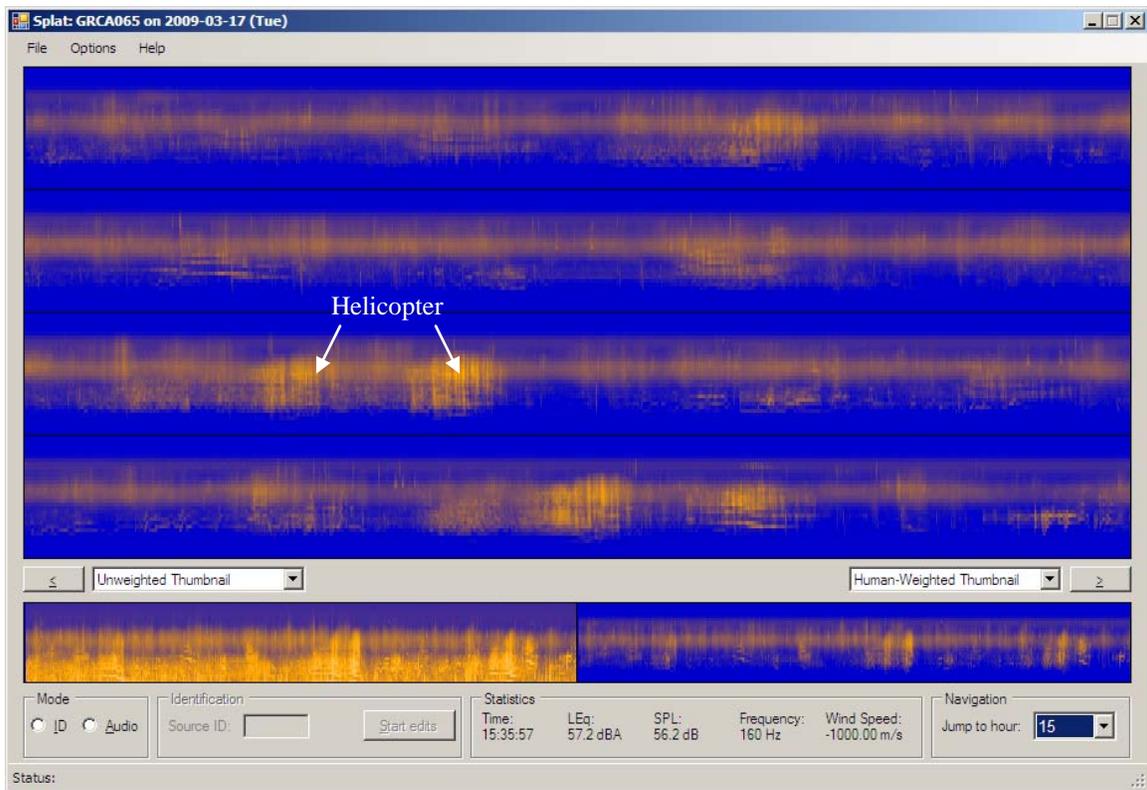
Park Sound Sources	Common Sound Sources	dBA
Volcano crater (HALE)	Human breathing at 3m	10
Leaves rustling (CANY)	Whispering	20
Crickets at 5m (ZION)	Residential area at night	40
Conversation at 5m (WHMI)	Busy restaurant	60
Snowcoach at 30m (YELL)	Curbside of busy street	80
Thunder (ARCH)	Jackhammer at 2m	100
Military jet at 100m AGL(YUCH)	Train horn at 1m	120

Table 2 summarizes sound pressure levels that relate to human health and speech, as documented in the scientific literature. Human responses can serve as a proxy for potential impacts to other vertebrates because humans have more sensitive hearing at low frequencies than most species (Dooling and Popper, 2007, p. 5). To help interpret the acoustic data collected within the park, and to better understand the implications of the data, it may be helpful to consider sound pressure levels in relation to the functional effects listed in Table 2.

Table 2. Effects of sound pressure levels on humans

SPL (dBA)	Relevance
35	Blood pressure and heart rate increase in sleeping humans (Haralabidis et al., 2008)
45	World Health Organization's recommendation for maximum noise levels inside bedrooms (Berglund, Lindvall, and Schwela, 1999)
52	Speech interference for interpretive programs (U.S. Environmental Protection Agency, 1974)
60	Speech interruption for normal conversation (U.S. Environmental Protection Agency, 1974)

Date	Time	Describe the Noise Source and Loudness	Initials	L _{max}	Minutes/seconds audible
3/17/09	3:30 pm	Helicopter out of corridor near museum. Very loud	EH	57.2 dBA	6 min, 20 sec



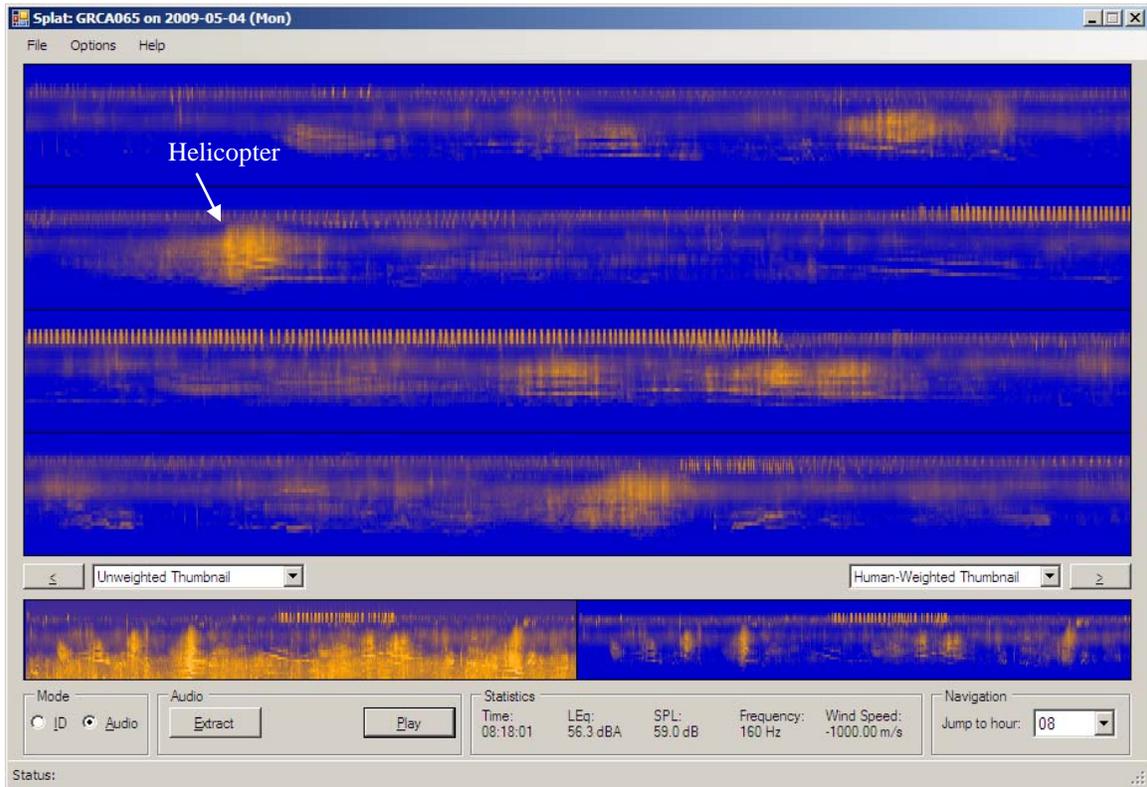
Comments: Level exceeds the EPA's speech interference for interpretive programs criterion **but not** the EPA's speech interruption for normal conversation criterion.

Listen to Recording: Recording distorted / not usable

Making it Tangible:

Levels of normal conversation occur between 50 to 65dB. 60dB may seem similar to conversation in a restaurant, to an office environment, or background music.

Date	Time	Describe the Noise Source and Loudness	Initials	L _{max}	Minutes/seconds audible
5/4/09	08:05am	Helicopter out of corridor over museum- East direction	LC	56.3 dBA	4 min



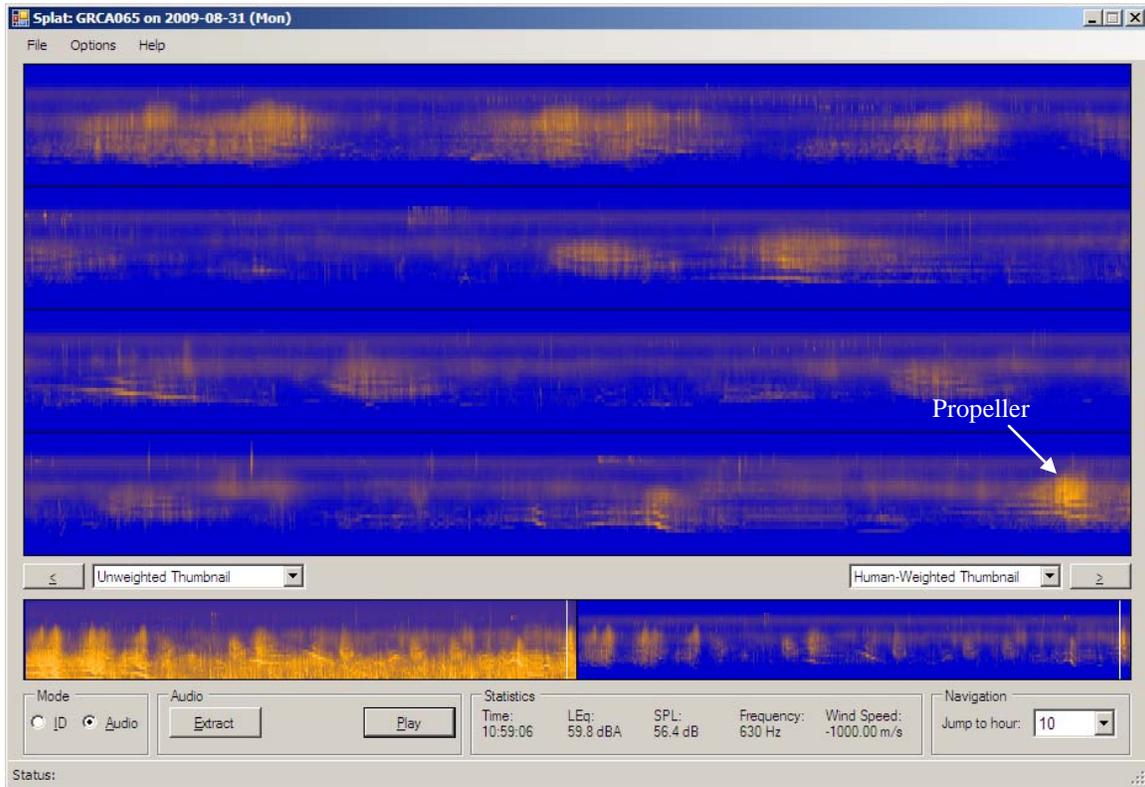
Comments: Level exceeds the EPA's speech interference for interpretive programs criterion **but not** the EPA's speech interruption for normal conversation criterion.

Listen to Recording: Recording distorted / not usable

Making it Tangible:

Levels of normal conversation occur between 50 to 65dB. 60dB may seem similar to conversation in a restaurant, to an office environment, or background music.

Date	Time	Describe the Noise Source and Loudness	Initials	L _{max}	Minutes/seconds audible
8/31/09	11:00 am	A plane heading east overhead	LC	59.8 dBA	2 min, 18 sec



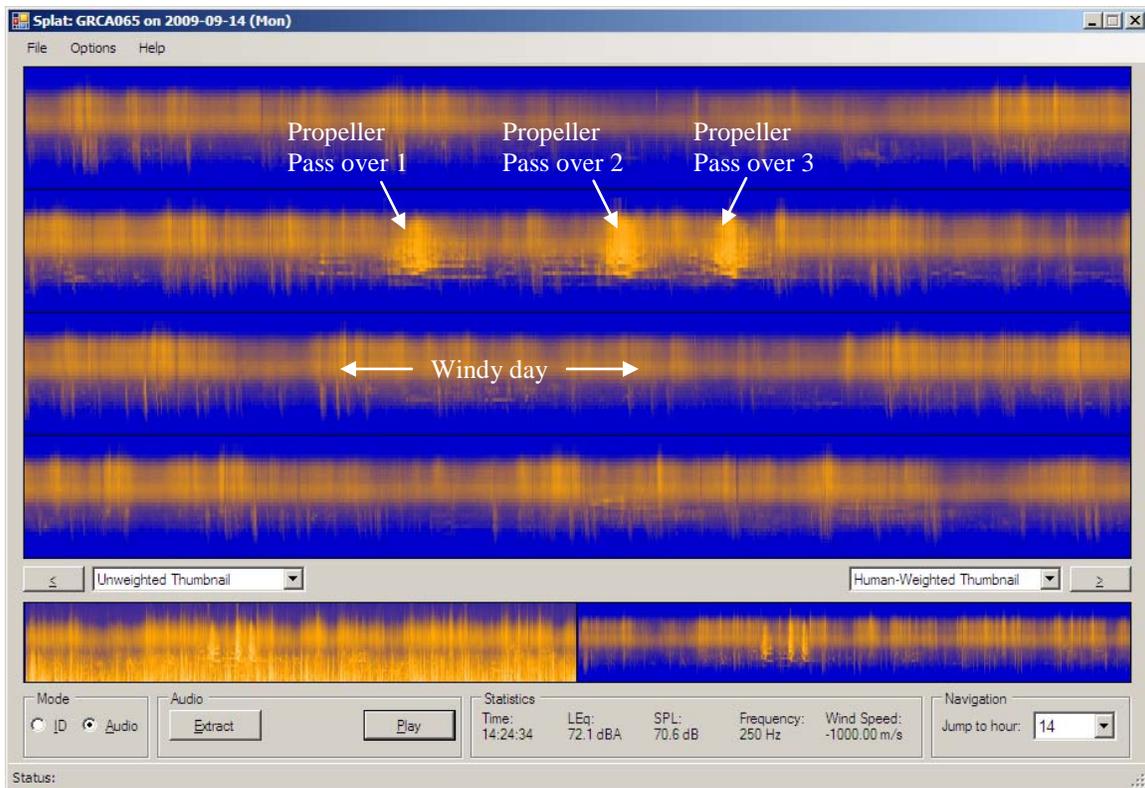
Comments: Level exceeds the EPA's speech interference for interpretive programs criterion **but not** the EPA's speech interruption for normal conversation criterion.

Listen to Recording: 20090831_1059am

Making it Tangible:

60dB may seem similar to conversation in a restaurant, to an office environment, or background music

Date	Time	Describe the Noise Source and Loudness	Initials	L_{max}	Minutes/seconds audible
9/14/09	2:40 pm	A plane went back and forth (3times) west to east	LC	<u>Pass over 1</u> 66.0 dBA <u>Pass over 2</u> 72.7 dBA <u>Pass over 3</u> 72.1 dBA	7 min total



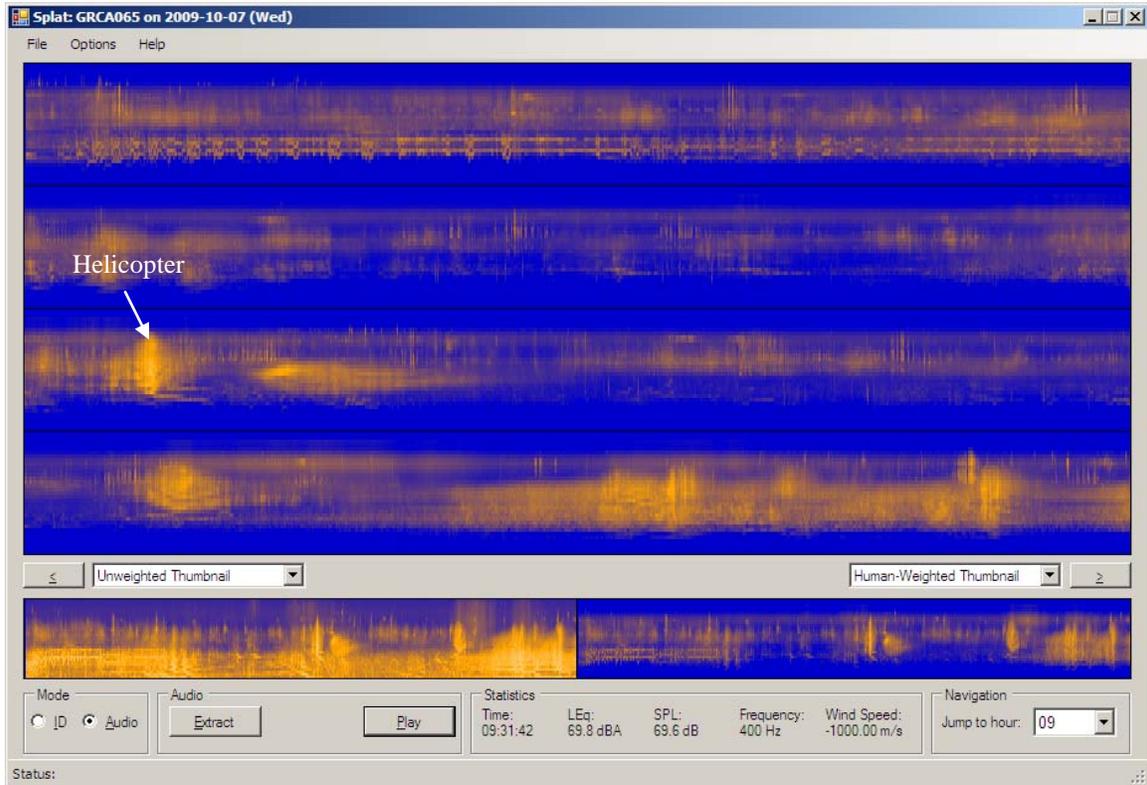
Comments: Levels far exceed both the EPA's speech interference for interpretive programs criterion and the EPA's speech interruption for normal conversation criterion.

Listen to Recordings: 20090914_0220pm, 20090914_0223pm, 20090914_0224pm

Making it Tangible:

70 dB may seem similar to freeway traffic at 15 meters, or to a vacuum

Date	Time	Describe the Noise Source and Loudness	Initials	L _{max}	Minutes/seconds audible
10/07/09	9:35 am	A plane went toward east right over office	LC	69.8 dBA	6 min



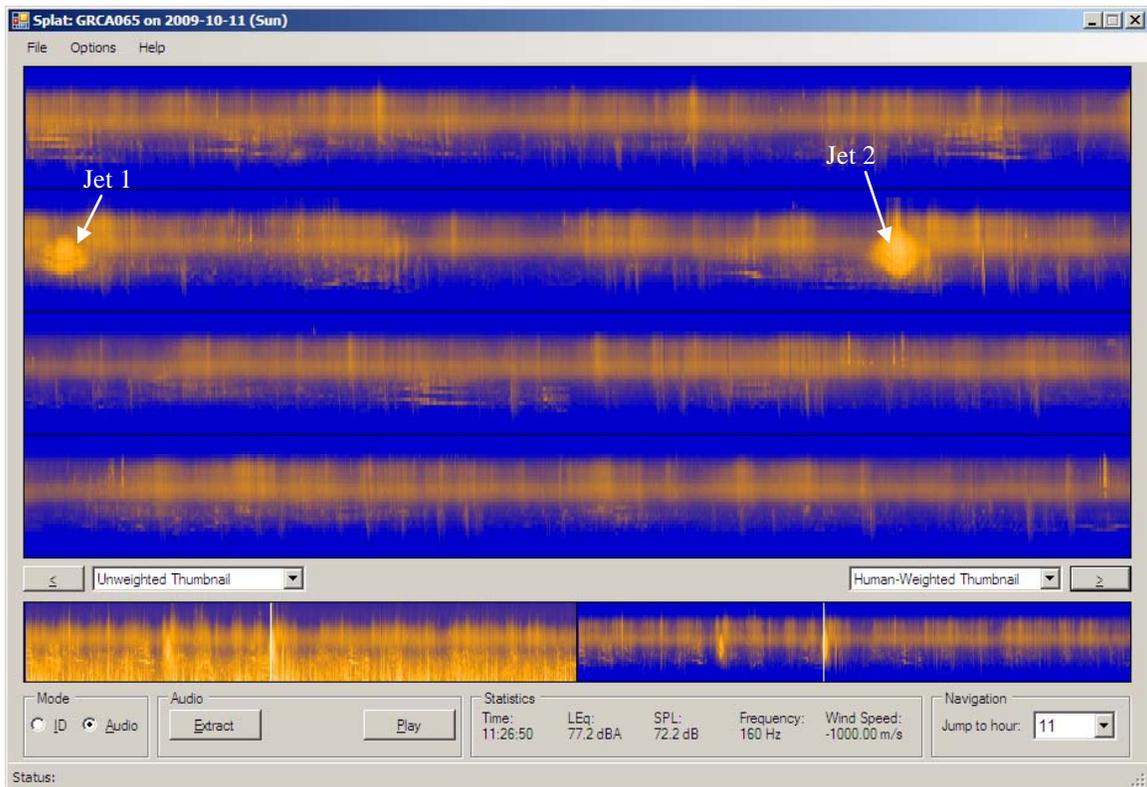
Comments: Level far exceeds both the EPA's speech interference for interpretive programs criterion and the EPA's speech interruption for normal conversation criterion.

Listen to Recording: 20091007_0931am

Making it Tangible:

70 dB may seem similar to freeway traffic at 15 meters, or to a vacuum

Date	Time	Describe the Noise Source and Loudness	Initials	L _{max}	Minutes/seconds audible
10/11/09	11:00 am	2 loud flyovers (military) during program, visitors complained	BG	<u>Jet 1</u> 65.1 dBA	<u>Jet 1</u> 1 min, 5 sec
				<u>Jet 2</u> 77.2 dBA	<u>Jet 2</u> 1 min, 15 sec



Comments: Levels far exceeds both the EPA's speech interference for interpretive programs criterion and the EPA's speech interruption for normal conversation criterion.

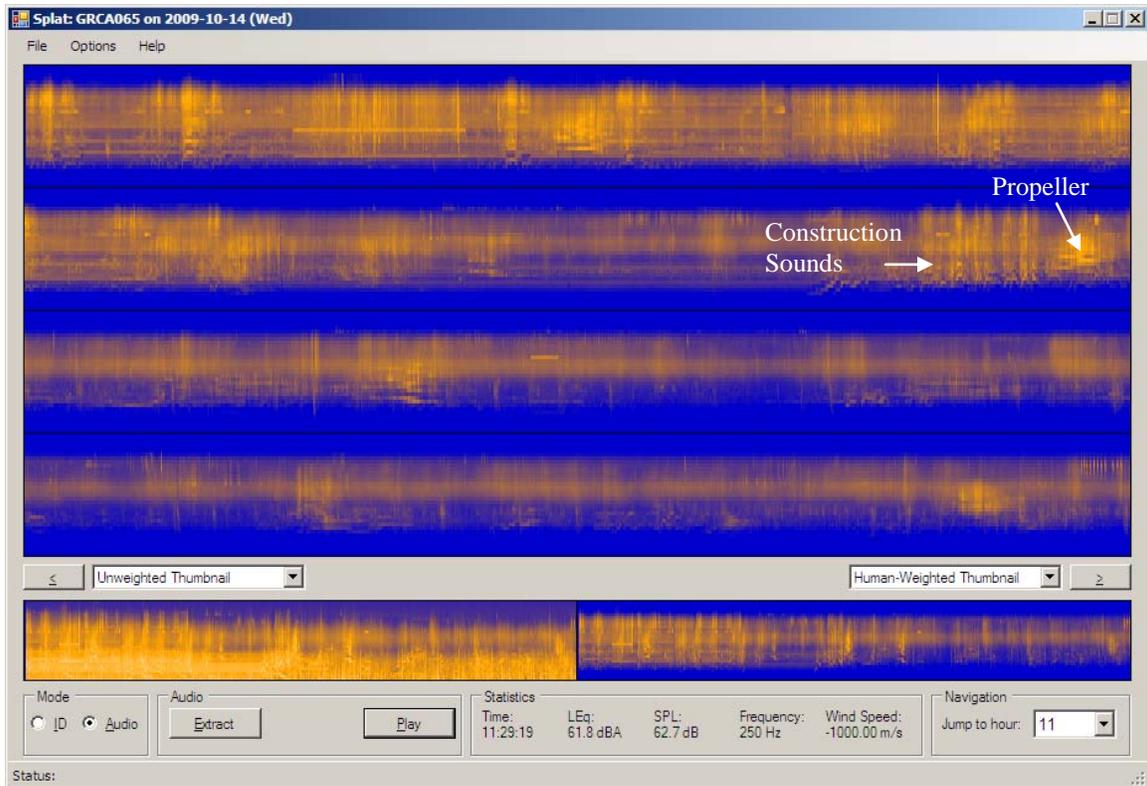
Listen to Recordings: 20091011_1116am, 20091011_1127am

Making it Tangible:

70 dB may seem similar to freeway traffic at 15 meters, or to a vacuum

80 dB may seem similar to freight train at 15 meters

Date	Time	Describe the Noise Source and Loudness	Initials	L _{max}	Minutes/seconds audible
10/14/09	11:30 am	Plane out of corridor over Tusayan Museum during Ranger Program	LC	61.8 dBA	1 min, 5 sec



Comments: Level exceeds both the EPA's speech interference for interpretive programs criterion and the EPA's speech interruption for normal conversation criterion.

Listen to Recording: 20091014_1129am

Making it Tangible:

60dB may seem similar to conversation in a restaurant, to an office environment, or background music

Literature Cited

Berglund, B., Lindvall, T., & Schwela, D.H. (Eds.). 1999. Guidelines for community noise. World Health Organization, Geneva.

Crocker, M. J. (1997). *Encyclopedia of Acoustics*. John Wiley and Sons, New York.

Dooling, R., & Popper, A. (2007). *The effects of highway noise on birds*. Rockville, MD: Environmental BioAcoustics LLC.

Haralabidis, A, Dimakopoulou, K., Vigna-Taglianti, F., Giampaolo, M., Borgini, A., Dudley, M., Pershagen, G., Bluhm, G., Houthuis, D., Babisch, & others. 2008. Acute effects of night-time noise exposure on blood pressure in populations living near airports. *European Heart Journal* **29**:658-664.

Harris, C. M. (1998). *Handbook of Acoustical Measurements and Noise Control*, 3rd ed. McGraw-Hill, New York.

U.S. Environmental Protection Agency (EPA). 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. EPA, Washington, D.C.

Making it Tangible References:

http://www.dangerousdecibels.org/teachers_guide/DDB_TRG_Appendices_3.pdf

http://www.nidcd.nih.gov/health/education/teachers/common_sounds.asp