MISTY FIORDS NATIONAL MONUMENT WILDERNESS
SOUND MONITORING PROJECT 2008

Ketchikan Misty Fiords Ranger District – Tongass National Forest

Introduction:

Located in southeast Alaska, Misty Fiords National Monument Wilderness is 22 miles east of Ketchikan. Created in 1978, the Monument encompasses 2,294,343 acres within the Tongass National Forest. In 1980, Congress passed the Alaska National Interest Lands Conservation Act (ANILCA) and designated all but 151,832 acres of the Monument as a Wilderness area.

Access to Misty Fiords National Monument Wilderness (MFNMW) is primarily via air or saltwater by floatplane, boat or kayak. Recreational use within MFNMW occurs mainly in easily accessed costal forest and beach environments.

Tourism in the Monument has been increasing steadily during the last two decades along with a corresponding increase in cruise ship traffic in SE Alaska. Most visitors arrive by tour boat or floatplane for a 2-4 hour tour of the Monument. Visitor use levels and social impacts from this use have been documented by the KMRD wilderness inventory and monitoring program since the late 1990's. The information gathered is often inconsistent from year to year as field crews adjust to changing priorities.

The Wilderness Act of 1964 defines a wilderness as having, "outstanding opportunities for solitude or primitive and unconfined type of recreation." In addition, the Chief's 10 Year Wilderness Stewardship Challenge includes an element requiring "adequate direction, monitoring, and management actions to protect opportunities for solitude or primitive and unconfined recreation" for each wilderness by 2015. Based on the Wilderness Act and agency direction, it has been determined that methods to measure impacts to and opportunities for solitude in Misty Fiords National Monument Wilderness are needed.

In 2008 Ketchikan Misty Fiords Ranger District (KMRD) established several new protocols for monitoring conditions relative to solitude; among them is a sound monitoring program which enabled wilderness managers to document sound from mechanized transport within the wilderness over a period of several months.

Sound Monitoring Proposal Overview:

Initiated in the spring of 2008 this project involved the use of sound monitoring equipment to record human created sound levels near several freshwater lakes in MFNMW. The equipment used consists of a small digital audio recorder, external batteries, and a small microphone. This setup has the capacity to record up to two weeks of continuous audio recording (MP3 format). These recordings are then processed using scripts developed by the National Park Service Natural Sounds Program to create Sound Pressure Level (SPL) data. The SPL data is measured in decibels and can be represented graphically for analysis.

This equipment and process allows wilderness managers to gather large amounts of data with minimal investments in money and field personnel time. The equipment is relatively inexpensive ($800) and the data can be collected unattended for 14 days. The main drawback of this method is a lack of accuracy resulting from the conversion from audio to SPL data. Simply put, this method does a poor job at getting accurate decibel levels for each sound event, but does a good job at capturing the time, duration, and relative decibels levels of each sound event. The data can, therefore, not be used to measure conditions in relation to a standard based on sound decibel levels. However, the approach is well suited for monitoring other conditions related to providing opportunities for solitude (e.g. number of human created sound events per day, duration and percentage of time during which sound levels at various intensities are expected).

The methods and equipment used in this project are being developed by the National Park Service Natural Sounds Program, which is directed to collect an acoustic inventory of all natural and human-made sounds in our National Parks. The NPS also uses other equipment to monitor human-made sound levels for compliance to sound level standards (measured in decibels). This equipment is expensive ($5,000 for a handheld SPL meter) and requires the use of solar panels and large batteries.

Equipment:

Minimal equipment is required for our sound monitoring approach. The basic setup consists of a recorder, a microphone, an external power supply, and two memory cards. Table 1 lists the equipment used in this project and a cost for each item.

Table 1. Sound Monitoring Equipment Costs

Equipment	Cost
Edirol R-09 Audio Recorder	$500.00
Omni Directional Microphone	$25.00
Two SD Memory Cards (8GB)	$220.00
Plastic Action Packer	$20.00
Small Pelican Case	$25.00
Two Radio Repeater Batteries	Free
Power Adapter Cable	$17.00
SD Card Reader	$13.00
Microphone Windscreen	$5.00
Microphone plug converter	$3.00
Total Equipment Cost	**$828.00**

Power for the recorder is provided by two radio repeater batteries, which we were able to get for free from the FS radio shop because they were expired. These batteries are well suited for powering devices with minimal power demand for long periods of time. Their primary drawback is their weight; about 25lbs each.

The recorder was packaged in a sealed Pelican Case, with the power and microphone cables exiting through a sealed port. This was then placed in a camouflaged action packer with the batteries. The microphone was mounted near the equipment, usually in a small dead tree, with zip ties. Weatherproofing the microphone was accomplished with saran wrap, electrical tape, and a foam microphone windscreen. The arrangement was inconspicuous and blended well with the natural surroundings.

Audio processing scripts and software were provided by NPS staff involved with the Natural Sounds Program. There were two scripts/programs used in this project. First, an R script was used to convert the audio to SPL data. R is statistical computing freeware available over the internet. The script developed by the Natural Sounds Program was opened and run using R. Second, a windows-based program called SPLat was used to graphically represent the sound data as spectrograms (sound intensity and frequency plotted over time). There was no cost associated with the use of these programs and the staff at the Natural Sounds program was very helpful in troubleshooting any problems that arose.

Data Collection Methodology:

This project was initiated without a structured methodology regarding sound monitoring locations and durations. Before the start of the season it was unknown if the recording arrangement would work well at remote wilderness locations. This season was treated as a trial run to test the monitoring equipment and start a baseline sound inventory. The initial recording locations were chosen based on accessibility, areas with high levels of mechanized use, and areas where we had additional work planned (so as not to incur extra costs). A total of five locations (Table 2), all situated near freshwater lakes in MFNMW, were monitored in 2008.

Table 2. Sound Monitoring Locations	
Location	**Description**
Punchbowl Lake	Located on a ridge about 1/10 mi from Punchbowl Trail and three sided shelter
Nooya Lake	Located above the shore of Nooya Lake about 100 yards from the three sided shelter
Big Goat Lake	Located on a small peninsula mid lake about 100 yards from the FS cabin
Manzoni Lake	Located on the SE end of the lake 50ft from the lake adjacent to an avalanche chute
Wilson Lake	Located at the north end of Wilson Lake near the Wilson View FS cabin

This project was supported by a hardcopy attended listening form (attached as Appendix A), which was filled out by our wilderness field crews throughout the season. This form captured the location, time, duration and intensity of each human-made sound event. A three-tiered sound intensity ranking system was developed for this form, as described below:

- 1 = Faint, barely audible; sound is not noticeable during conversational speech.
- 2 = Clearly audible; sound is as loud or louder than natural sounds (e.g. wind, water); Conversational speech at 5 feet is not interrupted.
- 3 = Loud; sound completely dominated soundscape, makes conversational speech at 5 feet difficult if not impossible.

While this classification scheme is subjective, and can yield variable results due to differences in hearing sensitivity and environmental factors, it does indicate what general sound levels a wilderness visitor would experience at that location. Collected in conjunction with the audio recordings, this information was used to interpret and verify data collected by the recording equipment.

Data Collection and Processing:

A total of 77 days of continuous audio data were recorded in MFNMW at 5 different locations between May and September 2008. The audio was collected in MP3 file format at 63kbps (medium to low quality recording) and as stated earlier would fill up an 8GB memory card in just over 14 days. The normal procedure was to visit the recorder before the memory was full and replace it with a new empty card. The monitoring equipment was moved to new locations periodically throughout the summer.

The conversion of audio to SPL data was started in early August. The processing time involved in the procedure is substantial, it takes roughly 8 hours to process 24 hours of audio data. Multiple audio files can be opened simultaneously allowing the script to process audio data for days on end uninterrupted. There were problems processing some (about 20%) of the audio files where the R script would terminate without completion of the SPL file. This problem was brought to the attention of the developers at the Natural Sounds Program.

Analysis:

Analysis of the data was performed using a program called SPLat. This program graphically represents the SPL data as a spectrogram plotting frequency and intensity (measured in decibels) over time. Each spectrograph represents a one-hour time period and users can page through an entire day of spectrographs. Sound events are shown in lighter color (greater intensity) along the Y-Axis which represents the frequency spectrum (12.5Hz-200000Hz).

The ability to link back and play the original audio file allows the user to confirm a sound source. Sound events were then given an intensity ranking by classifying them visually using the intensity ranking from the attended listening forms. It was found that sound events classified as 1 (faint, barely audible sounds) on the attended listening forms were not reliably picked up by the recording equipment. Often natural background sounds would mask these sound events in the spectrographs. It was decided to drop these from the analysis and proceed with the level 2 and 3 classified sound events. These were easy to recognize and classify and undoubtedly have more effect on opportunities for solitude.

Major human-made sound events (such as an aircraft over flight or takeoff) are represented prominently on the spectrograph and form a recognizable pattern. Almost all human sound events recorded this season were aircraft over flights and/or takeoffs. Other events that display prominently are rain, wind and bird calls. These other sound events are distinguishable from the aircraft-related noise as their frequency, duration and intensity are quite different.

Results:

Table 3 and Table 4 summarize 44 days of aircraft sound information as classified using SPLat spectrograms. A day is defined as 15 hours between 0600 through 2100 to exclude the night hours. Only days with a full 15 hours of uninterrupted data were used in this analysis. Of the total 77 days of original audio recording, 44 days were successfully processed into usable, contiguous SPL data.

Table 3. Average number, duration, and time audible for mechanized transport sound events per day[1]

Location	# of Sound Events		Total Duration	Duration per Event	% Time Audible
	(average per day)	(average per hour)	(minutes per day)	(average minutes)	(average per day)
Big Goat Lake (9 days sampled)					
Sound Intensity 2	7.7	.5	9.6	1.1	1.1
Sound Intensity 3	2.0	.1	1.0	.4	.1
Total	**9.7**	**.6**	**10.6**	**1.0**	**1.2**
Manzoni Lake (5 days sampled)					
Sound Intensity 2	7.3	.5	9.2	1.3	1.1
Sound Intensity 3	1.9	.1	1.1	.6	.1
Total	**9.1**	**.6**	**10.2**	**1.2**	**1.3**
Nooya Lake (10 days sampled)					
Sound Intensity 2	56	3.7	65.2	1.2	7.2
Sound Intensity 3	16.5	1.1	5.0	.3	.6
Total	**72.5**	**4.8**	**70.2**	**1.0**	**7.8**
Punchbowl Lake (17 days sampled)					
Sound Intensity 2	33.4	2.2	78.9	2.4	8.8
Sound Intensity 3	3.4	.2	.9	.2	.1
Total	**36.8**	**2.4**	**79.8**	**2.2**	**8.9**
Wilson Lake (3 days sampled)					
Sound Intensity 2	8.7	.6	7.0	.8	1.2
Sound Intensity 3	1.0	.1	.4	.3	.1
Total	**9.7**	**.7**	**7.3**	**.8**	**1.2**

[1] Data analyzed for a 15-hour day, from 0600 to 2100 daily.

From this data we can accurately describe the frequency and duration of sounds associated with motorized transport for these locations in MFNMW. We can also make some general suggestions about how these sounds would affect wilderness visitors in these areas using the sound intensity classification associated with each event.

Table 4. Average time of first and last mechanized transport sound events and maximum duration in minutes.			
Location	**First Sound Event** (average time)	**Last Sound Event** (average time)	**Maximum Duration**[1] (average # of minutes)
Big Goat Lake			
Sound Intensity 2	**07:43**	09:27	2.6
Sound Intensity 3	08:51	09:14	
Manzoni Lake			
Sound Intensity 2	10:13	11:27	2.3
Sound Intensity 3	09:24	11:27	
Nooya Lake			
Sound Intensity 2	08:39	14:22	3.5
Sound Intensity 3	08:37	12:31	
Punchbowl Lake			
Sound Intensity 2	08:32	15:52	**6.7**
Sound Intensity 3	11:06	13:13	
Wilson Lake			
Sound Intensity 2	11:35	**16:57**	1.9
Sound Intensity 3	09:13	11:30	
[1] **Average maximum duration for sound events includes time at sound intensity levels 2 and 3.**			

This information indicates that there is a substantial amount of floatplane traffic in this portion of MFNMW, with the most sound impacts occurring around Punchbowl and Nooya Lake. While this confirms what wilderness managers have known for years, the information allows managers to accurately describe what an experience at a particular lake would be like on a typical summer day.

> **Example 1:** Nooya Lake. At 0830 an aircraft over flight creates a sound so loud that conversational speech is impossible for 6 seconds. The aircraft sound is then clearly audible for over another minute. This is repeated 16 more times throughout the day. Because most aircraft visit the Monument during the morning and early afternoon, these interruptions will occur approximately three times per hour until 1400. During this 15-hour day aircraft sound will be clearly audible at this site for 70 minutes, or about 8% of the day.
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> Most of the very loud (intensity level 3) sound events at Nooya Lake are associated with aircraft landings, which are permitted by the Forest Service. Data indicate an average of 8 landings per day (16/2=8) are occurring on Nooya Lake. If lake landings constitute social encounters, then this area consistently exceeds the standard of 6 social encounters per day established in the Forest Plan for the Semi-Primitive Motorized Recreational Opportunity Spectrum (ROS) Class.
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> **Example 2:** Punchbowl Lake. At 0830 a clearly audible sound from an aircraft persists for two and a half minutes. This occurs 33 more times, or approximately every 15 minutes, until 1600. A total of three very loud sound events occur, interrupting conversational speech briefly during the middle of the day. For about 80 minutes, or 9% of this 15 hour day, aircraft sound will be clearly audible at this site.
>
> **Example 3:** Big Goat Lake. At 0800 a clearly audible aircraft sound is present for about one minute. This happens 10 more times before noon. Two of these sounds are loud enough to interrupt conversational speech. For the rest of the day there is little to no aircraft noise.

Manzoni Lake and Wilson Lake had relatively small sample sizes and the results were more variable. Generally, however, the sound events at these lakes were less in both number and intensity.

Information about aircraft landings and takeoffs could not be consistently obtained with the locations selected this year. The primary limiting factor is the size of some of the lakes and higher levels of natural ambient sound (e.g. rain, waterfalls). A few of the lakes sampled were smaller and some success was had in identifying landings. When aircraft landed relatively close to the recording equipment (< 0.5 mile) and there was a low level of natural ambient sound, aircraft takeoffs could be clearly identified in the spectrographs. Also, it was easier to identify aircraft landings in areas where aircraft sound related to flyovers is infrequent because of the lack of low level, background aircraft sounds.

Standards and indicators related to solitude have not yet been established for MFNMW. Data used from this sound monitoring program may be used to help quantify and evaluate conditions related to opportunities for solitude and establish related standards. This equipment should also prove useful in assessing aircraft landing levels at our more remote wilderness lakes. The information gathered could guide future management decisions regarding the allocation of special use permits for freshwater lake landings.

As stated earlier in the report, some of the Park Service software used in this process is still in the developmental stage. Future improvements should cut down on processing time and improve the success of the audio – SPL conversion. Also, the addition of the total decibel level measure (Leq) to each identified sound event in SPLat should increase our accuracy and consistency when evaluating the spectrograms.

Recommendations:

- Develop a stratified, random sampling methodology in 2009 for MFNMW, with a focus on wilderness lakes.

- Put the audio recorder on a timer and omit nighttime recordings. This would extend recording capacity to three weeks. Investment in new SD data cards would further extend recording capacity to 35 to 40 days. The end result would be reduced transportation cost – a significant factor when accessing remote areas.

- Have wilderness field crews continue attended listening sessions with revised forms or electronic data collectors. Emphasize accurate data collection in the direct vicinity of the recording equipment. Investment in a field data collector will streamline the data entry process.

- Continue to work with the National Park Service and the Natural Sounds Program to obtain updated versions of the software and scripts. Future improvements should cut down on processing time and improve the success of the audio to SPL conversion. Also, the addition of the total decibel level measure (Leq) to each identified sound event in SPLat should increase our accuracy and consistency when evaluating the spectrograms.

APPENDIX A: Sound Monitoring Form

MECHANIZED TRANSPORT SOUND MONITORING AT FRESHWATER LAKES

MONITORING DATE *: _______________ RECORDER ____________________________________

LAKE MONITORED*: __________________________ START *: _________ STOP*: _________

START	STOP	INTENSITY	COMMENTS
1010	1020	1	Floatplane
1020	1028	2	
1028	1033	3	Taquan Landing
1033	1037	2	

SOUND INTENSITY RATINGS

1 - Faint, barely audible, sound is not noticeable during conversational speech.

2 – Clearly audible, sound is as loud or louder than natural sounds, i.e. wind, water. Conversational speech at 5ft is not interrupted

3 – Loud, sound completely dominates the soundscape, makes conversational speech at 5 feet difficult if not impossible.