A new low-power acoustic bat detector for long-duration observations

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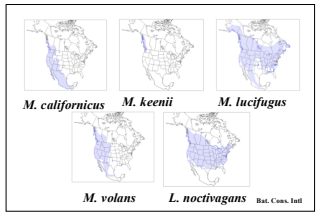
ABSTRACT

A new low-power, computer-based acoustic sensor for long-duration (~100 days) observations of bats has been developed. This poster will describe the system and the development decisions driving the final design for the system, specifically the tradeoffs between power consumption, processing power, and scientific and monitoring needs. Long duration monitoring of several different types of area (such as old-growth vs recently logged forest) will provide knowledge to improve management practices in regards to bat ecology in Southeast Alaska. The role of long duration acoustic monitoring and deployment strategies for Southeast Alaska will be described. [Work supported by Alaska Department of Fish & Game.]



MOTIVATION

The five species in Alaska have ranges shown. Four of the known Alaskan species are limited to Southeast Alaska. Two studies addressing status of bats in Alaska have used traditional methods including museum vouchers, field work, and reports (Parker/Cook 1990s and Boland/Hayes present). The field work components of the above research has included mist-netting, radio-tracking, and acoustic analysis.

Southeast Alaska is the northern extent of the coastal temperate rainforest. The Tongass National Forest and Glacier Bay National Park and Preserve combined total 20 million acres of federally managed land. The large geographic range, coupled with access issues, presents challenges for any field-based monitoring project.

This project utilizes low-cost, low-power technology to improve knowledge regarding bat populations in Southeast Alaska.

The karst geology and logging on Prince of Wales makes it an especially interesting focus for bat conservation research and has been the focus of a great portion of this project.


POW Bat (J. Boland)


El Cap Cave on POW


Second Growth on POW

SYSTEM DESIGN

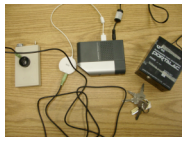
HARDWARE

The major design criteria for the hardware are low power consumption and low cost.

The original design used the 200 MHz Gumstix computer. The Gumstix is $129US with power consumption of 0.8 W. However, at the time, a soundcard and USB host configuration was not an option.


Gumstix computer, sound card, network, knife.

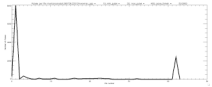
The hardware solution for this project is the Linksys NSLU-2, a 266 MHz computer at 2.5 W with a price of $80US. The lower cost is less an issue than the higher power compared to the Gumstix and illustrates the design tradeoffs.


NSLU2,battery, sound, microphone, keys

Both of these systems are Linux based and able to process in real time the 44.1 kHz audio stream. The transducers used to date are the Anabat II systems, but lower cost microphones (shown in Figure at right) are being tested currently.

SOFTWARE

The software processes the data in real time. The software has been designed using the IDL analysis package. Validation of software pulse identification has been done using Raven on over 80 hours of recordings from 2005 and 2006 field seasons and comparing the results from night vision observations and field observations logs.


Sample pulse rate output--this example has not been properly filtered to remove Anabat calibration tones at the beginning and end of the observation period.

The software is a noise-riding, amplitude threshold system which tests pulse duration to discriminate against rain and other noises. The computers do not have math co-processors. This sacrifice means that only time domain analysis in real time is possible.

SYSTEM STATUS

HARDWARE: The system has been built and tested. New versions of the Gumstix computer have been released recently and will be evaluated for incorporation as the computer element.

SOFTWARE: The latest version of the pulse detection software (used for analysis presented in this poster) will be recoded for real-time operation on the NSLU2 computer.

POWER: The system is powered by solar panel recharged marine batteries. Wind power generators are being evaluated as an alternative power source.

RECORDING LIBRARY: The majority of the bat recordings were made using Raven and an Anabat2 on a laptop to produce a high fidelity library of bat recordings.

OVERALL: The NSLU2 system currently records time and pulse duration. The pulses are recorded to an 8 GB USB memory stick and can be analyzed on more powerful computers after the data is returned from the field.

Measuring only bat activity, the system can be used for monitoring cave mouths, streams, or other geographic "pinch points." The observations could be used to assist planning for more tradition summer campaigns. The activity data can also be used for monitoring bat activity during the winter.

For forest management, long term monitoring of multiple watersheds and cave entrances to better understand the possibly diverse habitat use of Southeast Alaska will be enabled with this low cost, long-duration recording capability.

The modular design allows for easy replacement of individual components and as technology evolves, the system can take advantage of technological advancements for power consumption, data processing, and data storage improvements.

After a winter season of durability evaluation in the Juneau area, this project will document the hardware used and identify the power/cost/processing capability tradeoffs and provide the options identified in the design process (for example, if power is not so limiting, more powerful computers could be used, providing frequency domain analysis capabilities).

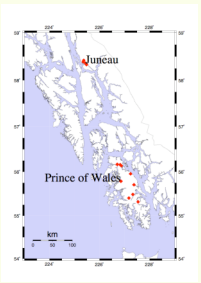
The software developed will be available for use by other groups. With hardware all available commercially, and software and documentation openly available, the system developed will be available for use by other researchers.

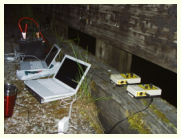
Sample Application: Foraging Patterns of Bats in Southeast Alaska through Acoustic Monitoring

Background and Methods

The most recent and extensive effort to document the occurrence of bats in Alaska confirms that five species, are part of the fauna of Southeast Alaska accounting for about 13% of all regional species of terrestrial mammals (Parker 1996). Bats typically forage during two feeding periods between dusk and dawn in riparian areas, the first feeding period falling before midnight and the second between midnight and dawn (Anthony and Kunz, 1977). It is not known, however, if the bats of southeast Alaska follow these activity patterns. It is likely that the shortened period of darkness during Alaska's summer may affect these feeding patterns. Based on analysis from data from two field seasons we find unexpected patterns in bat activity throughout the night.

This study was conducted in southeast Alaska during the summers of 2005 and 2006. Study sites were located on northern and central Prince of Wales (POW) island, and in Juneau, Alaska. Southeast Alaska is a part of the Tongass National Forest which is a north-temperate coniferous rainforest. The climate is strongly maritime, with cool summers, mild winters, and abundant precipitation throughout the year.





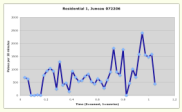
Recordings took place at a total of 12 sites on POW and 5 sites in Juneau. An Anabat II detector and a laptop running the recording software Raven 1.2 (Cornell Ornithology Laboratory) were used to record bats. Recording began each night at dusk (just after sunset). Recordings were analyzed using custom software for the presence or absence of bats and nightly activity patterns. We measured the nightly activity patterns as the change in the number of pulses per ten minutes from sunset to sunrise.

Most recordings were made at a water source where bats would be foraging for insects. One exception, for example, is the site "Scallop cave" which is a high elevation cave located in the heart of a clearcut. Recording sites were located in differing forest types: clearcut areas, old growth areas and second growth areas. Some Juneau sites were in a residential neighborhood where bats were known to roost in man-made structures. Recording locations also include areas with and without karst, and sites at a high elevation. Each of these factors may affect the foraging behavior of bats. Rain was also noted since precipitation may affect the availability of insects and thus the presence of bats.

Preliminary Analysis

Below are some examples of individual results of the bat activity for specific sites.

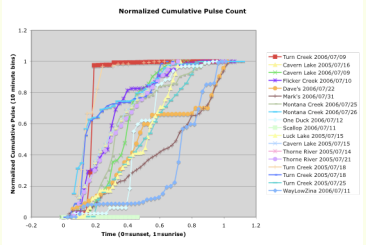
Turn Creek is an old growth area with karst. This recording observed one peak of bat activity early in the night and then no activity the remainder of the night.



Residential 1 is a residential area where bats are known to roost. This is an example of continuous activity from sunset to sunrise.

Results

The plot graphically summarizes the results of this study to date. In order to overplot all 18 nights of observations, both the horizontal time axis and the vertical pulses-per-ten-minute-bin axis have been normalized. Length of night can change more than five minutes per day at the latitude of southeast Alaska. The cumulative pulse vs. time plot allows easy visual determination of changes in bat activity rate through the night. For example, the Turn Creek 2006/07/09 plot shows an early evening pulse of activity. The Mark's 2006/07/31 plot shows continuous and steady bat activity through the night.



Bat activity patterns have been analyzed at 18 recordings sites. Activity patterns vary greatly from location to location and even night to night. Although statistical analysis of this data is in progress, it is clear that the data shows little bimodal pattern of foraging Out of 17 locations only one, Way Low Zina, shows the expected bimodal pattern.

Literature Cited

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