Lausen, Cori. An overview of bat detectors and acoustic analysis.
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There are many bat detectors on the market these days and if you are new to the field of bat acoustics, it is hard to know which ones do what. I present an overview of the detectors and software packages most used in North America. There are basically 2 types of bat detectors suitable for monitoring passively at wind development areas: full spectrum and zero-crossing. The former method digitizes the ultrasound by sampling at high rates (>190 kHz), retaining all aspects of the sound including multiple harmonics and amplitude. Popular full spectrum detectors currently being used in North America include Pettersson D500x (Pettersson Elektronik), AR125 with FR125/iFR4 (Binary Acoustic Technology), and SM2Bat (Wildlife Acoustics); subsequent visualization and analysis of this digitized sound can be done in software such as Sonobat (Joe Szewczak), Scan'r (Binary Acoustic Technology), BatSoundPro (Pettersson Elektronik), Songscope (Wildlife Acoustics), etc. The three above-listed bat detectors record in real-time; in the not too distant past, full spectrum recordings employed time expansion, a way of slowing down the sound to hear or record, causing periods of 'deafness' during the recording down-time. Technological advancements now allow for real time direct digital recordings, although time expansion units are still available (e.g. Pettersson D240x, D1000x). The main disadvantage of recording full spectrum is that sound files are very large (1-2 megabytes per bat pass). Most full spectrum detectors provide an option for compressing the wave files during recording, but when uncompressed during downloading, memory demand remains high.

Zero-crossing bat detection, specifically the Anabat detector (Titley Electronics), works by counting each time a sound wave passes the *zero point* (imaginary line drawn through the middle of a sound wave); at a preset number of crossings (called Division Ratio, often 8 or 16), a time measurement is made (allowing frequency to be recorded). This provides a time-frequency output of the ultrasound, recording only one frequency, the most intense one. As such, only one harmonic is displayed at any one time, and no amplitude data are retained. The main advantage of this system over full spectrum is that file sizes are significantly smaller (2-5 kilobytes per bat pass), requiring small memory cards in detectors, short download time in the field, and storage of files does not generally require back-up hard-drives; additionally, zero-crossing detectors use less energy during operation than full spectrum units. However, the primary reason to use full spectrum over zero-crossing in some situations is that full spectrum may allow for better species differentiation given that all properties of the original sound are recorded. Unfortunately, there are currently no published studies comparing these two types of detectors' abilities to resolve species, and until this happens, it is difficult to conclude how much detail about of the original ultrasound needs to be recorded to sufficiently meet various monitoring goals.

As passive monitoring of wind development areas continues to generate extremely large datasets of files, automated identification of files (noise vs. bat and file labels indicating bat species or species groups) is being sought. Two popular software packages currently offer auto-ID options: AnalookW (for zero-crossing data) and Sonobat (for full spectrum data). Only one bat detector, the SM2Bat, produces files that can be analyzed in either software package. Auto-ID is in its infancy and does not come without a set of inherent problems: bats use ultrasound as a functional tool to navigate and find insect prey, and as such, similar sized bats in similar

environmental situations (degree of clutter) can produce similar echolocation calls, making differentiation difficult. However, used cautiously, auto-ID software can provide bat biologists with substantial time-savings by not having to view each file. Sonobat uses discriminant function analysis (DFA) and other hierarchical decisions to arrive at labels for files, while AnalookW uses filters that match pulses in files to a set of criteria that describe the shape and frequency of bat pulses. Other auto-ID software packages are on the horizon (e.g. BCID [Bat Call Identification Inc.], SongScope [Wildlife Acoustics]).