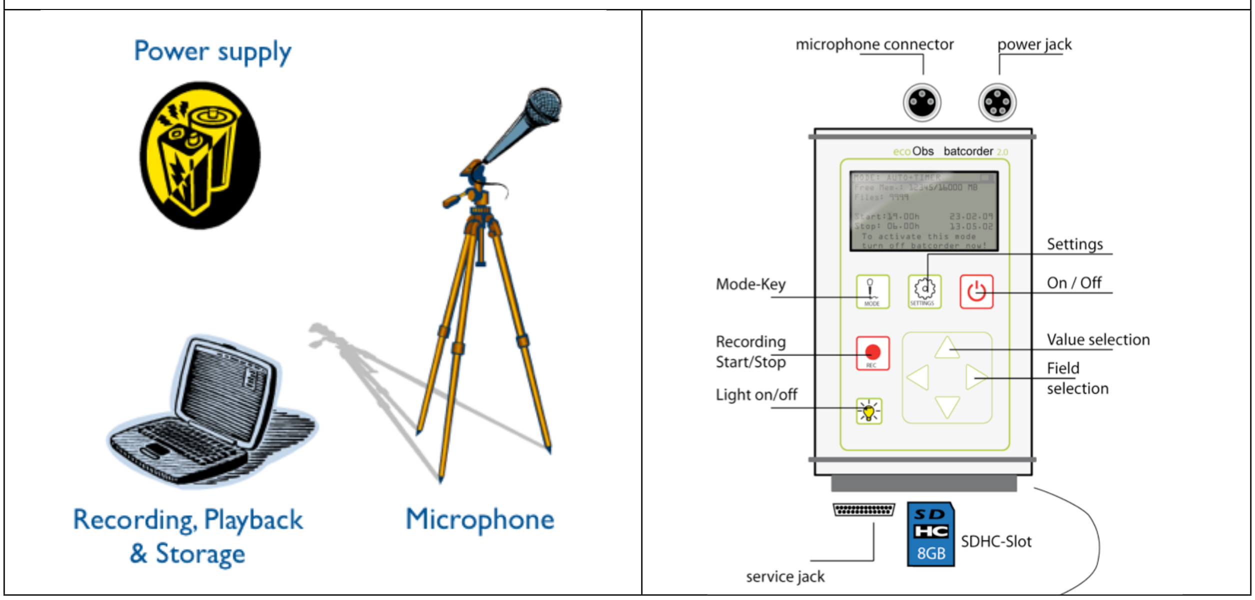
BAT DETECTORS

Bat detectors convert the ultrasonic calls of bats to sounds which are audible to humans. The main components of a bat detector are:

- Microphone: sensitive to high-frequency sounds
- Electronic circuit: converts the microphone input into a signal of lower frequency
- Playback system: either audio playback through speakers or visual through processing software
- Power supply: to power the recording and data storage devices

Connect to external recording device vs. self-contained hand-held



There are three basic kinds of microphones (also known as transducers) in bat detectors:

- Crystal: tuned to one specific frequency (typically to 40 kHz)
- Electret: permanently polarized material, analogous to a magnet; respond to a broad range of frequencies both within and above the range of human hearing
- Condenser (capacitor): pair of conductors which which require a polarizing voltage; respond to a wide range of frequencies, typically from about 5 - 500 kHz, but some up-to 1000 kHz.
- **ALERT:** Microphones and electronic equipment generate their own ultrasonic frequencies which can affect the signal-to-noise quality of recordings!

DETECTION PARAMETERS

Like the echolocation signal of bats, bat detectors may be **Narrowband** or **Broadband**. Narrowband detectors respond at any time to a small range of frequencies -- they are limited either by the electronic circuit or because their microphones are sensitive to just one frequency. Microphone-restricted "leak detectors", originally marketed as devices for detecting leaks in high-pressure gas lines, are typically sensitive to sounds at 40 kHz. They can be appropriate for eavesdropping on the echolocation signal of any bat that broadcasts at the same frequency . . . but won't be appropriate for Jamaican bats, which echolocate at frequencies ranging from as low as 16 kHz to at least as high as 180 kHz.

Other narrowband bat detectors consist of a broadband microphone (either Electret or Condenser), and use circuits that allow the user to tune-in to one specific frequency at a time. Many models can be tuned from 10 to 250 kHz. The main drawback to this kind of narrowband detector is that one can listen to just one frequency at a time. This system is often called "Heterodyne" listening and recording: **Heterodyne = Narrowband**.

Pettersson D1000X
Heterodyne set for 50 kHz (blue)
Broadband Sampling Rate 384 kHz (yellow)
Toggle enables quick switch-over

Broadband detectors, in contrast, can scan simultaneously the entire frequency spectrum for which they are programmed. This offers the greatest flexibility because it allows for simultaneous eavesdropping on the full complement of bats in an area. Broadband detectors usually have the capacity to switch between broadband and heterodyne detecting.

To listen to or analyze ultrasonic recordings, the frequencies must be converted to audible human hearing range. **Frequency Division (FD)** means the incoming signal is divided by a constant factor selected by the detector's user. For example, FD-10 will convert a 40 kHz bat call to 4 kHz and 50 kHz call to 5 kHz. A good detector will offer several FD settings, so you can tune the detector to what sounds "best" to your hearing. The shape of the FD-transformed signal closely follows that of the original signal.

Another way to convert an ultrasonic signal into audible hearing range is to replay the recording at a slower speed, to stretch-out the signal in time: "**Time Expansion**" will reveal the greatest detail of a sound . . . but will drive you nuts in the field because it will be out-of-sync with the bat you see flying past (unlike FD, which "chirps" in-sync with a passing bat).

In the old days (1990s!), the output from microphones was recorded onto cassette tape recorders for further analysis or review. With improving technology, the output from microphones is now saved electronically, onto storage media such as CF/SD cards or onto a computer hard drive. But be warned: a 1-minute uncompressed **Broadband (= Full Spectrum)** *.WAV file can contain up-to 50 MB of data. Continuous recording for a night could generate > 10 GB of data from a single detector!

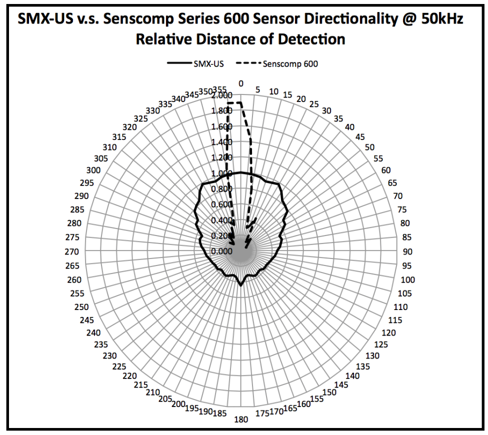
WHICH DETECTOR IS BEST[1] ?

The simple answer: What do you need to do? And where will you be doing it?

Your choice of bat detector will depend upon the use you plan for it and your budget.

Questions to explore include:

- What is the frequency range of the species you anticipate encountering? If you were in Canada, a detector with a "Sampling Rate" of 192 kHz (which records to a Maximum Frequency of 96 kHz) is more than adequate. In the tropics (incl. Jamaica), you need a detector with a Sampling Rate of at least 300 kHz (Max. Freq. 150 kHz) if you want to collecting recordings of species in the families Phyllostomidae and Natalidae.
- What is the "Call Quality" of recordings? Are higher frequencies or lower-decibel (weak) segments of a call systematically missing from the recordings? Is the signal : noise ratio poor? Does this actually affect your ability (or that of your auto-detection software) to identify a species?



- What is the "Detection Distance" of the detector's microphone? Is it an omni- or uni-directional microphone?
- Are you planning to conduct behavioural, bio-acoustic, dynamics-of-flight, etc. research?
- Do you need to leave a detector unattended, subject to weather, guano (e.g., inside a cave), etc. during a recording session?
- How long does a recording session need to last (power source and power consumption!)?
- What is the manufacturer's Custom Service record?
- The NASA question: does 1 expensive or 5 cheaper models enable you to best fulfill the mission?

BAT DETECTORS (MANUFACTURERS):

AnaBat (Titley Scientific, Ballina, NSW, Australia): www.titley-scientific.com
BAT (Binary Acoustic Technology, Tucson, AZ, USA): www.binaryacoustictech.com
Avisoft UltraSoundGate (Avisoft Bioacoustics, Berlin, Germany): www.avisoft.com
Batbox Duet (Batbox, Ltd, Steyning, UK): www.batbox.com
Batcorder (ecoObs, Nürmberg, Germany): www.ecoobs.com
Batlogger (Elekon AG, Lucerne, Switzerland): www.elekon.ch/en/batlogger/products/
D500X / D1000X (Pettersson Elektronik AB, Uppsala, Sweden): www.batsound.com
Song Meter / Echo Meter (Wildlife Acoustics, Inc., Maynard, MA, USA):
www.wildlifeacoustics.com

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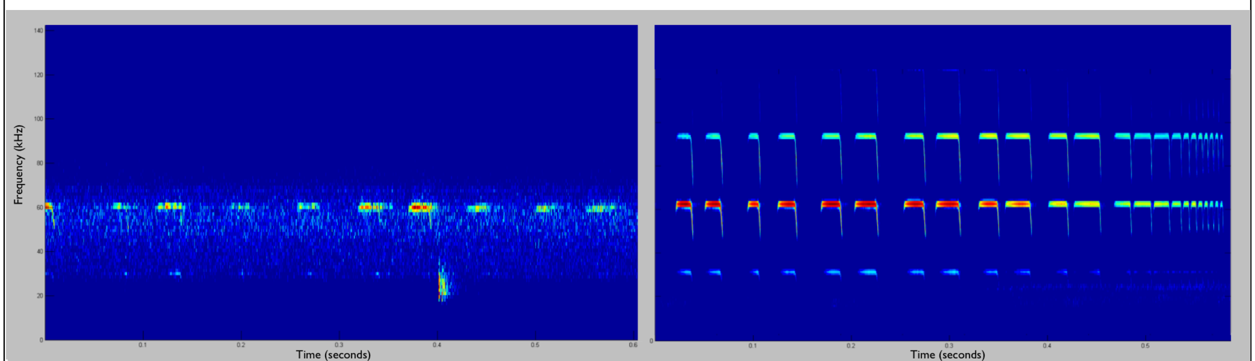
[1] A useful starter reference is:
Adams, A. M., M.K. Jantzen, R.M. Hamilton, and M.B. Fenton. 2012. Do you hear what I hear? Implications of detector selection for acoustic monitoring of bats. *Methods in Ecology and Evolution: 2012 (3):* 992-998.

EXAMPLES OF BAT DETECTOR COMPARISONS

<table>
<tr><td colspan="2">Microphone Quality Comparison:
Parnell's Mustached Bat @ distance ~ 5 m at Windsor, Trelawny</td></tr>
<tr><td>Wildlife Acoustics SM2BAT-384kHz logger (USD 850) with SMX-US omni-directional, Electret microphone (USD 150)</td><td>Avisoft UltraSound CM16/CMPA uni-directional, Condensor microphone (USD 4,000 with UltraSoundGate interface (USD 2,000) [+ laptop required]</td></tr>
<tr><td colspan="2">
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From Adams *et al*. (2012): In a field comparison of Hoary Bats (*Lasiurus cinereus*) in Canada, wild bats flew past test microphones 26 times, with a minimum of seven consecutive calls per pass. Avisoft, Batlogger, and Songmeter all recorded the full number of passes; AnaBat and Batcorder failed to detect two of the 26 passes. Avisoft detected more calls than any of the other detectors: using Avisoft data as the baseline, Batcorder, Songmeter, and AnaBat detected fewer than 50% of the calls in the passes which Avisoft detected.

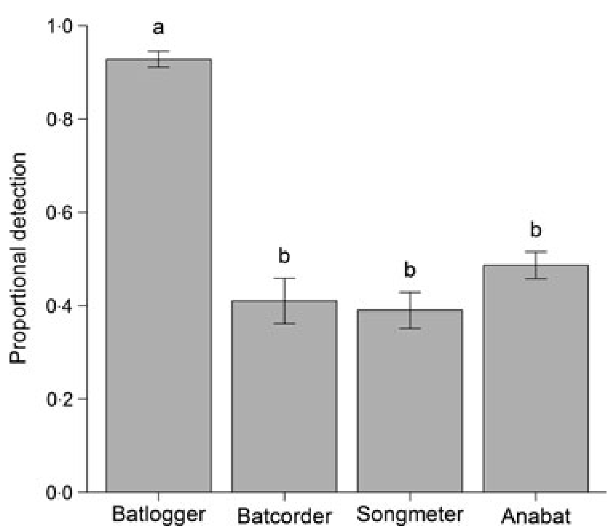

Fig. 4. Mean number of calls ± SE per pass relative to Avisoft for each bat detector from recordings of free-flying *Lasiurus cinereus* on three nights. Batlogger detected more calls than any of the other systems (detectors with the same letter superscript were not significantly different from each other).