

# FIELD RECORDING EQUIPMENT

## OVERVIEW

Recording birds, frogs, mammals, insects and other natural sounds can be very challenging and rewarding. The proper selection of field recording equipment will help you make the most out of every recording opportunity and will probably save you time and money in the long run. Equipment choices are very limited due to the specialized requirements of natural sound recording work. Issues surrounding the choices have to do with quality, specific application, durability, ease of operation and last, but certainly not least, the cost. Suitable formats for use in natural sound recording include cassette, open-reel and digital systems. Microphone systems include the shotgun and the parabolic reflector. The following sections provide details on the options available to the field recordist based on our in-house testing and extensive field experience. Hyperlinks to Manufacturers and Vendors are provided if you desire additional information.

Topic Quick Finder:

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Digital R-DAT MiniDisc (MD) MiniDisc (Hi-MD) Hard-drive Solid-State	Infrasonic Hydrophones Bat Detectors		Speed Accuracy Protective case Reading List Vendors Additional info

## RECORDERS

### Analog Cassette

These popular devices are widely used for recording birds and natural sounds. Among the cassette recorders we have tested that are appropriate for natural sound recording are two machines manufactured by the [Sony Corporation](#) and one machine manufactured by the [Marantz Corporation](#).

Sony currently offers one monaural machine, the TCM-5000EV (\$479.00) and in limited quantities one stereo machine, the TC-D5Proll (\$1175.00).

The TCM-5000EV mono machine features a third head that serves as a playback/monitor head. This feature allows the recording to be monitored as it is being created which can

assist the user in determining the quality of the recording. The recorder has a somewhat limited high-frequency response that falls off rapidly above 10.0 kHz. The electronic design of the recorder dictates the use of Type I tapes only. It also offers a good built-in playback speaker. Input/output connectors utilized are 3.5mm mini-jacks that are not very durable for field use. The response time of the VU meter is quite slow which makes it highly inaccurate for most natural sound recording work.

The TC-D5ProII stereo machine is a solid performer that offers considerably better high frequency response that is usable up to roughly 15.5 kHz. The recorder has the ability to record on cassette Type I, II, & IV tapes. This unit also has adequate VU meters, an additional peak level indicator light and a small internal monitor speaker. Input connections are made via professional 3-pin XLR style connectors and output connections are RCA phono jacks. This machine is a two-head version that does not permit off-tape monitoring while recording.

Marantz offers a monaural machine, the PMD-222 (\$402.00)

The PMD-222 mono recorder features a third head that serves as a playback/monitor head. This allows the recording to be monitored as it is being created which can assist the user in determining the quality of the recording. Type I, II, & IV cassette tapes can be used with this machine. The recorder also includes a reasonably good VU meter and a peak level indicator light. A professional 3-pin XLR style connector is used on the microphone input and the output connections are made via RCA phono jacks. High frequency response is usable up to about 14.5 kHz. This unit also includes an internal playback speaker.

The choice between the mono recorders is fairly straightforward. The Marantz PMD-222 performs (records) much better than the Sony TCM-5000EV however, if the recorder is to be used for serious playback work the user will probably find that the Marantz speaker is not adequate for the task. One must consider adding an external powered speaker such as the [Radio Shack](#) model 277-1008 to equal what the Sony TCM-5000EV's speaker can provide.

When evaluating various models there are certain capabilities to consider. One of the most important features to look for is a manual record level control. The automatic level control (ALC) that is found on many portable cassette recorders is very handy for dictation but is totally ineffective for recording natural sounds. Machines that support Type II or Type IV tapes will also do a better job than machines that can only support Type I tape. Type II & IV tapes offer better high-frequency response, lower distortion and better signal-to-noise ratios. Noise reduction systems, such as Dolby or DBX, although a benefit for music and voice recordings will not work well for recording natural

sounds. While these systems certainly will reduce tape hiss, they can also add distortion, breathing, pumping and limit the amplitude of the higher frequencies of many bird vocalizations. If you require the ability to play back sounds in the field, you will want to consider a machine that offers a built-in speaker. The decision between stereo and mono is governed by the uses you have for your recordings. For most bird recording work, stereo might be an unnecessary complication. However, if you are interested in recording ambient environmental sounds, or want the ability to discern individuals that might be calling simultaneously, then a stereo machine is preferred.

## **RECORDERS**

### **Analog Open-Reel**

The open-reel recorder was until recently one of the top choices of the seasoned professional field recordist. Although now being displaced by newer, lightweight, high-resolution digital systems many of these machines are still in use. The advantages are sheer durability, fidelity, long battery life, immunity to humidity-related problems, and accuracy. The disadvantages are generally weight, higher cost and frequent tape changes. Three companies, [Nagra](#), [Uher](#) and [Stellavox](#) manufactured portable audio open-reel recorders suitable for natural sound recording work. To the best of our knowledge only the Nagra and Stellavox are still currently available. Nagra offers a stereo machine (Nagra IV-S) that costs about \$14000.00. Stellavox offers the SP-9 for about \$5000.00-\$7000.00 depending on head block configuration. Good used machines can often be found at substantial savings. Our experience has shown that the Nagra is the most durable tape recorder that one can purchase. They simply do not fail. The Lab has 25-year old Nagra's that are still in regular service. One other important factor to consider is the availability of open-reel tape stock. Current market trends are favoring digital recording devices, however there is still one analog tape manufacturer [Quantegy, Inc.](#) offering stocks for these portable machines.

## **RECORDERS**

### **Digital**

#### **R-DAT**

The R-DAT (Rotary-head Digital Audio Tape) format while quite popular in the mid 1990's is slowly disappearing from the market place. Very similar in design to a VCR (video cassette recorder) only much smaller this device uses a R-DAT cassette tape which measures 2 7/8" x 2 1/16" x 3/8". A variety of lengths are available which permit continuous recording or playback for up to two hours. This linear PCM-based (un-compressed data) recording system offers very ultra-low distortion levels and is immune to speed errors, tape noise (hiss) and non-linear frequency anomalies (within its usable bandwidth) which is typically 20Hz-22kHz.

Portable R-DAT recorders are small and relatively lightweight making them very easy to carry around in the field. Features include real-time tape counters, the ability to stamp the current date and time on the tape automatically (available on certain models only) and a built-in indexing system which allows the operator to mark and quickly access the starting points of up to 99 selections. Professional models also offer low frequency filters, 48-volt phantom powering for microphones and incorporate high-quality microphone preamps.

Although it appears from the above information that R-DAT is the answer to all field recording problems and needs, there are problems and pitfalls that one should consider before purchasing an R-DAT machine.

1. Most of the inexpensive digital recorders being sold today do not allow off-tape monitoring (the ability to monitor a recording as it is being created). Read-after-write, or confidence playback heads, are not commonplace therefore recording problems cannot be detected during the recording process.
2. R-DAT is not a very robust tape format. R-DAT systems utilize a very narrow tape that is only 3.81 mm wide. Their extremely slow linear tape speed coupled with a rapidly spinning head assembly writes the data on the tape in a very compact form. Dirt, dust or foreign debris that migrates into the machine can potentially cause recording problems. The R-DAT recorder has built in error correction circuitry that does help offset many recording errors, however, very large errors can cause signal drop-outs or complete mutes. Needless to say these problems could render a recording useless.
3. R-DAT recorders are not the most reliable units for operation in very high humidity (condensing) environments. Most R-DAT recorders have a "dew" or humidity sensor built in which shuts the machine down whenever high humidity is detected. Recording in the tropics or rainforest could therefore render the machine useless unless proper precautions are taken.
4. Some R-DAT machines utilize non-standard rechargeable NiCad or NiMH batteries. The typical recorder will operate for approximately two hours per battery charge. This means many rechargeable packs must be carried and kept charged to allow for lengthy recording trips. Other possible means of powering are available from sealed rechargeable lead-acid batteries (described in a later section), or standard drycell packs which can be adapted to work on certain machines.

Nonetheless, the features of the R-DAT recording systems are simply too great to be ignored.

The price range on currently manufactured portable R-DAT machines is between \$795.00 and \$3390.00. Listed below are the units we have field-tested.

[HHB](#) PDR-1000 PORTADAT \$2790.00 (production discontinued 10/2000)  
This rugged professional machine offers read-after-write capability, date and time stamping, low frequency filters, phantom powering and an internal playback speaker. High resolution backlit metering is provided. Professional 3-pin XLR style connectors are utilized for microphone inputs and RCA phono jacks are used for outputs. Digital input and output capabilities are provided. Field powering is accomplished by proprietary, internal, rechargeable NiMH batteries, or via 12 volt DC external supply. A standard 4-pin XLR power connector is provided.

[Tascam](#) DA-P1 \$1638.00  
This is the lowest priced professional recorder built for serious fieldwork. It does not offer read-after-write capabilities or low frequency filters, however, it does provide 48 volt phantom powering for microphones. A good high-resolution backlit meter is provided. Input connectors are professional 3-pin XLR style and RCA phono jacks are used for the outputs. Digital input and output capabilities are also provided. Field powering is accomplished by proprietary, internal, rechargeable NiCad batteries, or via DC external supply, however a special power connector is required.

[Sony](#) TCD-D10ProII \$3390.00  
This rugged machine does not offer read-after-write capabilities, low frequency filters or phantom power. It does offer excellent backlit metering as well as date and time stamping on the tape. A small internal speaker is also provided. Input connectors are professional 3-pin XLR style and RCA phono jacks are used for the outputs. Digital input and output capabilities are provided but require an optional specialized cable assembly. Field powering is accomplished by proprietary, internal, rechargeable NiCad batteries, or via DC external supply, however a special power connector is required.

[Sony](#) PCM-M1 \$795.00  
This small pocket sized recorder is a pro/consumer device that was not designed for the daily rigors of field use, but will perform well in the field if handled with proper care. It does not offer read-after-write capability, low

frequency filters or phantom powering. Input and output connectors are 3.5mm stereo mini-jacks that are not very robust. Backlit metering and automatic date-stamping on tape are provided. No internal speaker is provided so all monitoring must be done via headphones. Digital input and output capabilities are provided but require an optional specialized cable assembly. Field powering is accomplished by AA batteries, or via DC external supply, however a special power connector is required.

## **RECORDERS**

### **Digital**

#### **MiniDisc (MD)**

Over the past couple of years we have received many inquiries regarding the use of MiniDisc (MD) recorders for fieldwork. Standard MD recorders utilize an audio compression algorithm known as ATRAC (Adaptive TRansform Acoustic Coding) that is based on psychoacoustic principles. The input signal is divided into sub-bands that are then transformed into the frequency domain using a variable block length. Transform coefficients are grouped into non-uniform bands to reflect the human auditory system, and then quantized on the basis of dynamic sensitivity and masking characteristics. ATRAC compresses compact disc audio (16-bit 44.1 kHz stereo) to approximately 1/5 of the original data rate with minimal loss in sound quality. This technology permits 74+ minutes of stereo sound to be recorded on a small 64mm optical disc.

Audio compression distorts sound, but in such a way that humans normally can't detect. The compression method used in MD recorders has frequency and timing constants built-in that are intended to make the compression inaudible to human ears, but which may make it audible to other species. For instance, humans can't hear a sound at a certain frequency if there is another, louder sound at a nearby frequency, so the compression algorithm will leave out the former sound. We can't hear the difference, but it's possible other species might and any scientific analysis of the compressed sound would have to work with a distorted version. Additionally, compression algorithms typically can't track very fast changes in overall loudness correctly, since humans can't hear such changes very well. Other species (e.g. many songbirds) do have significant variation in amplitude over very short time periods in their vocalizations. If you try to record such species with a MD, you'll likely introduce some distortion.

We tested a popular early-entry portable field machine that utilized ATRAC 2 and found it to be unacceptable for natural sound recordings especially recordings that might be subjected to scientific analysis.

Newer machines that utilize ATRAC 3.5 & 4.5 versions are considerably better. When

recordings made on these machines are compared to similar recordings created by high-quality analog cassette recorders the results typically favor the MD version. The total lack of tape hiss, wider frequency bandwidth of the MD system, and lower overall distortion levels all contribute to favoring the MD. Low-level high-frequency information that the MD ATRAC system might have masked would have been buried in tape hiss on the analog cassette version so frequency masking is not an issue when these two formats are compared.

Two popular current generation MD recorders are the HHB PORTADISC MDP500 (\$1399.00), and the Sony MZ-N10 (\$345.00).

The HHB unit is a professional, rugged, field device that utilizes ATRAC version 4.5. It features XLR style microphone input connectors, 48-volt phantom power, low frequency filters, 6-second pre-record buffer, 40-second memory buffer to prevent glitch-free recordings, large backlit metering display, and a USB port for up/downloading audio data files directly to both Macintosh and Windows computers. Both optical and coaxial digital inputs and outputs are provided as well as analog line outputs. Field powering is accomplished via rechargeable NiMH, standard AA alkaline batteries, or via 12-15-volts DC external power.

The Sony unit is a small compact Walkman style device that utilizes ATRAC DSP-Type-S. It features a small, but useful backlit display and manual record level control. Skip-free "G" protection is provided as well as date/time stamping. Microphone inputs and headphone connectors are 3.5mm stereo mini-jacks. Field powering is accomplished via standard alkaline AA style or re-chargeable batteries.

## **RECORDERS**

### **Digital**

#### **MiniDisc (Hi-MD)**

Exciting news on the portable recording scene in January 2004 is the Hi-MD. The Hi-MD is nearly a complete revamping of the original MiniDisc system. Several significant changes include the Hi-MD media (a new 1.0GB disc), and the ability to record in a linear PCM (uncompressed data) format. These both are important factors for individuals recording natural sounds. No longer are we constrained by the ATRAC coding algorithm (although it is still an available recording format choice). Additionally, the 1.0GB disc capacity can yield an impressive 1-hour/34 minutes of stereo recording time. Using Sony's new improved ATRAC 3plus coding @256kbps will render 7-hours/55 minutes of recording time per disc.

As with all new technologies, machine choices are very limited. The Sony MZ-NH900 (~\$300.00) is a small Walkman style machine. Microphone and headphone connections utilize 3.5mm stereo mini-jacks. Digital record level is provided as well as a small, but useful backlit display for metering. Anti-skip “G” memory buffer is also employed. A USB port is on-board for off-loading digital audio files directly to a Windows based computer. The caveat is that only audio files that were originally recorded via the analog microphone or line inputs can be digitally transferred via the USB port. Audio captured via the digital inputs cannot. Field powering is accomplished via NiMH rechargeable or standard alkaline AA style batteries.

## **RECORDERS**

### **Digital**

#### **Hard-drive**

Relatively new on the portable digital recording scene are the hard-drive audio recorders. These easy to use devices utilize specially formatted, rugged computer hard-drives (typically 40GB or greater) for storage. The digitized audio is simply stored as data files on the disk making random access very easy. While a few multi-channel devices have been available for some time ([Zaxcom](#)- Devall, [HHB-PORTADRIVE](#), and the [Aaton-Cantar-X](#)) the market place has been void of simple two & four channel units. [Sound Devices, LLC](#) is introducing in the 2nd quarter of 2004 two new audio recorders, models 722 and 744T. They are being marketed as the next logical successor to the time-code and portable R-DAT machines.

The model 722 (~\$2000.00) is a high-resolution 2-channel recorder. It will feature high-resolution A/D and D/A converters, high-quality microphone preamps, active-balanced XLR style microphone inputs, 48-volt phantom power, high-pass filters as well as real-time post-record monitoring. A user adjustable pre-record buffer is provided to eliminate missed takes. A large backlit display for metering is viewable in all lighting conditions. Digital inputs and outputs are available via either TA3 or BNC connectors. Multiple sampling rates are supported including 44.1, 48, or 96kHz. Selectable bit-depths are either 16 or 24. Recording format is un-compressed linear PCM. A 40GB field removable/replaceable hard-drive is standard. External data interface is via a 1394 (Firewire 400) port. Field powering is accomplished via removable Lithium Ion rechargeable batteries, or via external 5-18 volts DC. External powering requires a 4-pin Hirose connector.

The model 744T (~\$4000.00) shares many of the above features except it offers 1,2, or 4 channels of recording plus an additional time-code track. Additional sample-rates are also standard to conform to the needs of the video/film user.

## RECORDERS

### Digital

#### Solid-state

These recorders are relatively new to the portable audio recorder scene. They offer many of the features currently available on cassette, R-DAT, and MiniDisc recorders, but instead of tape or disc, they utilize standard computer compact-flash memory cards or a Microdrive as storage medium.

Most units offer several recording format choices such as, MPEG1 Layer II & Layer III compression (commonly known as mp2 & mp3), and 16-bit linear PCM. For high-quality, natural sound recording, and to avoid data compression the latter must be used. Due to the increased data rate that linear PCM generates relative to compressed formats one must carefully select the appropriate sized storage for their specific application. For example a 512MB flash card will store roughly 7 hours of mono material using the mp3 format @160kbps data rate. Whereas the same 512MB card will only be able to store roughly 1 hour/36 minutes of mono material in the linear PCM mode utilizing a sample rate of 44.1kHz.

Currently, flash cards are available in a variety of sizes ranging from 32MB-1024MB. Microdrives can extend the capacity even further. Although large memory cards and Microdrives are somewhat expensive right now, this is a growing industry and prices will continue to drop.

The real beauty of this recording device/format is the ability to create high-quality recordings stored short-term in a robust format with no moving parts. These can be easily edited within the device and instantly downloaded into a computer for detailed analysis, or perhaps to create compact discs for longer-term storage.

One such device the [Marantz](#) PMD-670 \$695.00 w/64MB card

This device offers many of the same professional features included on other industry standard recorders. Including balanced XLR style microphone inputs, 48-volt phantom power, noise filters, internal speaker, 2-second pre-record buffer, one-touch record, and a large backlit display for metering. Digital audio in/out is accessible via RCA connectors (S/PDIF format). Line level audio in/out is unbalanced via RCA connectors. Available data/sampling rates range from a low of 32kbps/mp2 through highest quality at 48kHz/16-bit linear PCM. Audio files are easily transferred directly into a computer by simply placing the recorded card or Microdrive into a computer attached card reader. Additionally, a computer data interface is provided that can communicate with a standard USB compatible port on either Macintosh or Windows based platforms. Field power options include removable, NiCad or NiMH rechargeable batteries, or 8-standard

AA alkaline batteries.

A slightly different variation is the new offering from The [Fostex](#) Corporation.

Announced in January 2004 is the introduction of the FR-2 Field Recorder (\$1499.00 without time-code option or storage media). This is the first solid-state field recorder to offer up to 192kHz sampling 24-bit operation, making it an ideal choice for recording situations that demand the highest quality, un-compressed data format possible.

The machine features a 10-second pre-record buffer, balanced microphone inputs via standard XLR style connectors, 48-volt phantom power, generous sized LCD display for high visibility in the field, and a tough rigid housing to withstand the rigors of field use. Of particular note is the “file per take”, and “auto take naming” systems to help organize and manage sound files within the device.

Recording media supported are PCMCIA: compact-flash or ATA Flash card, and ATA type hard disk. Sampling rates supported from 22.05kHz-192kHz. Bit depths of either 16 or 24. Full SMPTE time-code is also an option. Field powering is via 4xAA style batteries (NiMH recommended). The unit can also be powered externally via 12-volts DC with (special connector required).

File transfers to either Mac or PC are easily accomplished via standard on-board USB connection. Digital audio I/O is via XLR connectors in both the AES/EBU and S/PDIF formats.

## **MICROPHONES/TRANSDUCERS**

### **Overview**

Along with a recorder you will need a microphone or transducer. The scope of this document is limited to 4-basic sound categories: audible range (20Hz-20kHz), ultrasonic (30kHz and higher), infrasonic (below 15Hz), and underwater sounds.

In the audible range category there are many brands of high-quality microphones available – [Sennheiser](#), [Shure](#), and [Audio Technica](#) just to name a few. We have tested, and are currently using, the Sennheiser line of microphones. They have proven to be extremely durable, exhibit very low self-noise figures, offer high output, and depending on the particular model selected, are almost completely immune to high humidity related problems.

Capturing ultra-high frequency sounds such as those created by Bats requires the use of a specialized transducer known as a Bat detector. These devices convert the ultra-high

frequency sounds down to a frequency range that can be heard as well as recorded. Capturing underwater sounds also requires the use of another specialized transducer type, the hydrophone. These specialized devices are covered in detail in later sections.

There are two types of microphones that are directional enough for natural sound recording at a distance, the shotgun microphone and the parabolic reflector microphone. To better understand the relative utility of different microphones and parabolas we have compared their beam-width (angle of acceptance) to the field-of-view of lenses commonly used on 35mm cameras. This comparison is approximate and assumes that the frequency of interest is around 2500 Hz. If the frequency of the sound is lower, a larger parabola is required for equal performance.

<u>Microphone Type</u>	<u>Diameter</u>	<u>Lens Size</u>
Parabola	12"	75 mm
Parabola	18"	100 mm
Parabola	24"	135 mm
Parabola	36"	200 mm
Short Shotgun		20 mm
Long Shotgun		28 mm
Cardioid (unidirectional)		(fish eye) 8-15 mm
Omni-directional		n/a

## **MICROPHONES/TRANSDUCERS**

### **Shotgun**

A good inexpensive shotgun microphone system for general use is the Sennheiser ME-66/K6/MZW66 combination. The cost of this system is about \$470.00. This modular system is the combination of the K6 power unit (requires one AA battery), the ME-66 shotgun microphone capsule and the MZW-66 foam windscreen. An additional feature of this modular system is the K6 power module can also be outfitted with another capsule the ME-67/MZW-67 that is a slightly longer, more directional shotgun capsule with windscreen.

The top-of-the-line Sennheiser shotgun microphones are the MKH-60 and the MKH-70 with the latter being the longer, more directional of the two. The MKH series microphones offer almost total immunity to high humidity related problems, exhibit extremely low self-noise, and offer very flat frequency response over the usable bandwidth. Their high sensitivity requires special shock-mounting and wind protection to make them suitable for handheld field use. Coupled with a Zeppelin style windscreen and a good shock mount the MKH-60 sells for about \$1950.00 while the MKH-70 sells for about \$2200.00.

The entire MKH series of microphones require 48-volt phantom power to operate. This

48-volt power can either be supplied by an external power-supply or by the recorder if it is so equipped. External power units include the Sennheiser MZA-14 which sells for \$400.00, the [Stewart Audio](#) BPS-1 which sells for \$125.00 and the [PSC](#) Universal Mic Supply which sells for about \$290.00. Both the Sennheiser and the PSC models also include dual position, low frequency filter and signal attenuation switches.

## **MICROPHONES/TRANSDUCERS**

### **Parabolic Reflector**

The parabolic reflector system is the combination of a reflector dish, typically between 13" and 36" in diameter, and a microphone. The microphone is positioned in the focal point region of the reflector (the area where all the collected sound is concentrated). Parabolic reflectors, by design, yield a tremendous increase in sensitivity without any added electronic noise. Microphones suitable for use in parabolic reflectors range in price from \$300.00-\$1200.00, with the more expensive units yielding flatter frequency response, improved signal-to-noise ratios and higher signal level overload capabilities.

Listed here are some of the different reflectors manufactured.

1. The [Telinga](#) Pro parabolic reflector is a clear, lightweight 22" reflector available in several models that include integral high-quality microphones, or as the Telinga Universal model that is designed to accept other manufacturer's microphones. All of these models offer excellent rejection to handling noises and can be completely disassembled for easy transport.
2. The [Mineroff Electronics](#) SME-PR-1000 (\$375.00 without microphone) is an 18" epoxy coated aluminum reflector that includes a pistol grip and adjustable microphone mount. It also offers a transparent viewing window at the center of the dish to assist in aiming. This reflector, coupled with an inexpensive microphone is a perfect starter system for low budget applications.

For the do-it-yourselfer, one can purchase high quality 24"-36" spun aluminum reflectors that are designed and sold as satellite receiving antennas. These units are perfectly acceptable; however, they are not supplied with a microphone or microphone mounting hardware. One can easily create a mounting system with aluminum bar stock that is readily available from most hardware stores.

Contact:           The Antenna Center, 505 Oak Street, Calumet, MI 49913. Phone 906-337-5062, Fax 906-337-5030.

## **MICROPHONES/TRANSDUCERS**

### **Omni-directional**

Even though omni-directional microphones pickup from all directions they can provide excellent results when used in the right situations. For example, positioning an omni near a bird's song perch can yield fantastic recordings in part due to the close proximity of the microphone to the bird (greatly reduces ambient background sounds), but also because it doesn't matter too much whether the bird is singing directly into the microphone or changing directions on the perch. The detail captured will be amazing. Other applications for omni microphones include using them in a parabolic reflector, or in stereo pairs for undertaking acoustic census work and general environmental recording.

The Sennheiser K6/ME-62 (\$360.00) omni-directional modular microphone system is a relatively low cost option. This is especially true if one already owns a K6 power module from the Sennheiser modular shotgun system. An accessory windscreen MZW-64 is recommended.

The high-end omni-directional microphone is the Sennheiser MKH-20 that sells for about \$1170.00. Just like other members of the MKH series, the MKH-20 is almost totally immune to high humidity related problems. They also exhibit extremely low self-noise, and offer very flat frequency response over the usable bandwidth. Their high sensitivity will require special shock-mounting and wind protection to make them suitable for handheld field use. 48-volt phantom powering is required.

## **MICROPHONES/TRANSDUCERS**

### **Uni-directional**

Uni-directional microphones (commonly known as cardioids or hyper-cardioids) feature a directional pickup pattern. This means that the device is most sensitive towards the front of the microphone, slightly less off to the sides, and has the least sensitivity from the back of the unit. This directivity can be used to ones advantage. For example, by positioning the backside of a cardioid microphone towards an unwanted noise source one can significantly reduce the level of the offending noise relative to the sound of interest. This feature can often help when recording in indoor locations such as aviaries, research cages, and observation booths. A pair of cardioid microphones can also be used to do stereo environmental recording where directionality is required.

The Sennheiser K6/ME-64 (\$380.00) cardioid modular microphone system is a relatively

low cost option. This is especially true if one already owns a K6 power module from the Sennheiser modular shotgun system. An accessory windscreen MZW-64 is recommended.

The high-end cardioid microphone is the Sennheiser MKH-40 that sells for about \$1170.00. Just like other members of the MKH series, the MKH-40 is almost totally immune to high humidity related problems. They also exhibit extremely low self-noise, and offer very flat frequency response over the usable bandwidth. Their high sensitivity will require special shock-mounting and wind protection to make them suitable for handheld field use. 48-volt phantom powering is required.

## **MICROPHONES/TRANSDUCERS**

### **Infrasonic**

The recording of infrasonic (ultra-low frequency) sounds requires the use of a specialized microphone. Some of the available models are relatively expensive “instrumentation” grade devices that are designed for noise and vibration analysis. These generally offer performance down to roughly 1.0Hz and include models from [Larson Davis](#) and [Bruel & Kjaer](#). There is however an affordable, high-quality solution providing you aren’t trying to capture sounds much below 4.0Hz. The [Earthworks](#) model QTC-1 is a high-performance, low-noise omni-directional microphone that is usable down to 4.0Hz  $\pm$  1.0dB. It utilizes standard 48-volt phantom power and terminates in a standard 3-pin XLR style connector.

## **MICROPHONES/TRANSDUCERS**

### **Hydrophones**

For underwater recording the [DolphinEAR/Pro](#) (\$299.00) is a high quality, low cost solution. The omni-directional device features a 10-meter cable (other cable lengths are optional), 600 ohm balanced output that terminates with a standard 3-pin XLR style connector, and a frequency response of 15Hz-20kHz  $\pm$ 3dB. The transducer is a high-output MPC (Piezo) style, fully encapsulated in a rugged epoxy case. No power is required.

## **MICROPHONES/TRANSDUCERS**

### **Bat Detectors**

Bat detectors provide a relatively inexpensive means of listening to and recording Bat vocalizations. These ultra-sonic signals are way above the range of human hearing and general use audio recording equipment. The Bat detector electronically converts the ultra high-frequency sounds down into the range where humans can hear and audio recorders can capture. There are many, many models on the market. Our hands-on field

experience with a Laar model BB-XL detector, coupled to an R-DAT machine has produced stunning results.

A special thank you to Karsten Passior [passior@nexgo.de](mailto:passior@nexgo.de). He has gone through enormous lengths to compile the most complete Bat detector comparison listing to date. Through his kind generosity we are able provide this in-depth comparison. The chart shown below is a subset of a much larger list of detectors. It contains detectors that are currently available as well as those recently discontinued. Practical factors like the availability of a frequency display light (LED or LCD), one or two hand operation, weight, basic noise, sensitivity, filtering technique, power requirements etc. are used to compare models.

Specifications	Laar Tranquility II	Laar-Classic NG	Laar-3 P	Laar-BB S	Laar-BB L	Laar-BB XL	Laar Explorer	Laar-PX1	ELV Bat Detector	Stag Bat Box III	Stag Microbat
Heterodyne	X	X	X	-	-	-	-	X	X	X	X
Panorama system	-	-	X	X	X	X	X	-	-	-	-
Frequency division	-	-	-	-	-	-	-	-	-	-	-
Time expansion	10 + 32 times	-	-	10 times	10 times	10 times	10 times	-	-	-	-
Storage time	1,28 s	-	-	1,5 + 2,6 s	3 + 5 s	5 + 10 s	2 s	-	-	-	-
Self scanning heterodyne system	-	-	-	memory 512 kB	memory 1 MB	memory 2 MB	memory 512 kB	-	-	-	-
Built-in loudspeaker	X	X	X	-	-	-	-	-	-	X	X
Headphone socket	X	X	X	X	X	X	X	X	X	X	X
LF output	X	X	X	X	X	X	X	X	-	X	-
HF output	-	X	X	-	-	-	-	-	-	X	-
Comment switch	-	-	-	-	-	-	-	-	-	-	-
Frequency display	digital	digital	digital	-	-	-	-	digital	analog	analog	low / high
Frequency display light	LED	LED	LED	-	-	-	-	LED	-	X	LED
Frequency range	10 - 200 kHz	15 - 150 kHz	15 - 150 kHz	15 - 160 kHz	15 - 160 kHz	15 - 160 kHz	15 - 120 kHz	15 - 160 kHz	10 - 100 kHz	20 - 120 kHz	26 / 46 kHz
Bandwidth	± 3 kHz	± 5 kHz	± 5 kHz	-	-	-	-	± 5 kHz	?	± 8 kHz	?
Bandsread	?	-	-	-	-	-	-	-	-	-	-
Band-pass filter	-	-	-	-	-	-	-	-	-	-	-
Accuracy	± 0,2 kHz	?	?	?	?	?	?	100%	?	?	?
Sensitivity	133%	133%	133%	115%	115%	115%	100%	133%	100%	100%	100%
Basic noise	low	very low	very low	low	low	low	low	very low	standard	standard	standard
Power supply voltage	4 x 1,5 V AA	2 x 9 V	2 x 9 V	2 x 9 V	2 x 9 V	2 x 9 V	9 V	9 V	9 V	9 V	9 V
Working time	?	8 h by accu	8 h by accu	8 h by accu	8 h by accu	8 h by accu	8 h by accu	8 h by accu	6 h by accu	8 h by accu	8 h by accu
Size (l x b x h) mm	155 x 90 x 48	196 x 100 x 54	196 x 100 x 54	157 x 84 x 30	157 x 84 x 30	140 x 90 x 48	120 x 67 x 32	106 x 62 x 24			
Weight	?	490 g	520 g	520 g	520 g	520 g	490 g	490 g	180 g	230 g	118 g
Handling	two hand	two hand	two hand	two hand	two hand	two hand	one hand	one hand	one hand	one hand	one hand
Accessories	-	head phone	head phone	head phone	head phone	head phone	head phone	head phone	-	-	-
Price ca.	966€	898€	1124€	1378€	1508€	1686€	827€	456€	71€	231€	101€
Vendor	2	2	2	2	2	2	2	2	2	2, 7	1, 2, 7
Notes		not available	not available	remote input	remote input	remote input	with CD-rom	with CD-rom			good for children

Bat detector vendor contacts:

1 = <http://www.juedes-ultraschall.de>

2 = <http://www.vonlaarmedia.de>

7 = <http://www.batbox.com>

## **PLAYBACK**

### **Headphones**

The ability to monitor and evaluate the quality of your recordings in the field is absolutely essential. The loudspeaker that is incorporated in the recorder (if so equipped) is not adequate because it can only be used in the playback mode. Good quality headphones allow you to monitor the incoming signal while the machine is in the record mode, thereby facilitating proper aiming of the microphone.

Another added benefit, provided the recorder being utilized is equipped with a third head, or in the case of a digital recorder either a confidence head or real-time post record monitoring, is the ability to monitor the quality of the recording as it's being created. Additionally, if there is a problem with the recorder, tape, microphone or cable, using a pair of headphones will allow you to identify the problem in the field and perhaps rectify it before the recording actually begins, rather than finding out hours, or perhaps days later that your recording was flawed.

The choice of headphones is highly personal as to style, isolation and comfort. Headphones must, however, provide an appropriate electronic match to the tape recorder thereby insuring adequate output level. The model selected should also offer some degree of isolation from ambient noises so you can listen accurately to your sound source.

A few of our favorite headphones are the following:

[AKG](#) K-240 Studio (high isolation rating and good output) \$159.00

[Sony](#) MDR-7506 (good isolation rating and high output) \$95.00

[Sennheiser](#) HD-25SP (lightweight with medium isolation rating) \$113.00

It is important to note that with many cushioned styled headphones, that certain types of insect repellents can over time disintegrate the foam cushion material. This also holds true for the foam material used on many microphone windscreens.

## **PLAYBACK**

### **Playback speakers**

We are often asked to suggest playback speakers that can be coupled to a portable recorder or a compact disc player for census/monitoring fieldwork or as a stimulus in research.

For relatively close work (under 100') the [Radio Shack #277-1008](#) (\$12.00) amplified speaker is a good inexpensive choice. It's very small, lightweight, and if not played too loudly, offers reasonably good quality sound for frequencies in the 1.0kHz-7.0kHz range. The effective radiation pattern is directional.

For slightly longer working distances, but with the added requirement of good lower frequency response, the larger, heavier [Mineroff Electronics SME-AFS](#) amplified speaker (\$185.00) offers very good sound quality over a usable frequency range from roughly 100.0 Hz-12.0 kHz. This device weighs 3-lbs. and runs off of 6-standard AA style batteries. The radiation pattern is directional.

An option for long-throw medium frequency (400Hz-10kHz) applications is the [Anchor Audio](#) model Megavox PB-35 (\$600.00). This device weighs in at only 15 lbs, yet can deliver 126dB SPL @ 1/meter. On-board 12-volt rechargeable battery provides 6-10 hours of operation. The unit offers line-level input via a standard 1/4" phone jack that can easily be fed from a cassette or CD player (RCA to 1/4" adapter available at any Radio Shack store).

For omni-directional playback, the [Soundsphere](#) models Q6, Q8 and Q15 are the recommended choices. The exact model is determined by ones specific bandwidth and power requirements.

Model	Weight	Frequency range	Max SPL	Sensitivity
Q6	8-lb.	70Hz-17kHz	103 dB	88dB SPL@ 1meter/1watt
Q8	22.5-lb.	55Hz-17kHz	114 dB	94dB SPL@ 1meter/1watt
Q15	45-lb.	35Hz-15kHz	122.5dB	97dB SPL@ 1/meter/1watt

These are not powered speakers and therefore require separate power amplifiers (see amplifier section).

## **PLAYBACK**

### **Amplifiers**

Occasionally the need arises to utilize non-amplified speakers in the field. Reasons

include having to generate higher than normal sound pressure levels for very long distance coverage, or perhaps trying to broadcast very low frequency sounds. Both of these require substantial power (watts) and large drivers (speakers). The best solution is found in the car stereo marketplace. Companies like [Crutchfield](#) offer a wide range of 12-volt DC powered amplifiers in both mono & dual channel configurations. Wattages range from roughly 40-300 watts per channel with offerings from industry leading companies like Sony, Alpine, Rockford-Fosgate, Kenwood, and US Acoustics.

## **MISCELLANEOUS**

### **Preamps**

Our fieldwork has revealed that the microphone preamps in many of the recording devices described above, although very quiet, do not always offer adequate gain under certain distant birdsong recording circumstances. High quality outboard preamps are available from several manufacturers that can help solve this problem. Another option available for the digital recording devices is to utilize a good external combination preamp/A/D converter. This offers the best of both worlds by providing not only a significant signal gain improvement, but also a dramatic improvement over the stock A/D converters found in most digital devices.

[Grace Design, Inc.](#) offers the Lunatec V3 that sells for about \$1600.00. This state of the art device is a two-channel, ultra low-noise preamp plus a high-resolution A/D converter system. It features 48-volt phantom powering, switchable high-pass filters, built-in mid/side recording matrix, and extensive metering capabilities. On the A/D converter side it handles sample rates up to 192kHz and bit depths of up to 24. Both professional and consumer digital formats are supported. Field power is supplied by an external 6 or 12-volt DC battery pack (not supplied).

[Sound Devices, LLC](#) offer two, high-performance, low-noise preamps. The MP-1 (single channel) and the MixPre (dual channel) sell for about \$420.00 and \$855.00 respectively. Both units feature switchable high-pass filters and 48-volt phantom power. Two AA batteries are required for power.

[Benchmark Media Systems, Inc.](#) offers the MicMan Jr. that sells for about \$435.00. This preamp is a high-quality, two-channel, high gain, low noise device. It does not offer 48-volt phantom power. Field powering is accomplished via a pair of 9-volt alkaline batteries.

## **MISCELLANEOUS**

### **External Power**

Many of the newer digital recording systems are quite power hungry. This factor coupled

with the short running time offered by factory supplied rechargeable batteries, and the memory effect that these types of batteries seem to develop over time can be quite a hassle for the field recordist.

[Eco-charge](#) offers external powering options for many digital recording devices. They utilize sealed, lead-acid rechargeable batteries that offer much greater running times (4-6 hours or more per pack depending on machine) and can be recharged over and over without any negative effects. The packages offered typically include two battery packs complete with carry cases, shoulder or belt straps, smart recharger and all necessary interconnecting cables. The up front cost might seem a little high, but over the long haul it is certainly worth every dollar spent.

## **MISCELLANEOUS**

### **Shock mounts**

One of the major problems encountered during field recording is handling noise. This noise is transmitted through the body of the microphone and is recorded along with the primary sound of interest. There are various shockmount systems available that are designed to reduce this interference. An inexpensive and somewhat universal model is the [Audio Technica](#) AT-8415 that sells for about \$50.00. An alternative to buying a shockmount is to build your own. [Click here](#) to view plans.

## **MISCELLANEOUS**

### **CABLES**

Often overlooked, yet very important, are the interconnecting cables that couple the microphone to the recorder. The best microphone/recorder combination is only as good as the cable that links them together. High quality cables are often 4-conductor (two twisted pairs) surrounded with a braided shield. These offer the highest immunity to stray electromagnetic and RF interference. Quality cables are a bit more expensive than run-of-the-mill style, however they will generally last longer and perform better. Some manufacturers offer cables that are extremely flexible, even in very low temperature environments. Cable flexibility helps lower handling noise, reduces stress and strain on machine connectors and is easier to coil when the recording session is complete. Consider carrying a spare cable set; it is cheap insurance.

The [Canare Cable Company](#) offers the model L-4E5C StarQuad (lightweight) and model L-4E6S StarQuad (heavy duty). These are both high-performance cables that are extremely flexible and durable.

The [Belden Cable Company](#) offers the Optima-Hi-Definition Quad and Belden Brilliance

Quad. Both offer reasonable flexibility, but are able to withstand more rugged field abuse due to their heavier outer jackets.

## **MISCELLANEOUS**

### **Speed accuracy**

Cassette machines are especially prone to speed variation problems. These variations can occur from tape to tape or even within any given tape. The age of the recorder, calibration, temperature and the quality of the shell that houses the tape all factor into the speed accuracy issue. If your recordings are to be used for any kind of scientific analysis work then knowing the exact speed is a must, as tape speed directly affects how accurately the signals recorded can be replayed on other equipment. An essential tool to help solve this issue is the pitch pipe or tuning fork. If a known pitch, e.g. A-440, is recorded every so often along the tape, it will be possible at a later time to adjust the playback speed of the recorder to match the original recording. Pitch pipes or tuning forks are available from most music stores and are not very expensive.

## **MISCELLANEOUS**

### **Protective cases**

Audio recorders are delicate precision devices, especially the digital versions. Providing a high quality field case for your recorder can prolong its useful life and also help insure its reliability. Dirt, dust and moisture can raise havoc with the internal mechanisms of these machines greatly reducing motor and bearing life and creating excess drag coefficients on other moving assemblies. This can lead to premature mechanical failure or other recording problems.

The [Porta-Brace Company](#) manufactures high quality rugged field cases that we use on every piece of recording gear we own. They are constructed with heavy- weight, padded, Cordura nylon material. Flaps, held shut with hook & loop style fasteners provide easy connector access. Areas over switch panels and meters are covered with a clear, yet flexible plastic material. Shoulder straps are over-designed for maximum comfort on even the heaviest recorders. Extra compartments are usually provided for spare cables, tape, etc. These cases are not waterproof, however they are water repellent. Additional padding helps provide extra protection to the recorder in the event the machine should fall or be dropped during field use.

## **MISCELLANEOUS**

### **Reading list**

Since it is impossible to cover all of the factors that should be considered when choosing

a recording system or method of using said equipment we have included a reading list of books and articles that can be very helpful. Some of the books are out of print, but your local library or bookshop may be able to help locate copies.

## TECHNICAL

1. "Techniques for Audio Recording Vocalizations of Tropical Birds"  
Gregory F. Budney and Robert W. Grotke  
in Ornithological Monographs, Volume 48, 1997
2. "Factors to Consider in Recording Avian Sounds"  
David C. Wickstrom  
In Acoustic Communication in Birds, Volume 1  
eds. D.E. Kroodsma, E.H. Miller, and H. Ouellet  
Academic Press, 1982
3. "Sound Recording"  
David J. Tombs  
David & Charles, Inc., 1980  
North Pomfret, Vermont
4. "Wildlife Sound Recording"  
John B. Fisher  
Pelham Books Ltd., 1977  
London
5. "Recording Bird Sounds"  
James L. Gullledge  
The Living Bird  
Fifteenth Annual  
Cornell Laboratory of Ornithology, 1976  
-A good general introductory paper to natural sound recording even though it contains some dated information.

## AUDIO THEORY & SOUND RECORDING

1. "The Science of Sound"  
Thomas D. Rossing  
Addison-Wesley Publishing Company, 1982  
Reading, Massachusetts  
-Covers acoustic theory and science.

2. "Practical Recording Techniques"  
Bruce & Jenny Bartlett  
Mix Bookshelf 1992  
6400 Hollis Street  
Emeryville, CA 94608  
Phone 800-233-9604  
Fax 510-923-0369  
<<http://www.artistpro.com/>>  
-A very good all around reference for the beginner or moderately experienced recordist. Descriptions of the recording process, types of microphones, microphone technique etc. are covered.
3. "The Recording Studio Handbook"  
John M. Woram  
ELAR Publishing Company, Inc., 1982  
Plainview, New York
4. "Sound Recording Practice"  
John Borwick  
Oxford University Press, 1980
5. "Sound Recording"  
John Eargle  
Van Nostrand Reinhold, 1976, 1980

## **MISCELLANEOUS**

### **Vendors**

Unless specially noted within specific sections, all of the items described in this paper can be purchased through the following vendors.

#### [Marice Stith Recording Services](#)

59 Autumn Ridge Circle  
Ithaca, NY 14850  
607-277-5920 (voice)  
607-277-5942 (fax)  
[msrsithaca@aol.com](mailto:msrsithaca@aol.com) (e-mail)

#### [Full Compass Systems](#)

8001 Terrace Avenue  
Middleton, WI 53562  
800-356-5844 (voice)  
608-831-6330 (fax)

[Sweetwater](#)

5335 Bass Road  
Fort Wayne, IN 46808  
800-222-4700 (voice)  
260-432-1758 (fax)

**ADDITIONAL INFORMATION**

For more specific information about bird song recording equipment or technique, please contact:

Robert Grotke  
Supervising Audio Engineer  
Macaulay Library, Cornell Lab of Ornithology  
159 Sapsucker Woods Road  
Ithaca, NY 14850  
607-254-2409 (voice)  
607-254-2439 (fax)  
[audioequip@cornell.edu](mailto:audioequip@cornell.edu) (e-mail)

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