

used to search and list the data. After a person has studied the Operator's Manual, he may request copies of disks for any one or all of the years. Data must be requested by year, however. It is not possible to obtain disks for just one test category, or site, or any other subset.

Prospective users wishing to obtain copies of the Operator's Manual or the database should contact Dr. Charles Walcott, Director, Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, New York 14850. Requests for the database must be accompanied by (1) the necessary number of Pascal-formatted disks (one disk for each year desired), (2) instructions about which years of results are being requested, and (3) a check payable to Cornell University in the amount of \$10.00 for each disk requested (to cover the costs of handling, copying, and mailing the data disks).

With so many different cues apparently playing roles in highly redundant navigation systems, Bill

Keeton's many diversified investigations will be stepping stones along the path to future discoveries. It is our hope that by making the Keeton database available to the scientific community, we will hasten the progress of others along this path. If the use of his unpublished data is valuable to others in stimulating them to further research, in helping them in the design of their own methodologies, or, indirectly, in leading them to new discoveries about animal orientation, then making these data available will have been worthwhile. Keeton would not have wanted it any other way.

LITERATURE CITED

EMLÉN, S. T. 1981. In memoriam: William T. Keeton. *Auk* 98: 167-172.

Received 28 June 1983, accepted 9 March 1984.

Depositing Sound Specimens

JOHN WILLIAM HARDY¹

As the curator of an animal-sounds collection, the Bioacoustic Archives of the Florida State Museum, I have become increasingly concerned that no published guidelines exist for the making of scientifically valuable sound recordings, their proper storage, and their use in published reports. This commentary deals briefly, but I hope constructively, with each of these topics.

Making sound recordings in the field.—At the Florida State Museum, we welcome collections of sounds made by amateur recordists and by professional scientists who have made recordings incidentally to their primary studies. Often, however, because such recordings are made first for strictly personal enjoyment or use in identification, much work is necessary in the sound laboratory to make these collections useful as permanent specimen materials in our archives. I do not wish to discourage contributions, but I wish to encourage anyone making field recordings to take just a little time to establish a slightly more formal routine in recording that will save hours for the laboratory technician later.

The collection of sound specimens should be as disciplined as the collection of any other kind of scientifically useful specimens. An attempt should be made to observe the following protocol, although field circumstances may not always allow perfect adherence to the scheme. First, begin a tape with an intro-

ductory announcement including tape number, your name, locality, date, time, weather, habitat, and kind of recording equipment being used. Then, let a few seconds of blank tape run. Now, try to make each recording a distinct unit or "cut" on the tape. If possible, quickly record on tape a very brief announcement of a species about to be recorded or rewind later and insert this information. Then, record the bird. Try to adjust the record level and then *avoid* changing the level during the cut. Also, stand as rigidly as possible, and try to avoid making sounds with your feet or with your hand moving on the microphone. If the bird is singing, try to record an uninterrupted sequence of at least 1 min before moving or making any commentary. Of course, if you are studying a particular species' song on a formal basis, you may wish to record much more! The suggestion of 1 min is arbitrary. The core of your specimen is a good, clean, uninterrupted sequence, however long you judge it desirable to be. Immediately after the recording, give the essential data right on the tape in your voice. Be sure to adjust the record level for your voice and to speak clearly. Give data *in full* so that this specimen can stand alone without reference to the rest of the tape, as it eventually may do in a well-curated sound archives.

What happens if another bird begins to sing just as your first one stops and you're afraid you won't get it on tape? It is best to run some blank tape quickly, thereby leaving space for you to fill in the above data later. Then, say the second species' name and record it. Continue to follow this procedure through-

¹ Department of Natural Sciences, Florida State Museum, University of Florida, Gainesville, Florida 32611 USA.

out the tape. Don't forget to mention changes in locality, date, time, weather, etc. Don't fail to record a bird simply because you can't identify it. If many birds are singing, try to describe the sound, in words, of the bird you are trying to record. Mention the names of other birds that are incidentally recorded. Finally, because you are not likely to be able to maintain this routine consistently, listen to your tape as soon afterwards as you can. Edit it by erasing false starts and installing corrections with your microphone and voice.

For research tapes compiled from several originals, such as surveys of the sound signals of individuals, populations, species, or groups, the examples should each be preceded by an announcement (as short as "Example number 22" will suffice).

Cataloging recordings for scientific use.—Do not use the tape-recorder index or counter units to refer to locations on a tape. These counters are not standardized, varying from manufacturer to manufacturer, from model to model, and even from one instrument to another of the same model! Instead, use minute and second timings from the beginning of the recording. This is especially important for sounds taken from a long or complex recording with several occurrences of similar sounds. Label the tape box clearly, listing the contents on the box or in notes that accompany your recordings.

Long-term preservation and published results.—I have recently read two manuscripts dealing with bird vocalizations, both submitted to me by journal editors. Over the past decade I have read, as a referee, dozens of such articles, all of which shared one thing in common: they always failed to mention where the sound specimens or copies thereof had been deposited for access by other interested scientists.

I always write in my critique that editors should require authors to treat sound recordings as they would study skins, skeletons, nests, or eggs—as specimens that other workers deserve to be able to reexamine and reanalyze. Reels of tape that support a publication and indices to the tapes' contents should be deposited in an archives or museum that is committed to the long-term preservation of magnetic tape in a controlled environment and to the provision of high-quality copies to researchers or permission to examine specimens on the premises of the archives. Moreover, published papers should say where the sound specimens are located and should refer to catalog and cut numbers of the specimens used. For a recent paper (Morrison and Hardy 1983) on hybridization between Hermit (*Dendroica occidentalis*) and Townsend's (*D. townsendi*) warblers, Morrison made the field recordings and referred to individual males by numbers. I later catalogued the tapes by master-reel number, cut number, and species-cut number, gave each song phrase in the song bouts a number, and made sonograms. Sonograms selected to illustrate the songs of warblers were referred to very spe-

cifically in the legends of figures. For example in Fig. 1, the sonogram was labeled: "A. Hermit Warbler: FSM 571-3-4 (individual 5, song phrase 6)."

Sonograms, the most common form of illustration of sounds in biological journals, are adequate in publications, but there are many ways to make sonograms (wide and narrow band, amplitude sections, amplitude displays, oscillograms, contour analyses, and scale magnifications, for example). There are also right and wrong ways to make sonograms; two investigators each making a wide (300 Hz) band 80–8,000 Hz impression of the same sound can, employing different mark and gain levels, come out with strikingly different results. Only if the original tapes are preserved and catalogued in a permanent archives can subsequent investigators reexamine those specimens and reevaluate results. Access to a previous worker's recordings may also allow investigators to proceed quickly from a descriptive to an hypothesis-testing stage. Thus, if a certain type of call is said to function in a specific context eliciting predictable responses from another bird and that call is recorded and preserved, access to copies of the taped call can lead directly to a testing of this assertion. Finally, when sounds are preserved in archives, investigators interested in comparative study, such as character convergence in song or calls, may conveniently listen to a wide array of species' sounds in the search for clues.

There are a number of archives in the U.S. that welcome the opportunity to help authors. As a general policy at the Florida State Museum, we will receive and duplicate at our expense copies for deposition, then catalogue the sounds, and relay this information to an author or editor. In addition, we are prepared to make sonograms for authors at no charge, or for a nominal charge if the work involves several hours or more. (Similar policies I believe exist at the Library of Natural Sounds at the Cornell University Laboratory of Ornithology and at other institutions housing sound collections, but investigators should inquire before assuming so.)

In conclusion, the study of bird sounds has become legitimate science in the past several decades. Unfortunately, the techniques of making scientifically valuable field recordings and then seeing to their preservation for future investigators have not received adequate attention. These problems, rather simple to solve, need our early attention.

I thank James Gulledge and Luis Baptista for constructive comments given in their roles as referees.

LITERATURE CITED

- MORRISON, M. L., & J. W. HARDY. 1983. Analysis of hybridization between Hermit and Townsend's warblers. *Murrelet* 64: 65–72.

Received 14 November 1983, accepted 9 March 1984.