# BRP SOUND ANALYSIS WORKSHOP DESCRIPTION

## Introduction

The Cornell Bioacoustics Research Program runs a one week long workshop on sound analysis approximately once every six months. The next one will be 8th to 12th September, 2008. We take a maximum of 10 participants in this course.

The course aims to provide a basic practical understanding of spectrographic analysis along with an introduction to a wide range of techniques used in sound analysis, and an introduction to applications of sound analysis techniques in biological research. We will focus primarily on the use of Raven and XBAT (two software programs developed at BRP) for two types of bioacoustics research:

a) Large-scale monitoring programs using recordings that may span many months, where the aim generally centers on counting and/or locating vocalizations.
b) Detailed analysis of selected calls, for instance investigating differences in vocalizations among individuals of a species.

We cannot cover all aspects of these topics in detail in one week so we tailor each workshop to best suit the requests of the participants for a particular workshop. We therefore ask you to follow this procedure as you explore your interest and potential participation in the course:

1. Read the detailed description of the workshop below. If you have specific questions, feel free to contact Liz Rowland (edr6@cornell.edu, tel. 607-254-2127). On the basis of this information, decide whether or not you'd like to attend the workshop. If you decide you would like to attend, contact Liz to check on availability. There is no entry requirement for the course – places will be offered on a first-come-first-served basis.
2. If you elect to attend, BRP will send you accommodation details and a questionnaire discussing your background and goals for the course. We will use the responses from these questionnaires to tailor the workshop, on a best effort basis, to suit the participants' needs. The cost of the course is $1300 due and payable upon confirmation of availability. Alternatively, we will accept a $300 deposit to confirm your space with the balance due on the first day you attend. A check made out to the Bioacoustics Research Program, or major credit cards are acceptable forms of payment. Fees include five days of instruction, lunch and all required course materials. Participants are encouraged to bring their own recordings for analysis during the workshop. Transportation, lodging and meals other than lunch are the responsibility of the participant.

NOTE: Although we briefly cover the topic of acquiring sounds (making digital recordings, and making them accessible to the sound analysis programs), this workshop is not designed to give detailed instruction on recording sounds. The Macaulay Library

(CLO) offers a course once per year, usually held in California, on this topic: http://www.birds.cornell.edu/macaulaylibrary/Contribute/soundRecordingWorkshop.html

If you are interested in deployment instruction for the recording devices designed here in BRP (http://www.birds.cornell.edu/brp/hardware/autonomous-recording-units) please call 607-254-2408.

Please read on for the description of the workshop. We look forward to hearing from you!

DESCRIPTION OF THE BRP SOUND ANALYSIS WORKSHOP

## General Information

i) Format
The course is held at the Cornell Laboratory of Ornithology in Ithaca, NY. Each participant (maximum of 10 people) is provided with a laptop. The course includes interactive instruction sessions, which usually include projected real-time laptop demonstrations and PowerPoint presentations. The daily schedule is presented below.

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| 9:00 am | Interactive instruction |
| 10:30 am | Individual hands-on work with one-to-one instruction (following up on the presentation). |
| 11:30 am | Guest presentation (biological focus). These will cover a broad range of topics and serve to illustrate how sound analysis is used to answer biological questions. Participants have the opportunity to talk informally with the presenter over lunch. Some examples of presentations are given below. |
| Noon | Lunch (provided), with guests. |
| 1:00 pm | Interactive instructive presentation |
| 2:30 pm | Individual hands-on work with one-to-one instruction (following up on the presentation). |
| 3:30 pm | Tour or guest presentation (biological focus). |
| 5:30 pm | Dinner break (participants on their own) |
| 7:30 pm | Seminar (selected evenings) |

*Examples of guest presentations given in the past*.

- XBAT detections, limitations of data template detector, by Danielle Cholewiak, current Ph.D. research on humpback whales

- Overview of approaches to bioacoustic research – Chris Clark, Ph.D., Director of Bioacoustics Research Program.

- Night flight calls of migrant birds, by Andrew Farnsworth, Ph.D.

- Investigating the entire repertoire of a species, by Erin Bohman, Bioacoustics Research Program Research Analyst.

- Acoustic location analysis, video, and elephant behavior, by Liz Rowland, Bioacoustics Research Program Research Analyst.

ii) Sound analysis programs used.
We use two programs during the workshop; Raven and XBAT. Details about these are shown on the websites: Raven http://RavenSoundSoftware.com and XBAT http://xbat.org.
Some practical considerations are:

*License fees*

Raven - There is a license fee of $800 for commercial research, $400 for academic, government, or non-profit research, and $100 for students, although there is a discount of 25-90% for users from developing countries.

XBAT - This is downloadable free of charge from the website, but, it runs in MATLAB http://www.mathworks.com/products/matlab/, which can be an expensive program to buy; however, many institutes and universities have affordable MATLAB licenses.

*Documentation*

Raven -This has a complete users' manual in PDF format within the program, and we provide a black and white hard copy of this to participants. Raven also provides a help and discussion forum and email support.

XBAT - Because XBAT is in an early stage of development, and is intended as an open-source platform for collaborative development of special-purpose extensions, documentation is accomplished through several Google user groups. The groups are monitored by the XBAT development team, and other users also contribute feedback.

iii) Costs: As explained above, the cost of the course is $1300 due and payable upon confirmation of availability. Alternatively we will accept a $300 deposit to confirm your space with the balance due on the first day you attend. Fees include five days of instruction, lunch and course materials.

iv) Location, hotels and airports: The course is held at the Cornell Laboratory of Ornithology, which is located about 6 miles from Ithaca town center and 4 miles from Cornell main campus. There are 4 hotels within 4 miles of the Lab, including one within walking distance. Most hotels provide a limited shuttle service to the CLO, Ithaca, or Cornell campus. There is also a limited bus service from CLO to Ithaca. More details on accommodation and available discounts will be provided once you register for the course, or contact Kevin White (wkw2@cornell.edu or tel. 607-254-2438) if you need information sooner. USAirways and Northwest Airlines provide limited service to the Ithaca airport, located less than a mile from CLO. More flight (and price) options are available through Syracuse (1 hour drive) Elmira (1 hour drive), Rochester (2 hours drive), Buffalo (3 hours drive). Ground transportation between Syracuse and Ithaca is available through Ithaca Airline Limousine service.

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## Details of course content

The topics covered in the workshop fall into three broad categories: basic principles, applications and hardware techniques (although we cover the latter only briefly). You may find it valuable to look at the Raven User's Manual Appendix A http://www.birds.cornell.edu/brp/pdf-documents/AppA-DigitalSound.pdf and Appendix B http://www.birds.cornell.edu/brp/pdf-documents/AppB-SpectrumAnalysis.pdf for more detail on the terms mentioned here, as well as the BRP website http://www.birds.cornell.edu/brp/.

**Basic principles**

To be able to use sound analysis tools effectively, it is essential to have a good understanding of the basics of the physics of sound, and of spectrographic analysis. We will work with Raven to illustrate these theoretical concepts in the workshop.

Basic physics of sound: waveforms, factors affecting the speed of sound, harmonics.
Digital audio: the difference between analog and digital sound, sampling rates the Nyquist frequency, aliasing, sample size (bit depth)
Time-domain vs frequency-domain representations of sound: waveforms and spectra; the Fourier Transform (conceptual).
Spectrograms and the Discrete Fourier Transform (DFT). Application of the Fourier Transform to successive short time-slices to represent time-varying spectra.
Spectrogram parameters. Tradeoff between time and frequency precision. The ideal spectrogram settings depend on the question being asked. Finding the ideal settings requires a thorough understanding of each of the parameters (FFT size, window size, overlap) and how they interact. Other topics that will be covered in this section include the 3dB bandwidth and window types.
Evaluating recording quality through understanding waveform and spectrographic displays: aliasing, clipping.
Understanding sound viewing techniques: waveforms, spectrograms, spectral slices.

**Applications**

The workshop focuses on two broad categories of bioacoustic research:

- Detailed analysis of specific vocalizations, for instance investigating differences in vocalizations among individuals of a species. We generally work with Raven in the workshop to illustrate these techniques.
- Large-scale monitoring programs using recordings that may span many months, where the aim generally centers on counting and/or locating vocalizations or other signals of interest. We generally work with XBAT to illustrate these techniques.

A list of the techniques used in these broad areas is given below, although there is some overlap in the techniques used in both areas.

<u>General instruction on Raven and XBAT</u>

Overview of working with and visualizing sound within both of these programs.

<u>Detailed analysis</u>

Measurements: How to make measurements of different aspects of the acoustic energy in signals of interest (e.g. vocalizations or man-made noise), and choosing the appropriate measures and views (waveform, spectrogram, spectral slice) to use. (Raven and XBAT)

Cross-correlation: Using this to ascertain degrees of similarity amongst signals of interest. (Raven)

Classification of vocalizations. A fairly common area of bioacoustic research involves categorizing vocalizations. For instance, can individuals within a species be distinguished on the basis of their vocalizations?. We study an example of this in the workshop. Both measurement and cross-correlation techniques can be used to classify calls. (Raven and XBAT)

<u>Large-scale monitoring</u>

Automatic detection: The ability to automatically detect calls in long recordings is very valuable. It is important to realize that these tools are just that – tools for assisting in the detection of signals of interest. An energy detector is available in both Raven and XBAT. In addition, Raven has an amplitude detector, while XBAT has a "data template" (or matched filter) detector, which searches for images in the spectrogram that match those chosen by the operator.

Beamforming to provide information on the bearing on which a call was made: In multichannel recordings (where 3 or more recording devices were set up in an array), it is possible to use the "Beamforming tool" in Raven to find the bearing on which the source of the call lay.

Batch-processing. XBAT allows the operator to run the same process (for instance running a detector) on a batch of days, which saves considerable operator time.

**Hardware techniques**

As mentioned in the introduction, we do not intend to give full instruction on these techniques in this course. The Macaulay library (CLO) offers a course once per year in

California on this topic.
http://www.birds.cornell.edu/macaulaylibrary/Contribute/soundRecordingWorkshop.html
However, we do give an introduction to the following:

Signal acquisition: making sound data available for analysis.

Overview of digital recording devices: Autonomous Recording Units (as used by BRP) and hand-held devices.