

An Immersion in Animal Vocalizations at the Houston Zoo

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Participants in this workshop recorded vocalizations of sea lions, birds, and other animals at the Houston Zoo. Audacity, a free downloadable software, was used to record and analyze these vocalizations. We recorded animals of interest and then returned to a computer lab to analyze the data. The Audacity files were opened and the sound tracings converted to spectrograms. Minimum and maximum frequencies were recorded. Patterns in the vocalizations such as growls, trills, or repetitions such as barks, or pecking noises of a woodpecker were discussed. An additional program, Praat, (free downloadable program) was used to fine-tune data from recordings and assist in presentations. This very interactive exercise engages students in the study of animals with a wide-range of implications, including behavior and conservation. In addition to the in-situ work, we used the Cornell Macaulay Sound Library. Students might directly record (and then analyze) sounds from this and other libraries.

Keywords: animal vocalization, animal behavior, bioacoustics

Introduction

The Houston Zoo contains a variety of animals that can be used for interesting recordings. The John P. McGovern Marine Mammal Marina houses sea lions. Primates such as the following: orangutan, ring-tailed lemur, black howler, Western lowland gorilla, Coquerel's Sifaka, siamang, red-tailed guenon, and patas monkey are located in the Wortham World of Primates. Terrestrial carnivores include the maned wolf, cougar, leopard, lion, African painted dog, jaguar, and fossa. Hoofed mammals include: eland, warthog, Speke's gazelle, yellow-backed duikers, lowland Nyala, Baird's tapir, and okapi. The McNair Asian Elephant Habitat contains eight elephants.

There are over 250 species of birds, in three habitats: the Fischer Bird Garden, the Tropical Bird House, and Birds of the World. A few include: Amazon parrot, green-winged macaw, go-away bird, hornbill, laughing Kookaburra, cassowary, and the Marianas fruit dove. There is an active breeding program, especially of endangered species, such as the Blue Billed Curassow and the Atwater prairie chicken. The latter two bird species are not available to the public.

Other places of interest include the Kipp Aquarium, Natural Encounters with fruit bats and endangered animals, the John P. McGovern Children's Zoo with African crested porcupine and talking parrots, and the Reptile and Amphibian house with over 140 species of

reptiles and 40 species of amphibians (However, most of the amphibians such as the frogs are only vocal at night.)
<http://www.houstonzoo.org/>.

Students at St. Francis College have been visiting zoos and aquaria in the New York City area for the past three years and have been recording sea lion vocalizations. We have uncovered patterns such as repeated barking as an indication of territoriality, and have heard mother and pup vocalizations (Nolan et al. 2015). We have also recorded vocalizations of various marine mammals from the Cornell University Macaulay Library of Sound (Nolan, 2015; Chu et al., 2016). This was in an attempt to hear and understand the astonishing variety of vocalizations of animals that we might never see in captivity, as well as in the wild, such as animals that live in the Arctic or Antarctic.

What are other things that could be learned by studying vocalizations? A perusal of the literature revealed many studies; a few are listed here. Some interesting bird studies were conducted by Baker et al. (2003) and Cox et al., (2014). Charlton et al. (2009) used vocalizations as a measure of relatedness in giant pandas, and Ichikawa et al. (2006) went a step further and analyzed dugong vocalizations using underwater hydrophones. (We would like to use hydrophones more in the future—we have recently used them to record ambient noise in a harbor seal enclosure at the Maritime Aquarium (Biolsi, personal communication).) There are many

references to sea lion vocalizations, especially those that document mother/pup interactions in Nolan et al. (2015).

Another body of literature of note is that that examines the relationship of the student to the environment after interacting with animals at zoos and aquaria. Parker (2014) and Sanford (2014) have found positive correlations between student engagement in zoos and aquaria and their future sense of stewardship of the environment.

In order to conduct this laboratory exercise at a zoo, or to do an on-line exercise in which students can record and analyze vocalizations from a sound library, it is necessary to download Audacity. This program was originally designed for musicians to record and remix songs and sounds. The program shows a waveform, which is the movement of air by a mix of frequencies from the vocalizations. These waveforms can be converted to spectrograms, which give one a three-dimensional view of sound: frequency is on the Y-axis, time is on the X-axis, and the amplitude or “loudness” can be visualized by color or shade. The louder sounds are red or darker, and the softer sounds are blue or lighter. (See Figure 1 for an effective visual on an explanation of the differences between a waveform and a spectrogram) The picture on the left shows 20 sinusoidal cycles of a single tone in 0.1 second, which translates into a frequency of 200 Hz, as shown on the right.

Distinction Between Waveforms and Spectrograms

Waveform (left) and spectrogram (right) of 200Hz sine wave

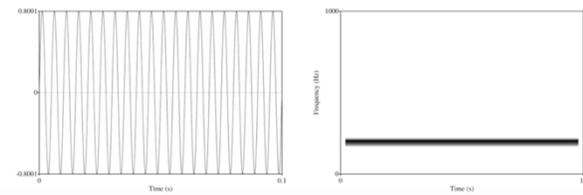


Figure 1. Screenshot captured on Praat tutorial on sound.

<https://www.youtube.com/watch?v=Gg4IHbiITd0>

Another free program, Praat, can be downloaded, (<https://www.fon.hum.uva.nl/praat/>) which will allow the user to pinpoint frequencies of formants, which are natural resonances that occur in sounds. Two videos that show the students how to use Audacity and Praat are: Exploring Audacity’s spectrogram view by Matt <https://www.youtube.com/watch?v=7WYw3qoTdU4> and a tutorial on using Praat to analyze spectrograms by Charles J. Pindziak <https://www.youtube.com/watch?v=Gg4IHbiITd0>.

We will not measure exact amplitude, which would be in decibels, because, in order to do that accurately, we would need to measure our exact distance from the animal vocalizing. However, one can plot a graph of decibels on the Y-axis versus frequencies on the X-axis that usually

shows an inverse relationship between decibels (loudness) and frequency.

Vocalizations do not usually occur in a single tone of a single frequency as depicted in Figure 1. Usually sound is complex and is composed of many different frequencies that occur simultaneously. A vocalization can have many “resonances” at different frequencies that are called formants. One of the objectives of this exercise is to determine how many formants a recorded vocalization contains. After recording with Audacity, the files should be saved with .wav at the end of the filename. The free downloadable Praat software allows one to download a recording into Praat as a .wav file for a more accurate viewing of the frequencies of the various formants.

Student Outline

- Download the free software Audacity to your PC or Apple laptop that has a built-in microphone. (**Note: it does not work with iPads.**) (Alternatively, you can use a microphone such as Zoom H4n in which you can insert an SD memory card. The recordings can then be saved directly on your computer after you return from the zoo.) What is nice about using your laptop is that you can see the waveforms directly as you are recording.
- Form into teams of three.
- Choose an animal or animals to record for twenty minutes to a half-hour.
 1. One person will turn on the laptop and open the Audacity program;
 2. The second person will record in a notebook the time of each vocalization and
 3. The third person will take a video of some of the behaviors of the sea lions (a cell phone works well).
- Open up Audacity. Press the “record” button. You should be able to keep the computer facing you so you can see the sound waveforms that range from -1 to 1.0. (purple waves will appear on a gray background) while your machine is recording.)
- A waveform shows displacement of air by sound. It represents a mix of frequencies over time. A spectrogram takes the waveform and subdivides it into frequencies from 0 to a fixed value on the Y-axis and time on the X-axis. A red color (Audacity) or a darker shade indicates a higher amplitude (loudness) than a blue color (Audacity) or a lighter shade in Praat. We will not measure exact amplitude, which would be in decibels, because, in order to do that accurately, we would need to measure our exact distance from the animal vocalizing.
- Have your partner take notes such as the time of each vocalization and the amount of time between each vocalization.
- Be careful for splashing! (An alternative to taking your laptop is to take a recorder).
- Record for twenty minutes to a half hour.
- Save the program, and analyze the data before you close it. The data also saves your recordings as a folder of MP3 files that are 6 seconds long, which is the time it takes for the sound to travel across your screen.
- Make a record of:
 1. Number of vocalizations
 2. The length of time of each short vocalization period (could include multiple barks)
 3. If there is a series of barks (trills, chirps, etc.), how long is each one?
 4. How many barks (sounds) are in each vocalization?
 5. Convert the sound tracing to a spectrogram by clicking on the arrow on the gray box to the left of your screen.
 6. What is the range (in hertz) of the sounds? (You can also go to “spectrogram settings” under the same arrow and change the frequency range.) You can also go back to “waveform” under the arrow. You can select a section and zoom in on it. You can also click on the Hz bar and zoom in that way. One mistake that people make, however, is that they zoom in too much. If that happens, just start over. You cannot undo the zooming.
 7. Note the multiple bands at various frequencies of each vocalization. These bands are called formants. If you would like to analyze these further, the free-downloadable program “Praat” can help you do this. Another possibility is to see a “plot spectrum” which is a choice under “Analyze”. This gives you a relationship between decibels (loudness) and frequency. Often there are negative numbers—you “lose” loudness with distance from the sound source.
 8. Save your recording of interest that you would like to analyze with Praat with the ending “.wav” attached.
 9. Open Praat, and import your file of interest.
 10. Find the spectrogram of your file in Praat, and click on “formants”. Red lines will appear and will indicate the frequency of each formant, which is more accurate than “eye-balling” it. Click on the actual formant on the screen and you will get a straight horizontal dotted line that gives you the exact frequency of that formant.
 11. An alternative or additional exercise is to analyze sounds that you can obtain on line from a sound library. If so, open the Cornell University Macaulay Sound Library. This contains recordings of over 150,000 digital audio recordings of every type of animal, from insects through marine mammals. (Other sound libraries are listed below the references.)
 12. Find a recording that you like, open Audacity, press record, then play your recording. Audacity will record the vocalization right from the sound. This is an excellent way to learn more about various vocalizations of a diversity of animals. You can actually visualize these recordings. Here are some interesting ones to look for and listen to: walruses, Weddell seals, and various types of whales. Since whales can use sonar to both locate food and each other, the recordings can look quite complex.

Selected data (Figures 2 and 3 were taken from Chu et al. (2016).

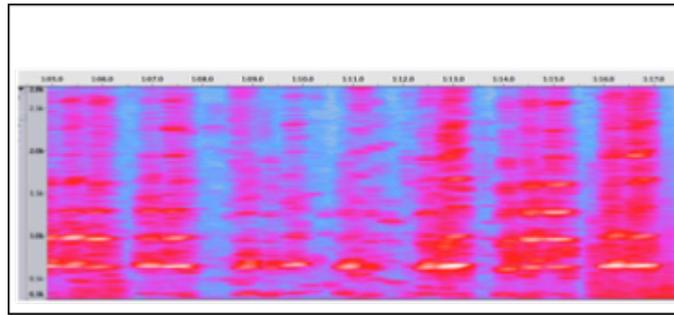


Figure 2. Formants of sea lion barks recorded at the Bronx Zoo (1/3/16) on an Audacity spectrogram (approximately 8 per bark).

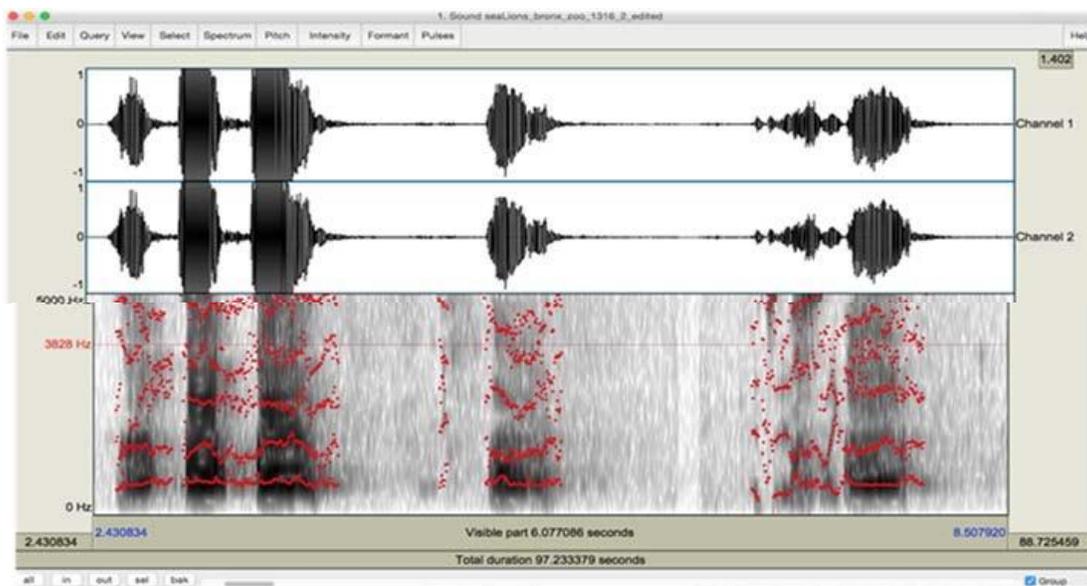


Figure 3. Incorporating a waveform into Praat to visualize formants.

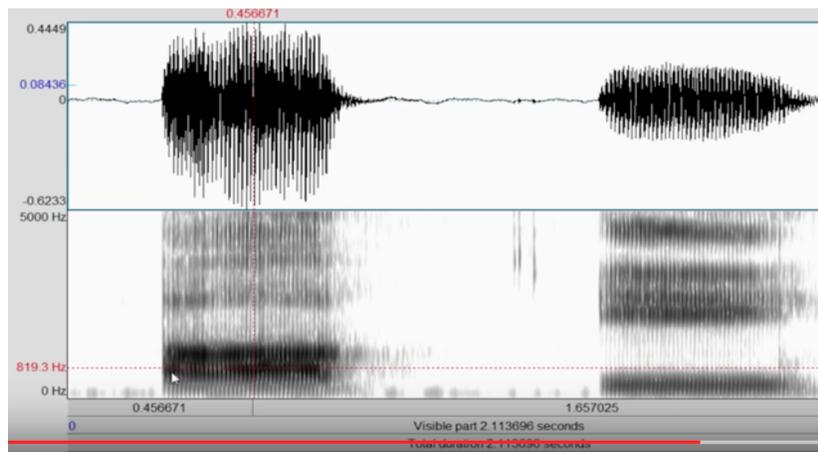


Figure 4. A view of formants from two different vowel sounds in Praat. (<https://www.youtube.com/watch?v=Gg4IHbiITd0>)

Selected Results from the ABLE Workshop

This is a recording from a babirusa, or an Indonesian wild pig (Figure 5). The recording is approximately 1.5 sec. long, with the bulk of the recording consisting of 13 distinct vibrations or sounds, with approximately four formants that range between 2000 and 7500 Hz. The purple graph on the right was obtained by clicking on “Analyze” and then “Plot spectrum” and plots decibels against frequency. This graph shows an inverse relationship between decibels and frequencies.

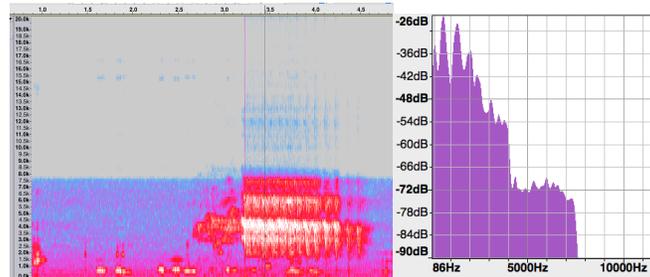


Figure 5. Babirusa recording at Houston Zoo, 6/21/16 by Sarah Lauren Carmona.

The waveform of a flamingo vocalization is revealed Figure 6 a, with the subsequent spectrogram in Figure 6b. (Several other recordings that depicted this same pattern were also recorded.) Additional animals that were recorded at the Houston Zoo on 6/21/16 included the St. Vincent Amazon parrots (Adam Andrews), a sea lion (Judy Guinan), and a woodpecker.

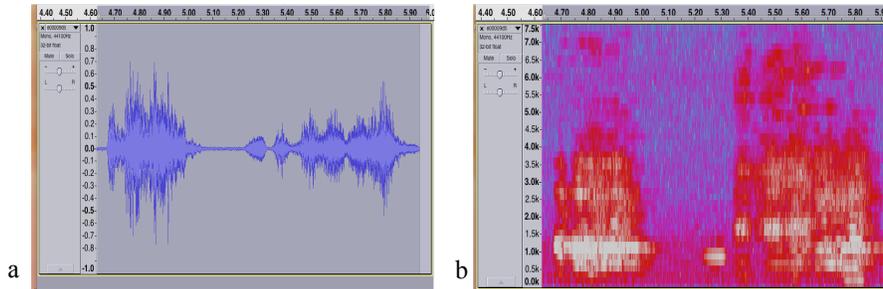


Figure 6a. Waveform of a vocalization of a flamingo in the Houston Zoo 6/21/16.
b. The spectrogram that matches the recording in Fig. 6 a. (Sarah Lauren Carmona and Mara Mays.)

Materials

Laptops with Internet access and the programs Audacity and Praat (freely downloadable) should be used for this exercise. Note: **Audacity does NOT work on iPads.**

Notes for the Instructor

Ask your students the question, “Why do animals vocalize?” Hopefully, they will come up with a series of answers, besides, “I don’t know!” although that is reasonable as well. They might offer such as answers as to establish a territory, attract a mate, find their offspring, warn others of predators, echolocation, and other forms of communication. It is good to get your students thinking about sound as another sense that animals and we can use to navigate our world. Then, go over physics terms with them such as: sound, frequency, waveform, decibel, amplitude, pitch, spectrogram and formant.

Show the students these two videos:

<https://www.youtube.com/watch?v=7WYw3qoTdU4>

Exploring Audacity’s spectrogram view by Matt Thibault

<https://www.youtube.com/watch?v=Gg4IHbiITd0>

Tutorial on Praat analysis of spectrograms by Charles J. Pindziak.

The first video shows the students how to use Audacity. It is quite clever and shows an analysis of a six second clip of sound. The second video explains formants and how to analyze them.

If you do not have a zoo or aquarium with vocal marine mammals nearby, you can use a sound library (see list) to obtain data. This exercise is a great way to obtain data (see list of questions about the data students are asked to answer above). All data can be entered into a Excel spreadsheet for further statistical analysis, either as a multiple of the same species studied as a group or individual species.

Cited References

Baker MC, Logue DM. 2003. Population differentiation in a complex bird sound: a comparison of three bioacoustical analysis procedures. *Ethology*. 109(3):223-242.

Charlton BD, Zhihe Z, Snyder RJ. 2009. Vocal cues to identity and relatedness in giant pandas (*Ailuropoda melanoleuca*). *Journal of The Acoustical Society of America*, 126(5): 2721-2732.

Chu A, Ellis H, Habiba U, McMaster A, Patel G, Yesko L, Nawaz N, Saleem S, Goble C, Nolan KA, Biolsi K, Burdowski A. 2016. The use of Audacity and Praat to record and analyze animal vocalizations. *In Vivo*. 38 (1):25-39.

Cox JA, Jones CD, Tucker Jr. JW, Budney GF. 2014. An unusual song-like vocalization produced by female Bachman’s Sparrows (*Peucaea aestivalis*). *Southeastern Naturalist*. 13(2):N9-N12.

<https://www.houstonzoo.org/>

<https://macaulaylibrary.org>

<https://www.youtube.com/watch?v=7WYw3qoTdU4>

Exploring Audacity’s spectrogram view by Matt Thibault

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Tutorial on Praat analysis of spectrograms by Charles J. Pindziak

Ichikawa K, Tsutsumi C, Arai N, Akamatsu T, Shinke T, Hara T, Adulyanukosol K. 2006. Dugong (*Dugong dugon*) vocalization patterns recorded by automatic underwater sound monitoring systems. *Journal of The Acoustical Society of America*. 119(6):3726-3733.

Nolan K, Biolsi K, Foo F, Salzillo A, Azaah A, Burdowski, A. 2015. Aquaria and Zoos as Labs: Recording Vocalizations of Marine Mammals using Audacity. *Tested Studies for Laboratory Teaching: Proceedings of the Association of Biology Laboratory Education Vol. 36. In press.*

Parker M. 2014. Conservation connections matter!. *International Zoo Educators Journal*. 50:6-10.

Sanford C. 2014. Informing leadership practices: exploring relationships between student engagement in science and zoo education programs. *IZE Journal*. 50:38-41.

Sound libraries

<http://macaulaylibrary.org>

Yellowstone National Park---Sandhill cranes, elks bugling

<https://www.nps.gov/yell/learn/photosmultimedia/soundlibrary.htm>

Sea world---an example is the beluga whale

<https://seaworld.org/en/Animal-Info/Animal-Sounds>

Borror Laboratory of Bioacoustics of The Ohio State University---over 40,000 recordings (look up Latin names of species for better results).
<http://blb.osu.edu/>

The Ocean Conservation Research website has many audio recordings of fish and whales. Especially fascinating to us are the drum fish.
<http://www.ocr.org>

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About the Authors

Kathleen A. Nolan, Ph.D. is a professor of biology and Chair of the Biology and Health Sciences Department at St. Francis College. She has been a long-time ABLE member and has presented numerous major and mini-workshops at ABLE conferences. She is interested in a wide variety topics, including fish population genetics, animal vocalizations, and biology laboratory education.

Kristy Biolsi, Ph.D., is an associate professor of psychology at St. Francis College, and is Dr. Nolan's inspiration for studying bioacoustics. She specializes in sea lion behavior, and in harbor seal ecology in the New York City vicinity

Allen Burdowski, Ph.D. is the Dean of Science and Health at St. Francis College. He loves to tinker with computer programs, and was the originator of the idea of using Audacity to record sea lions.

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