The Importance of Biological Sound Archives

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Central to the effort to understand sounds produced by the natural world is the effort to document and catalogue sounds produced by animals and plants (see **Table 1** for examples of many of the sounds and sound libraries mentioned in this article). As such, the establishment and maintenance of biological sound archives is an integral part of deriving ecologically meaningful conclusions from large acoustic datasets. Since the creation of the Macaulay Library see (macaulaylibrary.org) by Cornell University, Ithaca, New York, in 1929, which is primarily dedicated to the cataloguing of bird sounds, many other biological sound libraries have since been established encompassing a wide array of ecosystems and species, such as marine mammals in the ocean, bats in woodlands, and frogs in rainforests (see examples in **Table 1**). The purpose of this essay is to get to the heart of why biological sound archives are essential, not just for the study of the natural world but for maintaining our connection with it, by hearing directly from the people involved in their creation and ongoing maintenance. In addition, to see how the creation of a biological sound archive is helping to unlock the secrets of a sonic frontier, the freshwater soundscape, a mysterious and often overlooked underwater acoustic world.

The Importance of Documenting Biological Sound

"[Biological sound] archives are vital as they provide data that is fundamental to the work many folks are doing" (Kieran Cox, cofounder of the online database Fish Sounds, personal communication, 2024) (see fishsounds.net/index.js). Fish Sounds is an online repository that was established in 2020 in the wake of the Covid pandemic and now hosts sound recordings from over 1,000 species of fish from around the world (Looby et al., 2023). "It may not be evident, but archives are a form of long-term monitoring, and this type of research is vital to identifying ecological change, supporting novel research, and training the next generation of scientists" (Cox, personal communication, 2024):

"Understanding long-term trends requires long-term datasets. There's a very good chance that they will be used for things we can't yet imagine" (Ed Baker, a data researcher at the Natural History Museum in London, personal communication, 2024). In 2014, Baker established BioAcoustica (see bit.ly/3XFOpuF), the biological sounds data archive for the museum. One of the many benefits acoustic monitoring provides is the opportunity to store large amounts of data for reanalysis in the future when new methodologies have been developed. "The Natural History Museum collection was started in the 1950s, made on tape, and analysed with an oscillograph. Now it's being used to train machine learning models inconceivable at the time the recordings were made. The value of well-made collections increases over time" (Baker, personal communication, 2024).

Beyond their scientific value, biological sound archives offer a unique chance for people to connect with the environment through an accessible medium: sound. Baker has recently helped establish the Nature Discovery Garden at the London Natural History Museum, which uses biological sound recordings to engage visitors in new and exciting ways. "In the Nature Discovery Garden, visitors can listen to environments where they might not think sound has a function, such as soils, timber and ponds. There are massive untapped opportunities to use biological sound archives to engage blind and partially sighted audiences with nature" (Baker, personal communication, 2024).

Exploring the Unknown: The Freshwater Soundscape

A new initiative in collaboration with Fish Sounds and led by me, The Freshwater Sounds Archive (see fishsounds.net/freshwater.js) is now seeking to catalogue the underwater sounds produced by freshwater species. The sounds of marine mammals, birds, and bats are fairly well studied and documented in biological sound archives. However, the mysterious underwater soundscapes of freshwater ecosystems remain poorly

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Table 1. *Notable biological sound archives*

Name	Target Realm	Target Taxa	Institution(s)	Country	Link
Discovery of Sound in the Sea	Marine	Marine mammals, marine fishes, marine invertebrates, anthropogenic sounds	University of Rhode Island and Inner Space Center	United States	dosits.org
Fish Sounds	Marine, Freshwater	Fish	University of Victoria, University of Florida, University of São Paulo, Meridian, FishBase	N/A	bit.ly/4crWuXV
The Freshwater Sounds Archive	Freshwater	Freshwater fish, freshwater invertebrates, freshwater plants	University of Victoria, University of Florida, University of São Paulo, Meridian, FishBase	N/A	bit.ly/4cv8VCk
British Library Sounds Archive	All	All	The British Library	United Kingdom	bit.ly/4ezlgac
BioAcoustica	All	All	Natural History Museum (London)	United Kingdom	bit.ly/3XFOpuF
Macaulay Library		Birds	Cornell University	United States	bit.ly/45Bd59C
Amphibiaweb	Terrestrial, freshwater	Amphibians	University of California, Berkeley	United States	bit.ly/3VvRGKk
Fonoteca Zoológica	Terrestrial, freshwater	Frogs	Consejo Superior de Investigaciones Científicas, National Museum of Natural Sciences (Madrid)	Spain	bit.ly/4cMLK6L
Frog Call Library	Terrestrial, freshwater	Frogs	Herpetological Society of Singapore	Singapore	bit.ly/3VQvLyD
Global Library of Underwater Biological Sounds	Marine	Marine mammals, marine fishes, marine invertebrates, anthropogenic sounds	28 Different institutions globally	N/A	glubs.org
ChiroVox	Terrestrial	Bats	Hungarian Natural History Museum (Budapest), Southeast Asian Bat Conservation Research Unit	N/A	chirovox.org
Bat Conservation Trust Sound Library	Terrestrial	Bats	The Bat Conservation Trust	United Kingdom	bit.ly/3XwpnOs
Xeno Canto	Terrestrial, freshwater	Birds, grasshoppers, bats, frogs	Xeno-canto Foundation, Naturalis Biodiversity Center	The Netherlands	xeno-canto.org
Avisoft Bioacoustics	Terrestrial, freshwater	Bats	Avisoft Bioacoustics	Germany	bit.ly/4evLDOi

understood. Recently, some researchers have been turning their attention to the study of the underwater soundscapes of ponds, rivers, and lakes to unlock their secrets (Linke et al., 2018).

Freshwater soundscapes are packed full of bizarre sounds produced by a wide array of species; it is like an underwater disco (Greenhalgh et al., 2023). Some sounds are more familiar, such as the croaking of frogs, and the drumming of fish (see tinyurl.com/va249nu4) because they use specialised muscles to vibrate air inside their swim bladders to communicate. However, many sounds are otherworldly and surprising, such as the strange whining and ticking sounds (see tinyurl.com/va249nu4) produced by submerged aquatic plants as tiny oxygen bubbles are released into the water. In addition, aquatic insects produce strange scratching, scraping, and rasping sounds as they rub hard body parts together in a process called stridulation. One particular aquatic insect is known for making the loudest sound in the animal

kingdom, when scaled to body size, by rubbing its penis against its abdomen (Sueur et al., 2011).

We have known for a long time that different species of aquatic insects must be able to produce different sounds because identification guide books draw on the differences in their sound-producing anatomy to distinguish between species (Greenhalgh et al., 2020; Desjonquères et al., 2024). If different species have different instruments, then logically it follows that they must be producing species-specific sounds. However, we know very little about which species are producing which sounds. This is important because many species of aquatic insects function as indicator species, meaning that they are indicative of specific ecological conditions and have been used by freshwater ecologists for decades to reliably assess the condition of rivers, lakes, and ponds (Hawkes, 1998).

The next big challenge in freshwater soundscape research therefore is to begin to catalogue the species-specific sounds produced by key indicator species groups, such as aquatic insects. As such, the creation of The Freshwater Sounds Archive is essential for understanding the associations between freshwater biodiversity, acoustic diversity, and ecosystem condition.

Conclusion

Biological sound archives are essential for unpicking the hidden complexities in soundscapes and for establishing meaningful links between biodiversity and acoustic monitoring. Moreover, the value of well-designed and maintained archives only increases in time as data are added and new methods for analysis are developed. However, the value of biological sound archives reaches far beyond its importance for biodiversity monitoring and extends into museum exhibits and classrooms around the world, reinforcing connections with people and the environment. Madeline Reilly works for the Lake Champlain Basin Program in Vermont and uses biological sound recordings while working with children. Reilly said it best while talking about the value that biological sound recordings have to engage and inspire a new generation: "People need tools to feel connected and hopeful — sound recordings provide a reminder of what we're trying to protect" (personal communication, 2024).

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