

PROJECTS FINAL REPORT		
<b>Call round: - UKAN+ Pilot Projects Round 2</b>		
<b>Project Title: Characterising spatial freshwater soundscapes on an urban-rural gradient</b>		
<b>PI: Prof Rob Briers</b>	<b>Research Organisation: Edinburgh Napier University</b>	
<b>Department: School of Applied Sciences</b>	<b>Start Date: 3/4/2023</b>	<b>Duration 6 months</b>
<b>Cost of award (80%): £27,769.55</b>	<b>Value of co-investment: -</b> <b>In kind:</b> <b>Cash:</b>	
<b>Co-I and associated RO: Dr Alastair Moore, SquareSet Sound</b>	<b>Acoustic Research themes:</b> Understanding of soundscapes Acoustics for understanding of climate change Impact of sounds on wildlife	
<b>Collaborations &amp; Partnerships involved in project:</b> Tell us about bi-lateral or multi-lateral partnerships/participation by the PI or research team in a network, consortium, multi-centre study		
<b>Project Partners</b>		
<b>Value and details of in-kind co-investment: -</b>	<b>Value and details of cash co-investment: -</b>	
<p><b>Summary:</b> A summary that can be published on our website (please do consider providing photo/images) Alternative methods of characterising freshwater pond soundscapes were compared, with a specific focus on quantifying spatial differences in soundscapes within a site and comparing existing methods with a custom hydrophone array. There were important differences in the soundscape characteristics recorded by the different methods and these did not relate in a simple fashion to invertebrate biodiversity or to differences between urban and rural sites indicating that using soundscapes for assessment of freshwater biodiversity needs to be carefully considered.</p>		
<p><b>Objectives:</b> As stated in the original case for support</p> <ul style="list-style-type: none"> <li>• Design and develop a custom hydrophone array for deployment in pond habitats</li> <li>• Apply different techniques to characterise the soundscape of a range of pond habitats along an urban-rural gradient</li> <li>• Compare how spatial variability in sound relates to measures of biodiversity and compares to the outcome of existing sampling methods</li> <li>• Examine variation in bioacoustic-based characterisation of pond communities in relation to effects of urbanisation</li> </ul>		
<p><b>Outcomes/Impact*:</b> Please refer to stated objectives. What impact has this had on the Acoustics Sector? How are the results being applied? Please provide specific examples/evidence to support the provided statements.</p> <p><b>Objective 1:</b> Having researched and collated contextual parameters in terms of the characteristics of the sounds that needed to be recorded, the custom hydrophone array was designed by the Co-Investigator who visited the</p>		

PI to provide training in usage and complete field-testing.

**Objective 2:** The PI and the RA employed on the grant, assisted by another research technician, undertook field sampling across a range of pond sites within the Scottish Central Belt and Borders. Following assessment of the availability of sites, it was decided to sample two groups of distinctly rural and urban sites to maximise the potential differences, rather than trying to sample across a gradient.

Each site was sampled using the Pond Audio Sampling Scheme (PASS) protocol, using Audiomoths and using the custom array to compare the outcomes between different methodologies. In a development from the original plan, multiple Audiomoths were deployed at each site to allow assessment of within-site variability due to locational differences as well. There was some delay in obtaining the recordings owing to poor weather conditions (notably extensive rain during which recordings cannot be effectively taken) during the period in which this was originally planned, but all the intended sites were sampled by early August.

**Objective 3:** Soundscapes captured in the recordings were characterised using the Acoustic Complexity Index (ACI), which is a widely used soundscape index in both aquatic and terrestrial ecosystems. Software to process the signals from the array was developed by the Co-I based on beamforming algorithms, allowing an evaluation of the variation in ACI values derived from sound arriving from different directions. The extent of variation between array signals differed between sites, however overall comparison of these values with those derived from a PASS sample based on a single hydrophone or Audiomoth recordings demonstrated that the array produced typically higher values of ACI. The relationship between ACI values and standard methods of biodiversity assessment also showed varying patterns, indicating a non-simple relationship between species richness and acoustic complexity (see Objective 4 as well). In addition to these methods, the Arbimon platform (<https://arbimon.rfcx.org/>) was used to characterise common sounds evident in the recordings and then process all the sound files from each site to enumerate the diversity of sound signals and frequency with which they were recorded. This provided an additional method to allow comparison of the freshwater soundscapes.

**Objective 4:** Variation in soundscape indices between urban and rural sites was assessed and there was no significant difference in the average values obtained, although for the Arbimon analysis, a greater frequency of sounds was registered per recording in the rural sites. As indicated above, there appears to be a non-simple relationship between the ACI values and overall invertebrate biodiversity. This is likely to relate to the fact that the sound-producing component of the invertebrate community (mostly true bugs and beetles) can have high diversity even in relatively poor-quality sites such as those found in urban areas.

**\*What activities have you undertaken to engage with research users, special interest groups and the general public to inform them about the research?**

During the fieldwork there was commonly significant interest in the activities being undertaken (most notably at urban sites) and these ad-hoc opportunities were taken to engage the wider public in the aims of the project and also to allow them to listen to the underwater soundscape of the ponds.

Sound recordings of common organisms within the sites were incorporated into a background soundtrack (along with sound from marine oyster reefs from a different project) for the Annual Research Conference at Edinburgh Napier in August resulting in interest in the project from attendees. The results of the work were also presented as a poster at the Annual UKAN+ meeting in Sheffield in September.

**\*Have any new research tools or methods been created or commissioned, if so, provide details: -**

The code for the processing tools developed by the Co-I as part of the signal processing aspect of the work is built on existing open-source components, allowing these to be utilised by other researchers.

**\*Have any new research datasets, databases and models making, or potential to make, significant difference to your research (or that of others), been created, if so, provide details: -**

Recordings from the sites will be incorporated into the Worldwide Soundscapes database ([https://ecosound-web.de/ecosound\\_web/collection/index/106](https://ecosound-web.de/ecosound_web/collection/index/106)). The PI has already contributed recordings to this. It requires significant processing of metadata to standardise it for inclusion and given the number of recordings undertaken, this is ongoing.

**Conclusion:** What is the primary outcome of this research?

Comparison of methods for characterising freshwater pond soundscapes has highlighted important differences that need to be accounted for in future research and the custom hydrophone array developed showed strong promise in terms of capturing spatial variation in sound signals within sites.

**Plans for follow-on activities/grants:** How are these results being used to further the area of research or its application in an industrial setting?

The team is continuing to explore other data-driven methods of using the hydrophone array recordings to quantify sound diversity within sites and if these prove promising then further funding applications will be made.

The recordings from the project have also been incorporated into broader funded work by the PI on temporal variation in urban pond soundscape characteristics which is ongoing.

Having established the utility of the custom array in ponds, it is intended to trial it in river ecosystems, to evaluate how it works in the substantially different environment of running waters.

**Weblink:** (to the outcome of the project, the Open Access repository for the data<sup>1</sup>, or press releases):  
The recordings will be uploaded into the Worldwide Soundscapes database as above, but no specific URL for the collection is available at this point.

**List of publications:** in peer reviewed or non-peer reviewed literature. If no publications are available, what are the plans to publish? Please follow UKRI guidelines for Open Access <https://www.ukri.org/manage-your-award/publishing-your-research-findings/>  
Analysis of the data collected is ongoing, with the intention to publish two manuscripts (one focused on methodological differences, the second on urban-rural differences) in peer-reviewed journals and drafting of ms has begun.

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<sup>1</sup> As a UKRI award holder you must follow their research data policies- <https://www.ukri.org/manage-your-award/publishing-your-research-findings/making-your-research-data-open>