Reconstructing an Ancestral Bat Echolocation Call

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WARWICK
THE UNIVERSITY OF WARWICK

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Acknowledgements

Prof. Mark Girolami
University of Warwick

Prof. Kate Jones
University College London

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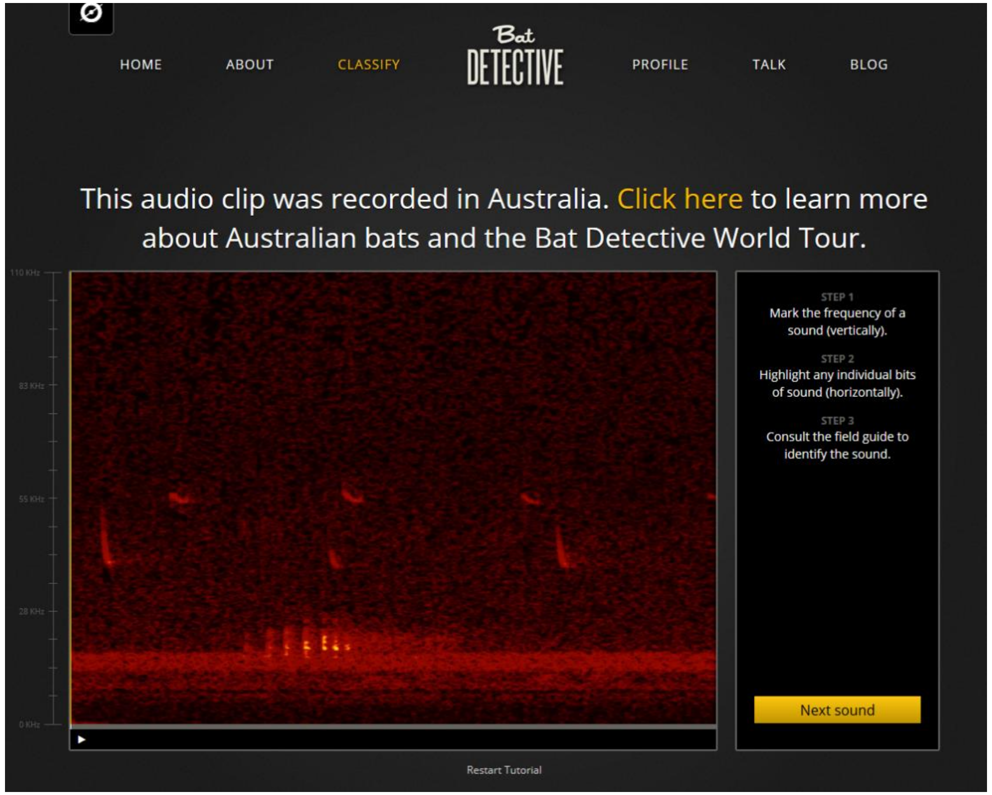

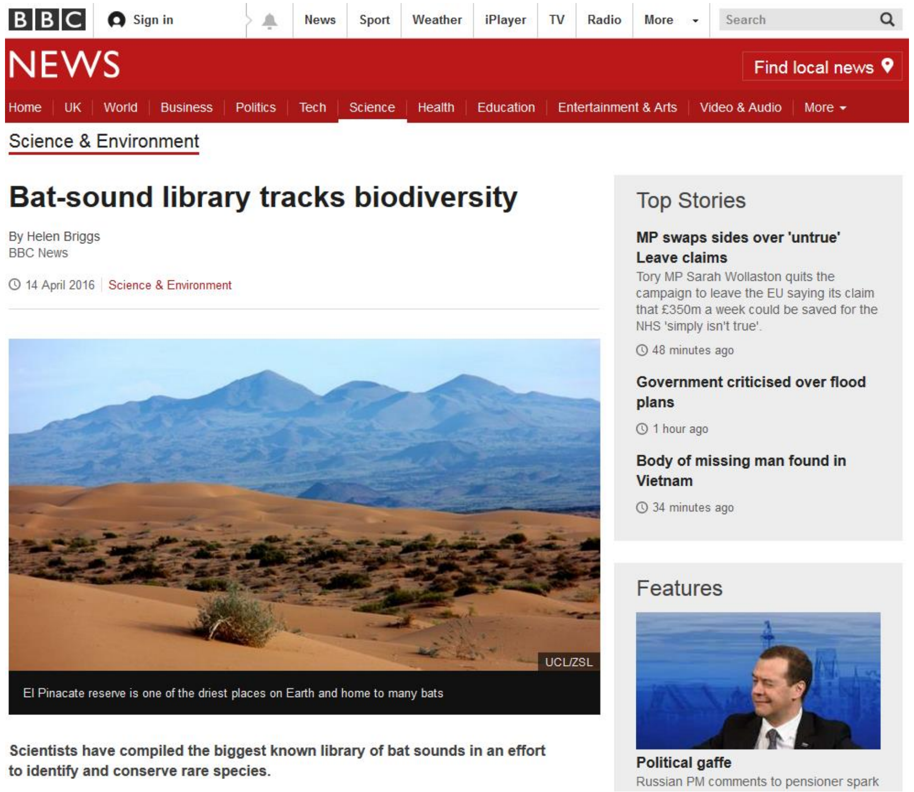

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Science & Environment

Bat-sound library tracks biodiversity

By Helen Briggs
BBC News

14 April 2016 | Science & Environment

UCL/ZSL

El Pinacate reserve is one of the driest places on Earth and home to many bats

Scientists have compiled the biggest known library of bat sounds in an effort to identify and conserve rare species.

Top Stories

MP swaps sides over 'untrue' Leave claims
Tory MP Sarah Wollaston quits the campaign to leave the EU saying its claim that £350m a week could be saved for the NHS 'simply isn't true'.
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1 hour ago

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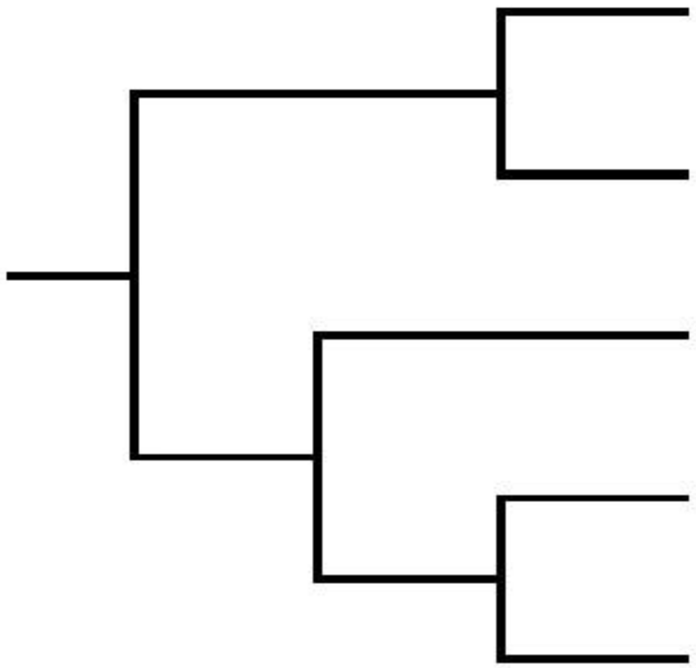
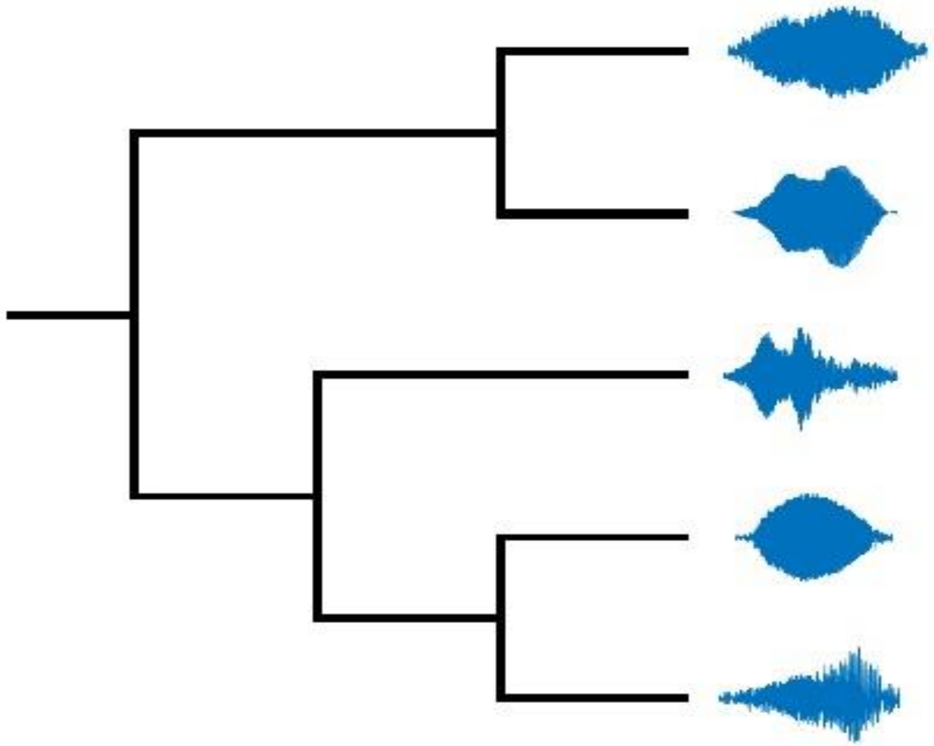
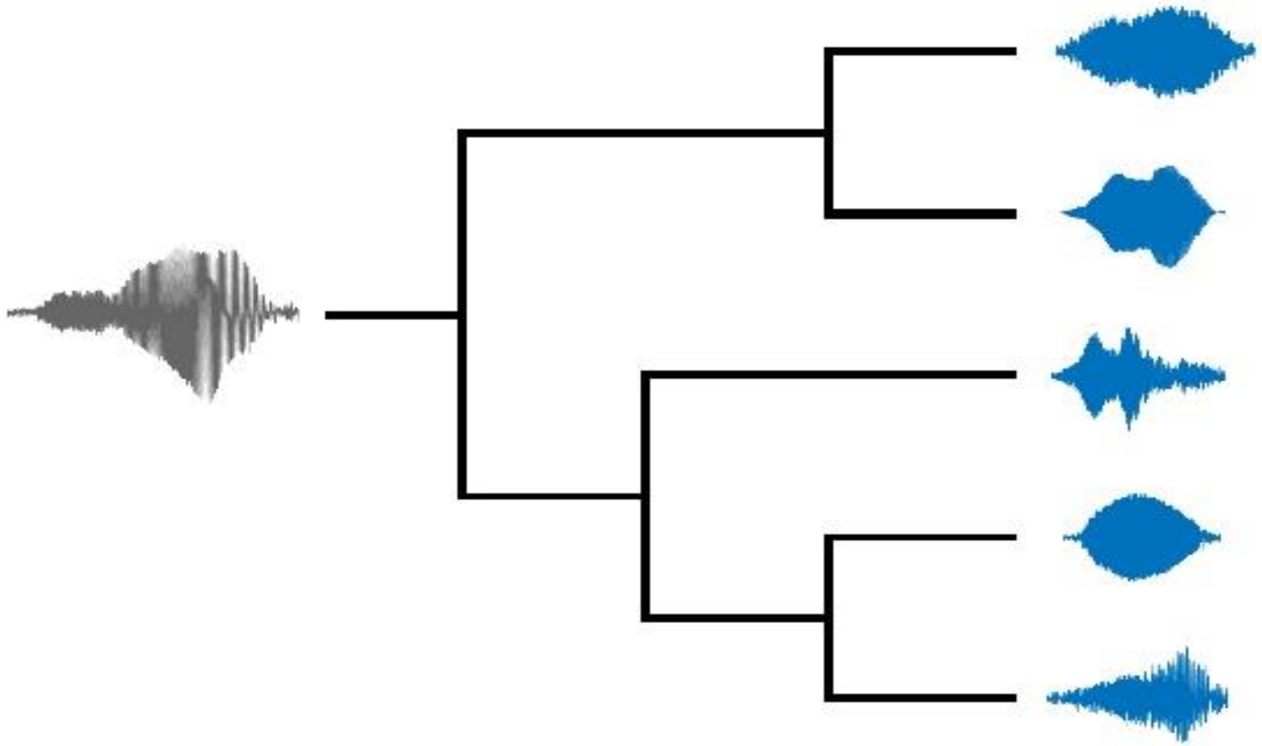
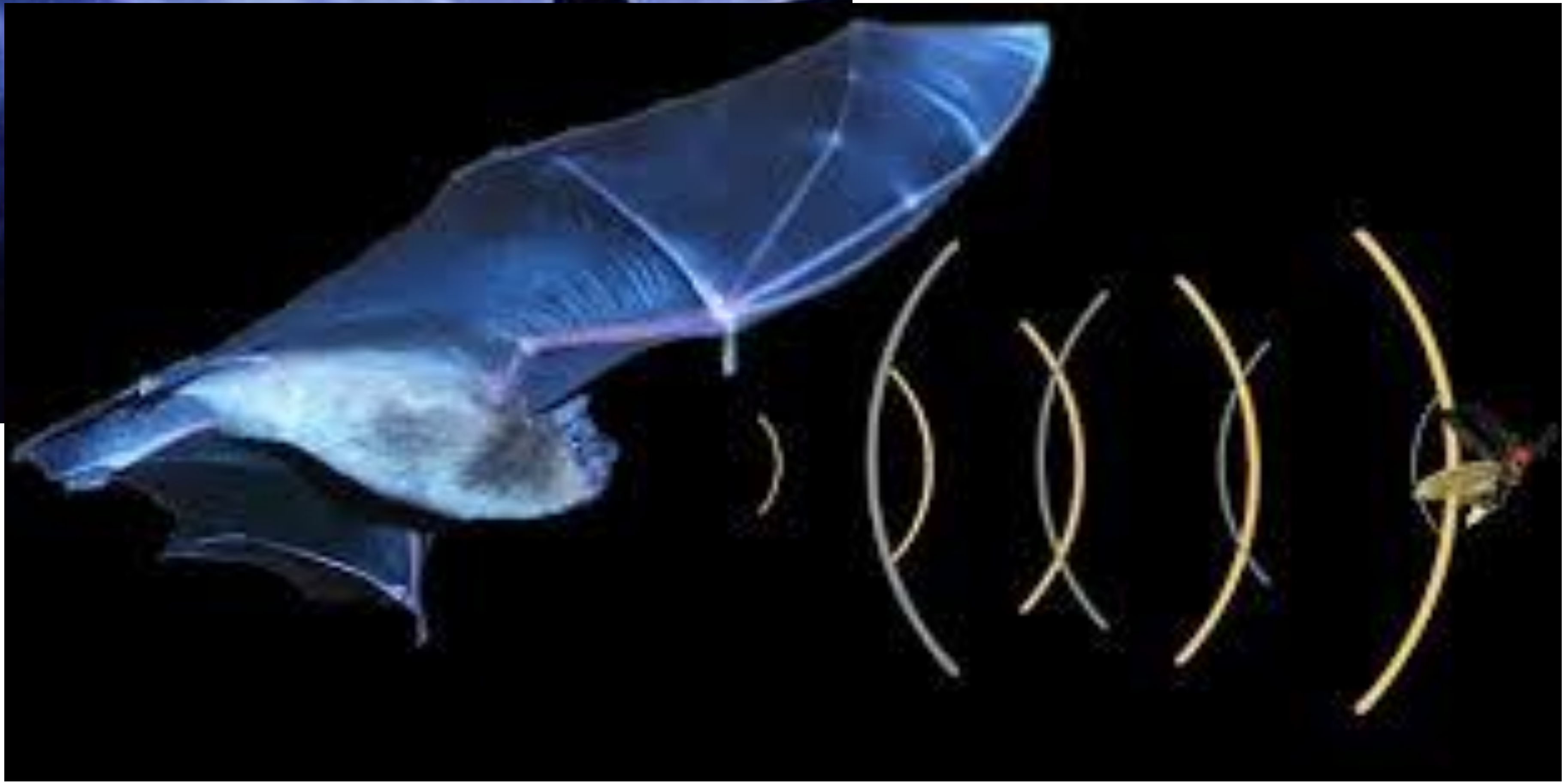
Political gaffe
Russian PM comments to pensioner spark







Related Research

Alanna Maltby. *The evolution of echolocation in bats: a comparative approach*. PhD thesis, Institute of Zoology, University College London, 2012.

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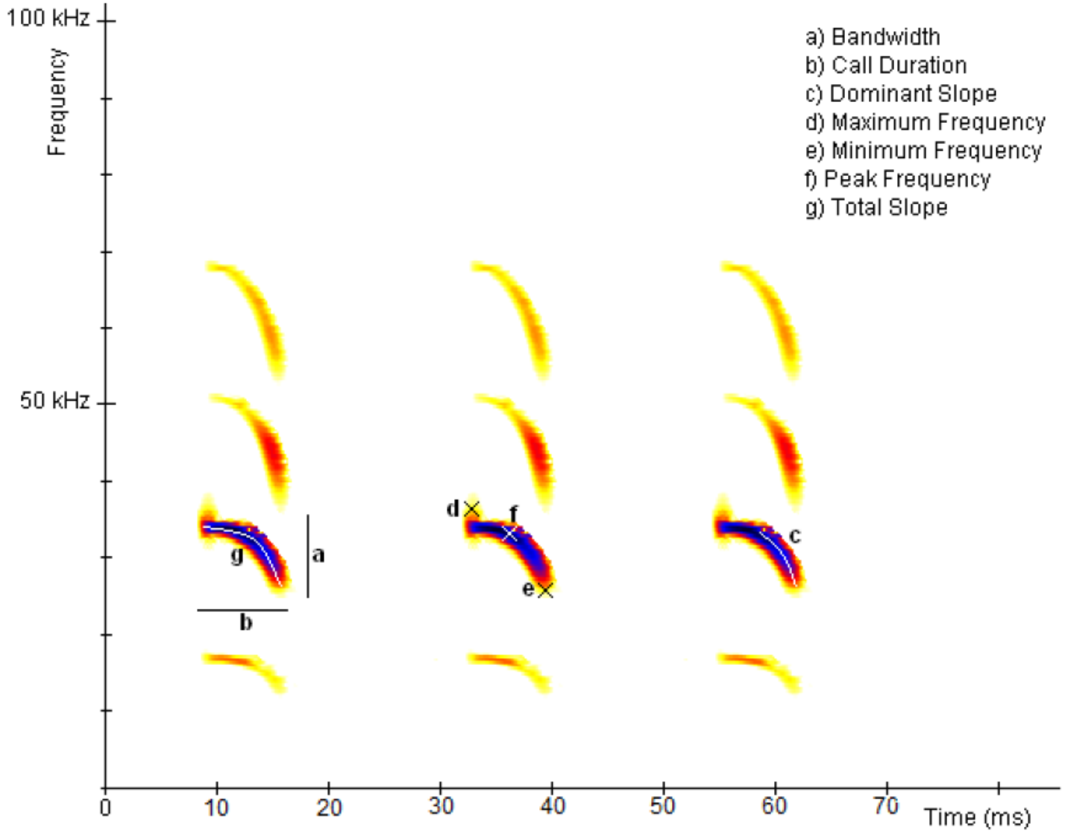

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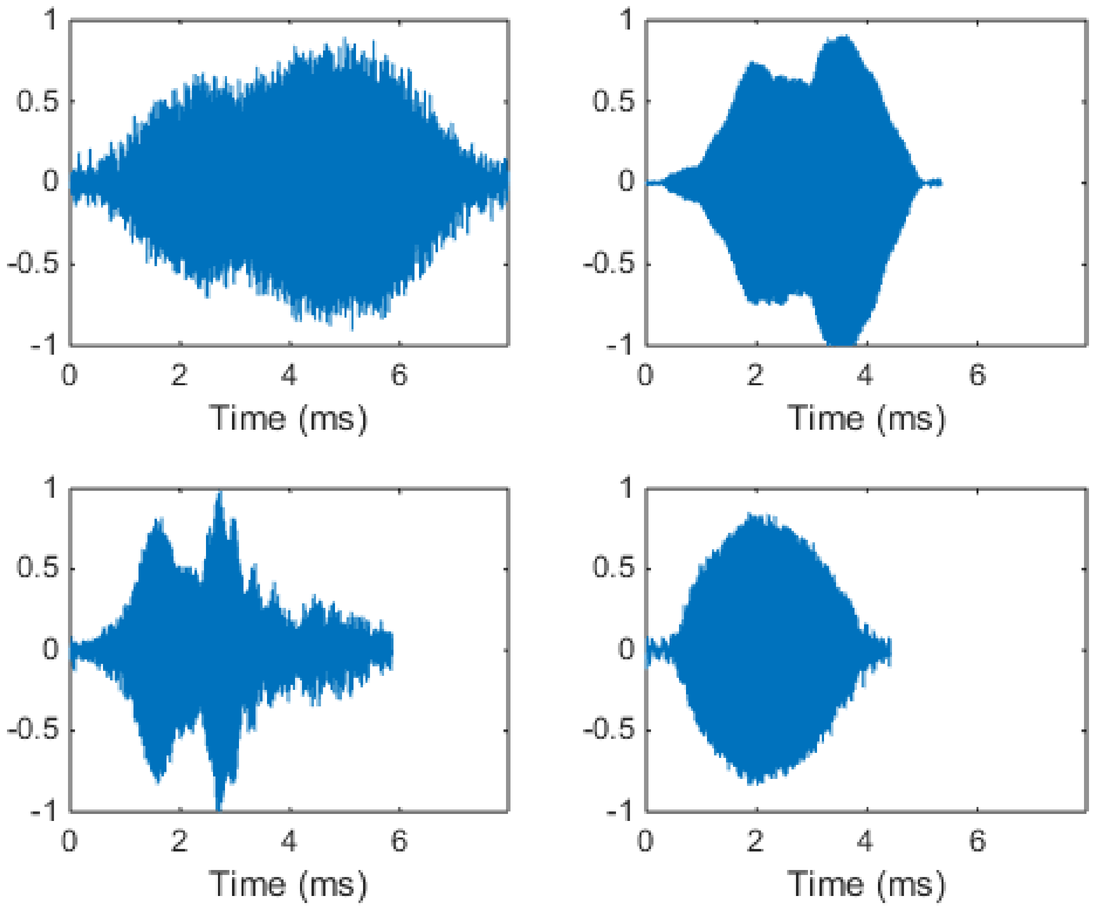
Nick S Jones and John Moriarty.
Evolutionary inference for function valued traits: Gaussian process regression on phylogenies.
Journal of The Royal Society Interface, 10(78):20120616, 2013.

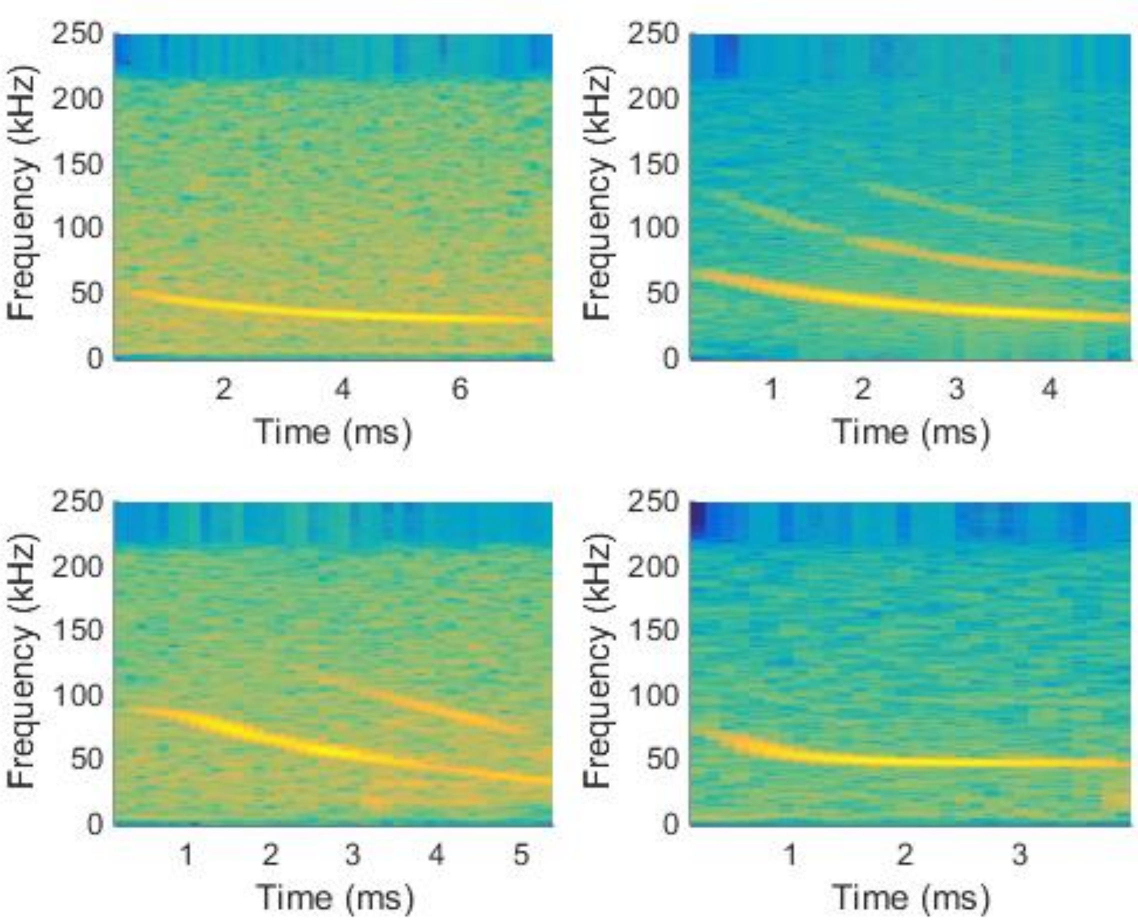
Get Call Recordings

Sample of Bat Echolocation Calls



Time-Frequency Representation

A Time-Frequency Representation - Spectrogram



A model for Spectrogram Surfaces

"Functional Data Analysis is a branch of Statistics providing information about curves, surfaces, or anything else varying over a continuum" - Wikipedia

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$$\mathfrak{S}_{lm}^{S}(t_j, \omega_k) = G_{lm}^{S}(t_j, \omega_k) + \epsilon_{lm}^{S}(t_j, \omega_k)$$

Spectrogram = Underlying Surface + Noise

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Spectrogram = Surface mapped from absolute to individual time scale + Noise

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Spectrogram = Surface mapped from absolute to individual time scale + Noise

$$\mathcal{S}_i(t, \omega) = \mu_i(t, \omega) + \delta Z_i(t, \omega)$$

Sample surface = Group Mean Surface + Noise Process

Statistical Analysis

Given a set of Surfaces $\bar{Y}_1, \ldots, \bar{Y}_N$

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Mean Surface Estimator

$$\bar{\mu}(t, \omega) = \frac{1}{N} \sum_{i=1}^{N} Y_i(t, \omega)$$

Statistical Analysis

Given a set of Surfaces $\bar{Y}_1, \dots, \bar{Y}_N$

Covariance Operator Estimator

$$\bar{C}(t, t', \omega, \omega') = \frac{1}{N-1} \sum_{i=1}^{N} \{ Y_i(t, \omega) - \bar{\mu}(t, \omega)\} \{ Y_i(t', \omega') - \bar{\mu}(t', \omega')\}$$

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Require a Simplifying Assumption – Separable Covariance Operators

$$\boldsymbol{C(t, t', \omega, \omega') = C(t, t')C(\omega, \omega')}$$

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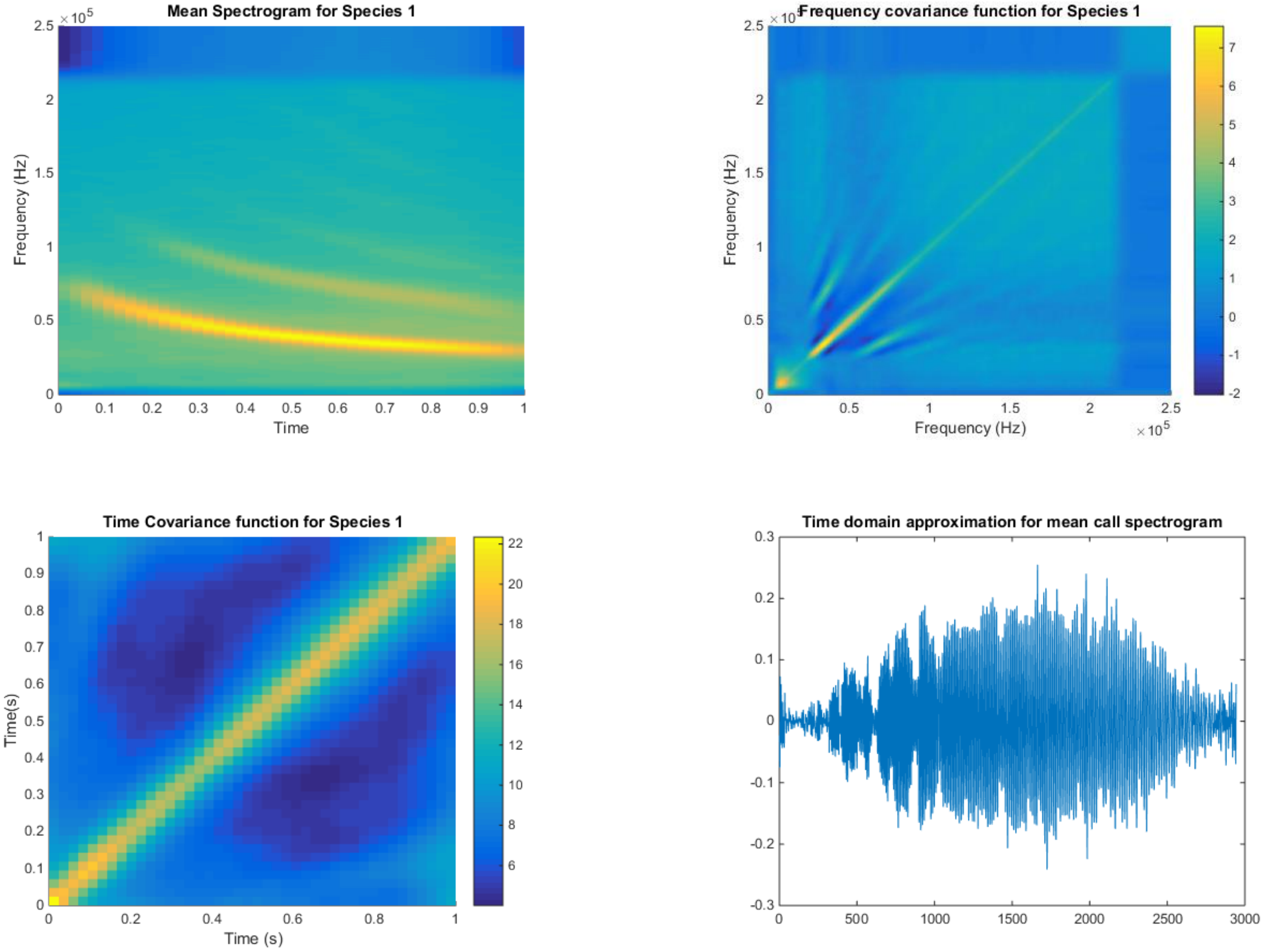
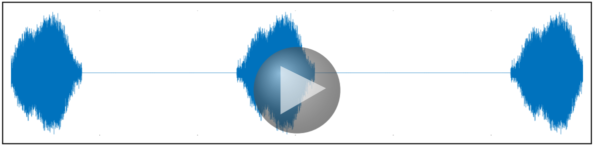
$$\widetilde{C}_t(t,t') = \frac{1}{N-1}\sum_{i=1}^{N}\int_0^F\{Y_i(t,\omega) - \bar{\mu}(t,\omega)\}\{Y_i(t',\omega) - \bar{\mu}(t',\omega)\}\,d\omega$$

$$\widetilde{C_\omega}(\omega,\omega') = \frac{1}{N-1}\sum_{i=1}^{N}\int_0^T\{Y_i(t,\omega) - \bar{\mu}(t,\omega)\}\{Y_i(t,\omega') - \bar{\mu}(t,\omega')\}\,dt$$

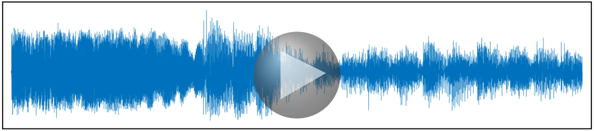


Mean Spectrogram for Species 1
Frequency (Hz)
×10^5
Time
Frequency covariance function for Species 1
Frequency (Hz)
Frequency (Hz)
×10^5
Time Covariance function for Species 1
Time(s)
Time (s)
Time domain approximation for mean call spectrogram

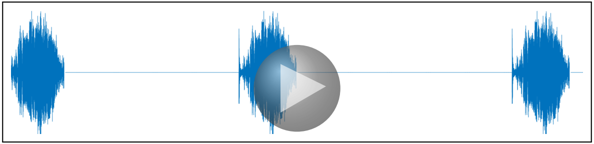
Time expansion of an Actual Echolocation Call



Time expansion of an Approximation for the Mean Echolocation Call 1



Time expansion of an Approximation for the Mean Echolocation Call 2



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Given a set of Surfaces from G groups, $\{Y_{ij}: i = 1, \ldots, N_i; j = 1, \ldots, G\}$

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find orthogonal basis functions which maximise the ratio of between group variation to within group variation

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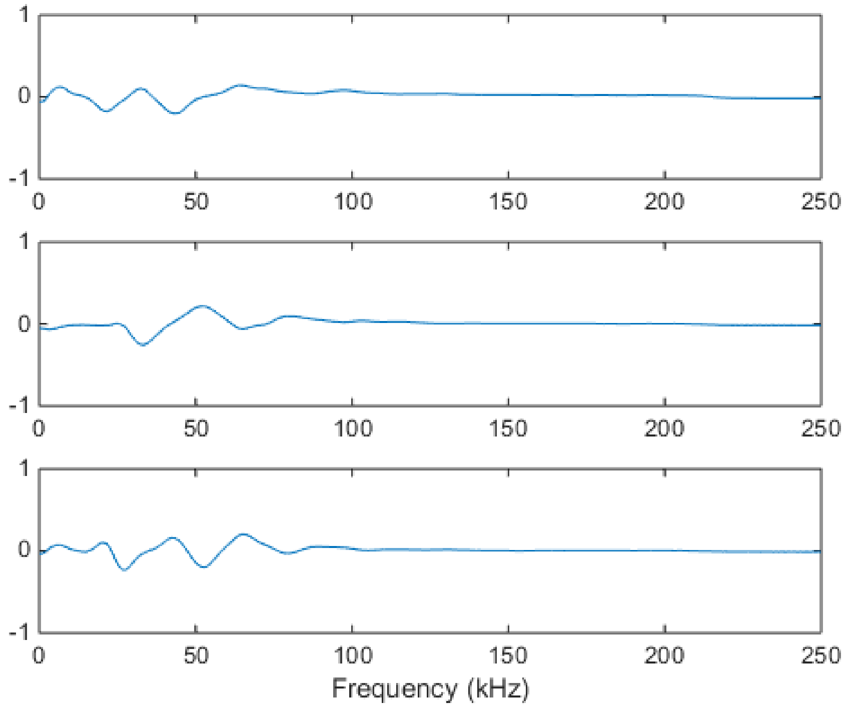
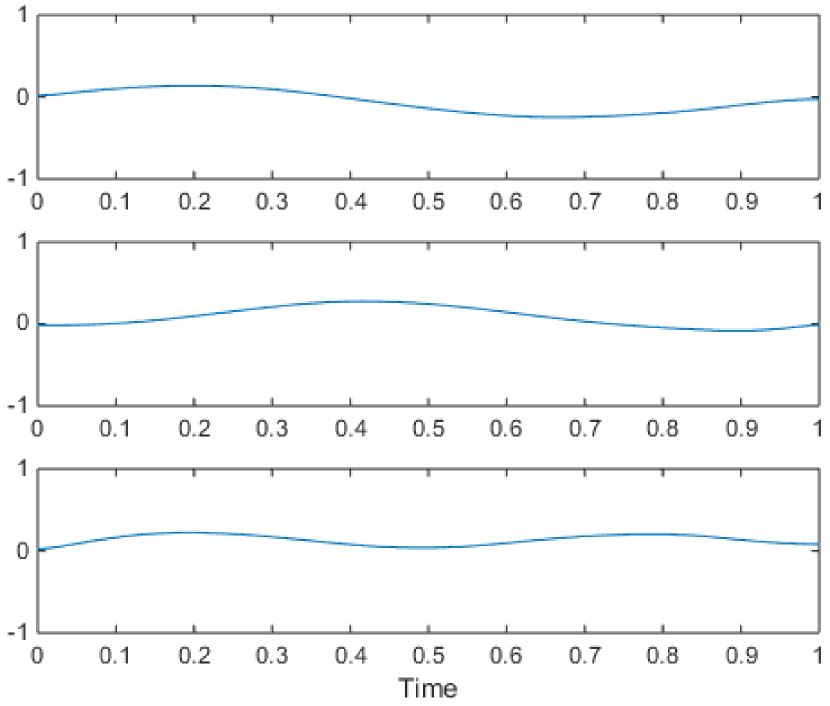
First Three Canonical Functions for Frequency



First Three Canonical Functions for Time




WAP WAP WAP
CALVIN! WHAT ARE YOU **DOING** TO THE COFFEE TABLE ?!?
IS THIS SOME SORT OF TRICK QUESTION, OR WHAT?
WATTERSON