The Rhythm and Rhyme of Animal Movement:

finding the beat by signal processing

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Signal processing techniques are becoming increasingly utilised in wildlife telemetry because of their ability to accurately summarise the relative importance of periodic components in time-series data. Here we describe a new application for these mathematical techniques to spatial data collected by an array of passive acoustic receivers.

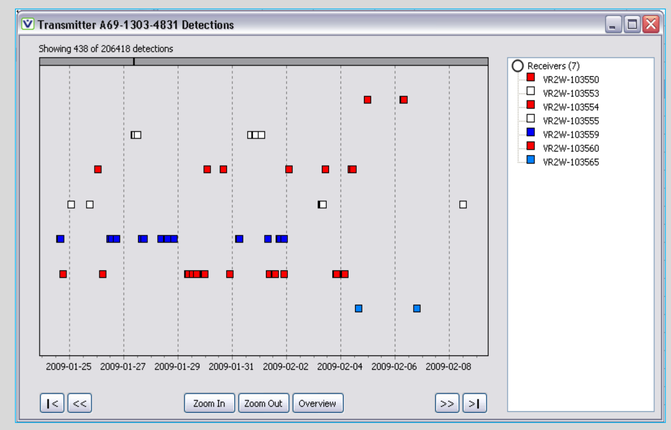
The VEMCO VR2W passive acoustic listening receiver (left) is being widely used to track the finite and broad scale movements of aquatic animals.

How it works: Multiple receivers are deployed over wide areas and the tagged animals are detected as they move between the detection range of each receiver.

Data collected by multiple receivers is stored within a detection database

THE PROBLEM: Signal processing relies upon the regular sampling of a continuous variable. Neither are present in data collected by passive acoustic telemetry, because the animal is only located when it is within the detection range of a static receiver.

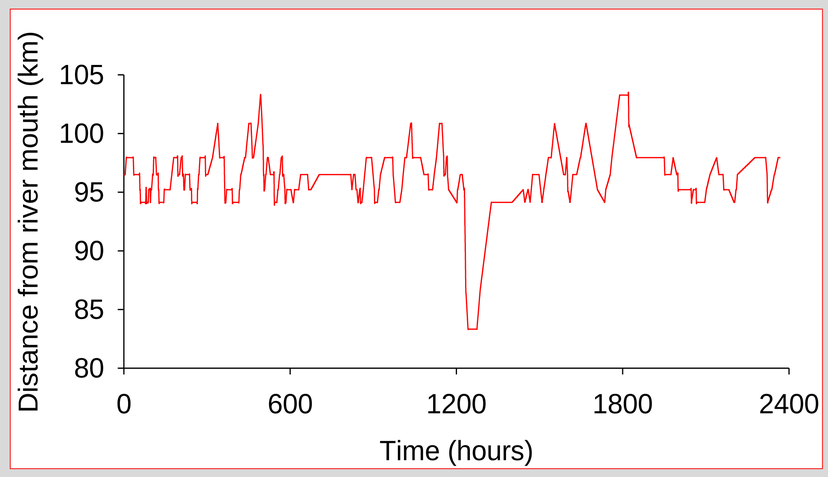
The abacus plot on left is from the VEMCO VUE software and shows the irregular sampling of the animal's location as it moves between seven static receivers (picture top right).



The detection data is interpolated to create the pseudo-waveform

THE SOLUTION*:* Step one

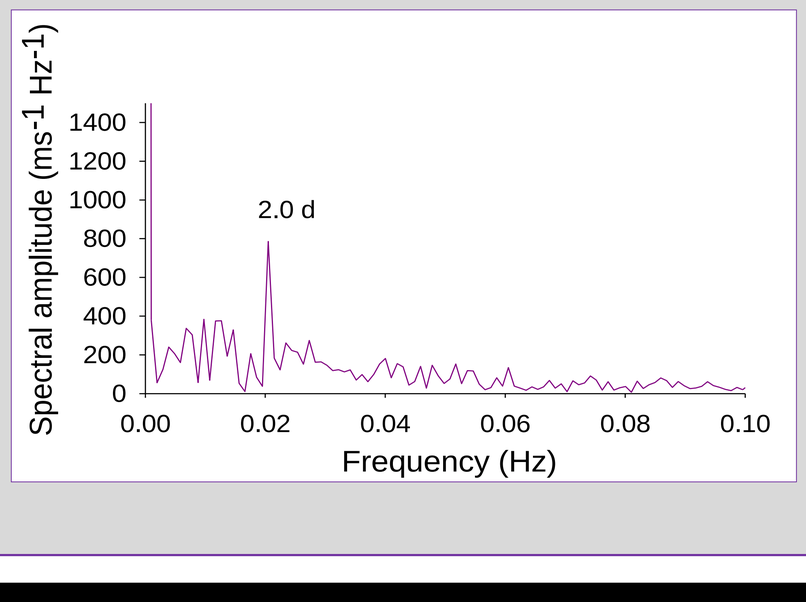
Calculate a receiver matrix, with the location of each receiver being on a linear scale and relative to all other receivers within the array. Here we use river distance to provide the continual scale for receiver location *(right)*. Using arrival and departure time from each receiver, the animal's location within the array is interpolated continuously through space and time. It is this pseudo-waveform which provides the samples of animal location at regular intervals (*graph shows hourly samples over 100 d).*



The Fourier transform is applied to the pseudo-waveform

THE SOLUTION: Step Two

The signal processing algorithm (Fast Fourier transform) is applied to the regularly sampled animal location data *(the sampling rate will determine the time-base of the periodic components*). The output spectrum *(right)* reveals a significant periodic component within the time-series data for the pseudo-waveform *(above)* at 0.02 Hz. Because the rate of sampling for animal location was hourly (1 Hz = 1 hr) the frequency of the oscillation in the time-domain is approximately 2 days (50 hours). Revealing the period by which the animal moves through the receiver array/home-range.



Significance: **This methodology overcomes the problem of irregular sampling (in time) of a discontinuous variable (in space) - inherent to data collected by passive acoustic telemetry. This enables signal processing techniques to be applied to the data, and will have numerous applications within the growing field of passive acoustic telemetry.**

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