FFT, overlap, frequency resolution, and type of window

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During the switch from the temporal to the frequency domain, it is necessary to input certain parameters into the code/software. These parameters include the overlap, the FFT length, and the type of window. The **overlap** represents the degree of overlap between the individual segments of the power-spectra. An example is the use of a minimum 75% overlap generally used for 4 kHz subsampled files to analyze fish sounds, while a 50% overlap can be used for higher frequencies to optimize computational time. The **FFT** length refers to the number of data points in the time domain signal on which the Fourier transform is computed. Different FFT lengths were used in this research thesis depending on the type of sounds (mainly fish vs. benthic invertebrate) and sampling rate. By dividing the sampling rate by the FFT length, the **frequency resolution** is obtained. As the FFT length increases, the frequency resolution decreases… and the temporal resolution increases (Fig. 1). Conversely, as the FFT length decreases, the frequency resolution increases. In comparison to fish sounds, benthic invertebrate sounds are typically broadband and of short duration. Therefore, a high frequency resolution is not necessary for their analysis.

One of the main issues with the FFT method is that it not only detects the frequencies present in the target segment, but also in the adjacent segments. This phenomenon is due to the assumption of periodic time-series data (i.e., data repeated over and over) in the FFT, which introduces an artifact [1]. To address this issue, **windowing** techniques are commonly used. In this thesis, we employed the Kaiser and Hann techniques among other existing techniques. Furthermore, the overlap parameter is also linked to the time resolution of the spectrogram [1].

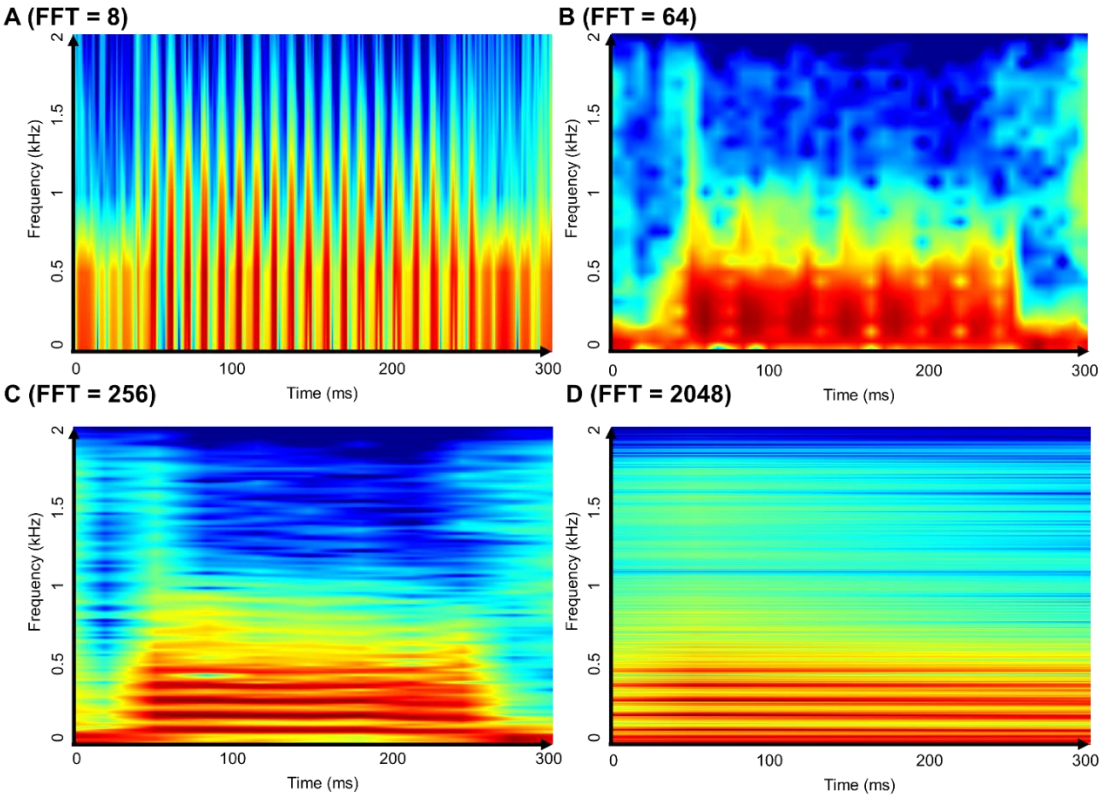

Fig. 1. Spectrograms of a harmonic fish sound composed of 19 peaks (sample rate: 4 kHz) with varying FFT lengths. (**A**) Frequency resolution: 500 Hz, (**B**) frequency resolution: 62.5 Hz, (**C**) frequency resolution: 15.6 Hz, D frequency resolution: 1.95 Hz. All other parameters remain constant. The intensity of the color indicates the sound's amplitude, with warmer colors indicating higher amplitudes.

REFERENCES

1. Sueur, J. *Sound Analysis and Synthesis with R*; Use R!; Springer International Publishing: Cham, 2018; ISBN 978-3-319-77645-3.