CHIRP SUB-BOTTOM PROFILER SOURCE SIGNATURE DESIGN AND FIELD TESTING

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Chirp sub-bottom profilers are widely used to collect very high resolution 2D marine seismic data. They produce high signal-to-noise ratio data using a repeatable source signature. A 3D chirp system is currently being developed at the Southampton Oceanography Centre and as part of this development we developed and tested a number of alternative source sweeps to optimise the vertical resolution and penetration capability of the system. The source sweeps use a maximum frequency range of 1.5 – 13 kHz and vary in their instantaneous frequency as well as their envelope function. Non-gaussian envelope functions and non-linear instantaneous frequency function are used. In field trials in the West Solent (UK) the same seismic line was repeatedly recorded using different source sweeps. The data sections were analysed for resolution and attenuation, and the results were compared to model results.

Here we demonstrate our approach using two of the used sweeps, shown in Figure 1, as an example.

A) B) C)

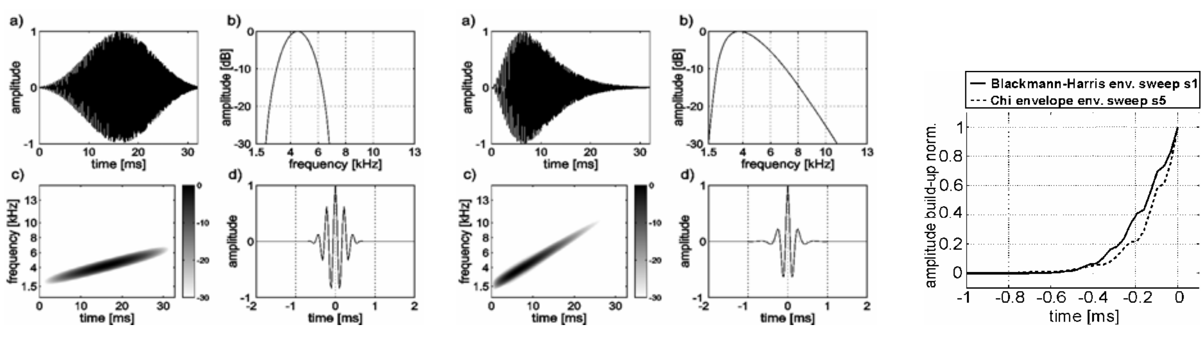

Figure 1. A) Traditional standard low frequency sweep with Blackmann-Harris envelope function S1. B) Linear sweep with Chi envelope function S5. a) source sweep, b) amplitude spectrum, c) spectogram, c) Klauder wavelet. C) Klauder wavelet amplitude build-up, used for resolution estimation.

The example sweeps have the same time duration of 32 ms. Sweep S1 has a frequency range of 2 - 8 kHz and a fundamental frequency of 4.5 kHz. Sweep S5 has a wider frequency range of 1.5 – 13 kHz but a lower fundamental frequency of 4.3 kHz due to an Chi envelope function that amplifies the low frequencies compared to the symmetrical Blackman-Harris envelope function of sweep S1. Both sweeps have a linear instantaneous frequency function as apparent in their spectograms. The resulting auto-correlation function, the Klauder wavelet, is tighter for sweep S5. To compare widths of the Klauder wavelets, a measure for the vertical resolution capabilites, we integrate the absolute amplitude values from a lag time of –1 ms to the peak of the Klauder wavelets. Subsequently we calculate the half width of the normalised amplitude build-up curves, both for theoretical curves and from the recorded data. For this example sweep S5 has a tighter normalised amplitude build-up compared to sweep S1 with half-width value 20% smaller.

Figure 2 shows the sections recorded with the example sweeps.

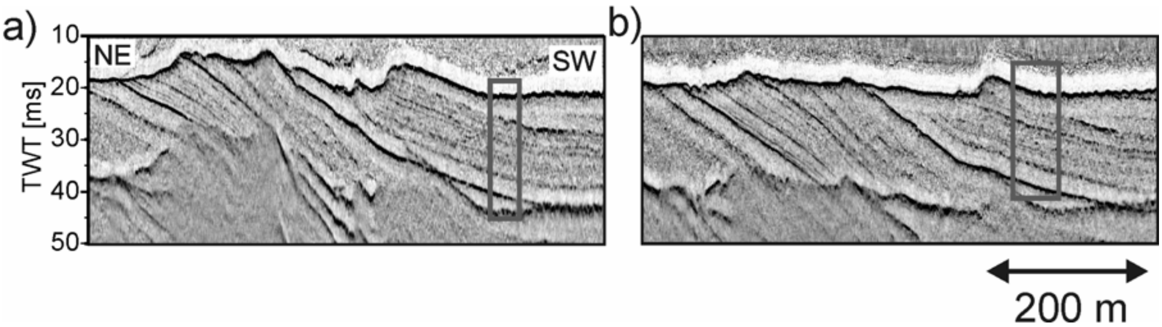

Figure 2. Parallel chirp seismic sections, West Solent, UK. a) Sweep S1. b) Sweep S5.

To estimate the attenuation of the different source sweeps we compared the reflection amplitudes of the seafloor and an internal reflector over the same, highlighted area of the sub-surface. We calculate an apparent attenuation value by correcting for geometrical spreading and assuming similar, unknown reflection coefficients for the reflectors in the sections. Additionally we model the attenuation using a relaxation time based algorithm. The example sweeps show similar attenuation values, both where modelled and calculated from the data.

Overall this example showed that sweep S5 compared to sweep S1 has better resolution capabilities, while offering similar penetration.

Comparing all tested sweeps in the described manner shows that a number of newly developed sweeps offer advantages in their resolution and penetration capabilities over the traditionally used signatures. The optimal sweep should be chosen depending on the resolution and penetration requirements of the survey.