Broadband Processing of Conventional Marine Streamer Data from Offshore West Africa

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Introduction

In towed streamer marine seismic acquisition, data is typically recorded over a bandwidth of 2-250Hz. This is represented by a wavelet of finite width with side lobes in the time domain when zero phased. This ideal wavelet is distorted by two major factors: the source and receiver-side ghosts and absorption due to various propagation effects (Q). This paper presents two case studies of a deghosting, broadband processing workflow on conventionally acquired (single sensor, flat streamer) data from offshore West Africa.

Background

Upward propagating seismic energy is reflected by the sea surface with a reflection coefficient of almost -1. Subsequent interference of the up and down going waves produces ghost notches at certain frequencies in the power spectrum of the data. There have been many attempts at solving this problem using acquisition technologies (Posthumus 1993, Carlson 2007), but a purely data processing deconvolutional approach (Baan, 2008, Zhang, 2011) has not proven to be satisfactory until recently.

The ghosting operator is a short finite impulse response (FIR) filter. Therefore its inverse is, in principal, an infinite impulse response (IIR) filter. Inversion methods can be used to derive this IIR by the minimisation of an error function (Zhou 2012). The angle dependency of the ghost delay can be removed by time stretching the data in x-t; in tau-p; or by f-k remapping in a Stolt migration. This was demonstrated by O'Driscoll et al (2013).

As P-wave energy travels through rock, its amplitude decays due to effective Q as a function of frequency and travel time. For a given distance travelled through rock, higher frequencies will have had more cycles than lower frequencies so will be more attenuated. Deghosted noise free broadband data has a flat amplitude spectrum prior to attenuation (observed at the water bottom reflection, for example) but with absorption and scattering the spectrum becomes dominated by the lower frequencies.

Results

The technique introduced by Zhou (2012) was tested on two datasets from West Africa. The first was acquired at 9m source and 12m cable depth respectively. This resulted in notches at 0, 63, 83Hz and higher harmonics. The broad-bandwidth deghosting operator was derived and applied after Radon demultiple. After this, amplitude Q compensation was applied to recover the high frequencies attenuated by effective absorption. A comparison with and without deghosting is shown in Figure 1. Good signal is present across a bandwidth of around 2-120 Hz.

The second dataset was acquired with two different acquisition configurations: deep tow (18m) and shallow tow (9m) receivers. The source was towed at 7m depth. Both were processed up to demultiple where respective deghosting operators were derived and applied. Final results after pre-stack depth migration are shown both with and without deghosting. The wavelet's amplitude and phase are analysed at different depths to demonstrate the veracity of the recovered bandwidth.

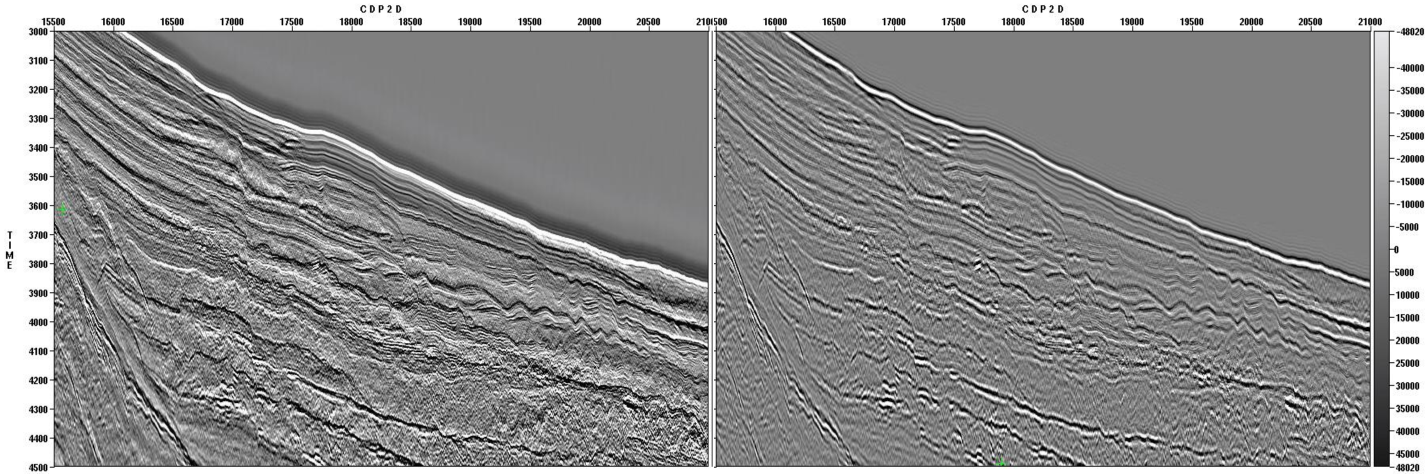

Figure 1 *Final PreSTM stack with amplitude Q compensation. With (left) and without (right) deghosting.*

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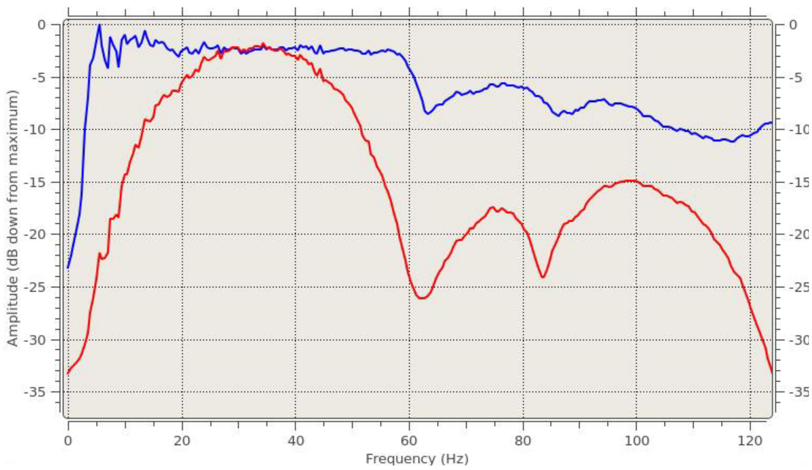

Figure 1a *Spectrun of final PreSTM stack with amplitude Q compensation. With (blue) and without (red) deghosting. Window as in Figure 1.*