Ghost removal with conventional marine streamers

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In Chapter 5 of "3D seismic survey design" I give quite some attention to new acquisition techniques that aim to solve the ghost problem. These techniques are over/under shooting (Section 5.3.10), the multicomponent streamer (dual sensor and quad sensor, Section 5.3.11), and the variable depth streamer (Section 5.3.12). The ghost effect itself is described in Section 5.3.9. It was just possible to include a section on the quad-sensor streamer (Isometrix^{TM}) of WesternGeco, but the rather unexpected new development of ghost removal using new processing techniques applied to conventional towed streamers was just missed. The following aims to make up for this.

In the past, using conventional streamers, the first ghost notch was pushed to the highest practical frequency by towing sources and streamers as shallow as feasible. Usually, all frequencies above the first ghost notch were considered to be lost. The reasons were that it is theoretically impossible to retrieve information for frequencies that have been canceled out by the ghost effect and that deconvolution of the recorded signal + noise around the notches led to data with low S/N. Even a rather recent method to deghost data acquired with a non-horizontal streamer assumes that the spectral notches of the streamer ghost lie outside the range of interest (Riyanti et al., 2008).

Most recently, a few papers have shown that the situation for deghosting conventional streamers is not as bleak anymore as it used to be (Zhou et al., 2012; Williams and Pollatos, 2012). Zhou et al. (2012) state: "It is our view that modern streamer acquisition equipment has advanced sufficiently so that the various modes of streamer-borne noises are much lower than even the very weak signal present at the notch frequencies." This statement implies that pure notches hardly ever exist (in fact, they exist in a very calm sea, when the reflection coefficient at the sea surface is exactly -1).

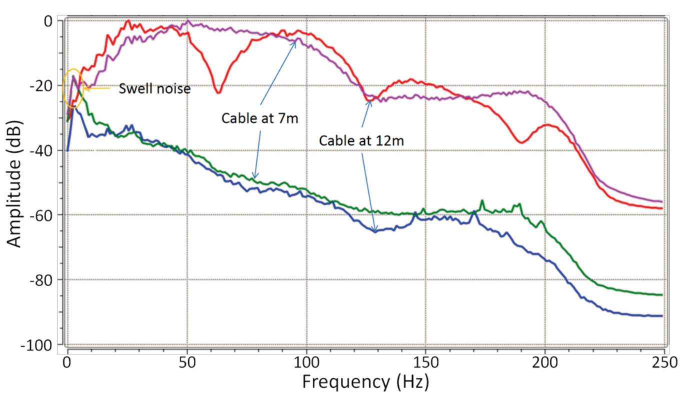

Figure 1. Signal and noise spectra of raw single channel sections (after Zhou et al., 2012).

Zhou et al.'s statement is illustrated with Figure 1. The spectra in this figure were computed for single channels of a shallow (7 m) and a deep (12 m) tow cable. The noise spectra were measured in a 600 ms data window below the direct arrivals and above the water-bottom reflections. The signal spectra were taken from a 600 ms data window starting 600 ms below the water-bottom reflection. The noise spectra only differ significantly for frequencies lower than 20 Hz, where the swell noise in the shallow cable is stronger than in the deep cable. Everywhere else the noise spectra show streamer-borne noise that stays well below the signal spectra.

Figure 1 illustrates the potential to remove the ghost notches without boosting the noise too much. Yet, deghosting cannot be carried out using some simple whitening technique, because the frequencies above the first notch have reversed polarity. Zhou et al. (2012) describe GX Technology's WiBand technique, which is a combination of a deghosting operator and a variation on the theme of "blind deconvolution". Using the technique on the data of a deep and a shallow streamer, the authors demonstrate that the deep-tow cable can give the same high frequencies (4 - 150 Hz) as the shallow cable with the added advantage of better low frequencies (see Zhou et al., 2012, for data examples and more frequency spectra).

Williams and Pollatos (2012) present similar signal and noise spectra as shown in Figure 1. They emphasize the point that *a calm sea is something one does not want to have*, because then the ghost notches may become too deep. This requires new recording specs. Hegna and Parkes (2012) discuss complementary acquisition components (velocity and pressure sensors for the receivers and varying depth and width of source arrays) to get rid of source and receiver ghosts. In his presentation Hegna also discussed the possibility of using conventional streamers for deghosting. He made the important point that, to prevent too deep notches, source and receiver ghosts should not coincide in the desired frequency band.

TGS (2013) claims to provide a processing technique "Clari-Fi Totus" that also creates broadband seismic from conventional streamer data using some deghosting technique.

Discussion

These new developments in processing of marine seismic data clearly improve the position of contractors who do not offer one of the acquisition solutions to ghost removal. Yet, the deghosting processing technique does not change S/N as a function of frequency. This means that deghosting can only be successful if there is a significant difference between the noise and signal strength at the ghost positions.

There may be plenty of data around that can be used to test the deghosting methods. Marine seismic data that have been acquired with relatively deep solid streamers may be turned into broadband data using one of these new processing methods.

References

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