REDUCTION OF ACQUISITION TIME-SHARING IN THE NORTH SEA BY SEISMIC-INTERFERENCE ATTENUATION

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Summary

In 2003, Seismic Interference (SI) was recorded during the simultaneous acquisition of BP's Valhall OBC data and towed streamer data in Quad 30 (Figure 1). BP and Veritas jointly initiated a project to investigate SI attenuation methods, in order to define new noise thresholds for acquisition in the presence of SI and so reduce the need for time sharing. A range of standard and non-standard processing algorithms and flows were evaluated on the contaminated data. It was concluded that the recorded SI could be successfully removed pre-stack from both datasets with accurate signal amplitude preservation. This extends the findings of Jack and Lancaster 1989 and Lynn *et al* 1987. In 2004 streamer test data were recorded containing SI from the Valhall source. These were used to build an interference noise library to model SI arrivals from a range of bearings and strengths. The results of subsequent processing and analysis enabled both companies to agree to acquire surveys in this area during 2005 with reduced time-sharing.

Background

Seismic Interference is recorded when two or more crews simultaneously acquire data. Excessive interference often results in time-share, which is costly for both the client companies and seismic contractors. BP's Life of Field Seismic (LoFS) OBC project on Valhall has required data to be acquired up to 4 times per year to provide 4D seismic images for monitoring and optimising field depletion. This resulted in significant exposure to seismic interference between Valhall and acquisition in nearby Quad 30. Distances between the surveys are as small as 20km, resulting in the potential to record significant broadside noise on the streamer data

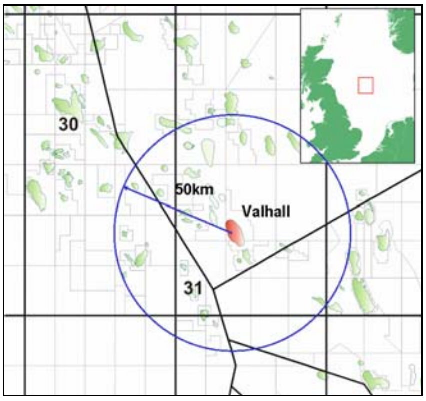

Figure 1: Location Map

SI Noise Characteristics

The characteristics of SI are controlled by the water depth and the nature of the sea-floor. In this case the water depth is around 70-80m (about 100ms two-way time) and the SI is super-critical leaky wave-guide propagation of up to 2.5 seconds in duration and with multiple modes. The noise is broadband, spatially aliased and dispersive with frequency (Figure 2). See Hargreaves *et al* 1997 for additional discussion.

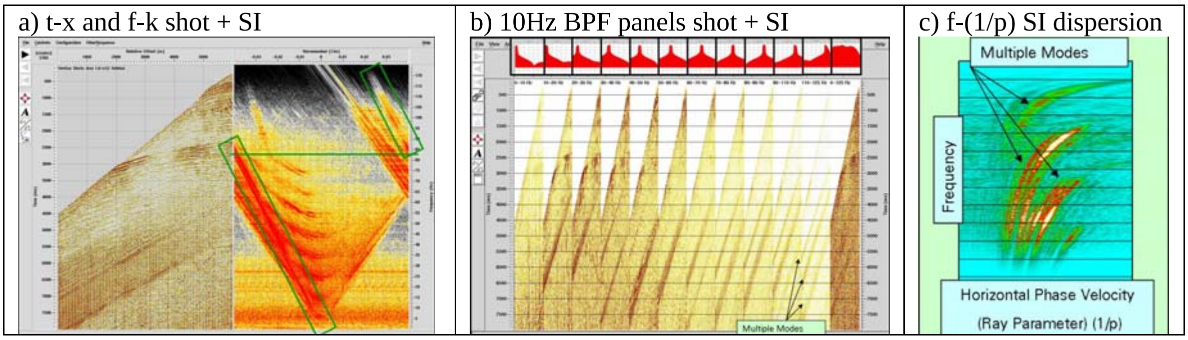

Figure 2 HT SI Noise Character Displays

For streamer data the noise train is often classified as arriving <u>H</u>ead-to-<u>T</u>ail (HT), <u>T</u>ail-to-<u>H</u>ead (TH) or <u>B</u>roadside (B), depending on the bearing of the interfering source relative to the streamer. In this case the OBS source had 20 second shot interval, so that the streamer data, which had a 10 second shot interval, at least every other shot was unaffected by the noise.

Initial Signal Processing Effort

The project initially focused on attenuating seismic interference on the towed streamer data using the range of processing techniques available. Processing aims were defined: 1) to minimise potential harm to primary energy - the SI removal technique should be applied only to the contaminated shots and limited to the contaminated t-x range, and 2) should not preclude real time (onboard) processing –

thus the attenuation technique should be reasonably automated and run on shot gathers. These two constraints should ensure high confidence that the recorded SI may be dealt with while processing line by line as they are acquired. Figure 3 illustrates the results of an automated τ-p technique on a shot which meets these aims. FX coherent noise attenuation, FX spectral editing and reconstruction, and FK filtering (protecting k=0 space) were also evaluated. In general, standard processing methods were very successful in attenuating the SI recorded on these data. An examination of the literature also confirms that processing techniques can effectively attenuate SI (Akbulut *et al* 1984, Gulunay and Pattberg 2001).

a) test line 1: Input Shot + SI | b) Tau-P SI model adaptively subtracted | c) Tau-P difference b minus a, shot and t-x restricted

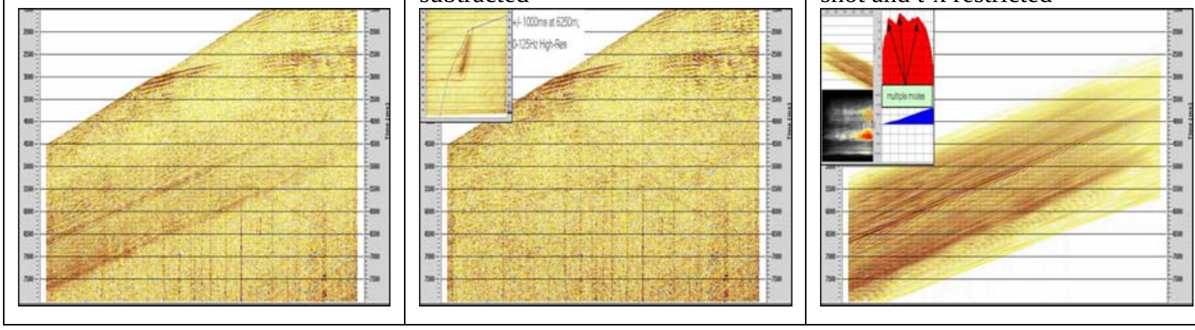

Figure 3 Some SI Attenuation options

Towed Streamer: Field Test and Modelled SI Attenuation Results

Having demonstrated that the recorded SI can be effectively attenuated, an existing SI-free prime line, acquired during time-sharing, was re-shot in the presence of SI from Valhall. In addition SI noise records were acquired while turning. This second test line was also contaminated with SI from other crews in addition to the Valhall survey. Comparisons with the clean prime line and processed test line with and without SI attenuation were encouraging. However, positioning repeatability issues and the presence of the SI from other sources meant that the fidelity of the Valhall SI attenuation could not be accurately assessed.

To develop a more controlled analysis, the SI noise records acquired while the vessel turned, were added into the clean prime line to simulate a range of different SI arrival directions and strengths. A series of fixed source locations relative to a nominal origin were selected and fired at regular intervals corresponding to the Valhall survey shot interval plus some random variation. Using the navigation data of the original prime line relative to the nominal origin, SI noise records were then selected and added to the data with compensation for range and feathering etc. This process is illustrated in Figures 4 and 5.

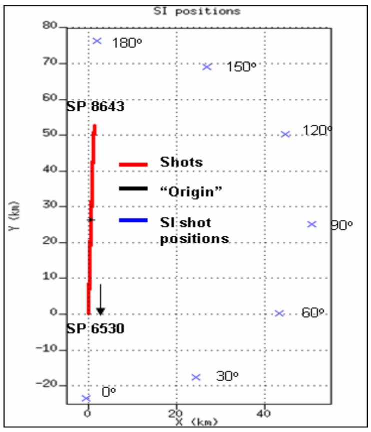

Figure 4: Geometry for SI modelling

High fidelity processing is important for detailed amplitude work, as the surgical blanking and interpolation method implemented by Jenkerson *et al* 1999 illustrates. Comparison with the processed data to which no SI had been added, allowed an accurate analysis of the amplitude fidelity achieved in removing the added SI. This quantitative analysis was done using a 4D NRMS (normalised RMS difference) measurement. A qualitative data review by experienced processors on shots, gathers and stacks was also carried out to confirm the analysis.

The NRMS analysis is illustrated in Figure 6. Each data point represents a trace to which an SI noise record has been added. The vertical axis shows the magnitude of the added SI in microbars and the horizontal axis the bearing. The distribution of data points shows the range of bearings and amplitudes of the SI simulated in these tests. The colour of each data point is the NRMS between the original trace and the data after SI simulation and attenuation. This quantifies the ability to accurately attenuate SI for different noise levels and bearings.

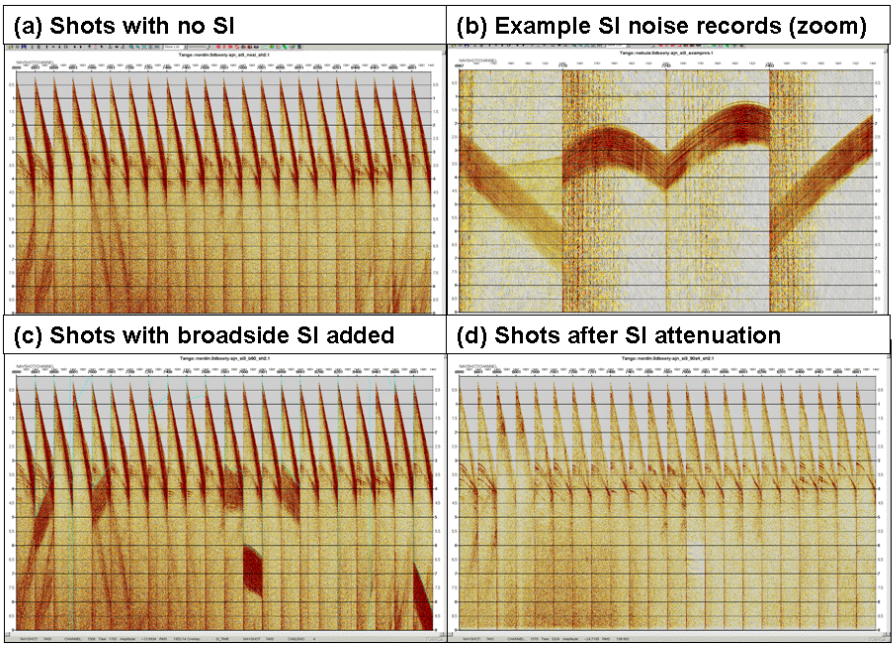

Figure 5 Outline of SI modeling and removal results using spectral editing and reconstruction

In Figure 6, the original SI thresholds for the streamer survey are shown as black bars. After SI simulation and attenuation, an NRMS below a threshold of 0.05 was chosen as an acceptable fidelity to the data without SI. The results determined by peer review as acceptable agreed well with this value. This was used to revise the SI acquisition thresholds for the streamer data, as shown by the blue bars. The thresholds for both head-to-tail and broadside noise were raised, while the higher tolerance for the tail-to-head noise remained unchanged.

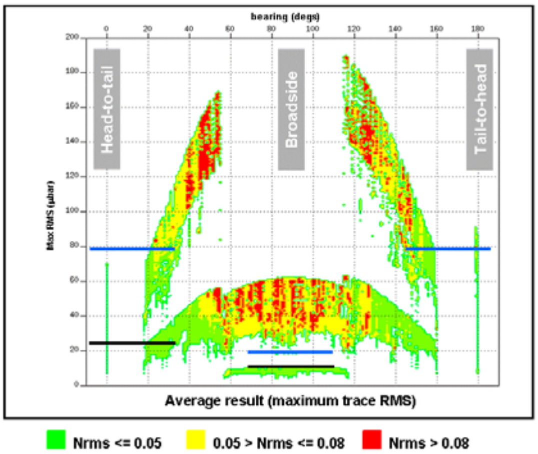

Figure 6 NRMS analysis for SI removal

OBS Field trials

For the 4D Valhall survey, 20 second record lengths were obtained, with the later 10 seconds providing SI models for the SI recorded in the first 10 seconds. Shot-by-shot autocorrelations determined the period to shift the SI model before simple subtraction (Figure 7). A superior result was obtained by using amplitude thresholding to limit the time and space extent of the SI model, and by using an adaptive subtraction. The wide azimuth acquisition geometry and high fold also help attenuate recorded seismic interference for this OBC data. The presence of other boat noise (Figure 7) also did not compromise the LoFS 4D results for these reasons.

Conclusions

There are many robust processing options to attenuate the SI encountered on these surveys and so minimise time-sharing. Some options may be automated and run during acquisition, for example, the τ-p route tested here. Accurate signal preservation is important for subsequent detailed amplitude work.

The use of noise records allowed the recording and attenuation of SI for a range of different amplitude levels and bearings to be simulated and evaluated. An NRMS tolerance of 0.05 was chosen as acceptable for this project. This was used to determine new SI noise thresholds for streamer acquisition in the presence of noise from the Valhall LoFS survey. The results of this study were used to acquire subsequent surveys in this area in the presence of Seismic Interference.

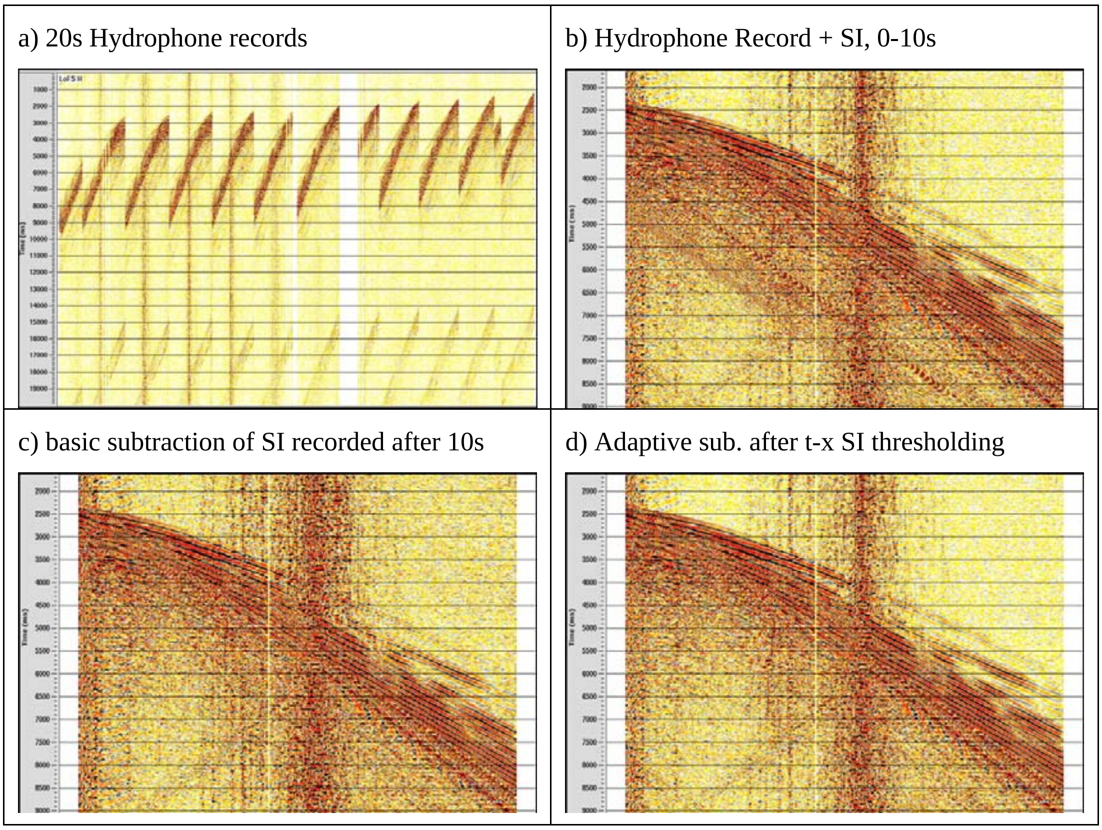

Figure 7 Valhall SI removal example

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