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Coordinating Marine Acquisitions to Tackle Seismic Interference Noise

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Summary

This paper show how new insight into seismic interference (SI) and cross-party coordination has eliminated the need to timesharing in the North Sea. With this new approach seismic vessels were in 2016 also allowed to operate as close at ~7km apart while acquiring seismic data. This stands in contrast to previous accepted guidelines stating that vessels should stay at least 40km. The end of timesharing and the added flexibility provided by allowing vessels to operate in close proximity represents a significant increase in acquisition efficiency, which also translates into cost savings.

The presented approach for SI-management can easily be adapted and applied in other areas.

Introduction

Seismic Interference (SI) occurs when two or more seismic vessels operate simultaneously and the acoustic energy from the source(s) of one vessel is recorded up by the receivers on the other vessel(s). In the relatively shallow waters of the North Sea SI noise can often be observed from as far as 100km away. In deeper water areas SI noise will typically dissipate faster, but even in, for example, the Gulf of Mexico, SI noise can often be observed from 50-60km away. The main component of SI is normally acoustic energy reflecting up and down in the water-layer. As such it has little value with regards to seismic imaging, and only represents noise that needs to be attenuated during seismic processing. Two examples of SI noise from the North Sea are shown in Figure 1.

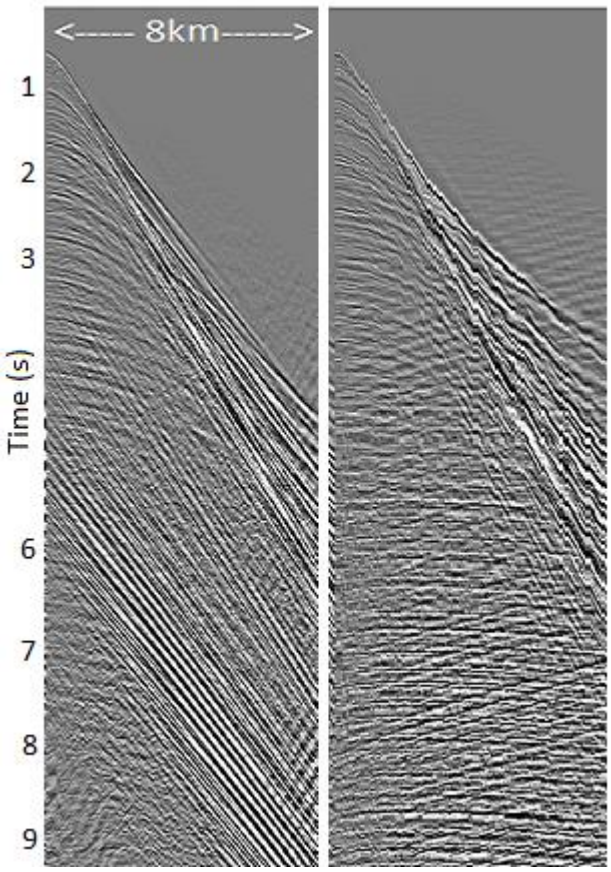

Figure 1. *Two shot gathers from the North Sea. Left: With SI coming from the front at a distance of ~20km. Right: With SI from the side and tail at a distance of ~70km.*

SI mitigation

To avoid detrimental SI noise, contractors have basically three options:

1. Timeshare, which means that the different parties agree to distribute the time slots to shoot the survey. This is both costly (as one vessel is acquiring while the others are on standby) and inefficient as the total acquisition time is increased.

2. Plan the acquisition such that vessels are sufficiently far apart to avoid heavy SI contamination. A rule of thumb has been that the minimum vessel separation should be ~40km. This requirement comes with a significant cost, as it can often result in sub-optimal line plans (shorter than optimal line-lengths), or that whole surveys have been cancelled/ postponed.

3. Acquire the data ensuring that the recorded SI can be handled during processing – and then remove any SI noise in processing.

In the North Sea, historical data from Statoil show that vessels on average have spent 12% of their time on standby due to SI (Laurain et al., 2015). It is also reasonable to stipulate that in congested areas the historical 40km minimum vessel separation has resulted in a similar (~10%) reduction in acquisition efficiency.

In previous work by Dhelie et al. (2013), Laurain et al. (2014) and Elboth et al. (2015) it was shown that controlling the move-out of the SI and the randomness of its arrival time on the seismic records, are key parameters to remove SI without significantly degrading the data. Results of SI management from the 2015 North Sea acquisition season were also presented in Laurain et al. (2016).

This article presents the advances achieved during the 2014, 2015 and 2016 North Sea acquisition seasons with regards to seismic interference management. These seasons typically lasted from April to October, but were often limited by various fisheries and weather. During these acquisition seasons typically 6-7 different surveys were conducted each year in a confined area, and up to 5 vessels were

sometimes operating simultaneously within a radius of less than 70km. An example snapshot of the vessel positioning from 2016 is shown in Figure 2. At that time two 4D acquisitions were conducted at Snorre (PRM by WGP) and Gullfaks (acquired by PGS), while two vessels (CGG) were conducting a multiclient survey. All vessels on this picture operate within a radius of ~50km. In this image a noise-cone (that will be explained in more detail later) is also drawn around each vessel.

This paper shows how insights into the nature of seismic interference (SI), combined with recent advances in SI attenuation algorithms completely eliminate the need for timesharing. Furthermore, during the 2016 North Sea acquisition season, vessels from different contractors successfully operated simultaneously as close as 7km apart. This allowed great flexibility and efficiency for the vessels involved.

Method

During the 2015 and 2016 acquisition seasons in the North Sea the following system was established: All seismic parties would on a daily basis be asked to share their line-plans with an independent third party. This third party would then coordinate the vessel movement according to the following rules:

1. Vessels operating closer than ~100km apart should try to have different speed (typically at least 0.2kn) or have a different shot point interval. This was achieved by asking vessels to speed up or slow down by a few percent.

2. Vessels should try (if possible) to avoid shooting broadside into the seismic spread of other vessels. If this cannot be avoided, the speed difference between the involved vessels should be increased (ideally to ~0.5kn or more).

3. Lines should not be aborted due to SI, and reshooting/timesharing should only be requested after extensive onshore processing trials showed that the SI could not be attenuated.

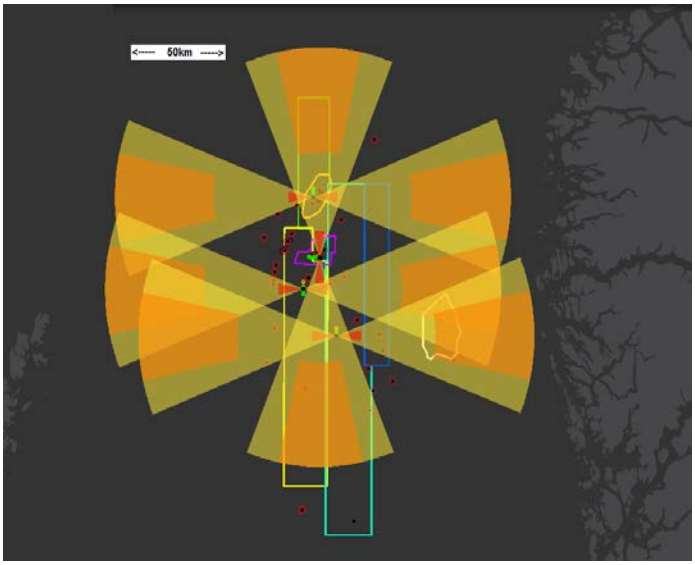

Figure 2. *Snapshot of the positioning of four seismic vessels operating simultaneously in July 2016.*

Laurain et.al (2016) describes that during the 2015 season, attempts were also made to extend a few line-changes, and in that way try to avoid broadside SI. In the busiest periods with up to 5 vessels operating simultaneously, this was difficult. As a result of this challenge, the coordination effort during the 2016 season was instead focused on adjusting vessel speeds to break up any shot-to-shot coherent SI, especially broadside SI. This was based on the observation that as long as any seismic interference (SI) was incoherent shot-to-shot, processing algorithms would normally succeed in attenuating the noise.
To illustrate these guidelines, the schematic shown in Figure 3 was proposed. It shows a seismic vessel, and a cone representing the area where SI recorded on that vessel is most problematic to process. This illustration also indicates two areas requiring special attention. These are when vessels are closer than ~6km, which typically result in very high amplitude SI (and may be). The other area is broadside SI that comes from more than 60km away. Experience from previous seasons demonstrated that such 'long distance' SI sometimes appeared as nearly continuous noise, and consequently could be seen as coherent shot-to-shot, even if vessels had significantly different speeds (shot-point

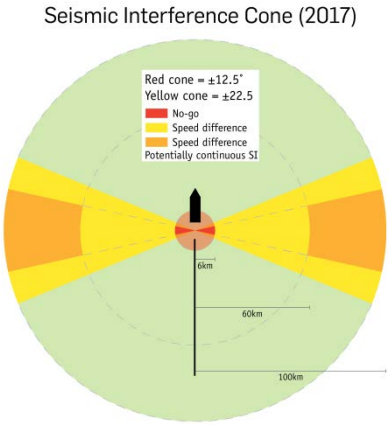

Figure 3. *A seismic vessel surrounded by its noise cone. This illustration emphasizes the fact that we wanted to avoid having SI coming in broadside.*

intervals). According to these guidelines, the amplitude of the SI is not a factor in any way. The SI is only assessed based on direction and shot-to-shot (in) coherence. This kind of assessment is not in line with most acquisition contracts today. However, processing results strongly indicate that these new guidelines are sufficient and appropriate to guarantee good data quality after SI attenuation. An example of SI attenuation processing is shown in Figure 4. Reference can be made to a separate paper by Elboth et al. (2017) for more details on the SI attenuation processing from the 2015 and 2016 North Sea acquisition seasons.

Having an independent third party doing the vessel coordination between the different contractors is also important in order to avoid/minimize any conflicts. This third party will coordinate the vessel movement in a way that benefits all contractors equally well. At the start of both the 2015 and 2016 seasons, some communication was required to convince new parties to participate in the coordination effort. However, once the benefits of the coordination were understood, all involved parties participated to the best of their ability. As of today parties from most major acquisition contractors have been involved in and benefited from this coordination.

Example

Figure 4 shows consecutive shot gathers before and after SI attenuation and the difference plot. No seismic reflection data is visible in the difference plot, and virtually all the SI has been attenuated. In this example the SI came from a vessel around 10km to the side of the recording vessel. The interfering vessel had a shot-point interval (SPI) of 25m, while the recording vessel was shooting with 18.75m. Different SPIs ensure that the SI arrives at different times in consecutive shots, and was the key to successful attenuation.

Season summary

During the 2016 shooting season in the Norwegian part of the North Sea almost 1.7 million seismic shots were fired from 7 different parties. All but one party (who was both unaccustomed to this new type of SI management and unfortunate to see a lot of nearly continuous SI noise), had zero percent standby or reshooting with a root cause of SI noise. Furthermore, seismic parties for both conventional exploration and 4D acquisition had vessels shooting and acquiring data as close as 7km apart. This is well below the minimum distance that was indicated before the start of the season. However, through close integration between on board processing, operations and the onshore data assessment, we became convinced that these close passes could be conducted without jeopardizing the ability to attenuate the SI in processing. At the time of writing, the data quality on the exploration seismic surveys is reported to be excellent. The 4D results also seem to be unaffected by the sometimes very strong SI recorded. More details on the 4D processing and SI attenuation can be found in a separate presentation by Laurain et al. (2017).

Conclusions

We have shown that by careful vessel coordination to avoid shot-to-shot coherent (and broadside) SI, it is possible to attenuate virtually any SI in processing. This type of coordination has been developed during the last few acquisition seasons in the North Sea, and has eliminated the need both to timeshare and reshoots due to SI noise. The new approach presented in this article does not assess the amplitude of the noise, but only looks at direction and incoherency from shot to shot. Processing results show that this is both sufficient and appropriate.

We believe the present guidelines from the IAGC stating that timesharing should be commenced if one party asks for it, should be revised. Instead we suggest that new guidelines should state that all seismic parties are obliged to participate in a coordination effort where vessel speeds may be adjusted in order to break up any shot-to-shot coherent seismic interference. The cost of this coordination is typically that some vessels have to slow down during some of the lines. On average the cost of these speed adjustments are less than 2%.

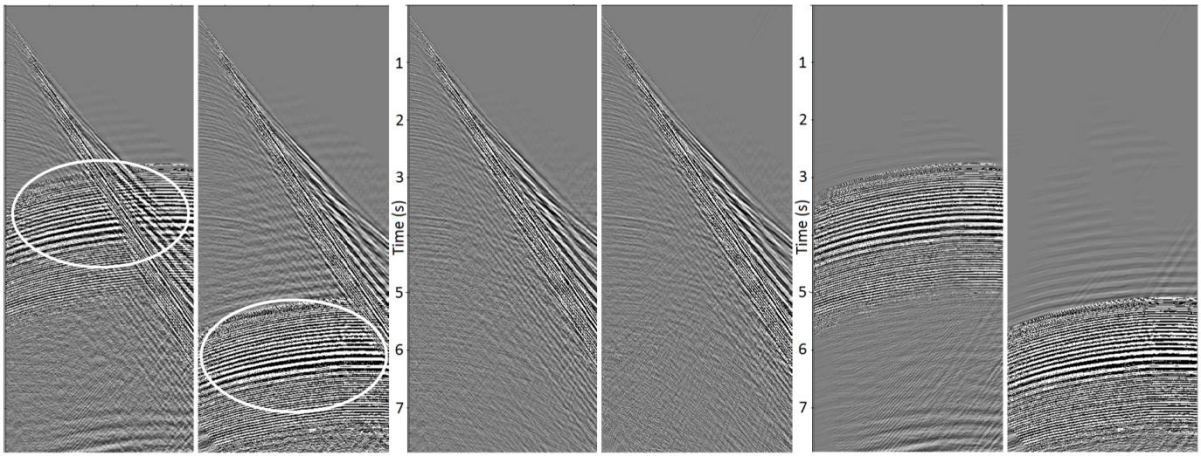

Figure 4. *Before, after and difference plots showing SI attenuation on two consecutive shot gather.*

This can be seen against an average reduction in standby time of 12%, and the added flexibility of now being allowed to operate seismic vessels as close as ~7km apart.
We therefore estimate that this new technology allows seismic parties to improve their overall efficiency by on average ~20% during a North Sea acquisition season.

Acknowledgements

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References

Dhelie, P.E., Harrison-Fox, D. and Abbasi, M.F. [2013] Increasing the Efficiency of Acquisition in a Busy North Sea Season - Dealing with Seismic Interference. 75th EAGE Conference & Exhibition incorporating SPE EUROPEC 2013

Elboth, T., Fakhreddine H. and Kashchiev, P. [2015] A Seismic Interference Noise Experiment in the Central North Sea. 77th EAGE conference and exhibition 2015.

Elboth, T., Khan, J. and Shen, H. [2017] Advances in seismic interference noise attenuation. Submitted to 79th EAGE conference and exhibition 2017.

Laurain, R., Elboth, T.[2017] SI coordination in Tampen – implication on 4D quality. Submitted to 79th EAGE conference and exhibition 2017.

Laurain, R., Ruiz-Lopez, F., and Eidsvig, S. [2015], Managing and Modeling the Seismic Interference, 77th EAGE Conference and Exhibition.

Laurain, R., Pattison, G., Elboth, T. and Pollatos, J. [2016] Cooperating for Optimizing Seismic Acquisition -A Case Study in the Horda Tampen Area, 78th EAGE Conference and Exhibition 2016