



Statoil

Managing Seismic Interference - Snorre 4D case study

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* Statoil, ** WesternGeco

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Introduction

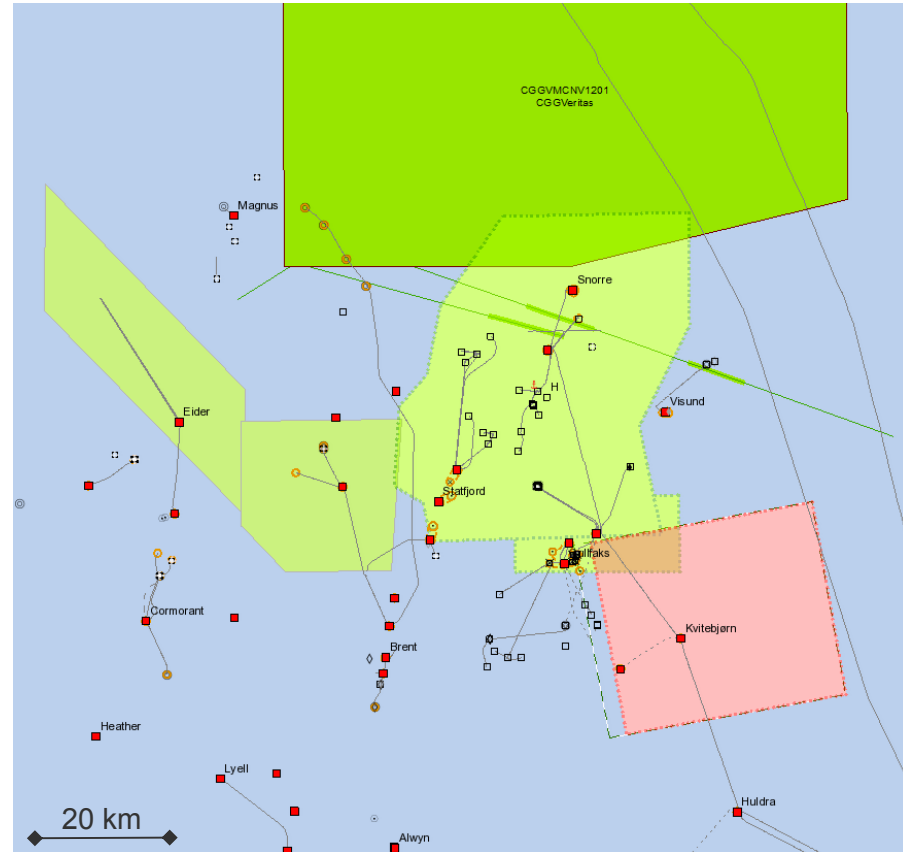
- 2011 experience
 - Encouraging experience in PL303 (Lupin)
 - Decision to continue to assess SI in 2012
- In 2012, most activity in Tampen area
 - Seismic and production related
 - Fishing activity
- Three surveys in Tampen area were operated by Statoil
 - Good control over time sharing
 - Cooperation with other players in the area when possible

Introduction

- Plan for seismic interference handling
 - Interference QC plan made in co-operation with WesternGeco who did both acquisition and processing
 - WesternGeco onboard processing and onshore support
 - Statoil geophysicists ready to perform QC with short turn around
 - No line should be interrupted due to SI. Acceptance stage after processing
- Snorre 4D
 - OBC survey less sensitive to SI (Kvitebjørn, Gullfaks)
 - Snorre 4D was most critical to be able to finish in time
 - High quality 4D acquisition
 - Large area, long survey duration and possible conflict with fishery

Interference sources

- Installation activity (e.g. pile driving, drilling, ...)
- Seismic activity
 - Statoil: Snorre 4D, Gullfaks OBS and Kvitebjørn OBS
 - TGS MC 3D
 - PGS 3D
 - Others?
- Fishing activity
 - Mackerel fishing started end July



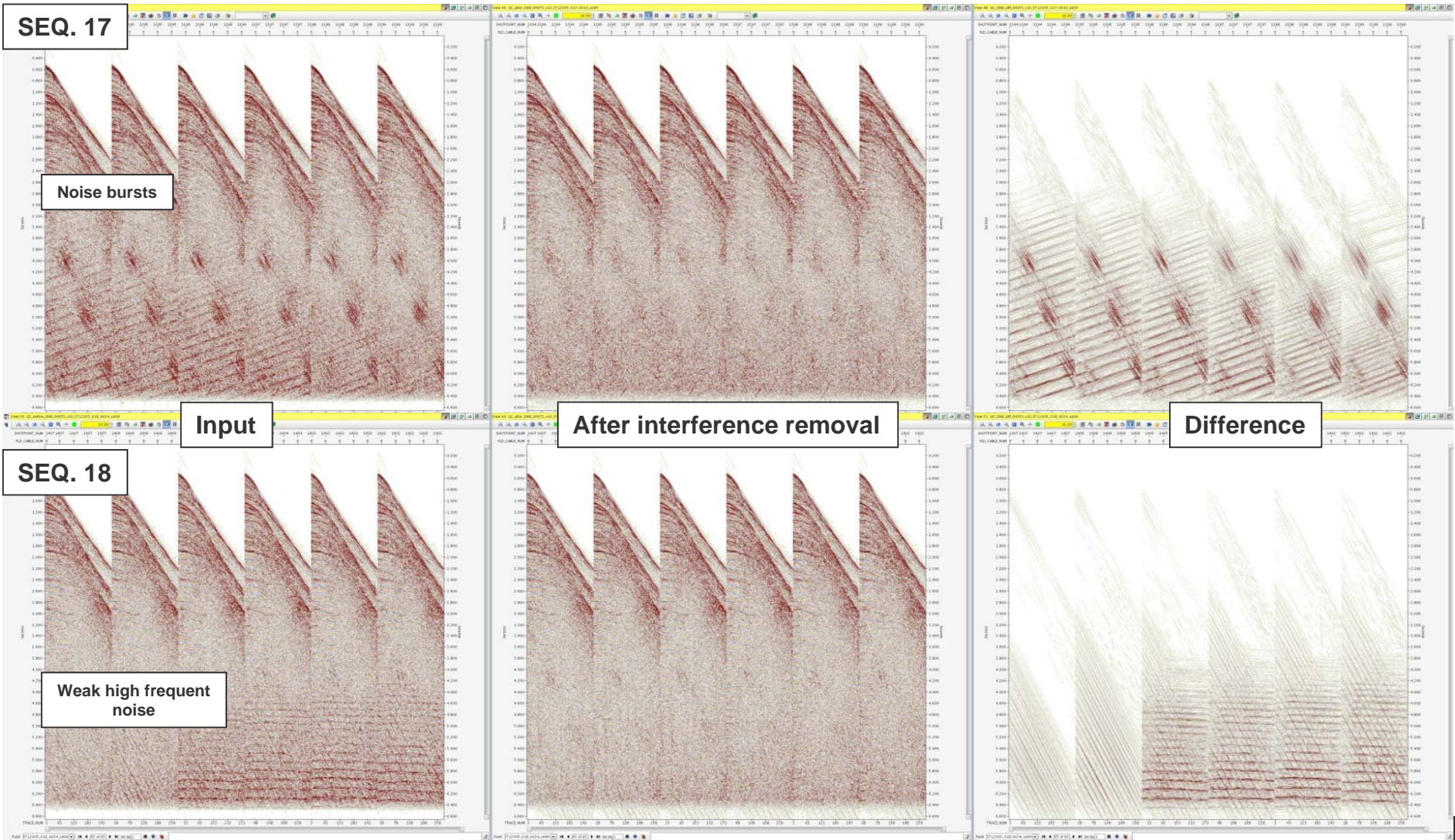
Interference removal

- Final 4D processing sequence was run up to interference removal Seismic
 - Navigation/ seismic merge; 4ms resampling
 - Deterministic zerophase designature; CMS deconvolution
 - Swell noise attenuation (3 passes); SINE – seismic interference elimination
- Interference Noise Elimination (SINE)
 - A multidomain 3D spatial filter was designed in the τ - ρ domain to scan for SI noise on consecutive shots along the line, based on amplitude and frequency attributes. SI noise is separated and transformed back to the x-t domain where it is subtracted from the original data set. Process has been applied to all acquired lines.
 - SEG San Antonio 2011 Annual Meeting / Margaret C. Yu, WesternGeco

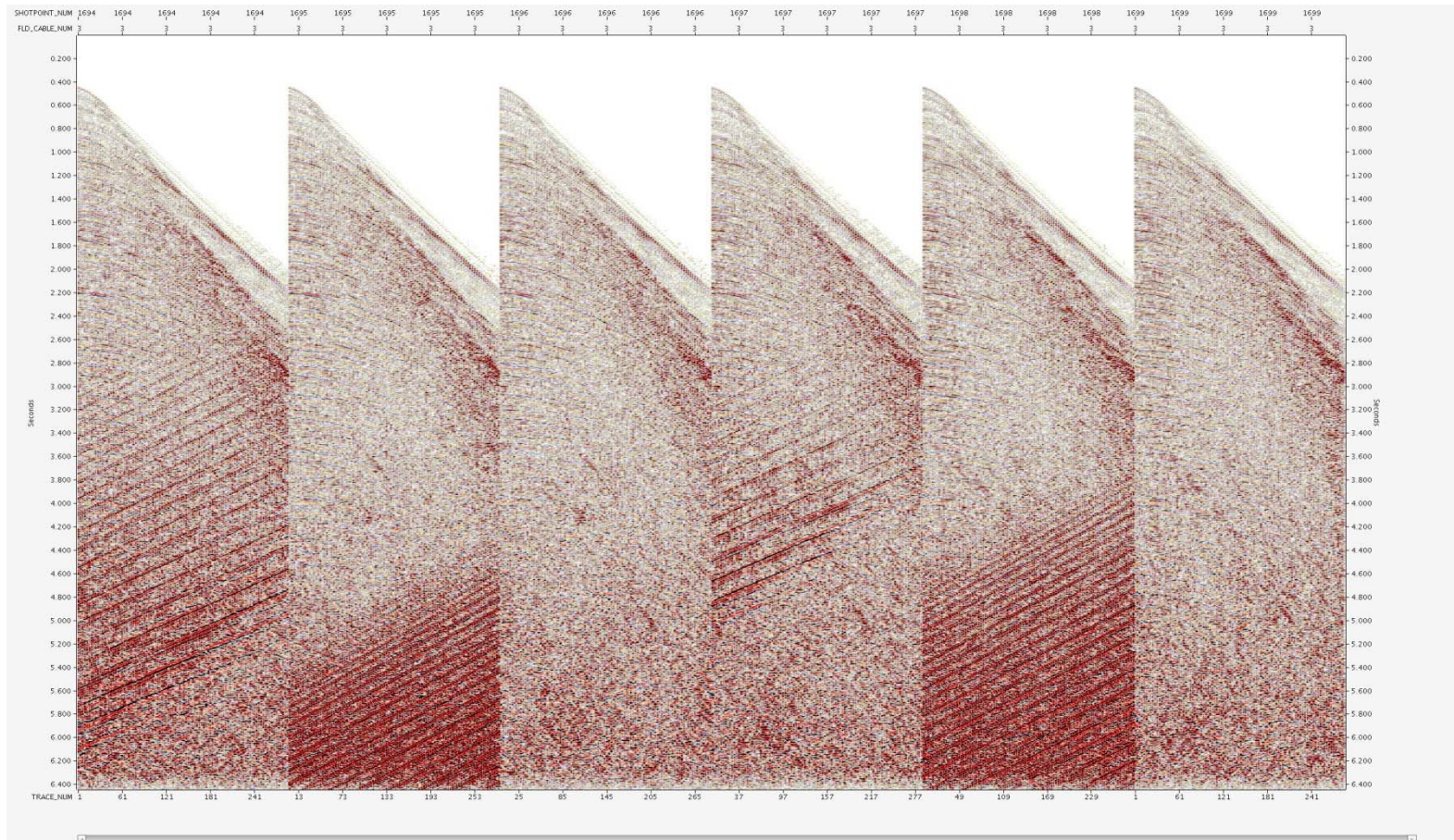
Interference QC

- Interference was QCed onboard with the following product for each sequence:
 - Every 3rd trace in every shot displayed before/after SI removal and difference
 - Brute stack before/after SI removal and difference
 - RMS SVT display of each trace for each sequence
 - SOL/EOL Noise
 - Background noise each streamer, each trace
 - Near trace display
 - Full 4D global QC: 4D difference cubes + 4D attributes maps – updated on weekly basis
- Onshore
 - Initial SI testing, onboard testing support & final parameters approval

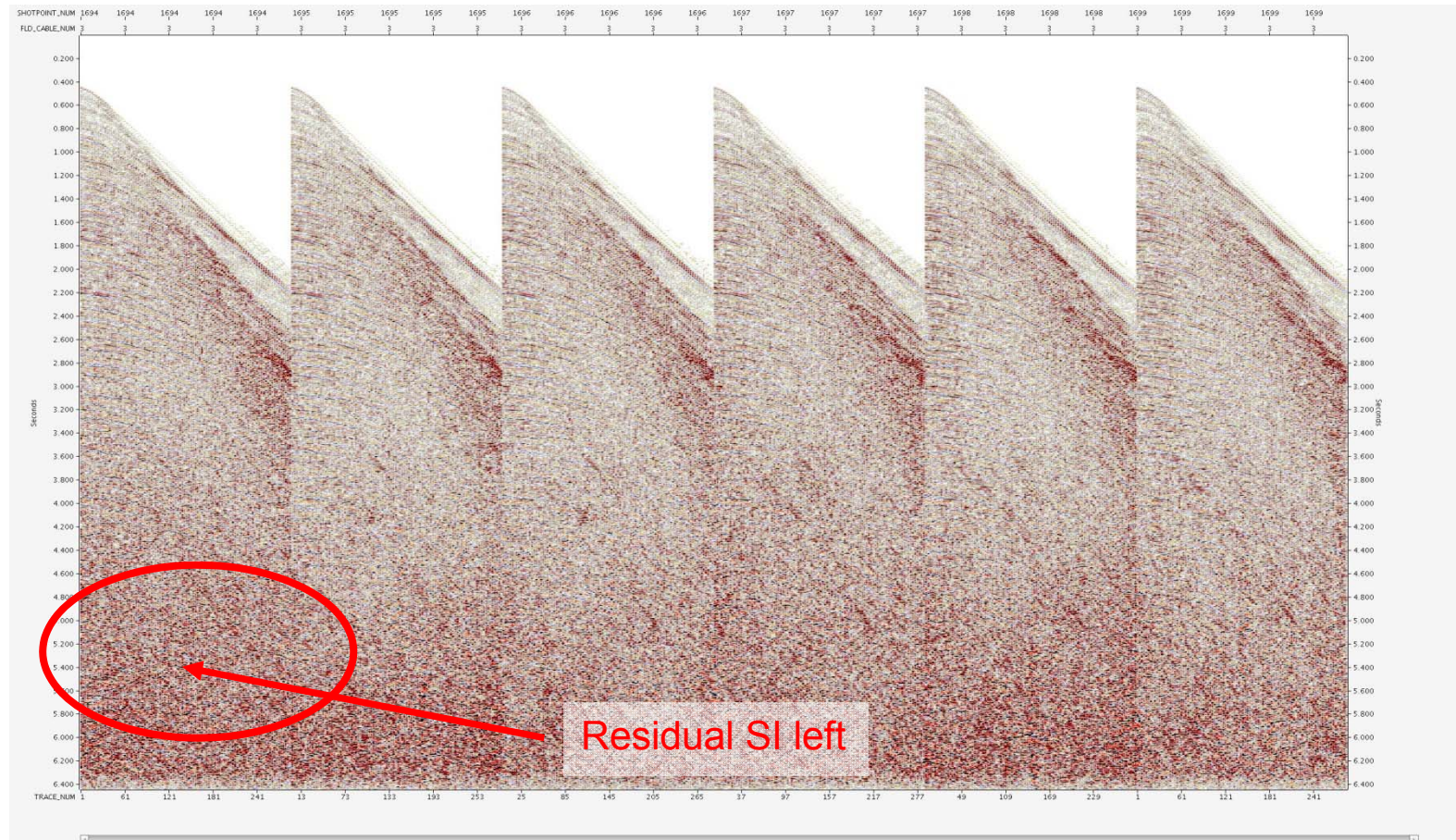
Interference from other than seismic sources



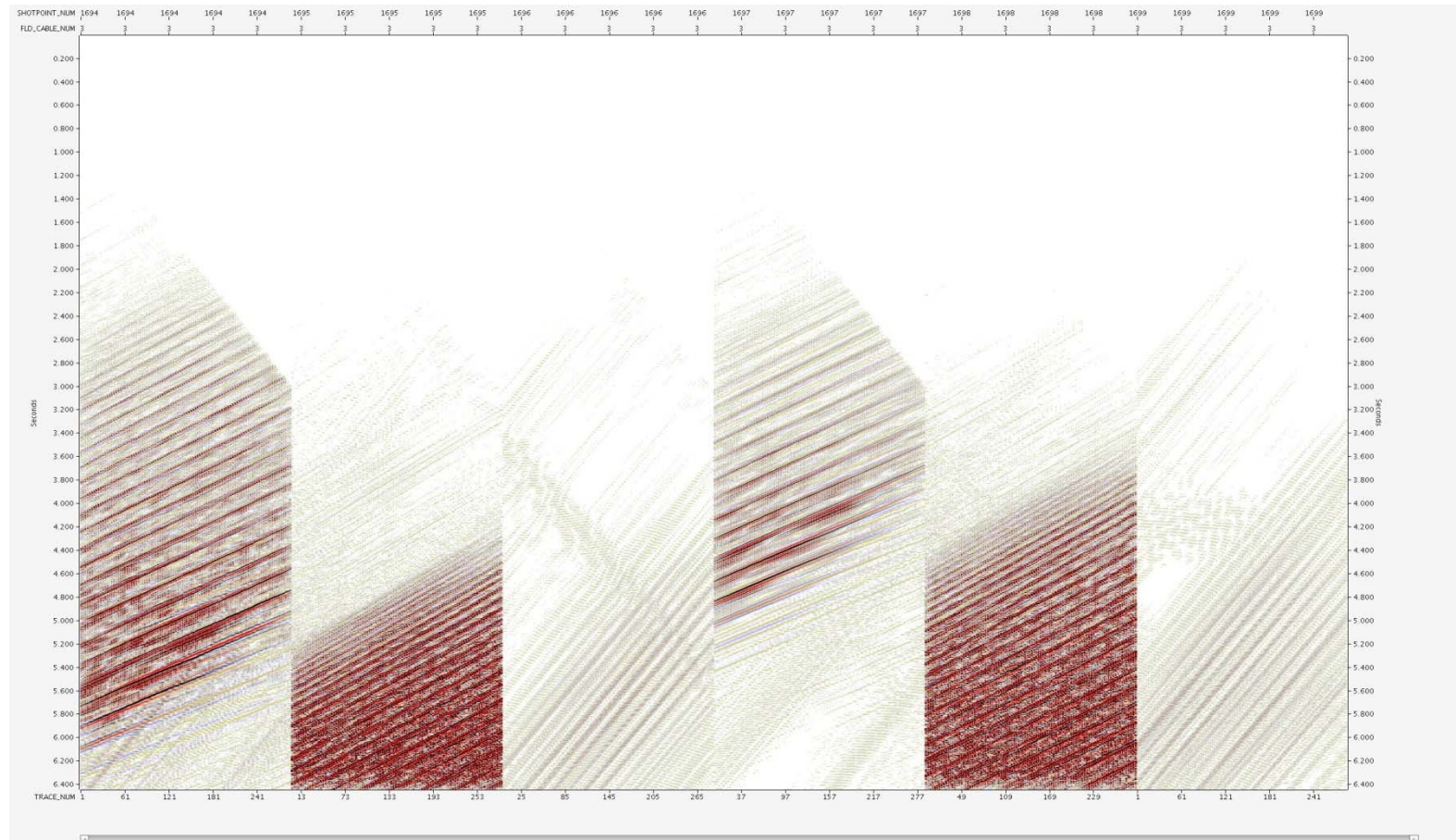
Shots Before SINE: Seq 182 ssl03



Shots After SINE: Seq 182 ssl03

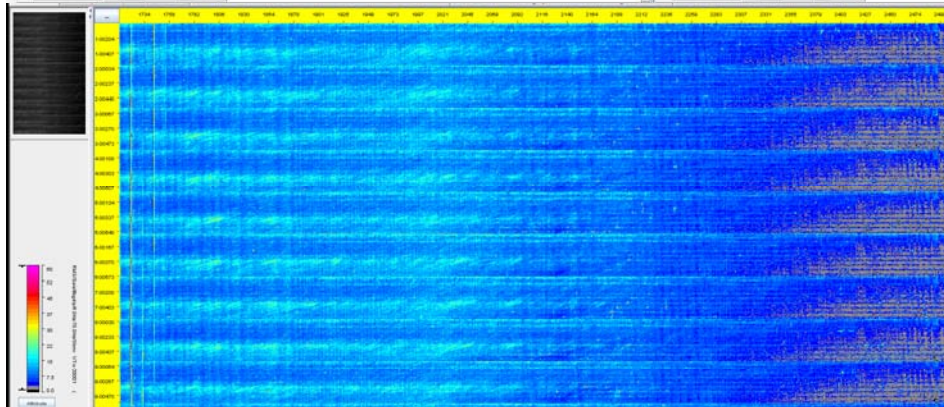
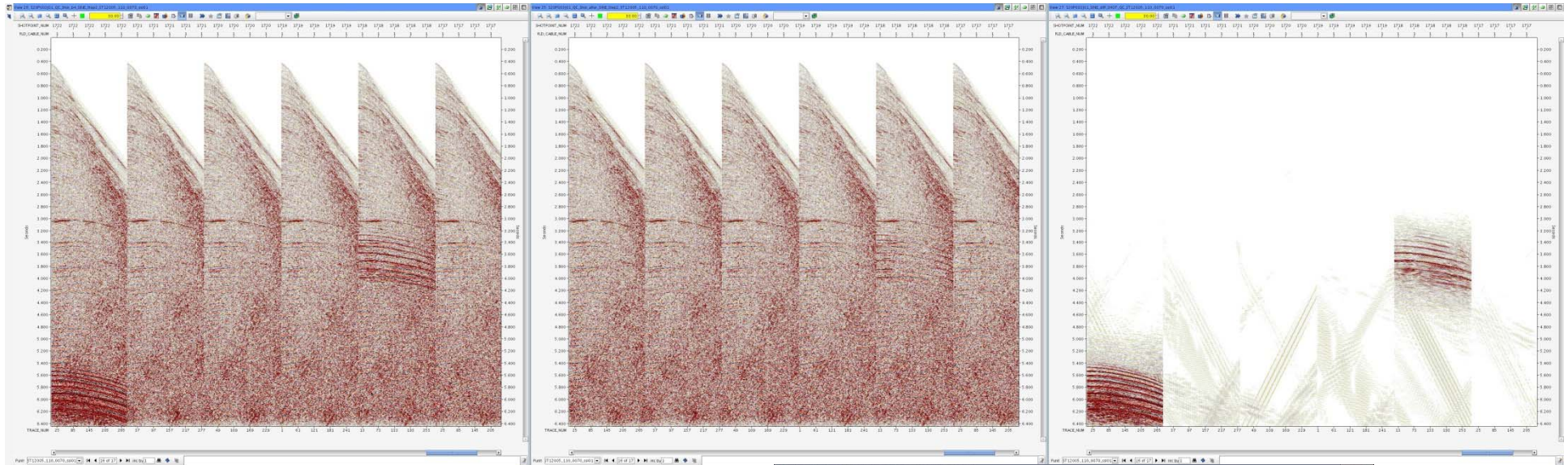


Shots Difference: Seq 182 ssl03



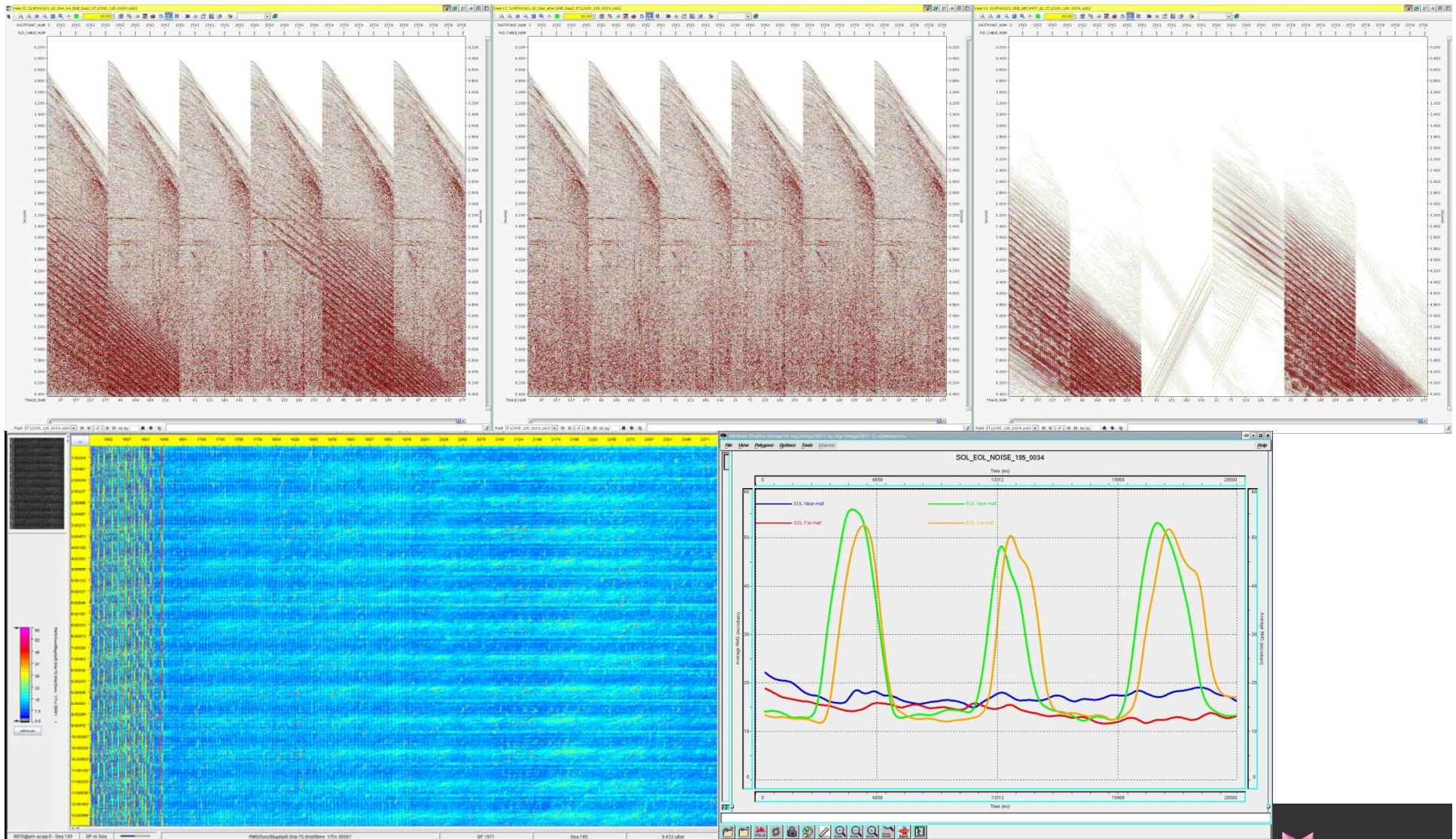
Seismic interference Seq 110

Gulfaks OBS



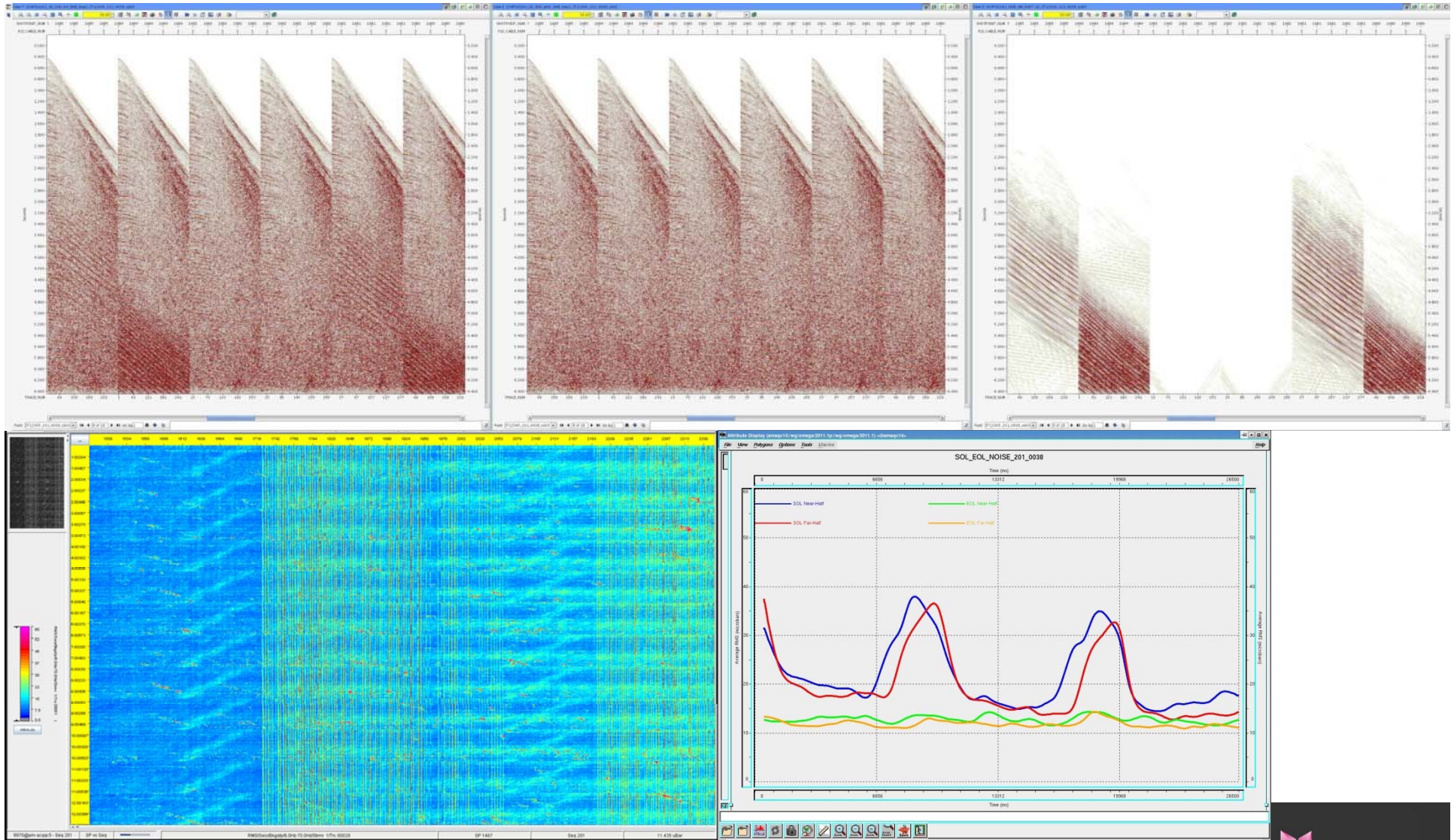
Seismic Interference: SP 2514-1714 - ahead to starboard, MO
 200-390ms/km, 6-8µb - High Frequency sample >70Hz - 10-15µb, Mid
 range sample - 6-70Hz - 2-4µb reducing along line., SP 1791-1711,
 abeam to starboard, 5-20µb - (Fairfield ramp-up)

Seismic interference from ahead Seq 195



Seismic interference from ahead Seq. 201

Kvitebjørn OBS

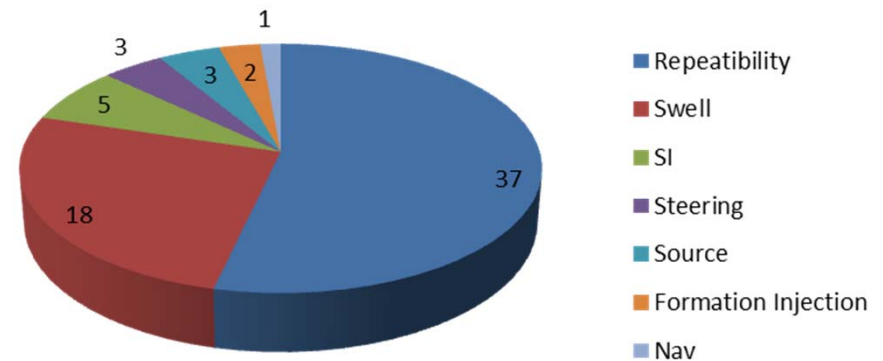


Statistics

- 307 sequences shot, 69 reshoot (22 %)

	Repeatability	Swell	SI	Steering	Source	Form. Inj.	Nav	TOTAL
# sequences	37	18	5	3	3	2	1	69
% of 307 sequences	12,1	5,9	1,6	1	1	0,7	0,3	22,6

- 49 sequences identified as affected by **seismic interference**
 - Statoil threshold is 18 microbar
 - 39 SOL/EOL noise over 25 microbar
 - 5 out of 49 sequences reshoot because of SI
 - 15 to 26 out of 49 sequences would have been reshoot with conventional QC
- **Survey completed 14 days ahead of schedule and below budget**



Conclusions

- Snorre 4D acquisition shows that large part of SI noise can be handled in processing
- Onboard processing capability made it possible to quickly and reliably perform acceptance QC
- Close cooperation between asset, processing, acquisition, client rep, onshore processing center was essential for the success of the operation

The way forward? (1)

- Great time saving can be achieved if all players (contractors, oil companies) cooperate
 - Try as early as possible to clarify the seismic activity in the area
 - Optimize the shooting patterns and identify the most critical situations related to SI
 - Share knowledge of SI handling with all staff involved (client rep, onboard processing, QC geophysicists)
 - Common Seismic Interference removal tool in the industry?

The way forward? (2)

- Soft start
 - Ramping up deteriorates the data quality of the other players in the area
 - Induces lost revenues and production time for those involved in the timeshare
 - Use a 40 cu.in mitigation gun instead
 - Example: 2 hour line in timeshare
 - 12 softstarts per 24 hours
 - 12x20 min = 4 hours lost production every day

Acknowledgements

- Partners
 - Centrica Resources (Norge) AS, Core Energy AS, ExxonMobil E&P Norway AS, Idemitsu Petroleum Norge AS, Petoro AS, RWE Dea Norge AS, Statoil Petroleum AS, Total E&P Norge AS
- Onboard / onshore processing
 - M/V WesternGeco Amundsen; Onboard Processing Team
 - WesternGeco Stavanger Data Processing Center
- Client representatives
 - Keith Mackie, Mark Maynard, Peter Allan (GeoGuide Consultants Ltd)
- Randi Kristin Tønnessen, Marit Bø Reitan and Kristian Stormark (Snorre asset), Daniel Fischer (SIP), Thor Evert Paulsen (GOP), Leif Fenstad (GOP)

There's never been a better
time for **good ideas**

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4D case study

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