

Seismisk innsamlingsteknologi under utvikling med mindre miljømessig fotavtrykk

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Outline

- Increased Efficiency – Reduced Exposure
 - High-capacity Seismic Vessels

- Alternatives to Marine Air Gun Arrays
 - Marine Vibrators
 - eSeismic



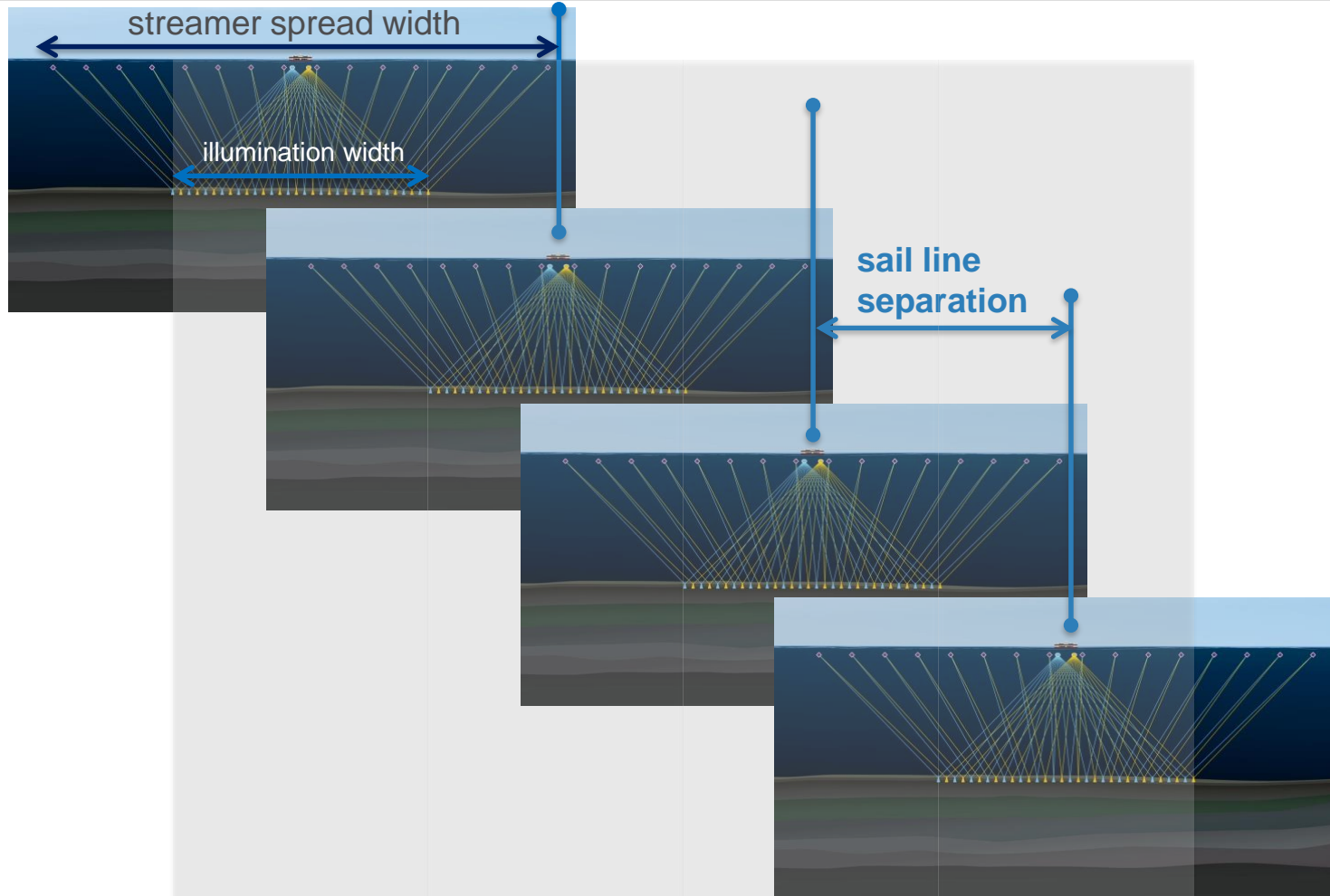
Increased Efficiency → Reduced Exposure

fewer days on each survey result in a smaller environmental footprint

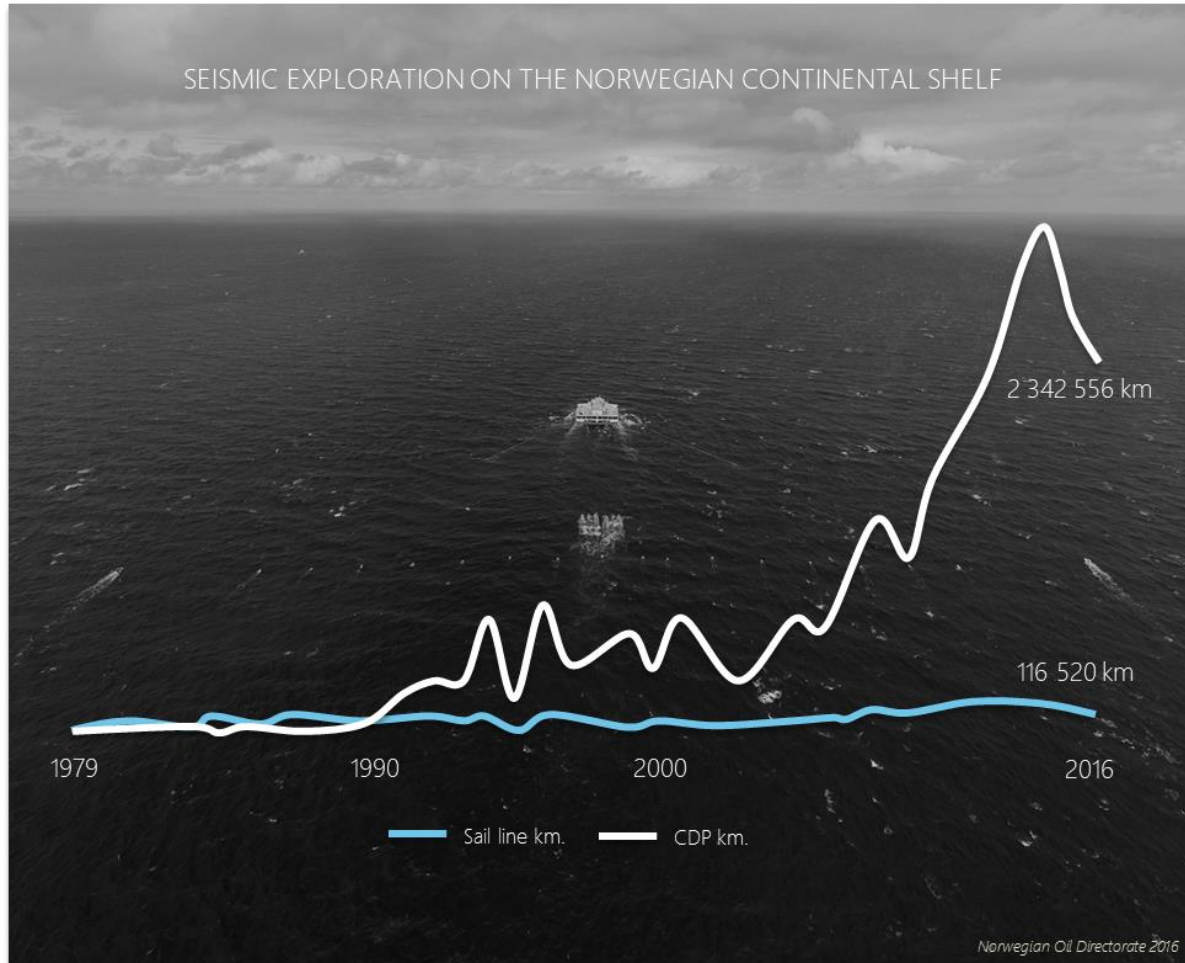
Towed Streamer Seismic Acquisition



Larger Spreads And Faster Turnaround (= Reduced Footprint)



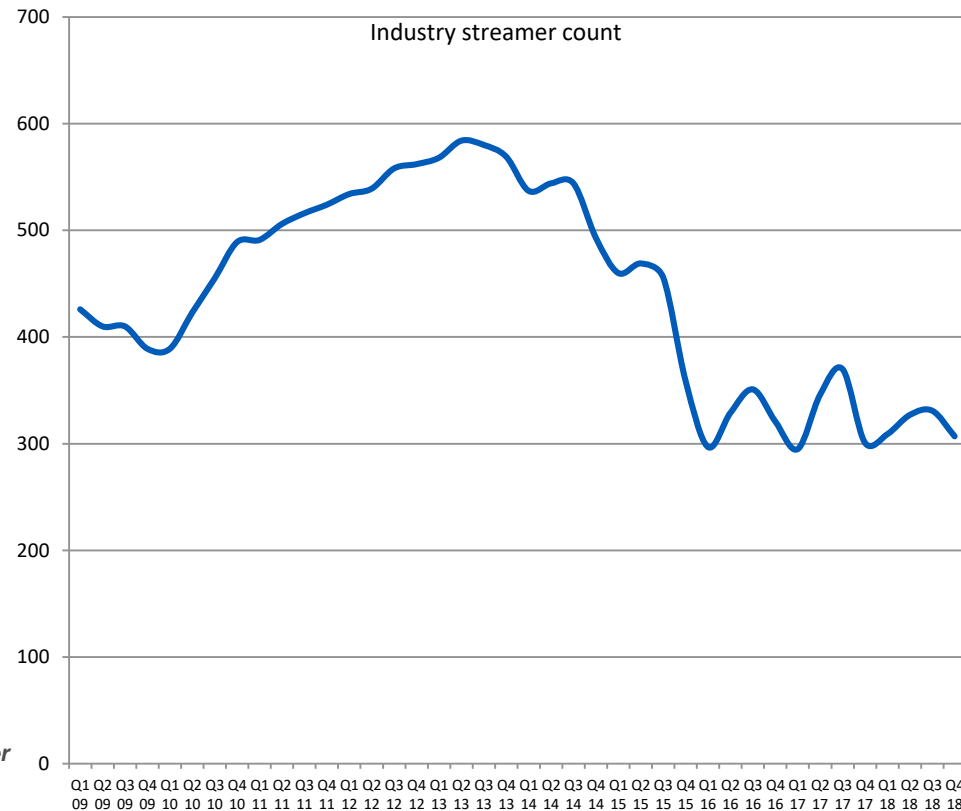
Footprint is drastically reduced with increased efficiency



Industry streamer fleet steadily reduced from 2014

PGS	Ramform Titan*	16
	Ramform Atlas*	16
	Ramform Tethys*	16
	Ramform Hyperion*	16
	Ramform Sterling*	16
	Apollo*	12
	Sanco Swift*	12
WGG	Amazon Warrior	14
	Amazon Conqueror*	14
CGG	Oceanic Sirius	14
	Oceanic Vega	14
	Oceanic Endeavour	14
	Oceanic Champion	12
	Geo Coral*	14
PLCS	Polarcus Adira	12
	Polarcus Alima	12
	Polarcus Asima	12
	Polarcus Nadia	12
Shearwater	Polar Empress	14
	Polar Duchess	12
	Polar Marquis	14
BGP	Prospector	12
		300

* Indicates equipped with multicomponent streamer



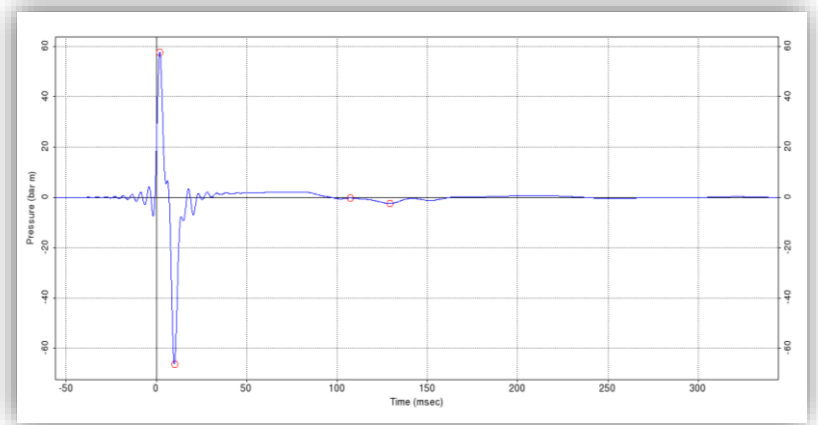
Active streamer fleet (Q1 2018) of main commercial operators is 22 vessels (does not include warm or cold stacked vessels)

Total streamer count approx 300, the lowest since 2006.....

Ramform Titan Class Vessels - up to 24 Streamers



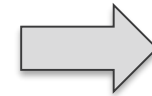
Alternatives to Marine Air Gun Arrays



Typical output (sound) from a marine seismic source array.

Alternatives to Marine Air Gun Arrays

Air-gun
Array



Single
Air-guns



Electrical
Vibrators



Alternative Marine Vibrator Concepts at PGS

Flex Tensional Shell

- Large displacement, small surface area



Modular Projector System (MPS)

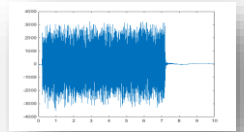
- Large surface area, small displacement



Potential Advantages of Marine Vibrator Technology compared to Conventional Marine Sources Arrays

Environmental Objectives

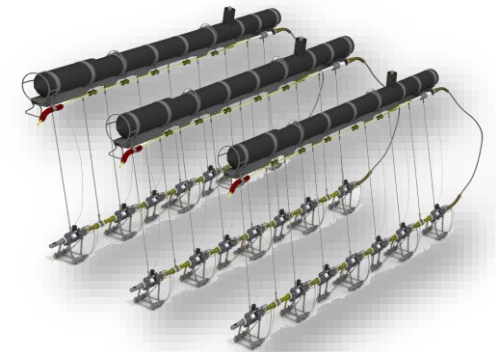
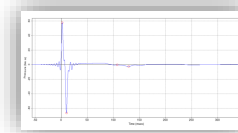
- Reduced peak output (reduced SPL)
- Frequency bandwidth control
- Control of waveform



marine vibrator (prototype, pool test)

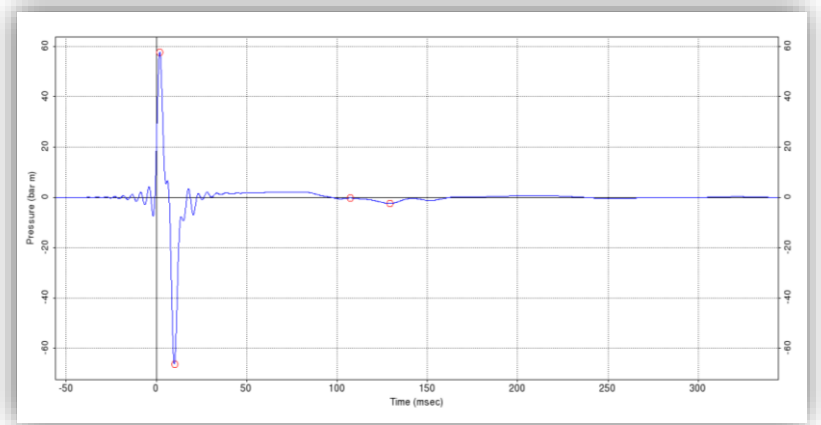
Geophysical Quality & Efficiency Objectives

- Ultra-low frequencies for FWI
- Improved seismic signal for 4D
- Better source separation for simultaneous source acquisition



seismic air gun array

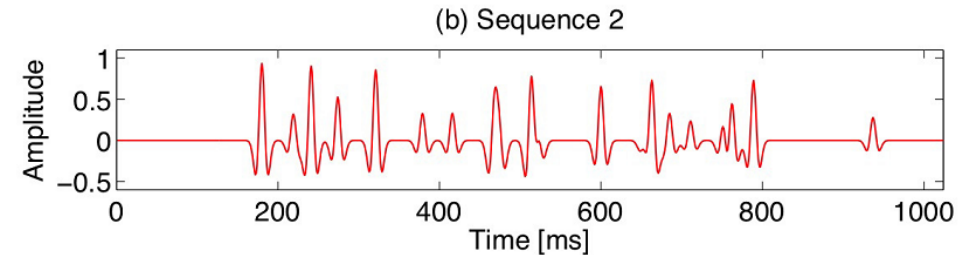
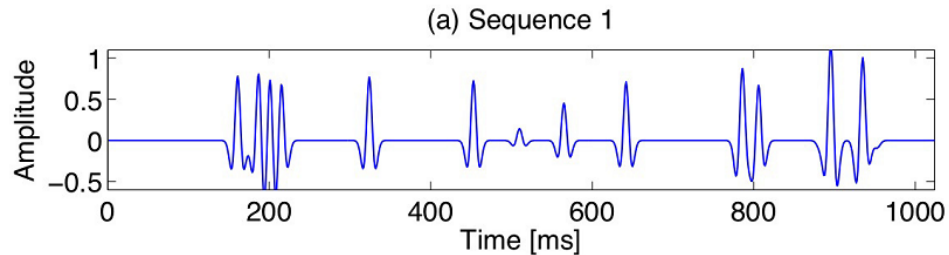
Alternatives to Marine Air Gun Arrays (2)



Typical output (sound) from a marine seismic source array.

Encoded Source Sequences (“Popcorn Shooting”)

- Robertsson et al. (2008) discussed the idea of firing a marine source array sequentially (rather than activating all sub sources at the same time).
- Sub-elements are fired individually over a range of time, yielding a sequence of smaller impulses.
- “Popcorn Shooting” can reduce peak sound level output.



References:

EAGE 2014: M.B. Mueller (ETH Zurich), J.O.A. Robertsson (ETH Zurich) & D.F. Halliday (Schlumberger Gould Research): Simultaneous Source Separation Using Encoded Source Sequences*

SEG 2013: Ray Abma and Allan Ross (BP), Popcorn shooting: Sparse inversion and the distribution of airgun array energy over time

eSeismic (R&D)

eSeismic – In a nutshell

eSeismic

eSeismic is a novel acquisition and processing method under development. The method utilizes continuous source and receiver wavefields to produce broadband subsurface images.

Geophysical and Operational Benefits

Efficiency

- No record length or shooting interval limitations

Quality

- Improved signal-to-noise ratio; broader bandwidth

Environment

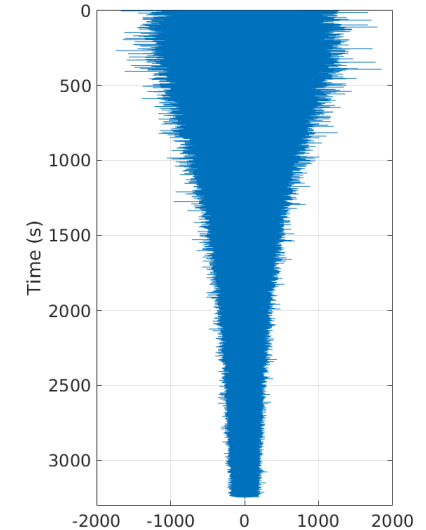
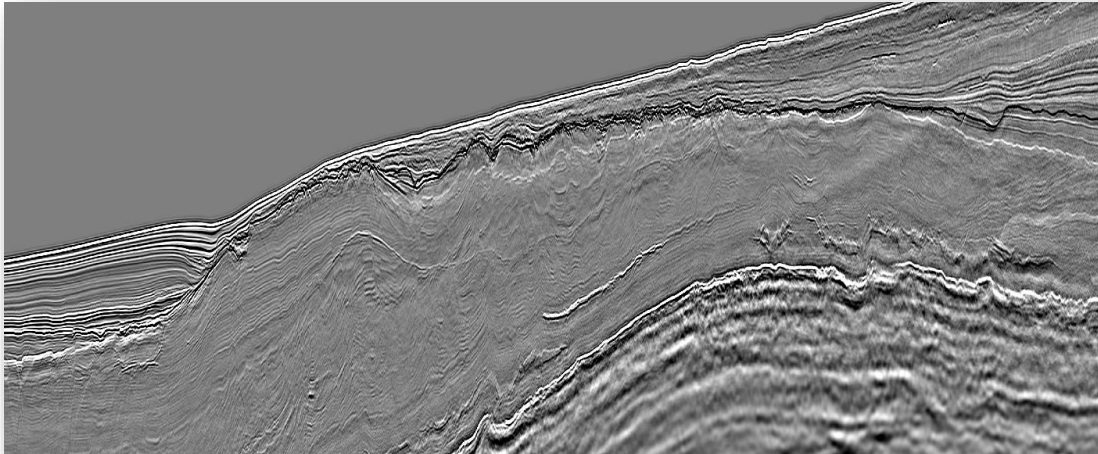
- Reduced Sound Exposure Level (SEL) and Sound Pressure Level (SPL)

A Demo 2000 R&D project funded by:



eSeismic – A new way of acquiring and processing marine seismic data

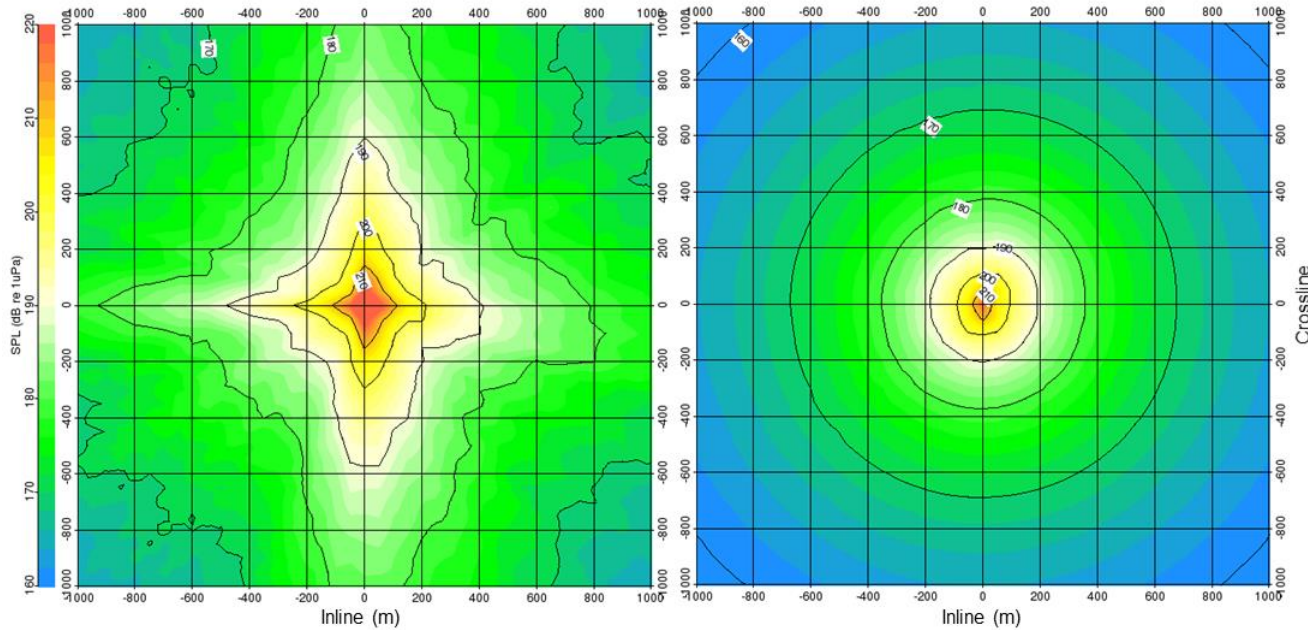
- eSeismic is an acquisition and processing method that utilizes continuous source and receiver wavefields.
- The continuous sources wavefields can be generated with both future marine vibrator technology as well as with existing air gun hardware.
- When using air gun sources to generate continuously signals individual air guns are triggered with very small randomized intervals instead of triggering an entire source array (see resulting receiver trace on the right).



Synthetic continuous receiver trace in a stationary receiver position

eSeismic field trial example (courtesy of PGS):
The dataset was acquired by firing single air guns generating a near continuous wavefield.

SPL comparison to a 4130 cubic-inch array

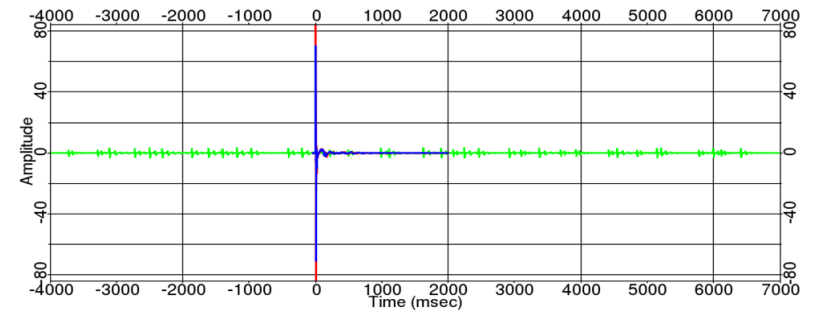


4130 cubic-inch array

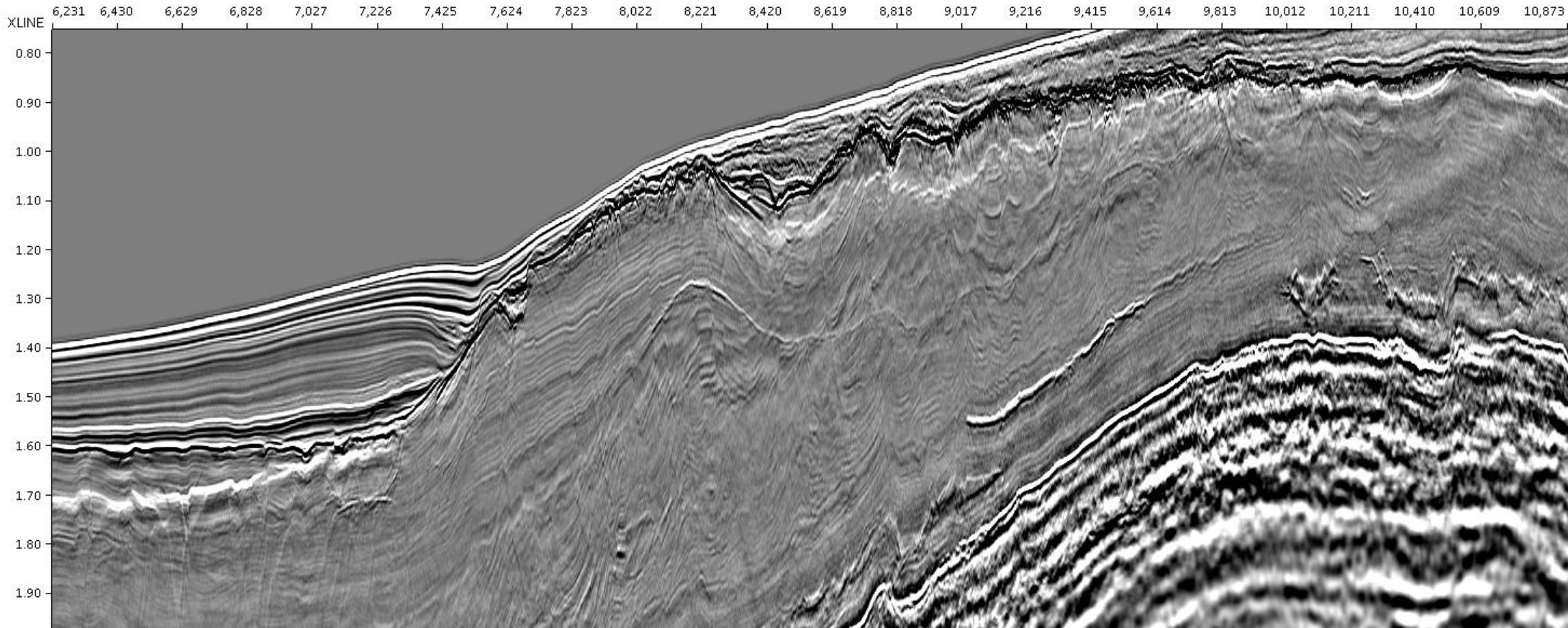
eSeismic

Peak sound pressure levels (in dB re 1 μ Pa) as a function of inline and cross-line distances in meters from the geometrical center of the source at a depth of 10 m (4 m below the source depth).

red: 4130 cubic-inch array
 blue: 3090 cubic-inch array
 green: eSeismic



Experimental eSeismic (2D)



Summary

- We want to conduct our business responsibly with regards to impacts on the ecosystem and with respect to other users of the ocean (e.g., fishermen).
- We are actively developing (and applying) advanced seismic technology in order to improve efficiency and to reduce the environmental footprint.
- The seismic contractors are dependent on the support from their customers and governments in order to achieve these goals.

Acknowledgements:

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