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

<table>
<thead>
<tr>
<th>Operator</th>
<th>Vessel Name</th>
<th>Count</th>
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<tbody>
<tr>
<td>PGS</td>
<td>Ramform Titan*</td>
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<tr>
<td></td>
<td>Ramform Atlas*</td>
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<td>Ramform Tethys*</td>
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<td>Polar Marquis</td>
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<tr>
<td>BGP</td>
<td>Prospector</td>
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</tbody>
</table>

* 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…..
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

Geophysical Quality & Efficiency Objectives

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

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)
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).

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

Peak sound pressure levels (in dB re 1 µPa) 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.

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