Ny Seismisk Kildeteknologi

Fisk og Seismikk, Tromsø, 5. april 2017

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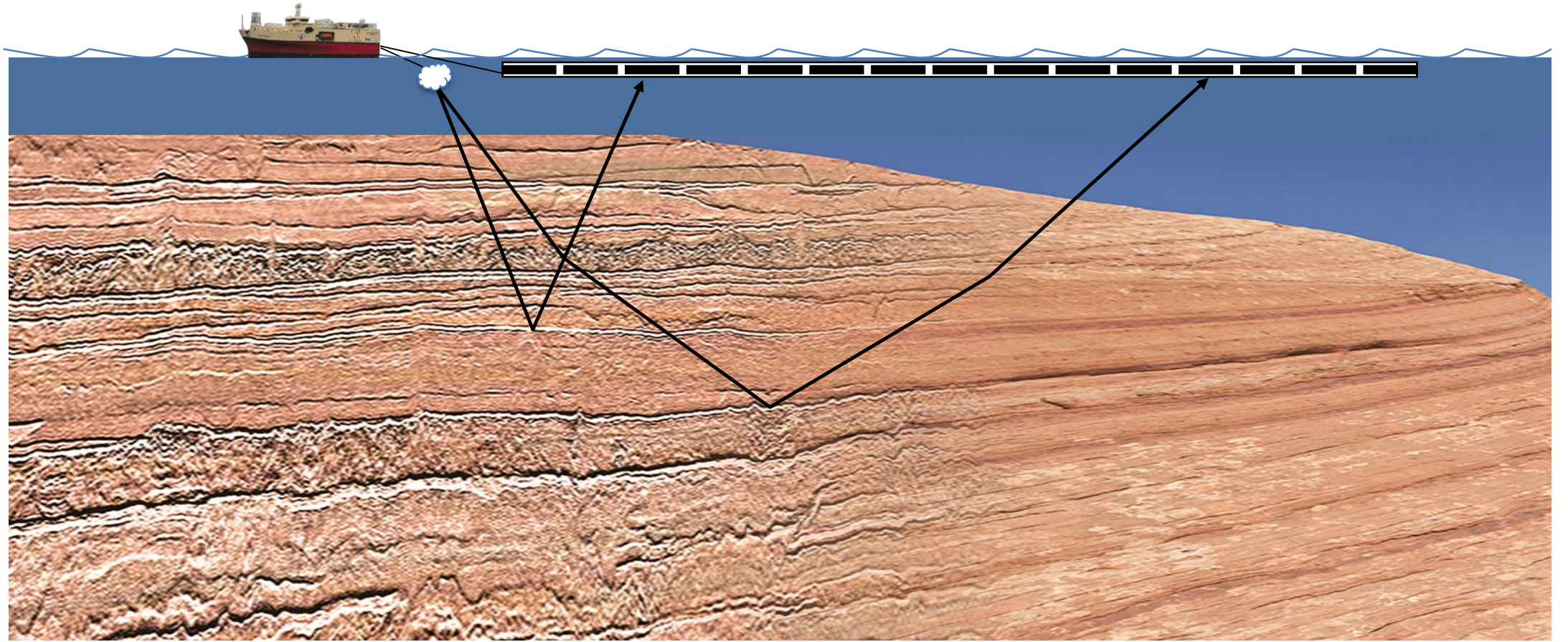
Innhold

- Seismikk – bilder av lyd
- Dagens lydkilder
- Miljøutfordringer
- Hva slags lydkilde trenger vi?
- Nye metoder med dagens kilder
- Nye kildetyper
- Oppsummering

Hovedelementene i seismiske innsamlinger

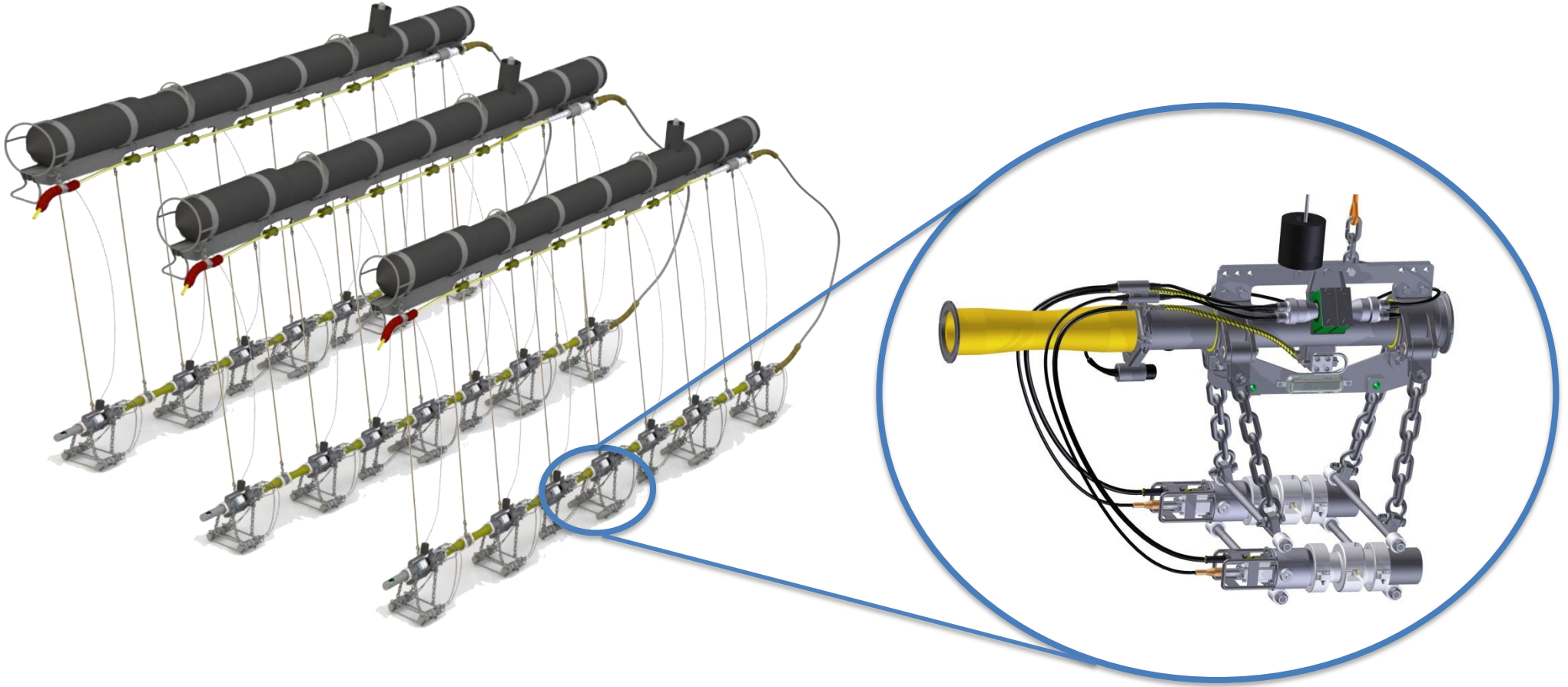
- Seismiske kilder
  - Genererer lyd som spres utover fra kilden
- Mottagere
  - Lyttekabler med sensorer
- Opptakssystem
  - Digitaliserer og lagrer data

Konsept: send ut lyd og lytt til «ekkoet»



Dagens lydkilder

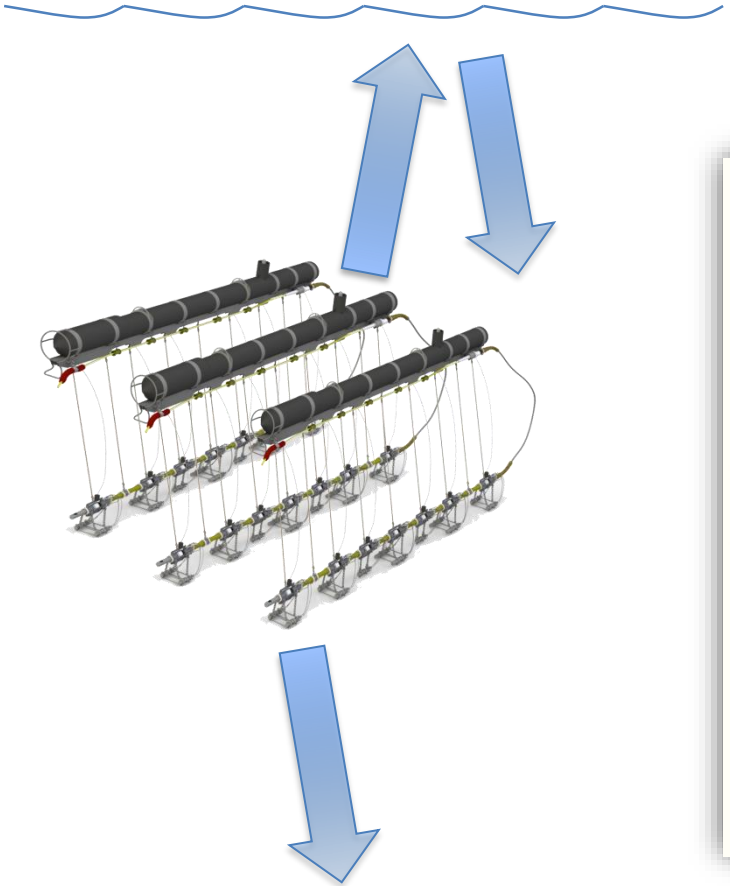
Seismisk kilde

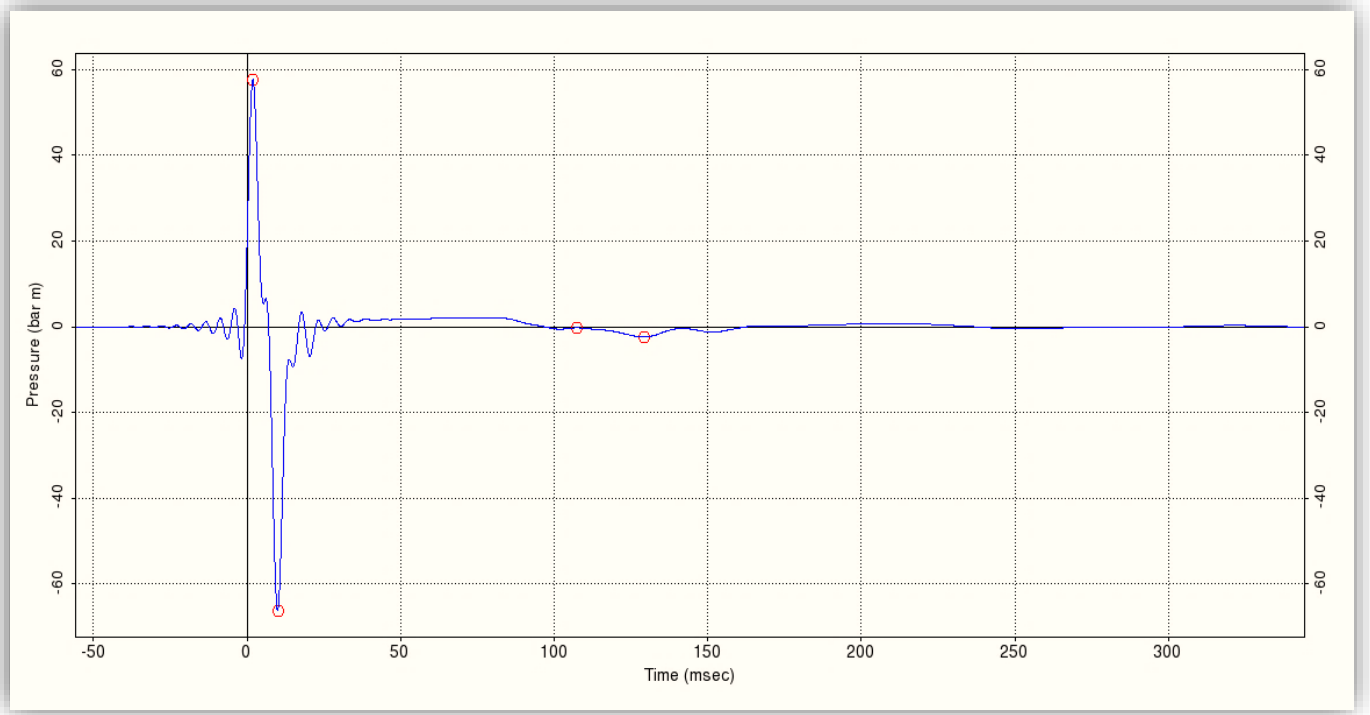


Enkelt kildeelement

- Luft under trykk slippes ut i vannet
- Luftboblen ekspanderer som fører til at trykket i boblen minker
- Når lufttrykket i boblen blir lavere enn trykket i vannet, vil trykkreftene virke i motsatt regning og bobla vil trekke seg sammen

Lyd fra en seismisk kilde

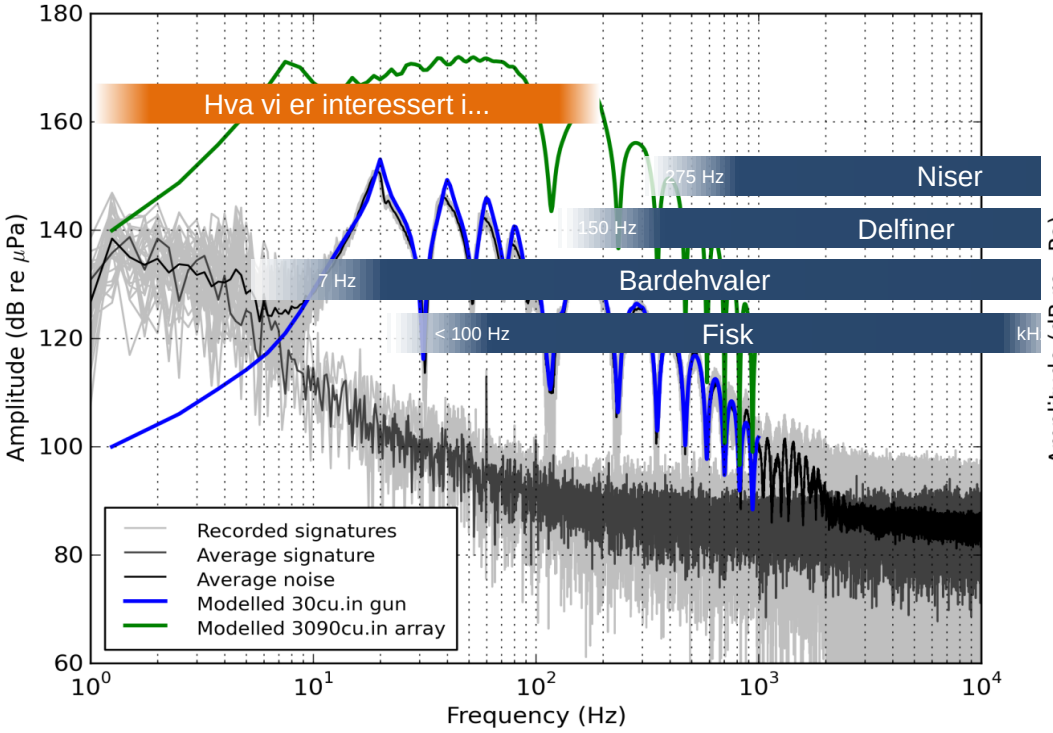




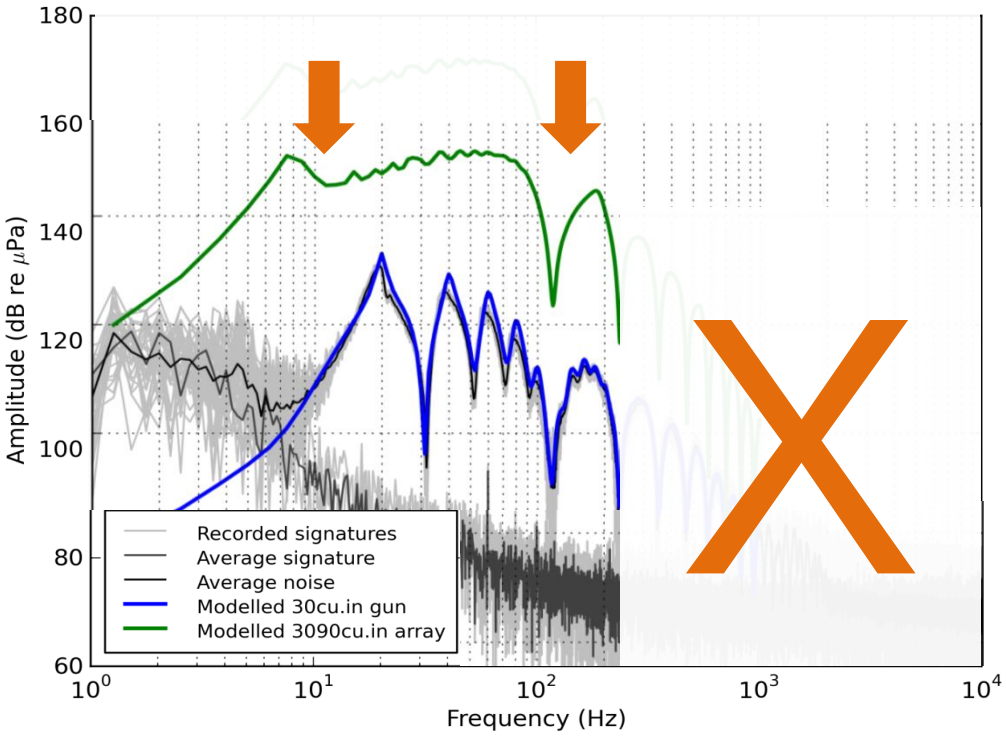
Miljøutfordringer

Miljøutfordringer med en seismisk kilde

Lyd fra en seismikk-kilde



Hva forsøker vi å gjøre noe med?



Eksempler på avbøtende tiltak

- «Soft-start»
- Observatører

National Marine Fisheries Service. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

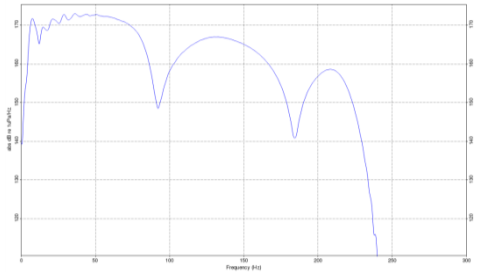
ASA S3/SC1.4 TR-2014. Sound Exposure Guidelines for Fishes and Sea Turtles

Hva slags lydkilde trenger vi?

Hva er viktig for å få gode bilder?

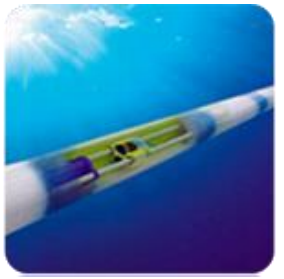
Lydkvalitet

- Frekvensinnhold
- Energinivå
- Direktivitet
- Repeterbarhet



Lyttekabler

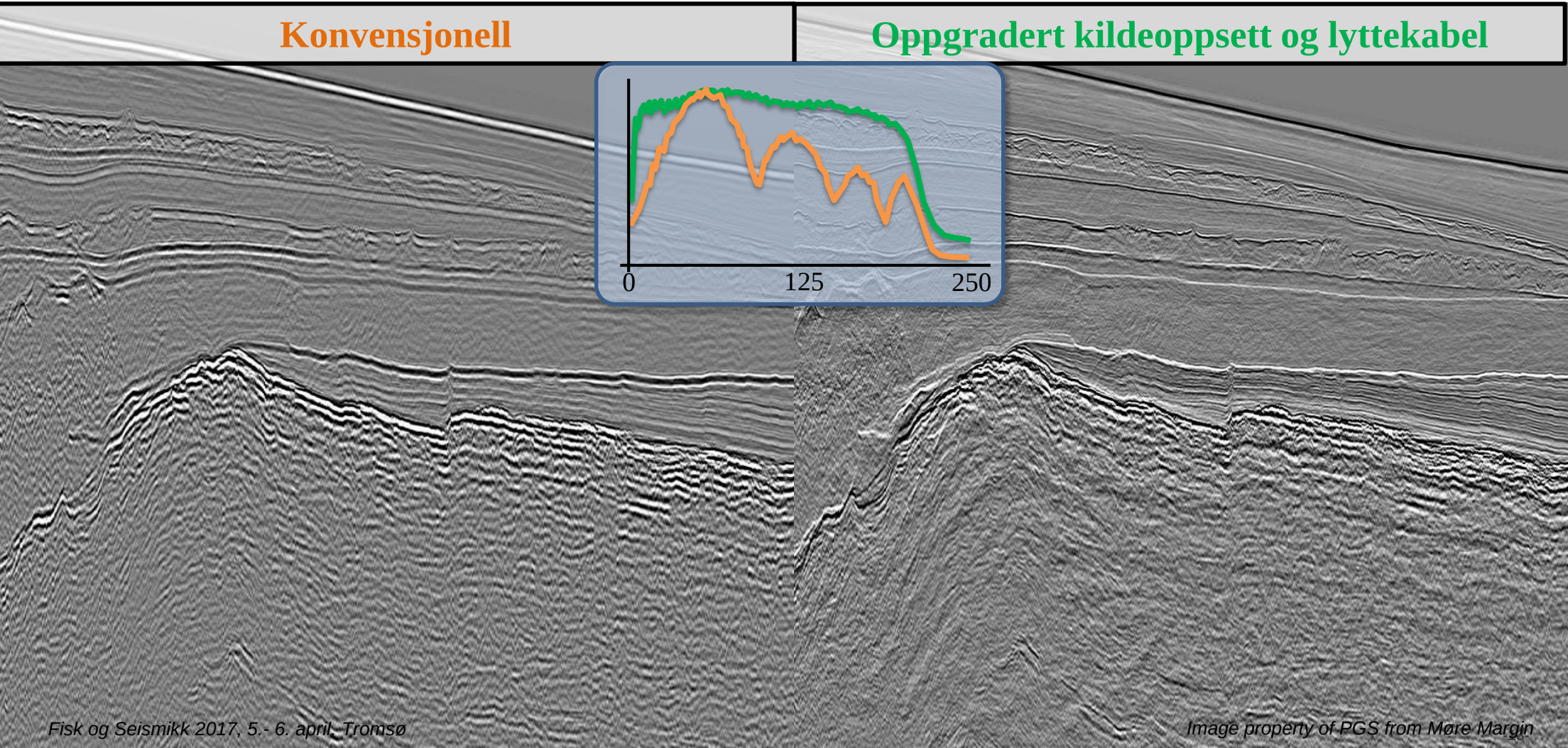
- Antall sensorer i lyttekablene
- Type sensorer
- Antall lyttekabler



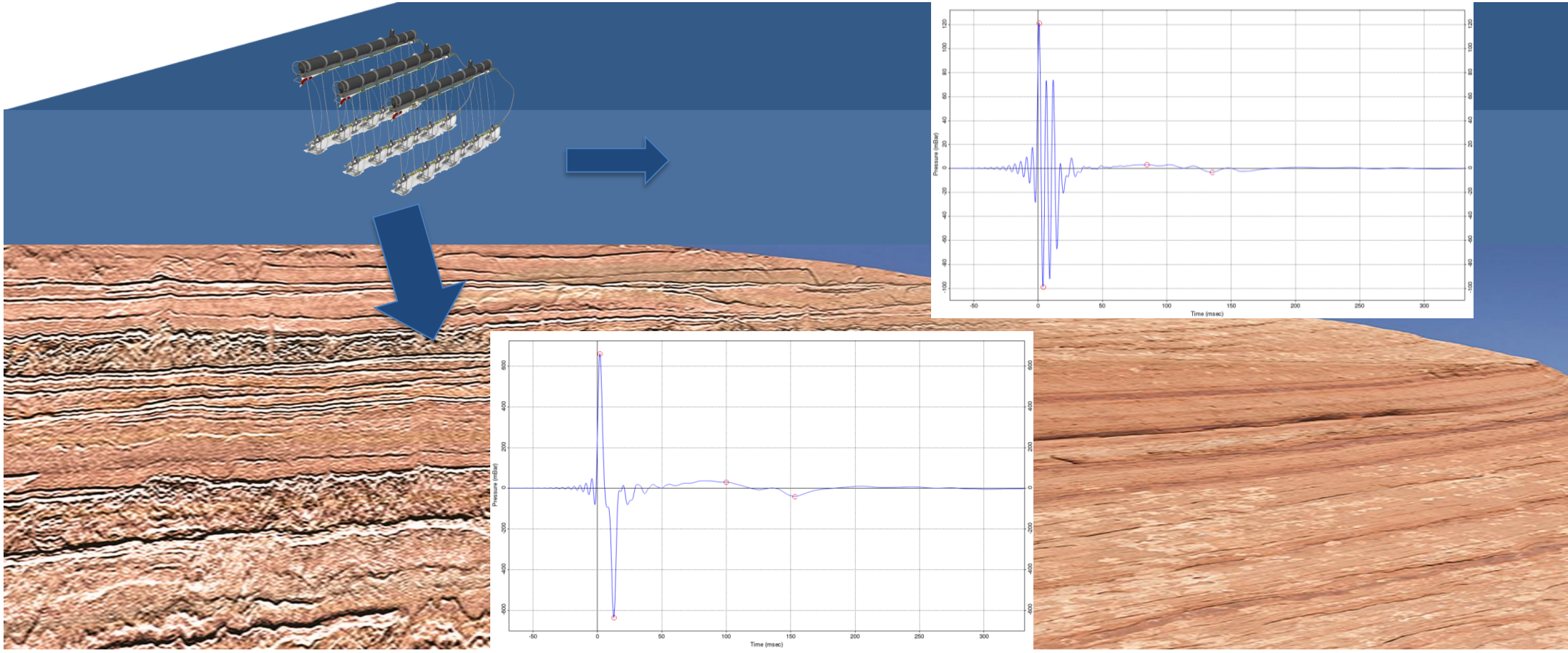
Prosessering

- Algoritmer
- Datakraft

Bildekvalitet



Kildeegenskaper – Eksempel: Direktivitet



Andre egenskaper ved lydkilden

Robust	• Tåler sjø • Lav feilrate
Fleksibel	• Modulær • Justerbar
Effektiv	• Kombinasjonen av robusthet og fleksibilitet

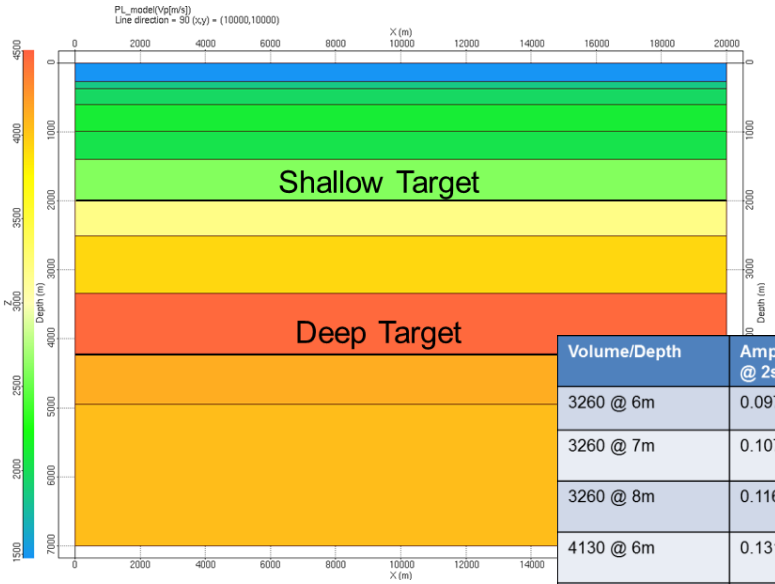
Image of Bolt Long Life Air Gun 1900 LLX-T courtecy of Teledyne Bolt Technologies (http://www.teledynemarine.com/bolt#)

Source Array in the Water image courtecy of Andy Wright, PGS

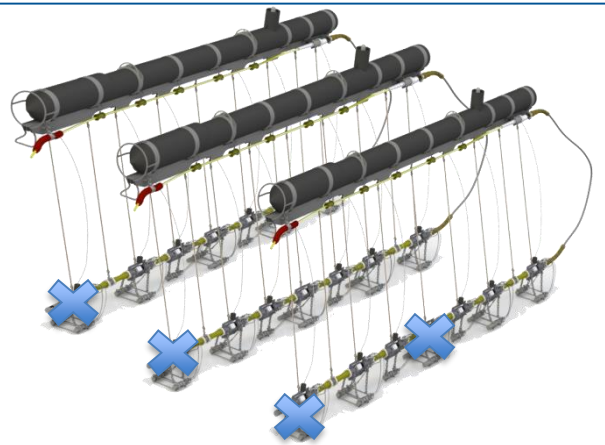
Alternative Seismiske Kilder

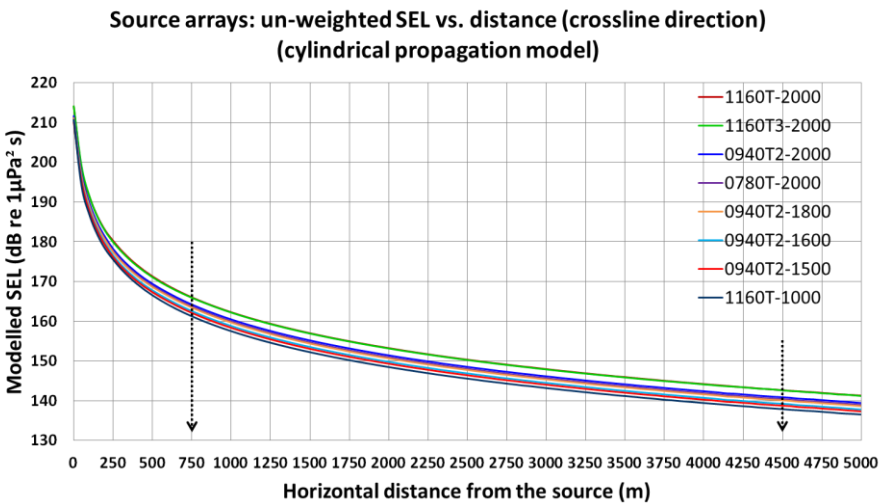
Justering av dagens kildeoppsett

- Justere kilden ved å
  - Mindre kildeelementer
  - Færre kildeelementer
  - Lavere lufttrykk



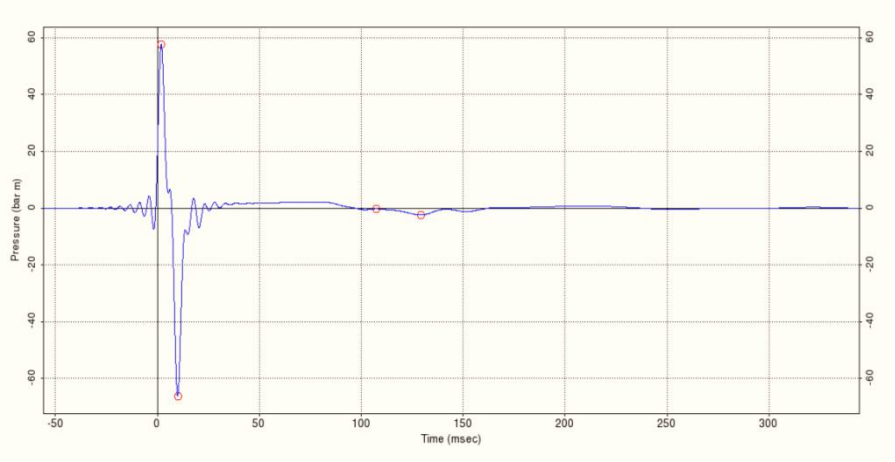
Volume/Depth	Amplitude at 20 Hz @ 2s TWT/Q=120	Amplitude at 20 Hz @ 3s TWT/Q=120
3260 @ 6m	0.097	0.054
3260 @ 7m	0.107	0.06
3260 @ 8m	0.116	0.065
4130 @ 6m	0.131	0.074
4130 @ 7m	0.143	0.08
4130 @ 8m	**0.153**	**0.086**

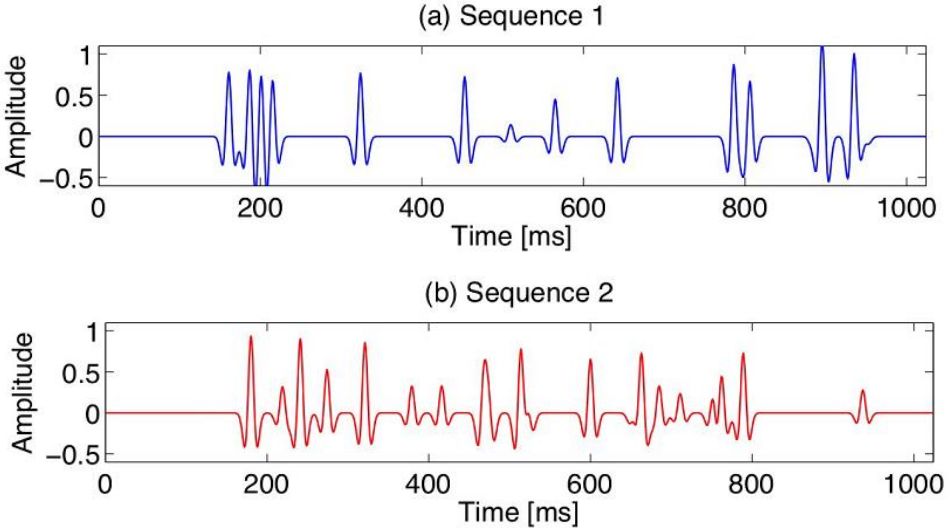




Designede kildesekvenser

- Robertsson et al. (2008) diskuterte ideen om å aktivere ett kildeelement om gangen
- Hvert enkel kildelelement blir aktivert fordelt utover et gitt tidsrom som resulterer i en serie med mindre impulser
- Redusere amplitude nivået





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 – Mot en ny marine seismisk teknologi

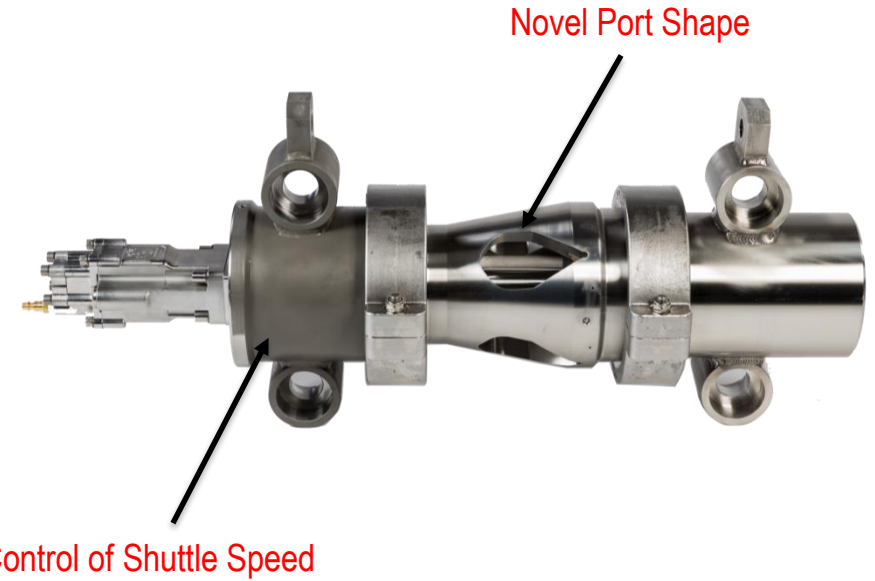
- eSeismic:
  - Kontinuerlig lyd, opptak og prosessering
- Mindre test utført i 2014 (2D)
- Større eSeismic pilot-test innsamlet i 2016 (3D)
- Et Demo 2000 FOU prosjekt, sponset av
  - Forskningsrådet
  - Statoil
  - PGS

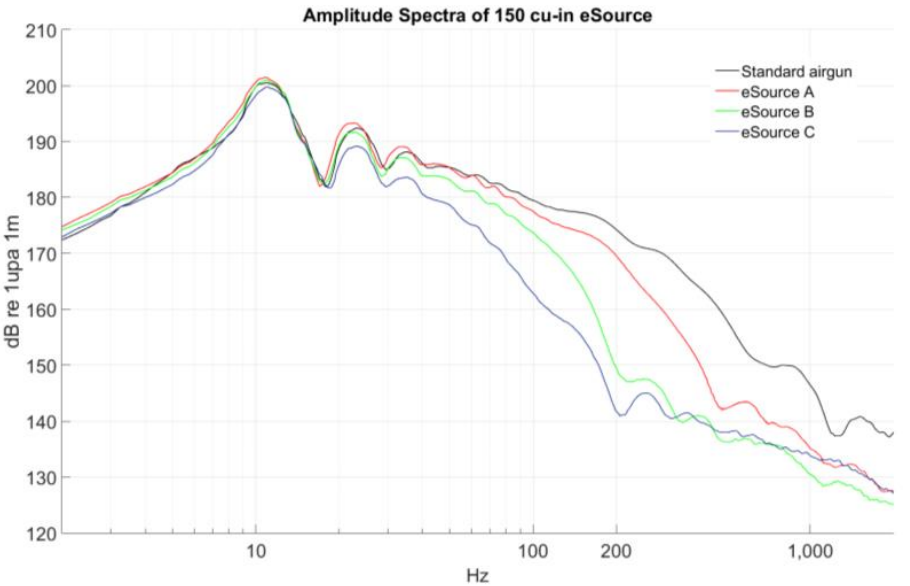
eSeismic informasjonsmøte (9.5.2016) under tildelingen av Demo 2000 støtte.
Bilde fra e24.no.

eSource – verdens første frekvenskontrollerte luftkilde

Guiding principle

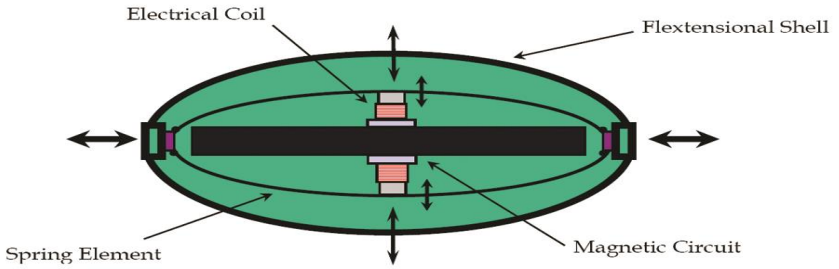
Emit only the energy that is required for seismic imaging

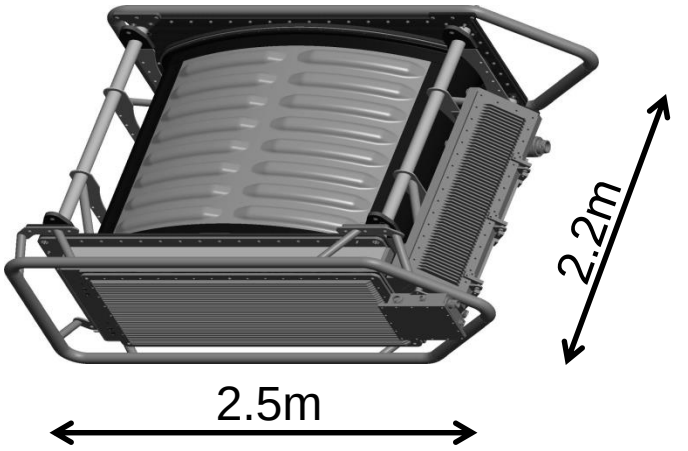




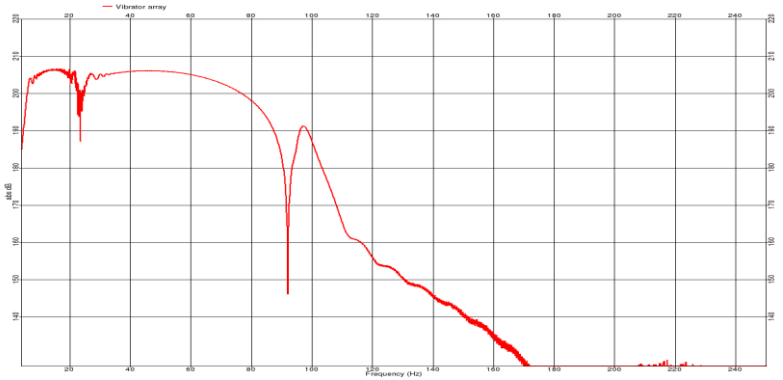
Source: SEG 2014, Robert Laws et al; High Frequency Attenuation from a new design of an airgun

Marine Vibrator Joint Industry Project





- **Frequency range 5-100 Hz**
- **Unique concept**
  - The voice coil concept with a spring element creates two resonances and a flat spectrum
  - A simple power and control system (no hydraulics) makes it possible to attenuate harmonics with a high degree of repeatability



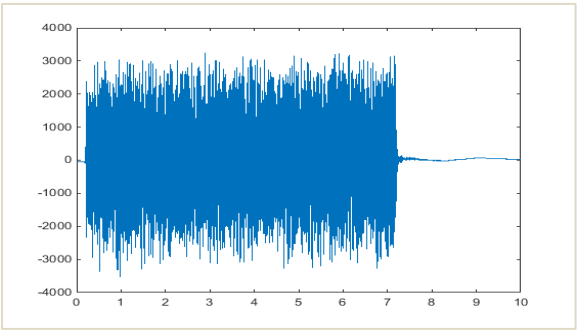
5 sec. sweep with a PGS Marine Vibrator Array

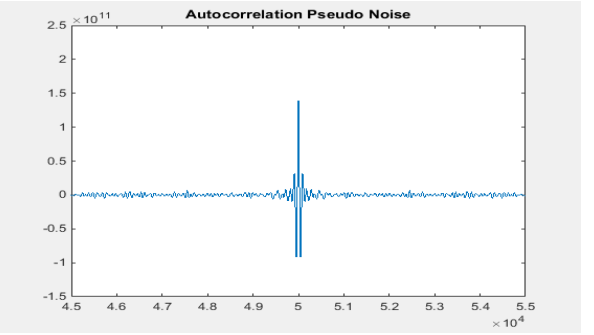
Marine Vibrator Prototypes

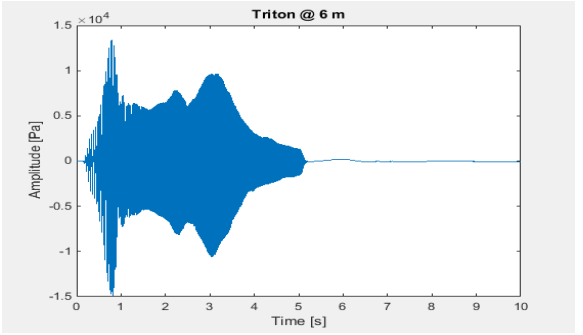
Source: SEG Workshop 2015 "Next Generation Marine Sources"

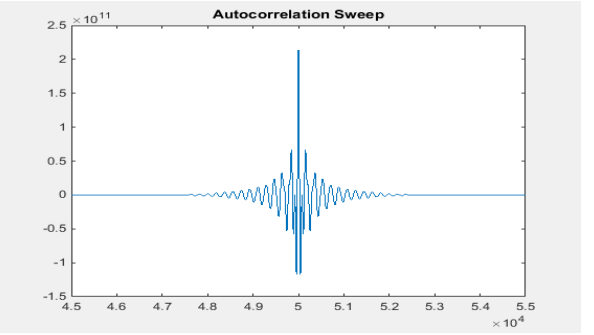
Designet kildesignatur

- Bruk av pseudo-støy reduserer amplituden betraktelig
- Lyden vil være av samme natur som bakgrunnsstøy



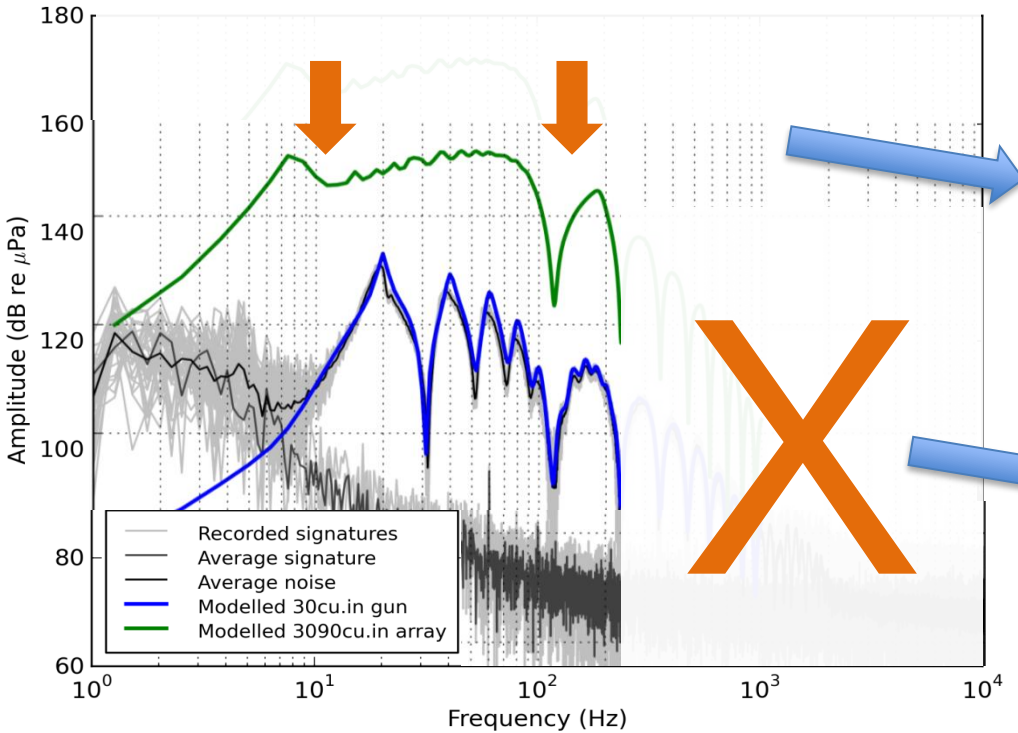






Alternative kilder

Hva forsøker vi å gjøre noe med?



- Justert kildeoppsett
- Distribuerte kilder
- Elektromekaniske kilder

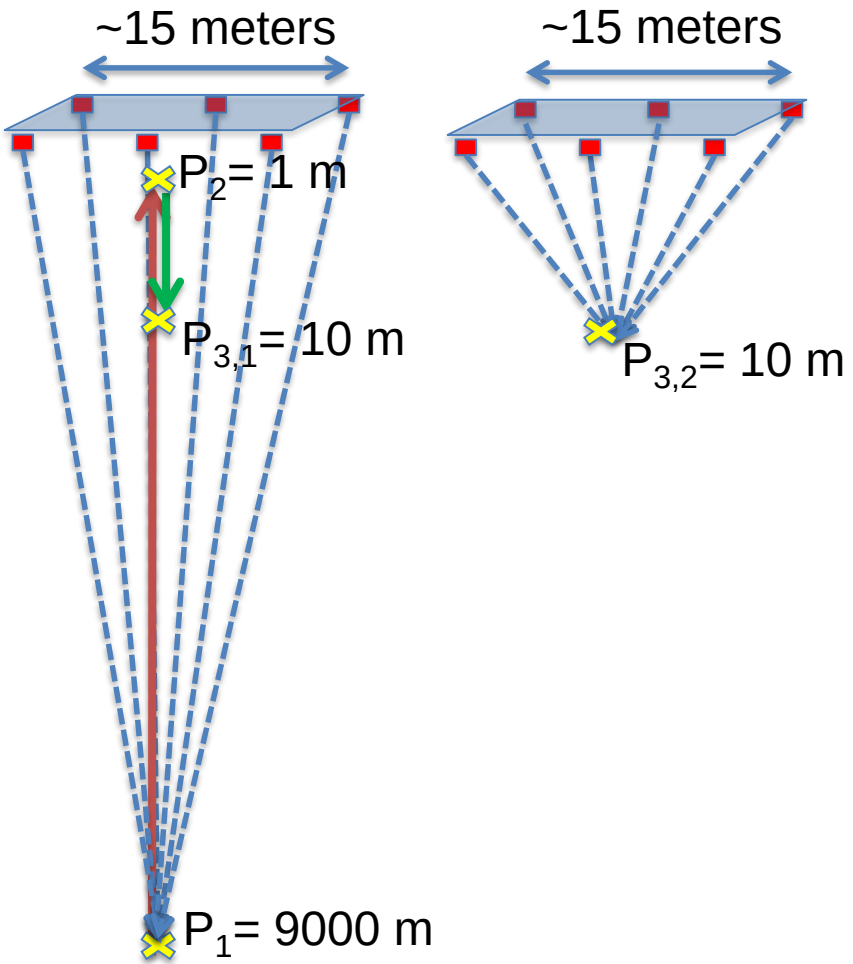
- eSource
- Elektromekaniske kilder

Oppsummering

- Dagens lydkilder: luft i vann
- Konfigurert til å best mulig kartlegge geologien
- Påvirkning på miljøet
- Evaluering av kildekonfigurasjoner gjøres jevnlig
- Ny kildeteknologi er et stort satsningsområde – fortsatt under utvikling
  - Distribuerte kilder
  - Elektromekaniske kilder
- Må både oppfylle de seismiske kriteriene og samtidig være miljøvennlige

Takk for oppmerksomheten

Backup: Farfield vs Nearfield



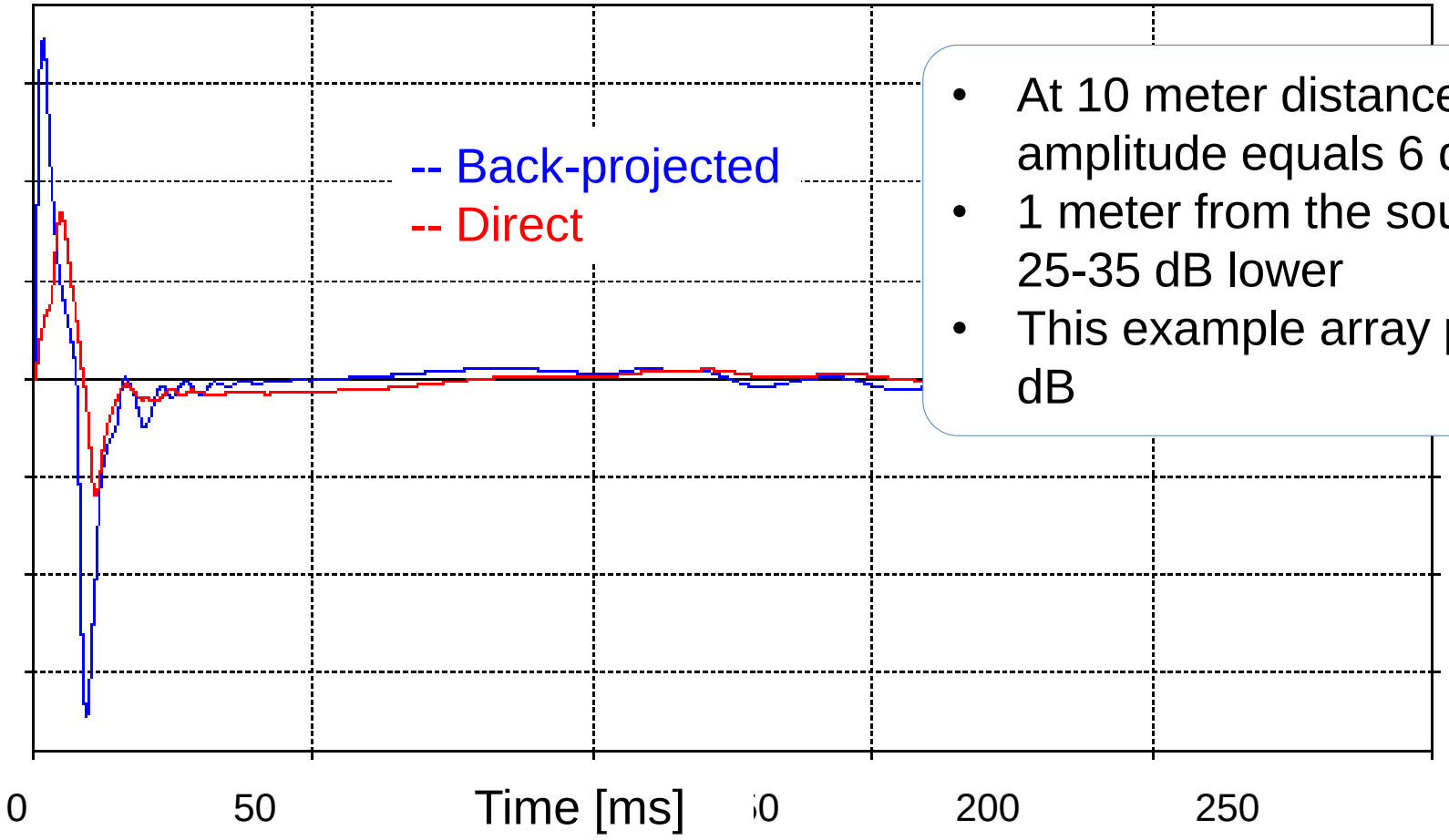
P_1: Default position used in the farfield calculation.

P_2: Back projected farfield signature to a distance of 1 m (definition of the unit *Bar-m*).

$P_{3,1}$: Received pressure at 10 meters vertical distance calculated from the farfield signature at P_2.

$P_{3,2}$: Received pressure at 10 meters vertical distance from the source calculated from the individual source elements.

Farfield vs Nearfield



- At 10 meter distance: Half the amplitude equals 6 dB lower
- 1 meter from the source you get 25-35 dB lower
- This example array peaked at 226 dB