



Avansert høgopplauseleg 3D seismikk – løysingar for nye energiformer

Martin Widmaier, Chief Geophysicist PGS Sales & Services
Fisk og Seismikk 2023, Bodø, 12.-13. April 2023

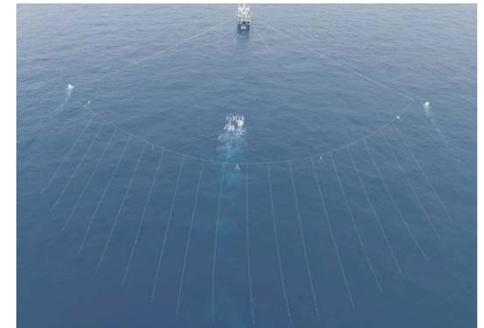


Outline

- Intro
- Why do we need high/ultra-high-resolution 3D seismic for new energy applications?
- Scale of acquisition systems; Spatial & temporal sampling
- CCS: Innovative high resolution acquisition solutions
- Wind: Ultra-high-resolution 3D site surveys with P-cable
- Summary

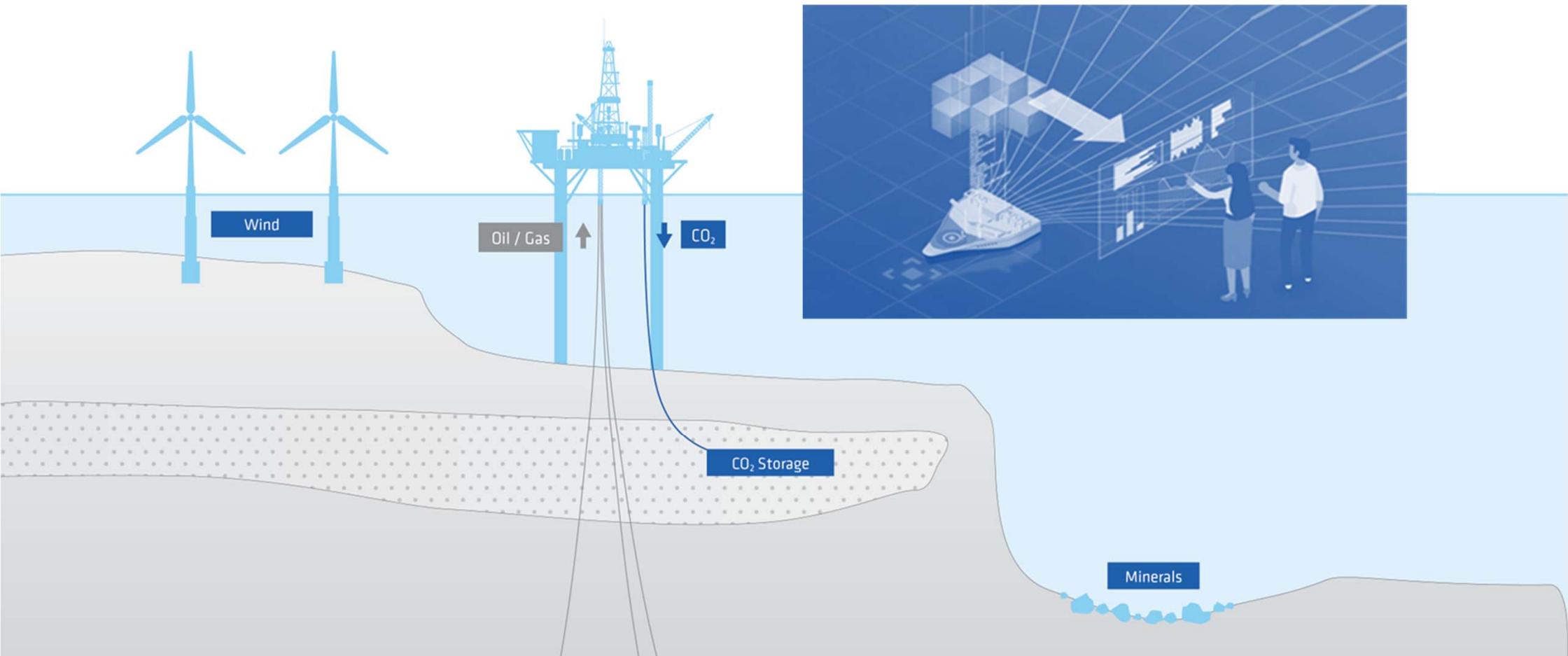


Exploration seismic survey with Ramform vessel.



Ultra-high resolution seismic acquisition with P-Cable.

Marine 3D Seismic Solutions for Evolving Energy Needs

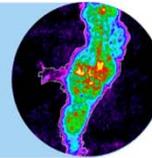


PGS projects 2022 related to Carbon Storage & upcoming Offshore Wind site surveys

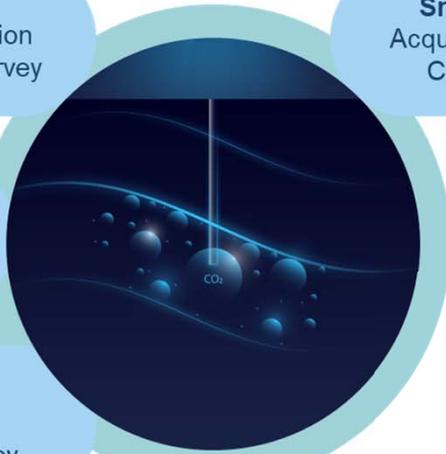


Smeaheia
3D High Resolution
Development Survey

Snøhvit and Sleipner
Acquisition and Processing
CO₂ Monitor Surveys



**Northern
Endurance
Partnership** 3D High Resolution
Development
Survey



**Northern
Lights** 4D High
Resolution
Baseline Survey

PGS Enters Offshore Wind Market



CCS seismic surveys acquired offshore Norway and UK in 2022.

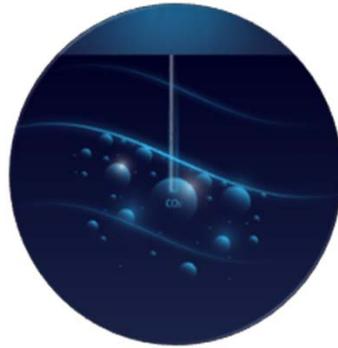
January 25, 2023

January 25, 2023, Oslo, Norway: PGS has been awarded its first ultra-high resolution windfarm site characterization project, sealing its entry into a strategically important new energy market.

Press release, January 2023

Why do we need high/ultra-high-resolution 3D seismic?

CCS



- Shallow hazards (e.g., gas)
- CO2 reservoir storage capacity
- Seal integrity
- Injection well planning
- Baseline for future seismic monitoring

Offshore Wind

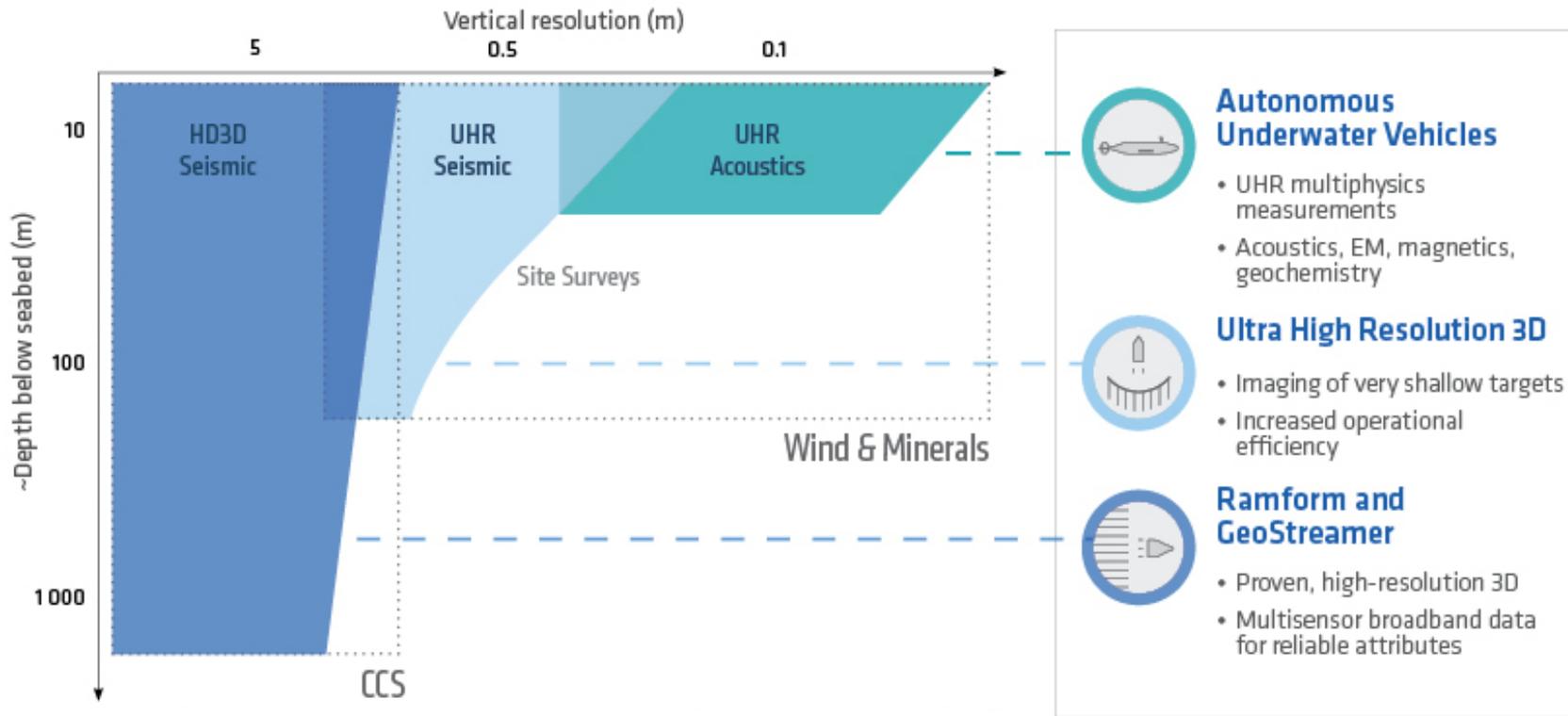


- Mapping of the ocean floor
- Detailed understanding of the properties of the upper 100 m of the sub-surface to position and install wind turbines
- Boulder detection, shallow hazards

Floating Offshore Wind Farm

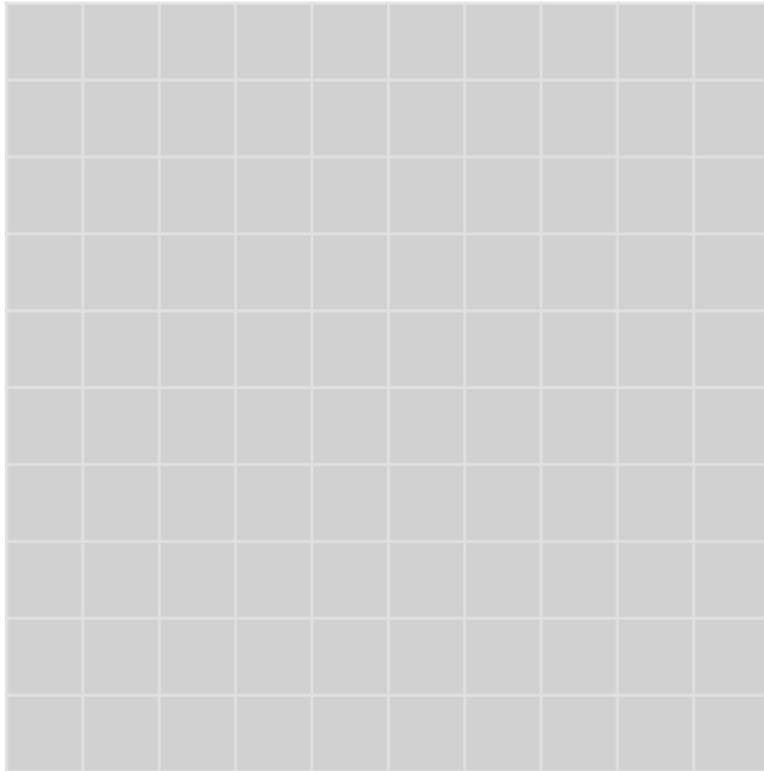
- Frozen methane hydrates
- Landslide risk assessment

Multi-scale Seismic Acquisition



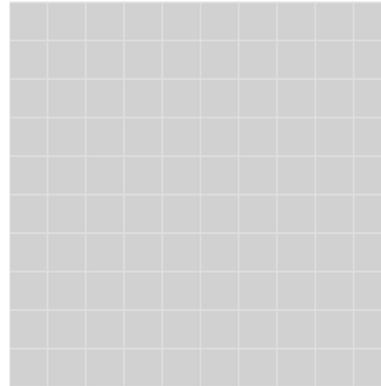
Spatial Sampling and Bin Sizes

typical exploration/production survey on the Norwegian Continental Shelf



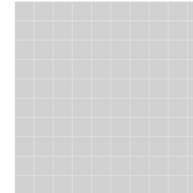
100 bins*
bin size 12.5m x 12.5m

High-res Barents Sea CCS baseline survey



100 bins*
bin size 6.25m x 6.25m

ultra-high resolution 3D seismic site surveys



100 bins*
bin size 3.125m x 3.125m



100 bins*
bin size 1m x 1m

Simple analogue:

It is sometimes hard to tell what a low-resolution pixelated image represents. Increase the number of pixels, and the picture becomes clearer.

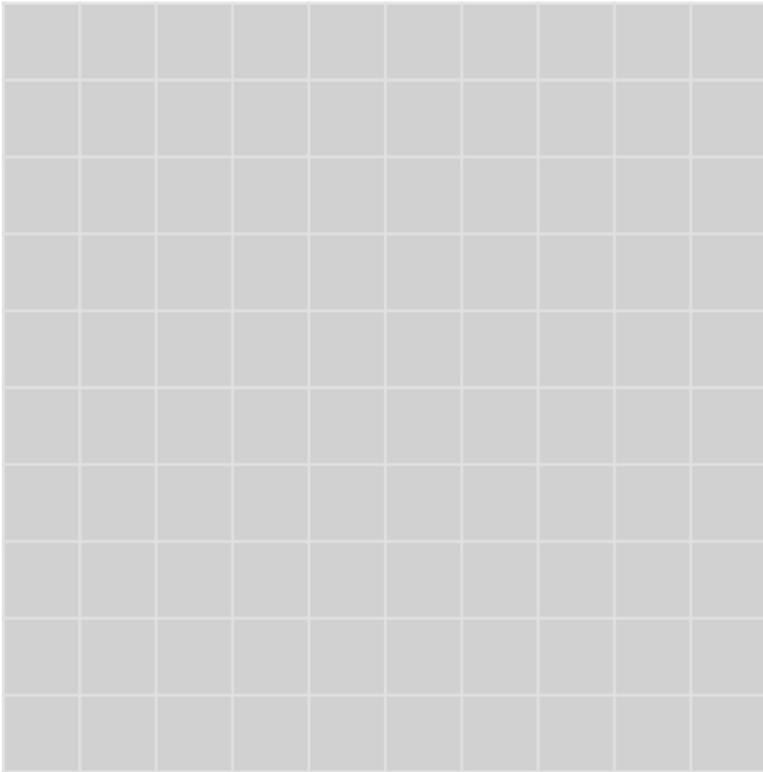
Decreasing the bin size provides more pixels per unit.



**) number of bins is kept constant for illustration and comparison purposes*

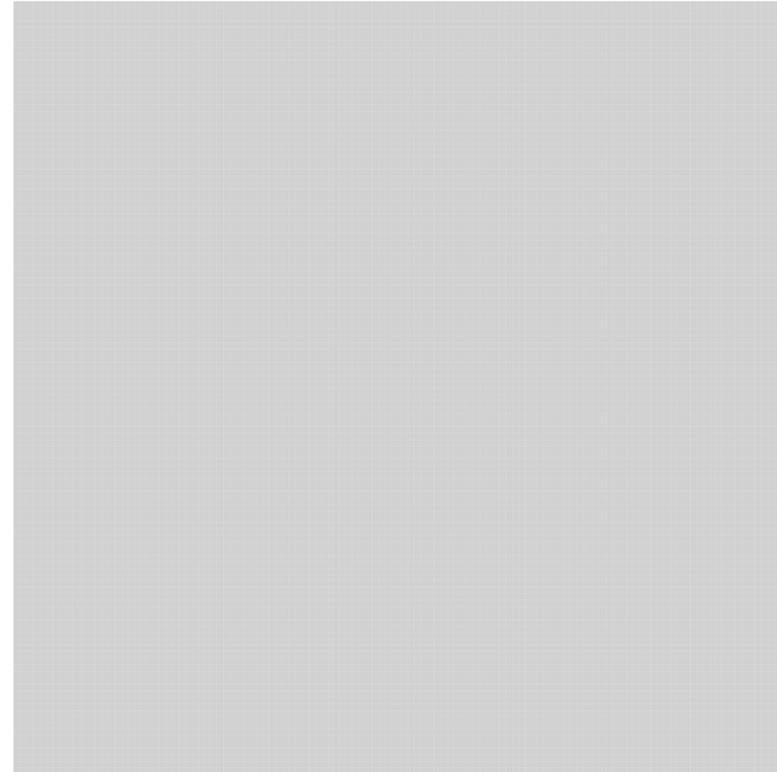
Spatial Sampling and Bin Sizes

typical exploration/production survey on the Norwegian Continental Shelf



100 bins*
bin size 12.5m x 12.5m

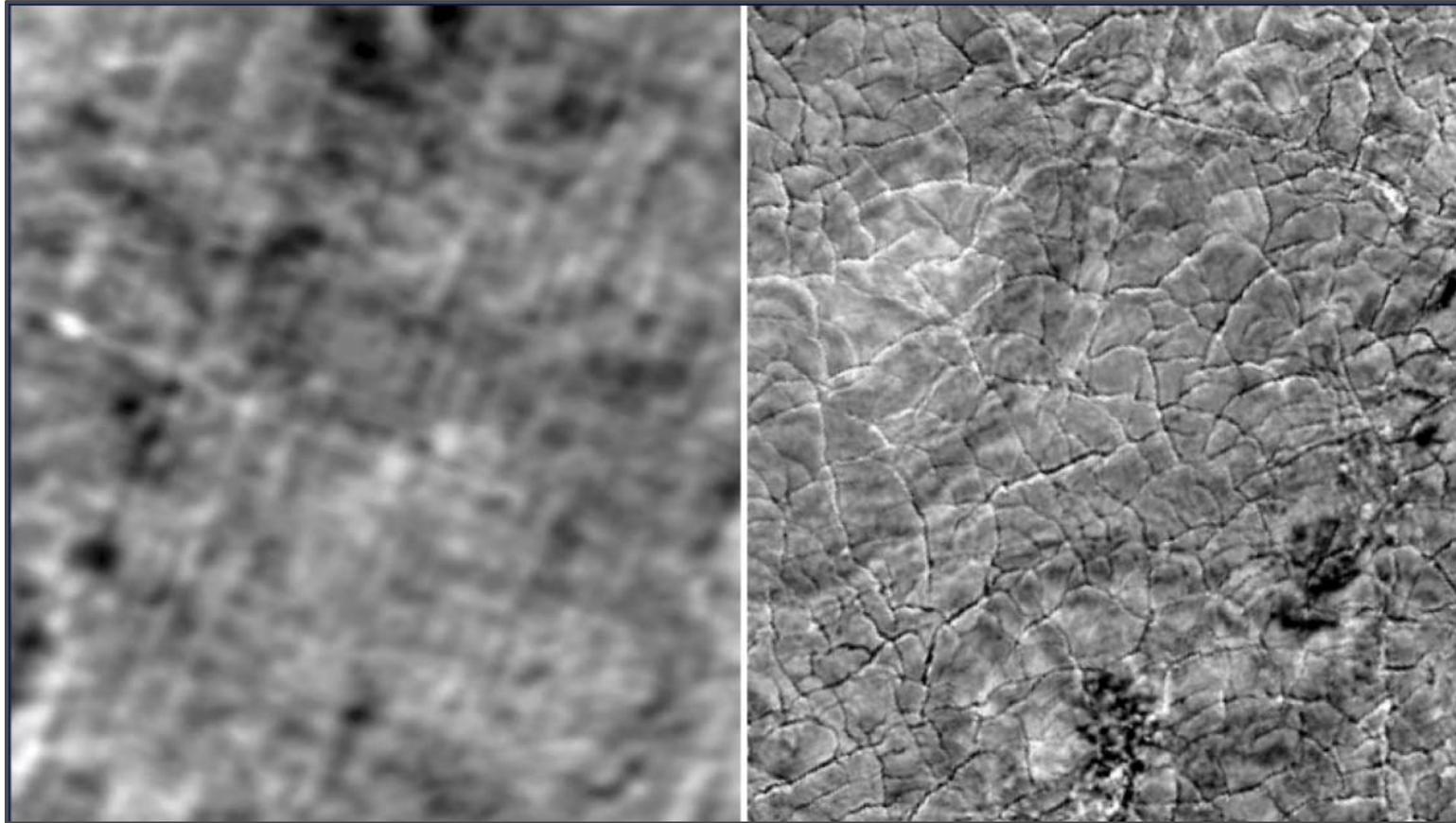
ultra-high resolution 3D seismic site surveys



15 625 bins*
bin size 1m x 1m

**) surface area is kept constant for illustration and comparison purposes*

Spatial Sampling and Bin Sizes



Legacy 3D Seismic. Bin size 25m x 25m.

P-Cable acquisition. Bin size 3.125m x 3.125m.

Scale of Acquisition Systems

Ultra-high resolution versus high-resolution 3D Seismic (1)



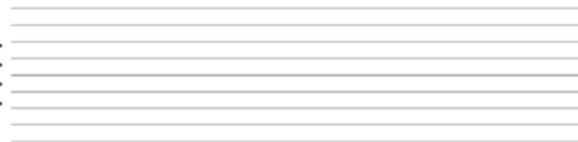
Typical 3D seismic streamer spread for hydrocarbon exploration offshore Norway



Northern Lights/Norway CCS seismic 2022

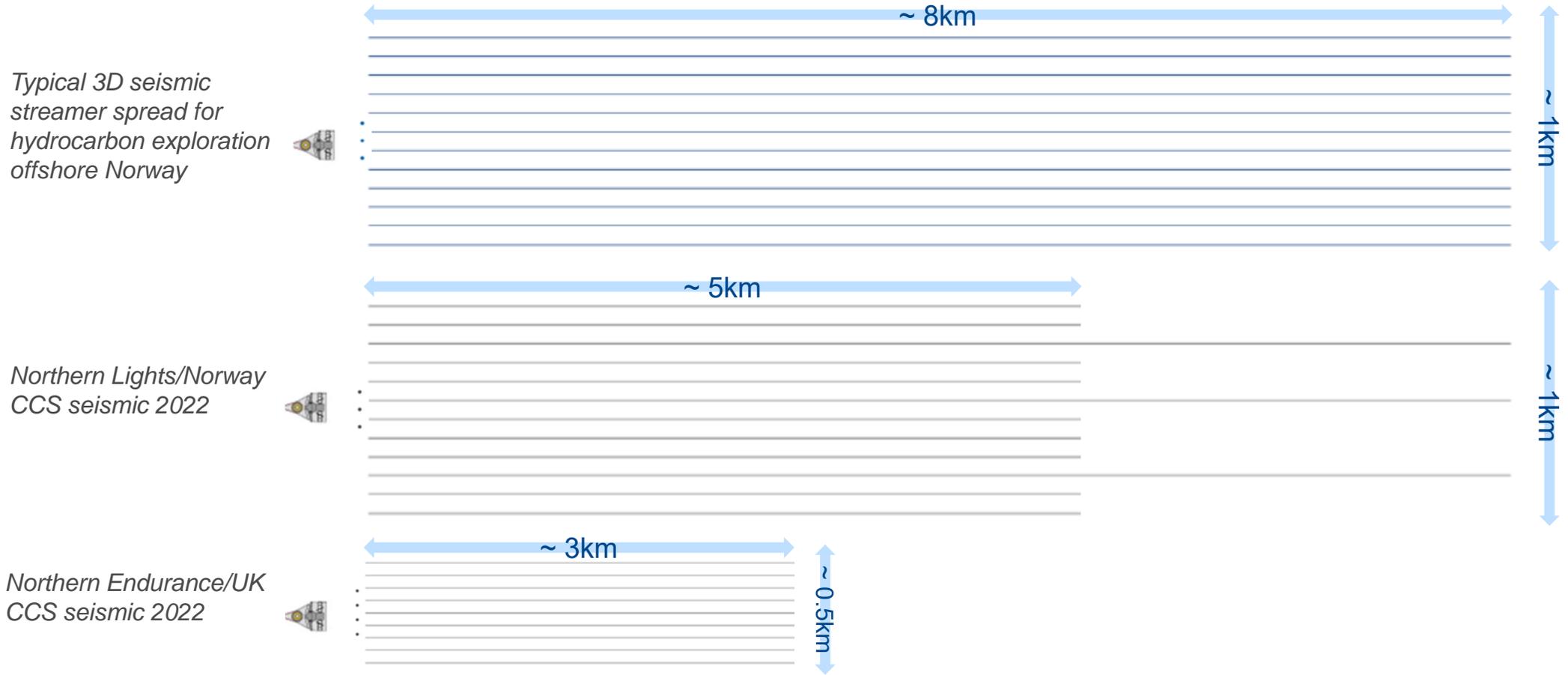


Northern Endurance/UK CCS seismic 2022



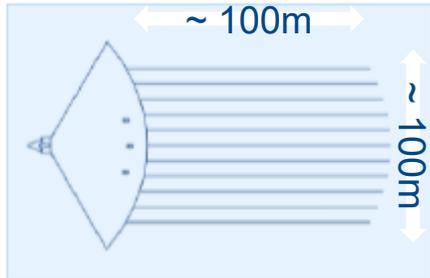
Scale of Acquisition Systems

Ultra-high resolution versus high-resolution 3D Seismic (1)

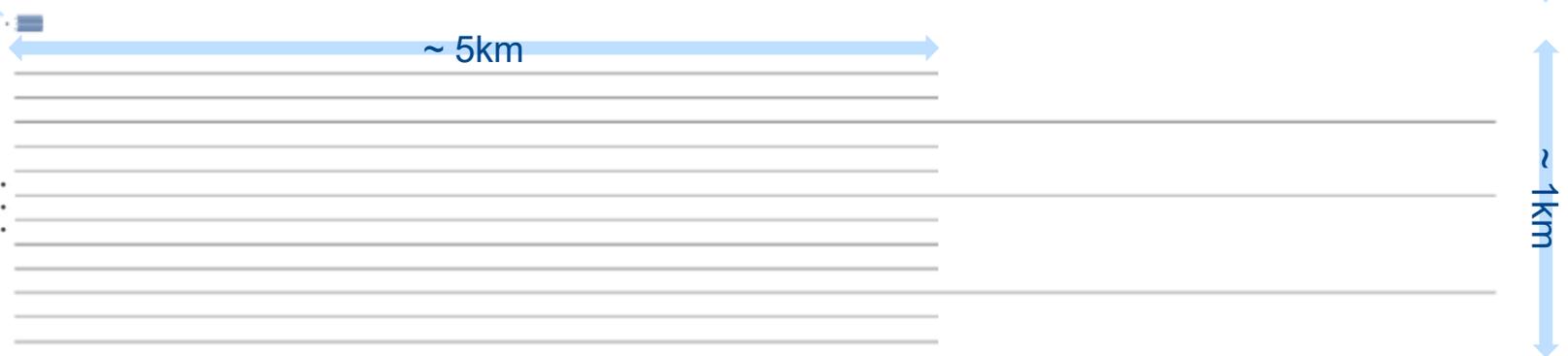


Scale of Acquisition Systems

Ultra-high resolution versus high-resolution 3D Seismic (2)



P-cable ultra-high-resolution system



Northern Lights/Norway CCS seismic 2022

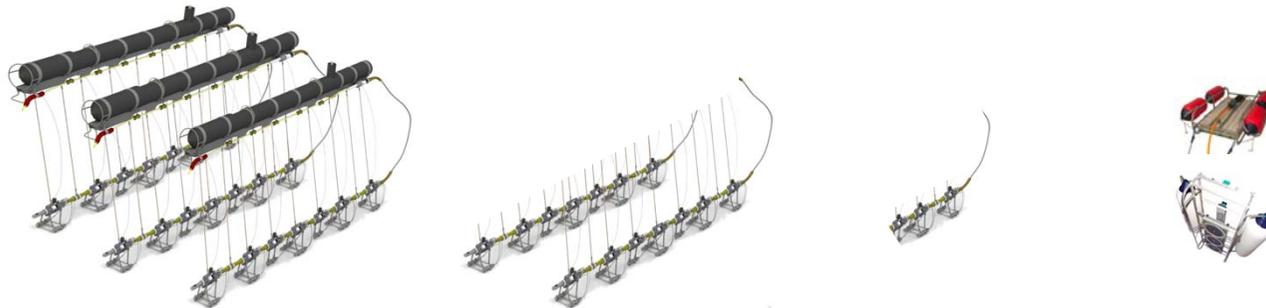
Northern Endurance/UK CCS seismic 2022

Scale of Acquisition Systems

Source types and frequency spectrum range



	Hydrocarbon Exploration and Production Seismic	CCS Development and Baseline Seismic	Wind Farm Site Characterization 3D Seismic
sampling rate	4ms - 2ms	2ms - 1ms	0.25ms - 0.125m
source	airgun array	smaller airgun array	Boomer or Sparker
frequency range	up to 125Hz - 250Hz	up to 250Hz	up to 4000+Hz



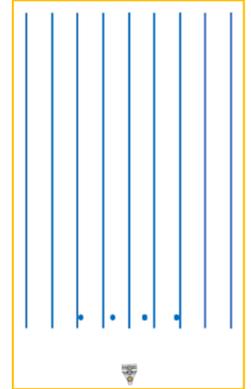
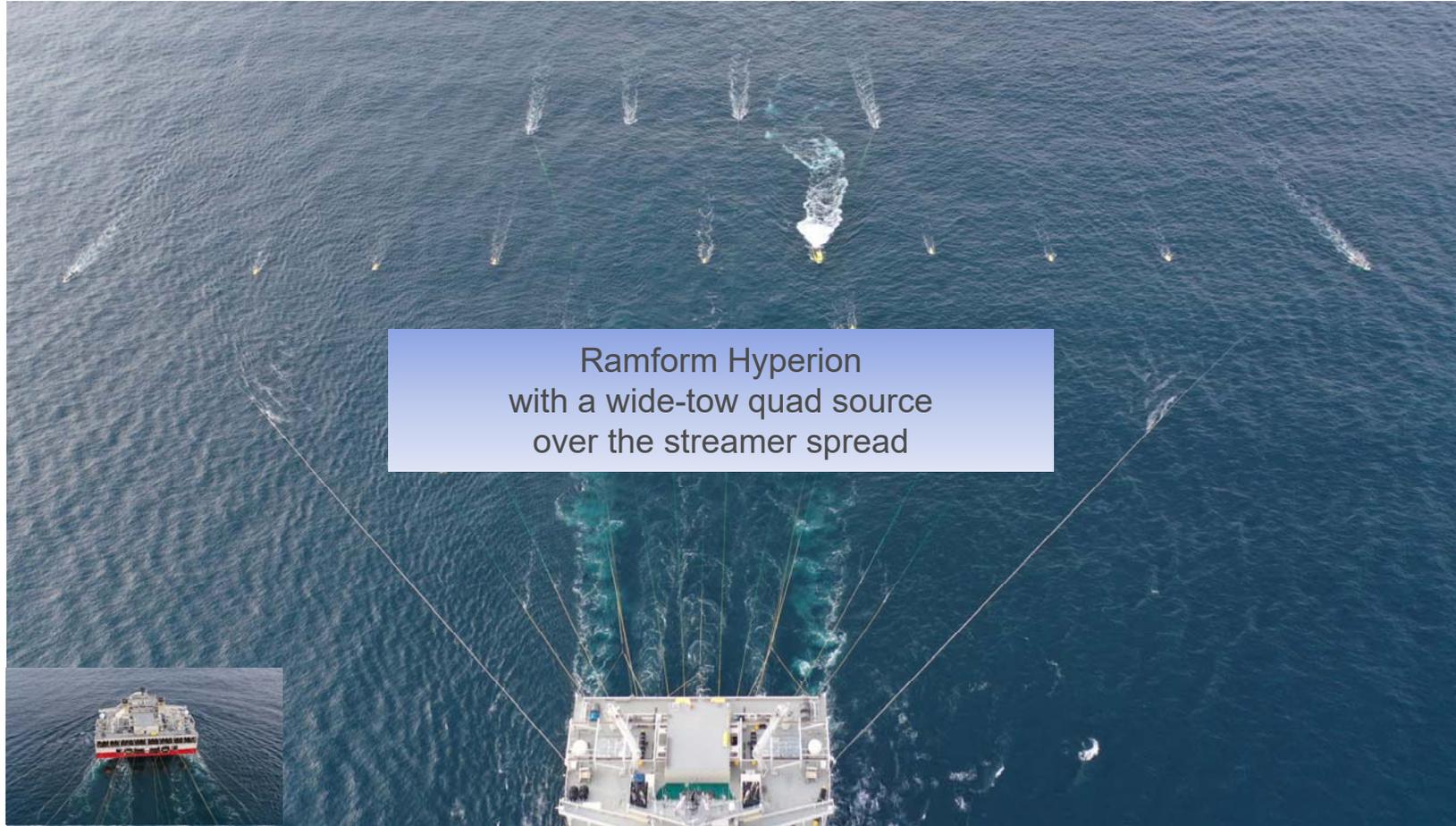
High resolution imaging of shallower targets typically requires increased bandwidth and less total sound output. Source dimensions are scaled down and output frequency spectrum is increased.

Innovative seismic acquisition solutions for CCS

1. Northern Endurance/UK
2. Northern Lights/Norway

Northern Endurance CCS Survey 2022*

(acquired for Northern Endurance Partnership; operated by BP)



*) Drone Photos, April 2022

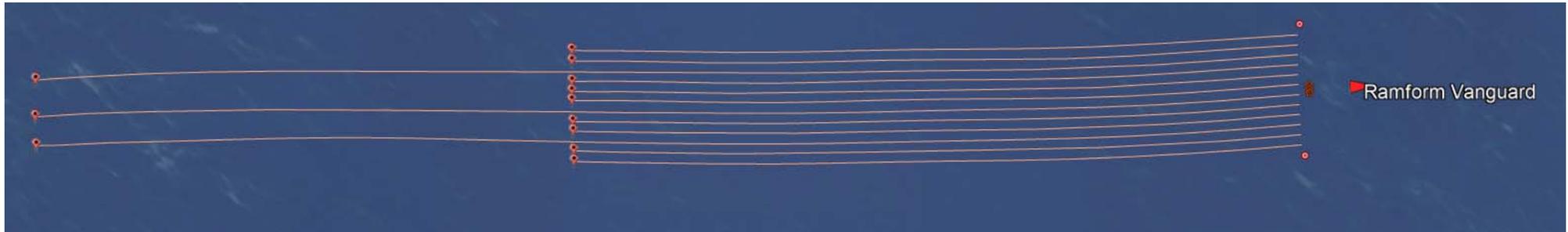
Northern Endurance CCS Survey 2022*

(acquired for Northern Endurance Partnership, operated by BP)



*) Drone Photo, June 2022

Northern Lights CCS Survey (acquired for Northern Lights JV DA; operated by Equinor)



Ramform Vanguard*
with a triple source, HD4D spread,
and three long streamer tails



*) Google Earth Snapshot, May 10th, 2022 and drone photo August 22nd 2022

P-Cable Technology: Ultra-high-resolution 3D

P-Cable*: Survey over Wisting/Barents Sea 2016

79th EAGE Conference & Exhibition 2017
Paris, France, 12-15 June 2017

Resolution, Resolution, Resolution - An Ultra-high Resolution Seismic Case Study from the Barents Sea

M. Garden* (OMV E&P GmbH), O. Michot (OMV E&P GmbH), M. Terenzoni (OMV E&P GmbH), H.H. Veire (OMV (Norge) AS), J.R. Granli (OMV (Norge) AS), L.M. Moskvil (OMV (Norge) AS), K.I. Krathus-Larsen (OMV (Norge) AS)

Bin size:	3.125m
Source line separation:	~100m
Sail line separation:	112.5m

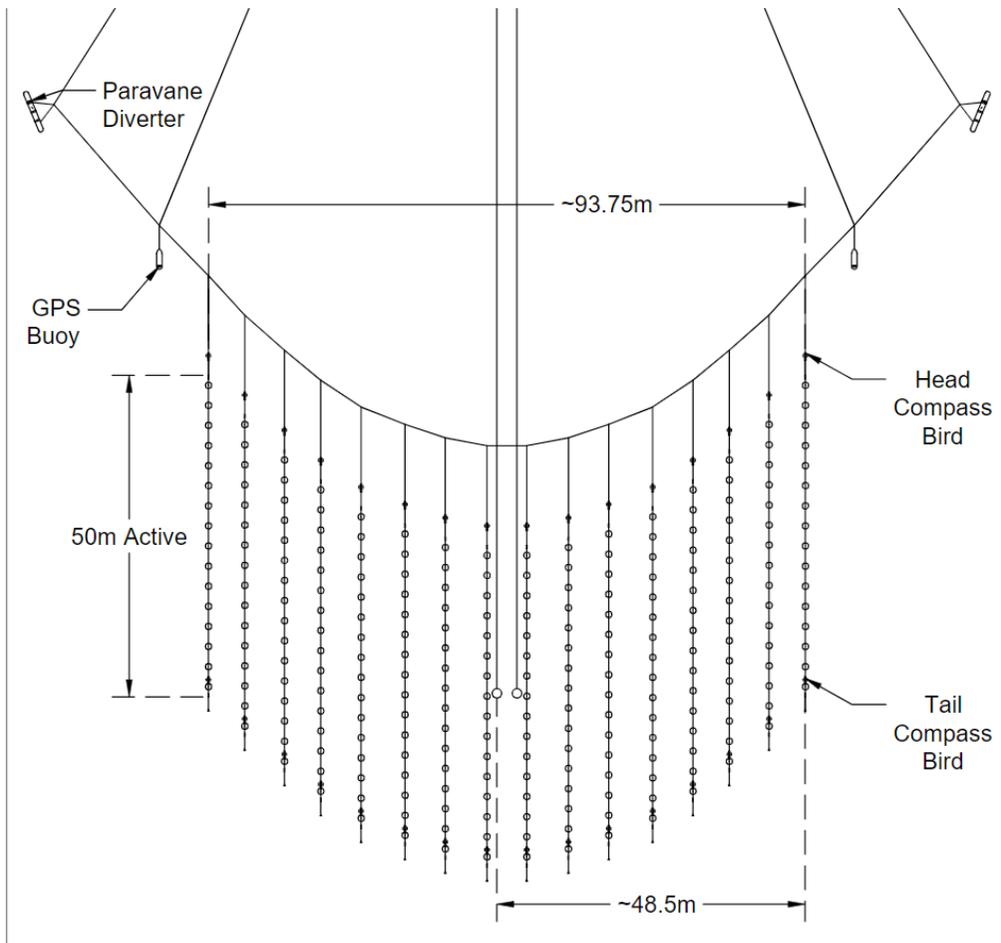


P-cable with 18 x 100m x 12.5m streamer spread and dual source (Wisting, 2016)

**) Sverre Planke and Christian Berndt first conceived the P-cable as an efficient way of collecting ultra-high-resolution 3D seismic data. The National Oceanography Centre, Southampton, built and tested a prototype between 2001 and 2004. Commercial surveying began in 2009, and since then, surveys have been conducted globally. The technology has applications from hydrocarbon exploration, appraisal, and 4D reservoir monitoring, to high-resolution mapping of the shallow subsurface for windfarm development.*

P-Cable: Ultra-high-resolution 3D Seismic Site Surveys for Offshore Windfarms

Example Acquisition Configuration (1)



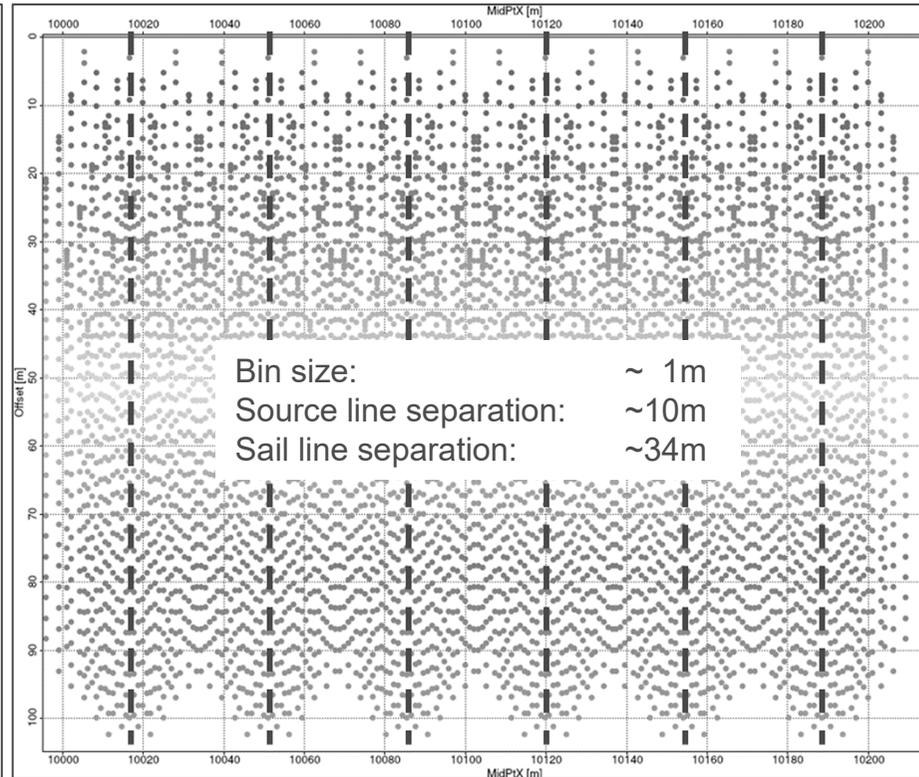
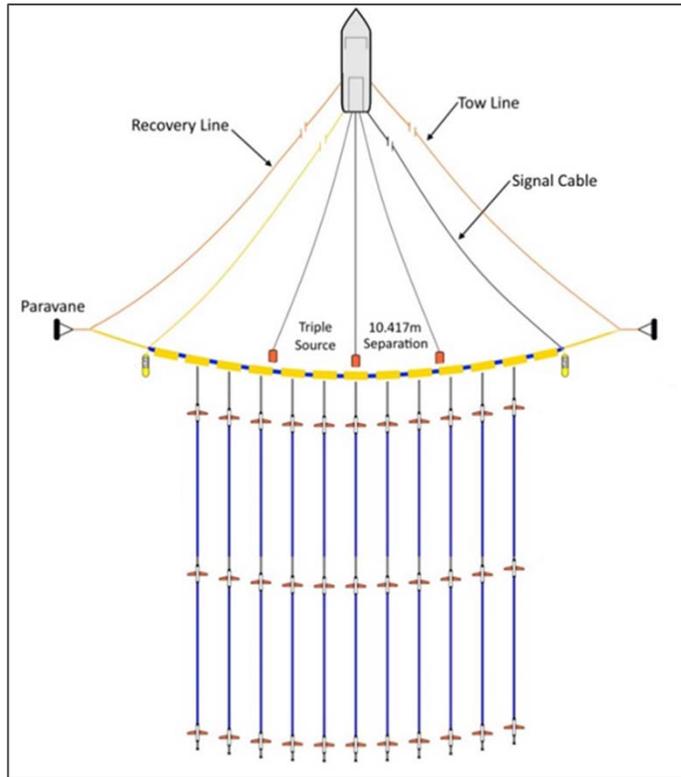
Applied Acoustics S-Boom

- Triple-plate boomer
- 1000J/s discharge rate
- 3 pulses per second
- Typical bandwidth
 - 300Hz – 2kHz



P-Cable: Ultra-high-resolution 3D Seismic Site Surveys for Offshore Windfarms

Example Acquisition Configuration (2)



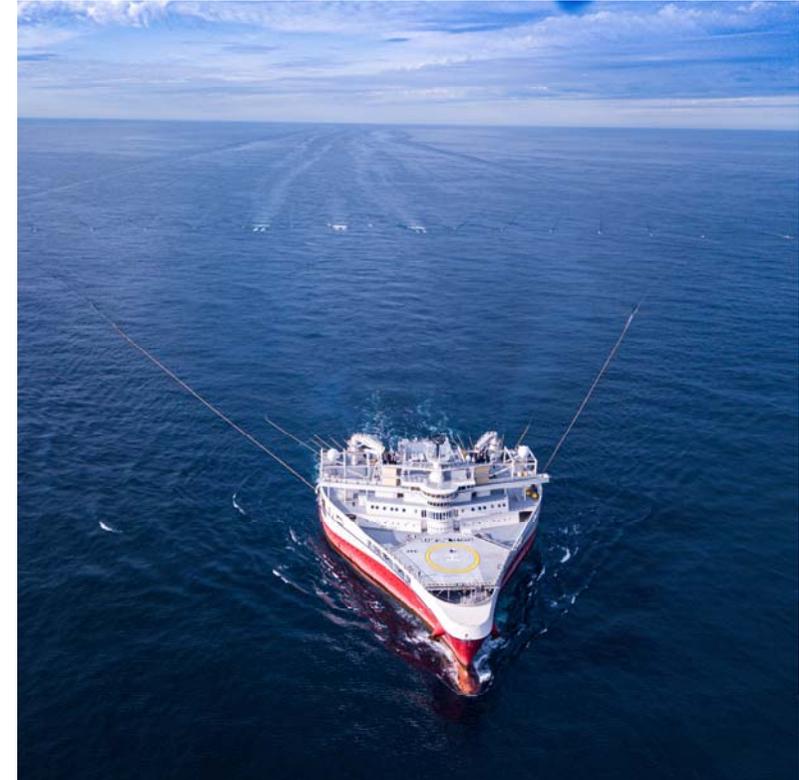
P-cable with 11 x 100m x 6.25m streamer spread and wide-tow triple source

Summary

Marine 3D Seismic Solutions for Evolving Energy Needs



- High-resolution and ultra-high-resolution 3D seismic surveys play a major role in the energy transition.
- The 3D survey design principles - that are well-established in hydrocarbon exploration and production seismic - can be applied to specialized 3D studies such as CCS site characterization, or offshore windfarm 3D site surveying.
- However, the typical scale of the acquisition technology systems can be very different.
- Several 3D seismic surveys for CCS and Offshore Wind have been acquired in recently. Several more are in planning.





Takk for oppmerksomheten!

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