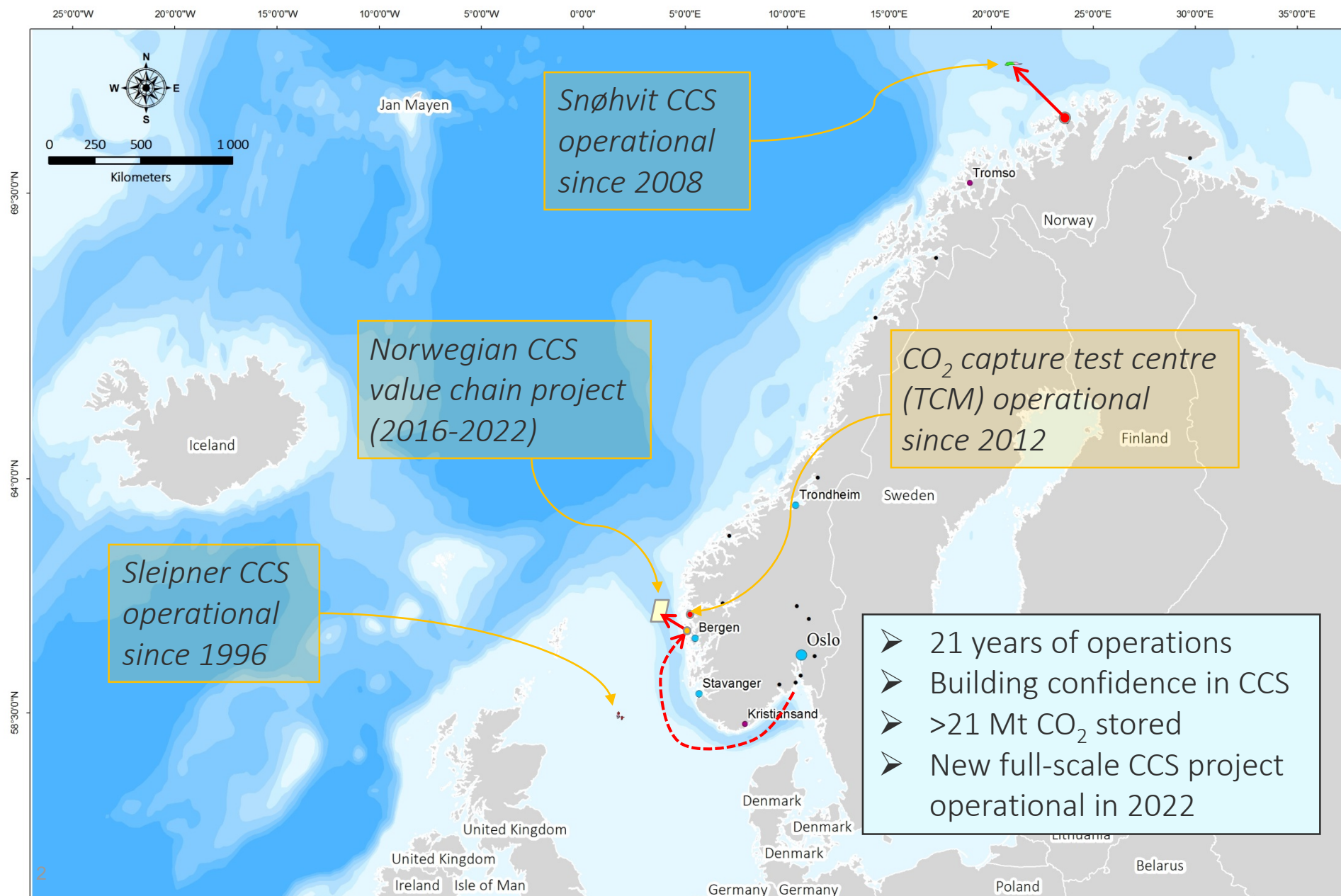


Geophysical monitoring offshore: past, present and future

3rd International Workshop on Offshore Geologic CO₂ Storage
3-4 May 2018, Oslo, Norway

Philip Ringrose
Statoil Research & Technology, Norway

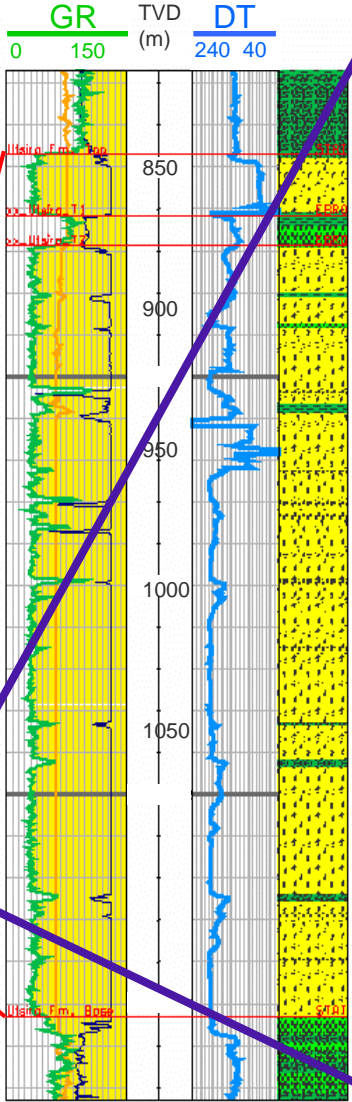
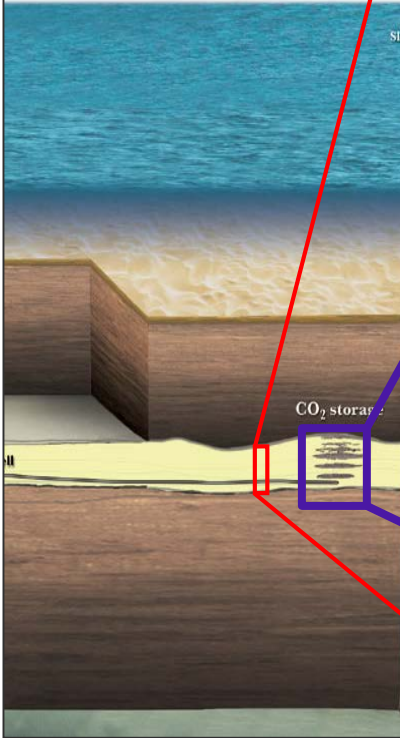
Norway CCS: Building on experience



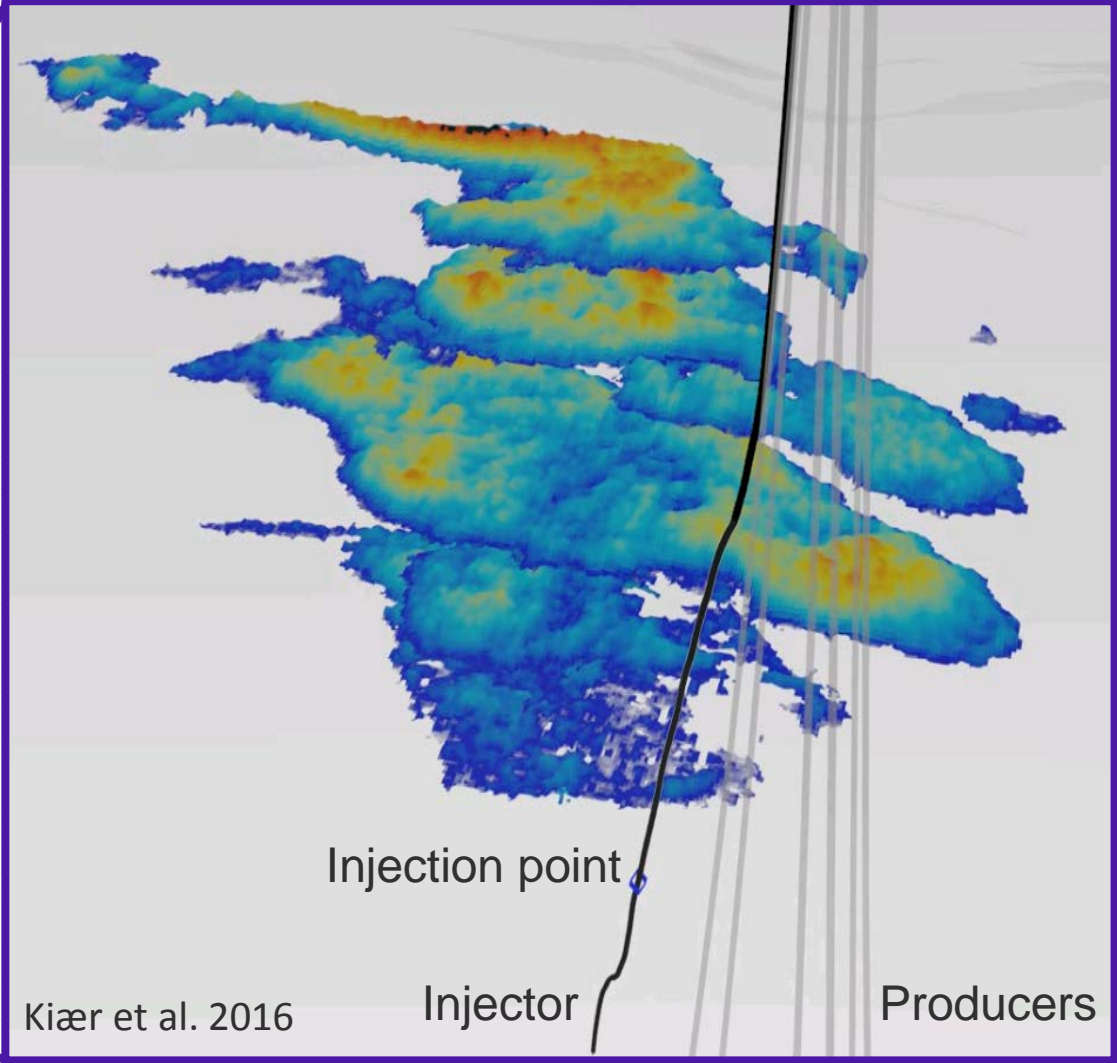
Sleipner Summary

Utsira Formation Summary

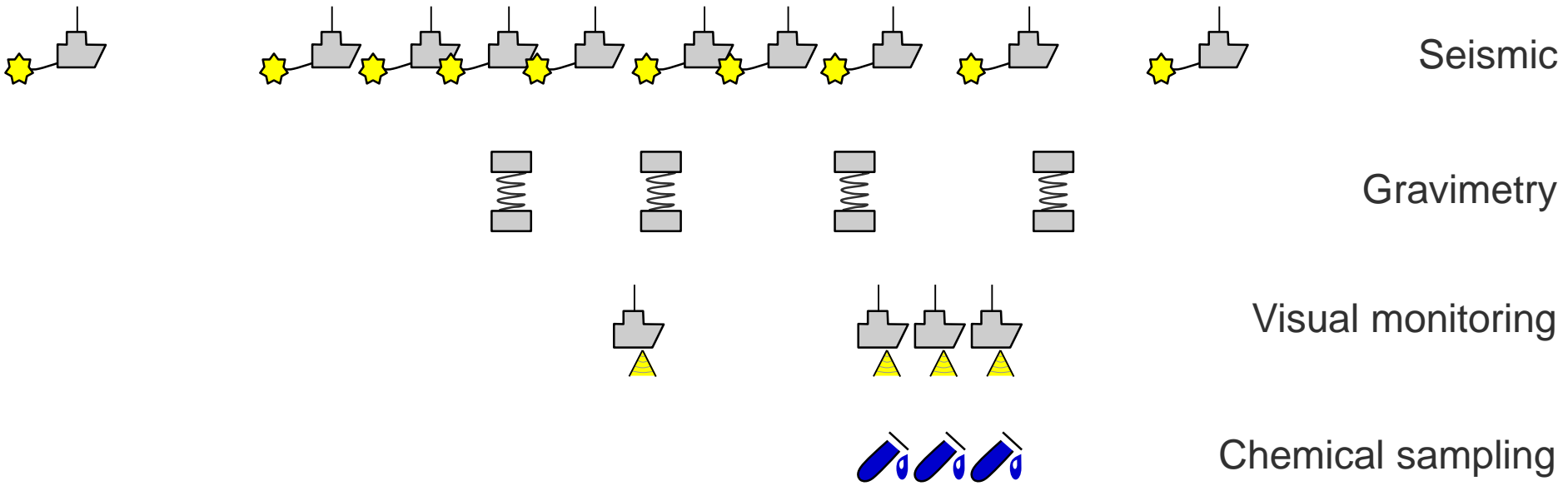
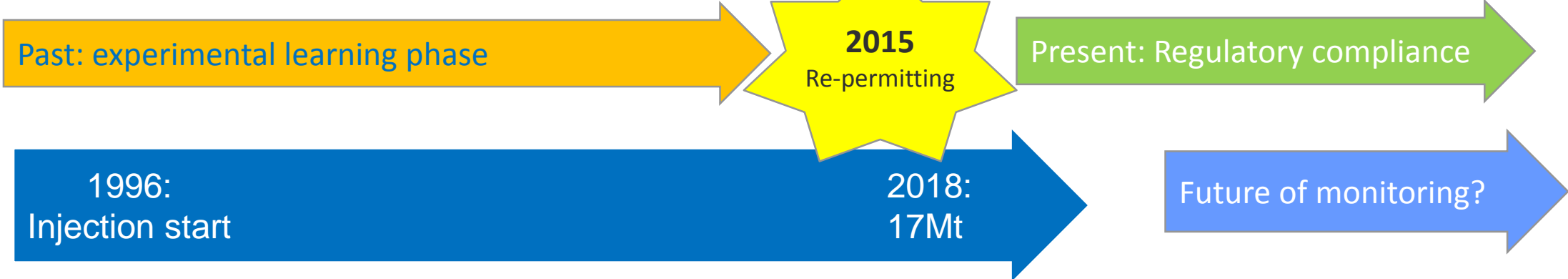
Net/gross: 0.98
 Porosity: 35-40 %
 Permeability > 1 D
 ~ 200 m thick



Insights from geophysical time-lapse monitoring



Sleipner monitoring programme overview



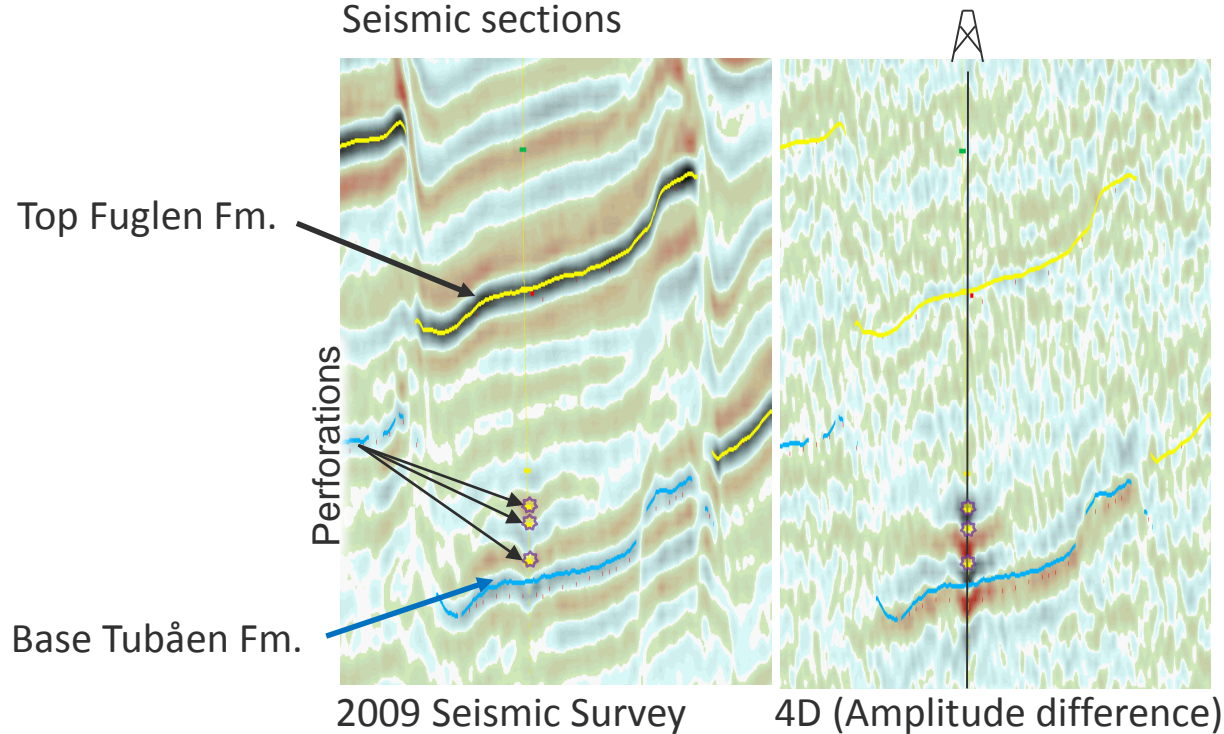
Snøhvit Monitoring Overview

- Continued and confirmed the value of 4D seismic monitoring
- Demonstrated value of downhole P/T gauges
- Developed operational value of monitoring

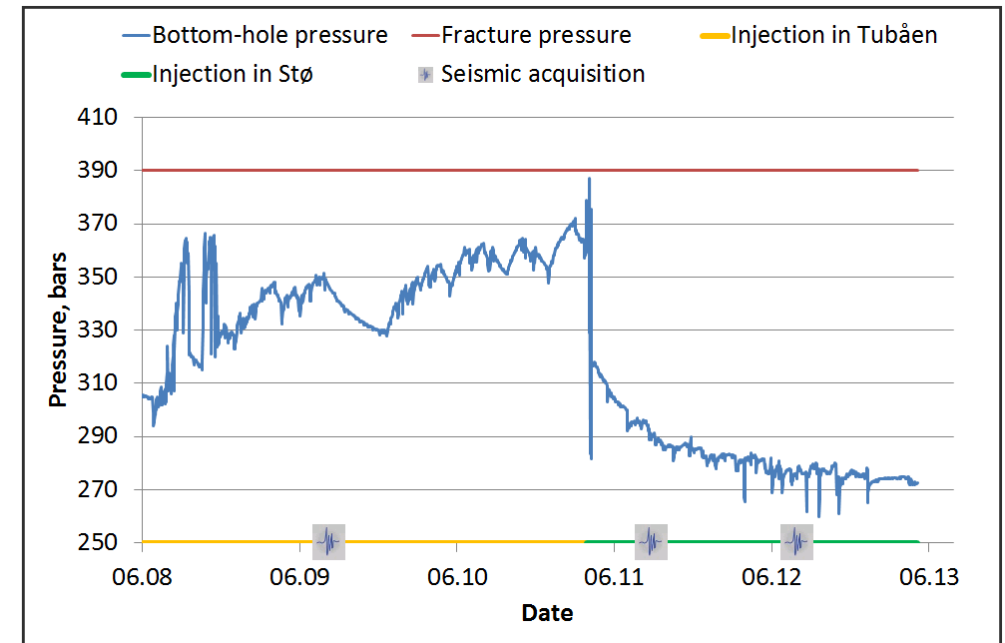
Value of monitoring:

- Reservoir management / operations
- Regulatory compliance

Seismic sections

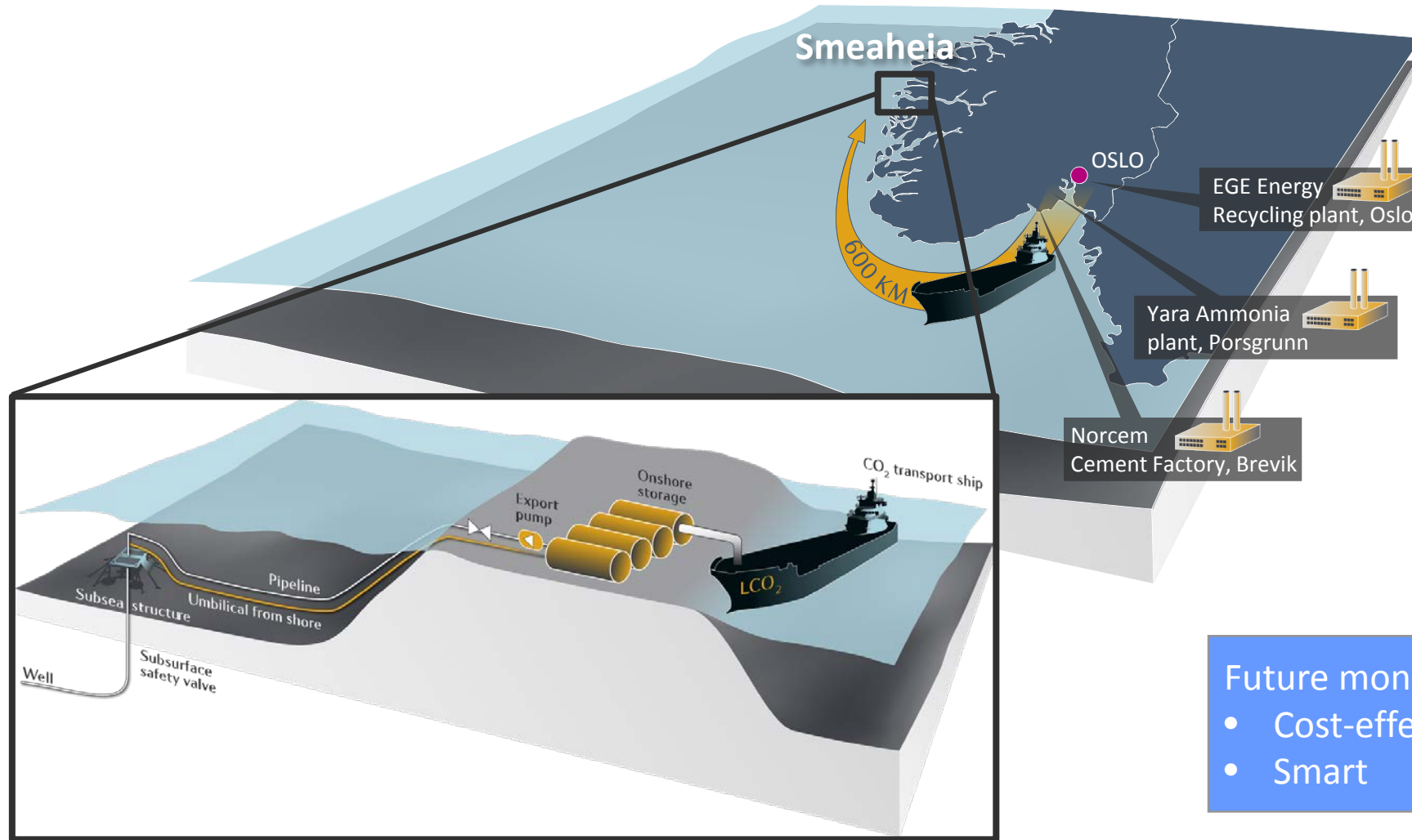


Down-hole pressure data



The Norwegian CCS Demonstration project

Smeaheia site



Future monitoring needs to be:

- Cost-effective
- Smart

What are the smart offshore monitoring solutions?

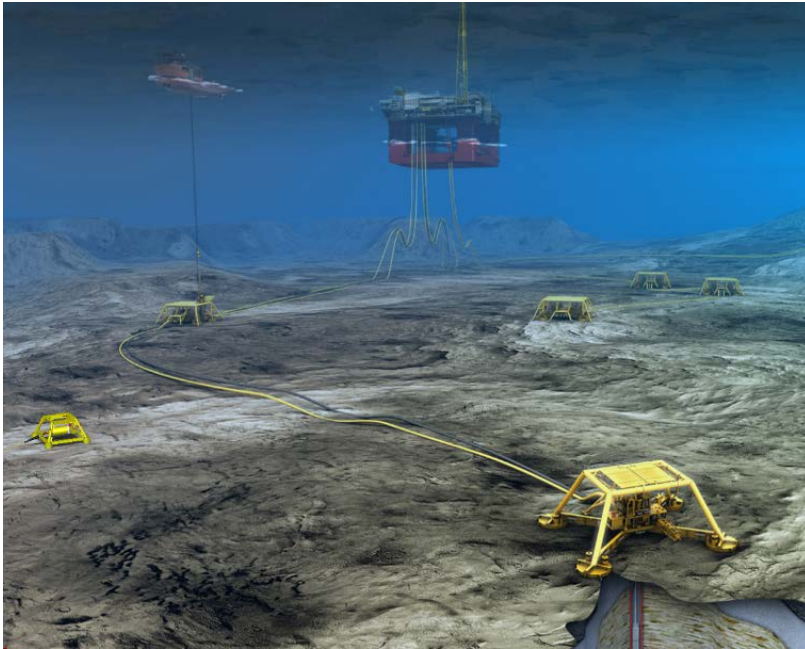
Developments in the offshore oil and gas sector include:

1. Increasing use of permanent reservoir monitoring (PRM) systems
2. Increasing use of downhole fibre monitoring
3. Use of advanced AUVs for environmental monitoring,
4. Use of advanced and integrated data analysis (digital world)

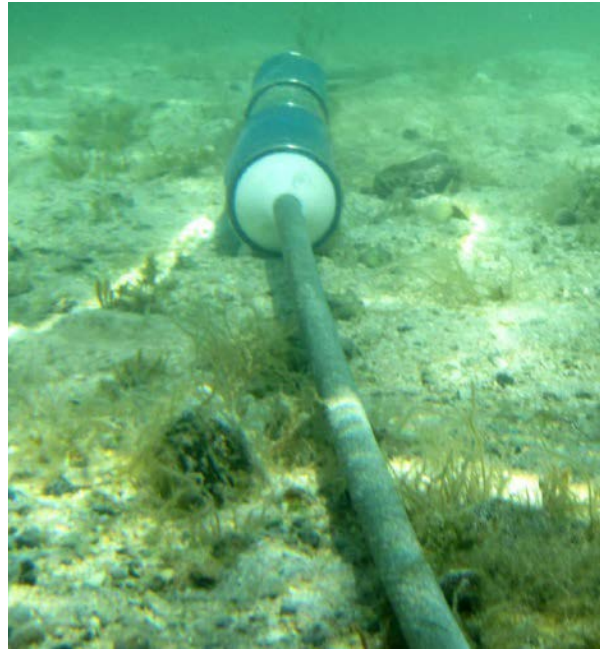
Challenges for CO₂ storage monitoring:

- Is it fit for purpose?
- Is it affordable?

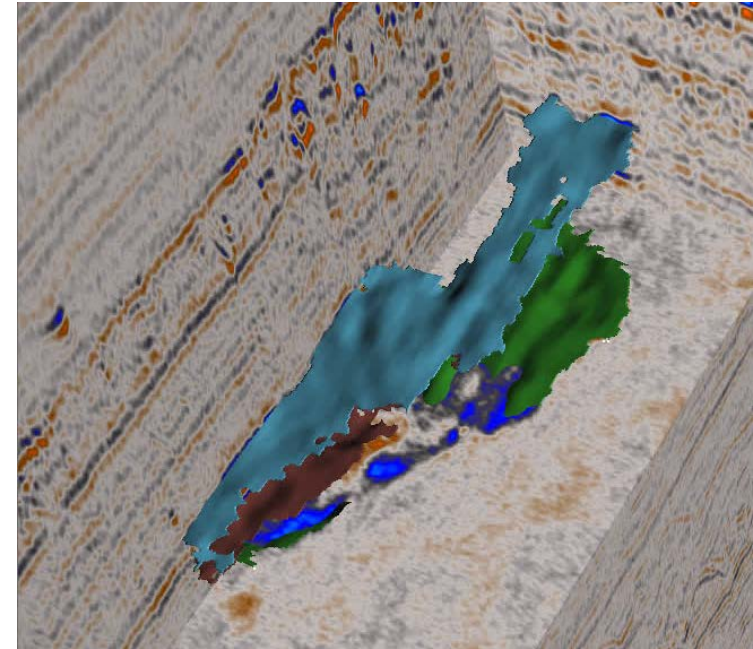
Subsea solutions



Permanent sensors



Advanced data analysis



Learning from onshore test sites

CaMI Field Research Station (FRS) in Alberta, Canada:

- Unique opportunity to develop and test monitoring technologies and integrated monitoring systems.
- Useful to build experience that could be taken offshore



blue = helical DAS fibre
black = straight DAS fibre
yellow = ERT cables

Images courtesy of Don Lawton, U. Calgary

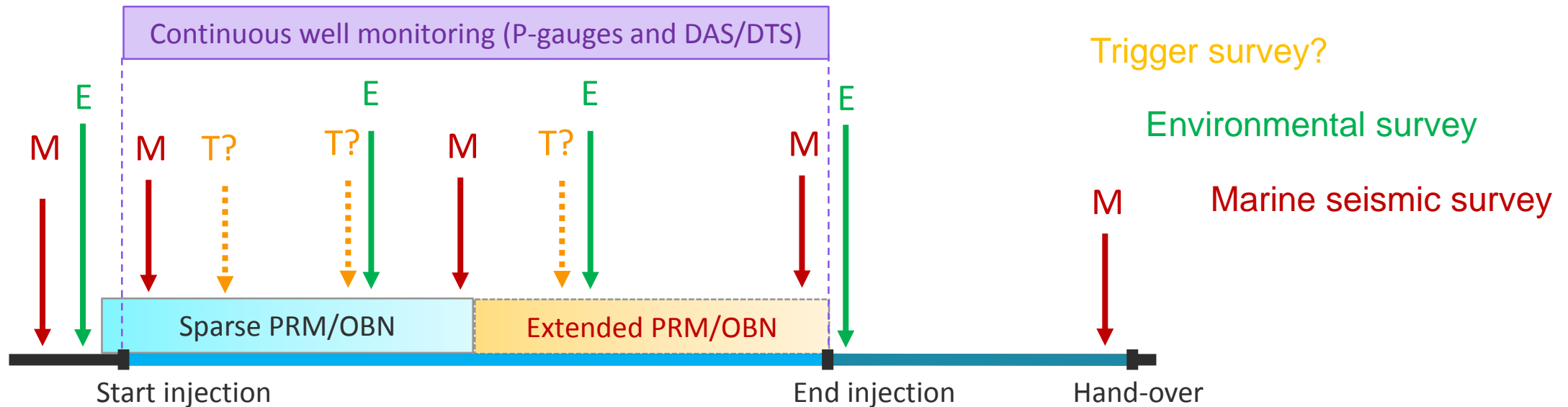


Working ideas for future offshore monitoring

1. Marine-streamer seismic acquisition – good baseline, fewer repeats
2. More use of downhole fibre-based monitoring - DTS/DAS
3. Development of trigger survey concepts – survey only if anomaly is detected
4. Environmental monitoring programme – using smart AUV based sensors
5. Advanced data analysis – Integrate multi-physics data, continuous/real-time

Challenges:

- Cost model (PRM needs upfront investment)
- Fibre-optic deployment in subsea injectors
- Handling multiple monitoring objectives



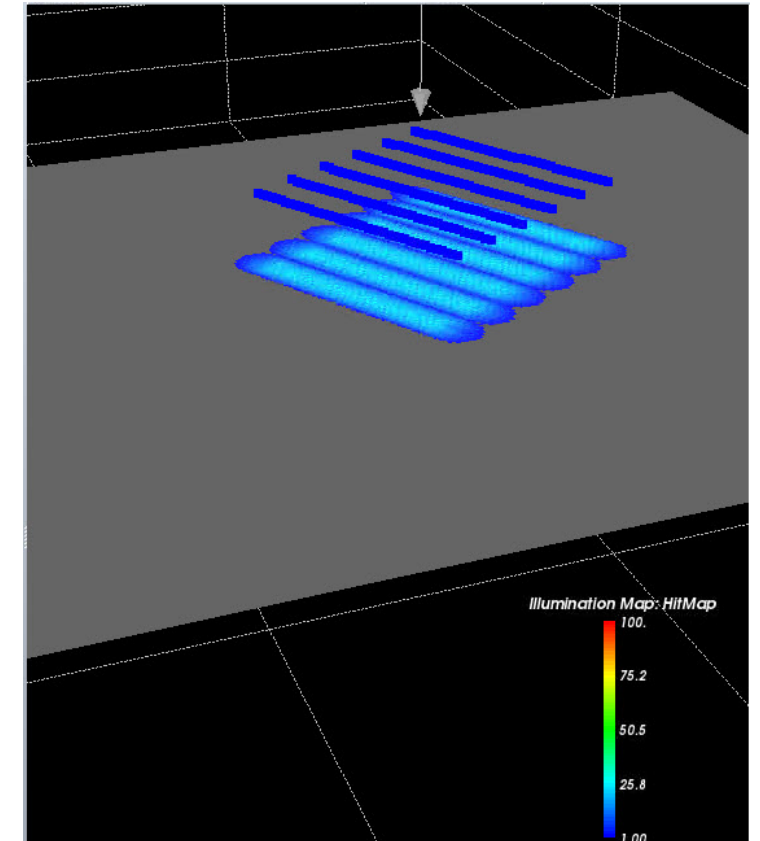
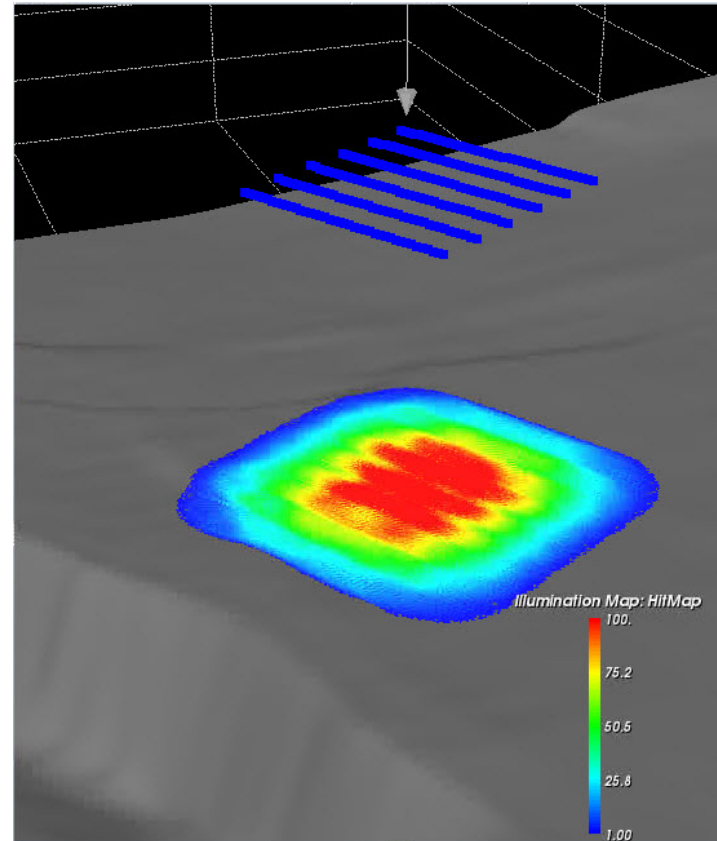
Value of permanent reservoir monitoring systems

PRM for CO₂ storage has several potential benefits:

- Continuous monitoring data
- More frequent repeat surveys
- Improved imaging of reservoir and overburden
- Passive listening (seismicity)
- Use of ambient noise methods
- Combining down-hole sensing with surface seismic
- Monitor geomechanics and plume
- Enables advanced processing (FWI, SWI, microseismic)

But it costs more ...

... so can we trim the costs and demonstrate the value?

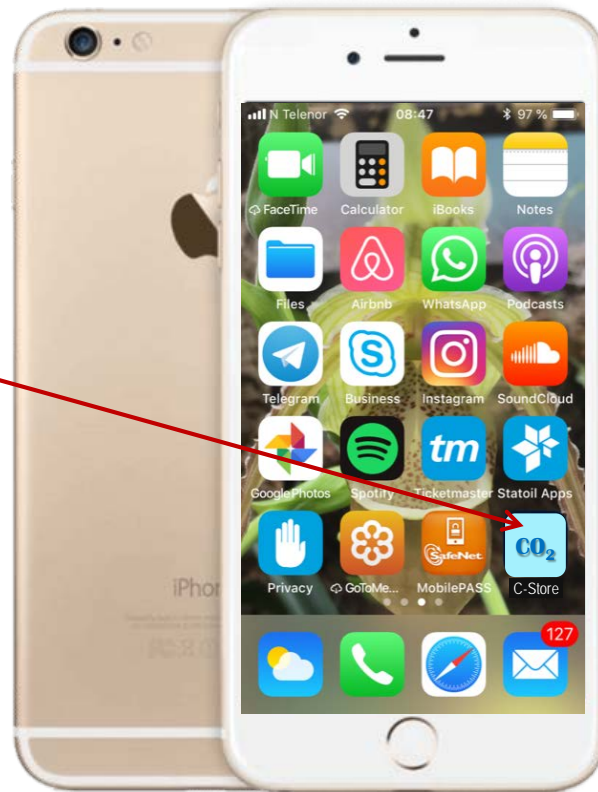


PRM study: Illumination hitmap at Top Sognefjord reservoir and at shallow overburden level (seabed plus 200m) from 2km x 2km seabed array (Roger Bakke, Statoil).

Conclusion

- How can we make monitoring smart and affordable?
- Will CO₂ storage move into the digital age?

My Smart-phone
With CO₂ app(?)



<http://www.france.no/no/norge-oslo/data-circulation-and-the-common-good/>

The Future of Augmented Reality (Infographic)

This innovative technology is disrupting nearly every industry.



Image credit: Westend61 | Getty Images



Rose Leadem



<https://www.entrepreneur.com/article/312271>

April 22 2 min read

References

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