

Stepping- and Mile-stones of Monitoring at Tomakomai

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Monitoring Techniques at Tomakomai

current



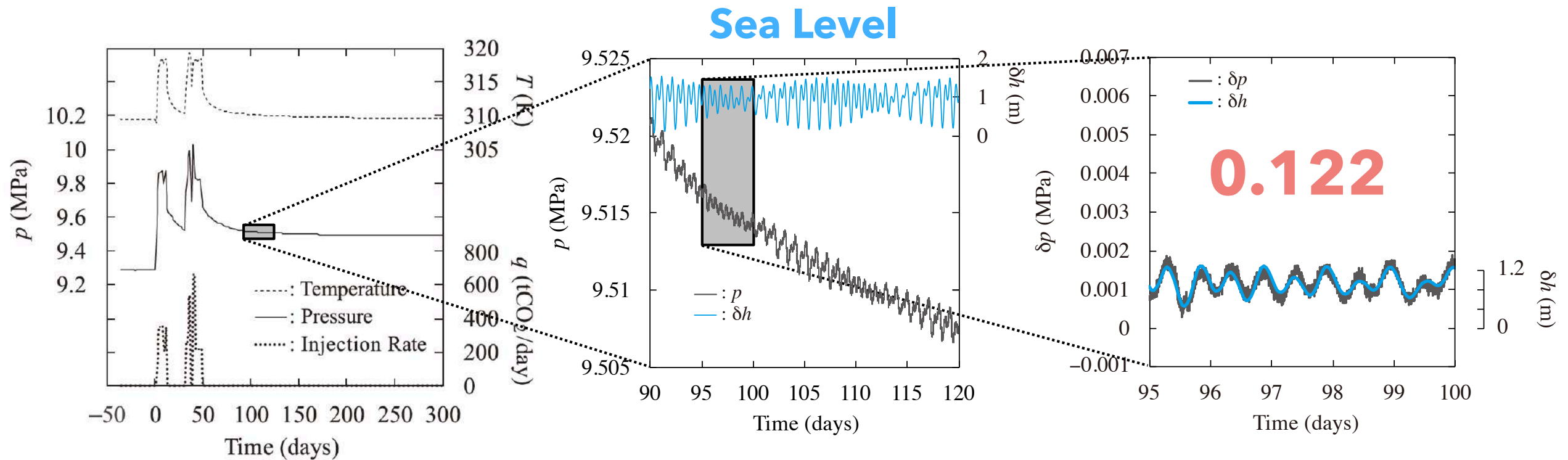
long-term

Monitoring Purpose	Injection Controls	Containment Assurance	Conformance Assurance	Environmental Impacts
Downhole Pres./Temp.	A	O	A	
2D/3D Seismic		A	A	
OBC/OBS	O			A
Surrounding Seismometry	O			A
Water Column Chemistry				A

Deep
 Shallow

A Appropriate
O Occasional

Tidal Signals in Pressure Transients

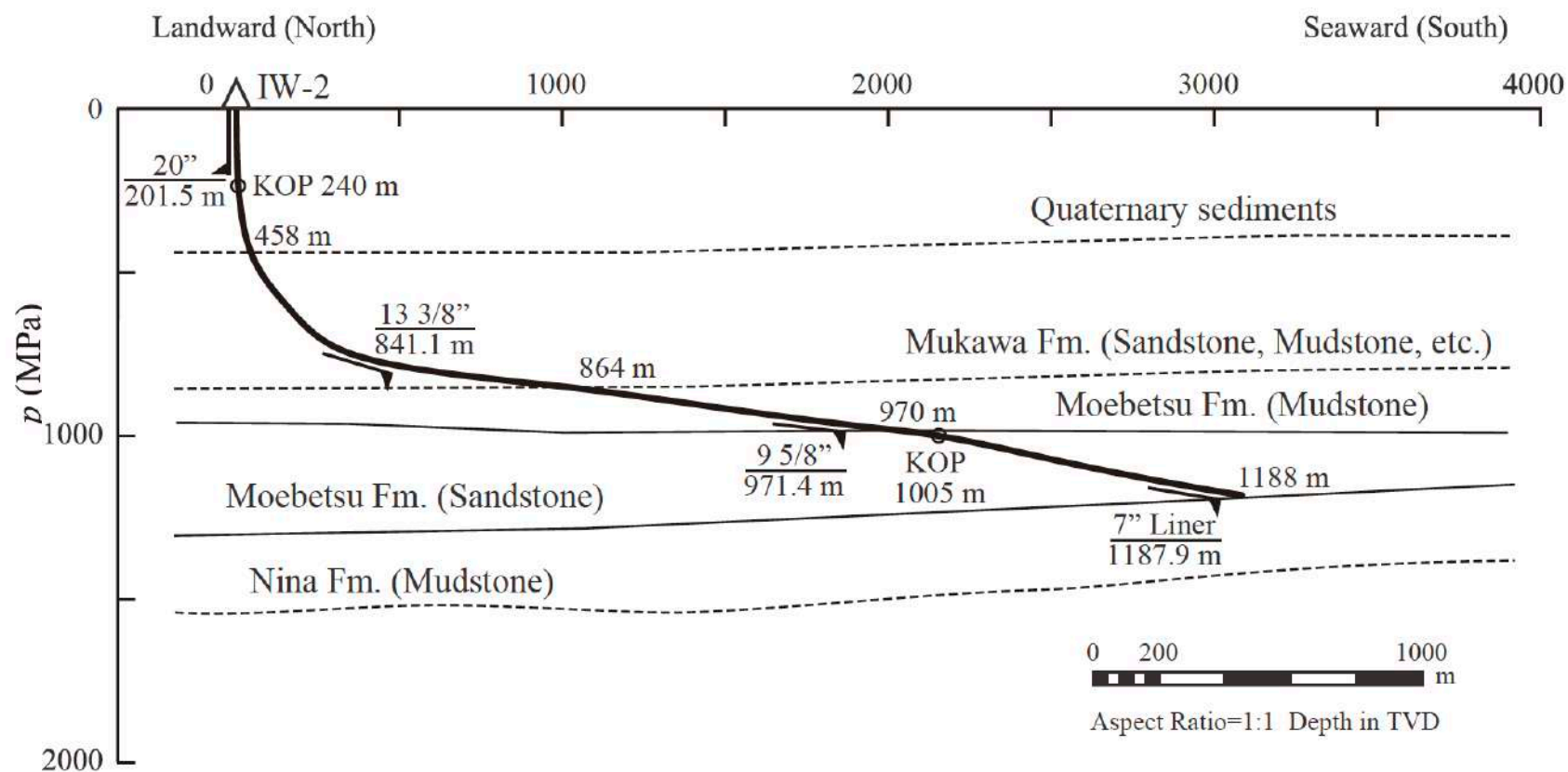


Resolution: 0.00005% FS

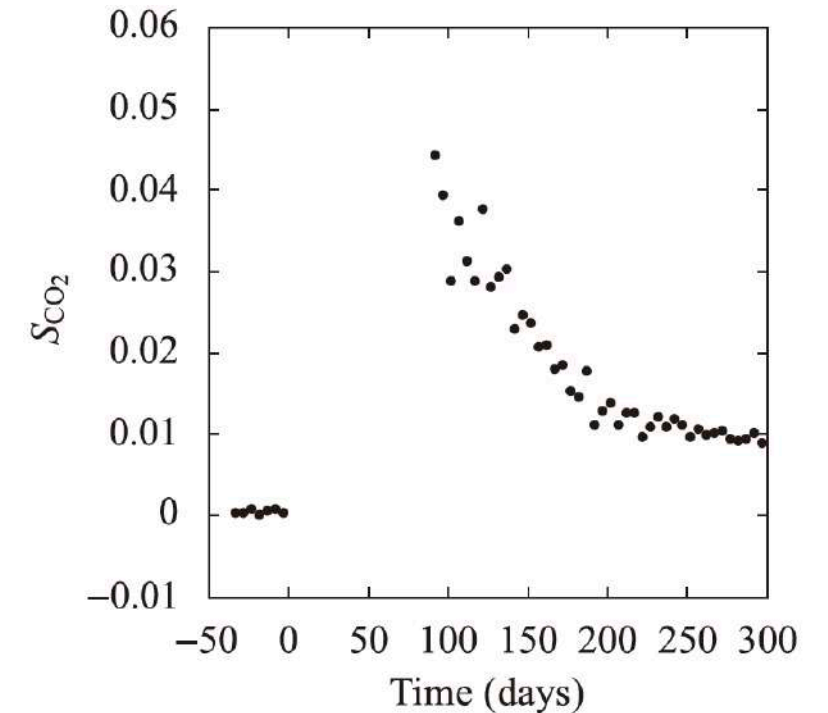
0.00001 MPa (0.00145 psi)

$$R = \frac{1}{\rho_w g} \frac{\delta p}{\delta h}$$

CO₂ Saturation for Conformance Assurance



$$R = f(S_{CO_2}, c_w, c_{CO_2}, c_{pp})$$



**Saturation Evaluation
without Well Intervention**

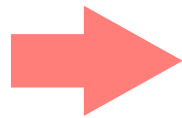
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OBC/OBS	O	Baseline Defensive		A
Surrounding Seismometry	O			A
Water Column Chemistry				A

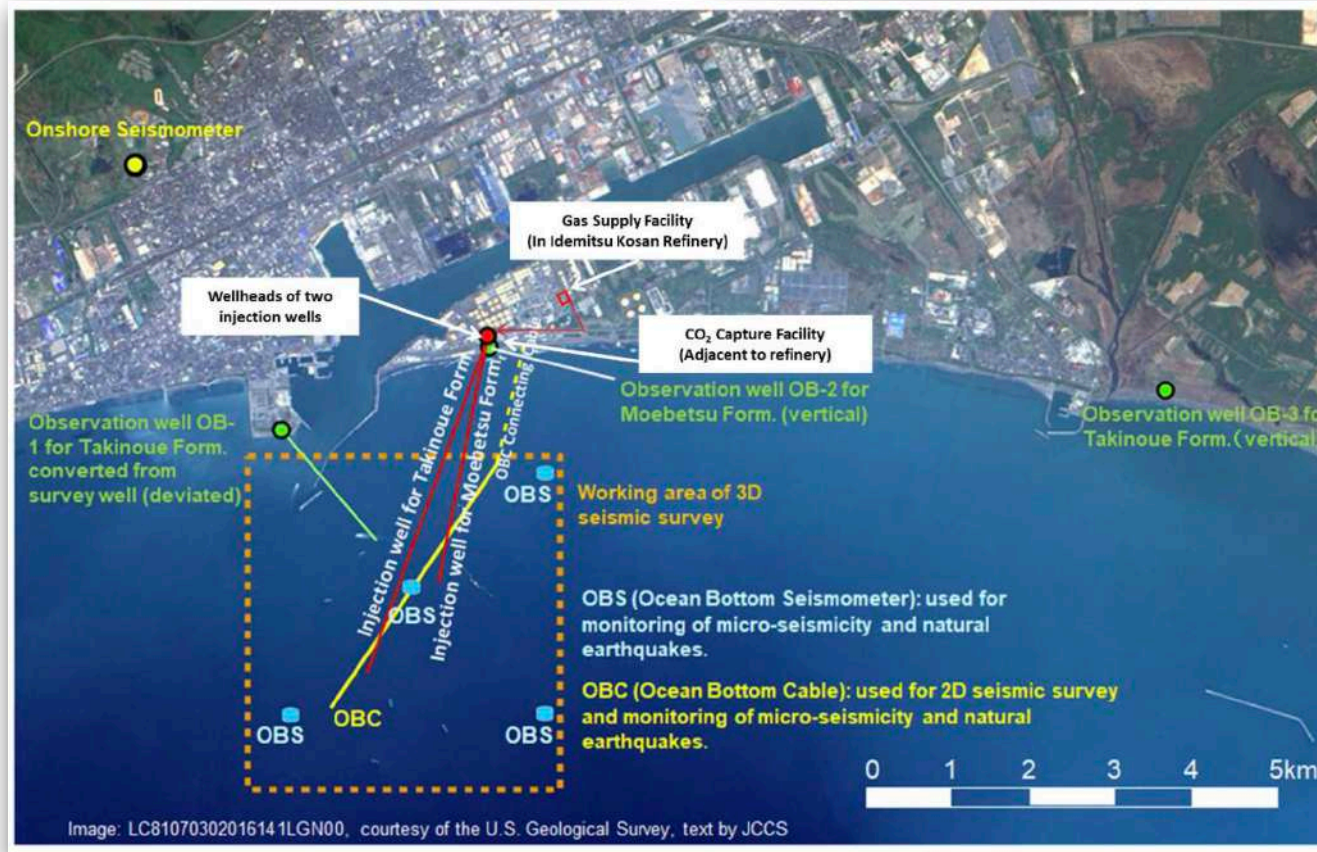


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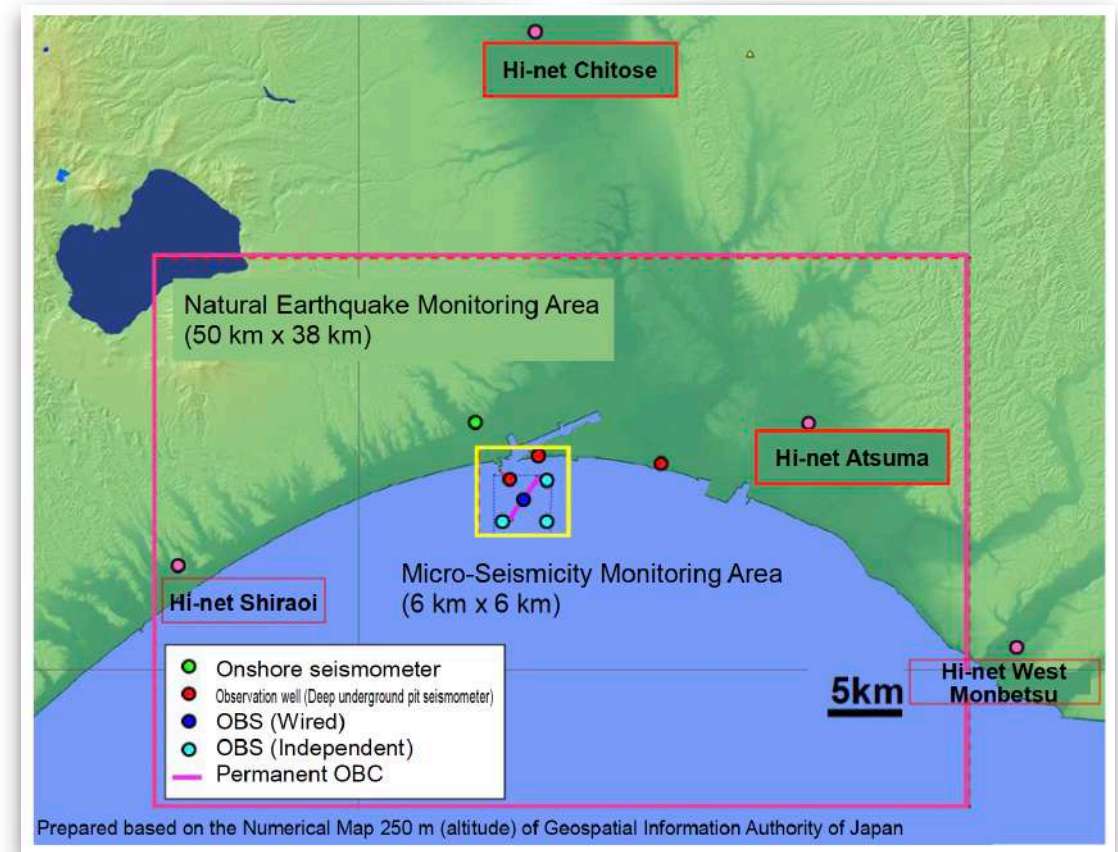
Comprehensive Monitoring of Seismic Activity

OBC (3.6 km)



4 OBS

Surface S. + 4 Hi-net

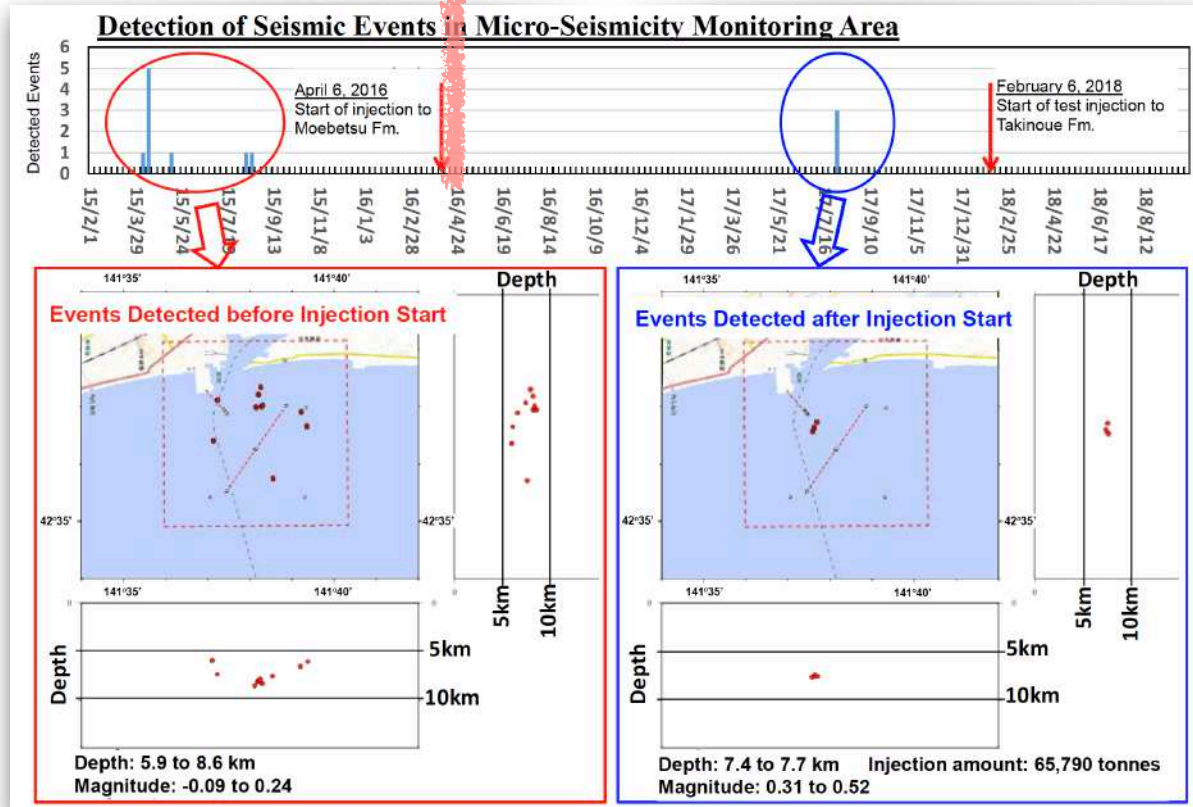


3 Monitoring Wells

(JCCS: Summary Report on Tomakomai CCS Demonstration Project, 2020)

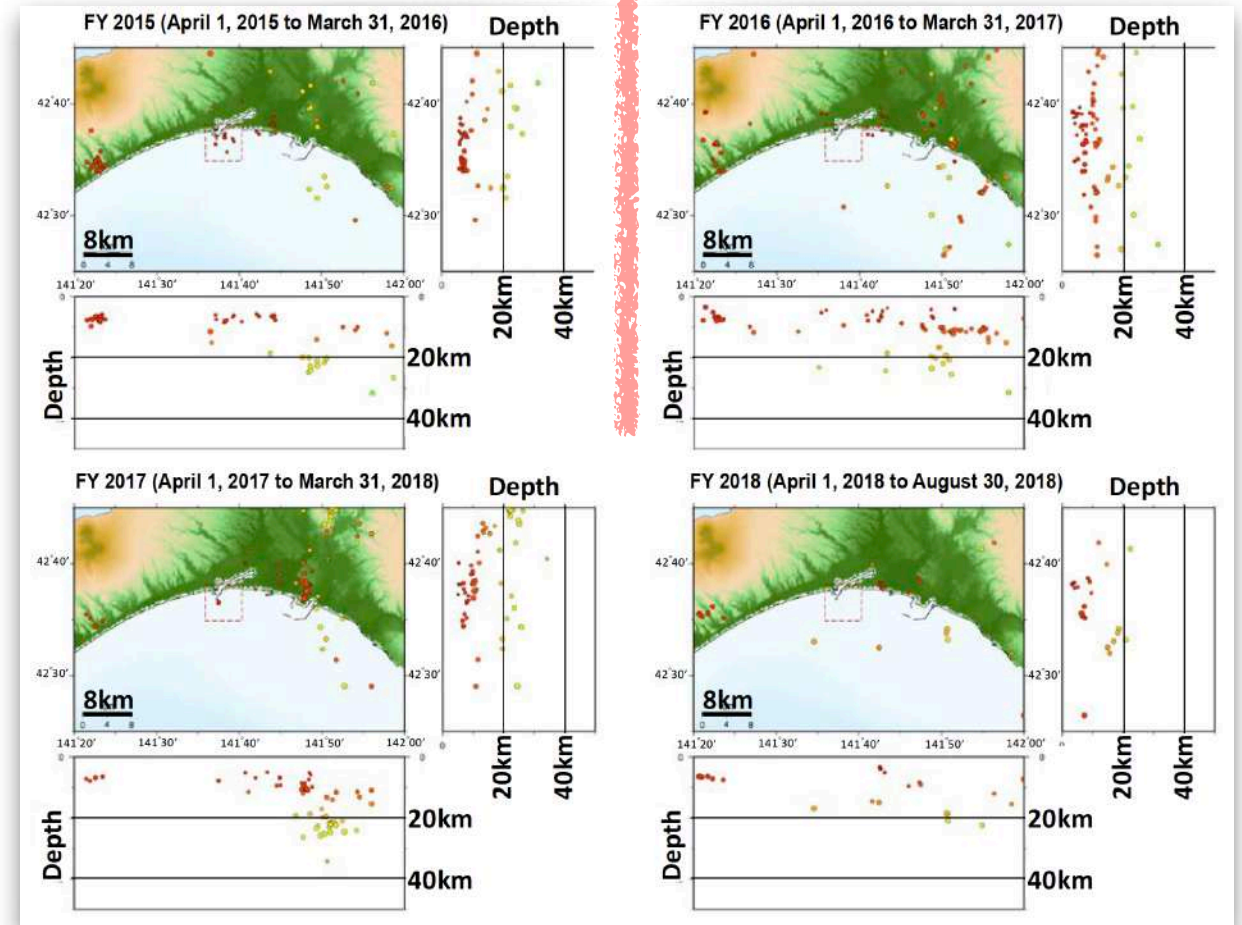
Accumulation of "Defensive" Baselines

9 vs. 3 events



> 6 km

< M 0.52

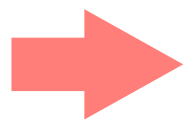


(JCCS: Summary Report on Tomakomai CCS Demonstration Project, 2020)

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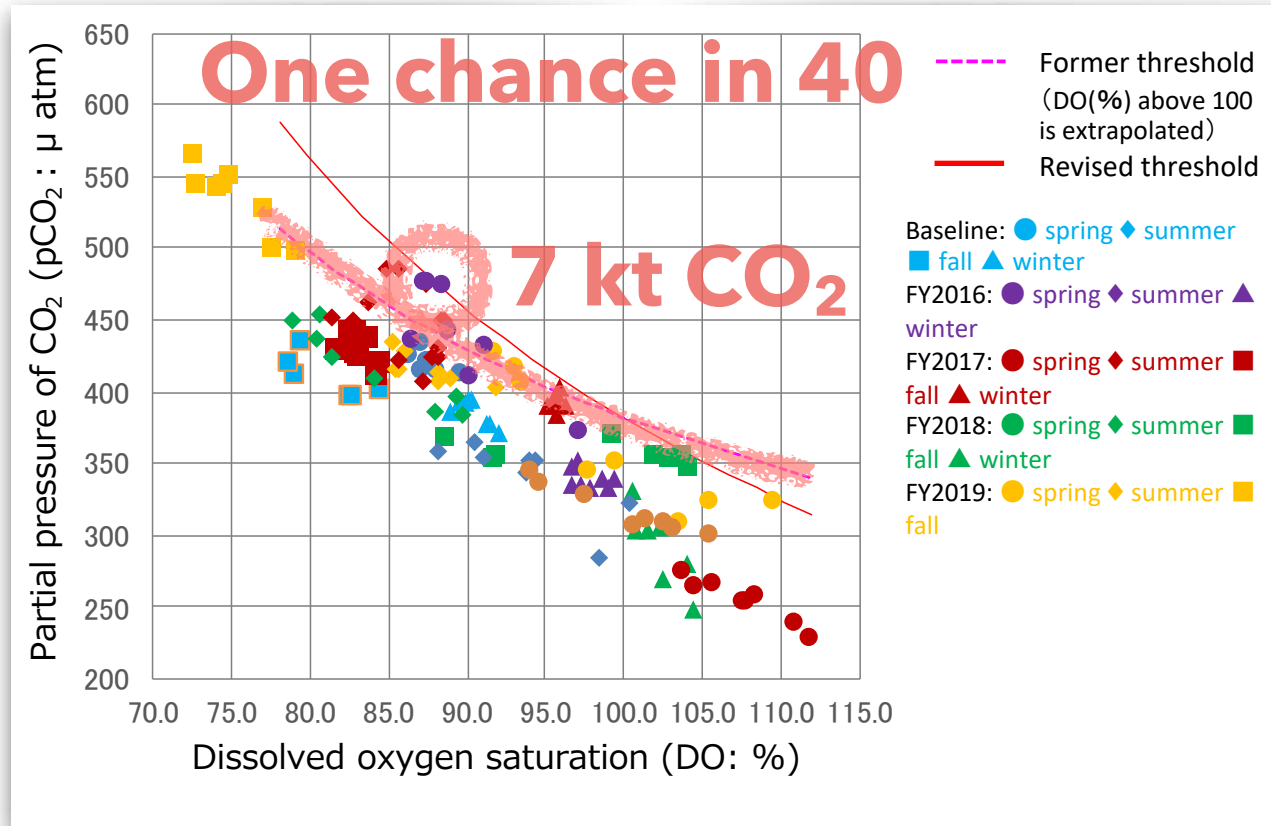
Baseline Defensive

 Deep
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Shallow Survey for Containment Assurance?

95% Confidence Interval



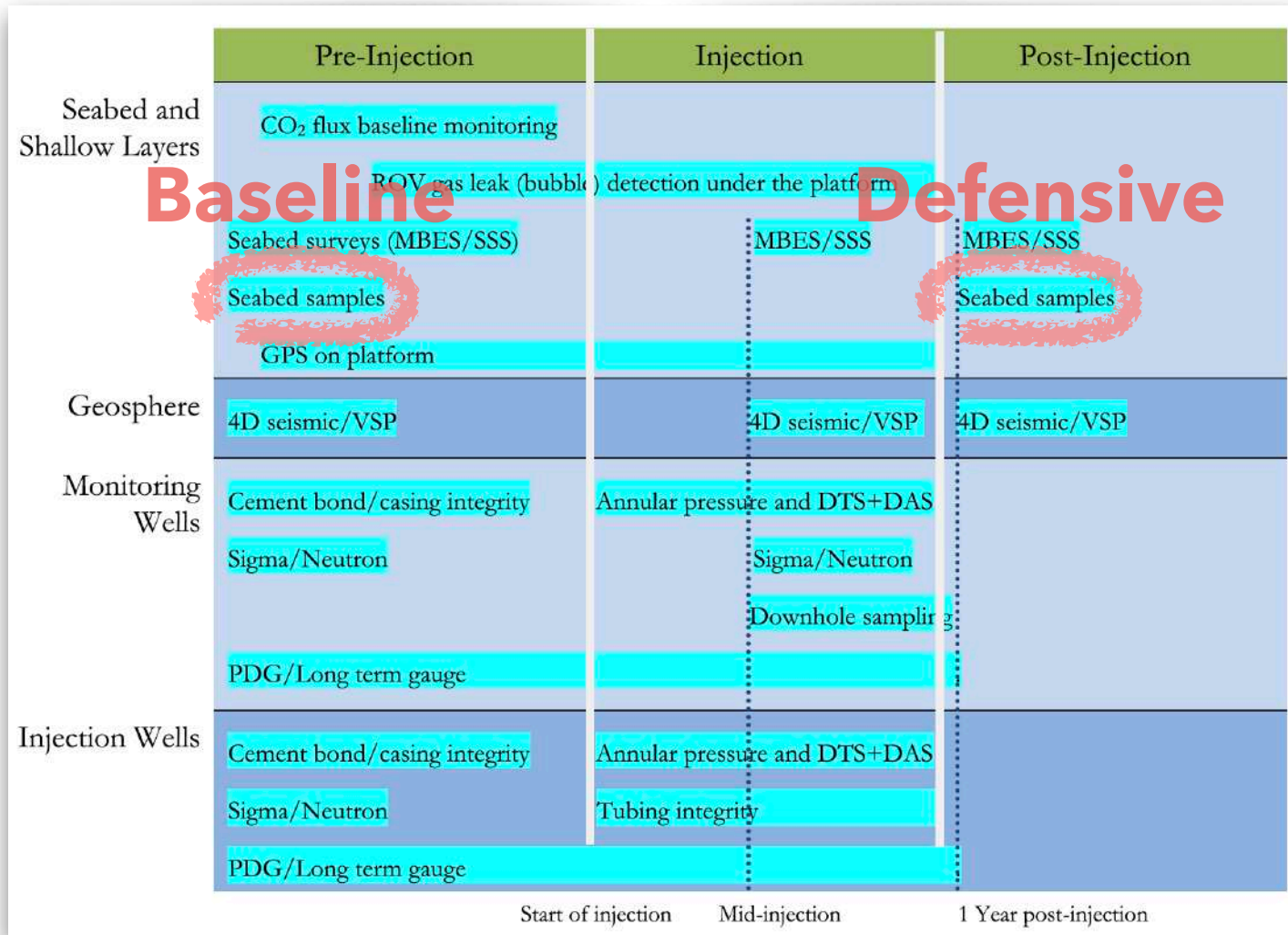
(JCCS: Summary Report on Tomakomai CCS Demonstration Project, 2020)

Project Suspension (6 months) due to False Positive

Shallow properties "are all part of open systems that are perturbed by many more things than containment failure."

M&V Reviewed and Revised: Quest to Peterhead

M&V plan reviewed every 3 years



(Dean and Tucker: IJGGC 61, 2017)

“Measurements intended to detect unlikely hazards were dropped or relegated to backup status.”

“... shallow monitoring should focus mainly on assuring against environmental impacts.”

(Jenkins et al.: IJGGC 40, 2015)

(Jenkins: IJGGC 100, 2020)

Concluding Remarks (1)

- Investigative Data Acquisition
 - ▶ Invariably measured pressure (with high resolution) was successfully used for estimating CO₂ saturation changes through tidal-signal analyses.
 - ▶ Comprehensive monitoring of seismicity provides sufficient evidence to dismiss the causal relationship between the Tomakomai CCS and the 2018 Hokkaido Eastern Iburi earthquake.

Concluding Remarks (2)

- Overuse of Shallow Monitoring
 - ▶ Loose correlation between pCO₂ and DO resulted in false positive and eventually hindered the operation.
 - ▶ A well-defined issue “containment” needs to be distinguished from vague concerns “environmental impact.”

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