CCS Technical Workshop 2010

CO2挙動モニタリング技術

海域における
CO2挙動観測・解析技術の挑戦
OBC（常設Ocean Bottom Cable方式）

Toward Offshore CCS Seismic Monitoring
－Development of Permanent OBC System－

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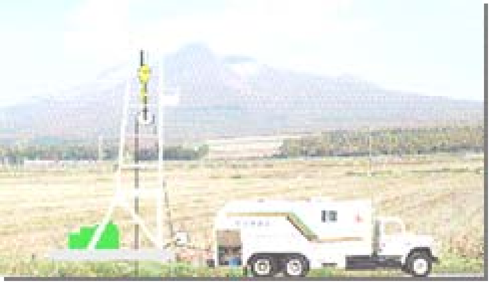
JGI, Inc

2010.12.9



JGI, Inc., Who?

A subsidiary of

Japan Petroleum Exploration Co., Ltd. (JAPEX)

Leading Japanese oil and natural gas E&P technologies

Group Companies

- JGI, Inc.(JGI) — G & G, Monitoring
- SK Engineering Co., Ltd. (SKE) — Drilling
- Geophysical Surveying Co., Ltd. (GSC) — Wireline Techs

With extent expertise and knowledge of E&P in Oil/Gas fields, JAPEX group will go ahead the development of technologies for CO2 Geological Sequestration, through G&G evaluation, drilling, well logging, reservoir engineering, monitoring and comprehensive coordination.

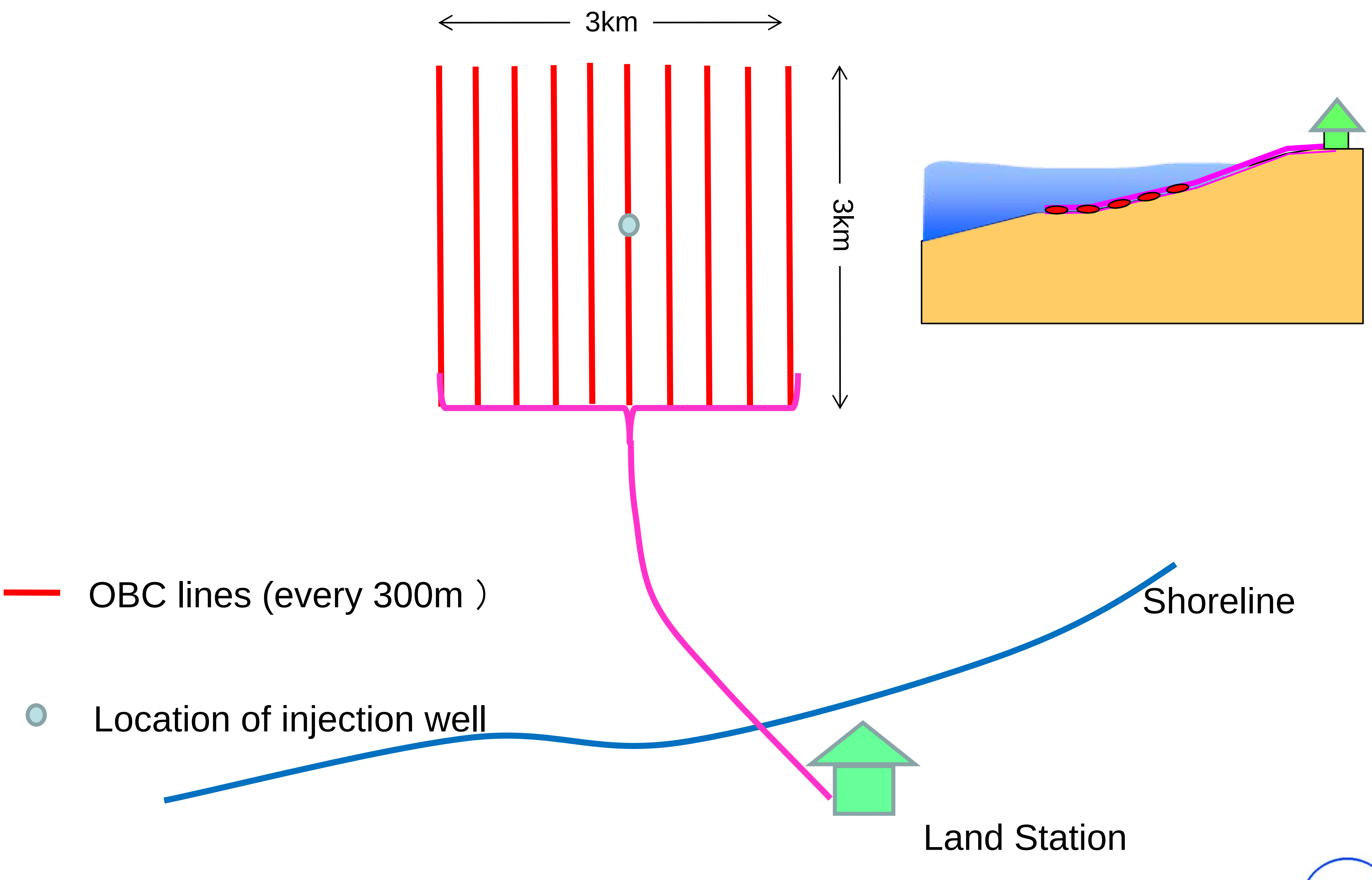
Necessity of Permanent OBC for CCS in Japan

- More strict requirements for the CCS monitoring exist in Japan as the candidate aquifers for the CO2 injection are mainly located near highly populated areas along the coast.
- High-fidelity time-lapse 3D seismic survey is necessary for the monitoring of CO2 geological sequestration.
- Passive micro-seismic observation is mandatory when following the guideline from METI.

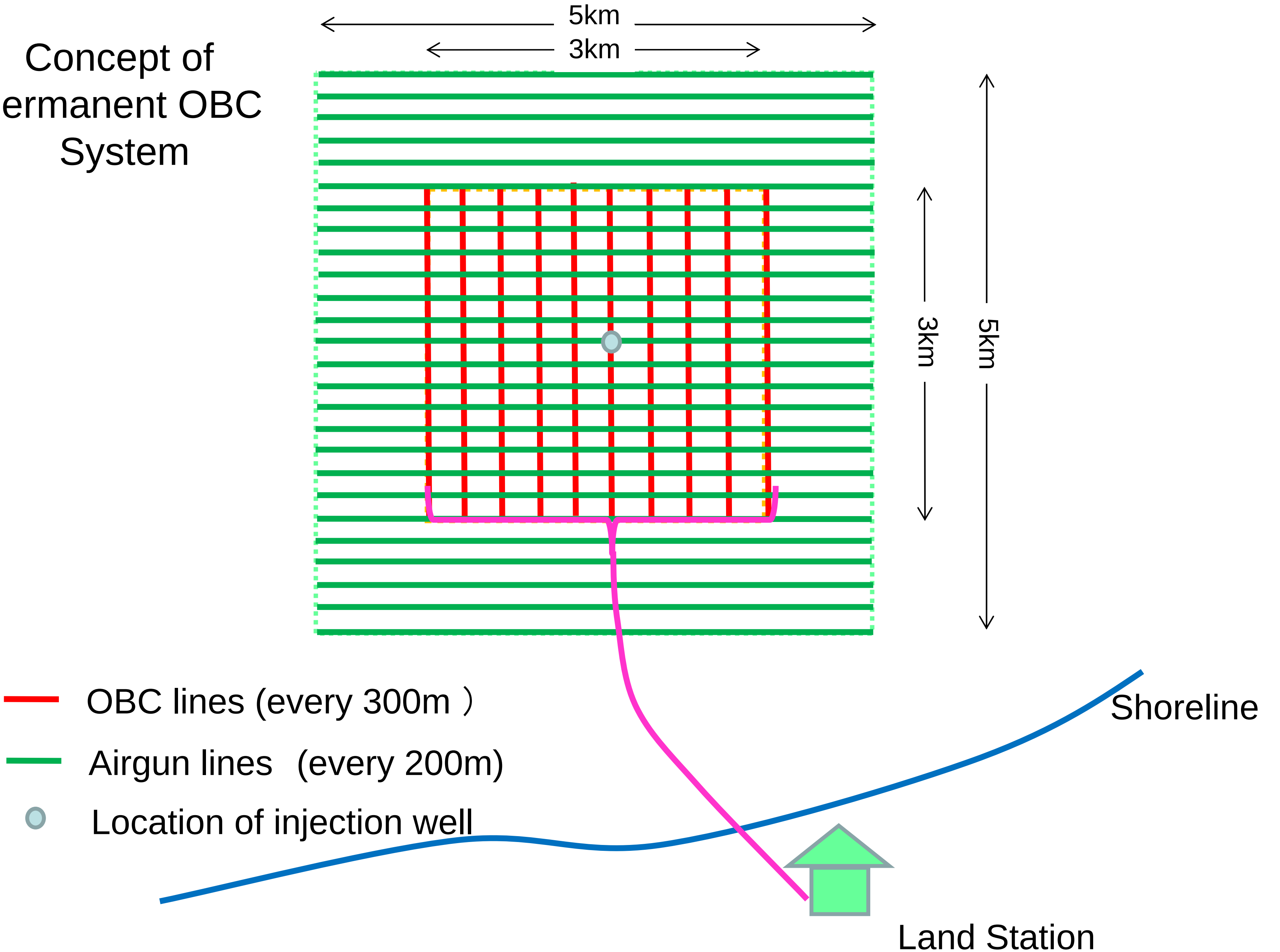
Advantages of Permanent OBC

- Removal of uncertainty of the sensor positions
- Consistent receiver response for the different surveys
- Prompt and economical operations of the time-lapse surveys
- Passive observation of micro-earthquakes

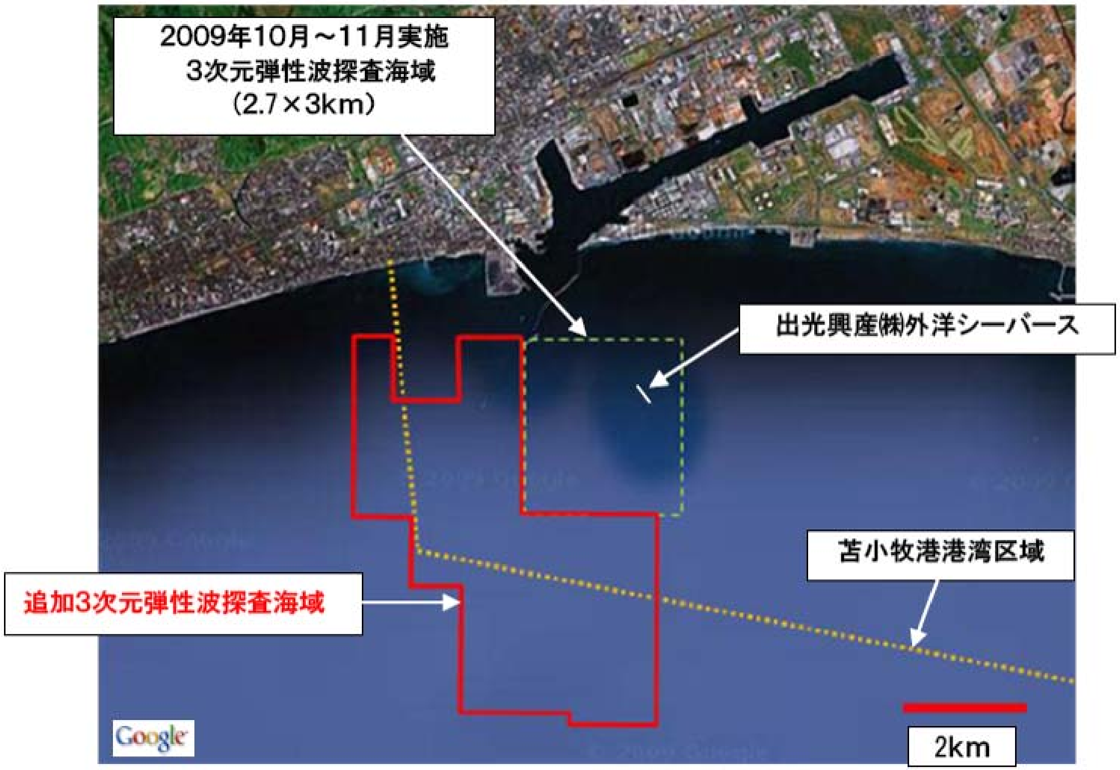
Concept of Permanent OBC System



Concept of Permanent OBC System



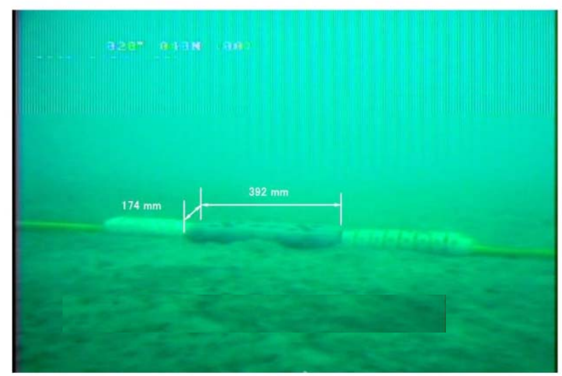
3D Seismic Survey (Shallow Marine) by Japan CCS Co., Ltd.



【調査位置図】

From JCCS Website

OBC cable deployment (by JGI)

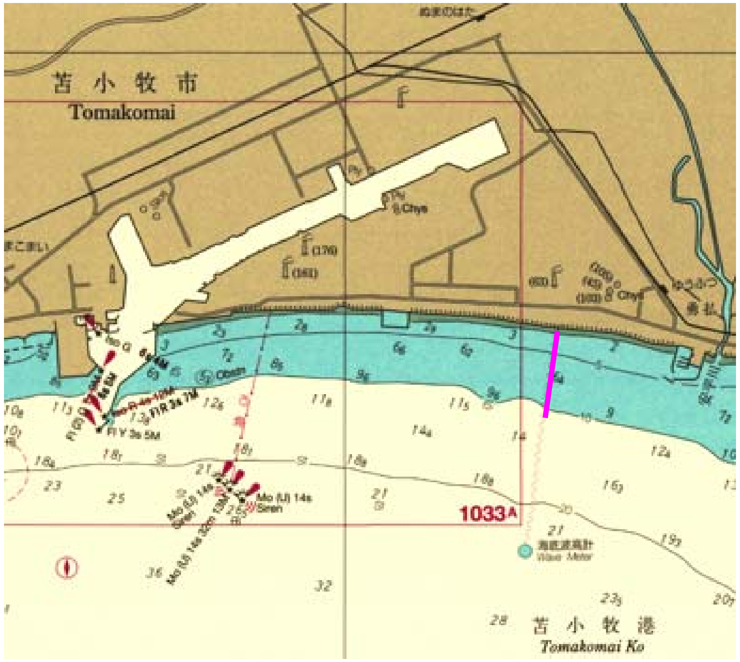


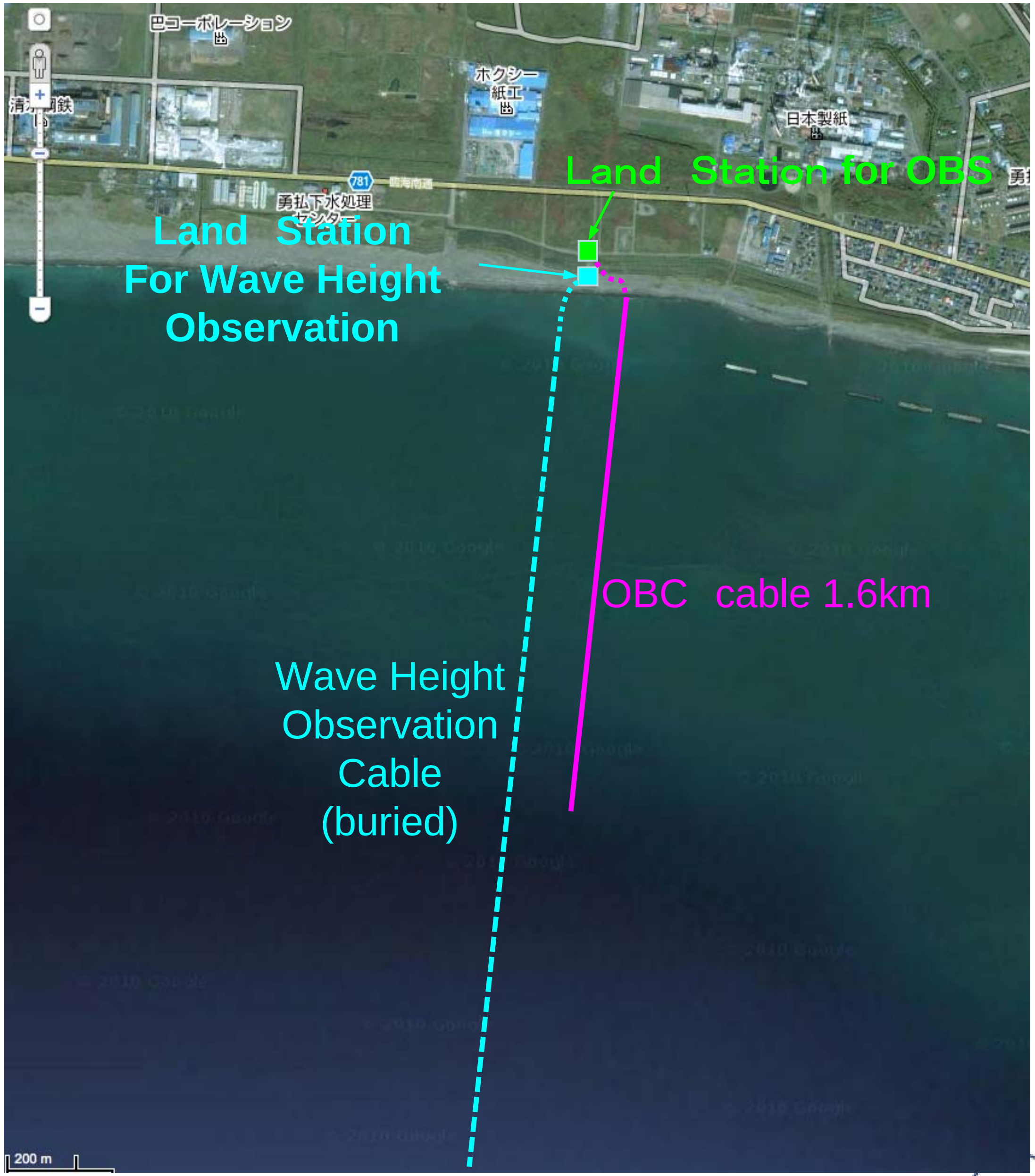
Sensor at the sea bottom

3D seismic surveys using temporal deployment of OBC have already been done in Japan.

Data Acquisition
using the permanent OBC system
in Tomakomai, JAPAN
by RITE

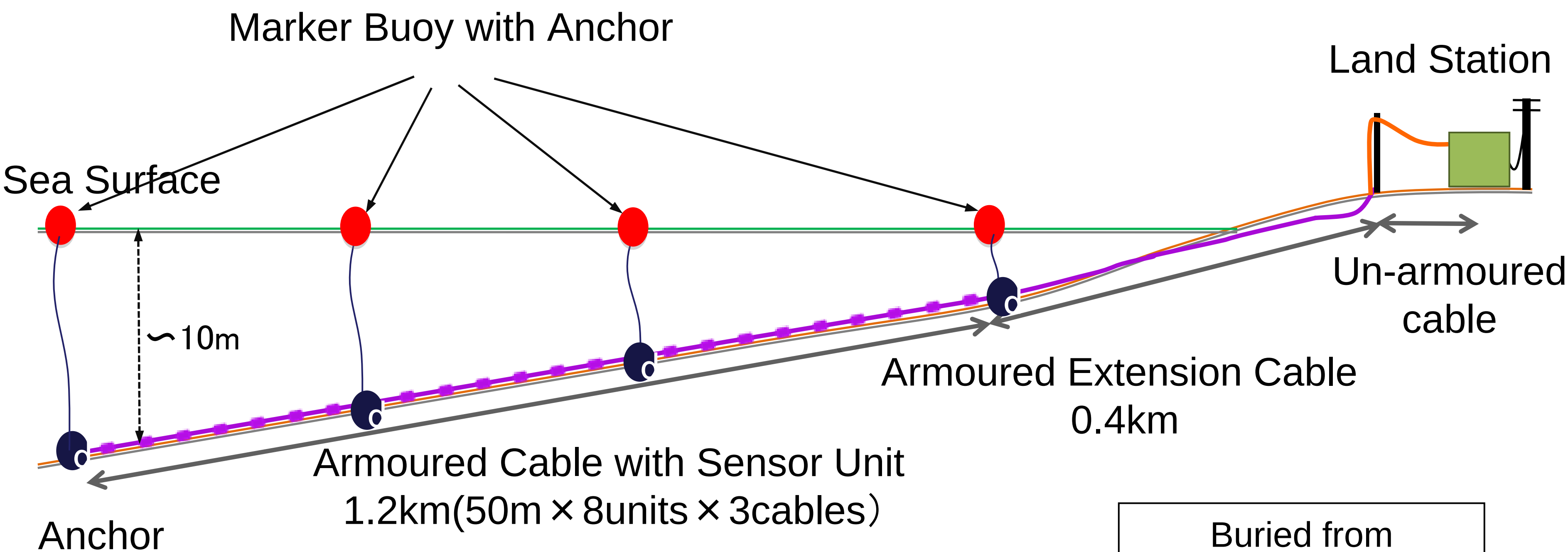
OBC Experiment Index Map





300m both side of wave height observation system is out the fishing area.

Permanent OBC Experiment Configuration



Buried from
Ebb Tide Line to
Utility Pole

Acoustic Transponders were set
at each sensor unit

OBC Deployment

Configuration	50m x 8 module / cable	
Max. Pressure	34.5 MPa	
【Cable】	Diameter	22.6 mm
	Weight (Air)	1.77 kg/m
	Weight (Water)	1.46 kg/m
【Module】	Diameter	86 mm
	Length	1.37 m
	Weight (Air)	12.6 kg
	Weight (Water)	7.7 kg

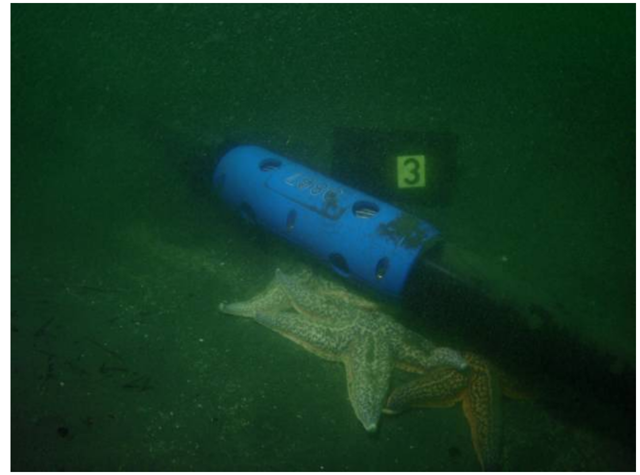
Burial from Ebb Tide Line to Utility Pole

OBC Setting （Landward Ch1, Ch.3)

After Deployment

Ch1

Ch 3



Before Retrieval

Ch 1

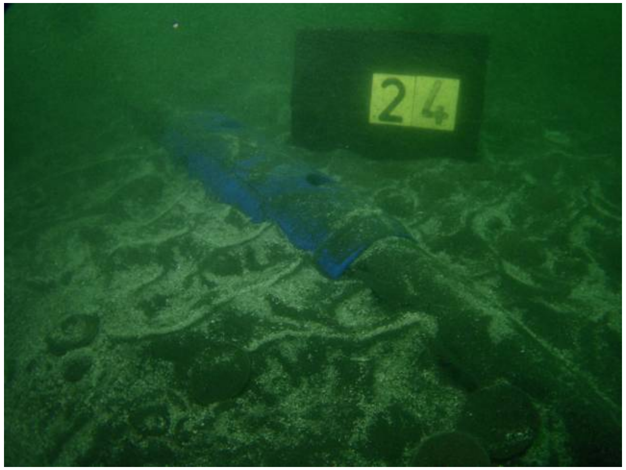
Ch 3

Hard to bury sensors when deploying due to cable tension.
Most landward sensors buried when retrieving.

OBC Setting （Seaward Ch21, Ch.24)

After Deployment

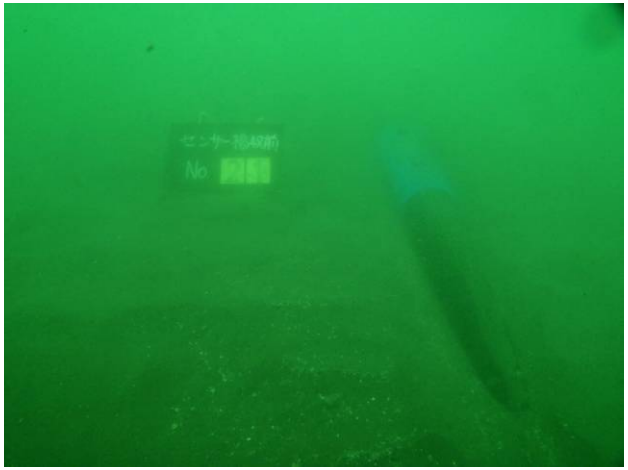
Ch 21

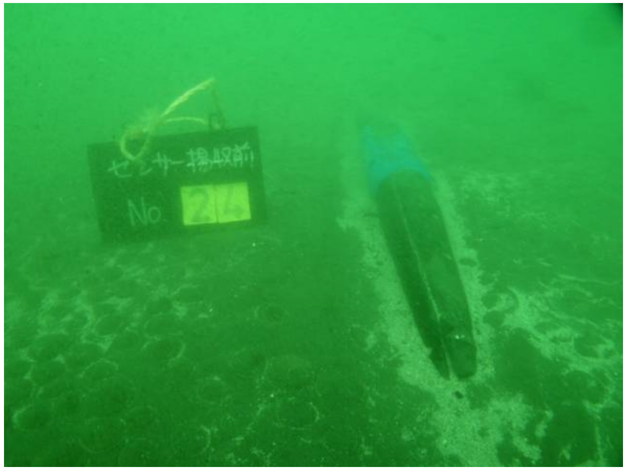


Ch 24

Before Retrieval

Ch 21

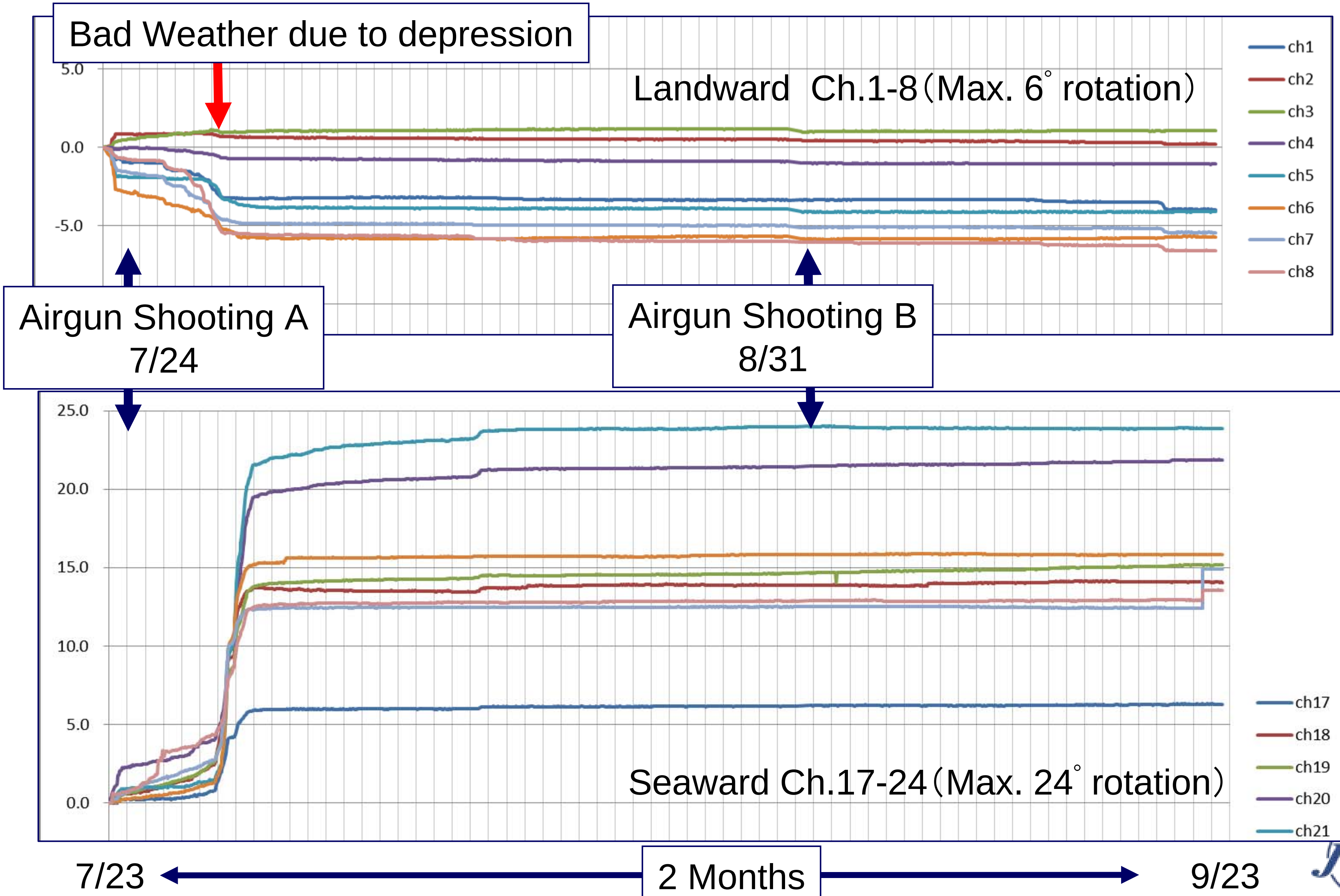




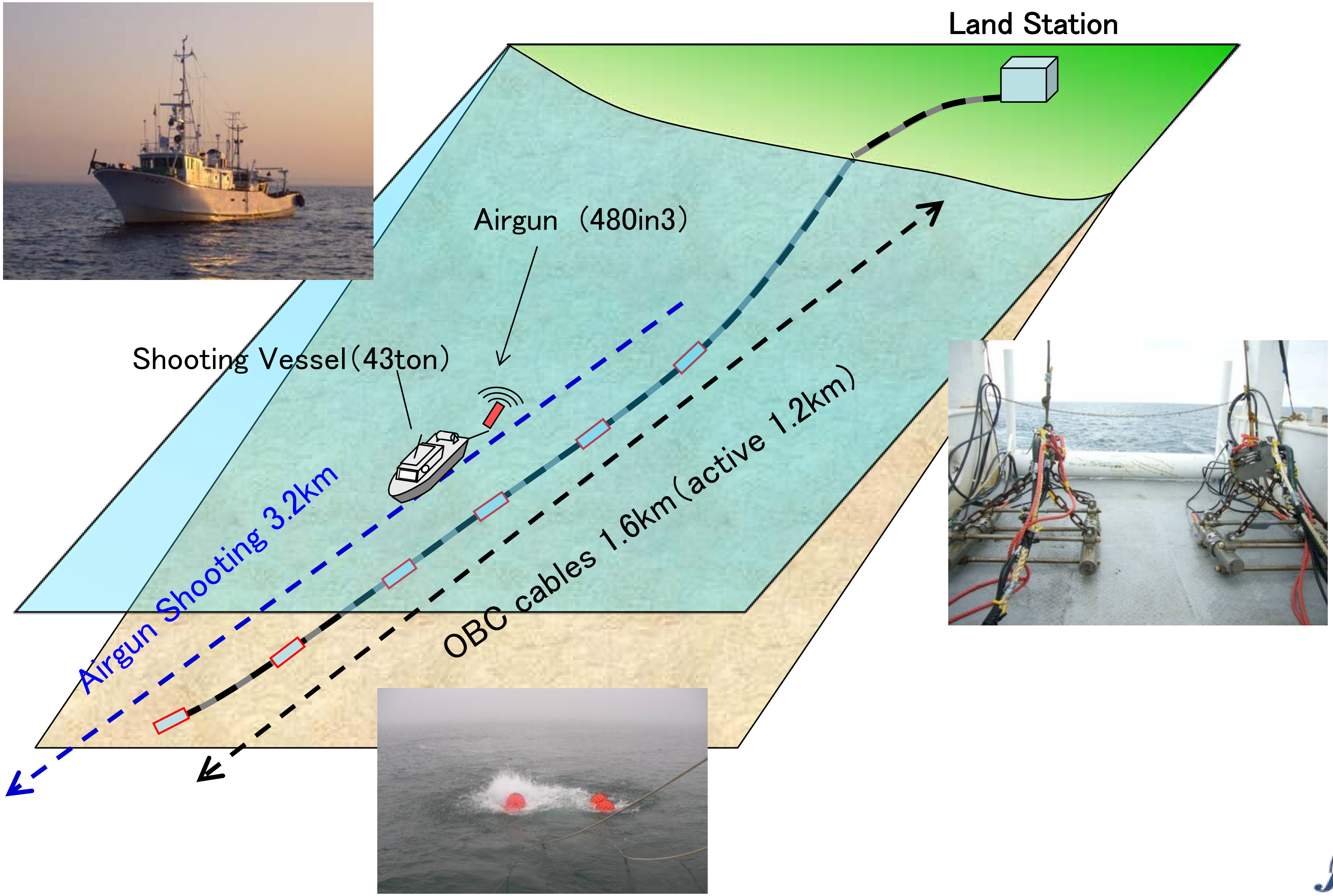
Ch 24

Situation not much changed.

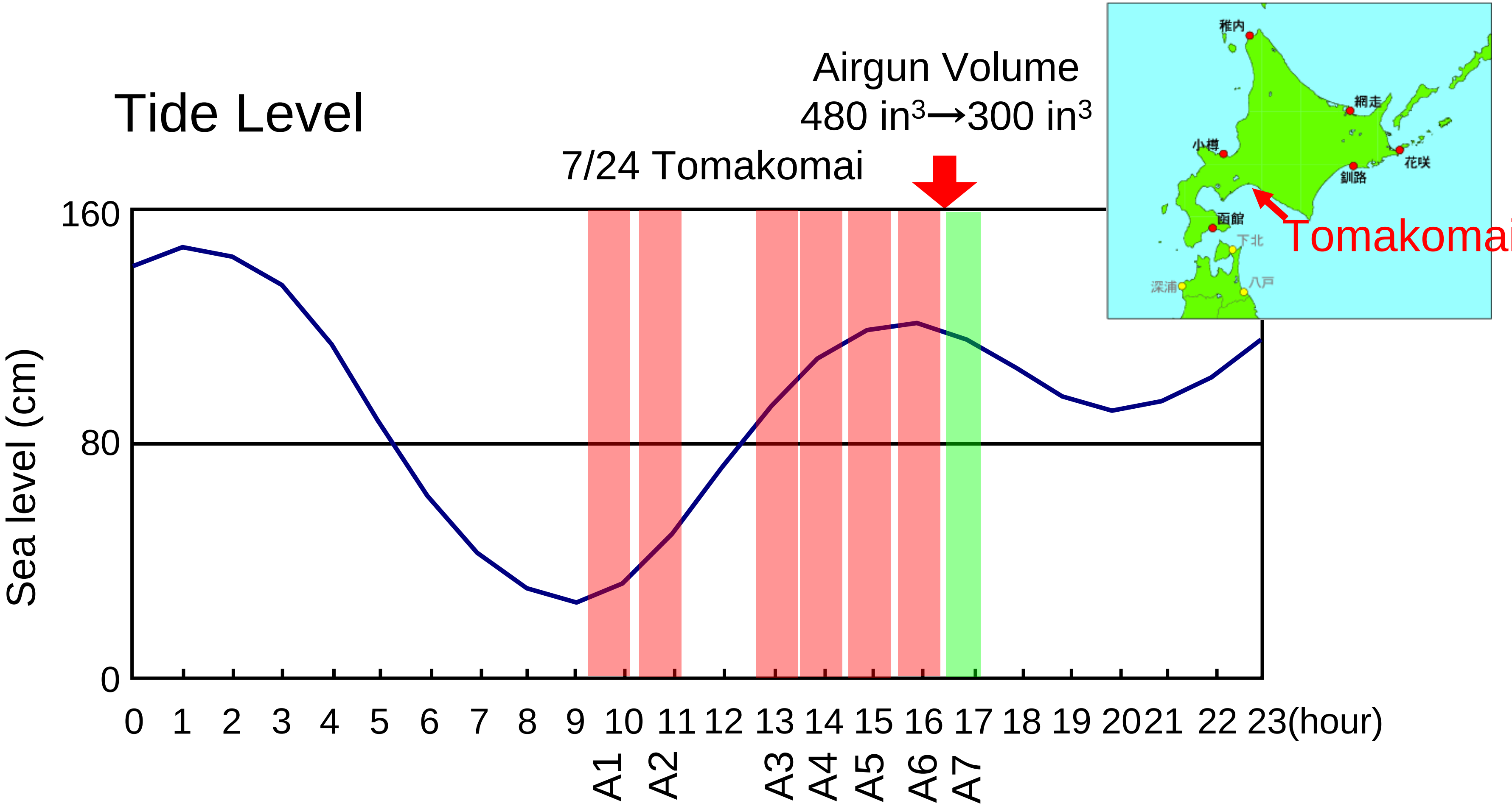
Rotation of Sensor Units



Overview of Airgun shooting



Schedule of Airgun Shooting A (7/24)



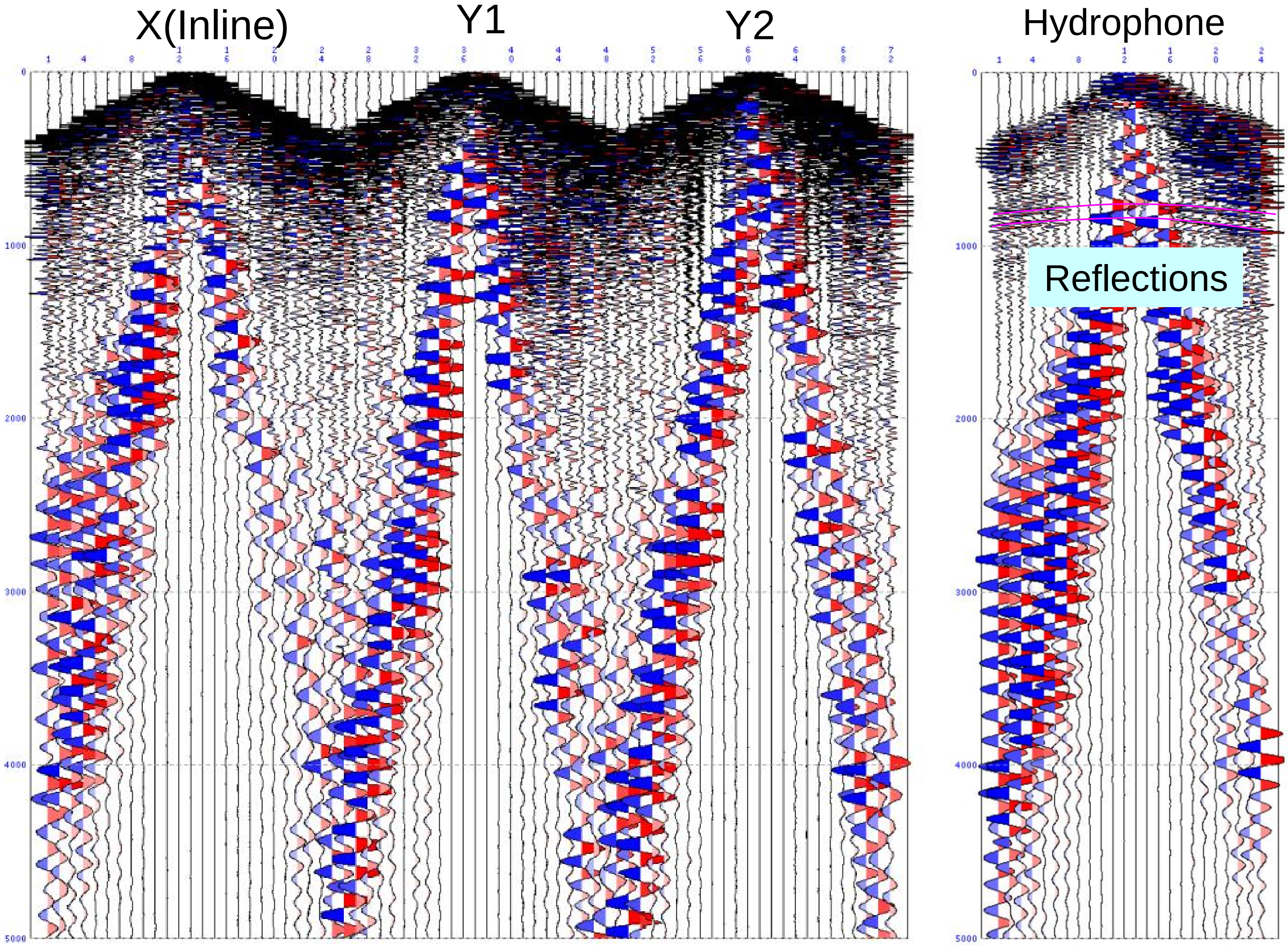
Shootings on the same line were repeated with the different tide levels (A1-A7)

Line Name Legend

A1H: Shooting A(7/24) 1st run Hydrophone

B6G: Shooting B(8/31) 6th run Geophone

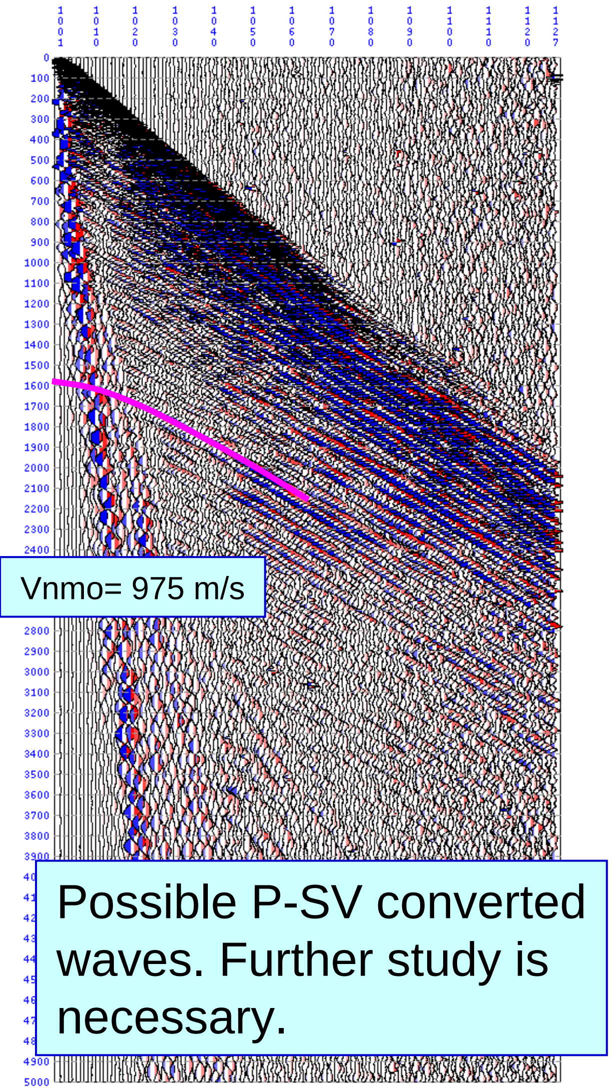
Common Shot Gather



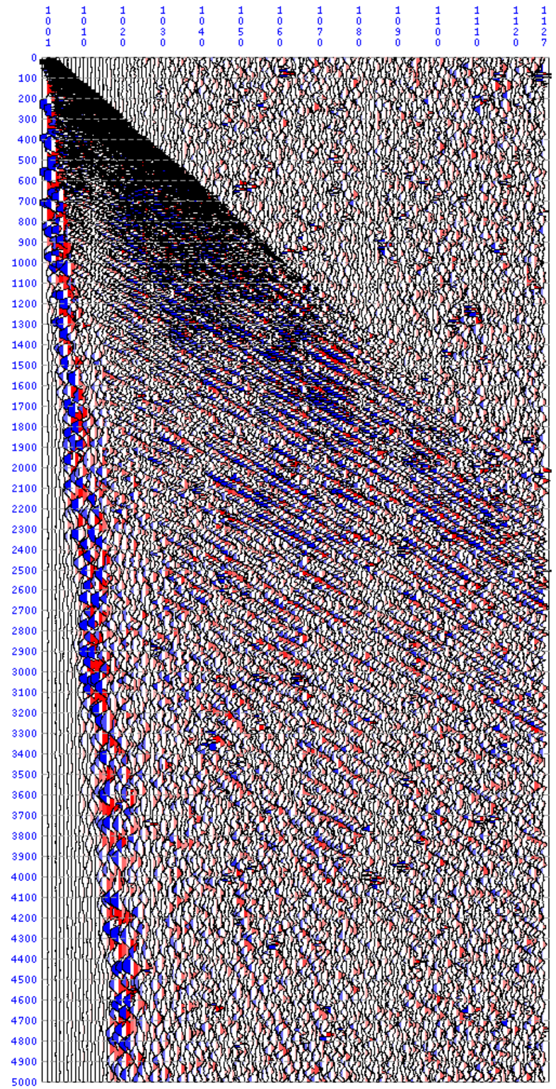
Courtesy of RITE

Common Receiver Gather (Ch1.) Geophone (After Rotation)

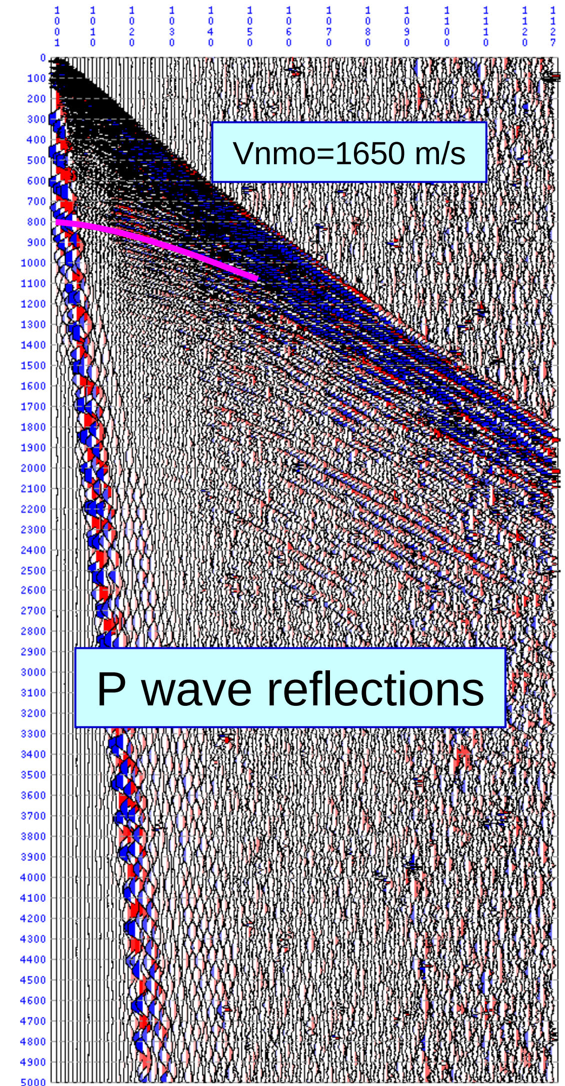
X(Inline)



Y (Crossline)



Z (Vertical)



Courtesy of RITE

Recorded on 8/31

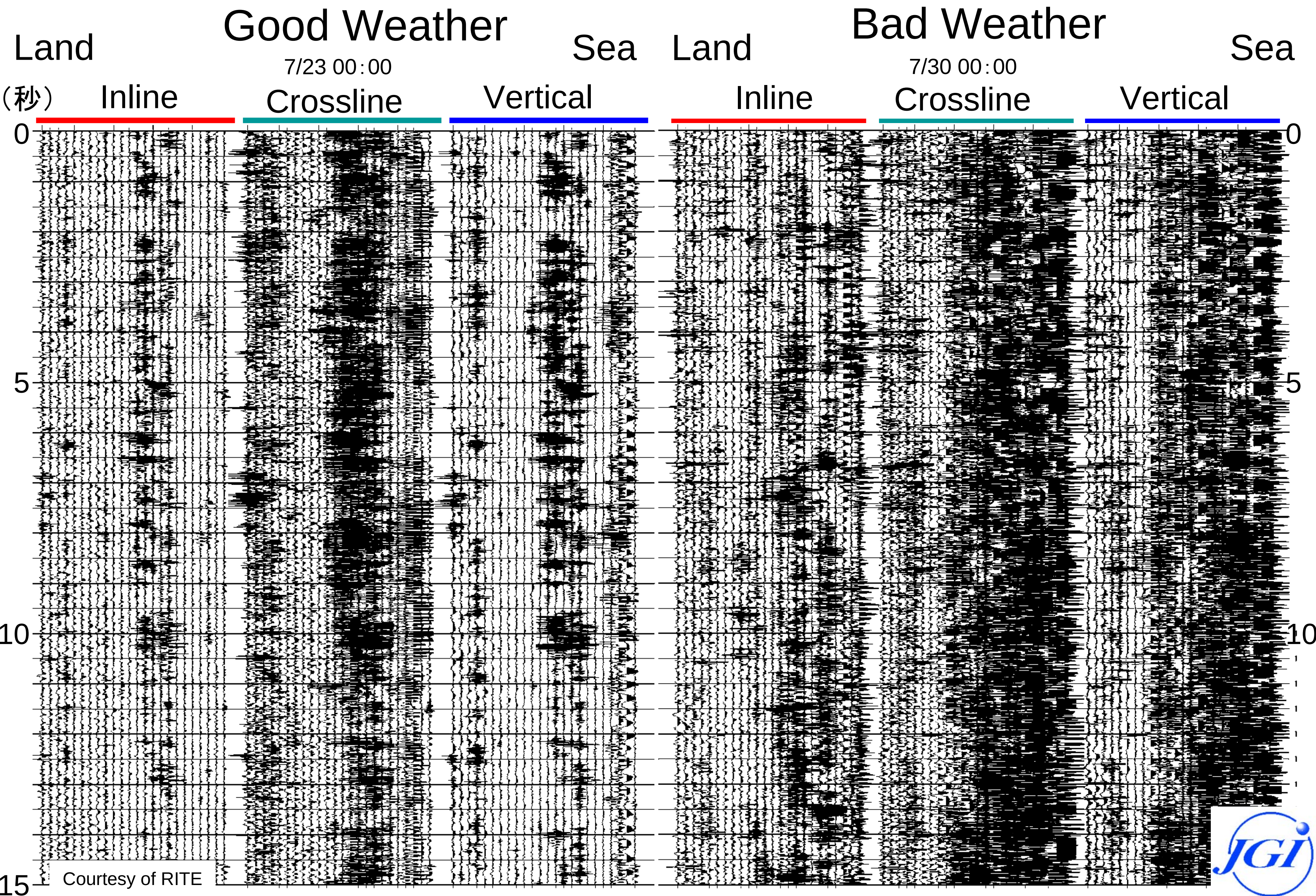
OBC Retrieval

Results from Data Analysis

- Noise Condition
- Repeatability（Shot/Receiver Loc. Uncertainty）
- Tidal Change
- Airgun Volume Change
- Possible Use of P-SV Converted Waves

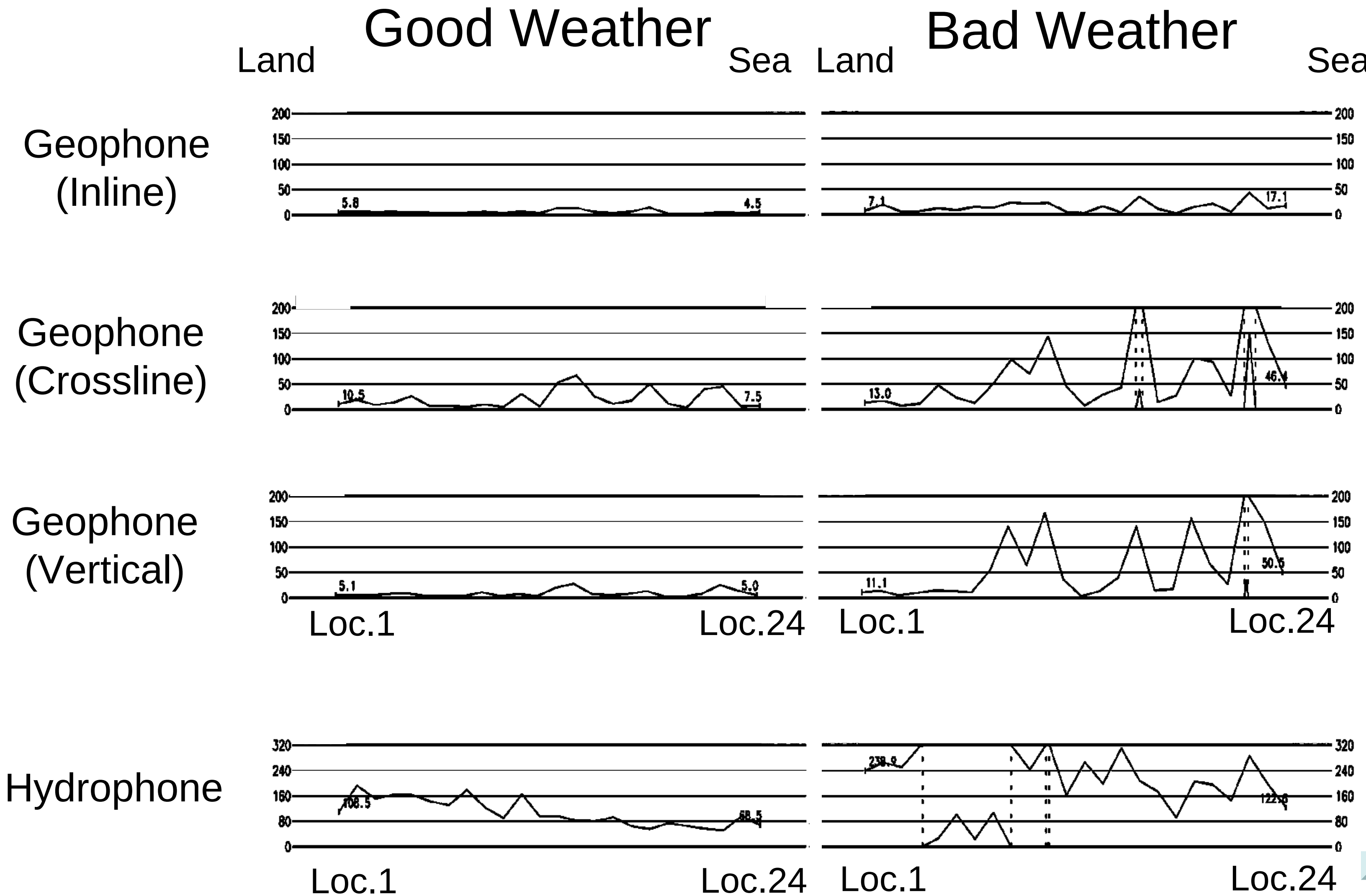
- Index for 4D Detectability
- Observation of Micro-Seismic

Geophone Noise Record



Noise Analysis

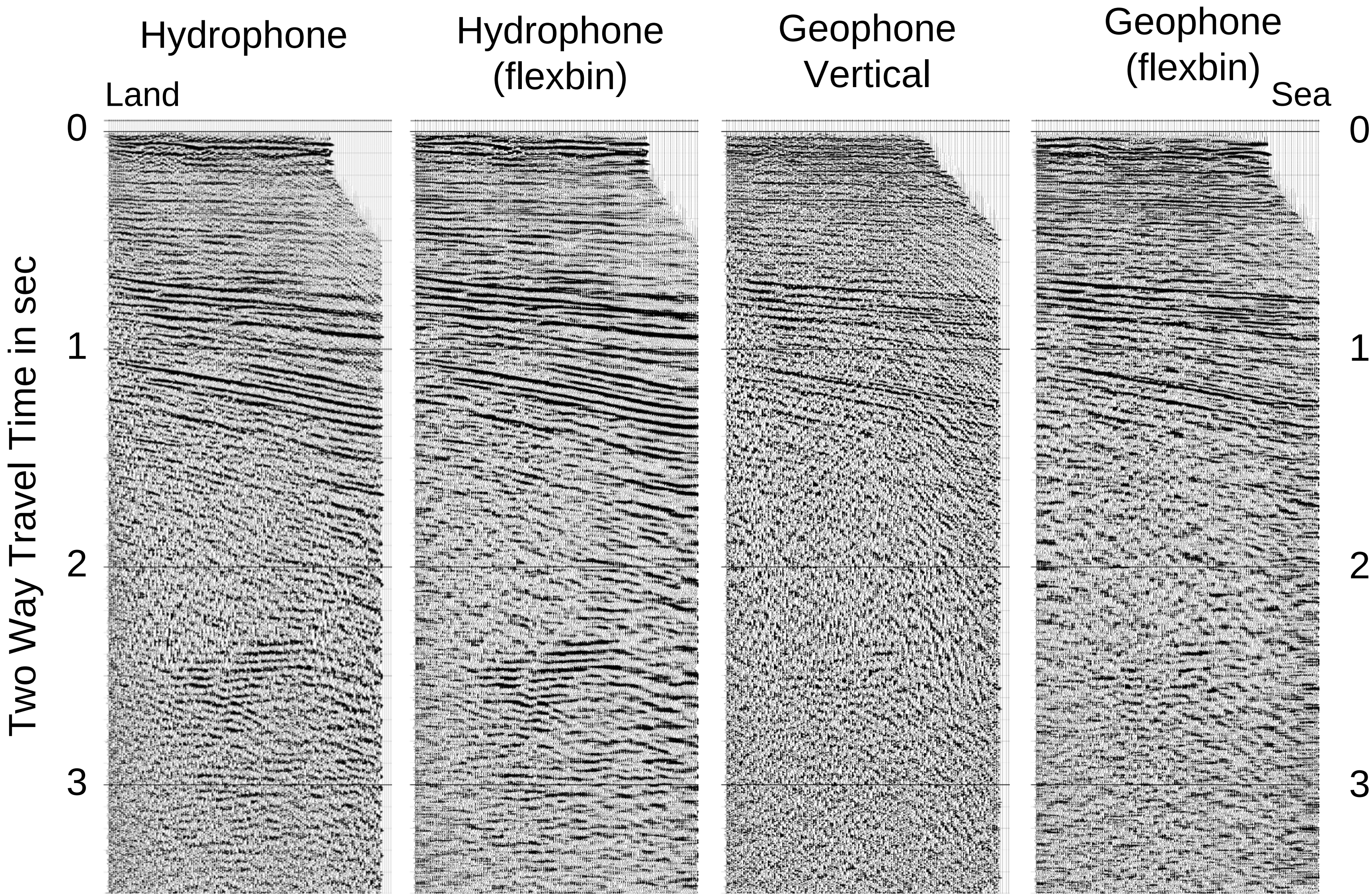
Vertical Axis: RMS Amplitude



Geophones (Inline) are stable. Geophones (crossline) noise level difference is larger seaward. Hydrophone noise is larger landward.

Courtesy of RITE

Stack Section from A1

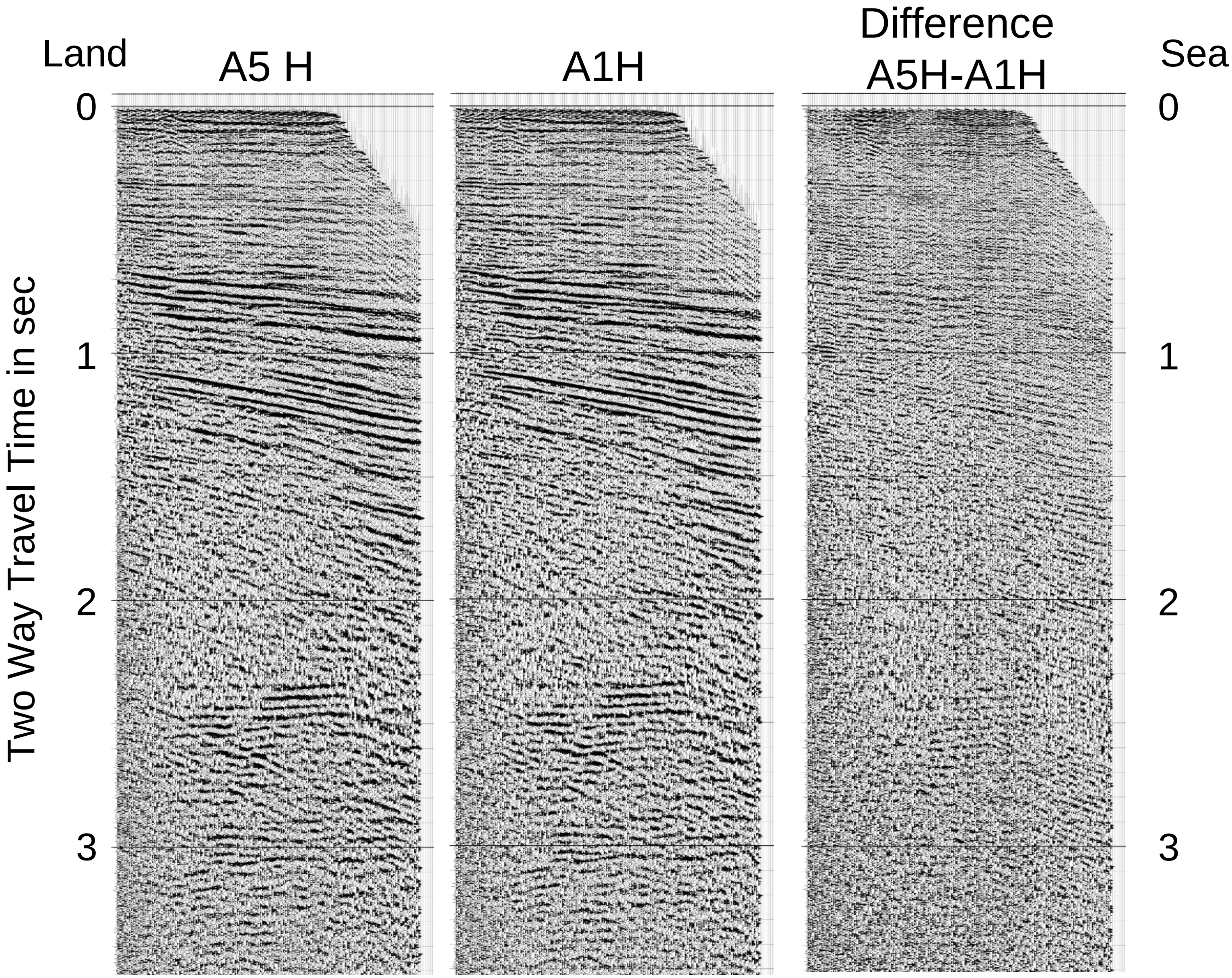


Courtesy of RITE

Raw Stack

Higher S/N ratio was obtained for the hydrophone survey.
Apparent higher resolution was obtained for the geophone survey .

Difference Section between A5H (high tide) and A1H(low tide)

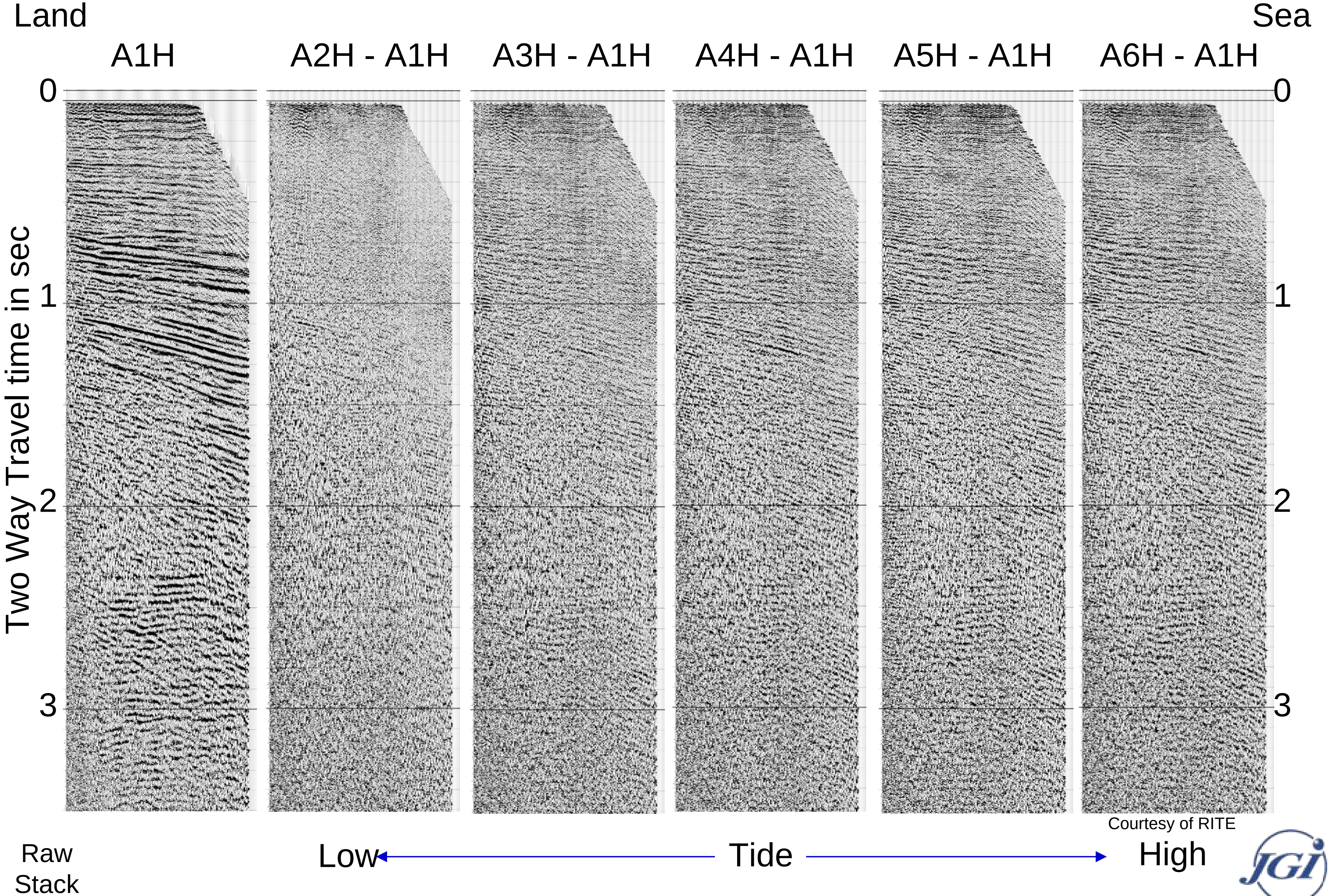


Raw Stack

Difference due to the tidal change was observed.

Courtesy of RITE

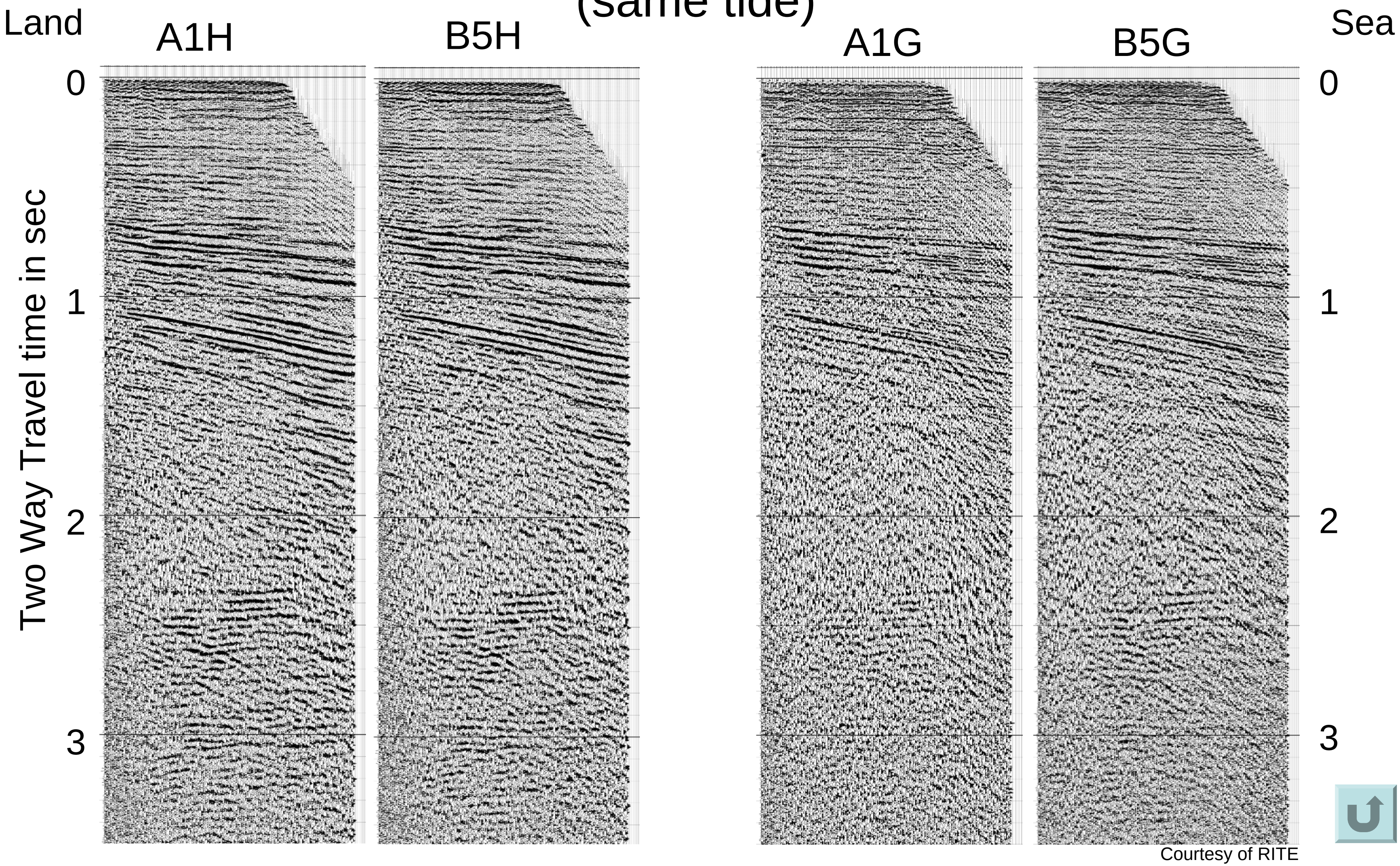
Difference Section from low tide to high tide



Courtesy of RITE

Comparison between A(7/24) and B(8/31)

(same tide)



Raw Stack

Geophone section for Shooting B has better S/N than that for Shooting A.
→improvement of coupling of the geophones should be contribute.

Index for 4D response evaluation

Kragh and Christie (2002)

Normalized RMS (NRMS)

$$NRMS = \frac{200 \times RMS(a_i - b_i)}{RMS(a_i) + RMS(b_i)}$$

a_i, b_i : Amplitude bfr/aft injection

NRMS = 0 : Identical
NRMS =200 : Reverse Polarity
NRMS =144 : Random Noise

Predictability (PRED)

$$PRED = \frac{100 \times \sum(\Phi_{ab}(\tau) \times \Phi_{ab}(\tau))}{\sum(\Phi_{aa}(\tau) \times \Phi_{bb}(\tau))}$$

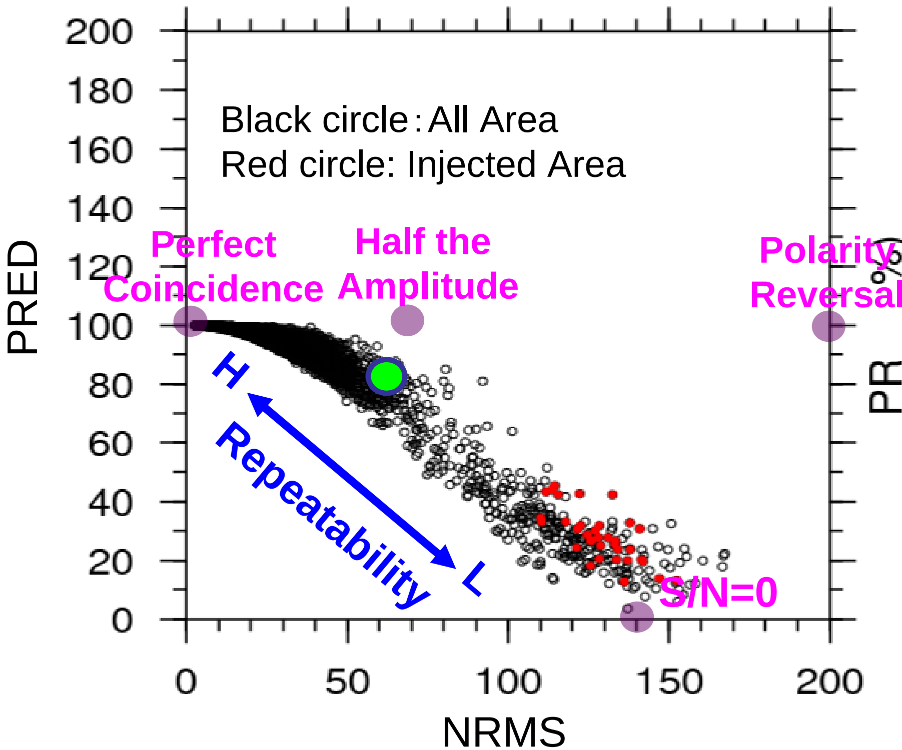
Φ : Cross correlation coefficient

PRED = 0 : No correlation
PRED =100 : ±100 % correlation

Repeatability Evaluation using Crossplot between NRMS and PRED

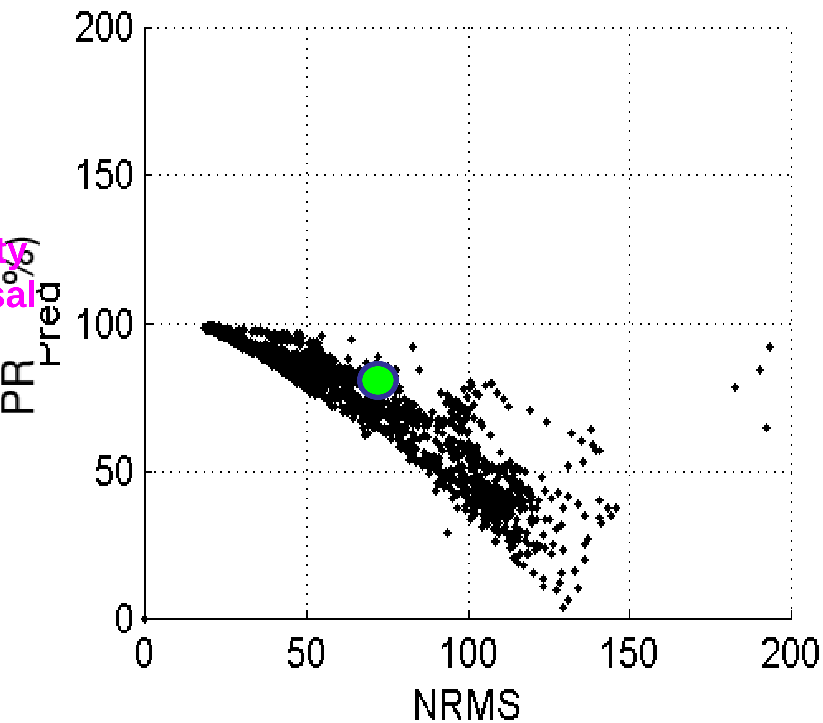
Simulation

(Iwanohara Model, White Noise 25%)



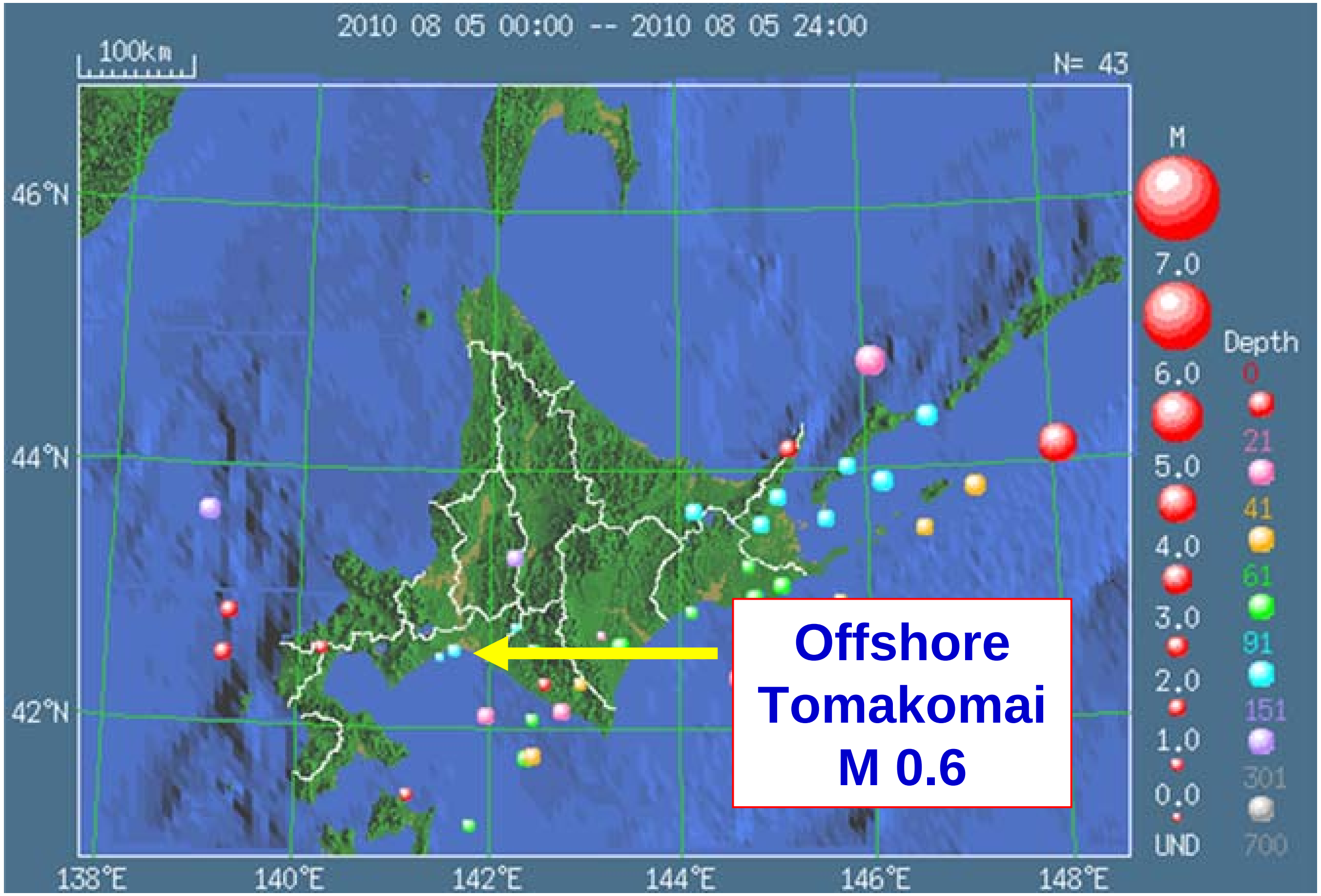
Real Data

(After kragh & Christie, 2001)



Current position of repeatability in average.
Calibration can increase the repeatability index.

Observation of Micro-Seismic



From JMA

8/5 21:44 Offshore Tomakomai
Magnitude 0.6 Depth 103 km

Offshore Tomakomai Micro-Seismic Event（after Rotation）

Land

Sea

Z
（Vertical）

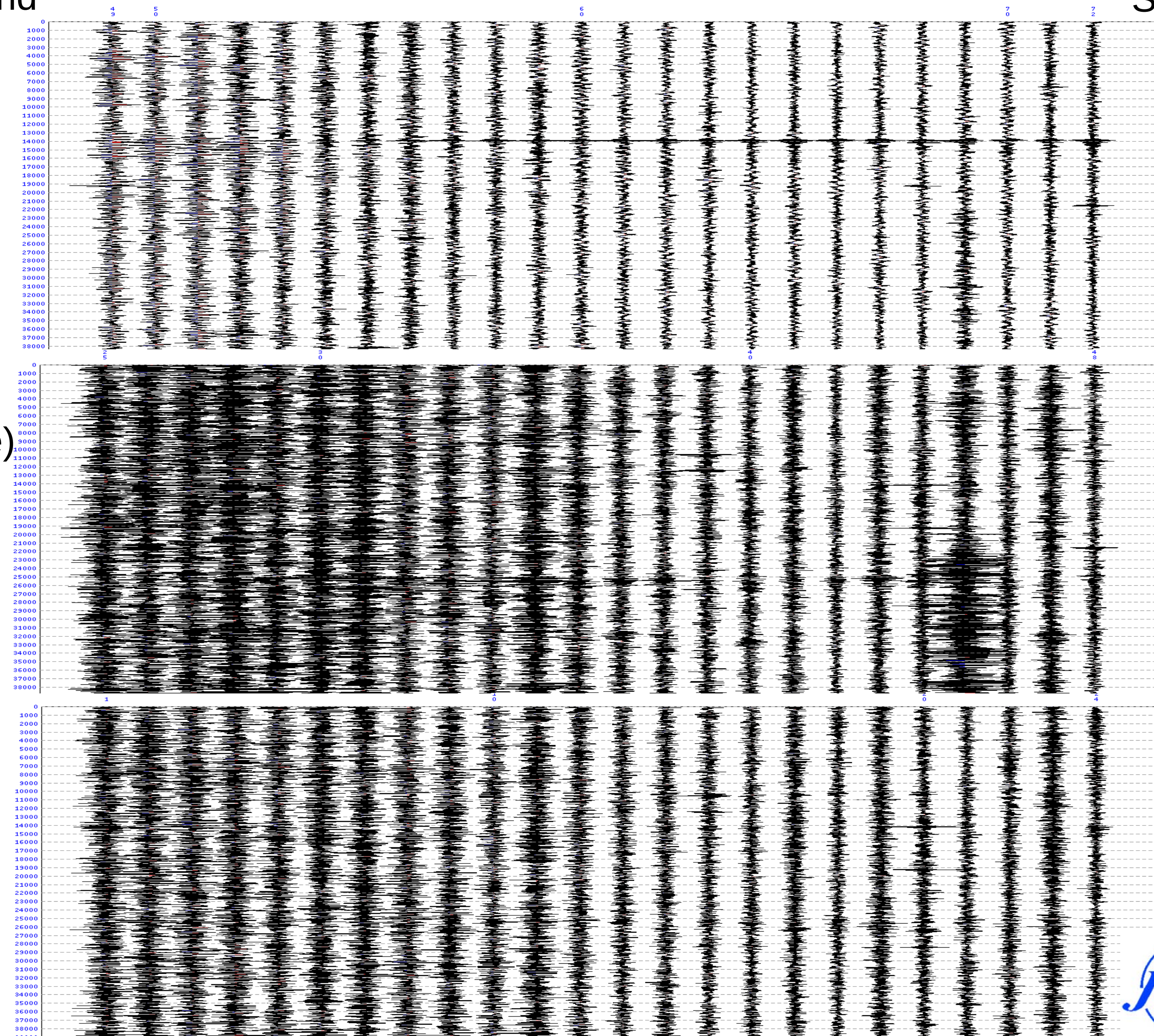
P

Y
(Crossline)

S

X
(Inline)

S



HCF:20Hz

Relative amplitude between components are not Preserved.

Courtesy of RITE

Conclusions

- Nearshore OBC observation was successfully conducted for two months.
- High-quality repeated reflection records were obtained and the effects of noise and tidal change were analyzed.
- P-SV converted waves are considered to be observed and further analysis will contribute to the reservoir characterization.
- Small local earthquake observation indicates the possibility of the passive monitoring of CCS.

Toward the Future

- Permanent OBC system is a promising tool for the nearshore CCS monitoring.
- Through more detailed and quantitative study on the influence of noise and tide on the 4D analyses, and P-SV analysis toward the reservoir characterization, development of practical procedure for the permanent OBC monitoring can be achieved.


Thank you very much
for your kind attention
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