Field Validation of MVA Technology for Offshore CCS, Tomakomai, Japan

Project Number DE-FE0028193

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with Tip Meckel

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Carbon Storage and Oil and Natural Gas Technologies Review Meeting
August 13-16, 2018

Acknowledgements

U.S. DEPARTMENT OF ENERGY
NETL

Thank you to our Japanese colleagues!

METI
Ministry of Economy, Trade and Industry

Japan CCS Co., Ltd.

JGI, Inc.

MERI
MARINE ECOLOGY RESEARCH INSTITUTE

RITE
Research Institute of Innovative Technology for the Earth

Presentation Outline

- Project Overview: Goals and Objectives
- Technical Status
  - HR3D Seismic (***Task 2***)
  - Sediment and water column sampling (***Task 3***)
- Accomplishments to Date
- Lessons Learned
- Summary

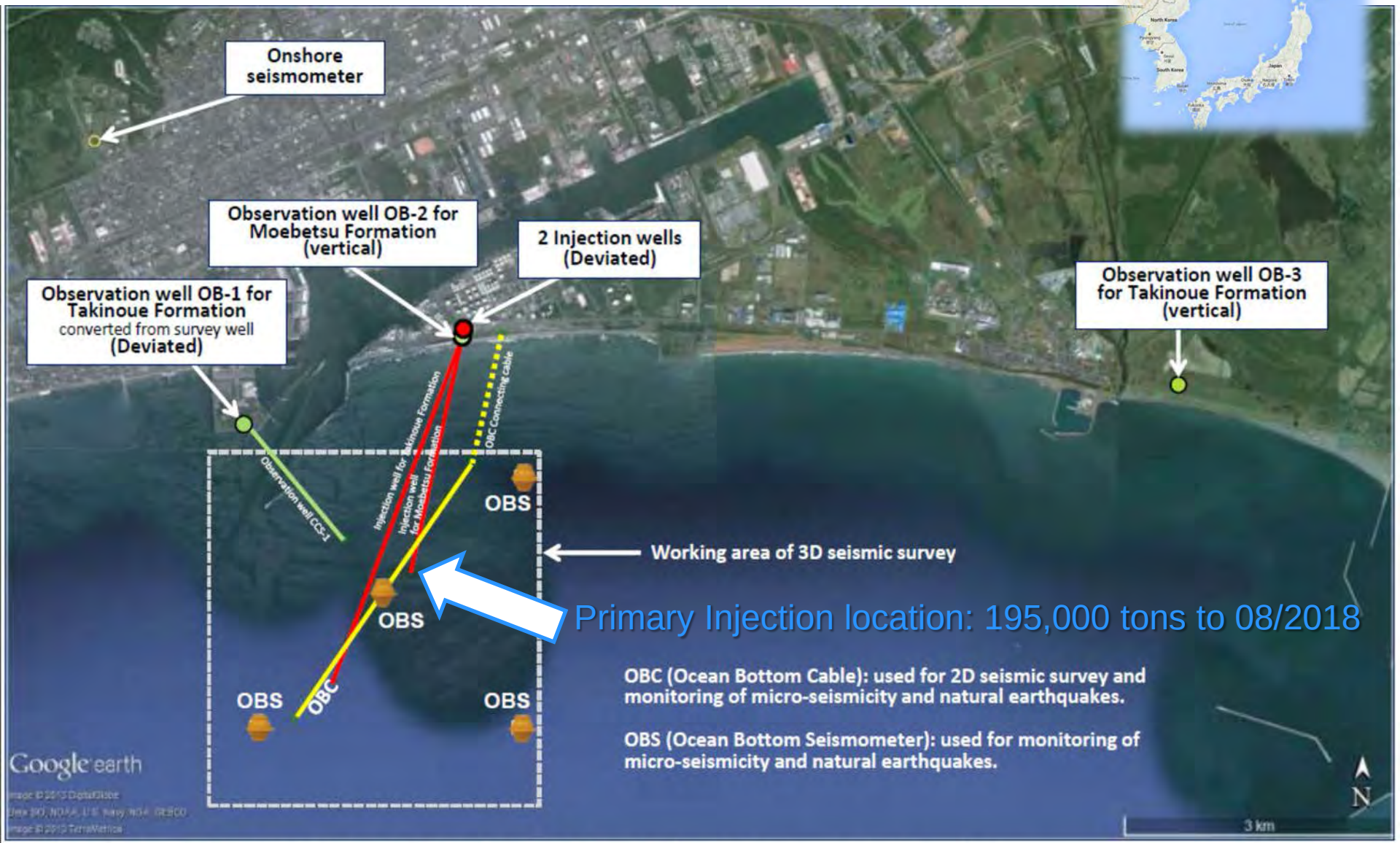
Goals & Objectives

Goal: Validate technologies to enhance MVA

Objectives:

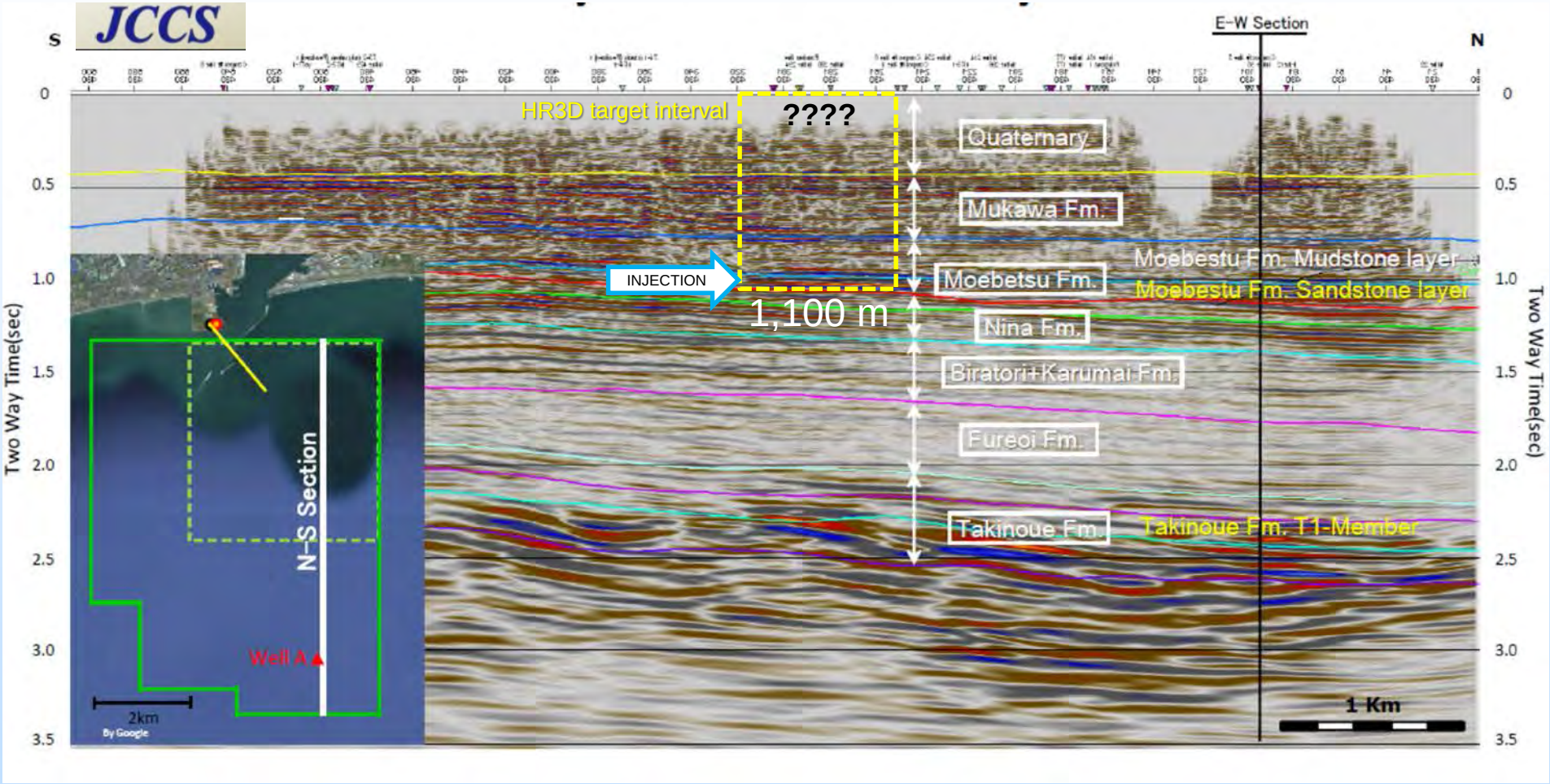
1) Acquire and validate HR3D technology for MVA at an operational offshore CCS field demonstration project.
2) Validate untested dynamic acoustic positioning techniques (SBL) for improved seismic imaging.
3) Constrain CO_2 plume boundaries.
4) Develop MVA techniques and strategies for near-surface seafloor sediment environmental monitoring

Technical Status



JCCS

Geological Structure: North-South Section
Conventional Seafloor cable 3D Seismic Survey

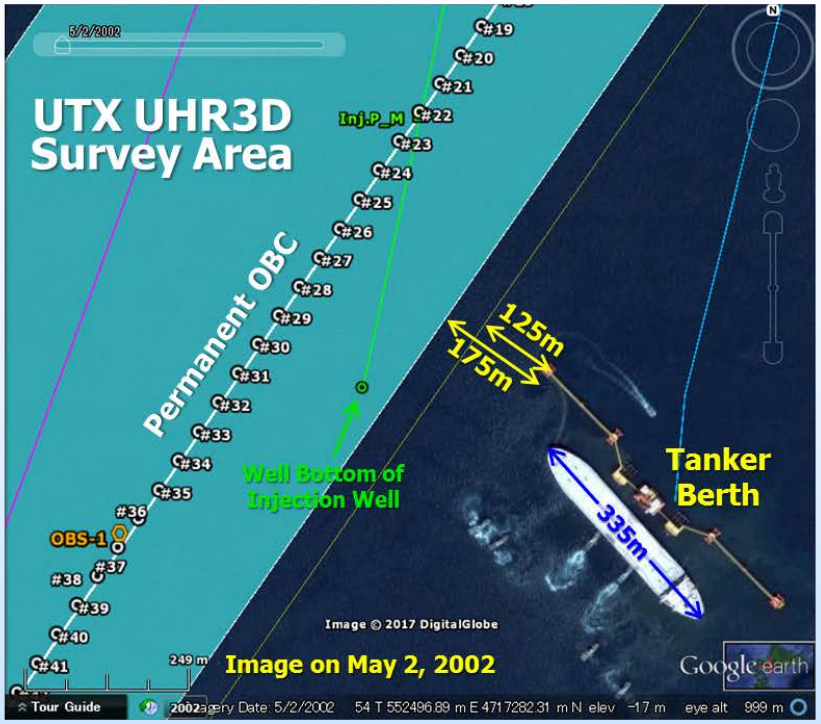


First HR3D Acquisition – August 2017

Mobile acquisition office

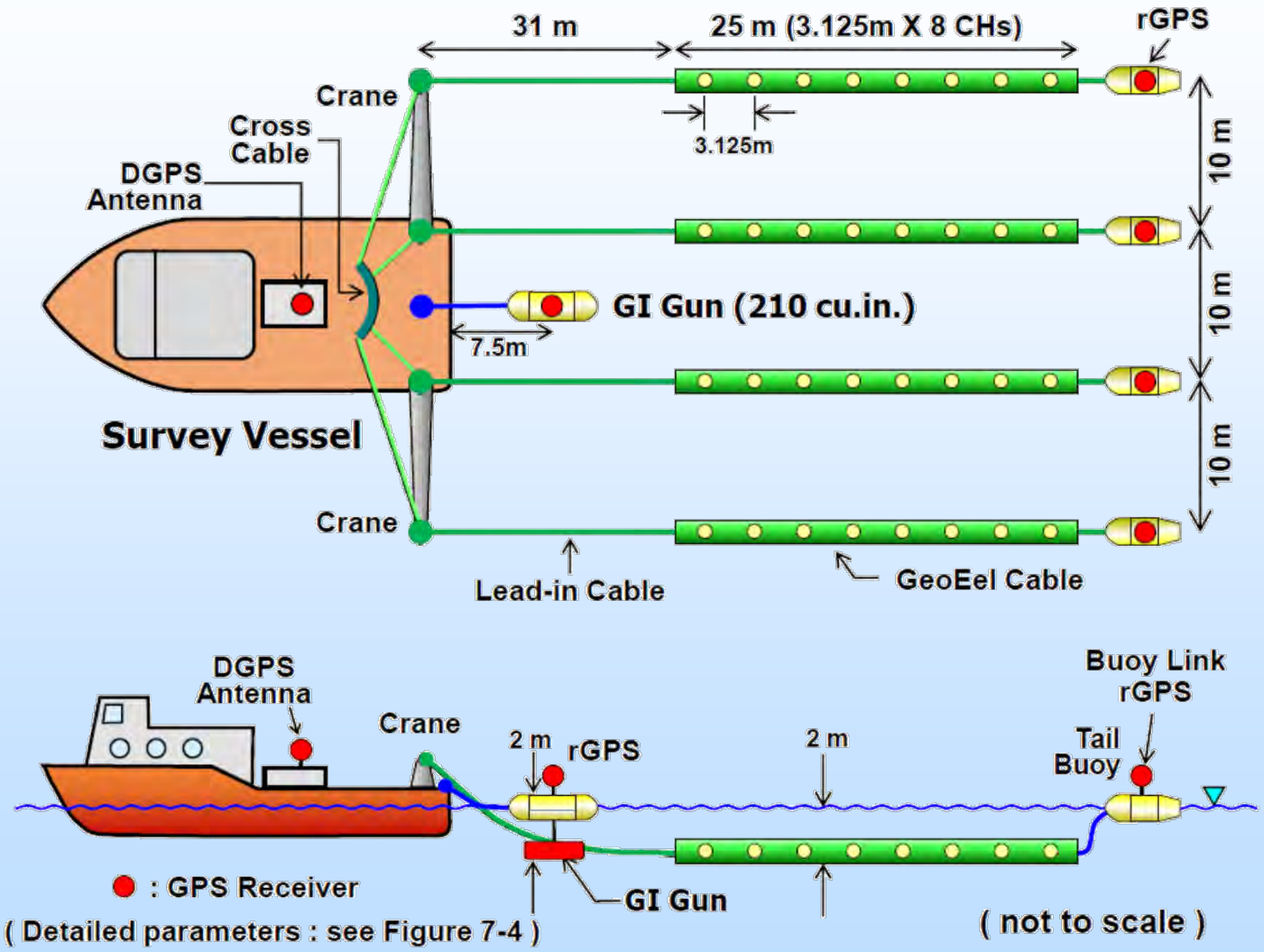
Survey Area of UTX UHR3D off Tomakomai (Final Plan)

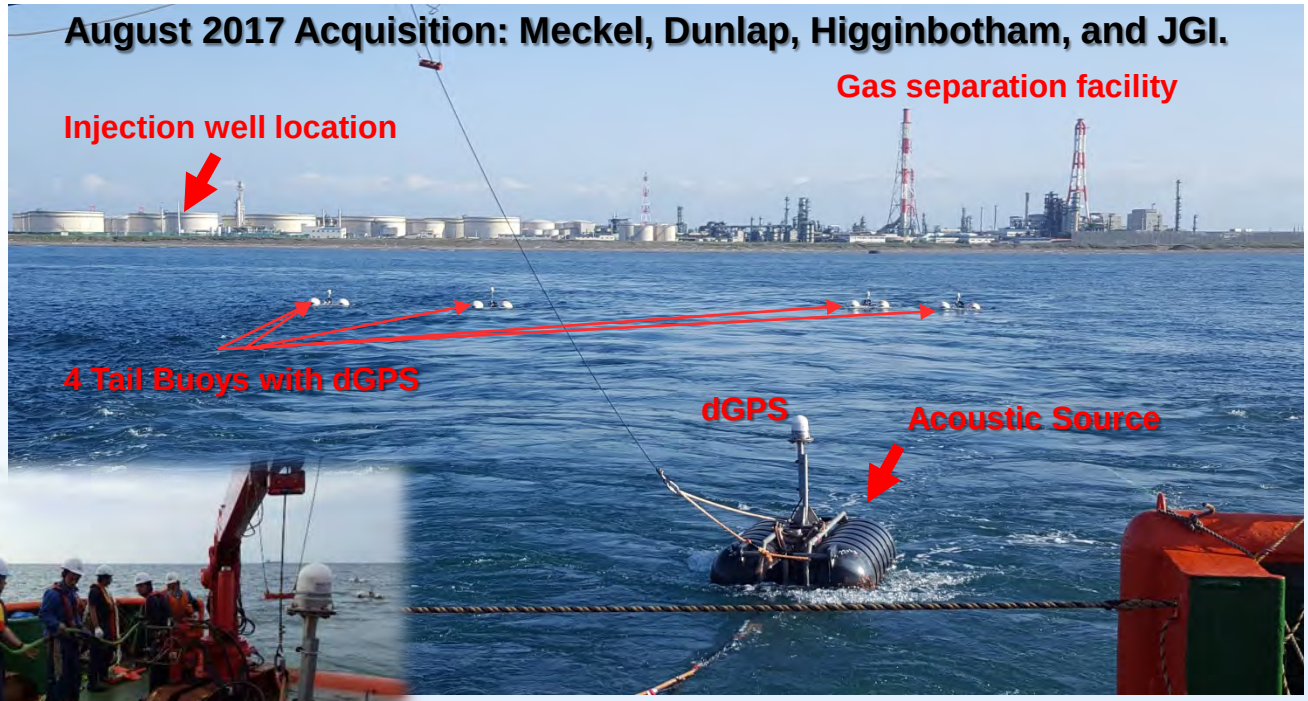
Rev. 2017.07.21

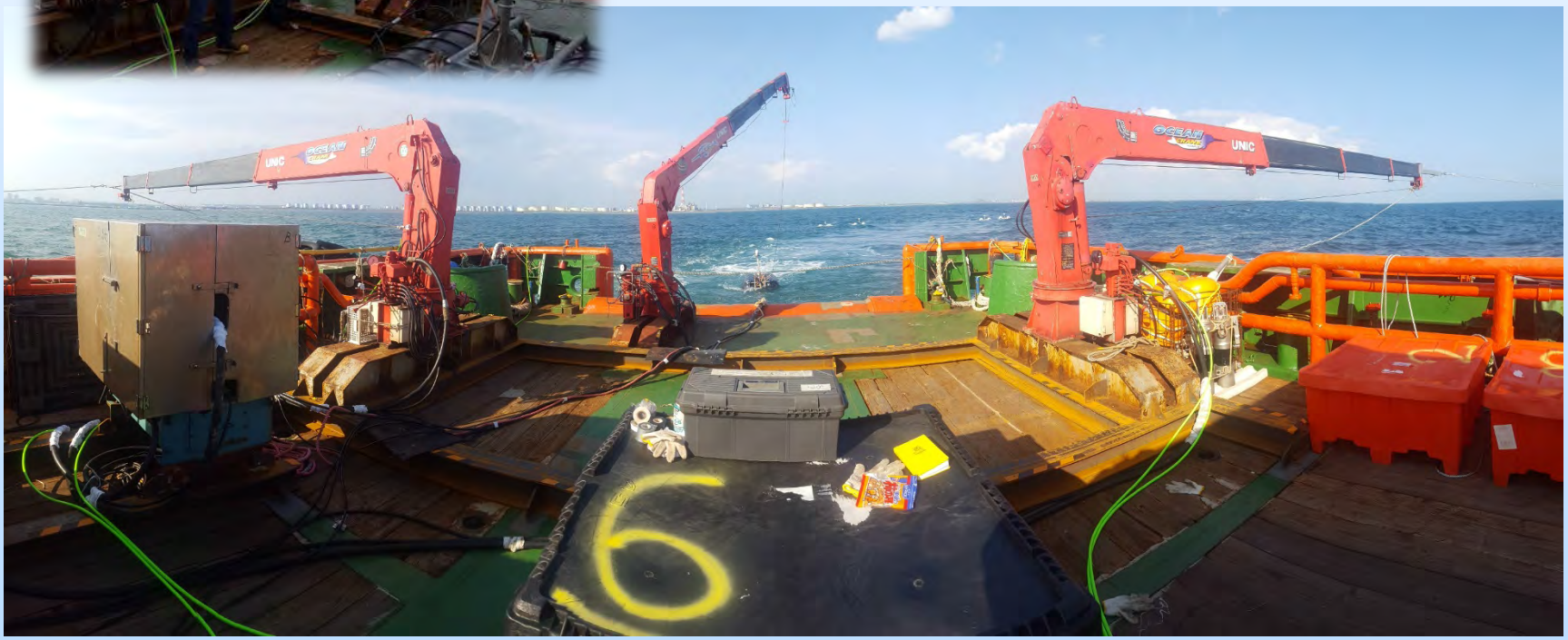


Google Earth Image on Oct.13, 2009 (1st 3D Survey in 2009)

August 2017 Acquisition Design




August 2017 Acquisition: Meckel, Dunlap, Higginbotham, and JGI.
Gas separation facility
Injection well location
4 Tail Buoys with dGPS
dGPS
Acoustic Source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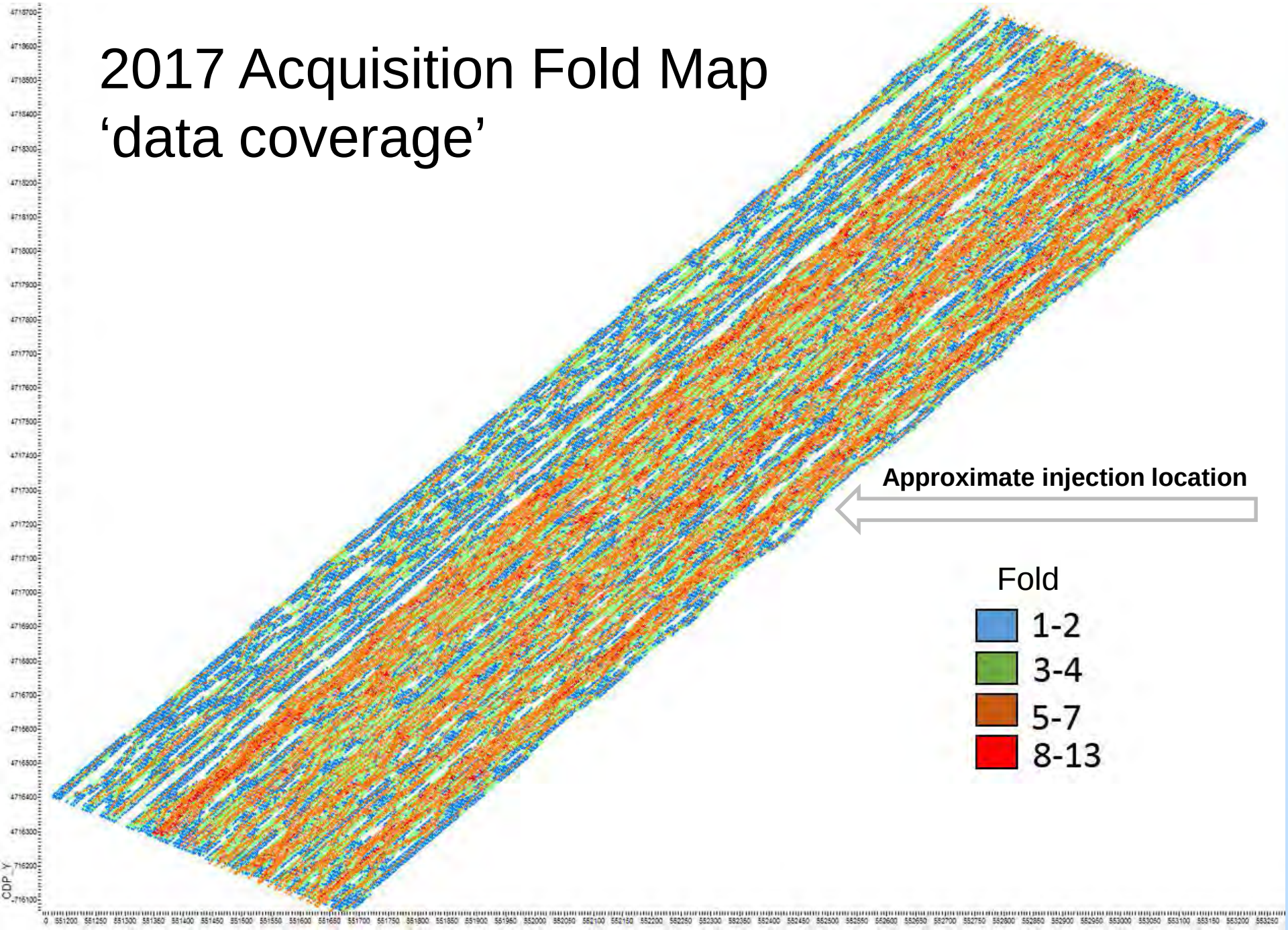
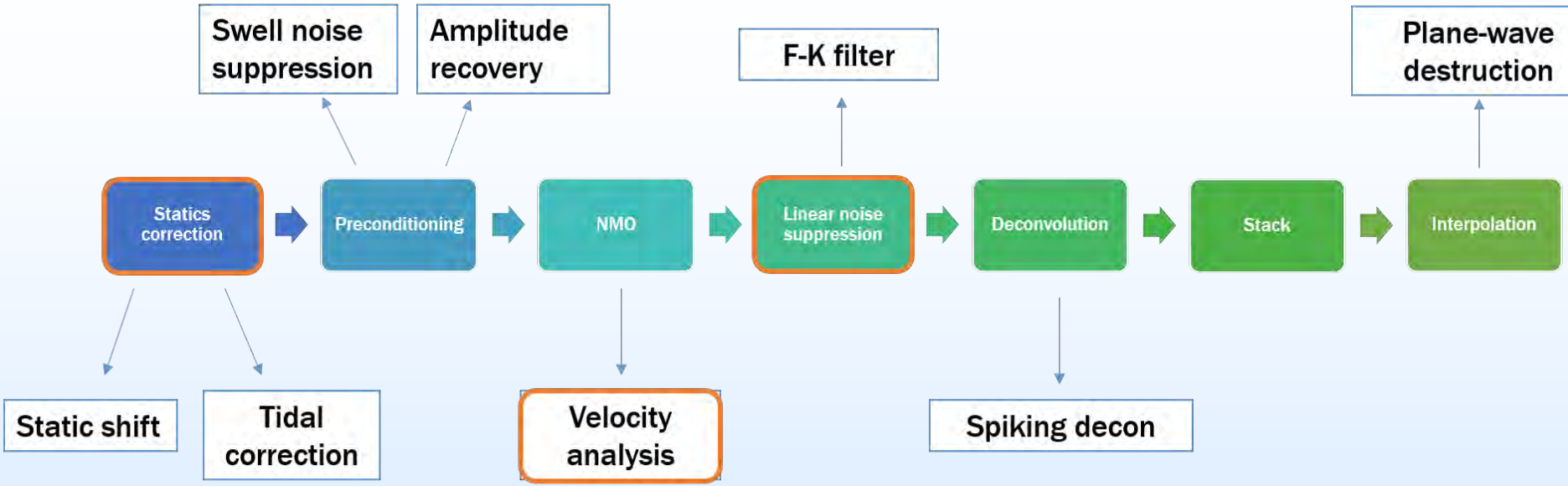
2017 Acquisition Fold Map ‘data coverage’



HR3D Processing Workflow



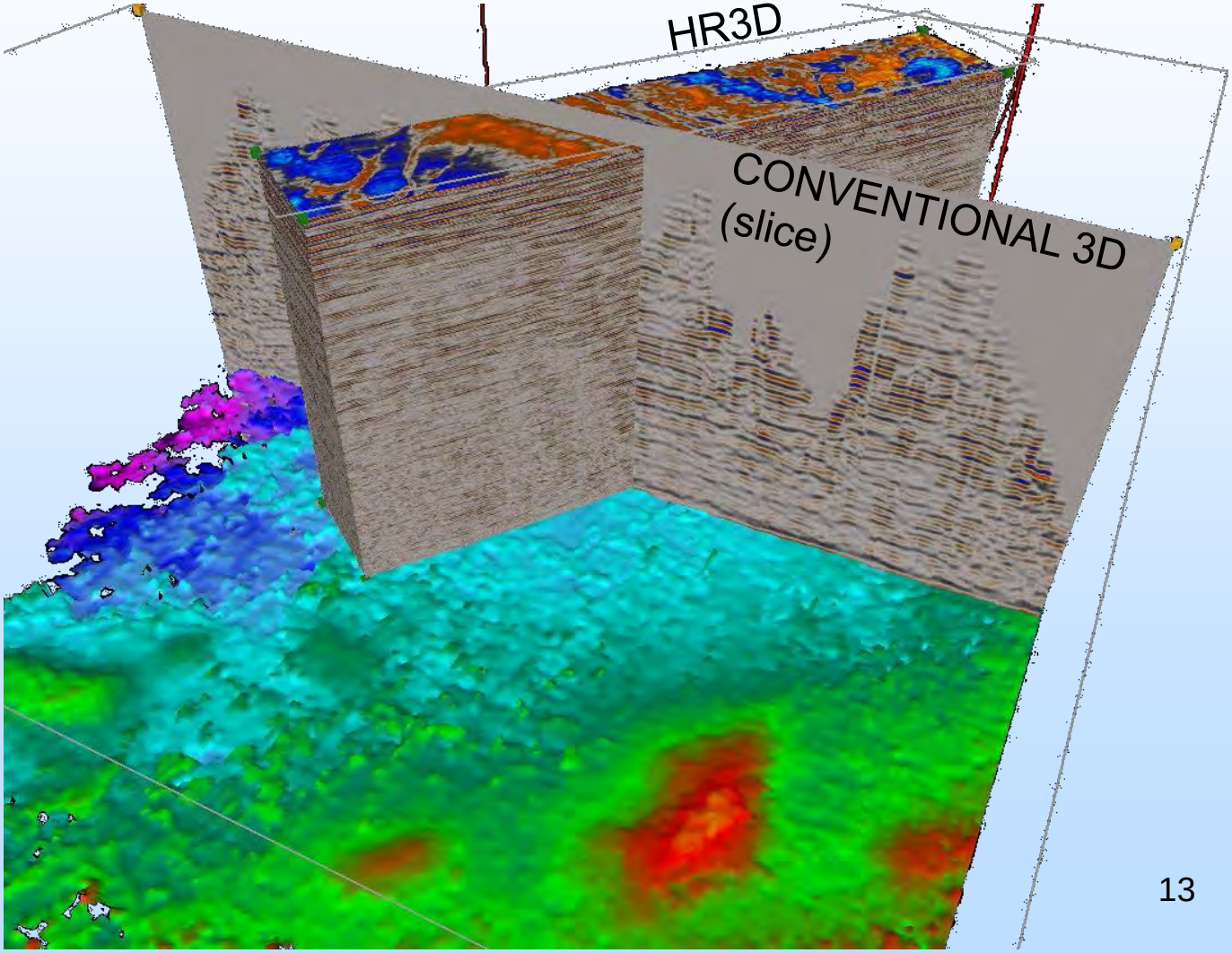
Lessons Learned

SBL Acoustic Task addresses this

Static issues	Better estimates of source and receiver depths Improve receiver locating algorithms/techniques	
Linear noise	Test the system to find out the source of linear noise	(Prior to next survey)
Deeper section	Increase source size / add an additional air gun	(Implement next survey)

Successful dataset integration

- Subsurface HR3D mapping, characterization, and interpretation has begun.



Horizon just above injection interval (color = elevation)

Accomplishments to Date: HR3D

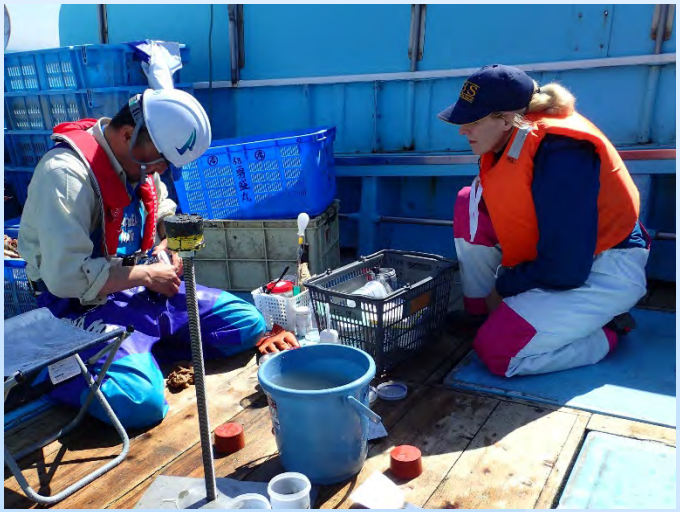
1. **Sensitivity study complete**
   - Deliverable D4; 06-2017
2. **First HR3D data volume acquired**
   - August 16-29, 2017 - Approximately 65,000 tons CO_2 injected
   - Milestone M3, 11-2017
3. **HR3D data successfully processed**
   - Milestone M4; 03-2018
4. **Repeatability study complete**
   - Deliverable D4; 03-2018.
5. **Advanced processing complete**
   - July 2018

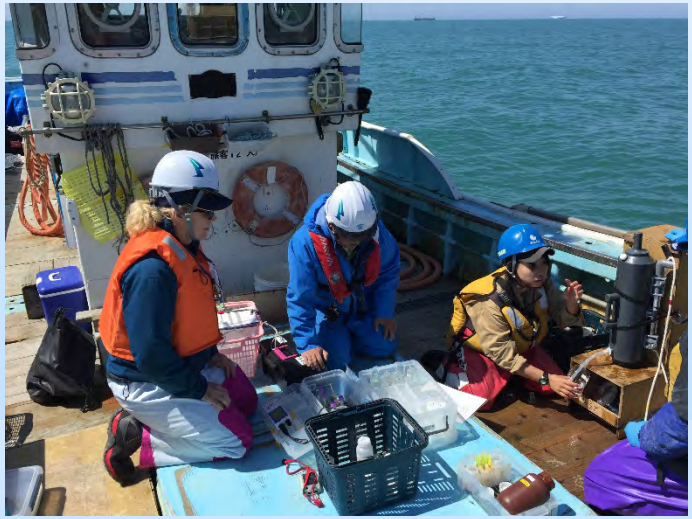
Lessons Learned: HR3D

- Selecting **short-baseline acoustic technology** for direct in-water ranging of streamer heads has been challenging.
  - Initial technologies identified not suitable for horizontal ranging through aft prop-wash; We continue to work with vendors.
- **Acoustic energy** (airgun) **source** of 210 cu. in. too small to accurately image injection interval at 1,100 meters depth.
  - Doubling of source volume recommended for next survey.
- **Ambient environment noise** at the survey site was significant (busy industrial port).
  - Integrated system test planned (Houston)
  - Acquisition parameter revision after on-site noise level assessment.
- Utilizing **multiple processing software packages** improves overall data quality.
  - Non-standard integrated workflows developed: RadExPro, Madagascar, Paradigm, OpendTect.

Task 3- Environmental Monitoring Objectives

- ✓ Learn marine monitoring techniques (May, 2017)



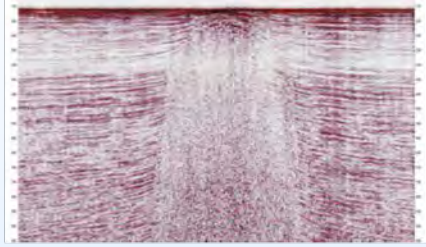


Many thanks to Jun Kita, Marine Ecology Research Institute and Japan CCS

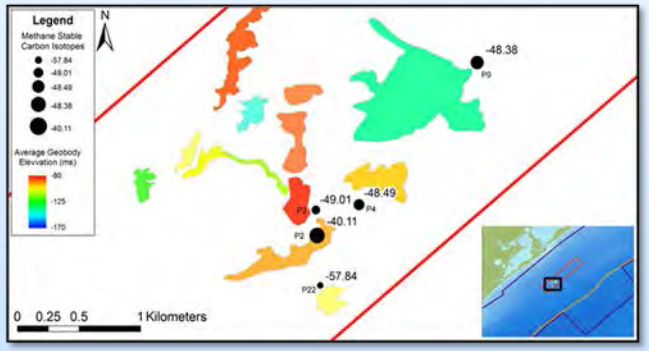
Task 3- Environmental Monitoring Objectives

- Provide insight into subsurface field conditions informed by HR3D seismic survey.
  - Link shallow subsurface seismic geology to geochemical signatures.
  - Characterize potential transmissivity and fluid flow

San Luis Pass, Gulf of Mexico



Tip Meckel, P-Cable seismic image GOM



Example of light hydrocarbon assessment of submarine anomalies, **San Luis Pass, Gulf of Mexico**

Anderson, Romanak, and Meckel, 2018, Assessment of shallow subsea hydrocarbons as a proxy for leakage at offshore geologic CO_2 storage sites, International Journal of Greenhouse Gas Control, 74,19-27.

Task 3- Environmental Monitoring Objectives

- Augment existing monitoring techniques- emphasis on stoichiometric methods
  - **Seawater**
    - Likely target for routine monitoring
    - Develop innovative geochemical methods and approaches for attribution
  - **Sediments**
    - QICS controlled release project - 85% retention in sediments (Blackford et al., 2014)
    - Link back to seismic features

Preliminary Results

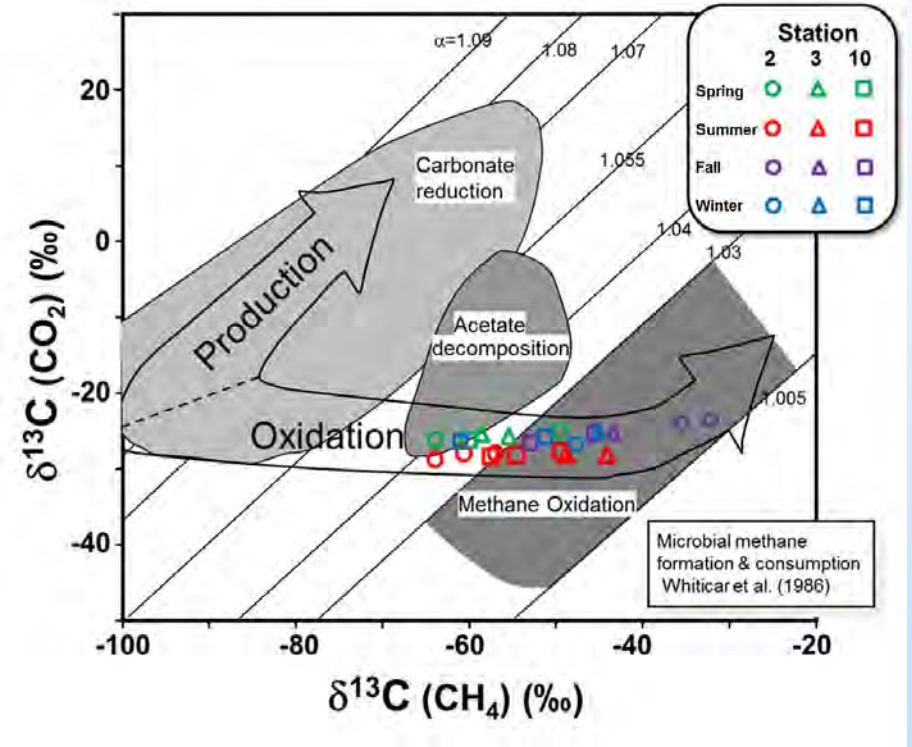
All needed data sets have been acquired as of August 9, 2018:

- Seawater
  - 2 months of data (February and May 2017)
- Dissolved gas in sediment pore water
  - Full seasonal range (May, August, November, 2017 and Feb, 2018)
- Injectate isotopic composition
- Reservoir geochemistry

Many thanks to Jun Kita, Marine Ecology Research Institute and Daiji Tanase of Japan CCS

Preliminary Results

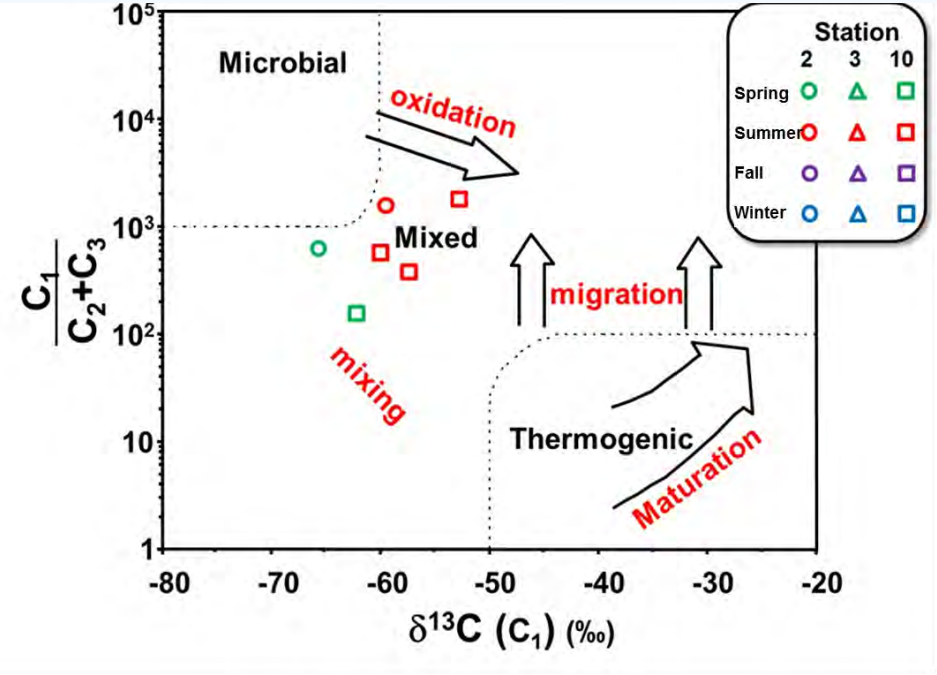
- CO_2 (300- 62,000 ppm)
- CH_4 (10-11,000 ppm)
- 6 samples have C_2- C_3
- CO_2 from the oxidation of CH_4
- Natural conditions are indicated



Whiticar, M.J. and Faber, E. (1986) Methane oxidation in sediment and water column environments—Isotope evidence. Org. Geochem. 10, 759-768.

Preliminary Results

- Bernhard ratios also support in-situ methane oxidation



Bernard, B.B. (1978) Light Hydrocarbons in marine sediments. Ph.D. dissertation, Texas A&M Univ. College Station, TX.

Accomplishments to Date: Geochemistry

- Learned marine sampling methods
- Acquired all needed data sets for advancing marine attribution methods
- Preliminary assessment of sediment geochemistry accomplished

Lessons Learned: Geochemistry

- Environmental monitoring and sediment sampling
  - Learned marine sample collection methods.
  - Data collection at sea is challenging

Synergy Opportunities

Offshore CCS at GCCC

- **GULF OF MEXICO**
  - GomCARB Partnership
  - CarbonSAFE
  - TXLA
  - BOEM
  - Miocene Megatransect
  - HR3D Seismic
  - Geochemistry
- **ATLANTIC**
  - Battelle Mid-Atlantic
  - SSEB South Atlantic
- **JAPAN**
  - Tomakomai
    - HR3D Seismic
    - Geochemistry
- **CHINA**
  - Pearl River Mouth Basin
- **NORTH SEA**
  - Scotland ACORN
  - NTNU
  - IODP GlaciStore
- **GLOBAL**
  - CSLF & IEA-GHG
  - International Offshore Storage Workshops
  - UNFCC (Nigeria)
- **HR3D SEISMIC**
  - 3 GoM 1 Japan surveys
  - Service Center

Meckel presenting Tomakomai summary at 3rd International Workshop on Offshore Geologic CO_2 Storage, Oslo, June 2018

Synergy Opportunities

- Last frontier – Overburden:
  - Plume mapping in the overburden and link to environmental risk- offshore and onshore.
    - Risk of overburden features- what do they really mean?
    - Link subsurface features to environmental outcomes LBNL in-situ continuous geophysics.
    - Parameters for feeding NRAP models (LBNL and others)
    - Location, attribution, quantification (IOS and LANL)
- Offshore:
  - Synergy with GoMCARB (BEG-GCCC), SECARB Offshore (SSEB), Offshore workshop series, and STEMM-CCS (UK)

Project Summary

- HR3D data have been **successfully acquired and processed** at an active international offshore CCS demonstration project at Tomakomai, and provide **excellent insight into subsurface geologic overburden** above injection interval.
  - Covers overburden interval not imaged by conventional 3D data.
  - Collaborative opportunity to digitally merge conventional and HR3D data for seamless product optimized for strengths of both imaging techniques.
    - Greer and Fomel, 2018, *Geophysics*: GoM Pcable data and conventional 3D success.
- **Second HR3D survey** planned summer 2019
  - Increase source size to attempt to image injection interval
  - Time lapse capability (repeatability) focus.
- **Geochemical sampling** of seawater and shallow marine sediments successful and results are being integrated into imaging interpretation.

Appendix

– These slides will not be discussed during the presentation, but are mandatory.

Benefit to the Program

Program goal being addressed:

- This study supports SubTER pillar 4 (new subsurface signals) and advances the long-term Carbon Storage program goal of developing technologies to ensure 99 percent storage permanence.

Benefits statement:

- The project will conduct research under Area of Interest 1, Field Demonstration of MVA Technologies, by deploying and validating novel ultra-high resolution 3D seismic technology for CCS MVA at an active operational field site. This research will advance the MVA technology development pathway to TRL 7 by validating a fully integrated prototype seismic imaging system including untested dynamic acoustic positioning. The technology will demonstrate significantly improved spatial resolution over a commercially-meaningful area with improved accuracy and economic viability, decreasing the cost and uncertainty in measurements needed to satisfy regulations for tracking the subsurface fate of CO_2.

Project Overview
Goals and Objectives

The primary goal of this study is to validate technologies to enhance the monitoring, verification, and accounting (MVA) of CO_2 injected underground for the purpose of long-term geologic storage and/or for enhanced recovery of oil and gas reserves.

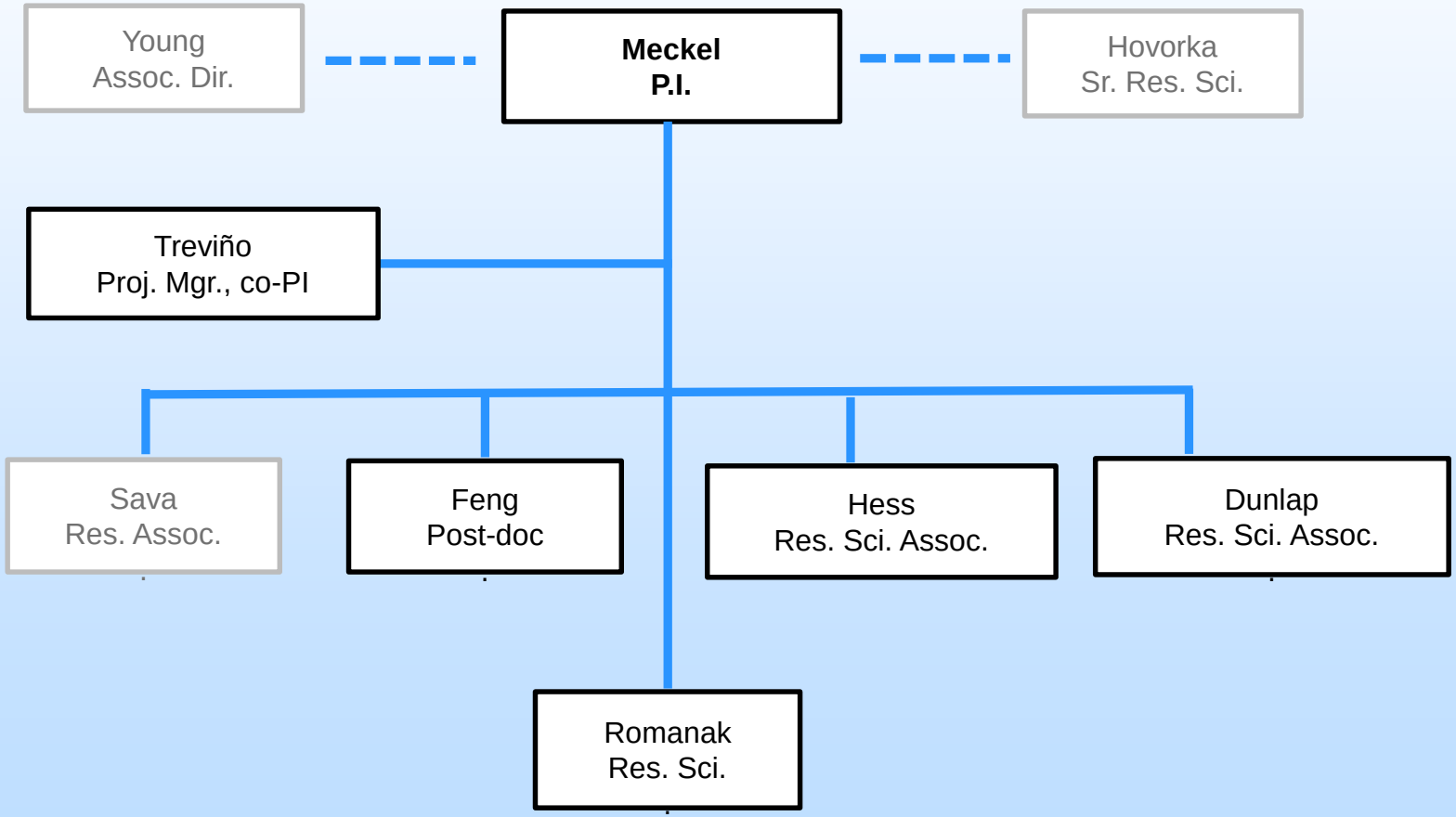
The objectives are to:

1) Acquire and validate at least one UHR3D seismic dataset at an operational CCS field demonstration project,

2) Validate untested dynamic acoustic positioning techniques during UHR3D data acquisition, and

3) Define the lateral extent and boundaries of the CO_2 plume, and to track and quantify uncertainty of spatial and temporal movement of CO_2 through the storage reservoir.

Organization Chart



Gantt Chart

		BUDGET PERIOD 1				BUDGET PERIOD 2				BUDGET PERIOD 3			
		YEAR 1				YEAR 2				YEAR 3			
Task	Tasks	qtr 1	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4
Field Validation of MVA Technology for Offshore CCS: Novel Ultra-High-Resolution 3D Marine Seismic Technology (P-Cable)													
1) PROJECT MANAGEMENT, PLANNING, and REPORTING													
1.1	PMP, TMP, DMP	D1 D2 D3											
1.2	Meetings												
1.3	Reporting	Q	Q	Q	Q A	Q	Q	Q	Q A	Q	Q	Q	Q A F
1,4	Project Management												
2) UHR3D SEISMIC IMAGING													
2.1	CO2 SENSITIVITY STUDY	M1		D4 DP1									
2.2	P-Cable ACQUISITION				M2 M3			M5	M6				
2.3	P-Cable PROCESSING					D5	M4 D6 DP2				M8		
2.4	P-Cable INTERPRETATION								D7			D9	M10
3) SHALLOW SEDIMENT CORE SAMPLING AND GEOCHEMISTRY													
3.1	Shallow Sediment Core Sampling									M7			
3.2	Core Geochemistry										M9		
3.3	Interpretation & Integration											D8	

Bibliography

- List peer reviewed publications generated from the project per the format of the examples below.

  - None to - date