RESEARCH PERFORMANCE PROGRESS REPORT

U.S. Department of Energy National Energy Technology Laboratory

Cooperative Agreement: DE-FE0031558

Project Title: Partnership for Offshore Carbon Storage Resources and Technology Development in the Gulf of Mexico

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Reporting Period End Date: December 31, 2020

Report Frequency: Quarterly

Signature Submitting Official: ____

EXECUTIVE SUMMARY OF RESEARCH DEVELOPMENTS DURING THIS QUARTER

Project Management

The subcontract with sub-recipient, Aker Solutions, was signed on November 12.

Deliverable 2.2a was submitted on December 3, 2020 to the NETL project manager.

On December 17, 2020, the Partnership was informed that it had received approval to proceed to budget period 2.

The Milestone 6 report was completed by the end of the reporting period.

Offshore Storage Resource Assessment

The total number of wells with LAS curves along the middle Texas coast as of the end of the reporting period was 1150.

The FF_3DCameron seismic depth volume ~~previously leased from FairField Geotechnologies~~ was interpreted to further extend our understanding of the subsurface of the near offshore Louisiana waters, Cameron Parish.

Well-log correlation and determination of gross-sandstone distribution of lower Miocene gross-sandstone distribution in Corpus Christi Bay and Redfish Bay and adjacent areas were conducted in the reporting period.

GCCC researchers consulted with Christopher Smith and Michael Smith, PhD, Senior Chemists at Advanced Hydrocarbon Systems, regarding possible utility of a fluid inclusions dataset, to which the project has access, to determine CO_2 retainment through geologic time by a primary confining zone of the study region. To-date, there are no conclusions.

Risk Assessment & Geologic Modeling

Researchers at LLNL created a finite element-finite volume model that incorporates a spatially heterogeneous permeability distribution model of the High Island 24L site. LLNL conducted a sensitivity analysis on the geomechanical parameters and investigated the influence of fault sealing on the fluid flow. Results of the simulations suggest that the reservoir has remarkable injectivity, allowing for a large amount of fluid to be injected without a substantial increase in pore pressure.

One major observation of the reservoir flow model scenarios reported in the previous quarterly report (i.e., Milestone 5) and in Milestone 6 of the current reporting quarter is that even injecting 50 million tonnes of CO_2 into the Miocene age reservoir, the CO_2 plume does not reach the models' faulted area. Even considering worse-case scenarios, where vertical permeabilities are exaggerated or hysteresis effects are completely ignored, although the CO2 plume grows larger, it still remains within the intended area and zone.

Monitoring, Verification, and Assessment (MVA)

The LBNL/Rice team initiated discussion with several GoM off-shore fiber providers (primarily Tampnet) to identify accessible dark fiber routes in TX state waters.

The team from Lamar University collected literature data and validated the CFD model used for the prediction of CO_2 leakage and dispersion. They also performed ANSYS Fluent CFD simulations of a CO_2 leakage scenario from a High Island 10L injection well with the validated model.

Infrastructure, Operations and Permitting

During this quarter, Trimeric began to organize major research areas from BP1 into summary memorandums. The purpose of the summary memorandums includes the following:

- Consolidate key findings from major research areas into individual documents to enhance accessibility and distribution to interested parties (e.g., in contrast to a single large report document).
- Provide references to more detailed research deliverables (e.g., spreadsheets/databases, detailed reports). In this respect, the memorandum also serves as a catalog of the deliverables produced.
- At the end of the project, the series of memorandums will serve as summary of the project findings.

During the past quarter, Trimeric prepared a draft memorandum summarizing research on re-use of existing pipelines. The memorandum is expected to be finalized in Q1 of 2021. In addition, analogous memorandums are being prepared for platform and well re-use.

Lamar University researchers prepared a manuscript for peer-review titled "Estimating the Power Requirements for a Carbon Capture and Storage Operation Based on the Total Operating Capacity of a Petroleum Refinery." They also conducted a literature search for data required for the Aspen HYSYS simulation to use ionic liquids as a replacement for amine compounds for the separation of CO_2 from flue stack gases.

A feasibility study report from Aker Solutions contains a proposed subsea system for CO_2 storage field solutions and main subsea equipment designs for Gulf of Mexico Partnership for Offshore Carbon Storage (GoMCarb) project.

The key focus areas for this GoMCarb subsea systems scope work have been:

- Screen and select a field architecture based on 5 wells development and location of Bottom Holes.
- Propose a safe and robust technical design, which would fulfil all project specific functional requirements.
- Identify all potential technology gaps related to subsea systems purposed for CO_2 injection in shallow waters. No significant gaps were identified at this point.
- Propose an efficient and cost optimal project execution model based on standard equipment.

Knowledge Dissemination

This team from the UT Stan Richards school of Advertising and Public Relations focused on finalizing the CCS message-testing survey of Texas residents in the Gulf Coast and fielding it among the target sample of 900 respondents in the study area. The contract with survey company, Ipsos, was signed by UT.

Technical outreach by several members of the GCCC as well as Lawrence Berkeley National Lab continued in the form of virtual presentations.

Task 1.0 – Project Management, Planning, and Reporting

Monthly spending and encumbrances were reported to the NETL project manager as were short summaries of monthly progress.

After over a year of effort, the subcontract between the University of Texas at Austin and sub-recipient, Aker Solutions, was signed on November 12.

Deliverable 2.2a, "Bulleted list of data gaps, acquisition strategies and plans to address data gaps," was submitted on December 3, 2020 to the NETL project manager.

Per discussions with the NETL project manager and feedback from the contract specialist on December 17, 2020, the Partnership was informed that it had received approval to proceed to budget period 2.

In December Trimeric provided a BP1 Wrap-Up for BEG Team Members: Trimeric provided a presentation summarizing BP1 progress and results for BEG, including a discussion of BP2 priorities opportunities. The meeting served two primary purposes:

a. Summarize all areas of BP1 progress in a single presentation to provide a snapshot of the project at the kickoff/initial scope and again at the end of BP1.

b. Served as a preliminary planning session for BP2 efforts. The group identified several areas of interest that merit further evaluation in BP2.

Task 2.0 – Offshore Storage Resource Assessment

Subtask 2.1 – Database development:

Well Database

During the quarterly reporting period, the undergraduate research assistants continued to populate the Petra™ project with well curve raster images and digitized well log curves. Raster images were loaded from Lexco OWL7 and log curves digitized from the images, thus, generating digital LAS (Log ASCII Standard) curves. Primarily, SP (spontaneous potential) curves have been digitized because they are used to define log facies and correlate wells. The total number of wells with LAS curves along the middle Texas coast as of the end of the reporting period was 1150. Figure 2.1.1 illustrates the distribution of wells and the primary 3D seismic datasets within the project area.

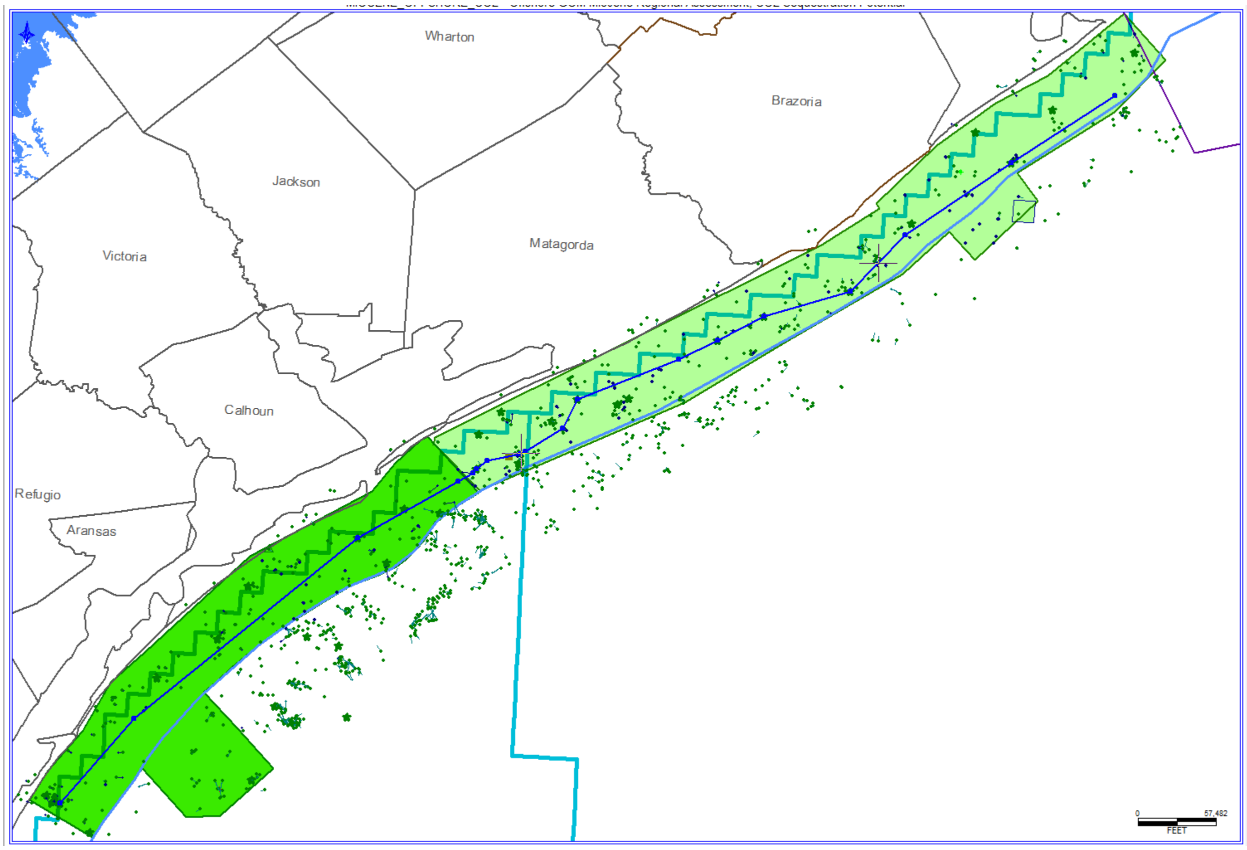


Figure 2.1.1 – Map of the study area from offshore Corpus Christi Bay to Galveston Bay showing the 3D seismic surveys (OBS - light green, OBS South - dark green) The state - federal waters boundary is demarcated by the blue line subparallel to the coast. There are 1150 digital wells in the study area, 1050 of which have LAS SP curves (green dots), 77 have LAS density, porosity and sonic curves (blue dots) and 55 have GR curves (red rhombs). A strike-oriented (SW-NE) cross-section (shown in Fig. 2.1.2) is indicated by the dark blue line.

Subtask 2.1.1 – Geographic Focus Area A - Lake Jackson, Lake Charles, and Lafayette (OCS) districts

Subtask 2.1.1.1 Western Louisiana, Lafayette and Lake Charles Districts

The 3D seismic depth volume, FF3D Cameron, ~~previously leased from FairField Geotechnologies~~ was interpreted to further extend our understanding of the subsurface of the near offshore Louisiana waters, Cameron Parish. (Figure 2.1.1.1.1).

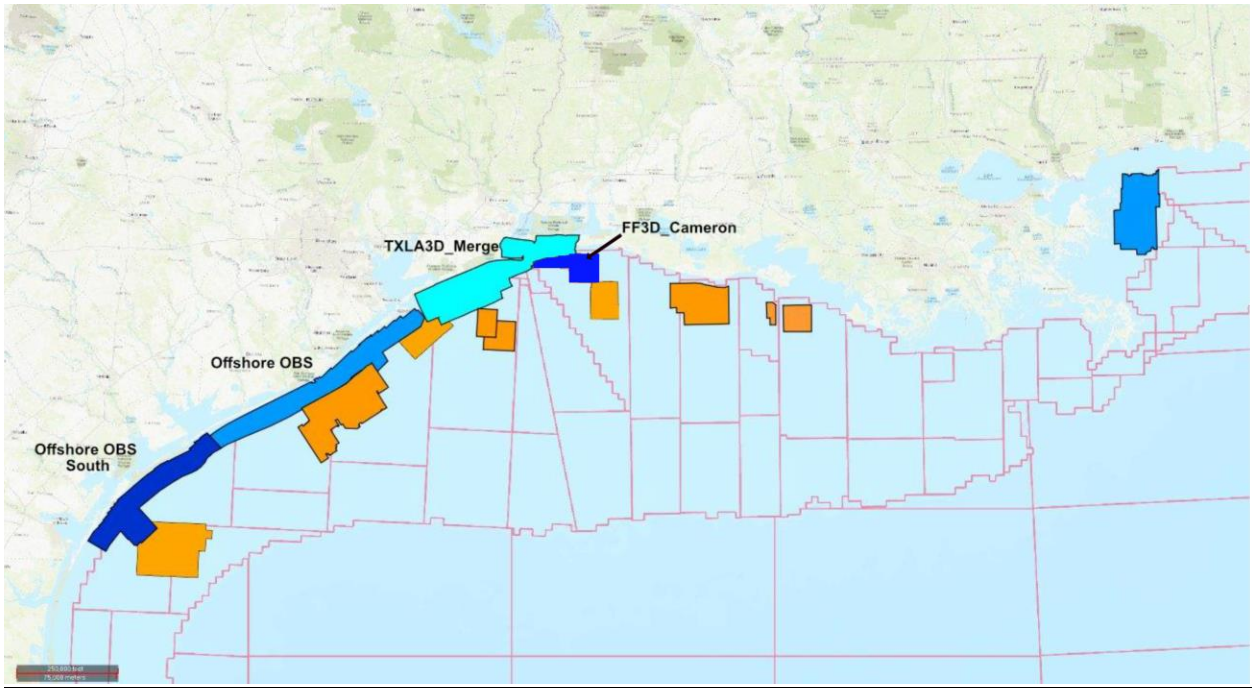


Figure 2.1.1.1.1. Base map of GoMCarb 3D seismic volumes with leased datasets in different shades of blue. From left to right: Offshore OBS South 3D (cobalt blue), Offshore OBS 3D (cerulean blue), TXLA Merge (turquoise blue), FF3D_Cameron (Navy Blue), and Chandeleur Sound 3D (cerulean blue), and publicly available NAMSS 3D seismic data sets (orange).

Site Assessment

Seven horizons interpreted in previous regional analyses were depth converted and used to correlate between two overlapping 3D surveys, TXLA_Merge and FF3D_Cameron (Figure 2.1.1.1.2). The depth conversion used a migration velocity volume generated during the TXLA_Merge data processing process to convert the two-way time horizons to TVD Depth. Figure 2.1.1.1.3 shows a map with annotated cross-section location extracted from the FF3D_Cameron seismic data. Figure 2.1.1.1.4 shows the un-interpreted north-south seismic dip line. Figure 2.1.1.1.5 has interpretations with SP logs, faults, picks, and associated horizons.

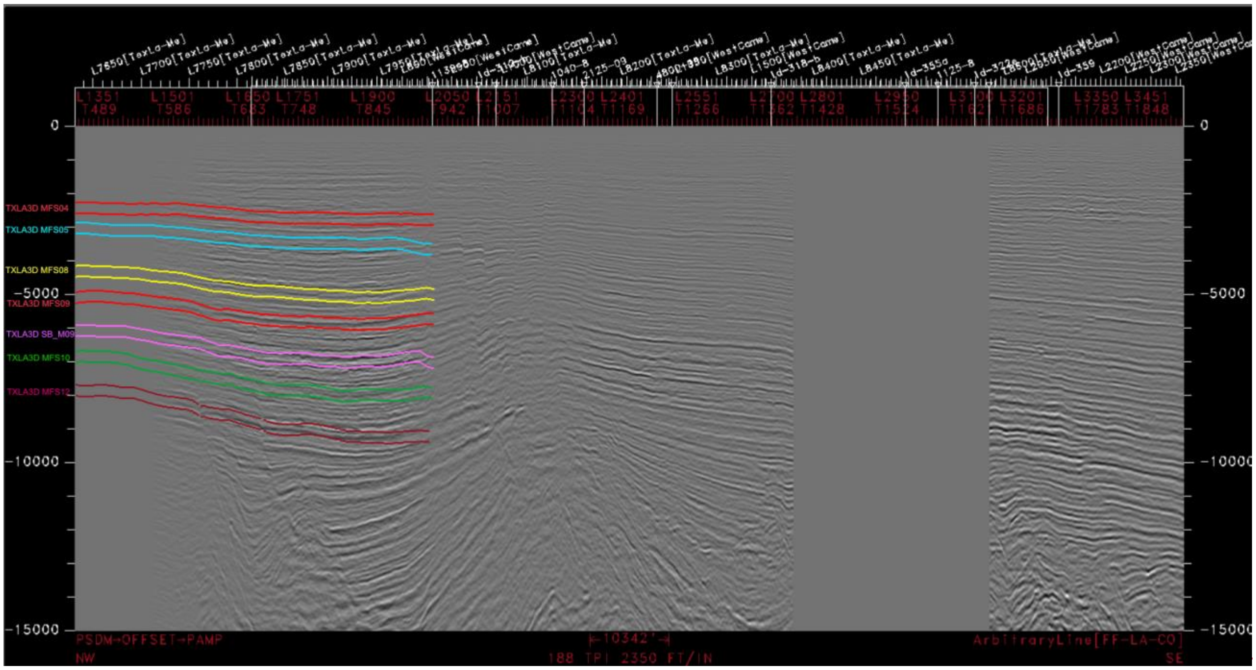


Figure 2.1.1.1.2. Seismic section showing seven key horizons mapped from previous regional analysis were extended into the overlapping FF3D_Cameron seismic survey. (Proprietary seismic data figure redacted.)

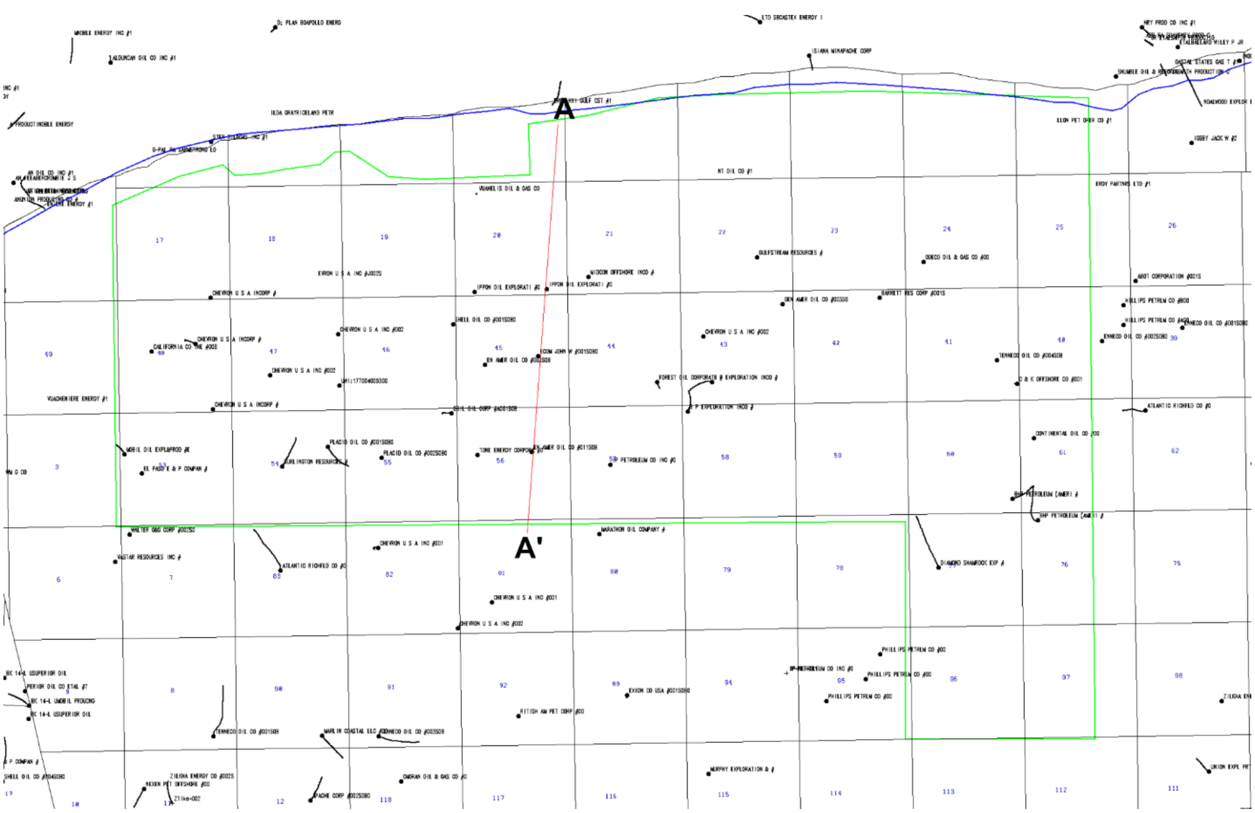


Figure 2.1.1.1.3. Base map of the FF3D_Cameron study area with cross-section A-A’ annotated.

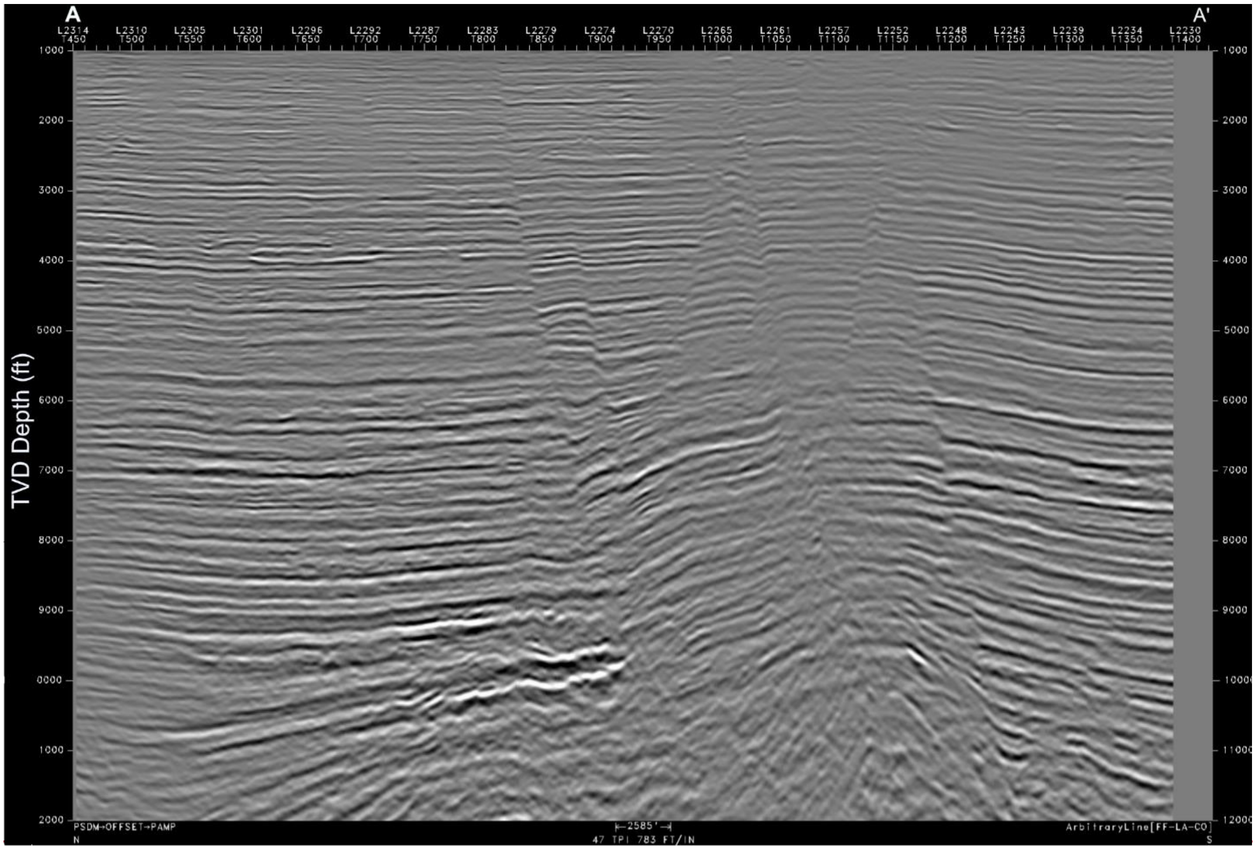


Figure 2.1.1.1.4. An un-interpreted seismic cross-section A-A'.. (Proprietary seismic data figure redacted.)

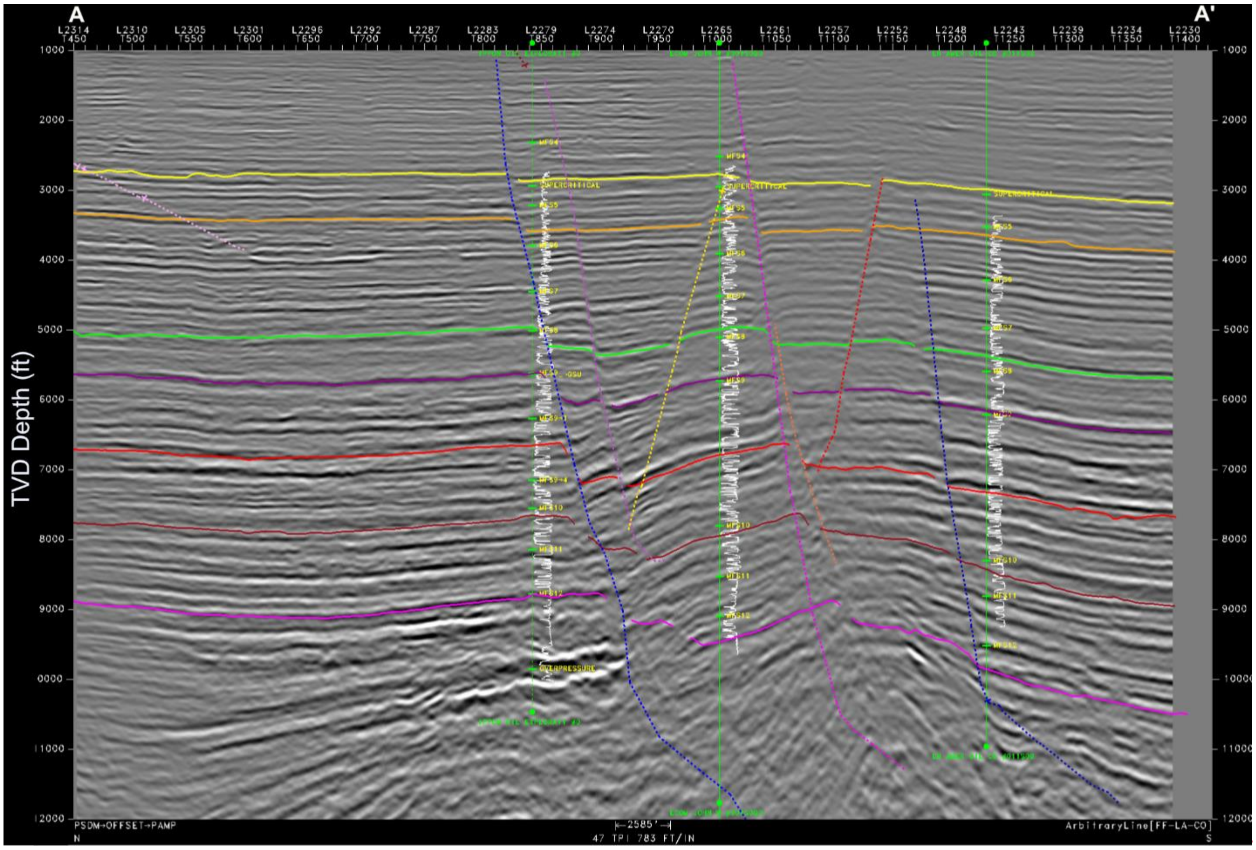


Figure 2.1.1.1.5. An interpreted seismic cross-section A-A'.

In the previous quarterly report, we showed structural and amplitude maps (Figures 2.1.1.1.6 and 2.1.1.1.7). The structural maps are used to identify areas that might be topographically conducive (high areas with closure/trapping features) for carbon capture and storage (CCS). The RMS amplitude maps can also identify mudstone-dominated rocks (shale), typically manifested, as low amplitude zones/areas in seismic. In addition, the RMS amplitudes are sensitive to sandstone-bearing depositional systems tracts, usually manifested as high amplitudes, within the reservoir-bearing successions and help define the spatial distribution of genetically related depositional successions. . (Proprietary seismic data figure redacted.)

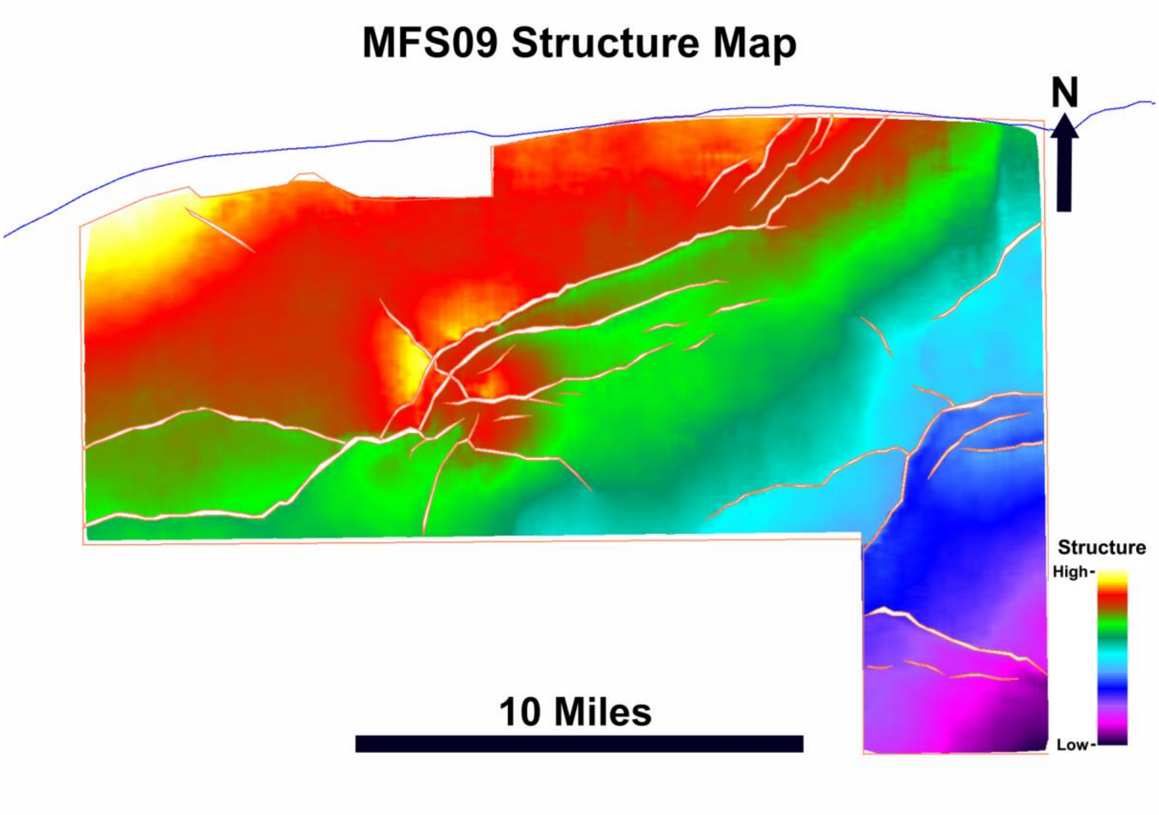


Figure 2.1.1.1.6. Surface MFS09 structure map in the FF3D_Cameron seismic survey. There are 34 interpreted fault planes (polygons) that contact this horizon.

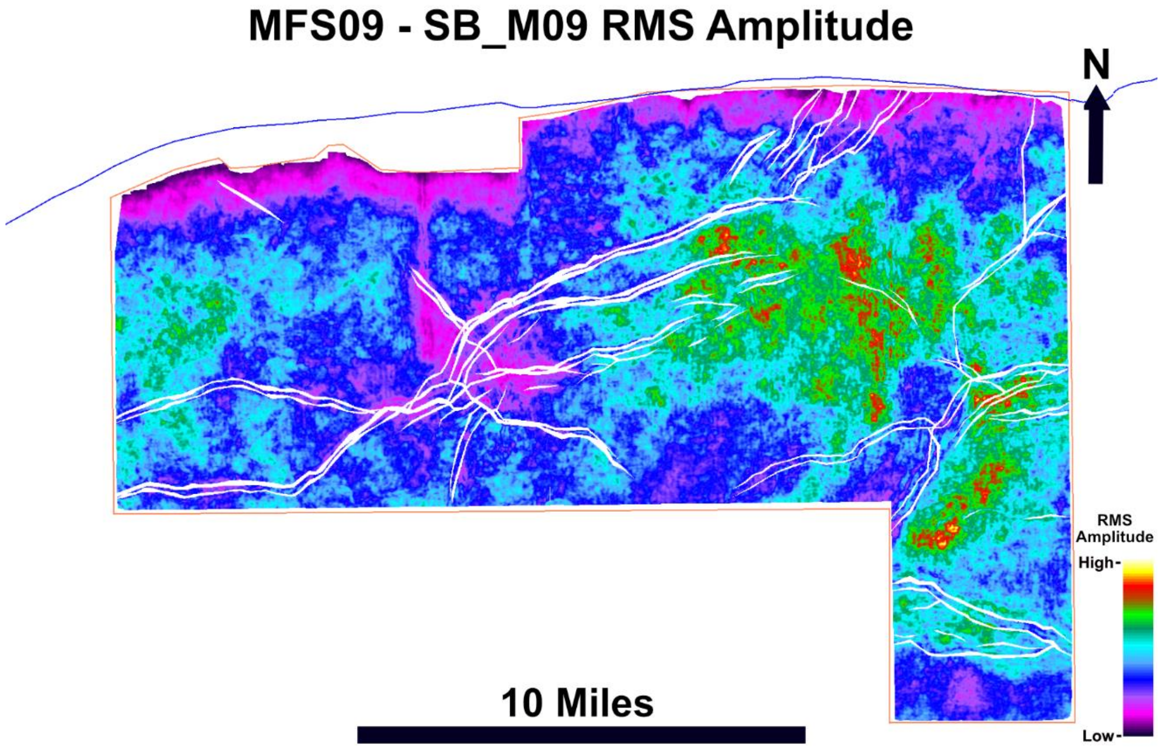


Figure 2.1.1.1.7. RMS amplitude map extracted from the interval between MFS09 and SB_M09 in the FF3D_Cameron seismic survey. High-amplitude signatures (yellow to red) record largely sand rich facies.

The MFS09 surface (top of the prime geological storage interval) was used to identify the largest 50 structural closures in the FF3D_Cameron study area. The associated "fetch areas" represent zones that would contain any potential migrating fluids by trapping in the associated closure, capillary trapping throughout the migration path, and/or dissolution (Figures 2.1.1.1.8, 2.1.1.1.9 and 2.1.1.1.10). Figure 2.1.1.1.11 shows known culture (pipelines, oil & gas fields, etc.) and the closure/fetch pairs within the study area. By combining the seismic structural interpretation, seismic attribute analysis, well logs, historical production, and closure/fetch analytical quantitative information, we can begin ranking potential CCS sequestration sites.

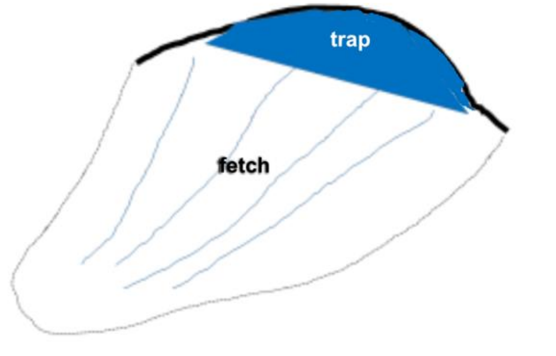


Figure 2.1.1.1.8. Depiction of trap and fetch.

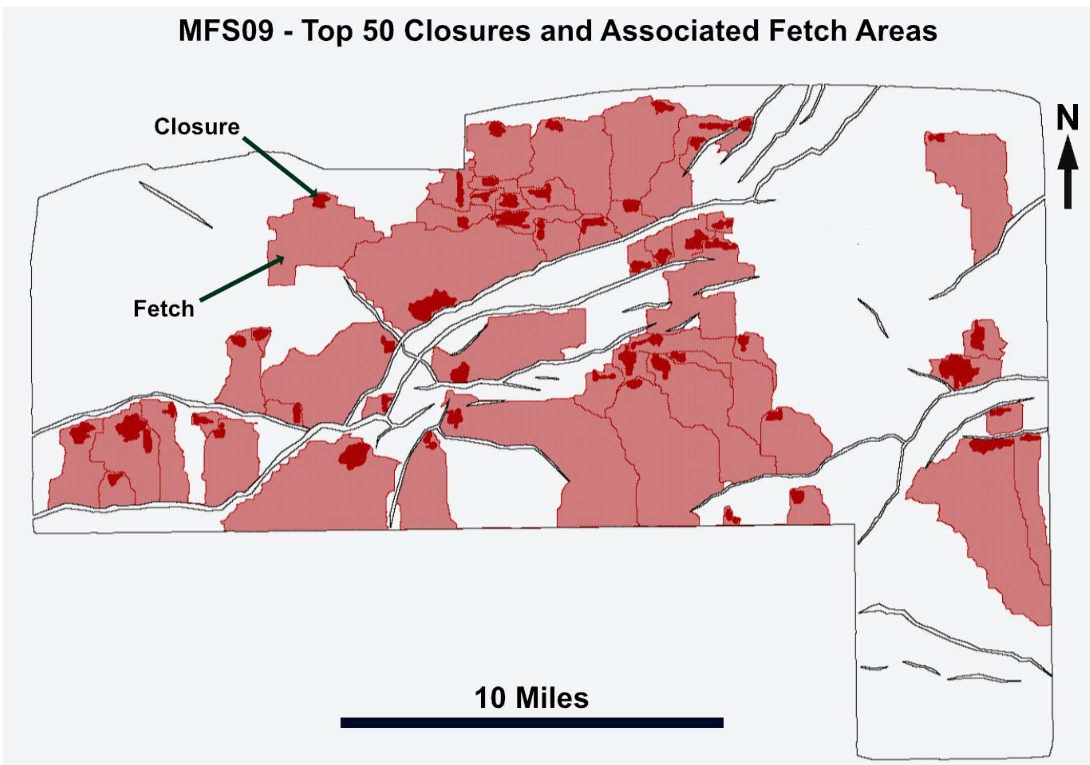


Figure 2.1.1.1.9. FF3D_Cameron survey showing the top 50 closures mapped on the MFS09 horizon with their associated fetch areas.

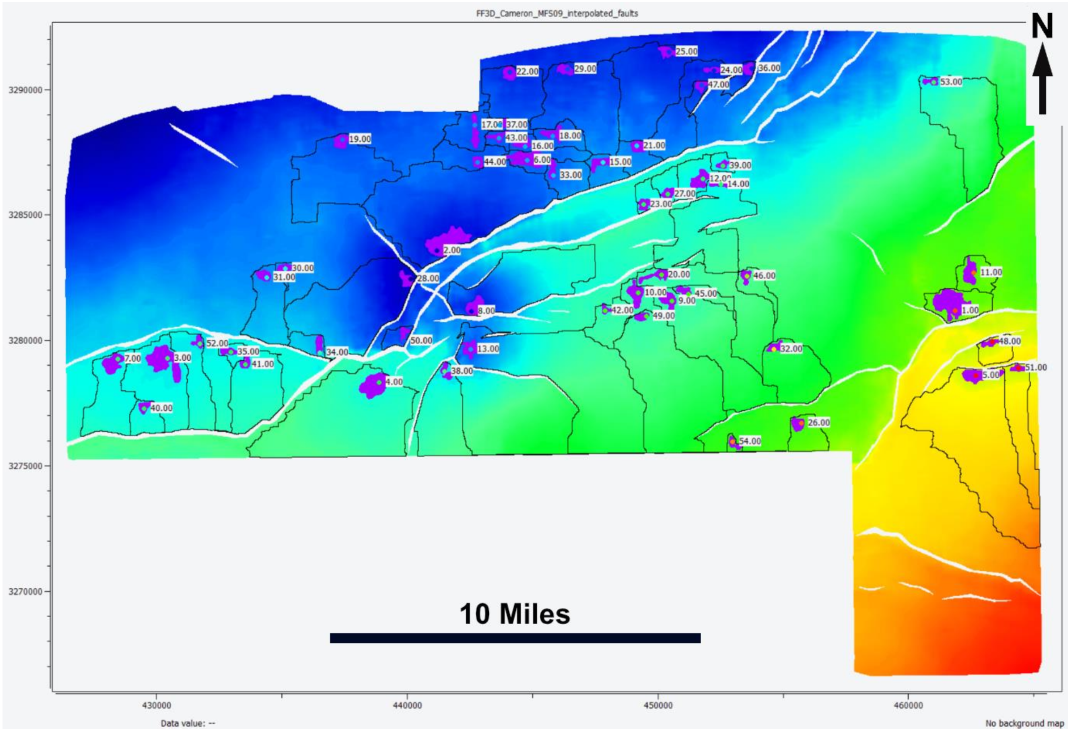


Figure 2.1.1.1.10. FF3D_Cameron survey showing the top 50 closures and fetch areas on the MFS09 horizon with their associated ID numbers.

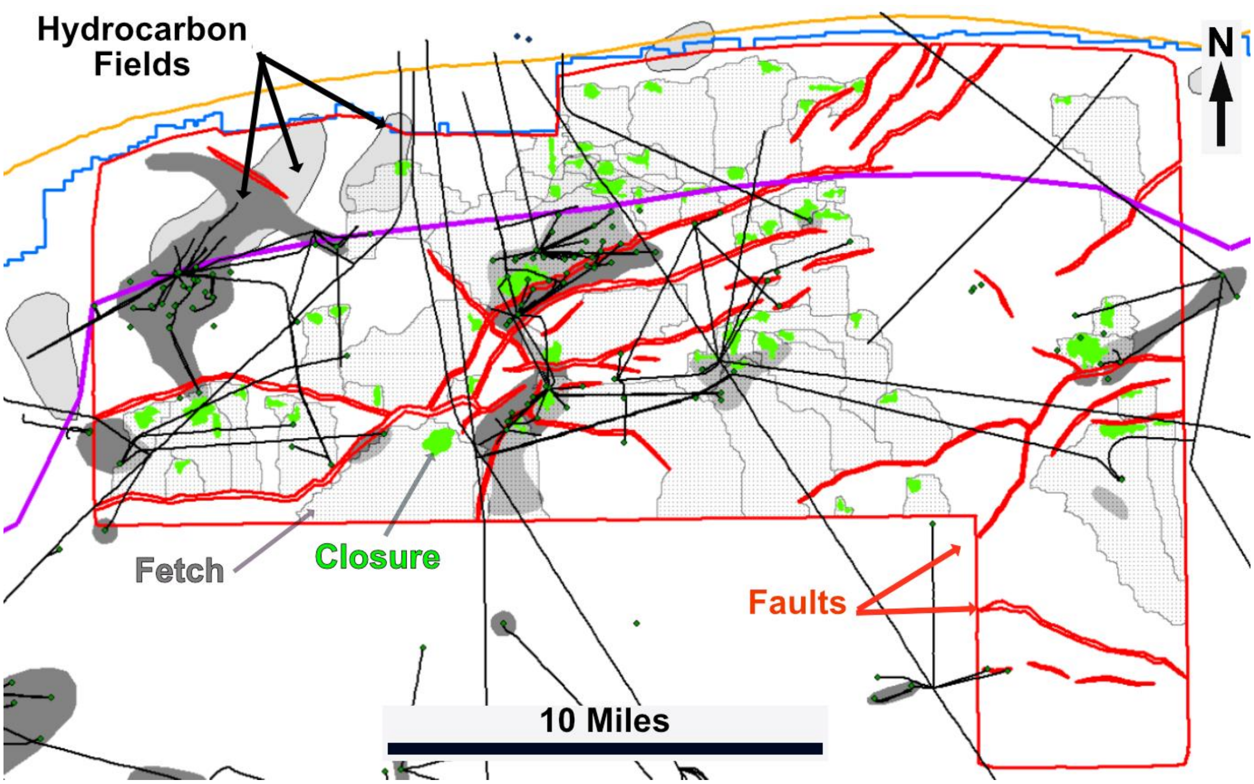


Figure 2.1.1.1.11. FF3D_Cameron survey showing the top 50 structural closures (green) mapped on the MFS09 horizon with their associated fetch areas (stippled gray) overlain with important culture (fault polygons [thick red lines], hydrocarbon fields [gray polygons, pipelines [thin black lines], etc.).

Subtask 2.1.1.2 Mid-Texas coast offshore Houston to Corpus Christi

Gross-Sandstone Distribution in Corpus Christi Bay and Redfish Bay

Well-log correlation and determination of gross-sandstone distribution of lower Miocene gross-sandstone distribution in Corpus Christi Bay and Redfish Bay and adjacent areas were conducted in the reporting period (Figure 2.1.1.2.1). Herein, we discuss final findings; correlation within the study area has been completed. The Corpus Christi Bay and Redfish Bay area constitutes the shoreward (northwestward) extension of the Texas State waters, the site of stratigraphic and sandstone-distribution study from previous study periods. Notably, the study area is the location of several major industrial sources of CO_2. Therefore, such characterization could eventually be used in identifying and evaluating site(s) for CO_2 injection in reservoir-quality sandstones.

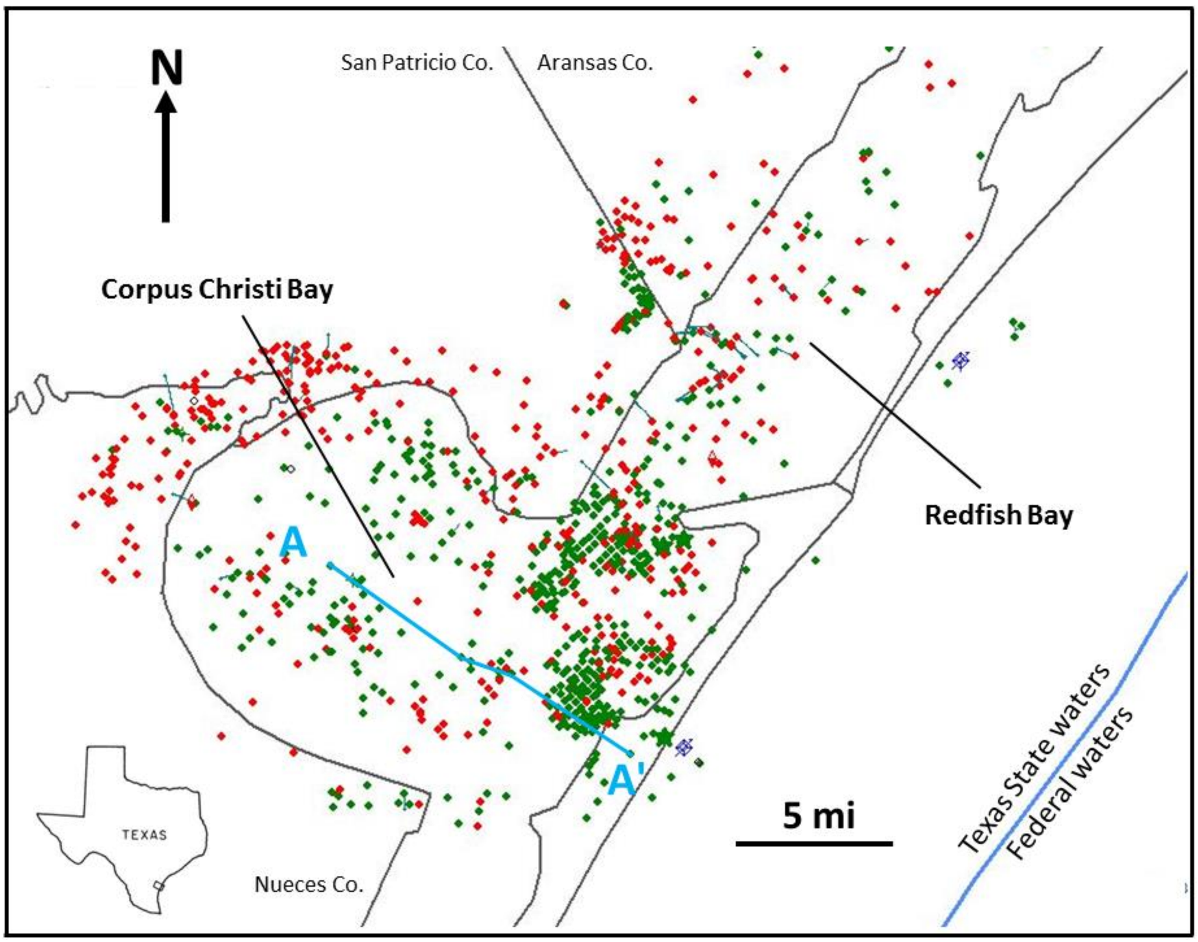


Figure 2.1.1.2.1 - Map of Corpus Christi Bay and Redfish Bay areas, showing distribution of 1,019 wells in the study area. Red spots represent wells with raster logs only; green spots are locations of wells with both raster and digitized logs.

Four stratigraphic zones extend continuously from the Texas State waters into Corpus Christi Bay and Redfish Bay— the Oligocene Anahuac Shale and lower Miocene sequences 10, 9, and 8 (Figure 2.1.1.2.2). The succession comprises several regional upward-coarsening (progradational) intervals that range in thickness from about 930 ft (~280 m, SB 9 to SB 10) to about 1,970 ft (~600 m, SB 9 to SB 8). As discussed in a previous quarterly report, these intervals are low-order transgressive and highstand systems tracts that record highstand barrier-bar facies within what Galloway (1985, 1989) termed the Matagorda Barrier/Strandplain System. This facies complex is bounded above by the *Amphistegina B* shale (MFS 9 interval) and below by the maximum flooding surface of the Anahuac Shale. Sequence 8 (SB 8 to SB 9) is a vertical continuation of this cyclic, upward-coarsening stacking pattern.

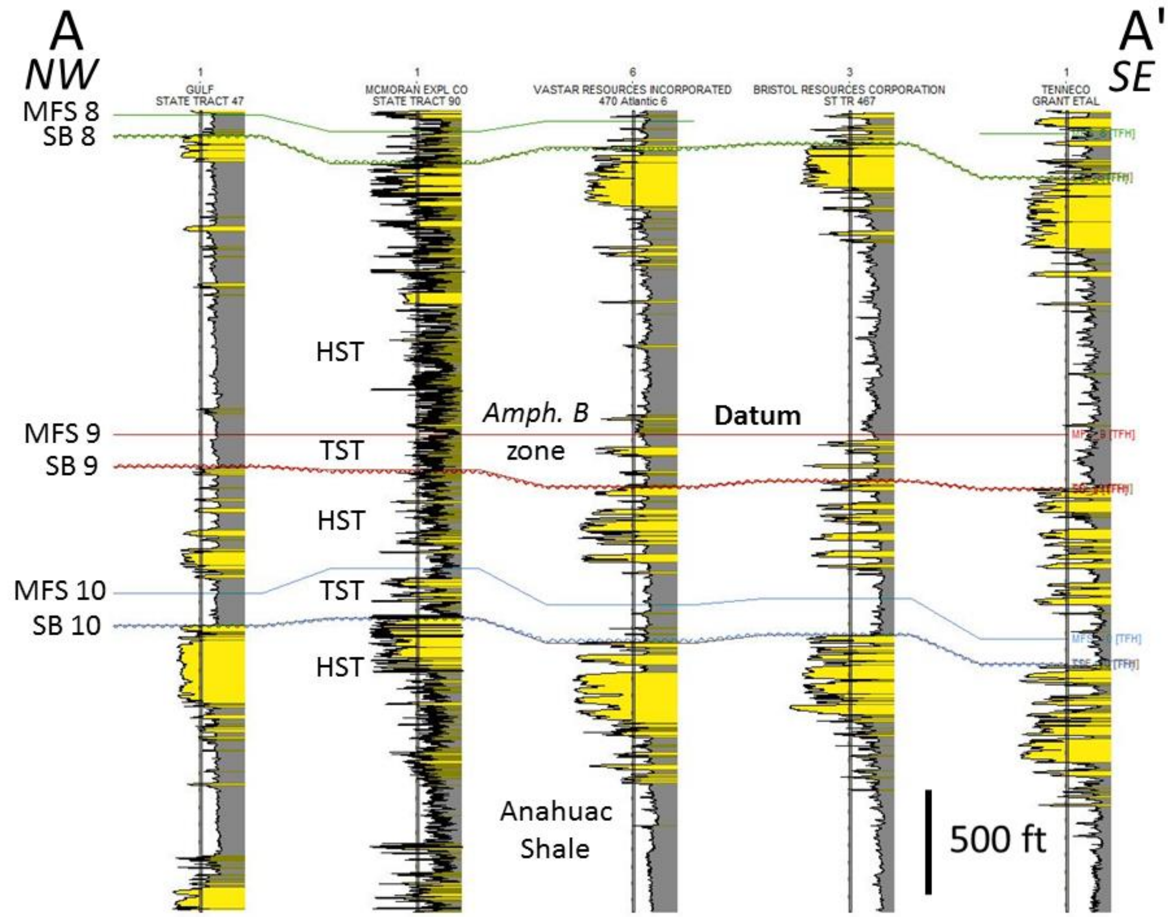


Figure 2.1.1.2.2. Depositional-dip cross section A-A'. SB = sequence boundary, MFS = maximum flooding surface, HST = highstand systems tract, TST = transgressive systems tract.

The Oligocene Anahuac Shale decreases in thickness from about 1,100 ft (~335 m) in downdip areas of Texas State waters (i.e., offshore from the barrier islands) to about 650 ft (~200 m) in the Corpus Christi Bay and Redfish Bay area. Sequence 8 (SB 9 to SB 8) is gradually truncated at the top of well logs toward the northwest because that part of the section was not logged in those wells. Thickness of individual sandstone bodies within upward-coarsening and blocky barrier-bar successions ranges from <100 ft (<30 m) to about 450 ft (~140 m) in the top-of-Anahuac Shale to SB 10 interval, <10 ft (<3 m) to about 150 ft (~45 m) in the MFS 10 to SB 9 interval, and <10 ft (<3 m) to about 415 ft (125 m) in the MFS 9 to SB 8 interval. Shaly, generally upward-fining, transgressive systems tracts (TST's) are much thinner than the sandy highstand systems tracts (HST's) (Figure 2.1.1.2.2), ranging from <100 to >300 ft (<30 to >90 m) thick.

Gross-Sandstone Mapping of Lower Miocene Sandstones

Areal delineation of the sandstone-rich lower Miocene strata of the Corpus Christi Bay and Redfish Bay region (Figure 2.1.1.2.1) was the primary task of this study period. Three stratigraphic zones bounded by a maximum flooding surface below and the overlying sequence boundary were mapped using the only well logs

1. Anahuac Shale to SB 10, (Figure 2.1.1.2.4)
2. MFS 10 to SB 9 (Figure 2.1.1.2.5), and the overlying
3. MFS 9 to SB 8 zone (Figure 2.1.1.2.6).

Strongly shoreline-parallel lower Miocene sandstone strata in the Corpus Christi Bay and Redfish Bay area record conformable, highstand barrier-bar facies. The system is flanked in the southwest and northeast by the North Padre and Calcasieu Delta Systems, respectively, of the early Miocene depositional episode of the southeastern Texas Gulf Coast.

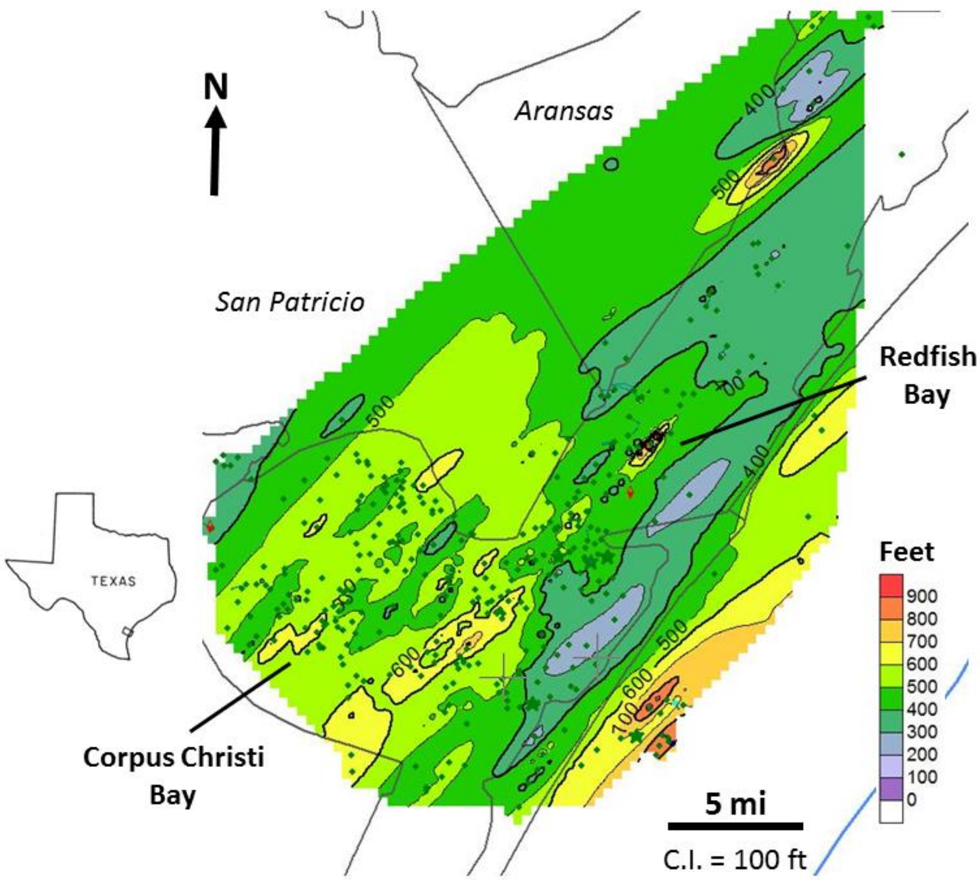


Figure 2.1.1.2.4. Gross-sandstone map of the Anahuac Shale to SB 10 interval. Note elongate

sandstone bodies trending southwest to northeast, sub-parallel to the modern shoreline. Contour interval is 100 ft.

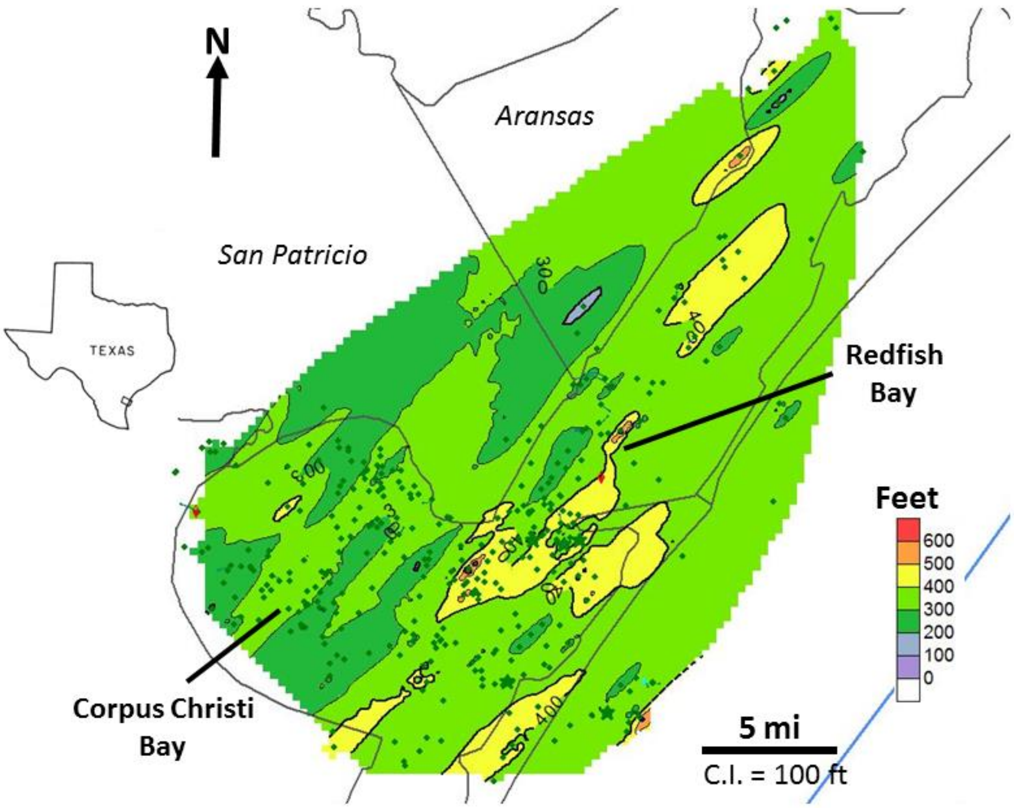


Figure 2.1.1.2.5. Gross-sandstone map of the MFS 10 to SB 9 interval. As in the underlying Anahuac Shale to SB 10 zone (Figure 2.1.1.2.4), sandstone bodies trend southwest to northeast. Contour interval is 100 ft.

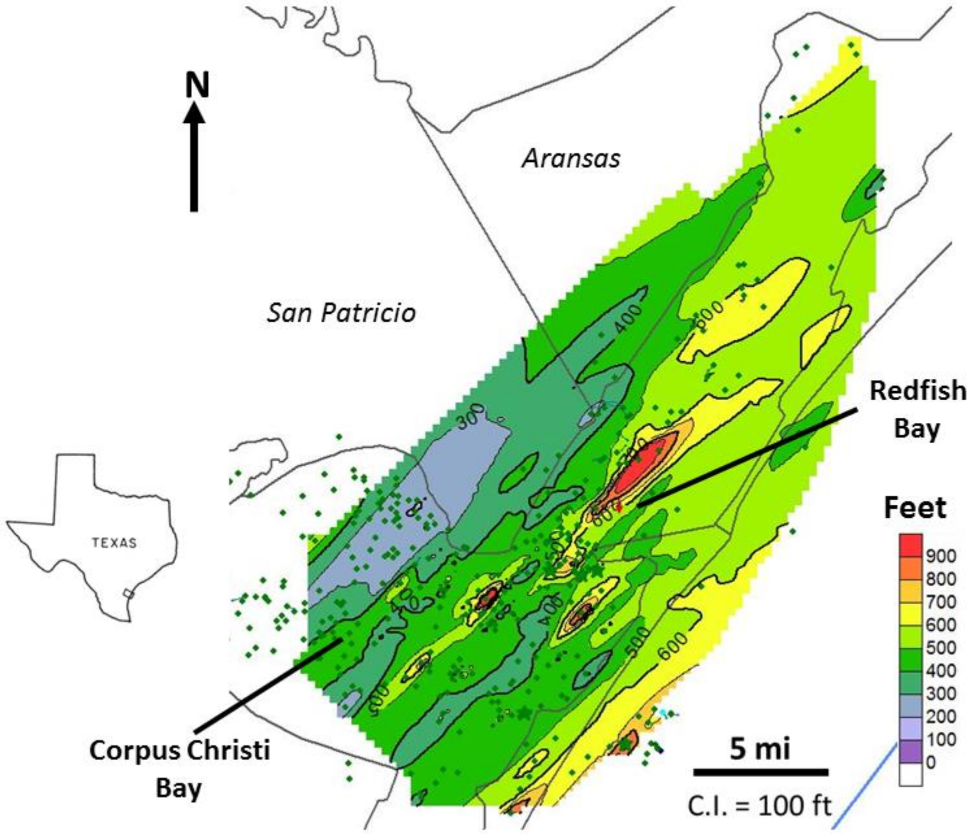


Figure 2.1.1.2.6. Gross-sandstone map of the MFS 9 to SB 8 interval.

In addition to well log-based geologic characterization, the availability and utility of seismic data in the region is being assessed.

References

Galloway, W. E., 1985, Depositional framework of the lower Miocene (Fleming) episode, northwestern Gulf Coast Basin: Gulf Coast Association of Geological Societies Transactions, v. 35, p. 67–73.

Galloway, W. E., 1989, Depositional framework and hydrocarbon resources of the early Miocene (Fleming) episode, northwest Gulf Coast Basin, *in* M. C. Hunt and S. V. Doenges (eds.): Studies Related to Continental Margins, Marine Geology, v. 90, p. 19–29.

Zeng, H., R. G. Loucks, and U. Hammes, 2008, Linear amplitude patterns in Corpus Christi Bay Frio subbasin, south Texas: Interpretive pitfalls or depositional features?: Geophysics, v. 73, no. 5, p. A27–A31.

The geologic sections available for storage in the Middle Miocene above MFS9 and Lower Miocene below MFS10 are limited by the depth of the supercritical (3300 ft) and top of the overpressure which varies across the area (Fig. 2.1.2). The stratigraphic interval between MFS9 and MFS 10 is entirely contained in the storage window.

Subsurface wire-line log correlations were performed using the genetic sequence approach of Galloway, 1989 because muddy intervals, such the regional *Amphistegina B* shale which are formed during marine transgressions, are easily identifiable (correlatable) on SP logs (Fig. 2.1.1.2.7). Stratigraphically, the Lower Miocene is bounded at the base by the *Anahuac* shale and at the top by the *Amphistegina B* shale (Galloway et al., 2000). The lower Miocene interval from *Robulus L* (MFS10) to *Amphistegina B* (MFS9) has been further subdivided into five 4th order cycles to provide finer scale stratigraphic detail and interpretation of depositional environments.

Sandstone and mudstone distribution were interpreted from electric log patterns. Since Self-potential (**SP)** log measurements have been recorded by various companies with different generations of logging tools and various scaling, normalization of the data was necessary. Self-potential values were normalized by rescaling all curves, either by stretching or squeezing them to correspond to a type of SP curve **(-80 to +20 MV)**. A cutoff value of -26 MV is used to differentiate lithologies (sandstone vs. mudstone). The normalized curves allow for sandy intervals (SP values between -80 and -26 MV) to be correlated enabling improved stratigraphic interpretation and mapping of sandstone bodies to depict depositional environments.

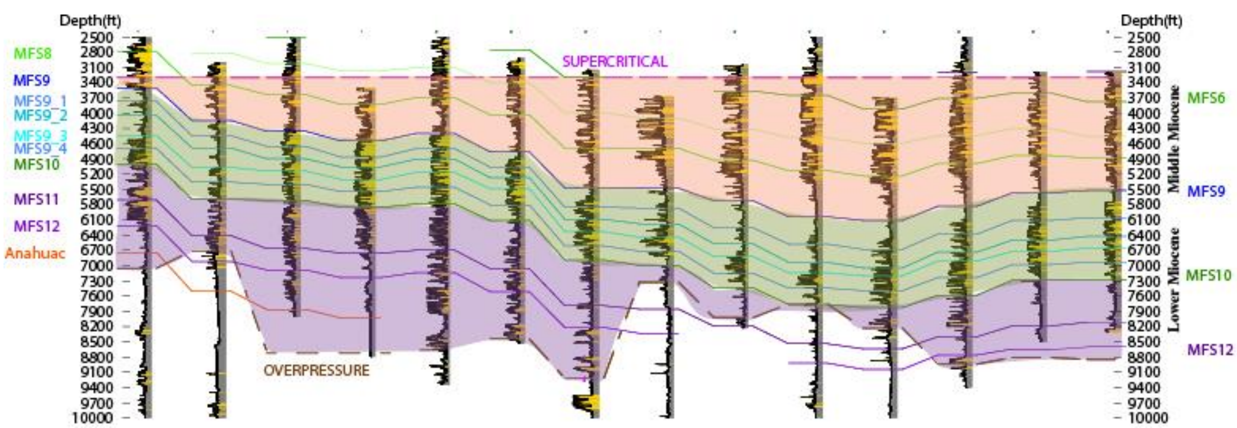


Figure 2.1.1.2.7 – Strike-oriented structural cross-section running offshore between Corpus Christi Bay and Galveston Bay (for location see Fig. 2.1.1) The potential stratigraphic interval suitable for CO2 storage between supercritical depth and the top of the overpressure is separated in three major intervals: Middle Miocene between supercritical and MFS 9, Lower Miocene between MFS 9 and MFS 10 and Lower Miocene between MFS10 and the top of the overpressure.

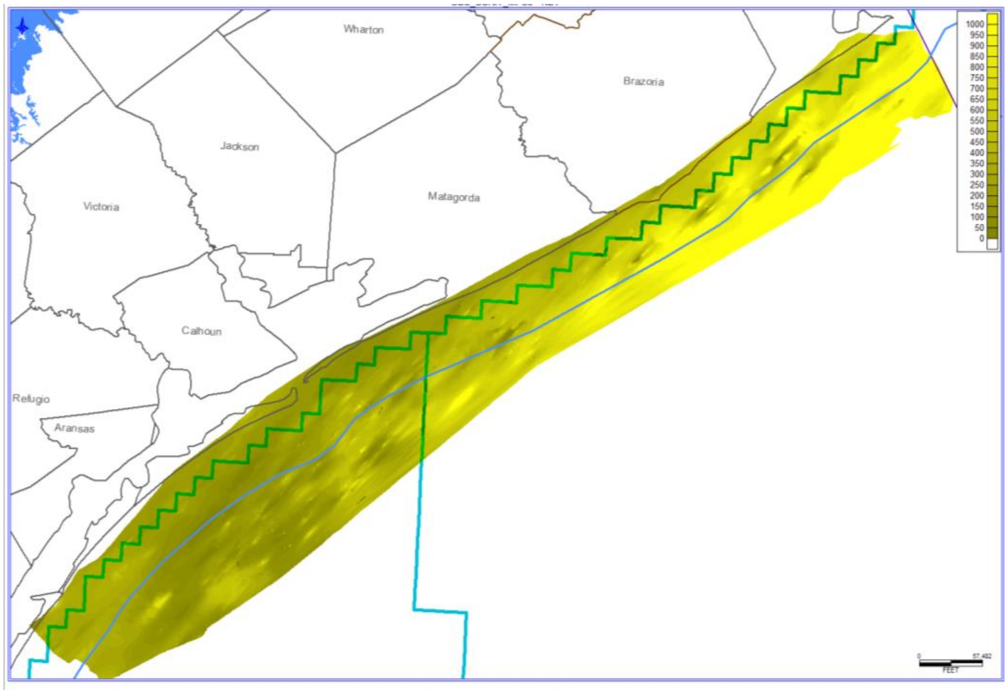


Figure 2.1.1.2.8 – Net sandstone thickness map showing the potential CO2 storage over the study area for the Middle Miocene between the supercritical depth and MFS9 net sandstone thickness reaches a maximum of 1500 ft (average = 430 ft). There is more potential for storage along the upper Texas coast (total sandstone volume = 7.5 km^3).

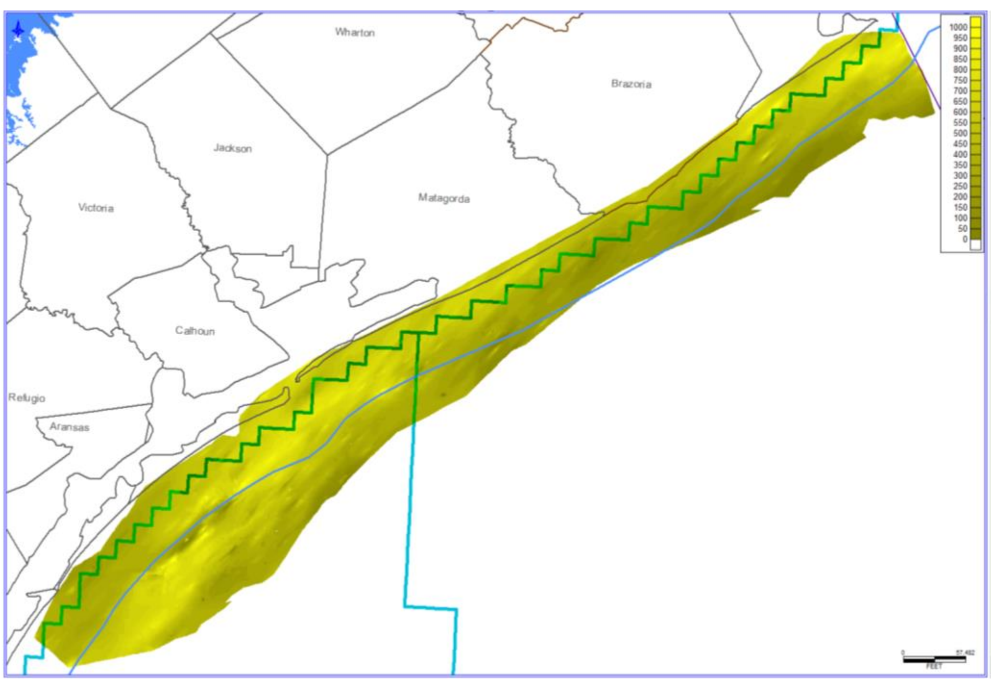


Figure 2.1.1.2.9 – Net sandstone thickness map showing the potential CO2 storage over the study area for the Lower Miocene between MFS9 and MFS10 Total sandstone thickness reaches a maximum of

1000 ft (average = 427 ft). There is more potential for storage along the shoreline (total sandstone volume = 6.4 km^3).

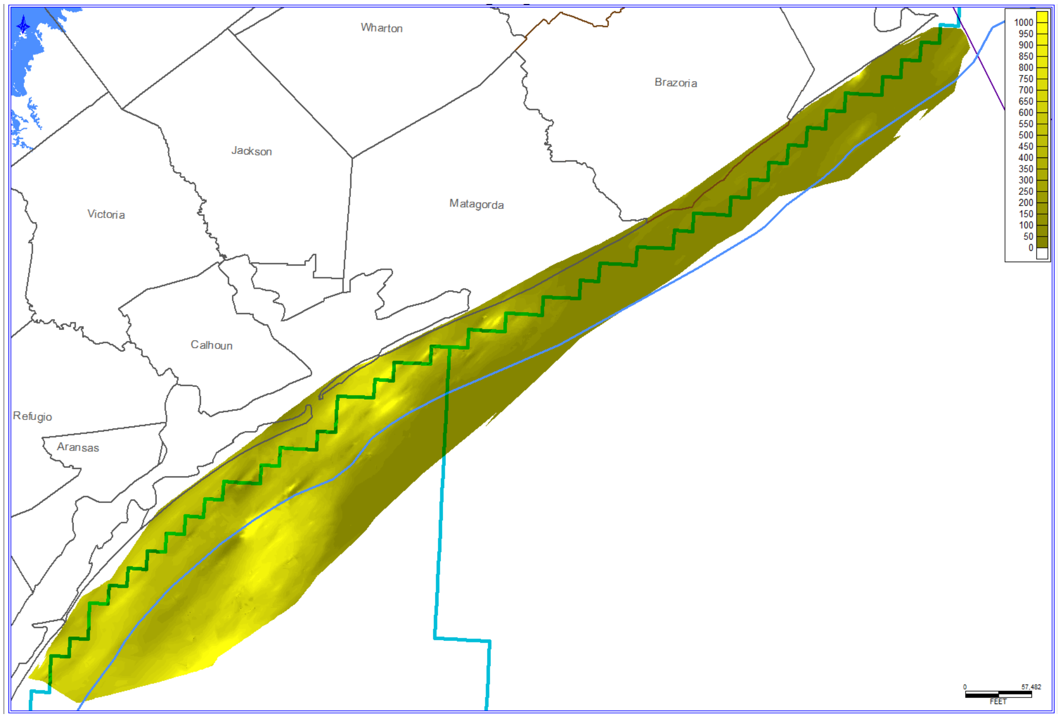


Figure 2.1.1.2.10 – Net sandstone thickness map showing the potential CO2 storage over the study area for the Lower Miocene between MFS10 and the top of the overpressure Total sandstone thickness reaches a maximum of 1100 ft (average = 375 ft). There is more potential for storage along the lower Texas coast (total sandstone volume = 4.85 km^3).

References

Galloway, W. E., 1989 (b), Genetic Stratigraphic sequences in basin analysis II: Application to northwest Gulf of Mexico Cenozoic basin, AAPG Bulletin v. 73 (2), p. 143-154.

Galloway, W. E., Ganey-Curry, P. E., Li, X., and Buffler, R. T., 2000, Cenozoic depositional history of the Gulf of Mexico Basin, AAPG Bulletin 84 (11), p. 1743-1774.

Subtask 2.1.1.3 Buoyant storage capacity

No activity this quarter

Subtask 2.1.1.4 Fluid inclusion stratigraphy

On December 8, 2020, Christopher Smith, PhD, Senior Chemist from Advanced Hydrocarbon Stratigraphy, presented a talk to the Gulf Coast Carbon Center (GCCC) about "rock volatiles stratigraphy (RVStrat), a patented technique using gentle vacuum extraction of present-day volatiles from old or new cuttings, cores, outcrop, or fluid samples," which Smith says can "demonstrate that old and new samples can be used to evaluate the movement of CO_2 in the subsurface and the integrity of compartments." Subsequently, GCCC researchers consulted with Christopher Smith and Michael Smith, PhD regarding possibly utilizing in a similar manner a fluid inclusion stratigraphy dataset to which the project has access. As of the end of the reporting period, there were still no conclusive results.

Subtask 2.1.2 – Geologic Characterization of Chandeleur Sound, LA

Continuation of log digitizing & interpretation

To date, 43 wells have been digitized and are in various stages of completion. Table 2.1.2.1 indicates well logs that are in the process of being digitized (In Progress); if logs have been digitized and are ready for review (Complete); if wells logs have been reviewed and require revisions (Revise); or if they are ready to be loaded into the Decision Space Project for interpretation (FINAL). After the revisions of the logs of these tabulated wells are complete, they will be ready to be loaded into the Decision Space project to build the new velocity model. This work is anticipated to occur in Q1 2021.

Table 2.1.2.1

API	State Lease	Log	Logging Interval	Progress (InProg/Done)
17727201290000	8244 #1	GR, SP, Res, Ind, Den, Por	300-19000	Revise
17727001280000	4558 #1	SP, Res, Ind	2600-9700	FINAL
17727001290000	4556 #1	SP, Res, Ind	300-10000	Revise
17727001560000	4548 #1	SP, Res, Ind	200-9700	FINAL
17727001730000	4566 #1	SP, Res, Ind	200-2600, 2500-9900	FINAL
17726200200000	5384 #1	SP, Res, Ind	2100-9000	FINAL
17727002360000	5114 #1	SP, Res, Ind	400-13900	FINAL
17727204900000	16164 #1	GR, SP, Res, Ind	4400-9600, 3400-8300	Revise
17727200650000	6668 #2	SP, Res, Ind, Sonic	1000-7500	Complete
17727200850000	6657?	SP, Res, Ind, Sonic	4500-6700	Complete
17727201220000	8241 #1	GR, SP, Res, Ind, Den, Por	11000-15500, 400-15800	Complete
17727201600000	9441 #1	SP, Res, Ind, Sonic	2600-8600	Complete
17727203480000	14055 #1	SP, Res, Ind, Sonic	2300-8100, 7800-8100	Complete
17727204250000	13308 #1	GR, SP, Res, Ind, Sonic	2500-10570	Complete
17727204610000	14055 #1	GR, SP, Res, Ind, Sonic	2300-8100	Complete

17727204750000	14594 #1	GR, SP, Res, Ind, Sonic	2400-8100	Complete
17727204760000	14595 #1	GR, SP, Res, Sonic	2400-9000	Revise
17727204780000	14525 #1	GR, SP, Res, Ind, Den, Por	2100-5300	Revise
17727204990000	16521 #1	GR, SP, Res, Den, Por	2500-7400	Revise
17727205010000	17393 #1	GR, SP, Res, Den, Por	2500-6800	Revise
17727205040000	17398 #1	GR, SP, Res, Ind, Sonic	2700-7500	Complete
17727205060000	17403 #1	GR, SP, Res, Den, Por, Sonic	2600-8000	Complete
17727205140000	17394 #1	GR, SP, Res, Den, Por, Sonic	2400-7100	Complete
17727205160000	17558 #1	GR, SP, Res, Den, Por	2600-9000	FINAL
17727205200000	17399 #1	GR, SP, Res, Den, Por	2400-7500	FINAL
17727205210000	17628 #1	GR, SP, Res, Den, Por, Sonic	2400-6800	Complete
17727205220000	17398 #2	GR, SP, Res, Den, Por, Sonic	2400-8400	FINAL
17727205230000	17583 #1	GR, SP, Res, Den, Por, Sonic	2500-9000	Complete
17727205320000	17390 #1	GR, SP, Ind, Res, Den, Por	2000-4700	Complete
17727205050000	17400 #1	GR, SP, Res, Den, Por, Sonic	2600-8100	Complete
17727205070000	17401 #1	GR, SP, Ind, Res, Den, Por	2600-9800, 8700-9800	FINAL
17727205170000	17557 #1	GR, SP, Res, Ind, Den, Por	2600-9200	FINAL
17727205310000	17405 #1	GR, SP, Res, Den, Por, Sonic	4000-10300	Complete
17727206340000	17986 #1	GR, SP, Ind, Res, Den, Por	2400-7900	In Progress
17727205350000	17987 #1	GR, SP, Res, Den, Por, Sonic	3100-10200	Complete
17727205410000	18333 #2	GR, SP, Res, Sonic	3000-10700	Complete
17730200230000	13547 #1	GR, SP, Res, Sonic	2000-4900, 3900-4900	In Progress
17730200300000	17387 #1	GR, SP, Res, Den, Por, Sonic	1900-5500	Complete
17730200320000	17659 #1	GR, SP, Res, Ind, Sonic	2400-6800	FINAL
17730200330000	17659 #2	GR, SP, Res, Inc, Den, Por	3500-10800	In Progress
17730200340000	17812 #1	GR, Res, Den, Por, Sonic	2000-4700	Complete
17730200350000	17388 #1	GR, SP, Ind, Res, Den, Por	2000-4600	Complete
17730200360000	17389 #1	GR, SP, Ind, Res, Den, Por	1900-4800	Complete

Extensive subsurface CCS modeling is in progress in other GoMCarb subtasks. Modeling includes storage capacity and seal sufficiency; migration behavior of CO_2; trapping mechanisms, including stratigraphic and structural seals, and pore-scale and residual trapping; and optimal depositional facies. The modeling related specifically to trapping mechanisms and optimal depositional facies are of particular interest in the Chandeleur seismic area. Trapping mechanism modeling is suggesting that CO2 sequestration may be achieved without strong stratigraphic and/or structural seals or, perhaps, in absence of them. And depositional facies modeling is suggesting that heterogeneous facies – facies with higher porosity and less permeability – are optimal for CCS. In Chandeleur, the Middle Miocene target interval is highly heterogeneous, and not highly faulted.

Subtask 2.1.3 – Geologic Characterization of High Island, TX

See subtask 2.1.1 for overlapping activities.

Subtask 2.1.4 NAMSS 3D seismic data sets from Federal waters

No activity this quarter

Subtask 2.2 – Data Gap Assessment

Subtask 2.2.1: Data gap assessments will focus on regionally relevant analog settings

No activity this quarter

Subtask 2.3 – Offshore and reservoir storage Enhanced Oil Recovery (EOR) Potential

No activity this quarter

Subtask 2.3.1 Texas (High Island area of Lake Jackson district) and Louisiana (Lake Charles and Lafayette districts)

No activity this quarter

Subtask 2.3.2 Initial scoping study of EOR potential in selected reservoirs in Federal waters, beginning in the High Island area of the Lake Jackson District

No activity this quarter

Task 3.0 – Risk Assessment, Simulation and Modeling

Subtask 3.1 – Risk Assessment and Mitigation Strategies

Subtask 3.1.1 Assess the adaptation of existing tools to offshore settings

No activity this quarter.

Subtask 3.1.2 Extend geomechanical assessment to additional areas of the basin

No activity this quarter.

Subtask 3.1.3 Dissolution and bubbling in water column

No activity this quarter.

Subtask 3.1.4 Numerical modeling of heterogeneous reservoirs

No activity this quarter.

Subtask 3.2 – Geologic Modeling

The goal of the study is to assess appropriate deformation monitoring techniques that have sufficient sensitivity to measure the seabed uplift induced by fluid injection into a depleted hydrocarbon field located in the near offshore coast of the Gulf of Mexico (identified by High Island 24L). Before deploying such measuring instruments in an offshore environment, it is essential that we first simulate the coupled solid deformation-fluid flow phenomena as realistically as possible to gain some insight into the precision of instruments needed for such field study. To this end, we, researchers at Lawrence Livermore National Lab, created a finite element-finite volume model that incorporates a spatially heterogeneous permeability distribution expected at this site (see Figure 3.2.1).

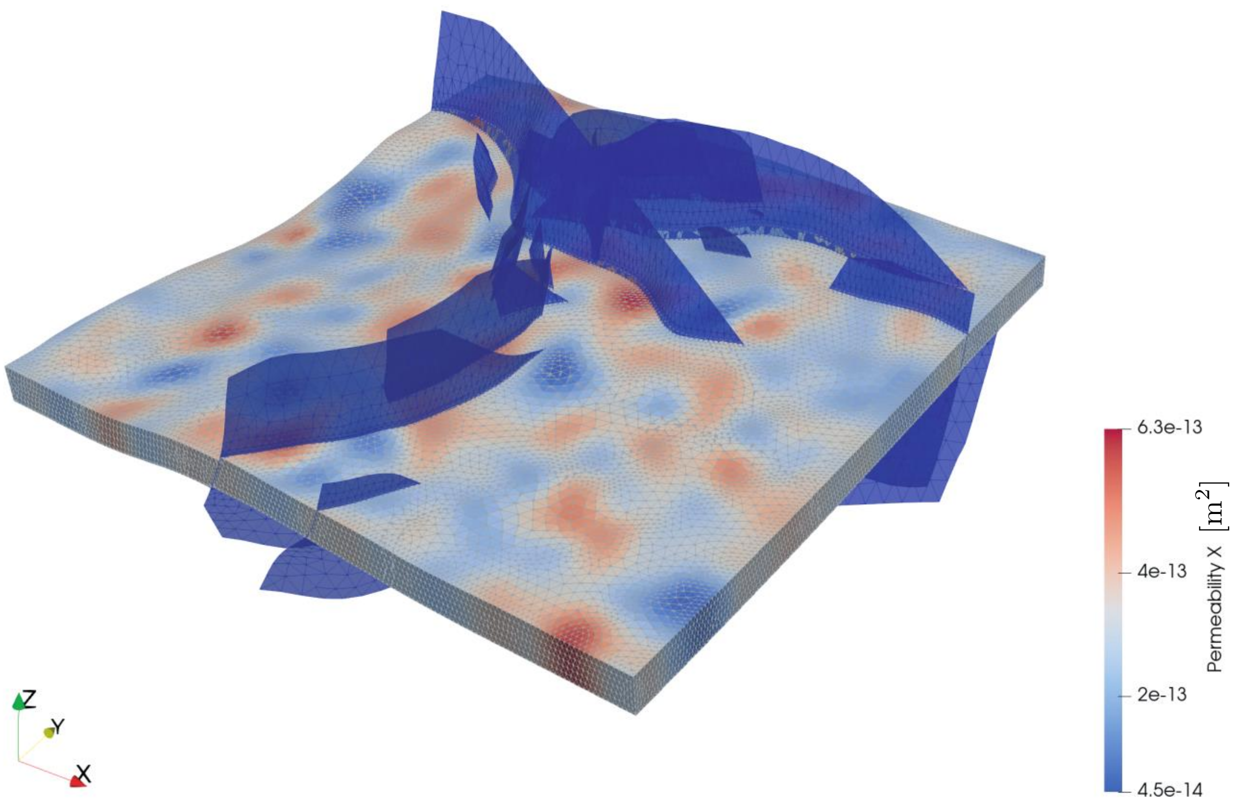


Figure 3.2.1 Horizontal permeability distribution in the reservoir, statistically generated. The faults cutting the domain are illustrated in blue.

We conducted a sensitivity analysis on the geomechanical parameters and investigated the influence of fault sealing on the fluid flow. Results of the simulations suggest that the reservoir has remarkable injectivity, allowing for a large amount of fluid to be injected without a substantial increase in pore pressure. The computed seabed deformations are equally small and could be monitored with distributed fiber optic cables and ocean bottom pressure recorders. The absolute accuracy of ocean bottom pressure recorders for the site is approximately 1 mm and most of the simulations from the sensitivity analysis indicate a maximum seabed floor uplift of more than 5 mm. Our results also show how fault sealing substantially changes the fluid flow and consequently the deformation pattern. Sealing leads to a concentration of excess pore pressure and vertical displacement in the vicinity of the injector well that is not crossed by a fault, as illustrated in Figure 3.2.2.

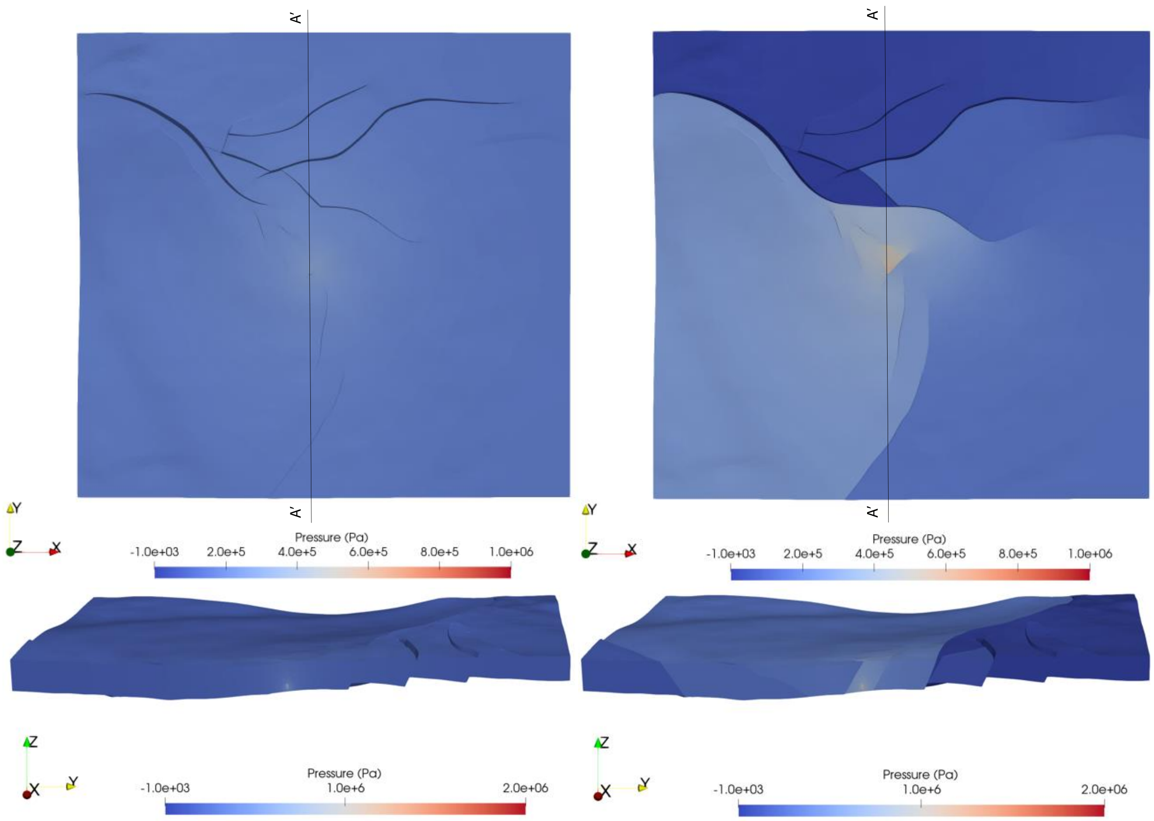


Figure 3.2.2 Simulation results for the base case scenario. Excess pore pressure after 3 years of injection at a rate of 1 Mt/yr for two cases: permeable faults (left) and impermeable faults (right) for top and lateral views of the reservoir.

This preliminary assessment has provided a comprehensive understanding of the reservoir and seal units' behavior. It has enabled us to draw practical conclusions on cost-effective monitoring systems, which are essential to better plan such a complex venture. However, many topics may be further explored to increase the reliability of the predictions. In particular, future work will focus on better geostatistical constraints on permeability and porosity, more detailed analysis of well log data to have a better estimate of anisotropic elastic properties, studies on the influence of finite-volume discretization chosen, and extension to true compositional flow simulation.

Subtask 3.2.1 – Reservoir modeling

The following in this subtask comprises the Milestone 6 report, which was separately submitted. It is included here for the convenience of the reader.

This milestone report builds on the results of the previous milestone report (M5). Most of the background information about the reservoir and simulation setup is presented in previous milestone report. The main goal in this milestone report was to run two more scenarios with focus on uncertain parameters that can potentially impact the results of the numerical simulations. Based on our experience, these parameters are believed to be the most important parameters that would impact our results. Considering that we presented three scenarios in our previous milestone, M5, we name these new scenarios as scenario #4 and scenario #5 to avoid future confusion in referring to the numerical simulations.

Using reservoir simulations, we investigated the behaviour of a CO2 plume and its extent during the injection and post-injection periods in a prospect located in the Miocene age geologic section of the upper Texas coastal waters. The simulations are carried out in CMG-GEM reservoir simulation software. We assume a continuous CO2 injection with a constant rate of 16×106 scf/day, injecting a total of 50 million tons over the 30-year period. The injection is accomplished through 5 injection wells. The numerical model is assumed to be isothermal, initially saturated with brine. In previous scenarios the anisotropy ratio (K_v/K_h) is considered to be 0.1, 0.001, and 0.00001 for the coarse-sand, fine-sand, and shale, respectively. In a scenario (scenario 4), we perform CO2 injection simulation in an isotropic formation $\frac{K_v}{K_h} = 0.5$ to better elucidate the effect of anisotropy on fluid flow dynamics and simulate a scenario were CO2 is allowed to move vertically in higher rates. Pore pressure is considered to be hydrostatic with the gradient of $0.465\ psi/ft$. Figure 1 represents the overall structure of the model and location of the wells.

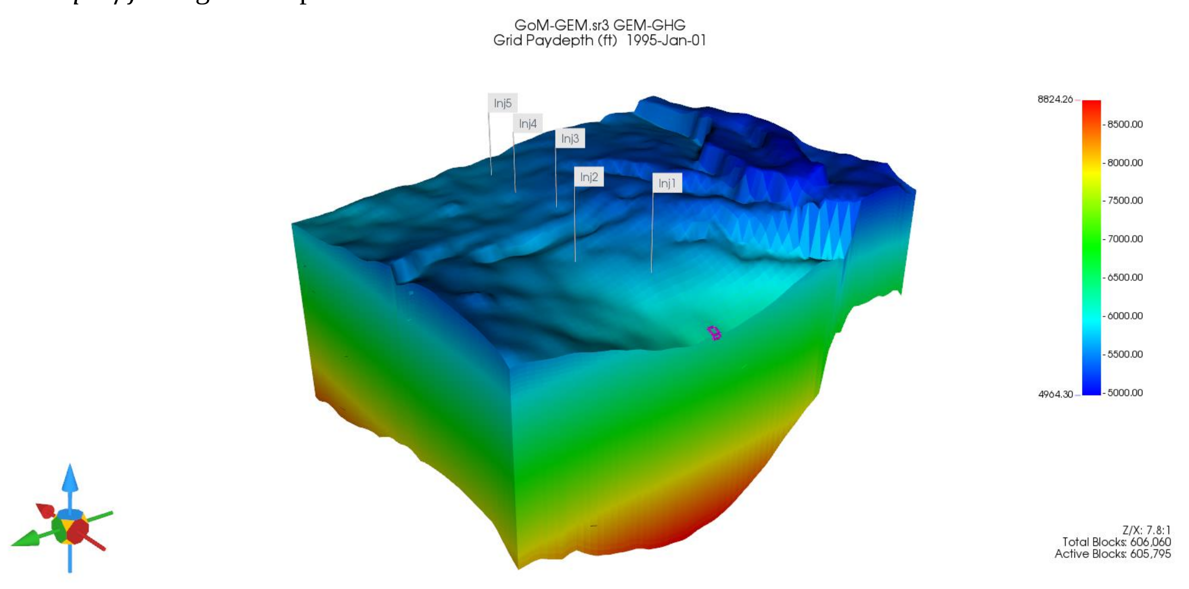


Figure 1. Reservoir model used in this study for running numerical simulations.

Scenario 4:

In scenario 4, we considered the geologic model to be semi-isotropic ($\frac{K_v}{K_h} = 0.5$), meaning that we alleviate the degree of heterogeneity in the formation. All other parameters including the location of well perforations are taken the same as those in scenario 1. (See Milestone M5 report). Snapshots of the CO_2 plume and its trapped portion at the end of injection and post-injection periods are shown in Fig. 2. We observe that an isotropic medium facilitates the upward movement of the plume, since vertical permeability imposes less restriction on the vertical movement of the CO_2 plume. Compared with scenario 1, we did not observe a significant variation in the bottom hole pressure of injection wells during the injection period, while the ultimate pressure observed in the post-injection period is the same as scenario 1 (Fig. 3). Another point to highlight here is that running simulations with higher Kv/Kh ratio takes much longer time. This is mostly because gravity forces are now dominant and numerical convergence rates are very slow. For scenario #4, after several days of running simulation stopped at year 2048 and this is the results we are providing here as end of post injection period.

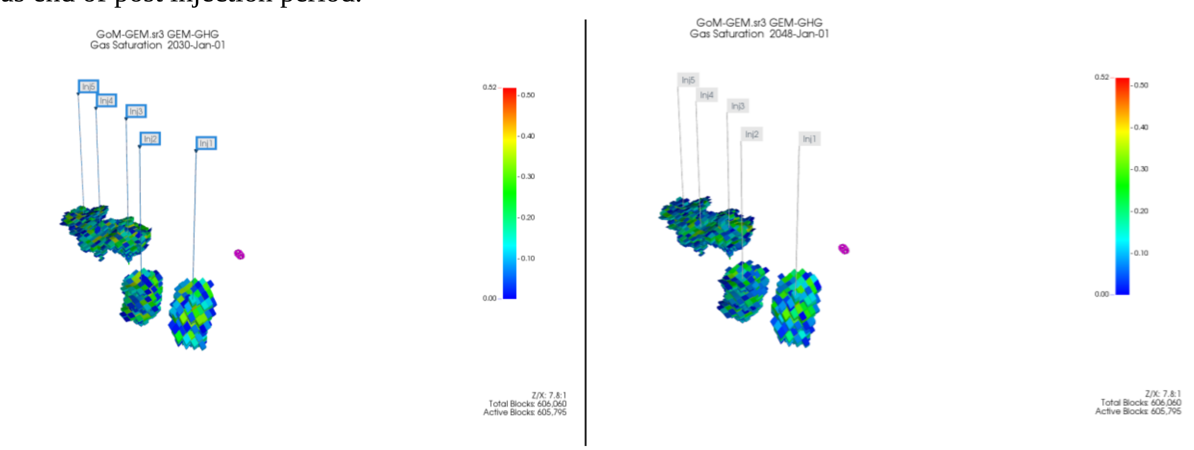


Figure 2. CO_2 plume at the end of injection (left) and post-injection (right) periods for scenario 4.

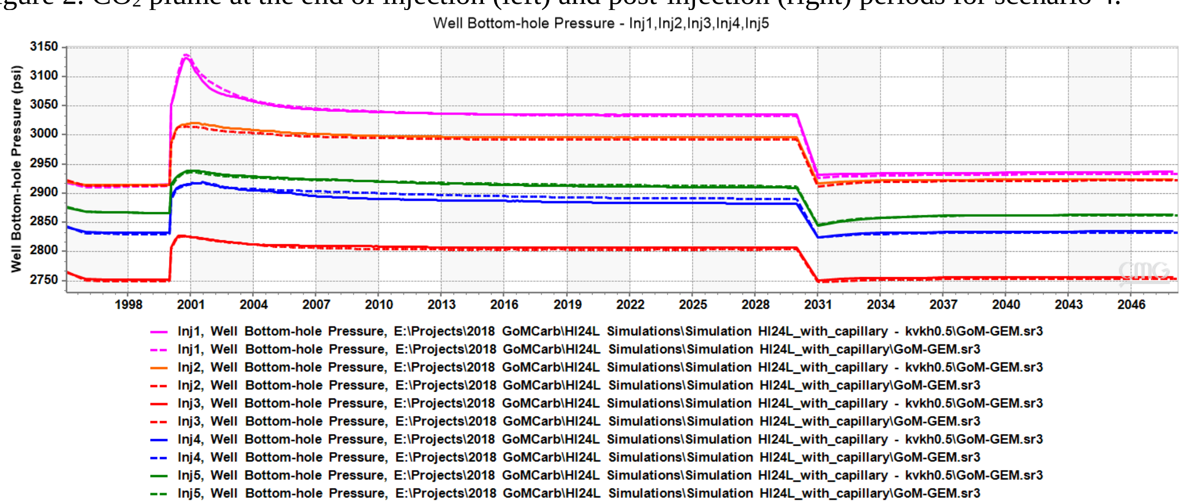


Figure 3 comparison of BHP values in scenario #1 vs. scenario #4 for all 5 injection wells.

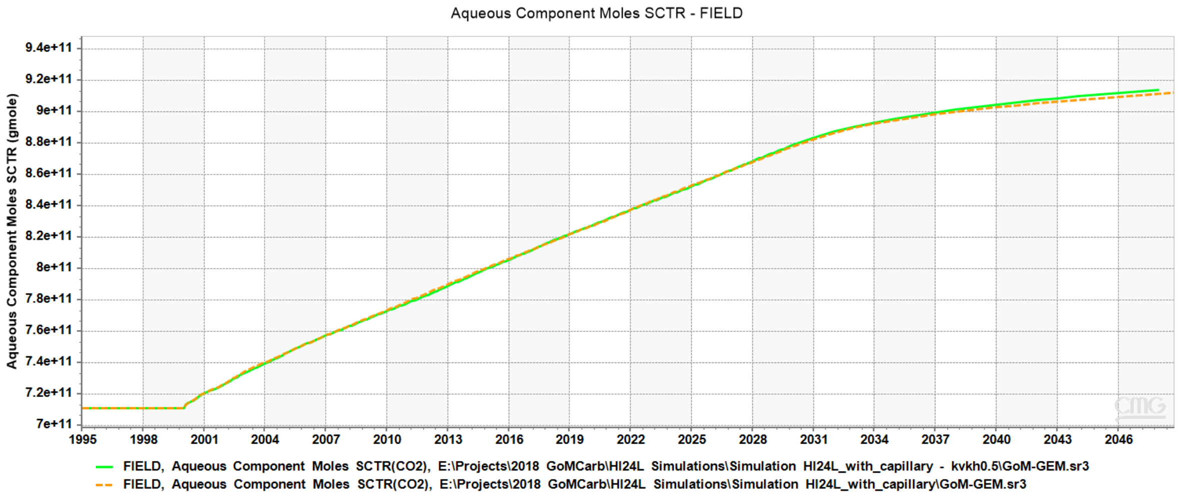


Figure 4. Time evolution of CO_2 dissolved into the brine for scenarios 1 and 4. Higher kv/kh ratio has slightly increased the amount of CO2 dissolution into the brine.

Scenario 5:

In this scenario, the effect of hysteresis is neglected, meaning that CO_2 cannot be residually trapped in the formation. All other parameters are taken the same as scenario 1. According to the shape of CO_2 plume shown in Fig. 5 and its comparison with that in scenario 1, we observe that the CO_2 plume is further extended in the absence of hysteresis, since no portion of plume can become residually trapped. No significant variation is observed in the reservoir pressure compared with scenario 1 (Fig. 6). In these simulations we were able to run the model for all period of post injection until year 2132.

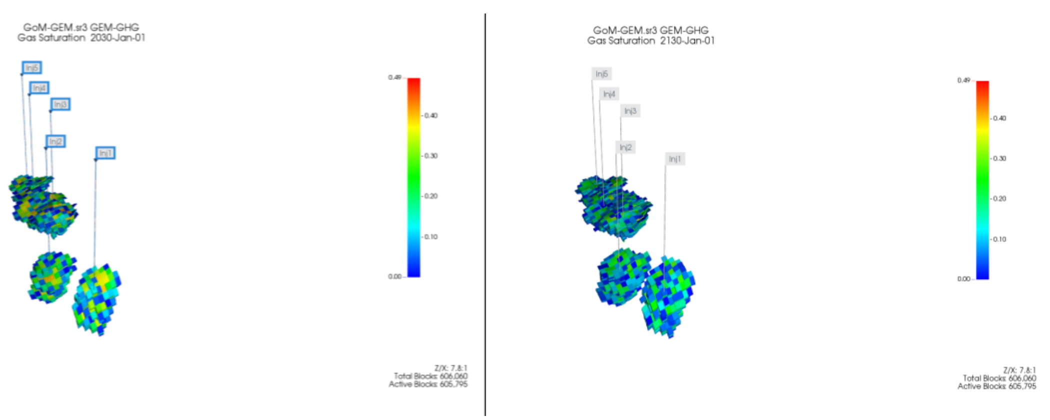


Figure 5. CO_2 plume at the end of injection (left) and post-injection (b) periods for scenario 5.

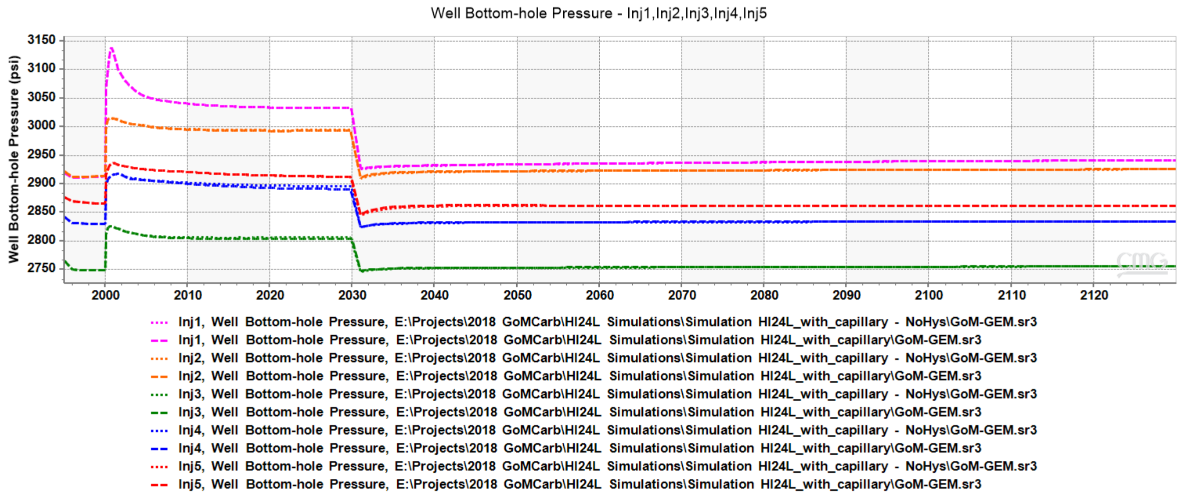


Figure 6. comparison of BHP values in scenario #1 vs. scenario #5 for all 5 injection wells.

One major observation for all these scenarios is that even with injecting 50 million tonnes of CO_2 into the Miocene age reservoir, the CO_2 plume does not reach the faulted area shown in Figure 1. Even when we consider worse case scenarios where vertical permeabilities are exaggerated or hysteresis effects are completely ignored – although the CO2 plume grows larger- it still remains within the intended area and zone.

Subtask 3.2.2 Sub-basinal scale modeling

No activity during this quarter.

Subtask 3.2.3 History matching experiment via modeling

No activity during this quarter.

Subtask 3.2.4 Economic modeling

No activity during this quarter.

TASK 4.0: Monitoring, Verification, and Assessment (MVA)

Subtask 4.1: MVA Technologies and Methodologies

Subtask 4.1.1 Geochemical Monitoring of Seabed Sediments

No activity during this quarter.

Subtask 4.1.2 Geochemical Monitoring of Seawater Column

No activity during this quarter.

Subtask 4.1.3 UHR3D Seismic

No activity this quarter.

Subtask 4.1.4 Distributed Acoustic Sensors

During this quarter, the LBNL/Rice team initiated discussion with several GoM off-shore fiber providers (primarily Tampnet) to identify accessible dark fiber routes in TX state waters. Two fiber paths in the Galveston and Sabine Pass areas will be explored in the following quarter. Several of the fiber paths are associated with retired risers and subsea facilities. The LBNL/Rice team also started development of a testing tank for future marine source/DAS testing configurations.

Subtask 4.1.5 Pipeline MVA

SUMMARY

1. Collected literature data and validated the CFD model used for the prediction of CO_2 leakage and dispersion.

2. Performed ANSYS Fluent CFD simulations of a CO_2 leakage scenario from a High Island 10L injection well with the validated model.

1. Mass Transfer Coefficient_(Revised)

The mass transfer coefficient was calculated from the mass transfer correlation for a pure gas bubble in an unstirred reactor (Equation 1) [1].

$$k = 0.31((d^3 * g * \Delta\rho_{water\text{-}CO2}/\rho_{water})/\nu^2)^{1/3} * (\nu/D)^{1/3} * (D/d) \qquad \text{(Equation 1)}$$

where k = mass transfer coefficient of CO_2, D = diffusion coefficient of CO_2, d = bubble diameter, g = gravitational acceleration, $\Delta\rho_{water\text{-}CO2}$ = density difference between water and CO_2 bubbles, ρ_{water} = density of water, and ν = kinematic viscosity of CO_2. For CO_2 bubbles (0.3 cm diameter) in seawater, the mass transfer coefficient is 2.21×10^{-5} m/s.

2. CFD Simulation to Validate the Mass transfer Coefficient

The mass transfer coefficient calculated with the previous correlation equation was validated with an experiment performed by Huser, A., et al. (2016) [2]. The experiment consisted of injecting 0.41 kg/s of gas CO_2 at the bottom of a tank. The cylindrical tank had dimensions of 3.4 m tall and 8.4 m diameter. The pH was measured 1.0 meter above the bottom of the tank, outside the CO_2 gas plume. The initial pH was 8 and then decreased to 6 after 500 s. The experiment was replicated with an Ansys Fluent transient simulation (Figure 4.1.5.1). The pH was measured at same location as in Huser's work (black square, Figure 4.1.5.1). The simulation results are in good agreement with experimental results (Table 4.1.5.1).

Table 4.1.5.1Experiment vs. Simulation pH Values

Time (s)	Experiment pH Measurements (Huser, A., et al)	Ansys Simulation pH
80	8	8
200	6.4	6.3
285	6	5.7

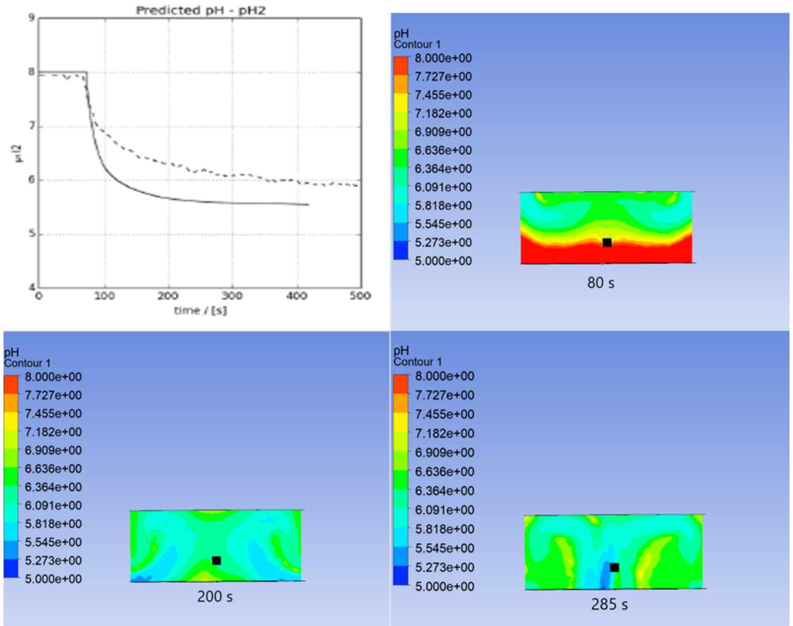


Figure 4.1.5.1 Measured vs. predicted pH in Cussler et al. 's work (Top Left, [2]) and pH profiles at various time intervals from CFD Simulations in this study (Top Right and Bottom figures).

3. CFD Model for 20 m Depth with Current

The case of a leak of 35 kg/s of CO_2 in 20 m depth of water with a current of 0.2 m/s was simulated with the Ansys Fluent software. The CO_2 inlet is at the bottom. The outlet is at the top, and water inlet and outlet on the sides (Figure 4.1.5.2).

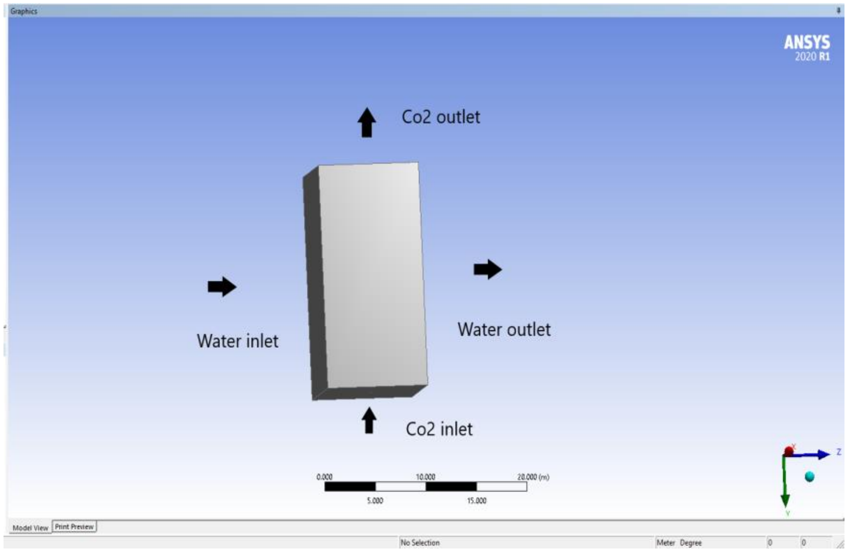


Figure 4.1.5.2 CFD meshing for CO_2 leakage at the Gulf of Mexico conditions.

The CO_2 dissolved in water was 5.5 kg/s and the water current moved the CO_2 plume slightly toward the water outlet (Figure 4.1.5.3). This simulation result is in disagreement with Oldenburg et al. (2020) [3]. For 20 m, 9 kg/s of CO_2 were dissolved and the current did not affect the CO_2 plume. Figure 4.1.5.3 shows that the pH at the center of the water outlet is close 6.8. Vortex currents were formed on the sides, increasing the mixing and lowering the pH.

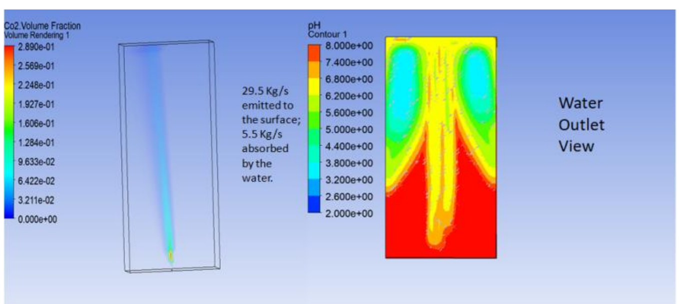


Figure 4.1.5.3 Simulation Results CO_2 Plume (L) and pH Variation (R)

4. References

1. Cussler, Edward Lansing, and Edward Lansing Cussler. *Diffusion: mass transfer in fluid systems*. Cambridge university press, 2009.
2. Huser, A., et al. "Accidental Underwater Release of CO2-CFD Modelling of the Underwater Plume and the Subsequent Above Water Gas Dispersion."(2016)
3. Oldenburg, Curtis M., and Lehua Pan. "Major CO2 blowouts from offshore wells are strongly attenuated in water deeper than 50 m." *Greenhouse Gases: Science and Technology* 10.1 (2020): 15-31.

Subtask 4.2: Plans for Testing of MVA Technologies

Subtask 4.2.1 Priority list for MVA Technologies and testing methods

No activity during this quarter.

Subtask 4.2.1.1 High-resolution 3D seismic (HR3D)

No activity during this quarter.

Subtask 4.2.1.2 Geochemical monitoring in the Seawater Column

No activity during this quarter.

TASK 5.0: Infrastructure, Operations and Permitting

In addition to the work completed under Task 5.0, Trimeric participated in the following general project activities:

1) Engaged with Aker Solutions on Role in Infrastructure Task Group
    a. Meetings with Aker to discuss Aker's scope of work and focus on subsea template application
    b. Discussed interface with Trimeric's broader efforts in Task 5 (i.e., places where infrastructure re-use might interface with Aker's scope)
    c. Planned for opportunities to collaborate in BP2 (e.g., knowledge -sharing on existing infrastructure, leveraging Aker's expertise and experience on infrastructure re-use where possible)
        i. Note: Aker's priority and primary focus is on the subsea template application in the GoM. (See appendix.)

Subtask 5.1: CO_2 Transport and Delivery

Subtask 5.1.1 Transport to near-shore sites (High Island area)

A key component of Trimeric's effort under Task 5 includes the assessment of existing infrastructure for re-use in CO_2 transport and storage applications. The objective of Subtask 5.1 (CO_2 Transport and Delivery) is to define what is known about infrastructure re-use and identify data gaps. The intent is to develop screening tools/methods that can be used to assess the potential of infrastructure assets (such as wells, platforms, and pipelines) for reuse. Trimeric is then applying these infrastructure screening criteria to specific assets (e.g., assets in the High Island Large Block 10L region) to validate and refine criteria. In this way, a more detailed and practical understanding of the infrastructure reuse will be developed for the context of an overall CO_2 capture, transport, and storage project.

Overall Reporting and Documentation Approach

During this quarter, Trimeric began to organize major research areas from BP1 into summary memorandums. The purpose of the summary memorandums includes the following:

- Consolidate key findings from major research areas into individual documents to enhance accessibility and distribution to interested parties (e.g., in contrast to a single large report document).
- Provide references to more detailed research deliverables (e.g., spreadsheets/databases, detailed reports). In this respect, the memorandum also serves as a catalog of the deliverables produced.
- At the end of the project, the series of memorandums will serve as summary of the project findings.

During the past quarter, Trimeric prepared a draft memorandum summarizing research on re-use of existing pipelines. The memorandum is expected to be finalized in Q1 of 2021. In addition analogous memorandums are being prepared for platform and well re-use.

As the project progresses, additional topic areas will be summarized in similar memorandums.

Platforms

During this quarter, Trimeric continued research on platform re-use opportunities in the Gulf of Mexico. The platform research effort led by Darrell Davis. The following outlines a summary of the progress in the platform re-use effort:

- **<u>Texas State Waters Database Development</u>**
    - Mapping shape files available from the Texas General Land Office (GLO) and the Oil Spill Mapping viewer served as the primary sources of data for platforms in Texas State Waters.
        - The total GLO database included 646 "entities" or structures (see Figure 5.1.1). The dataset was reduced to 189 items by restricting the search to the Gulf of Mexico (i.e., excluding structures in bays, estuaries, rivers. Etc.).
        - Of the 189 structures in the Gulf of Mexico, 89 are platforms.
            - >95% of the platforms are inactive, and therefore may be available for re-use, but require further vetting for the condition of the platform.
        - In initial communications with GLO, there may be processes for conveying a platform to a new owner for re-purposing/re-use. This process will need to be reviewed in further detail, perhaps as part of a case study for re-using specific platforms.
    - A spreadsheet database for Texas state water platforms was developed from this research effort, which includes coordinates for the platform location, identification numbers from GLO database, geographic location (differentiates between Gulf of Mexico and other bodies of water), and the lease tract number.
        - The Oil Spill mapping viewer for GLO identifies the location of each platform but also provides pictures for each structure. A separate PowerPoint/pdf file was developed cataloging pictures of platforms in Texas State waters to provide additional context for the type of platform and condition of the platform (at the time of the pictures, which were taken in 2016-2017).

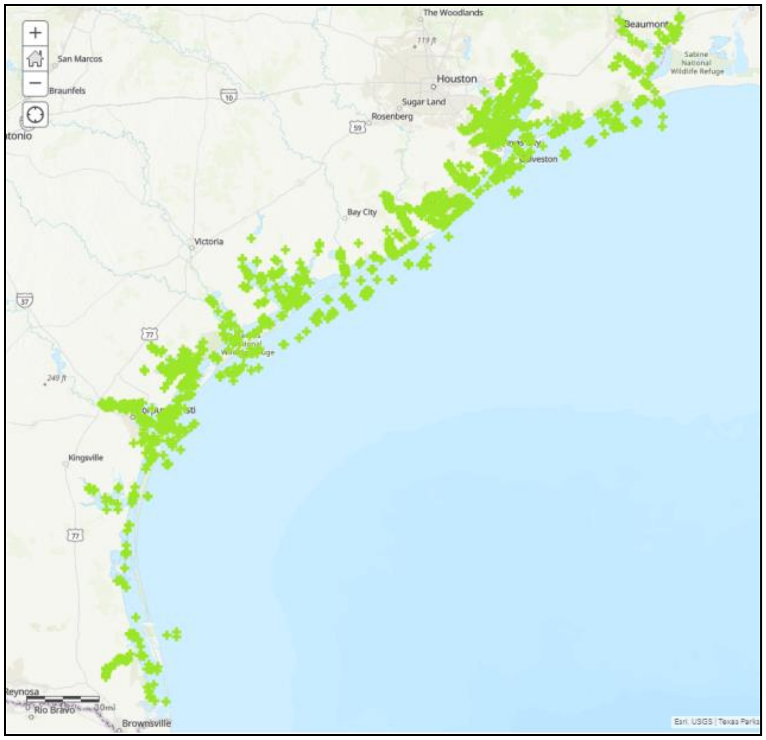


Figure 5.1.1: Texas General Land Office Map of Offshore Oil and Gas Structures

- **<u>New Platform Costs</u>**
    - Three sources were contacted for estimates of new platform costs in the GoM in regions near existing platforms. New platform costs provide context for potential savings for re-use of existing platforms. The new platform estimates were based on a single-deck, 4-pile platform.
        - The owner of existing platforms in two tracts in Texas State Waters (24 and 98) estimated that a new platform would cost $2-3 million.
        - An offshore technology consultant/expert indicated the platform would cost $4-$6.5 million dollars, installed, with a detailed breakdown of installation, materials, and component costs to serve as the basis of the topline cost number provided.
            - Water depth has a strong influence on costs and the range presented reflects some of the potential variability due to water depth.
        - A fabrication yard provided an estimate of $3.82 million for a new platform. A separate budgetary estimate for transport and install was $1.95 million, for a total installed cost of $5.77 million. The table below summarizes the details of this estimate:

Table 5.1.1 Cost Estimate to Fabricate and Install 4-Leg Platform

Item	Estimated Weight (tons)	Unit Rate ($/ton)	Estimated Cost ($)
4-Leg Jacket	400	$4,500	$1,800,000
Piles for Jacket	250	$2,000	$ 500,000
Deck (Structure Only)	200	$7,000	$1,400,000
Loadout & Tiedown onto Cargo Barge			$ 120,000
Transport & Install			$1,950,000
Total			$5,770,000

- **<u>Platform Re-Use Information</u>**
    - The same offshore technology consultant that provided new platform costs provided input on platform re-use:
        - As an approximate estimate the consultant indicated a re-purposed platform would save ~30% of the costs of an equivalent new platform.
        - If the platform to be re-purposed is in shallow waters (< 20ft), lift barges will not be able to operate, and a jack-up platform may be needed to support structural work or topsides modifications (e.g., deck replacement). This would likely wipe out the cost savings of re-purposing a platform.
            - Trimeric plans to further investigate the impact of water depth on re-use costs and activities.
        - Repurposing a platform would include the following key steps:
            - Inspection of the existing platform (in accordance with API RP 2-A standards). The inspection costs were estimated to be on the order of $30,000 - $40,000 offshore.
                - Main inspection focus: wall thickness of pilings, jacket, and deck; check for severe corrosion
            - Decks for existing platforms are typically replaced.
                - If platform decks are re-purposed, the modifications are typically completed offshore since the cost of barge transport back and forth from the shore can be prohibitive.
            - Existing jackets often do not meet current code, so jackets are frequently replaced as well (upgrades to existing jackets are not typically cost-effective).
    - API RP-2 A includes Section 17 added in the 1990's that is specific to evaluation of existing platform integrity. In 2003, the MMS (Minerals Management Service) released an NTL (Notice to Lessees and Operators) requiring Gulf of Mexico platform owners to assess their platforms to Section 17 requirements. This standard would govern re-purposing of a platform.

- Platforms built after 1988 meet "100-year storm" design standards, which make them potentially more desirable targets for re-use (however, most platforms in Texas state waters were built prior to this date).

- **Louisiana State Waters**
    - The SONRIS (Strategic Online Natural Resources Information System) for Louisiana includes data on wells and other oil and gas facilities offshore.
    - Each point in the mapping utility (Figure 5.1.2) includes well records and well inspection reports, which may contain photos, including platforms.

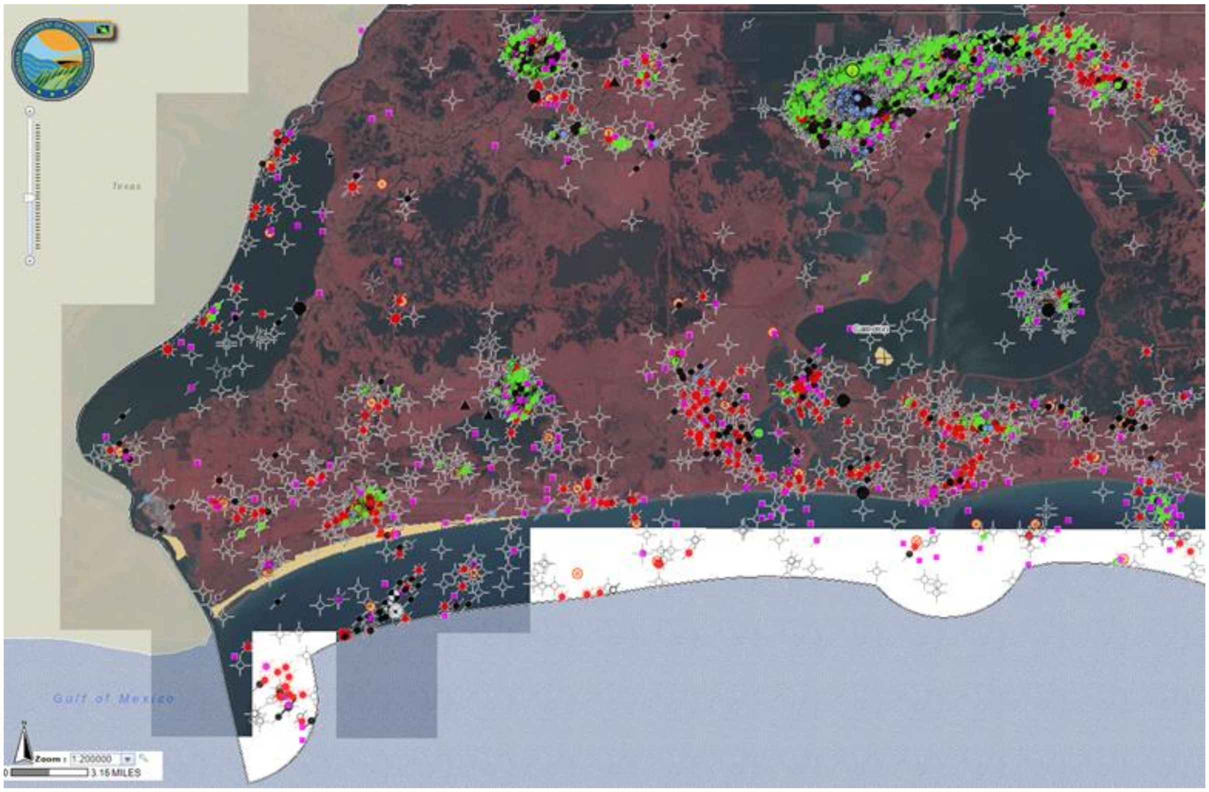


Figure 5.1.2: Map from Louisiana SONRIS Database

- **Federal Waters Database**
    - BOEM/BSEE data were used to develop a spreadsheet database of platforms in federal waters in the Gulf of Mexico
    - Initial screening of the data resulted in 136 platforms along the Texas coast and 1671 platforms along the Louisiana coast
    - The database includes coordinates for the structures, lease block number, installation date, operator, water depth, and other general information. Table 5.1.2 represents a section of the database of platforms off the Texas coast.

Table 5.1.2 Texas Gulf Coast – Federal Water Platforms

Area Code	Area Name	State	Block Numb	Field	Structure Name	Struc Type Co	Latitude	Longitude	Bus Asc Name	Install Dat	Water Depth (fe
AC	Alaminos Canyon	TX	857	AC857	A(Perdido)	SPAR	26.12890071	-94.89791489	Shell Offshore Inc.	11/12/2009	7835
AC	Alaminos Canyon	TX	25	AC025	A-Hoover Spar	SPAR	26.93905139	-94.68872137	Exxon Mobil Corporation	4/25/2000	4825
BA	Brazos Area	TX	A 105	BA105A	A	FIXED	27.90277900	-95.98763500	Fieldwood Energy LLC	1/1/1975	188
BA	Brazos Area	TX	A 133	BA133A	E	FIXED	27.83512500	-96.01263000	GOM Shelf LLC	1/1/1990	204
BA	Brazos Area	TX	538	BA538	A-VALVE(DOT)	FIXED	28.31463900	-95.62057600	Transcontinental Gas Pipe Line Company, LLC	1/1/1969	95
BA	Brazos Area	TX	491	BA491	4	CAIS	28.39258928	-95.87933736	Fieldwood Energy LLC	9/4/2005	70
BA	Brazos Area	TX	A 133	BA133A	D	FIXED	27.83876500	-96.02819000	GOM Shelf LLC	1/1/1987	204
BA	Brazos Area	TX	491	BA491	A	FIXED	28.39665300	-95.86190600	Fieldwood Energy LLC	1/1/1988	70
BA	Brazos Area	TX	491	BA491	5	CAIS	28.39031940	-95.88750716	Fieldwood Energy LLC	5/5/2006	75
BA	Brazos Area	TX	A 133	BA133A	A	FIXED	27.85449600	-96.03641800	GOM Shelf LLC	1/1/1976	200
BA	Brazos Area	TX	A 133	BA133A	B	FIXED	27.83513500	-96.01305700	GOM Shelf LLC	1/1/1984	204
BA	Brazos Area	TX	A 133	BA133A	C-AUX	FIXED	27.83517400	-96.01394400	GOM Shelf LLC	1/1/1986	204
BA	Brazos Area	TX	A 105	BA105A	B	FIXED	27.88216900	-95.96550600	Fieldwood Energy LLC	12/30/1994	188
EB	East Breaks	TX	602	EB602	A(NANSEN SPAR)	SPAR	27.36713710	-94.46765355	Anadarko Petroleum Corporation	11/10/2001	3675
EB	East Breaks	TX	159	EB158	A	FIXED	27.82739500	-94.62602300	Fieldwood SD Offshore LLC	1/1/1982	924
EB	East Breaks	TX	165	EB165	A	FIXED	27.81873500	-94.32283600	Fieldwood SD Offshore LLC	1/1/1985	863
EB	East Breaks	TX	160	EB160	A-Cerveza	FIXED	27.83272600	-94.55131100	Fieldwood SD Offshore LLC	1/1/1981	935
EB	East Breaks	TX	643	EB643	A-Boomvang Spar	SPAR	27.35356527	-94.62531327	Anadarko Petroleum Corporation	4/28/2002	3650
GA	Galveston	TX	209	GA209	B	FIXED	29.13028400	-94.54656800	Arena Offshore, LP	8/9/1996	58
GA	Galveston	TX	A 244		JP	FIXED	27.91656285	-94.78618800	Williams Oil Gathering, L.L.C.	9/21/2001	363
GA	Galveston	TX	255	GA255	A	FIXED	29.00029800	-94.76461500	Fieldwood Energy Offshore LLC	1/1/1972	61
GA	Galveston	TX	A 155	WILD	A	FIXED	28.16048463	-94.73975396	Peregrine Oil & Gas, LP	1/14/2009	180
GA	Galveston	TX	210	WILD	B	CAIS	29.13186744	-94.60674197	Fieldwood Energy LLC	6/1/2006	60
GA	Galveston	TX	A 133	WILD	A	FIXED	28.19409765	-94.76399094	Peregrine Oil & Gas II, LLC	6/12/2011	177
GA	Galveston	TX	210	WILD	2	CAIS	29.13187157	-94.60686718	Fieldwood Energy LLC	7/5/2005	60
GA	Galveston	TX	288		C(JUNCTION PLAT	FIXED	28.89360324	-94.70424792	Blue Dolphin Pipe Line Company	4/25/2001	68
GA	Galveston	TX	209	GA209	C	FIXED	29.12999081	-94.54595707	Arena Offshore, LP	10/13/1999	58
GA	Galveston	TX	209	GA209	A	FIXED	29.13036300	-94.54597200	Arena Offshore, LP	1/1/1990	58
GA	Galveston	TX	210	WILD	1	CAIS	29.13185523	-94.60695565	Fieldwood Energy LLC	12/21/2004	60
HI	High Island	TX	117	WILD	A	FIXED	29.28406304	-93.87255876	Castex Offshore, Inc.	12/14/2013	51
HI	High Island	TX	A 547	HI545A	C	FIXED	28.01486634	-93.95569344	Arena Offshore, LP	8/5/2014	253
HI	High Island	TX	A 379	HI384A	B	FIXED	27.92977000	-93.80147500	W & T Offshore, Inc.	10/14/1994	390
HI	High Island	TX	A 442	HI442A	A	FIXED	28.39026518	-93.93340690	Sanare Energy Partners, LLC	8/10/1995	172
HI	High Island	TX	A 545	HI544A	JA	FIXED	28.05664117	-94.02297862	Fieldwood Energy LLC	7/11/1998	235
HI	High Island	TX	A 531	HI537A	A	FIXED	28.08467007	-94.44392302	McMoRan Oil & Gas LLC	1/1/1976	200
HI	High Island	TX	A 536	HI537A	C	FIXED	28.04914800	-94.43834200	McMoRan Oil & Gas LLC	1/1/1977	200
HI	High Island	TX	A 563	HI563A	B	FIXED	27.96405200	-94.38891200	Cox Operating, L.L.C.	1/1/1977	305
HI	High Island	TX	110	HI111	B	FIXED	29.29856900	-94.22407100	W & T Offshore, Inc.	1/1/1977	40
HI	High Island	TX	206	WILD	B	CAIS	29.09359814	-94.38575542	Fieldwood Energy LLC	2/11/2003	55
HI	High Island	TX	129	HI129	17	CAIS	29.24273559	-93.80873435	Fieldwood Energy LLC	11/17/2003	51
HI	High Island	TX	A 589	WILD	A	FIXED	27.89309660	-94.32367099	Bennu Oil & Gas, LLC	7/15/2007	477
HI	High Island	TX	A 268	HI283A	A	FIXED	28.41132767	-93.88791867	Sanare Energy Partners, LLC	7/7/2007	220
HI	High Island	TX	A 489	HI474A	B	FIXED	28.22773600	-94.18563400	McMoRan Oil & Gas LLC	1/1/1976	180
HI	High Island	TX	A 536	HI537A	C-AUX	FIXED	28.04902900	-94.43822600	McMoRan Oil & Gas LLC	1/1/1979	200

- **Reporting**
  - A draft report was prepared by Darrell Davis and is under review alongside the spreadsheet database tools generated as part of the platform analysis.
  - Additional platform analysis (e.g., case studies) may be pursued in BP2 following the review of the first phase of work on platform re-use assessment.
  - As with pipelines, Trimeric will prepare a summary memorandum to highlight key findings of the platform re-use assessment.

Subtask 5.1.2 Evaluate feasibility of subsea template in GoM

(See Appendix for the report from Aker Solutions.)

Subtask 5.1.3 Preliminary Risk Assessment of CO2 Release from Truck/Barge Transfer Operations

No activity this quarter.

Subtask 5.1.4 Site Leasing

No activity this quarter.

Subtask 5.2: Scenario Optimization

SUMMARY

1. A manuscript for peer-review titled "Estimating the Power Requirements for a Carbon Capture and Storage Operation Based on the Total Operating Capacity of a Petroleum Refinery" has been developed for journal submission in early January 2021.
2. Conducted literature search for data required for the Aspen HYSYS simulation to use ionic liquids as a replacement for amine compounds for the separation of CO_2 from flue stack gases.

Background

The simulation performed for the total framework for the separation, compression, and dehydration (Figure 5.2.1) identified the separation of CO_2 from flue stack gases as the key area for energy minimization. Of the possible alternatives to amine absorption/stripping processes, ionic liquids were identified as substitute absorbents as well as replacement of the absorption/stripping process with pressure swing absorption processes.

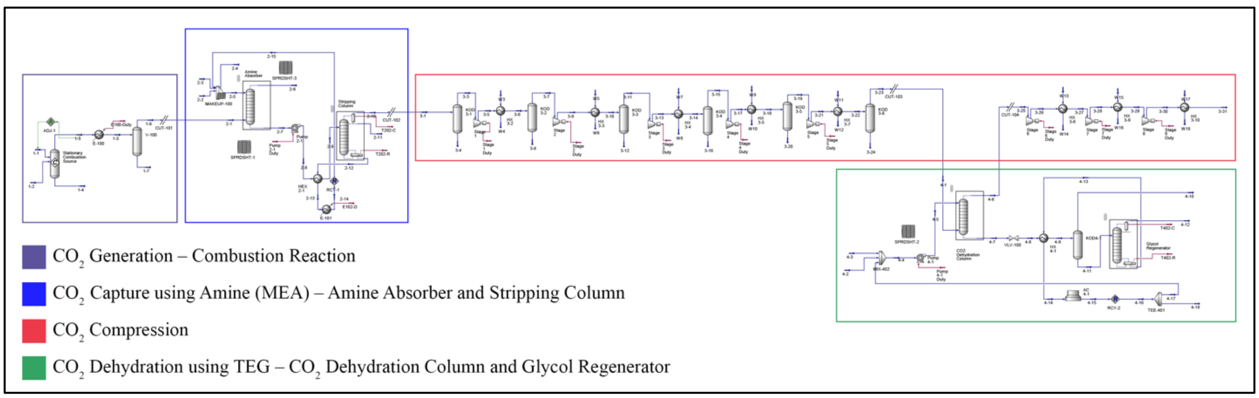
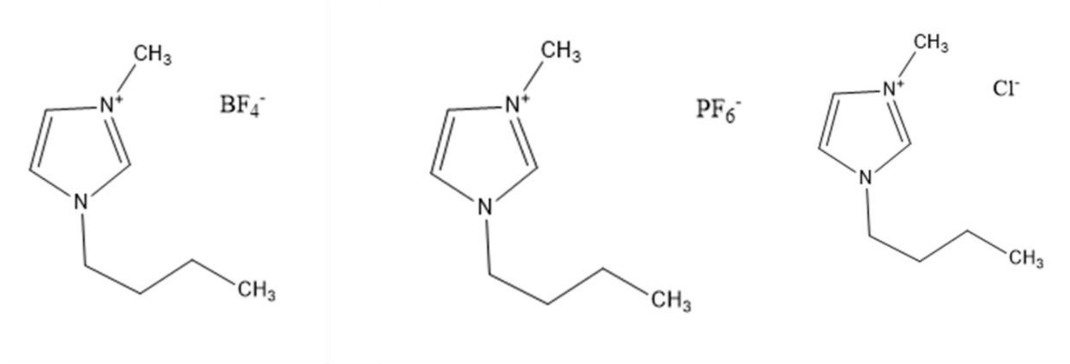


Figure 5.2.1. Process diagram for the separation, compression, and dehydration of CO_2 from flue stack gases

The use of amine absorbents (i.e. monoethanolamine, diethanolamine, methyldiethanolamine, and diglycolamine) often lead to higher concentrations of volatile organic compounds (VOCs) during the stripping phase of a cyclic absorption/stripping process. In more recent years, ionic liquids (Figure 5.2.2) have been explored as alternatives to these amine compounds since ionic liquids have negligible vapor pressures, high temperature stabilities, tunable properties (i.e., solubility) due to functional groups, and operational along wide temperature and pressure ranges.



$[C_4mim][BF_4]$ $[C_4mim][PF_6]$ $[C_4mim][Cl]$

Figure 5.2.2. Ionic Liquids that have been identified for CO_2 solubility where the cations contain the organic constituent, and the inorganic constituent contains the delocalized charge. $[C_4mim]$ = 1-butyl-3-methylimidazolium.

References

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[3] Mota-Martinez, M.T., Althuluth, M., Berrouk A., Kroon, M.C., Peters, C.J. (2014) High Pressure Phase Equilibria of Binary Mixtures of Light Hydrocarbons in the Ionic Liquid 1-hexyl-3-methylimidazolium Tetracyanoborate," Fluid Phase Equilibria, 362, 96 – 101.

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[5] Mortazavi-Manesh, S., Satyro, M., Marriott, R.A. (2013) "Modeling Carbon Dioxide Solubility in Ionic Liquids," Canandian Journal of Chemical Engineering, 91, 783 – 789.

[6] Budhathoki, S., Shah, J.K., Maginn, E.J. (2017) "Molecular Simulation Study of the Performance of Supported Ionic Liquid Phase Materials for the Separation of Carbon Dioxide from Methane and Hydrogen," I&EC Research, 56, 6775 – 6784.

[7] Budhathoki, S., Shah, J.K., Maginn, E.J. (2017) "Molecular Simulation Study of the Solubility, Diffusivity and Permselectivity of Pure and Binary Mixtures of CO_2 and CH_4 in the Ionic Liquid 1-n-Butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide," I&EC Research, 54. 8821 – 8828.

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Equilibria, 315, 53 – 63.

[10] Mortazavi-Manesh, S., Satyro, M., Marriott, R.A. (2011) "A Semi-empirical Henry's Law Expression for Carbon Dioxide Dissolution in Ionic Liquids," Fluid Phase Equilibria, 307, 208 – 215.

[11] Jalili, A.H., Mehdizadeh, A., Shokouhi, M., Ahmadi, A.N., Hosseini-Jenab, M., Fateminassab, F. (2010) "Solubility and Diffusion of CO_2 and H_2S in the Ionic Liquid 1-ethyl-3-methylmidizolium Ethylsulfate," J. Chem. Thermodynamics, 42, 1298 – 1303.

Subtask 5.2.1 Extend Scenario optimization to mid-Texas Coast

No activity during this quarter

Subtask 5.2.2 Analog Site Optimization

No activity during this quarter

Subtask 5.3: Communication

No activity during this quarter

TASK 6.0: Knowledge Dissemination

Subtask 6.1: Stakeholder Outreach

This quarter the team from the UT Stan Richards school of Advertising and Public Relations focused on finalizing the CCS message-testing survey of Texas residents in the Gulf Coast and fielding it among the target sample of 900 respondents in the study area. After months of delay, the contract with survey company, Ipsos, was officially signed by UT, and we were able to move forward with launching the survey. In October, we finalized the question items and our project manager at Ipsos formatted the survey for their platform. After a pre-test in late November, it was officially launched the beginning of December.

Subtask 6.2: Technical Outreach

GCCC

On October 14, 2020, Research Program Coordinator Emily Moskal gave a presentation, "Carbon Capture and Storage for Climate Change Mitigation along the Texas Coast," at the virtual American Shore and Beach Preservation Association's national conference titled, "2020 Vision for Our Coasts: Navigating Stormy Times." The conference consisted of more than 70 speakers, not including a poster gallery. The American Shore and Beach Preservation Association is a national network of professionals with regional chapters working to "advocate for healthy, sustainable and resilient coastal systems to sustain four inter-connected core values provided by shores and beaches: community protection, a strong economy, ecologic health and recreation, according to their website.

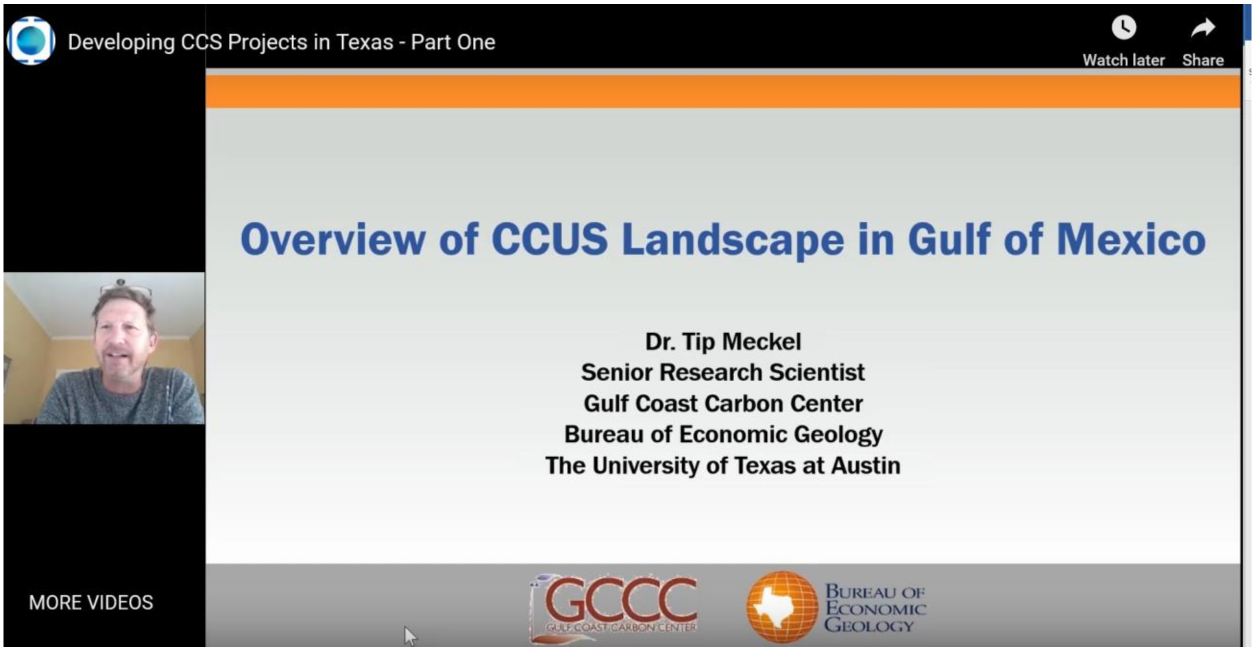


Figure 6.2.1 – On October 21, 2020, co-PI, Dr. Tip Meckel presented "Overview of CCUS Landscape in Gulf of Mexico" at the "Developing CCS Projects in Texas – Day1" webinar, which was hosted by USEA and was supported by DOE FE. https://www.globalccsinstitute.com/resources/audio-and-visual-library/ .

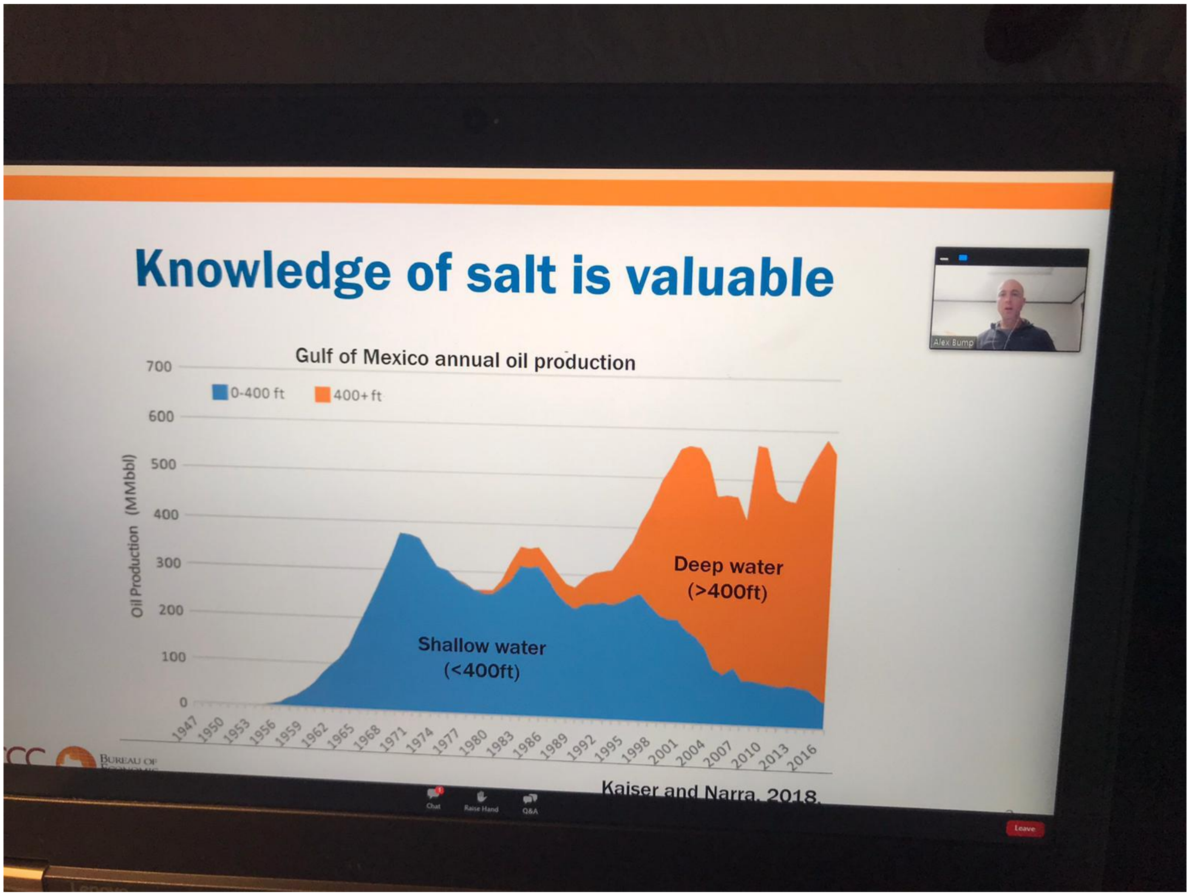
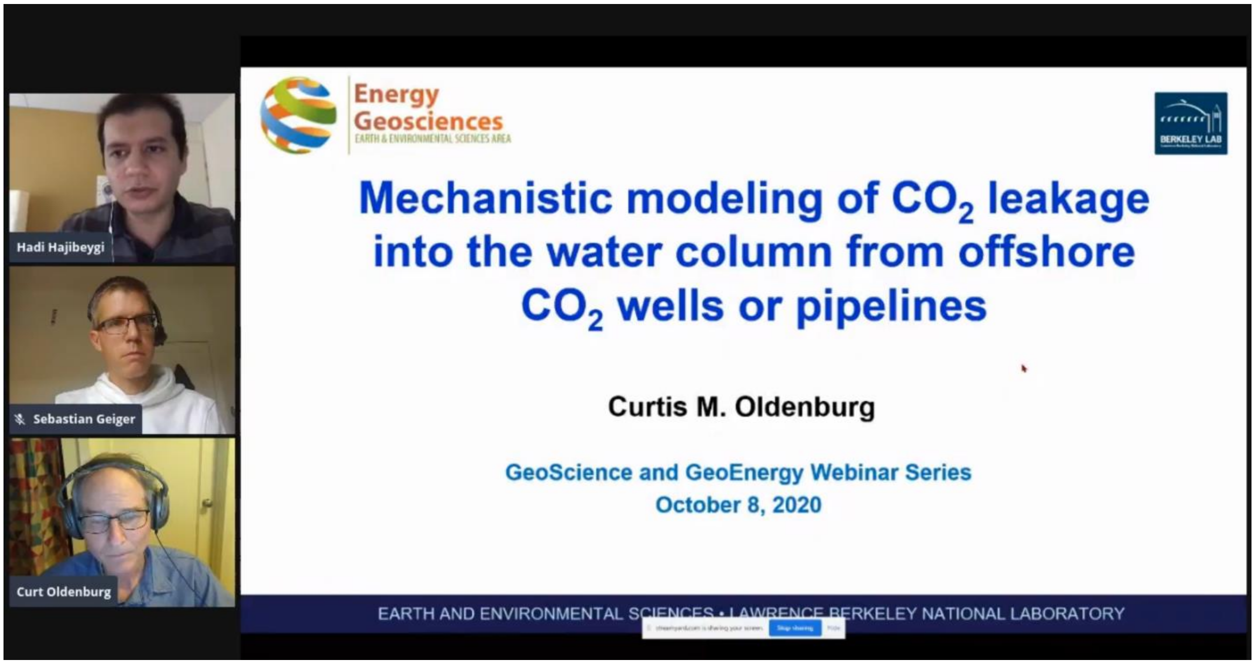


Figure 6.2.2 – On November 12, Dr. Alex Bump presented, “Can We Apply Salt and Salt-sediment Learnings to Carbon Storage?” to the annual sponsors’ meeting of the Bureau of Economic Geology’s Advanced Geodynamic Laboratory industry consortium.

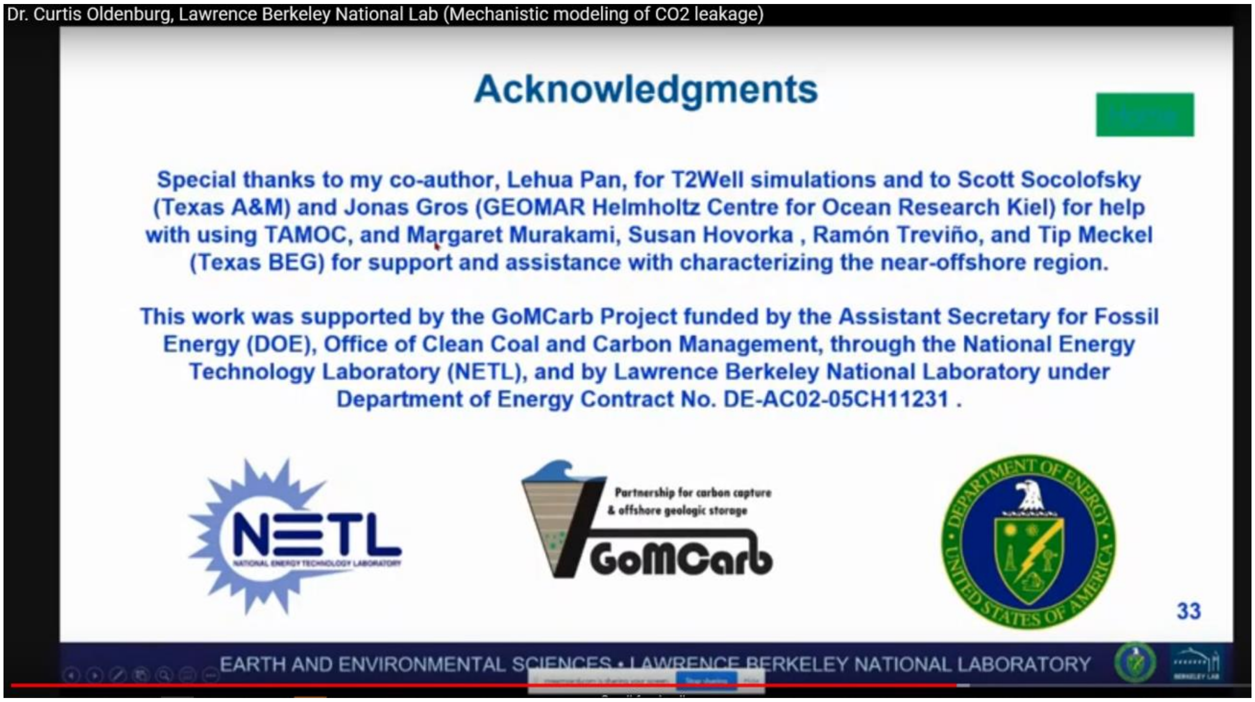
On November 13, Dr. Alex Bump conducted an informational call with Teyshas Energy, a small privately held oil and gas consultancy firm in Dallas that describes itself as an integrated technical, commercial and business development team with a proven track record in the US and Latin America. Teyshas was interested in CCS as possible future business, and wanted to know about GoMCarb.

Lawrence Berkeley National Laboratory

On October 8, 2020, Dr. Curtis Oldenburg gave a presentation, “Mechanistic Modeling of CO_2 Leakage into the Water Column from Offshore CO_2 Wells or Pipelines,” (Figures 6.2.3 and 6.2.4) to a symposium hosted by the Delft Technical University, Netherlands.



Figures 6.2.3 – Dr. Curtis Oldenburg presenting a talk to the Delft Technical University.



Figures 6.2.4 – Dr. Curtis Oldenburg's acknowledgement slide for his October 8, 2020 presentation to the Delft Technical University.

On December 18, 2020, LLNL Partner PI, Dr. Josh White gave a presentation to the University of Texas at

Austin, Bureau of Economic Geology weekly seminar. The title and abstract follow:

> Induced seismicity and carbon storage: Moving towards improved risk assessment and risk mitigation strategies
>
> Geologic carbon storage (GCS) is widely recognized as an important strategy to reduce atmospheric carbon dioxide emissions. Like all technologies, however, sequestration projects create a number of potential environmental and safety hazards that must be addressed. These include earthquakes—from microseismicity to larger events—that can be triggered by altering pore-pressure conditions in the subsurface. To date, measured seismicity due to CO2 injection has been limited to a few modest events, but the hazard exists and must be considered. This presentation will focus on strategies for assessing and mitigating seismic risk, with an emphasis on maintaining public trust in GCS. We will also highlight research avenues which could have a substantial impact on this subsurface engineering challenge.

Subtask 6.3: Advisory Committee

No activity during this quarter.

PLANS FOR THE NEXT PROJECT QUARTER

Task 1

- Extend subcontracts of subrecipients and add funds for budget period 2.

Task 2

Subtask 2.1:

- Subtask 2.1.1.2 – Summarize well-log correlation in Corpus Christi Bay and Redfish Bay and adjacent areas, and assess potential 3D seismic datasets.
- Subtask 2.1.2 – Continue digitizing well logs, prioritizing wells to be used for velocity model generation.

Task 3 Risk Assessment, Simulation and Modeling

- Subtask 3.2 – LLNL will continue developing an elastoplastic model to analyze the potential for ductile deformation at the High Island analogue site. We plan to continue this work through the next two quarters.
- Subtask 3.1.3 – Begin work on atmospheric dispersion of the CO_2 that breaches the sea surface in blowout scenarios.
- Subtask 3.1.4 – Check with BEG on the status of the geological model with hydrofacies distributions.
-

Task 4 Monitoring Verification and Assessment

- 4.1.4 – Develop subcontract from LBNL to Rice University to allow Jonathan Ajo-Franklin to continue working on this subtask.
- 4.1.5 – Obtain signatures on the subcontract from LBNL to Rice University.

-

Task 5 Infrastructure, Operations and Permitting

Trimeric

- Subtask 5.1: Summarize well re-use assessment in BP1 in a memorandum.
- Subtask 5.1: Consider case study approach for wells, specifically in the context of assessing wells for risk (vs. exclusively re-use).
- Subtask 5.1: Complete platform infrastructure re-use assessment, including summary memorandum. Define next phase of re-use assessment.
- Subtask 5.1: Issue the pipeline re-use assessment memorandum to broader project team. Consider additional screening analyses and case studies to expand re-use assessment of pipelines.
- Subtask 5.2: Continued development of CO_2 source list along the Texas and Louisiana coast, including outreach and education of industry in the region.

Lamar

- Subtask 5.2: The next phase consists of developing the Aspen HYSYS model and developing model predictive control strategies for a "drop in" replacement of amines with ionic liquids.

Task 6 Knowledge Dissemination

- LBNL - Present a talk to TU Delft (Netherlands) on the modeling of a CO_2 leak in a water column.
- GCCC - Give a presentation to the GCCSI/USEA "Developing CCS Projects in Texas – Day1" webinar.

STATUS OF PROJECT SCHEDULE AND MAJOR GOALS/MILESTONES OF PROJECT

Schedule/Timeline

The project schedule/timeline is shown in the following Gantt chart. The project is currently on schedule.

Task	Partnership for Offshore Carbon Storage Resources and Technology Development in the Gulf of Mexico	BUDGET PERIOD 1											BUDGET PERIOD 2								
		2018			2019				2020				2021				2022				2023
Task	Tasks	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1
		A-M-J	J-A-S	O-N-D	J-F-M	A-M-J	J-A-S	O-N-D	J-F-M	A-M-J	J-A-S	O-N-D	J-F-M	A-M-J	J-A-S	O-N-D	J-F-M	A-M-J	J-A-S	O-N-D	J-F-M
1	**Project Management, Planning, and Reporting**	**M1**		**M2**																	**M11**
	Revision and Maintenance of Project Management Plan								**G-NG**												
	Progress Report	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
2	**Offshore Storage Resources Characterization**						**M4**			D2.1a		D2.2a	D2.3a		**M8**						
2.1	Database Development				**M3**																
2.2	Data Gap Assessment																				
2.3	Offshore EOR Potential																				
3	**Risk Assessment, Simulation and Modeling**				3.1a				**M5**		**M6**				D3.2a						
3.1	Risk Assessment and Mitigation Strategies																				
3.2	Geologic Modeling																				
4	**Monitoring, Verification, Accounting (MVA) and Assessment**					D4.1a							**M7**				D4.2a				
4.1	MVA Technologies and Methodologies																				
4.2	Plans for Field Testing of MVA Technologies																				
4.3	Testing MVA Technologies																				
5	**Infrastructure, Operations, and Permitting**						D5.1a						D5.2a							D5.3a	
5.1	CO2 Transport and Delivery																				
5.2	Scenario Optimization																				
5.3	Communication																				
6	**Knowledge Dissemination**			6.1a				6.2a			D6.3a					D6.3b	**M9**		**M10**		
6.1	Stakeholder Outreach																				
6.2	Technical Outreach																				
6.3	Advisory Panel																				

Q = Quarterly Report; A = Annual Report; M = Milestone; DP = Decision Point; D = Deliverable; G-NG = Go/no-go decision point; FR = Final Report

MAJOR GOALS / MILESTONES

Task/ Subtask	Milestone Number and Title	*Planned* Completion *Date*	Verification method
1	M1: Attend Kickoff meeting	4/30/2018	Submit Presentation File
1	M2-1: Partnership Fact Sheet	8/31/2018	Fact Sheet file
2	M3: Data submitted to NETL-EDX	1/31/2019	List of data submitted
2	M4: Identification of geologic storage prospects & data gaps	11/1/2019	Summary Report
3	M5: Risk assessment, simulation and modeling of prospects	9/30/2020	Summary Report
3	M6: Modified risk assessment, simulation and modeling of prospects	12/31/2020	Summary Report
4	M7: Modified MVA technologies and testing plan identified for prospects	*2/26/2021*	Summary Report
2	M8: Refinement of geologic storage prospects & data gaps	*9/30/2021*	Summary Report
6	M9: Summary of Advisory Committee recommendations	*3/31/2022*	Letter Report
6	M10: Outcomes of public acceptance studies	*9/30/2022*	Letter Report
1	M11: Upload results to EDX	*3/3/2023*	Summary Report

3. PRODUCTS

Publications, conference papers, and presentations.

The following was published during the quarterly reporting period:

Bump, A. P., Hovorka, S. D., Meckel, T. J., Nuñez-López, V., Olariu, M. I., and Treviño, R. H., 2020, Carbon capture and storage potential in southern Louisiana: a new business opportunity: GeoGulf Transactions, v. 70, p. 73–84.

Websites

http://www.beg.utexas.edu/gccc/research/gomcarb

Technologies or techniques

None generated to date.

Inventions, patent applications, and/or licenses

None generated to date.

Other products

None to date.

4. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

The University of Texas at Austin

Bureau of Economic Geology, GCCC (Gulf Coast Carbon Center)
Name: Susan Hovorka, PhD
Project Role: Principal Investigator
Nearest person month worked: 1
Contribution to Project: Leadership in planning and negotiating

Name: Tip Meckel, PhD
Project Role: Co-Principal Investigator
Nearest person month worked: 1
Contribution to Project: Dr. Meckel oversaw geologic interpretation work

Name: Ramón Treviño
Project Role: Co-Principal Investigator (project manager)
Nearest person month worked: 1
Contribution to Project: Mr. Treviño provided project management and project reporting; he acted at the primary contact for the NETL project manager and contracting specialist.

Name: Michael DeAngelo
Project Role: Researcher (geophysicist seismic interpreter)
Nearest person month worked: 1
Contribution to Project: Mr. DeAngelo conducted structural interpretation of the "TexLa Merge," "Texas OBS" and "Chandeleur Sound" regional 3D seismic datasets.

Name: Iulia Olariu, PhD
Project Role: sedimentologist
Nearest person month worked: 1
Contribution to Project: Interpretation of subsurface geology nearshore federal waters; supervisor of undergraduate research assistants.

Name: Dallas Dunlap
Project Role: seismic interpreter,
Nearest person month worked: 1

Contribution to Project: worked with Dr. Purkey-Phillips to interpret seismic in the Chandeleur Sound area.

Name: Tucker Hentz
Project Role: seismic interpreter,
Nearest person month worked: 2
Contribution to Project: Interpretation of subsurface geology Texas state waters, lower coast.

Name: Katherine Romanak, PhD
Project Role: geochemist
Nearest person month worked: 1
Contribution to Project: Liaison with GERG

Name: Alex Bump, PhD
Project Role: geologist
Nearest person month worked: 1
Contribution to Project: Regional geologic interpretation and CCS assessment

Name: Sahar Bakhshian, PhD
Project Role: reservoir engineer
Nearest person month worked: 1
Contribution to Project: micro-scale fluid flow for flow modeling

Name: Vanessa Nunez-Lopez
Project Role: petroleum engineer
Nearest person month worked: 1
Contribution to Project: oil & gas production data analysis

Name: Hongliu Zeng, PhD
Project Role: geophysicist
Nearest person month worked: 1
Contribution to Project: post-stack re-processing of HR3D survey

Name: Ramon Gil-Egui
Project Role: outreach
Nearest person month worked: 1
Contribution to Project: outreach to Hispanic community

Name: Damayanti Amy Banerji, PhD
Project Role: seismic assessment
Nearest person month worked: 1
Contribution to Project: assessing availability of seismic data (Corpus Christi area)

UT Institute for Geophysics, GBDS (Gulf Basin Depositional Synthesis) Industrial

Associates Program

Name: Marcie Purkey-Phillips
Project Role: Biostratigrapher
Nearest person month worked: 1
Contribution to Project: contributed expertise in biostratigraphy as well as integrated well and seismic data in the Chandeleur Sound 3D survey area.

Fugro Marine Geoservices, Inc.

Lamar University

Louisiana Geological Survey

Trimeric Corp.

Lawrence Berkeley National Laboratory

Lawrence Livermore National Laboratory

TDI-Brooks, Inc.

Texas A&M University GERG (Geochemical & Environmental Research Group)

U.S. Geological Survey (USGS)

5. IMPACT:

6. CHANGES/PROBLEMS

Changes in approach and reasons for change: **Staff mostly working remotely due to Covid-19 pandemic**

Actual or anticipated problems or delays and actions or plans to resolve them: **None**

Changes that have a significant impact on expenditures: **First HR3D survey will not occur before end of BP1 due to Covid-19 and inability to socially distance on a research vessel. (See Task 1 for details.)**

Change of primary performance site location from that originally proposed: **None**.

7. SPECIAL REPORTING REQUIREMENTS

Respond to any special reporting requirements specified in the award terms and conditions, as well as any award specific requirements. **None**

8. BUDGETARY INFORMATION

Cost Plan Status Report

Appendix