SECARB Offshore Gulf of Mexico
Project Status Highlights – August 2019

Presented by: Michael Godec, Advanced Resources International

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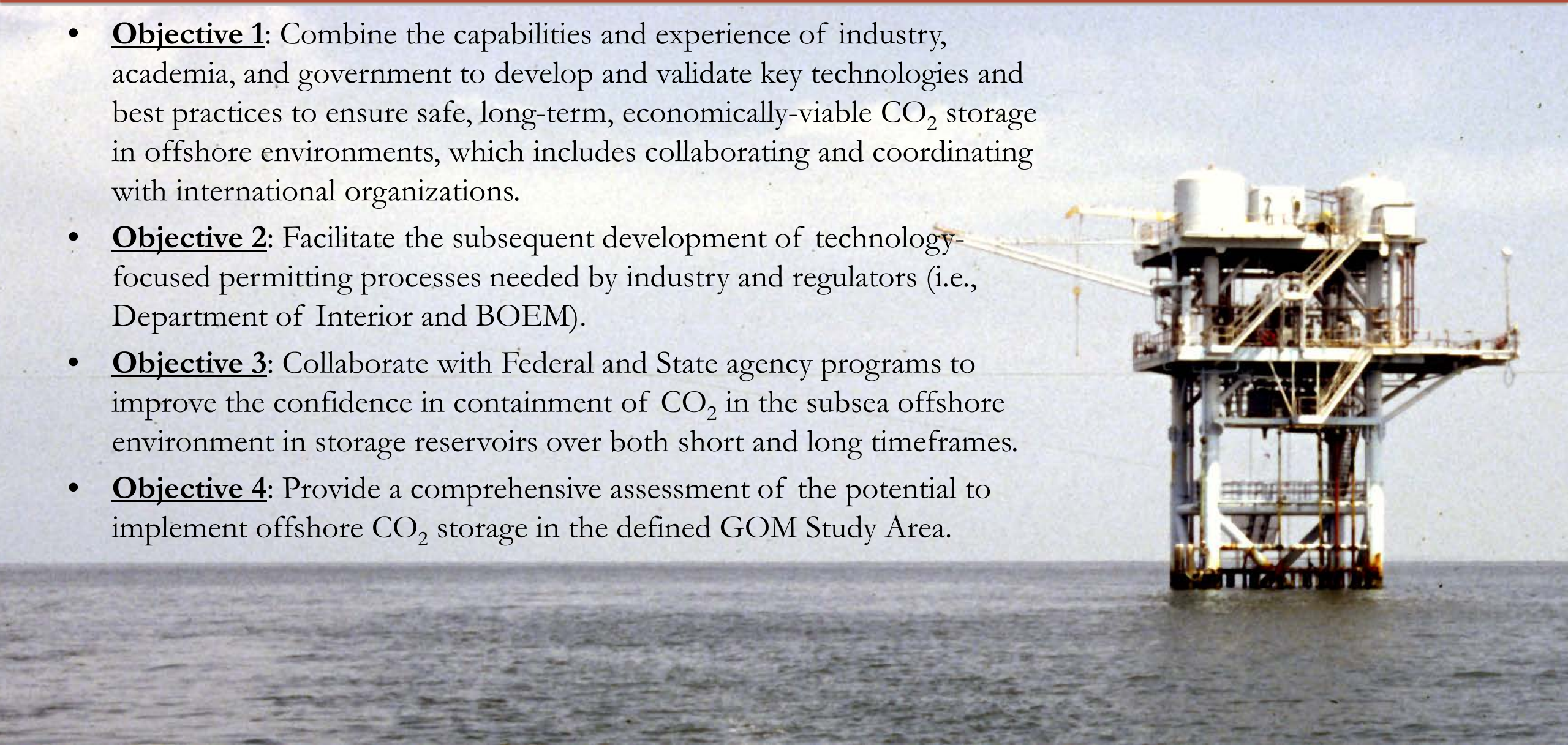
Disclaimer

SECARB Offshore Project Objectives

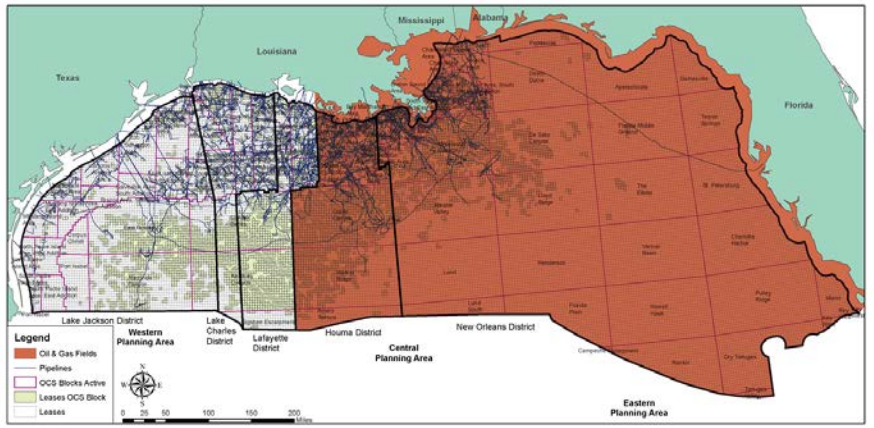
- **Objective 1**: Combine the capabilities and experience of industry, academia, and government to develop and validate key technologies and best practices to ensure safe, long-term, economically-viable CO_2 storage in offshore environments, which includes collaborating and coordinating with international organizations.
- **Objective 2**: Facilitate the subsequent development of technology-focused permitting processes needed by industry and regulators (i.e., Department of Interior and BOEM).
- **Objective 3**: Collaborate with Federal and State agency programs to improve the confidence in containment of CO_2 in the subsea offshore environment in storage reservoirs over both short and long timeframes.
- **Objective 4**: Provide a comprehensive assessment of the potential to implement offshore CO_2 storage in the defined GOM Study Area.



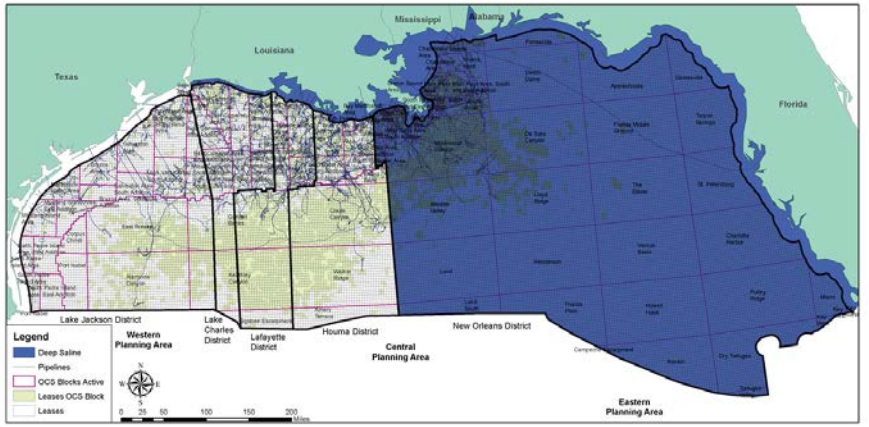
SECARB Offshore Study Area & Project Boundaries

FEDERAL WATERS		
	Depleted Oil & Gas Fields, and Potentially Associated CO_2-EOR	Deep Saline
Western Planning Area	No	No
Central Planning Area	Study Area is East of Houma District's Western Boundary (includes Houma District)	Study Area is East of New Orleans District's Western Boundary (excludes Houma District)
Eastern Planning Area	All	All
STATE WATERS		
	Depleted Oil & Gas Fields, and Potentially Associated CO_2-EOR	Deep Saline
Texas	No	No
Louisiana	Partial, Includes State Waters East of Houma District Boundary Extension	Partial, Excludes Chandeleur Sound/Islands
Mississippi	Yes	Yes
Alabama	Yes	Yes
Florida (West Coast)	Yes	Yes

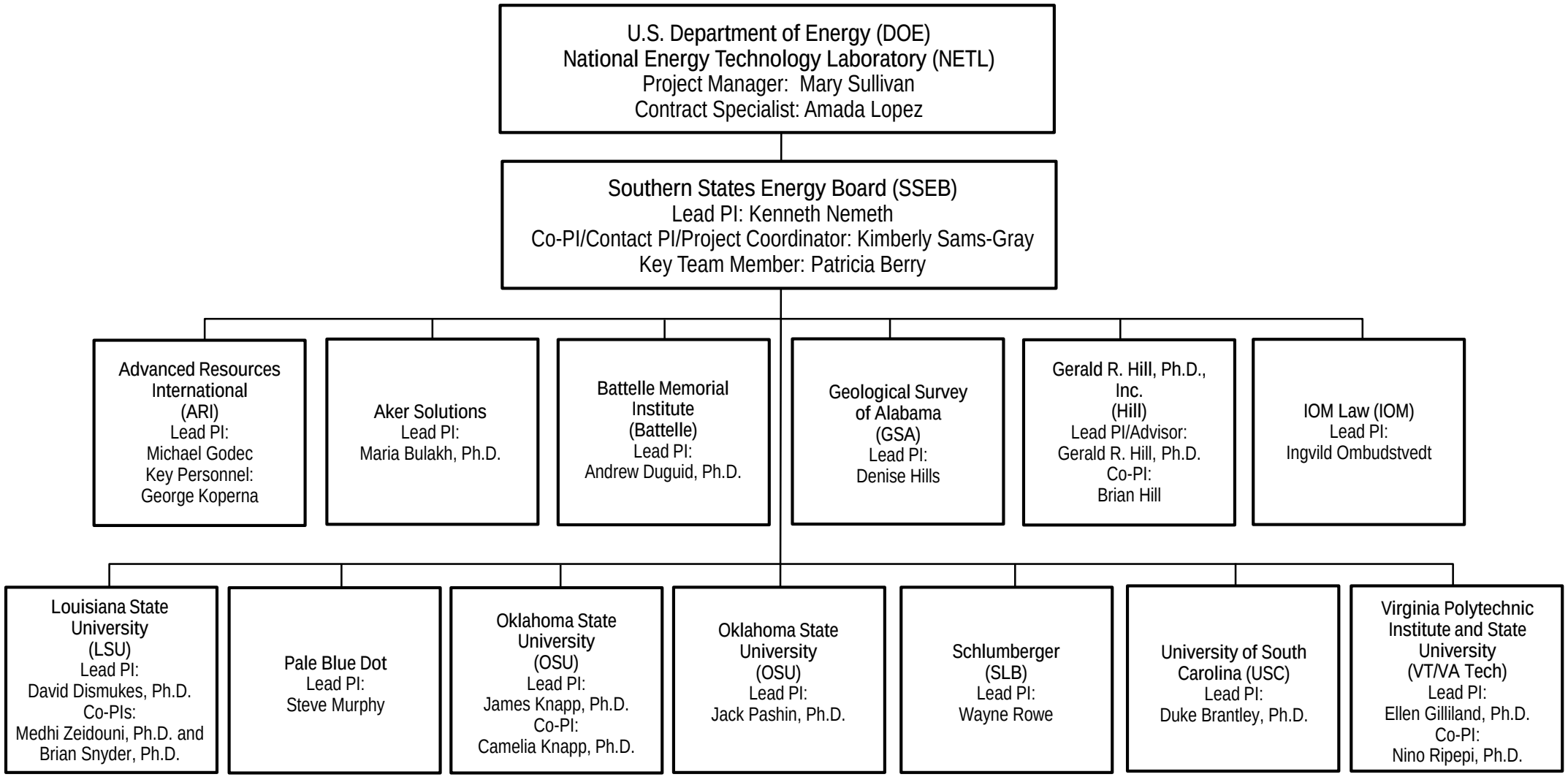
Study Area | Oil and Gas



Study Area | Saline Aquifers

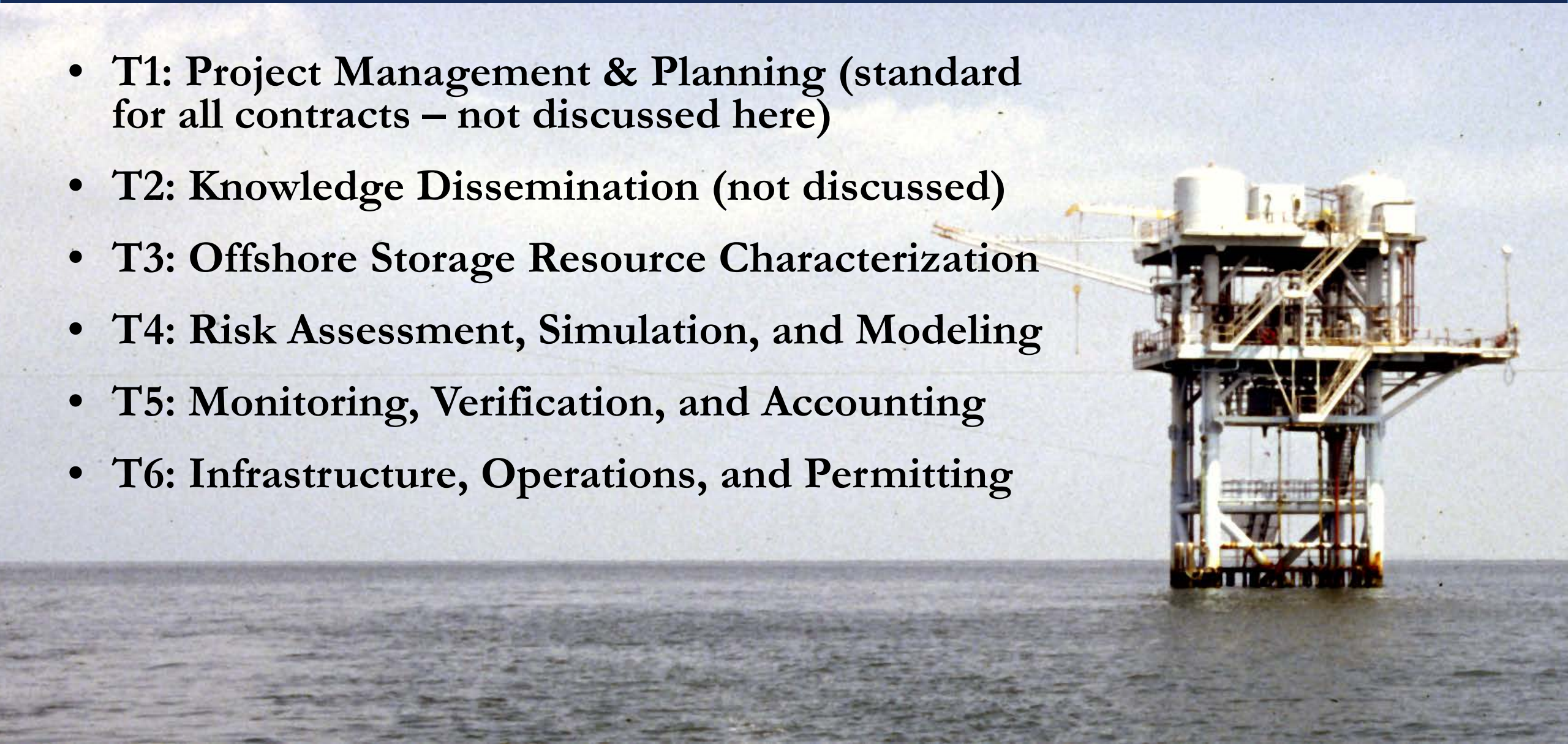


Partners & Contractual Organizational Chart



Primary Tasks

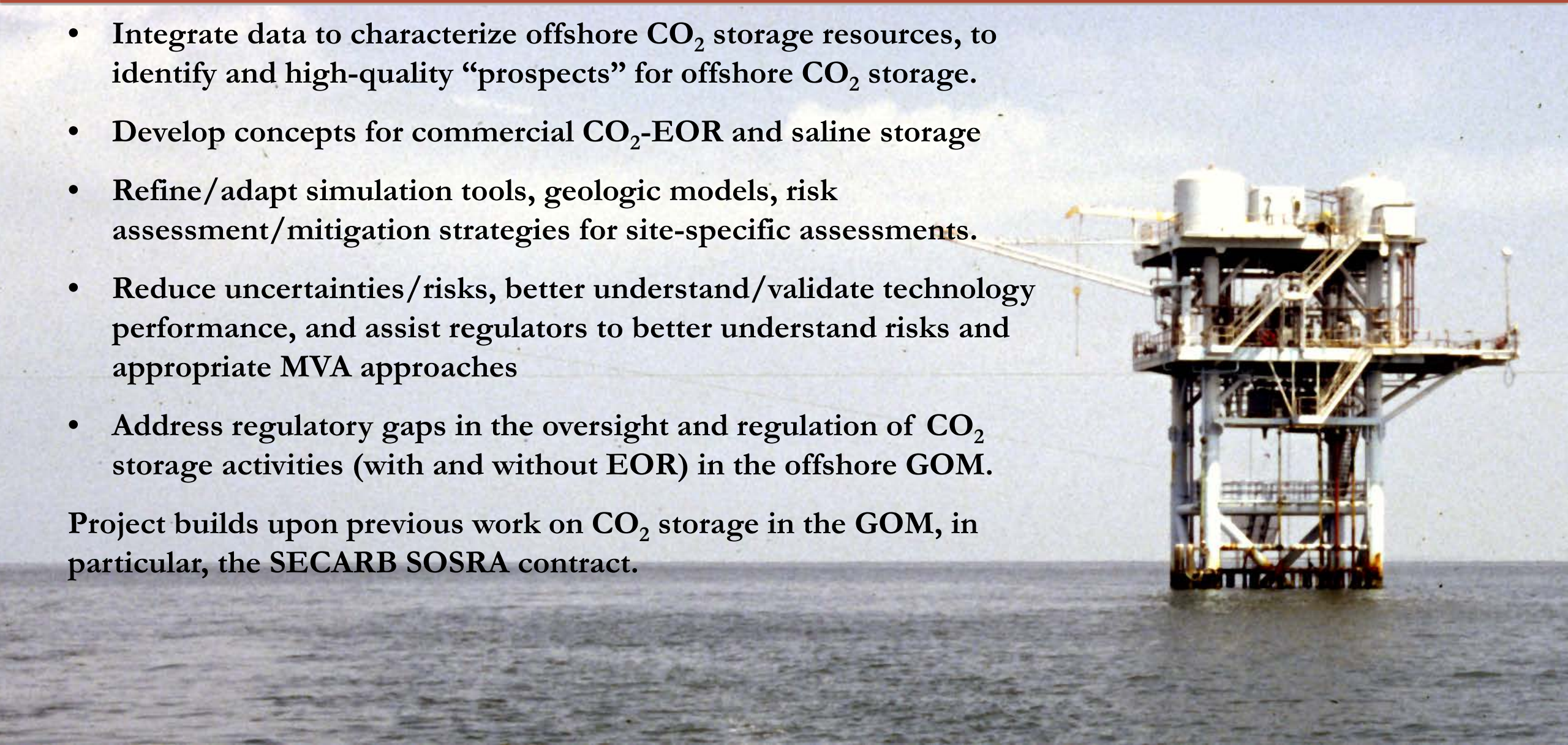
- T1: Project Management & Planning (standard for all contracts – not discussed here)
- T2: Knowledge Dissemination (not discussed)
- T3: Offshore Storage Resource Characterization
- T4: Risk Assessment, Simulation, and Modeling
- T5: Monitoring, Verification, and Accounting
- T6: Infrastructure, Operations, and Permitting



Anticipated Project Outcomes

- Integrate data to characterize offshore CO_2 storage resources, to identify and high-quality "prospects" for offshore CO_2 storage.
- Develop concepts for commercial CO_2-EOR and saline storage
- Refine/adapt simulation tools, geologic models, risk assessment/mitigation strategies for site-specific assessments.
- Reduce uncertainties/risks, better understand/validate technology performance, and assist regulators to better understand risks and appropriate MVA approaches
- Address regulatory gaps in the oversight and regulation of CO_2 storage activities (with and without EOR) in the offshore GOM.

Project builds upon previous work on CO_2 storage in the GOM, in particular, the SECARB SOSRA contract.



Task 3: Offshore Storage Resource Characterization

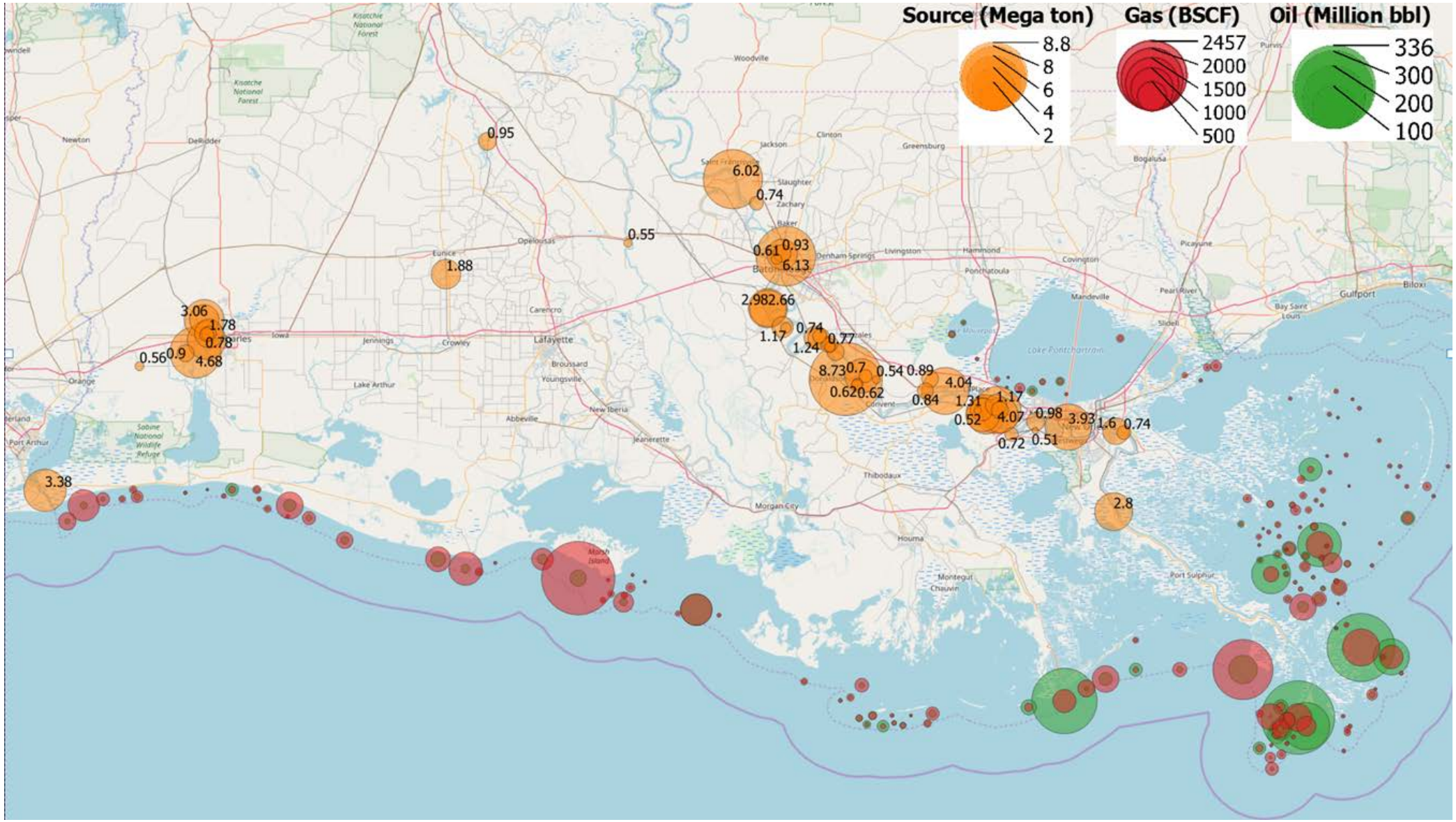
Objective: Assemble, review, analyze, integrate, assess existing available information on storage resource potential in the GOM.

- **Task 3.1: Assemble Data and Review Existing Information**
  - Saline storage prospects, depleted oil and gas fields, including that associated with CO_2-EOR – in Federal and State waters.
- **Task 3.2: Integrate and Assess Available Information**
- **Task 3.3: Screen for "Representative" Storage Opportunities**
  - For variety of geologic and operational settings, including stacked storage and CO_2-EOR.
- **Task 3.4: Identify and Address Risks and Data Gaps**
  - By identifying and partnering with private companies or organizations to obtain real-world data.

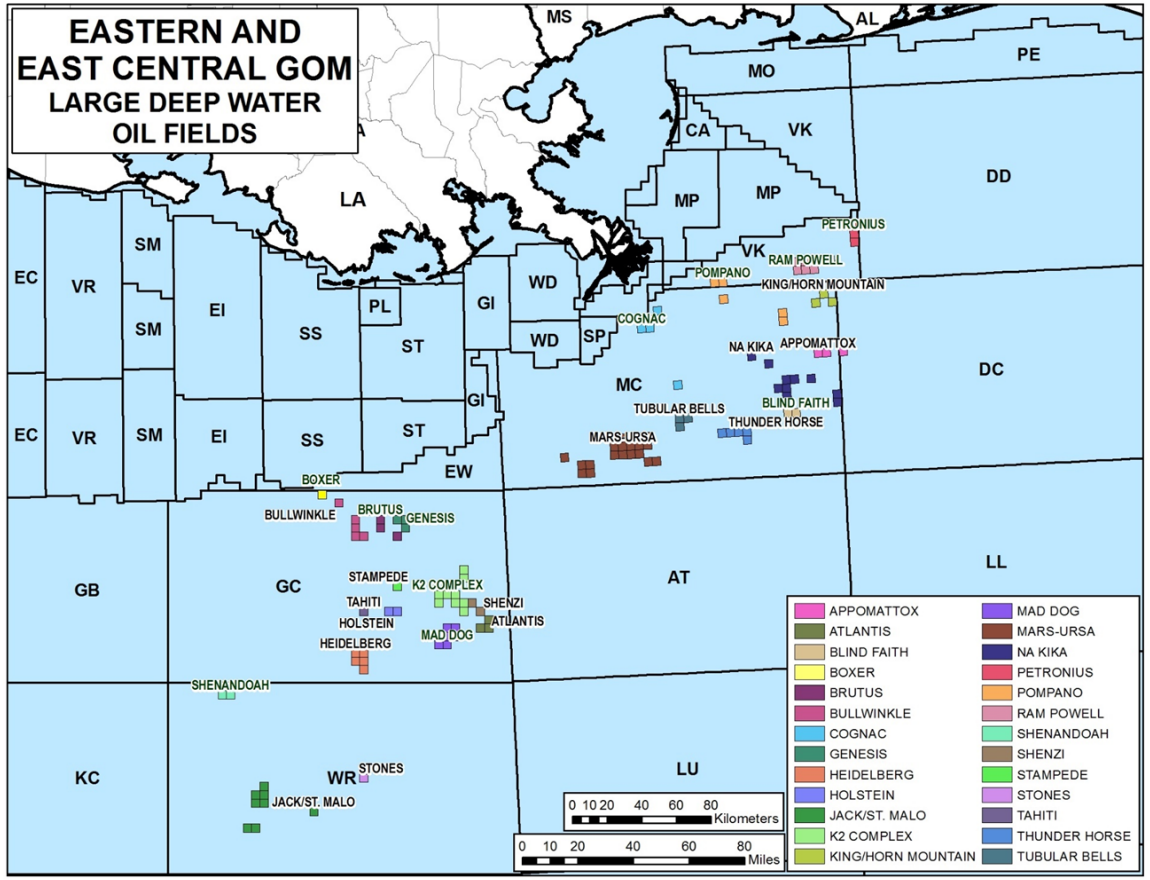
Acquisition and Analysis of 3-D Seismic Data (OSU)

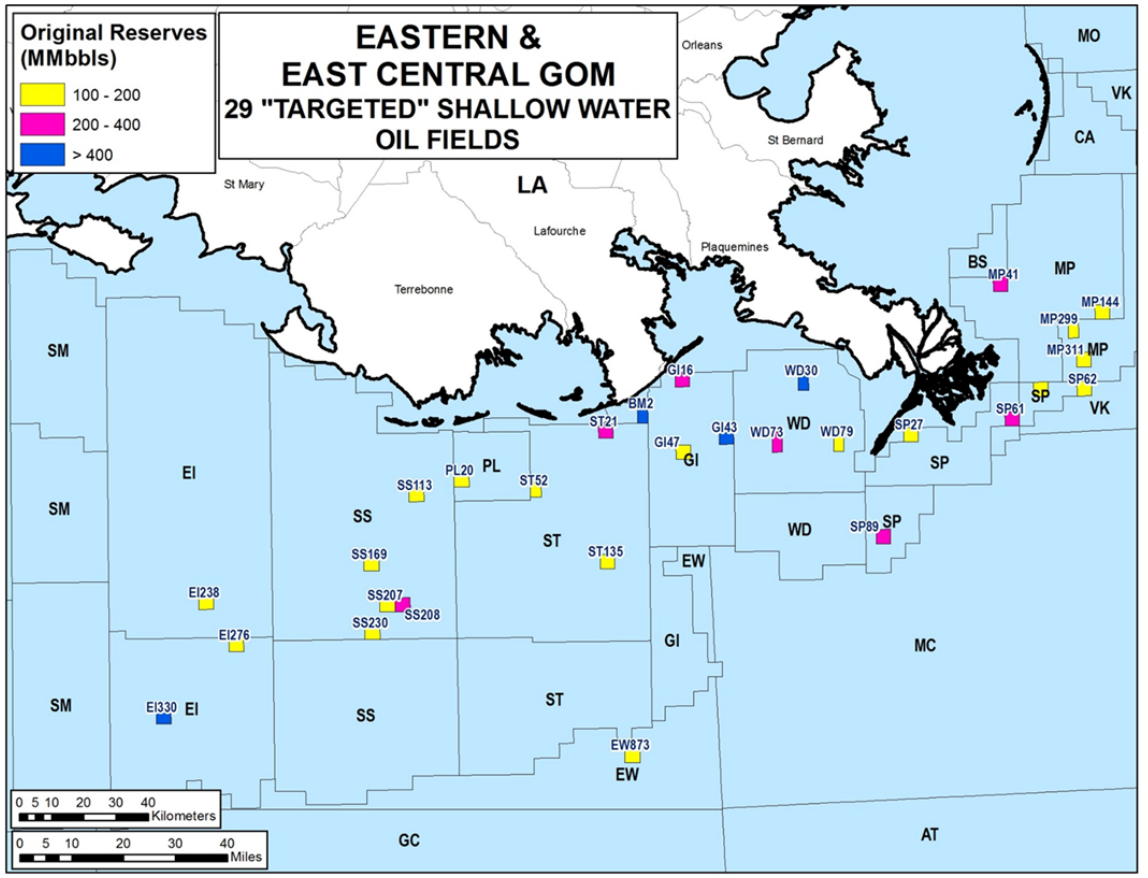
- OSU in process of purchasing three 3-D seismic datasets from Mississippi Canyon 118 block
- Research focused on performing AVO analysis and inversion to identify and corroborate the presence of bright spots and identify the base of the gas hydrate stability zone.

Prospective Oil and Gas Fields in LA State Waters Relative to Large Nearby CO_2 Sources (LSU)



Offshore GOM Oil Fields Targeted for CO_2-EOR (ARI)



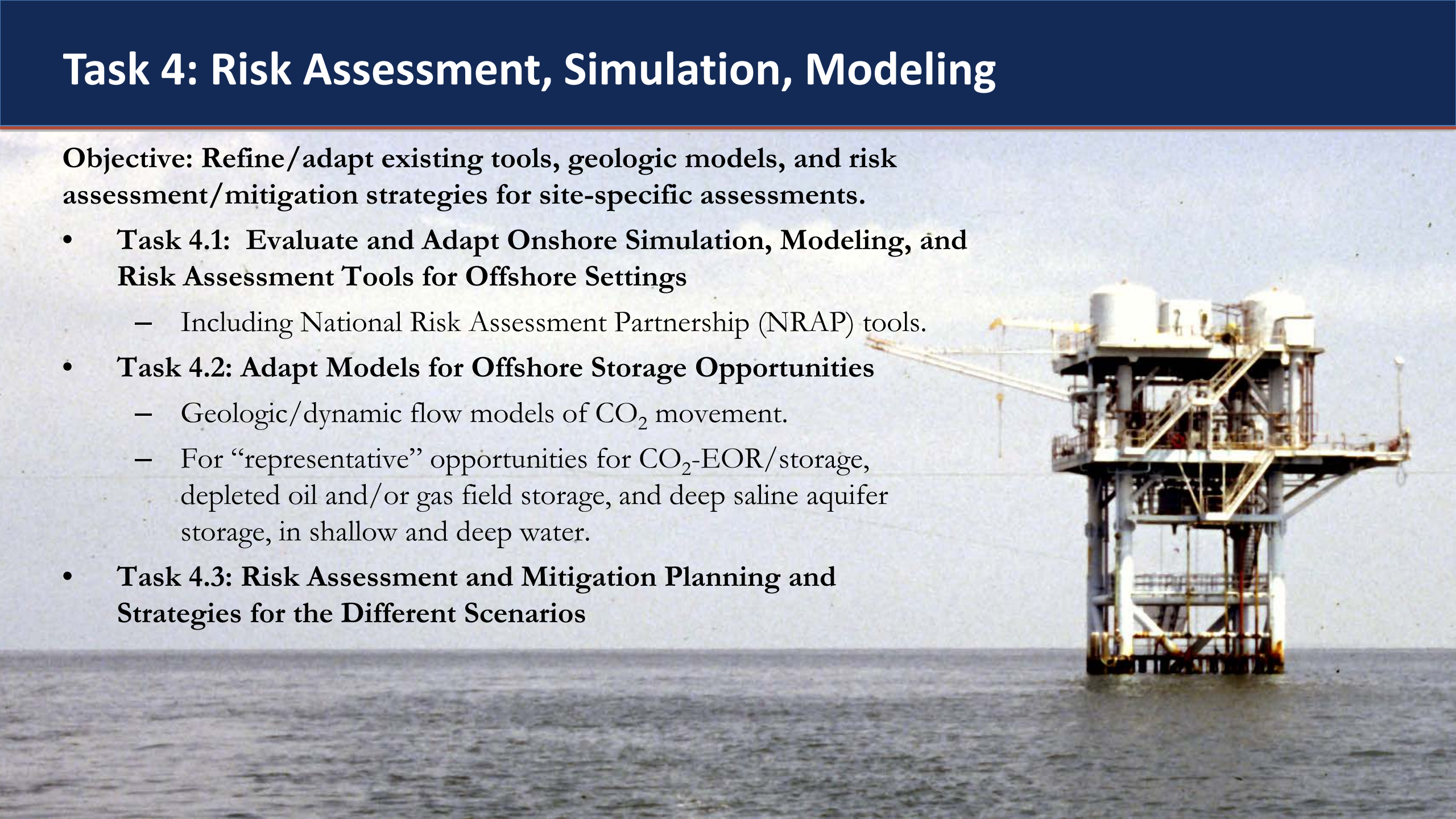


- Assessing the potential of CO_2-EOR in the Petronius field in .
- 63 large deep water Eastern & East Central GOM oil fields, mostly in Green Canyon & Mississippi Canyon, contain 8.6 BB of original reserves, with about half produced.

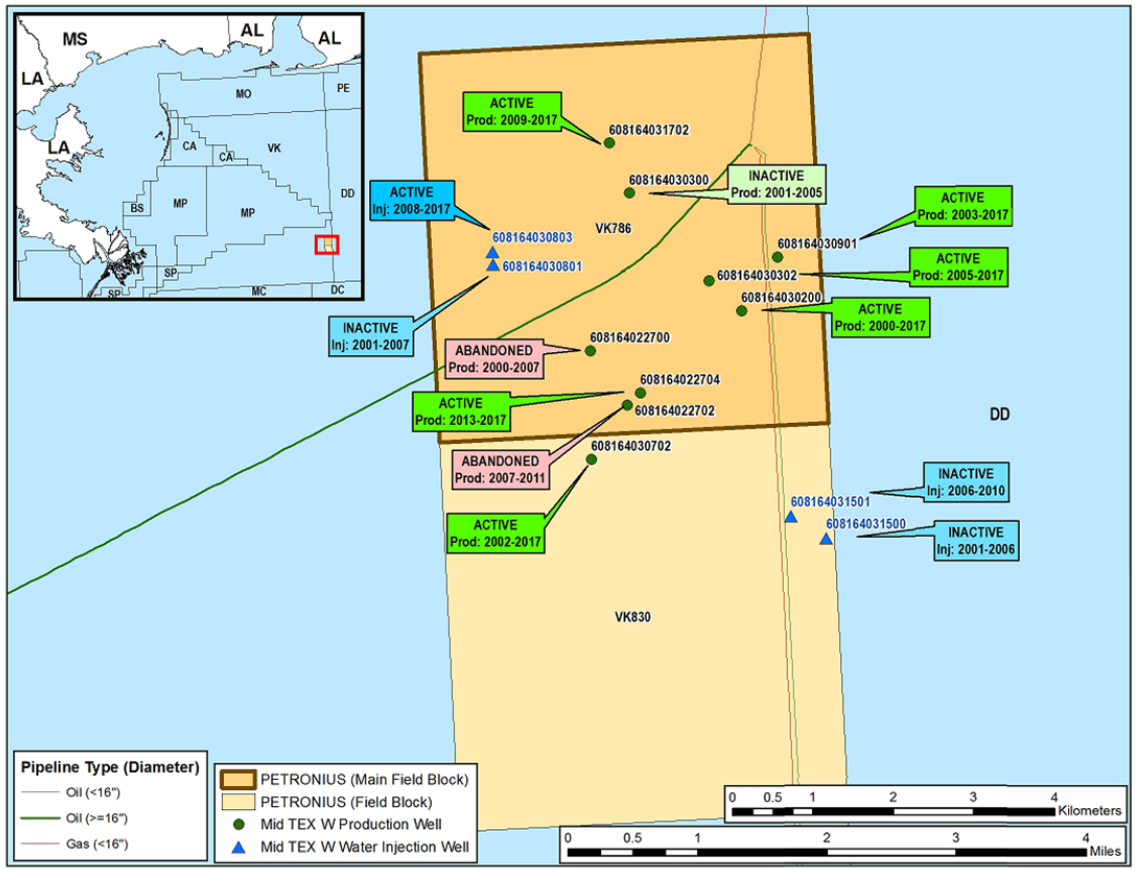
Task 4: Risk Assessment, Simulation, Modeling

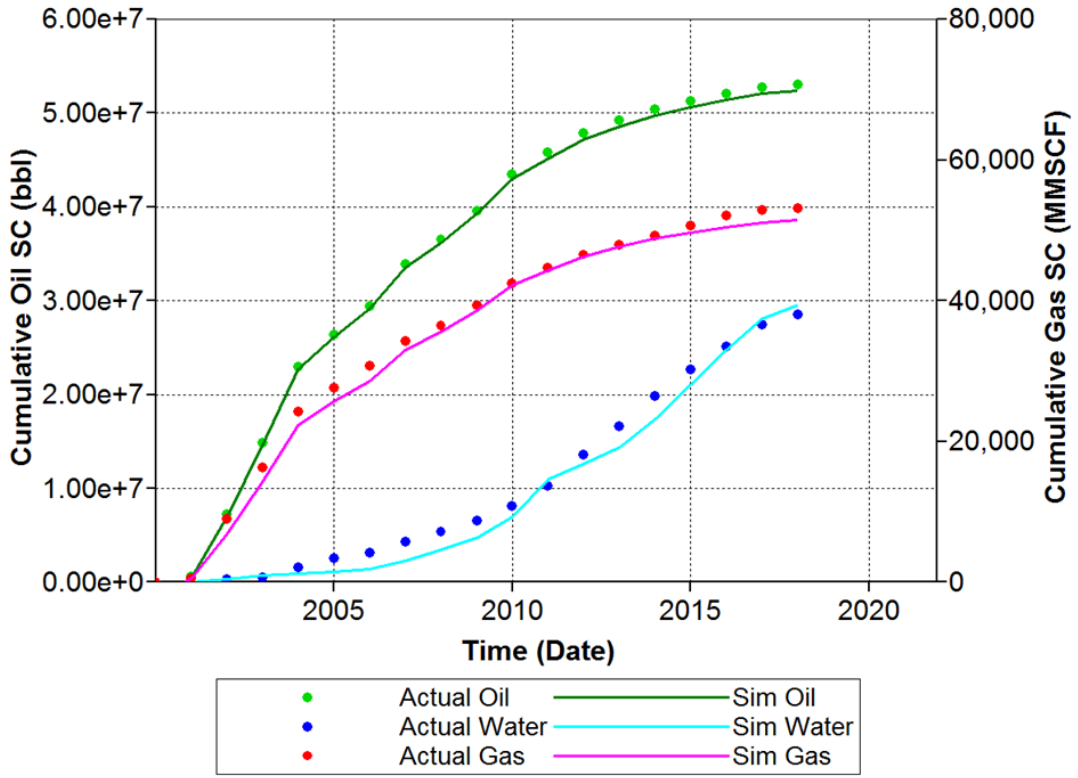
Objective: Refine/adapt existing tools, geologic models, and risk assessment/mitigation strategies for site-specific assessments.

- **Task 4.1: Evaluate and Adapt Onshore Simulation, Modeling, and Risk Assessment Tools for Offshore Settings**
  - Including National Risk Assessment Partnership (NRAP) tools.
- **Task 4.2: Adapt Models for Offshore Storage Opportunities**
  - Geologic/dynamic flow models of CO_2 movement.
  - For "representative" opportunities for CO_2-EOR/storage, depleted oil and/or gas field storage, and deep saline aquifer storage, in shallow and deep water.
- **Task 4.3: Risk Assessment and Mitigation Planning and Strategies for the Different Scenarios**



Prospect Modeling – Representative GOM Prospects for CO_2-EOR – Petronius (ARI)





- Located in Viosca Knoll, Block VK786, 130 miles southeast of New Orleans
- 9 producers and 4 injection wells are completed in the J2 sand formation

Prospect Modeling – Representative GOM Prospects for CO_2-EOR – Petronius (ARI)

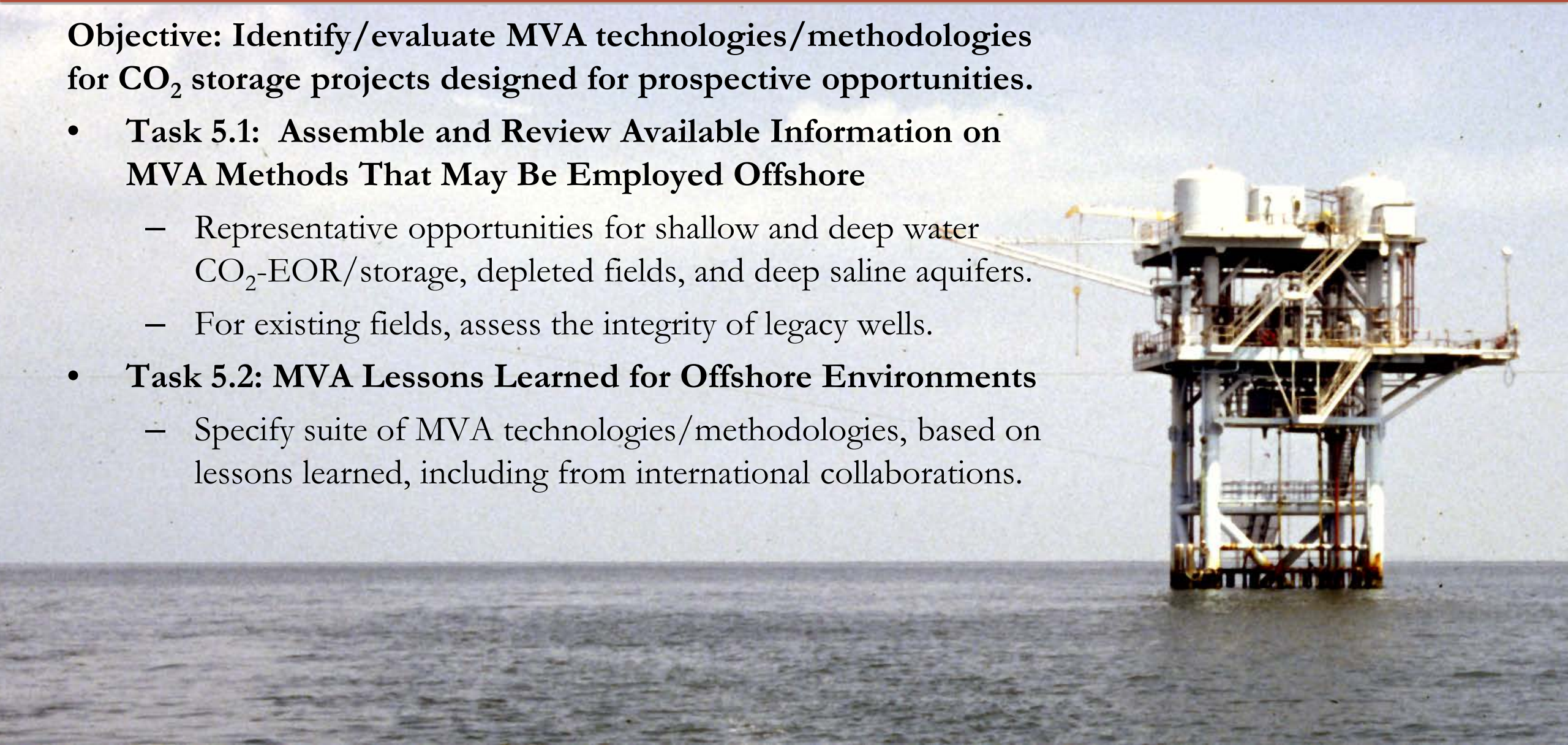
Scenario	Scenario Description	Results
1	Because oil saturation at the end of waterflooding is towards the northeastern corner of the field, a gas injector was assumed to be drilled there. CO_2 is injected at 25 MMscfd for 20 years (water injection is stopped)	An incremental 12.4 MMBbl of oil is produced over a non injection case (no water or CO_2 injection). 182.6 Bcf of CO_2 is injected with 104.4 Bcf reproduced
2	2 water injectors (one from the west side and one from the south side) are converted to CO_2 injectors. Each injects at 25 MMcfd for 20 years	An incremental 18.8 MMBbl of oil is produced over a non injection case (no water or CO_2 injection). 364.8 Bcf of CO_2 is injected with 161.5 Bcf reproduced
3	2 water injectors (one from the west side and one from the south side) are converted to CO_2 injectors + 1 new injector assumed drilled in the northeastern corner Each injects at 25 MMcfd for 20 years	An incremental 20.7 MMBbl of oil is produced over a non injection case (no water or CO_2 injection). 544 Bcf of CO_2 is injected with 293 Bcf reproduced

- **ARI draft report on Petronius (and a comparable study for Cognac) intended to provide the starting point for developing design specifications to examine alternative deployment options**
- **Aker Solutions examining subsea options, Pale Blue Dot alternatives using existing vs new infrastructure.**

Task 5: Monitoring, Verification, Accounting

Objective: Identify/evaluate MVA technologies/methodologies for CO_2 storage projects designed for prospective opportunities.

- **Task 5.1: Assemble and Review Available Information on MVA Methods That May Be Employed Offshore**
  - Representative opportunities for shallow and deep water CO_2-EOR/storage, depleted fields, and deep saline aquifers.
  - For existing fields, assess the integrity of legacy wells.
- **Task 5.2: MVA Lessons Learned for Offshore Environments**
  - Specify suite of MVA technologies/methodologies, based on lessons learned, including from international collaborations.



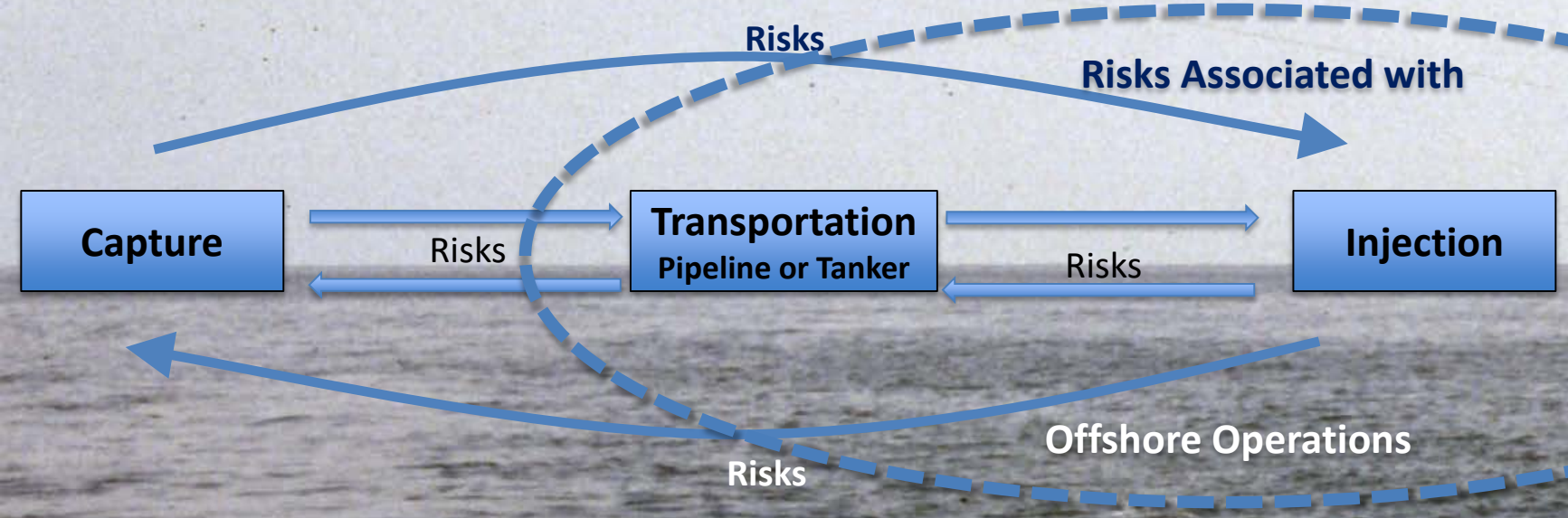
Risk Assessments: SECARB Offshore GOM

Risk Assessments for CO_2 Transportation & Storage, Including Storage with Utilization

- Risk & Data Gaps in Characterization (Subtask 3.4): partner with private companies & organizations to obtain real-world data for use in risk assessment and gap analysis
- Risk Registry for Fully Integrated Systems (Subtask 4.3): develop preliminary risk registry on infrastructure issues and uncertainties in offshore CO_2 transportation and storage
- Risks Associated with Infrastructure, Operations & Permitting (Subtasks 6.1 & 6.2): Address risk management & mitigation strategies as they pertain to CO_2 transport, delivery, and storage options in the offshore environment.

Project Risks

- An Integrated Offshore Project will need to overcome many of the same risks present in onshore projects but will also encounter risks specific to the offshore.
- While challenging, the subsea does provide some benefits relative to onshore projects



Risk Framework for CO_2 Injection in the Offshore Gulf of Mexico

Attribute/Risk	Offshore GOM	Comparison to Onshore
Caprock seal properties	Generic risk of CO_2 leaking through the caprock, through the overburden, and to the seabed is considered negligible.	No difference between onshore and offshore
Geologic structure/lateral containment	Conventional stratigraphic and structural traps	No difference between onshore and offshore
Induced seismicity; stress	Low risk item (Soft rocks and large sedimentary stack above crystalline basement) but micro-seismic monitoring is an option onshore (surface or well based)	Risk not as critical due to a lack of buildings offshore; also, basin characteristics in the Gulf not prone to significant seismicity concerns
Existing faults. fractures	While the controlling mechanisms, location and nature of faults are well understood, the potential scale and duration of an event resulting in leakage depends uniquely on the nature and location of the fault. However, the generic risk of leakage is expected to be very low provided the fault does not extend from the storage site to the seabed.	No difference between onshore and offshore
Ground surface/seabed	Difficult, expense to monitor; lower density that onshore	Easier access to monitoring locations onshore; lends itself to frequent, high density monitoring
Operating wells		
Legacy wells; P&A'd wells	Probably highest risk category for leakage from offshore operations	Similar relative risks in the offshore
Reservoir properties	Generally porous and permeable clastics	No difference between onshore and offshore
Monitoring Wells	Relatively inexpensive	Very expensive. Focus in offshore will be limiting new wells, little or no dedicated monitoring wells offshore
Injection strategy	Goal is generally to limit plume area/AoR	Plume area offshore is of lesser concern a long as there are manageable leakage risks within AoR. Goal is to limit number of injection wells

Summary of Threats to CO_2 Containment (based on Tucker, et al., 2013)

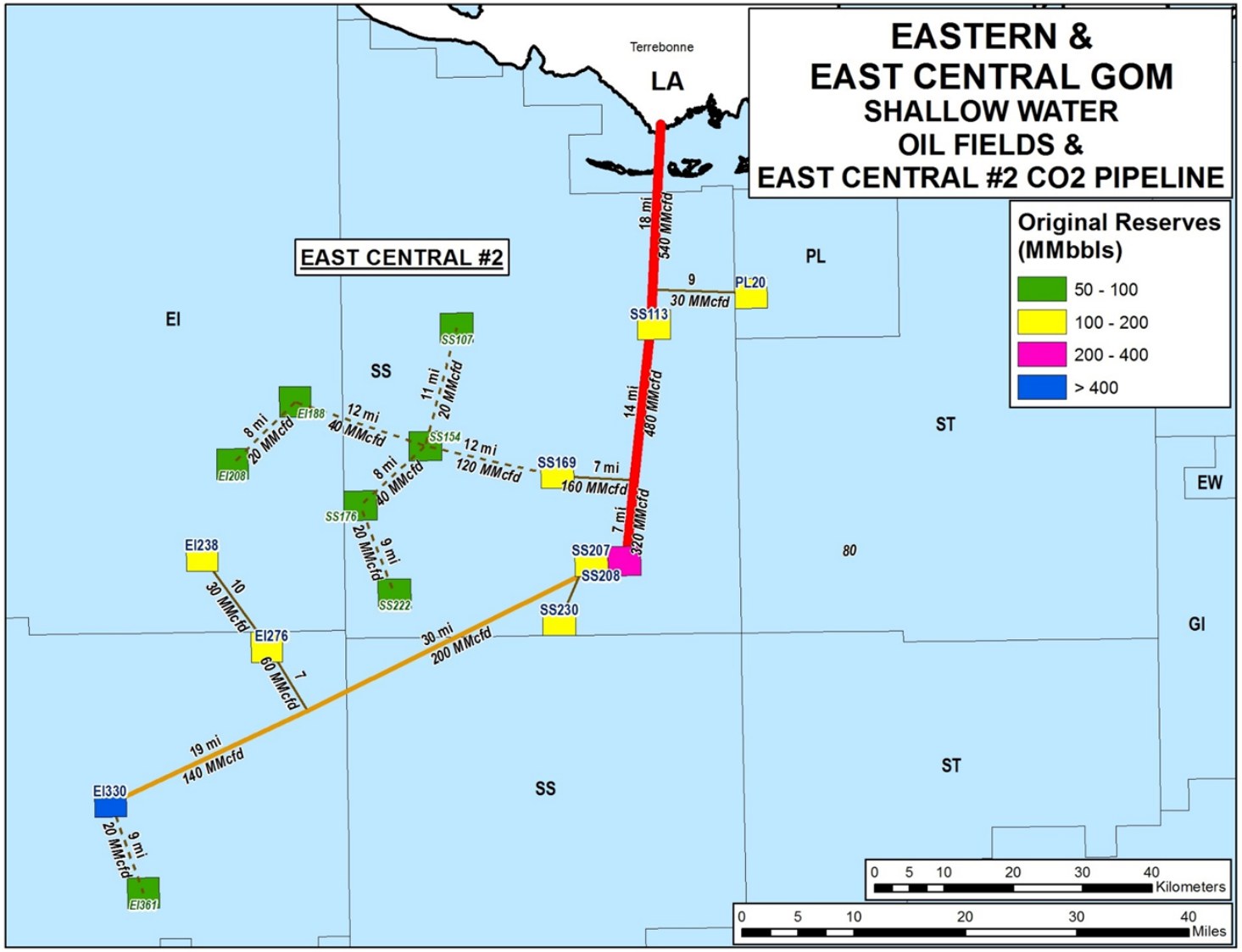
THREATS	RELEVANT CCS STAGE
Acid fluids	
Acid fluids perforate primary seal	Post-closure at hydrostatic
Acid fluids react with minerals in existing fault / fracture cement making them conductive / open	Injection, post-closure below hydrostatic and post-closure at hydrostatic
Acid fluids react with minerals in the reservoir weakening the formation and causing failure (geomechanical failure)	Injection, post-closure below hydrostatic and post-closure at hydrostatic
Acid fluids react with minerals in the fault / fracture cement allowing fault to reactivate (reactive transport)	Injection, post-closure below hydrostatic and post-closure at hydrostatic
Diffusion	
Pure diffusion of CO_2 through primary seal	Injection, post-closure below hydrostatic and post-closure at hydrostatic
Stress of injection	
Stress of injection / refilling causes fault opening or formation of new open fault in seal	Injection
Stress of injection / refilling causes tensile / shear fracture opening or formation of new open fractures in primary seal / cap rock	Injection
Faults, fractures and features	
Existing faults, mapped / unmapped crossing primary seal (not secondary seal) create leak path	Hydrostatic
Existing faults / features that cross primary and secondary seal	Injection and post-closure at hydrostatic
Lateral migration	
Lateral migration beyond the storage complex	Injection
Abandoned wells	
Flow up abandoned exploration and appraisal wellbores to near surface	Injection, post-closure below hydrostatic and (particularly) post-closure at hydrostatic
Abandoned injection wells create leak path	Post-closure below hydrostatic and (particularly) post-closure at hydrostatic

Task 6: Infrastructure, Operations, and Permitting

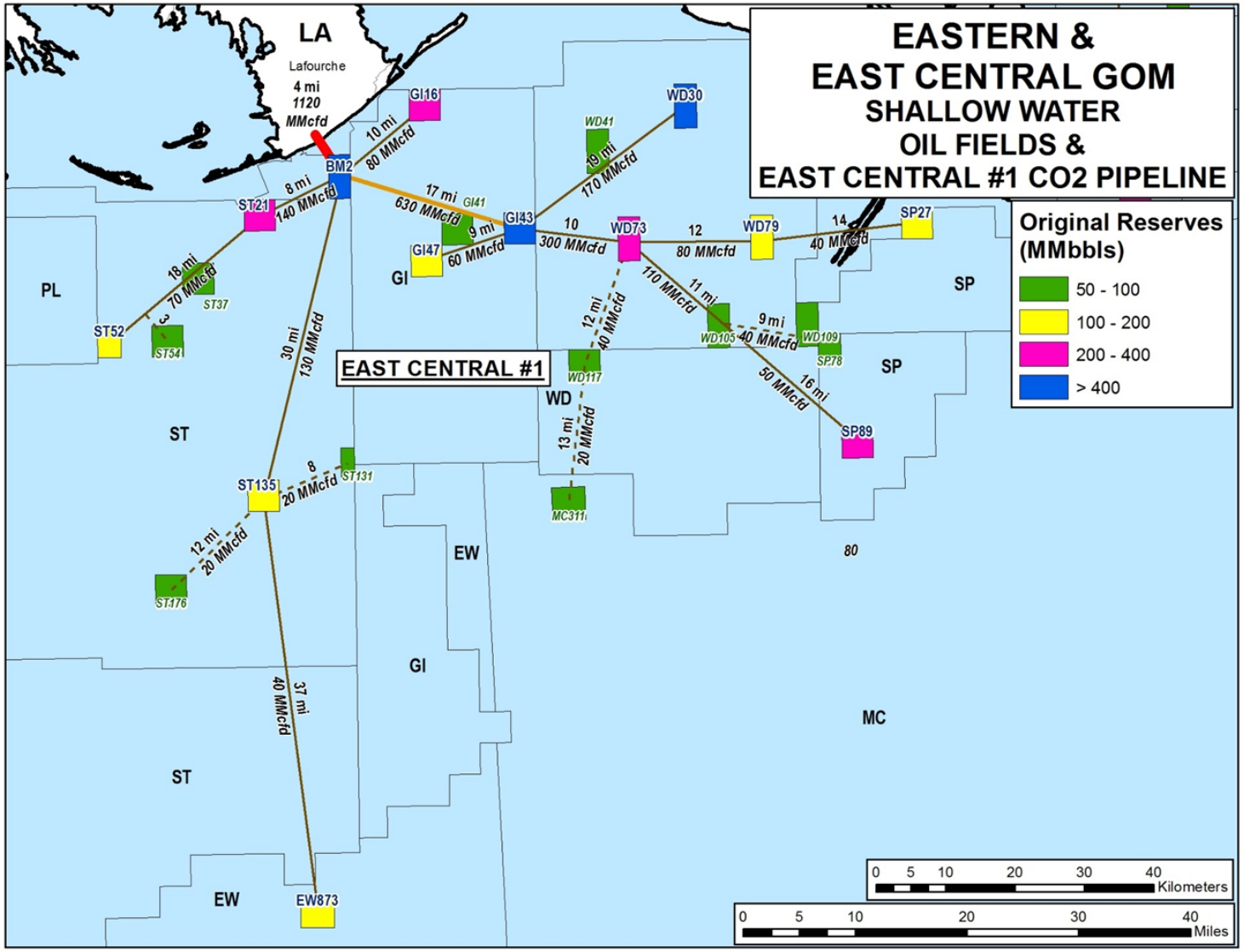
Objective: Address infrastructure, operations, permitting topics for offshore CO_2 transport, delivery, storage.

- **Task 6.1: Offshore CO_2 Transport/Delivery Options**
  - Assess feasible CO_2 options: existing infrastructure and potential accessibility; logistical/regulatory obstacles; and requirements of decommissioning.
- **Task 6.2: Legal and Regulatory Frameworks**
  - Communicate with BOEM, other agencies.
  - Updated assessment of legal and regulatory frameworks applicable to U.S. offshore storage.

East and Central Shallow Water GOM CO_2 Pipeline Example (ARI)

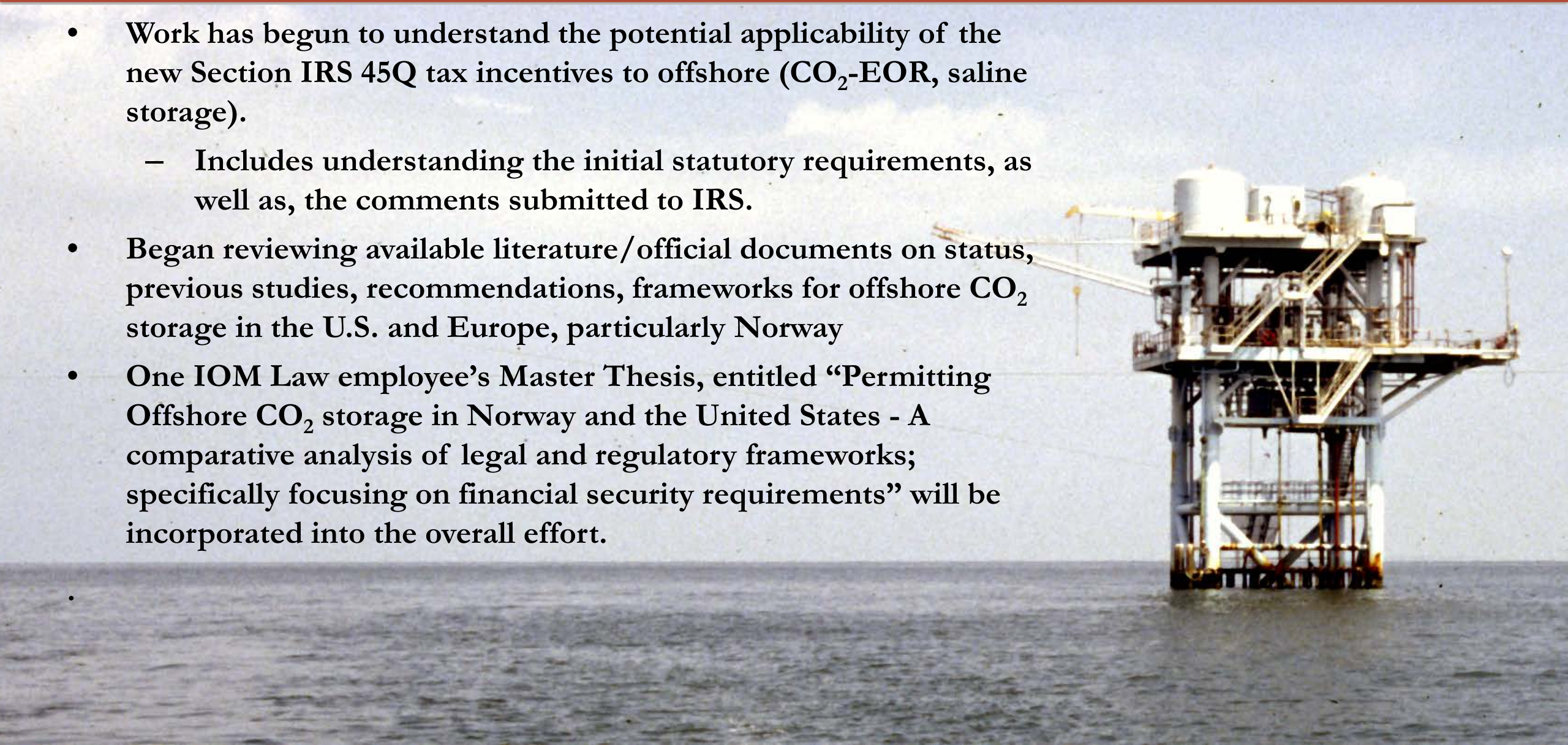


East and Central Deep Water GOM CO_2 Pipeline Example (ARI)



Review of Legal and Regulatory Frameworks

- Work has begun to understand the potential applicability of the new Section IRS 45Q tax incentives to offshore (CO_2-EOR, saline storage).
  - Includes understanding the initial statutory requirements, as well as, the comments submitted to IRS.
- Began reviewing available literature/official documents on status, previous studies, recommendations, frameworks for offshore CO_2 storage in the U.S. and Europe, particularly Norway
- One IOM Law employee's Master Thesis, entitled "Permitting Offshore CO_2 storage in Norway and the United States - A comparative analysis of legal and regulatory frameworks; specifically focusing on financial security requirements" will be incorporated into the overall effort.



THANK YOU!

SOUTHERN STATES ENERGY BOARD | 6325 AMHERST COURT | PEACHTREE CORNERS, GEORGIA 30092
PRINCIPAL INVESTIGATOR (PI): KEN NEMETH, (770) 242-7712, NEMETH@SSEB.ORG
CO-PI: KIMBERLY GRAY, (770) 282-3576, GRAY@SSEB.ORG