Gulf of Mexico Miocene CO_2 Site Characterization

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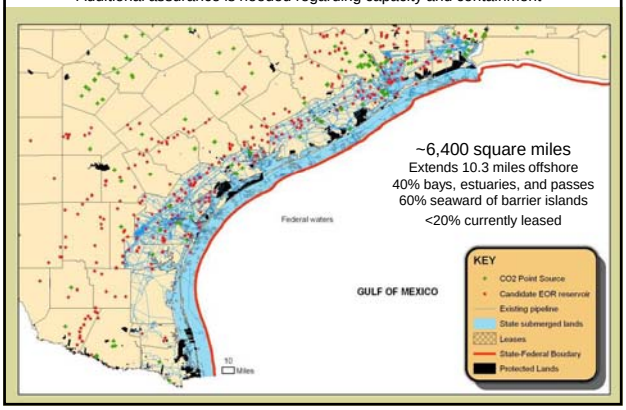
Offshore State-owned lands

Additional assurance is needed regarding capacity and containment



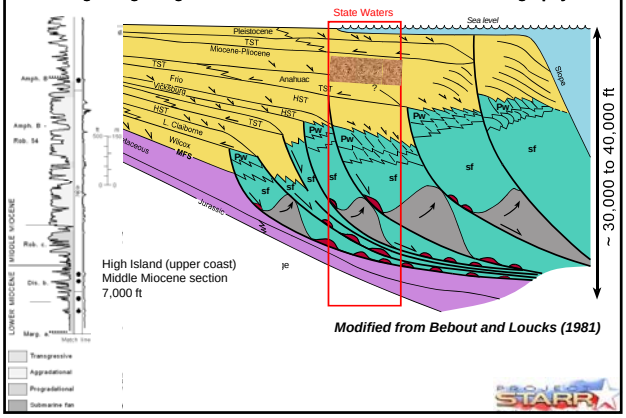
Texas State Offshore Lands & CCS

- General Land Office (**GLO**): Revenues to Permanent School Fund (lower taxes) - $11B since 1854
- **HB 1796** (2009) – Offshore CCS feasibility study (GLO)
- **NETL FOA-33**: Characterization (through 2014)

- **Single land owner** avoids NUMBY, pore space ownership, trespass, and liability issues.
  - Focus on long-term containment issues.
- Reduced risk to **USDW** (protected groundwater)
- **Monitoring** techniques exist and can be applied to CCS, but have not to date.
  - Acquisition of high resolution offshore seismic data acquisition system.
- **Risks** need thorough evaluation
  - LANL : CO2-PENS
  - Environmental Defense Fund
  - Utilize evolving international experience
    - Sleipner (Statoil-Hydro); Australia; UK.

Tremendous potential in offshore wedge

Prograding wedge of fluvio-deltaic sediments in Miocene stratigraphy

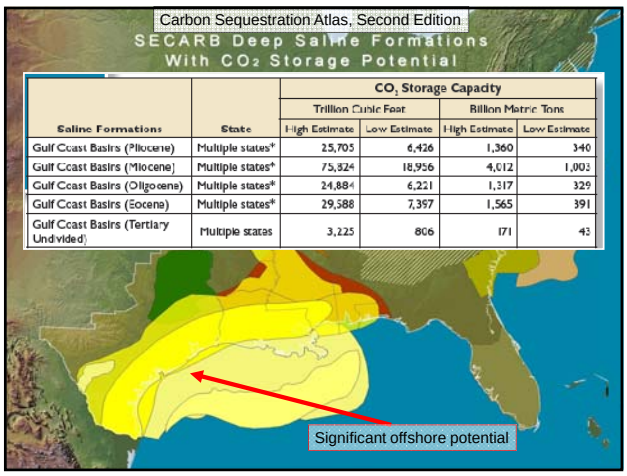


Modified from Bebout and Loucks (1981)

Carbon Sequestration Atlas, Second Edition

SECARB Deep Saline Formations With CO_2 Storage Potential

Saline Formations	State	CO_2 Storage Capacity			
		Trillion Cubic Feet		Billion Metric Tons	
		High Estimate	Low Estimate	High Estimate	Low Estimate
Gulf Coast Basins (Pliocene)	Multiple states*	25,705	6,426	1,360	340
Gulf Coast Basins (Miocene)	Multiple states*	75,524	18,956	4,012	1,003
Gulf Coast Basins (Oligocene)	Multiple states*	24,884	6,221	1,317	329
Gulf Coast Basins (Eocene)	Multiple states*	29,588	7,397	1,565	391
Gulf Coast Basins (Tertiary Undivided)	Multiple states	3,225	806	171	43



What will it take?
Assumptions for back of envelope

- Single zone well completions.
  - A well could access multiple sands through time, but only one at a time per well.
- Main development limitation is number of wells per platform/subsea completion.
  - Pipeline delivery.
  - Engineering.
- Default to simplest (least optimistic) scenarios.

How many wells possibly?

~700 Mt/yr Total State emissions

Avg. Inj. Rate (MMSCFD)	Tons per day per well	Tons per year per well	# wells for 1 Mt/yr	# wells for 700 Mt/yr
1	53	19,211	52	36,438
5	263	96,053	10	7,288
10	526	192,105	5	3,644
20	1,053	384,211	3	1,822
50	2,632	960,526	1	729

6,237 currently identified wells in State waters, dominantly in bays.

Development needs

	WELLS PER PLATFORM	
	10	20
Avg. Inj. Rate (MMSCFD)	# PLATFORMS	
1	3,644	1,822
5	729	364
10	364	182
20	182	91
50	73	36

What area involved?

3,800 sq miles offshore from barrier islands.

What percentage of area would be used for CCS?

Avg. Inj. Rate (MMSCFD)	Nominal Well spacing (acres)			
	40	80	160	320
1	60%	120%	240%	479%
5	12%	24%	48%	96%
10	6%	12%	24%	48%
20	3%	6%	12%	24%

< 20% currently leased for hydrocarbon activities.
100's of lease blocks possibly needed.

Back of the envelope suggests…

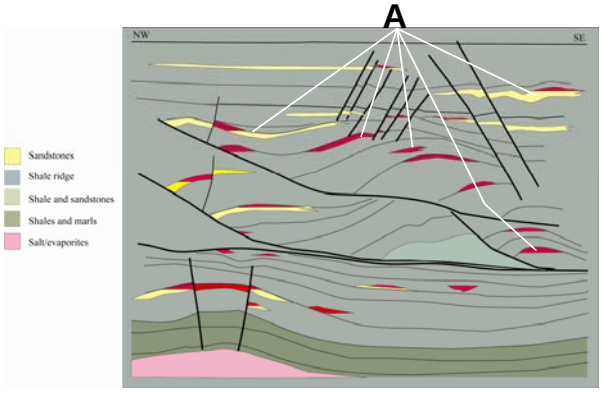
- Thousands of injection wells.
- Hundreds of platforms.
- Hundreds of lease blocks.

- Comparable to historical hydrocarbon use.
  - Implications for economic activity is considerable.
- What about monitoring?

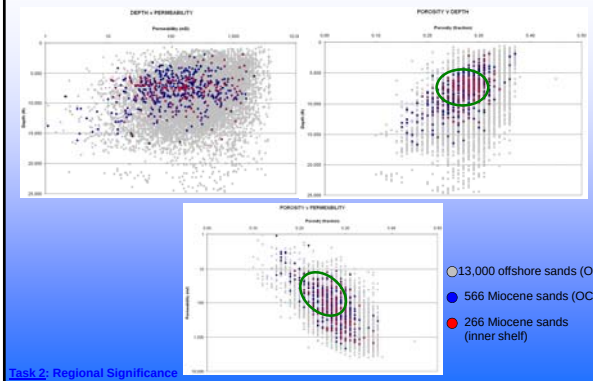
How much monitoring can we afford? What could it achieve?

	WELLS PER PLATFORM			
	10		20	
	Annual Offshore CCS Monitoring Budget			
	$ 50,000,000		$ 500,000,000	
	$ per platform (site) per year			
Inc. Avg. Inj. Rate per well ↓	$ 13,722		$ 274,436	
	$ 68,609	(729)	$ 1,372,180	(364)
	$ 137,218	(364)	$ 2,744,361	(182)
	$ 274,436		$ 5,488,722	

Geologic setting absolutely critical for development



Characterization of Miocene sands



13,000 offshore sands (OCS)

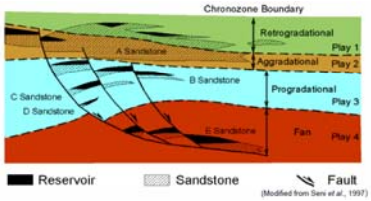
566 Miocene sands (OCS)

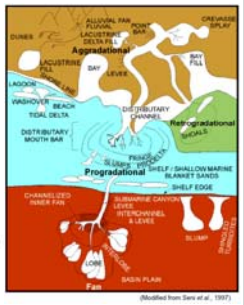
266 Miocene sands (inner shelf)

Task 2: Regional Significance

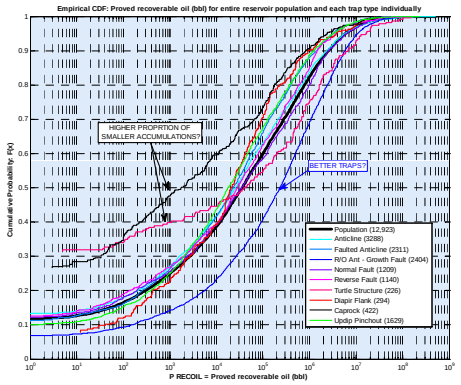
Task 3: Site Capacity Estimates

Depositional system approach





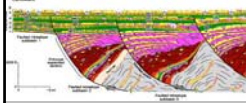
Structural setting



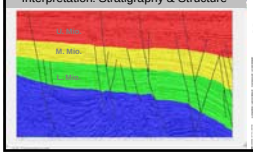
Modeling & Simulation

Focus on:

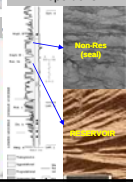
- Potential long-term migration (invasion percolation – Permedia MPath)
- Fetch areas & flow focusing; fill & spill sequence.
- Influence of faults (compartmentalization)
- Pressure evolution

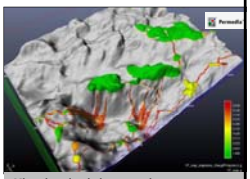


Interpretation: Stratigraphy & Structure

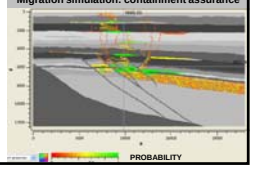


Lithofacies & Proportions





Migration simulation: containment assurance



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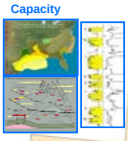
Characterization & Capacity



Environment

Containment

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