

Hydrocarbon Production from the South Ellwood Field and the Effects on Naturally Occurring Oil and Gas Seeps*

Christer B. Peltonen¹ and James R. Boles²

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Abstract

A reduction in natural marine hydrocarbon seepage is occurring above the South Ellwood oil field. Decades of development from Platform Holly has led to the production of nearly 80 million barrels of oil and 75 billion cubic feet (BCF) of gas. This has significantly reduced the amount of oil and gas available for seepage and it has reduced the buoyancy force within the reservoir, which is the driving force for hydrocarbon escape. The rate of hydrocarbon extraction from producing wells far exceeds the rate of natural hydrocarbon generation, migration, and accumulation, resulting in reduced reservoir fluid pressure. All of this is occurring in the vicinity of Platform Holly where production from wells is influencing the volume of hydrocarbons that escape to the surface. A portion of seep volumes can be directly measured due to the placement of seep tents in 1982. These structures were set on the sea floor directly above the reservoir in an active seep area. The tents have captured 7.6 BCF of natural gas to date. The decline of seep gas measured in the tents correlates with production decline at Platform Holly and corresponding decrease in reservoir pressure. The seep tents provide a unique opportunity to directly link hydrocarbon production at Platform Holly to a measured reduction in natural gas seepage. The tents can also be used to extrapolate the effect of future oil and gas production on seepage beyond the limited footprint of the seep tents.

The South Ellwood anticline and corresponding South Ellwood oil field extend far beyond the existing easterly boundary of State lease PRC 3242. Known oil and gas reserves exist in this area and they are located directly below some of the most active seeps in the Santa Barbara Channel. Estimates of original oil in place for this area are upwards of 2 billion barrels. Oil and gas

production from that area has the potential to remove a large volume of hydrocarbons, which would lead to a reduction in reservoir pressure and buoyancy force. Measurements from sonar studies indicate the total area of seepage to the east of State lease PRC 3242 covers about 2.3 km². Gas seepage rates in that area are estimated to be as high as 5 million cubic feet per day. Consistent with observations made within the existing State lease PRC 3242, further development to the east could result in reduction of gas seepage on the scale of several million cubic feet per day. This would equate to a removal of an estimated 10 to 20 tons per day of reactive organic compounds (ROC's). It is reasonable to assume that the reduction of seepage would be long-lasting since the rate at which hydrocarbons are removed from the reservoir is considerably faster than the geological processes that replenish the reservoir.

Reference Cited

Quigley, D.C., J.S. Hornafius, B.P. Luyendyk, R.D. Francis, J. Clark, and L. Washburn, 1999, Decrease in natural marine hydrocarbon seepage near Coal Oil Point, California, associated with offshore oil production: *Geology*, v. 27/11, p. 1047–1050.

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May 5, 2015

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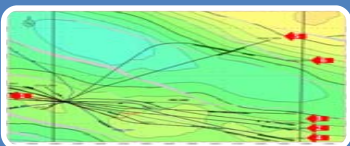
Outline



Platform Holly



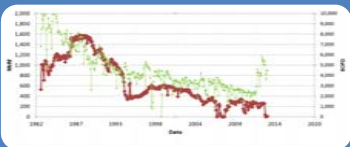
South Ellwood Field



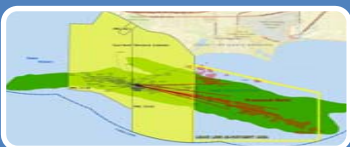
South Ellwood Field Development



Natural Oil & Gas Seeps



Seep Reduction

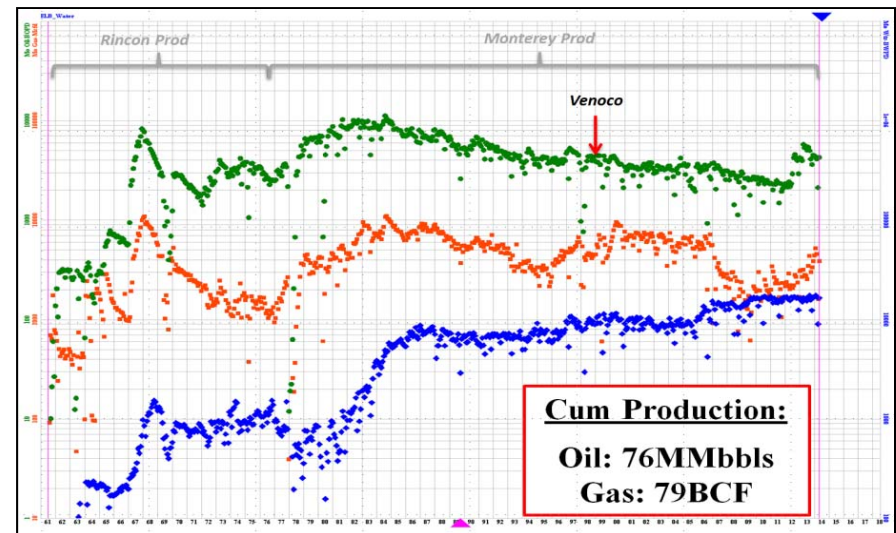
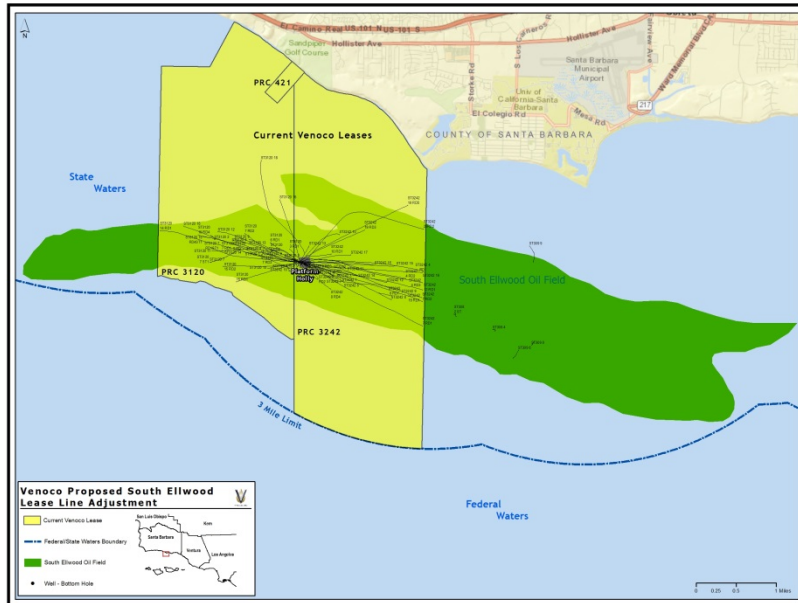


Future Development and Impact

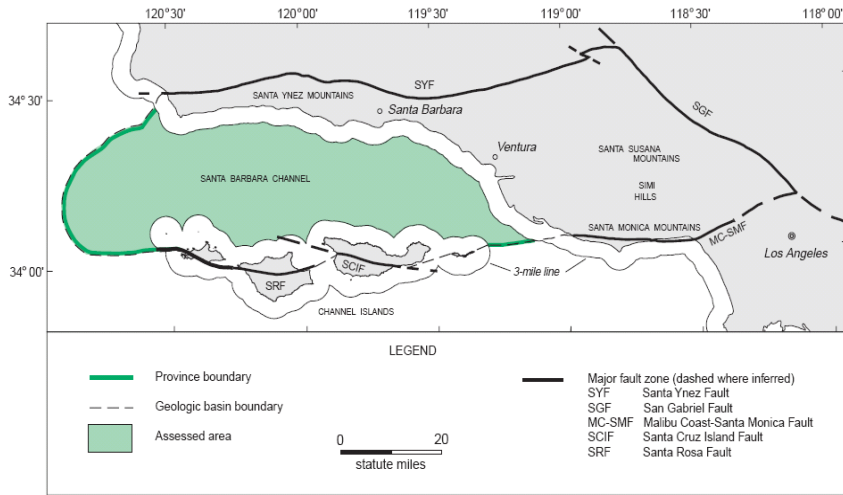
Platform Holly



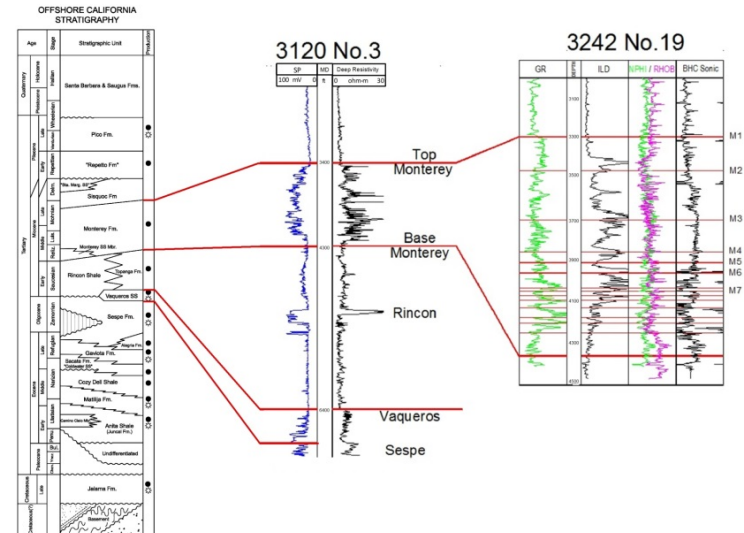
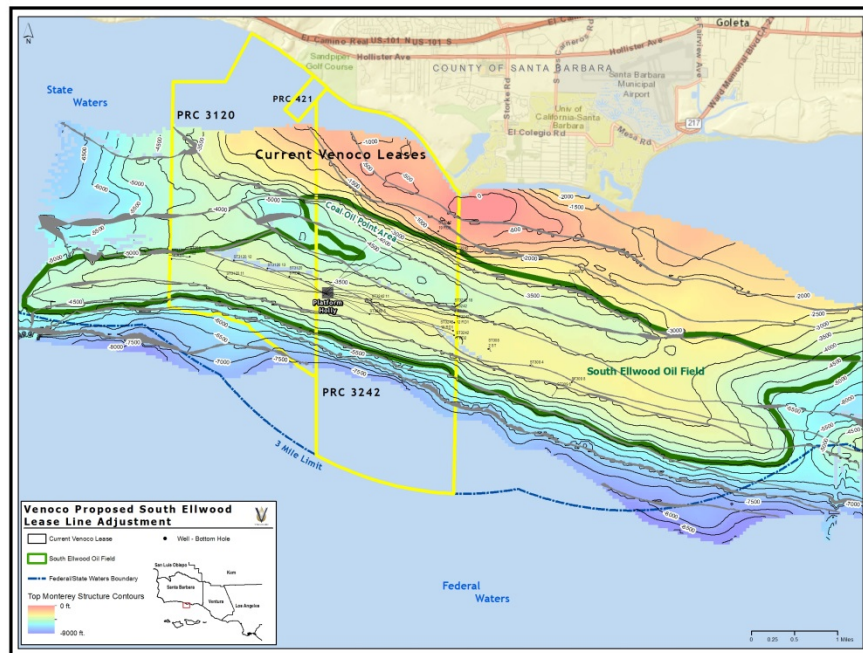
- Set to develop Rincon Formation - First offshore California field to produce from the Monterey (1969: Well 3120-8 2100 BOPD)
- 1993-1997 Mobil – Clearview
- 1997 Venoco
- 2012-2014 Venoco development – 6 well program
- 2014 Submission to CSLC to adjust the eastern extension of PRC 3242.



South Ellwood Field



- South Ellwood is part of a regional E-W anticlinal trend that includes the northern flank of the Santa Barbara Channel and the onshore Ventura Basin.
- ~9-mile long doubly-plunging and faulted anticline that has a trend of N70W.
- Monterey source rock with reservoirs in Rincon & Monterey. Monterey reservoir section greater than 1000' thick
- The South Ellwood field extends far beyond the current lease boundaries
- ~1 Billion bbls OOIP w/ 76 MMbbls produced to date; Additional 1 – 2 Billion bbls beyond the lease boundaries



Evolution of Development

Phase I: Near Platform / Initial Development

- 12 Wells: IP from 1972-1978
- 5-45° Inclination
- M1-M7 Sequential “Bottoms up” Recompletions
- EUR Average: 1.7 MMBO
- Key Learning: Easy Drilling in Virgin Monterey

Phase II: Step Out / North and South Flanks

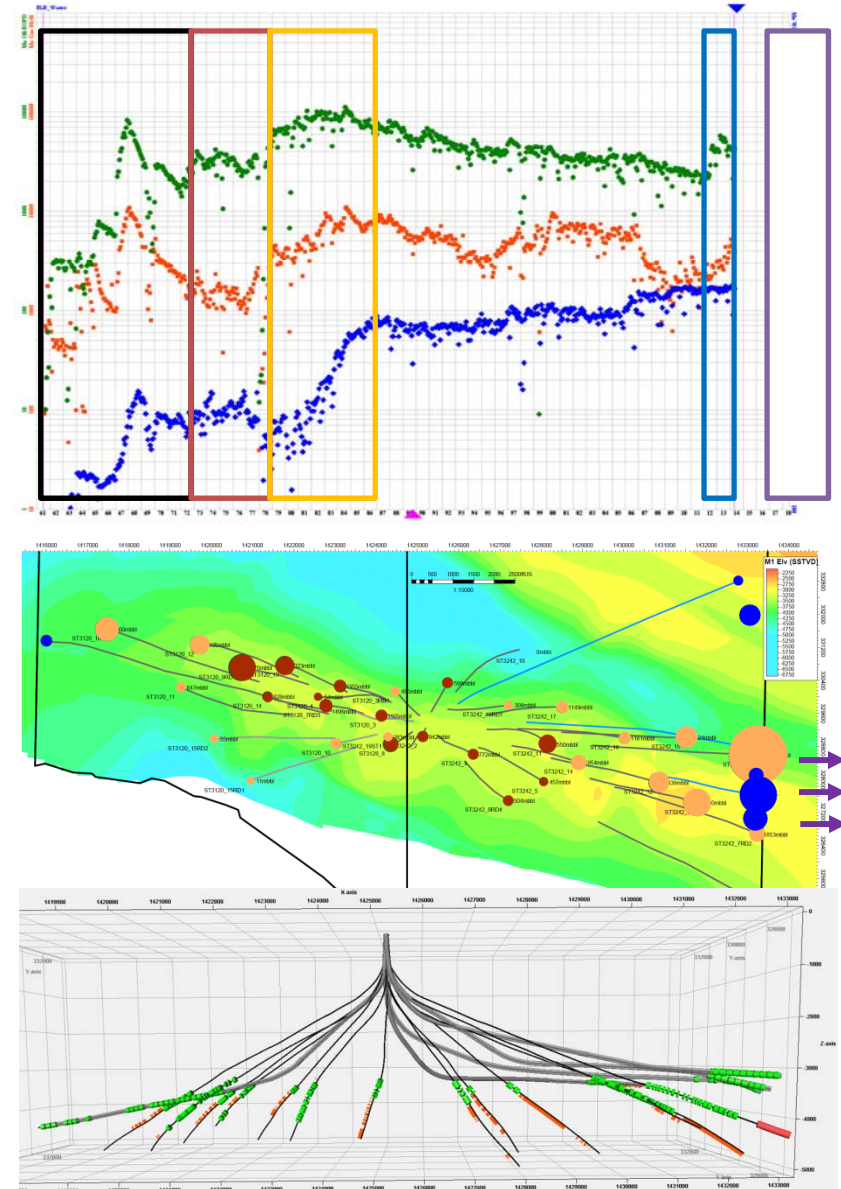
- 15 Wells: IP from 1979-1986
- 50-65° Inclination
- Open All M1-M7 During Completion
- EUR Average: 2.8 MMBO
- Key Learning: Parallel to Fault = High EUR (3242-18!)

Phase III: End of Lease Line / Coal Oil Point

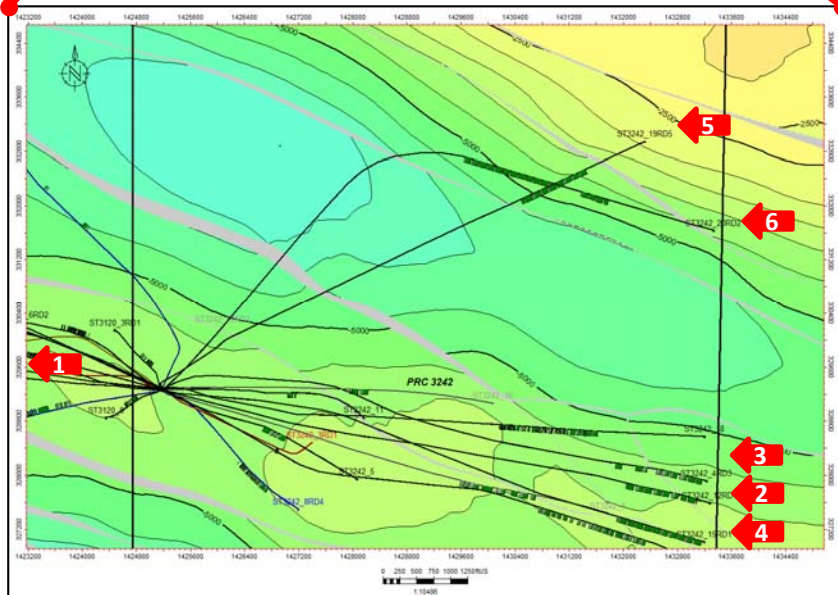
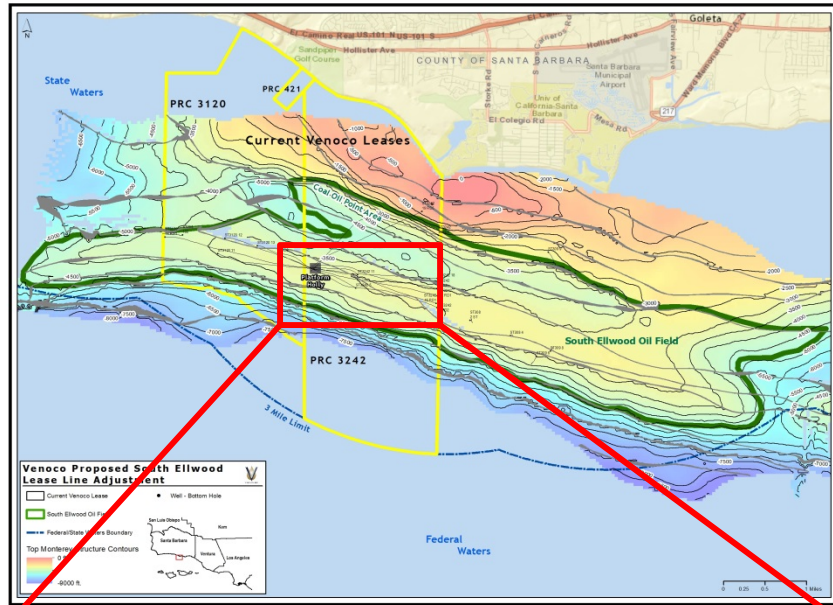
- 6 Wells: IP from 2012-2014
- 70-85° Inclination
- Selectively Complete Toe Based on Fracture Logs
- EUR Average: 4.5 MMBO (lease line)
- Key Learning: Upper Monterey toward 3242 Lease Line

Phase IV: Lease Line Extension ERD

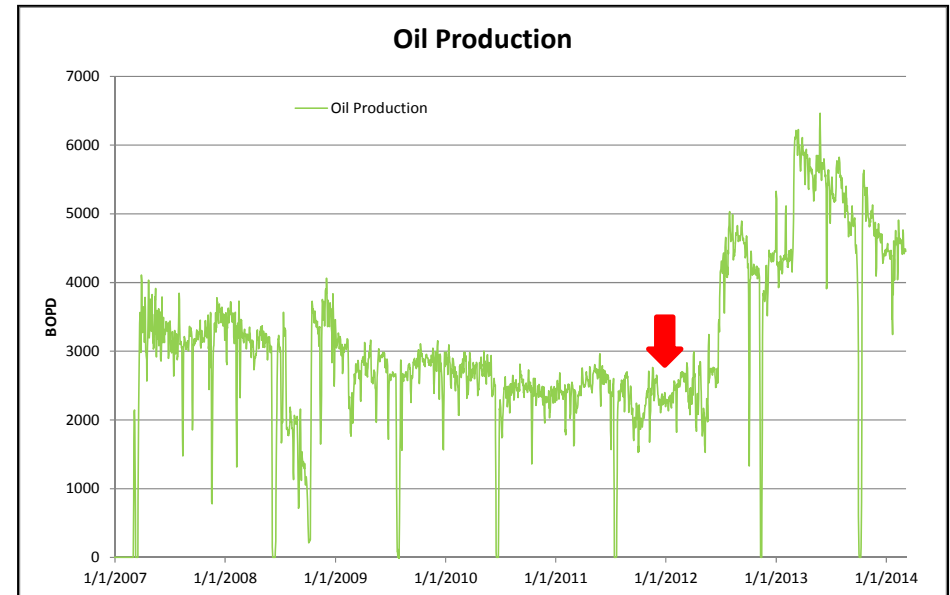
- 6 Wells: Planned from 2017-2022
- 75° Inclination across Monterey (Up to 22,000' MD)
- Intelligent Completions / Coiled Tubing / Wireline Tractors
- >4000' of Monterey section
- Expected EUR: 7-10 MMBO/well



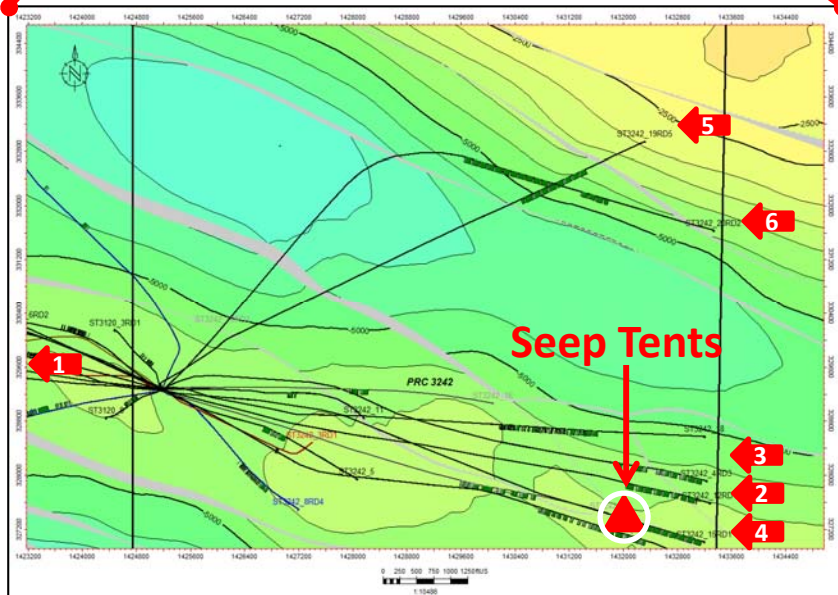
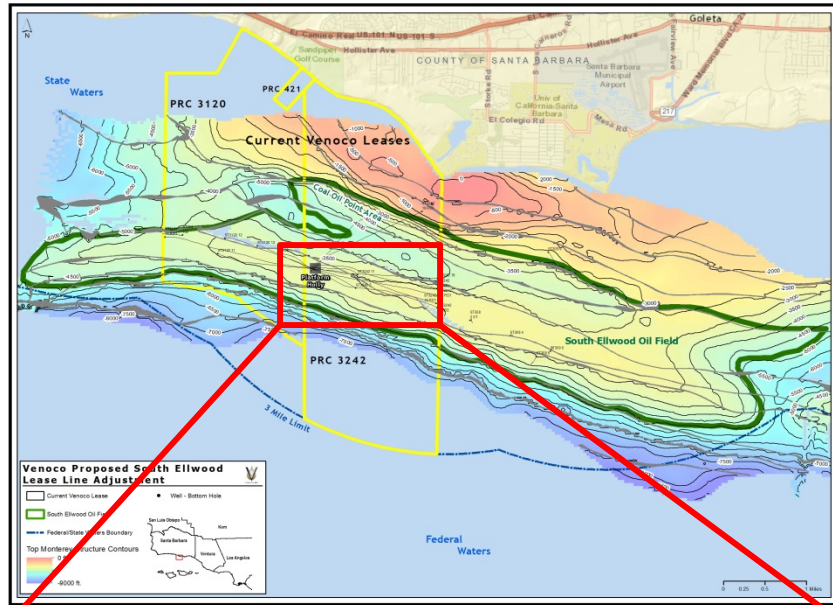
Recent Development



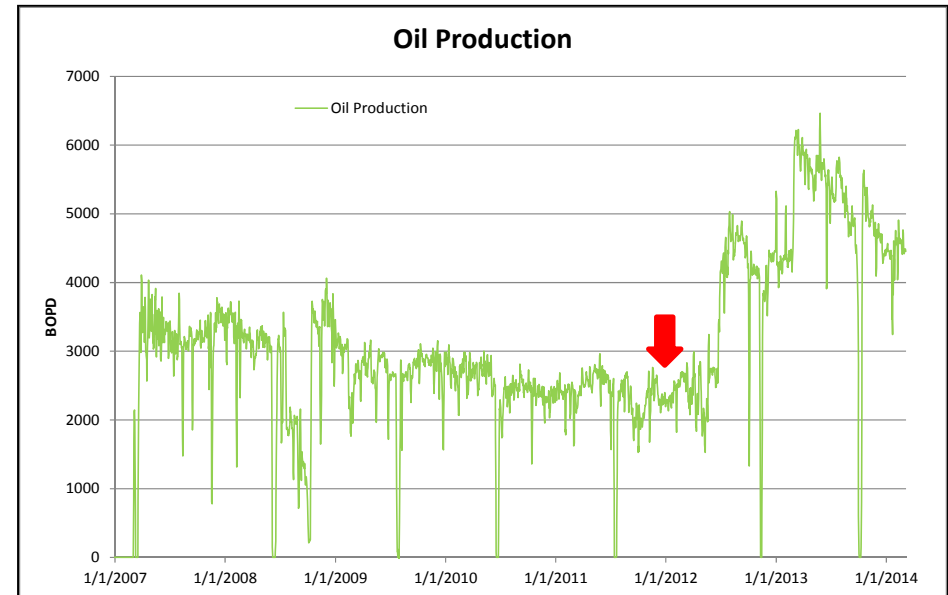
- 6 wells drilled since 2012; 5 wells drilled on the 3242 side with focus along the eastern boundary and northern flank
- Doubled production from 3000 BOPD to 6000 BOPD
- Sharp decline indicates some interference along lease line; starting to stabilize.
- Discovery and development of the northern flank (Coal Oil Point South) has led to an increase in reserves.
- Future activity will focus along the northern flank in addition to the ongoing project to adjust the eastern boundary of the 3242 lease (1-2 Billion bbls OOIP)



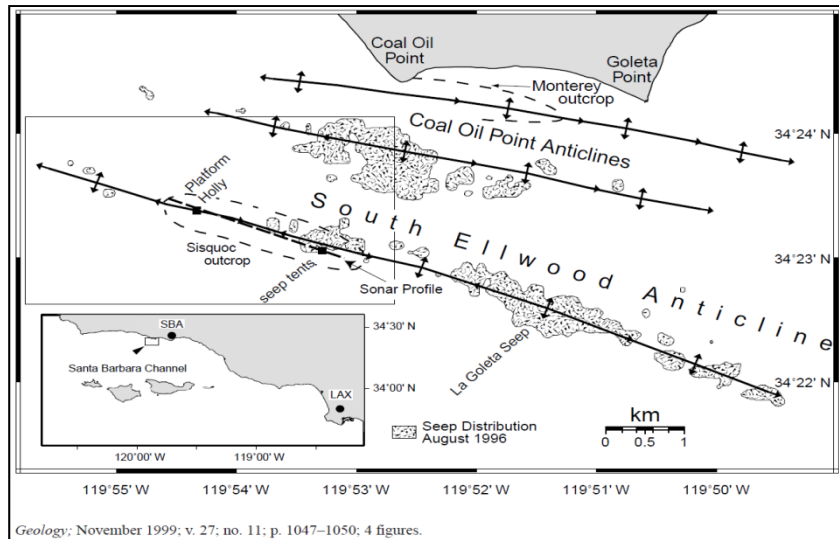
Recent Development



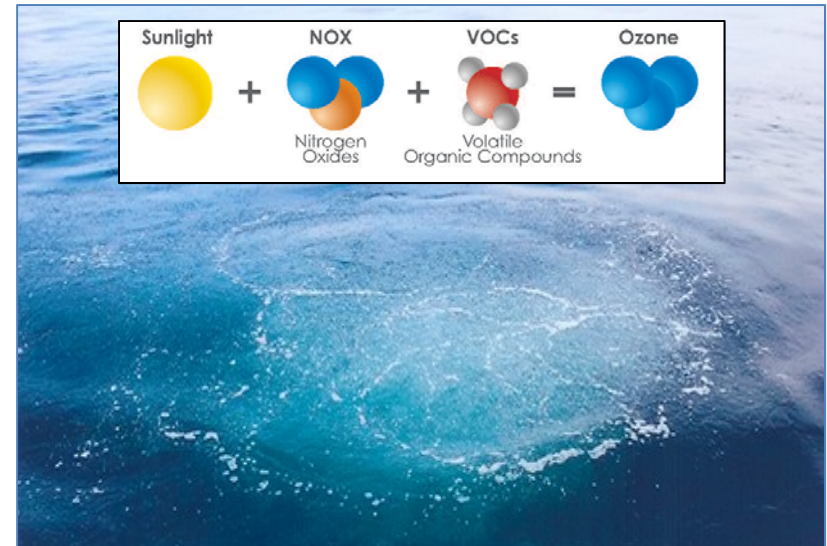
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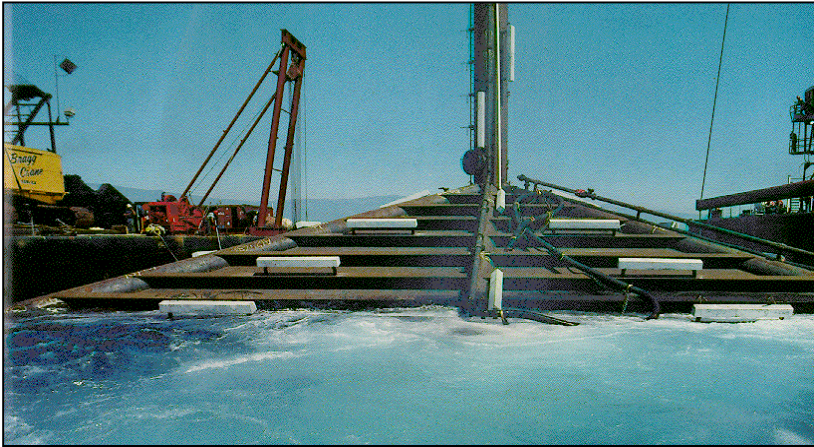
Natural Marine Hydrocarbon Seeps



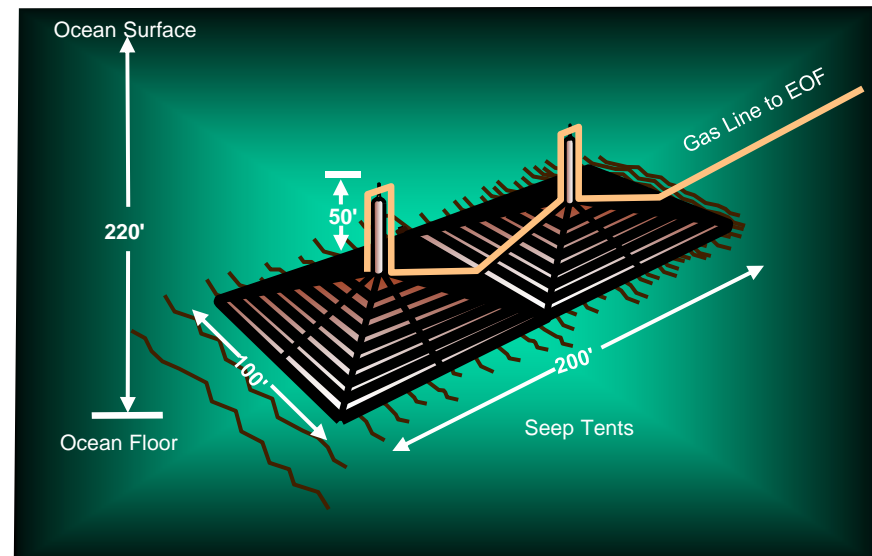
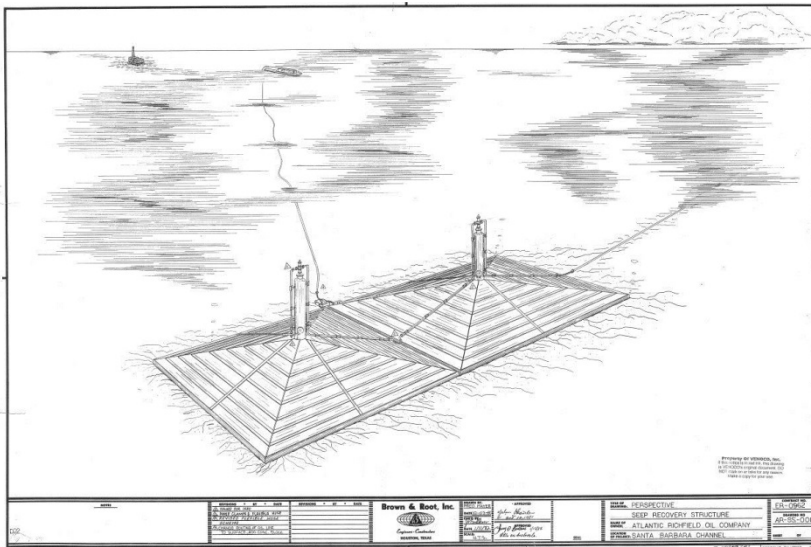
- Santa Barbara Channel seeps release ~100-150 BO/day and up to 55,000 BO/year
- Santa Barbara Channel seeps release ~3-7MMCFPD
 - Predominantly methane
- Second largest source of GHG emissions in the SB County
 - APCD estimates ~700,000 Tons CO₂e/year
 - APCD estimates 24 tons/day ROC
- Majority of the mapped seeps occur east of PRC 3242. Estimate ranges from 2 – 5 MMCF/day



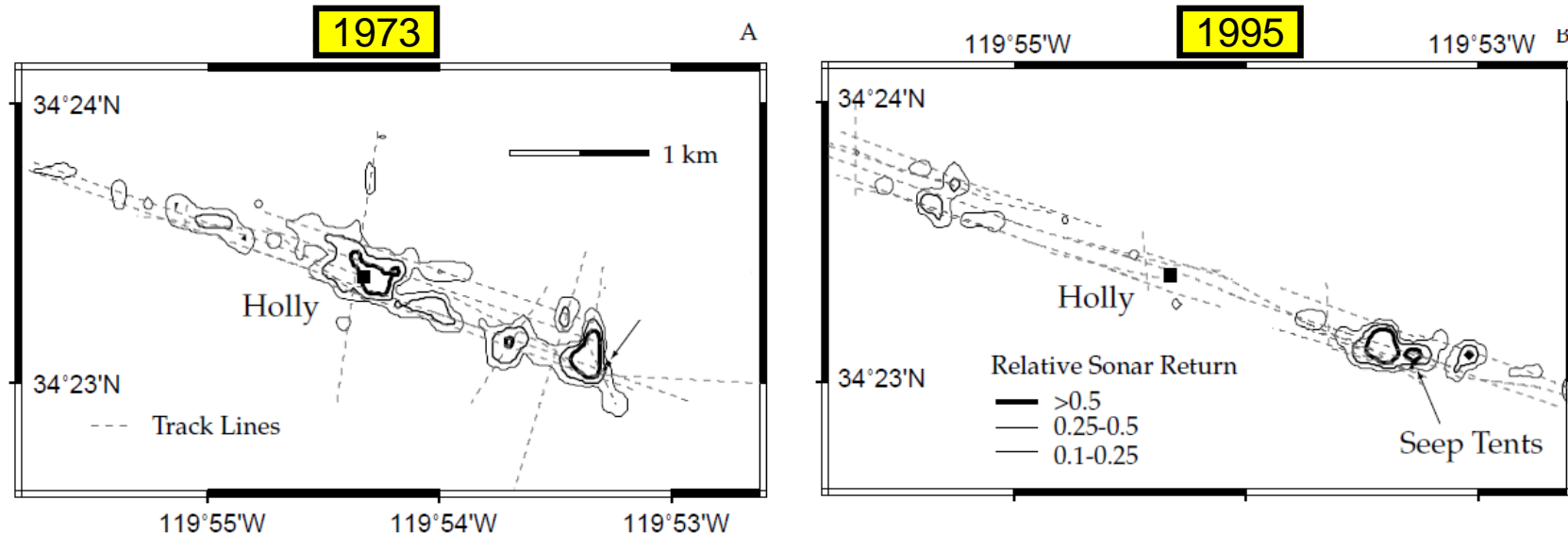
Seep Containment Project



- The Seep Containment Project was developed in 1982 by ARCO and several other partners to capture this large concentration of naturally seeping gas
- First project of its kind, to capture and sell natural gas from sea floor seeps
- Two 50-foot high steel pyramids (tents) were positioned on the ocean floor over this seep. They weigh 900,000 pounds each and measure 100 feet by 100 feet.



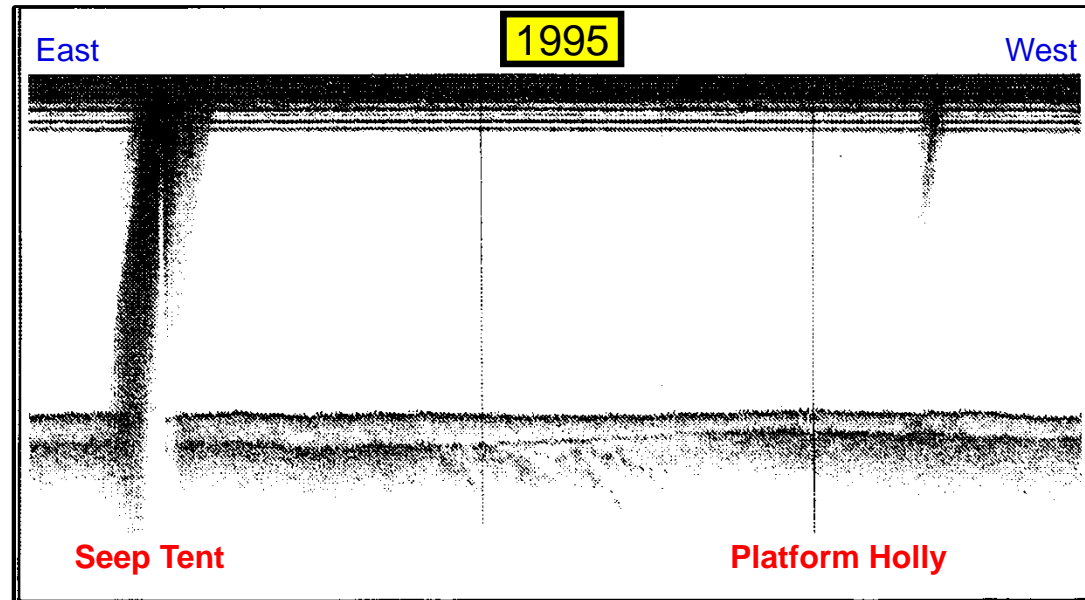
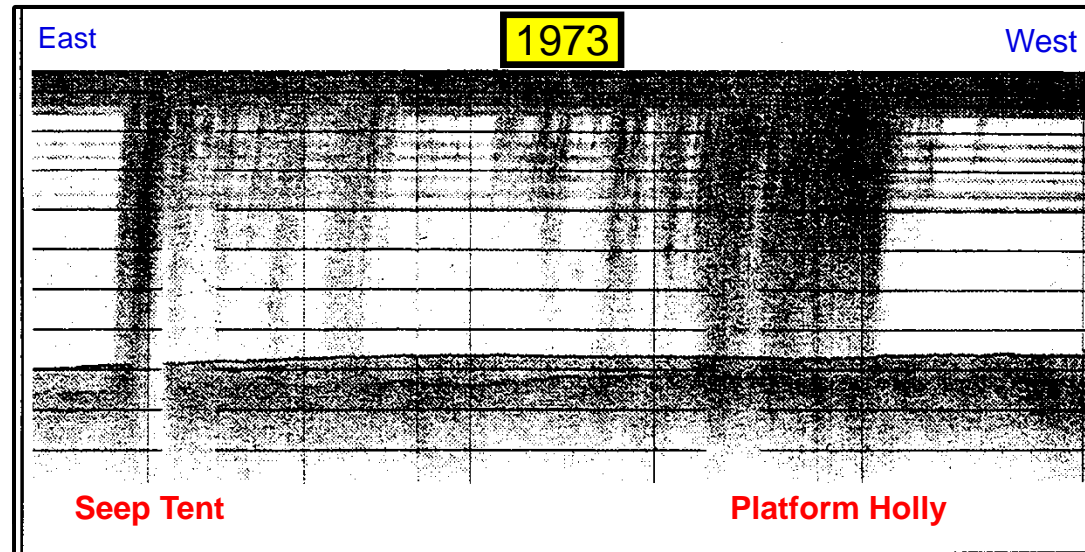
Seep Reduction/Cessation



*“Comparison of the seep distributions over time reveals **more than 50% decrease** in the areal extent of seepage, accompanied by declines in seep emission volume...Declines in reservoir pressure and depletion of seep hydrocarbon sources associated with oil production are the mechanism inferred to explain the declines...”*

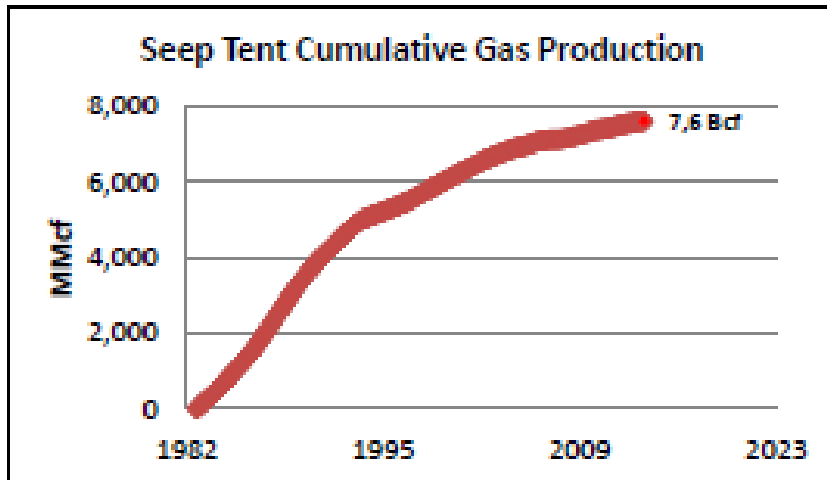
*“Oil production from the Monterey Formation oil and gas reservoir caused subsequent declines in reservoir pressure, thus removing the **primary driving mechanism of the seepage**”
(Quigley et al. 1999)*

Seep Reduction/Cessation

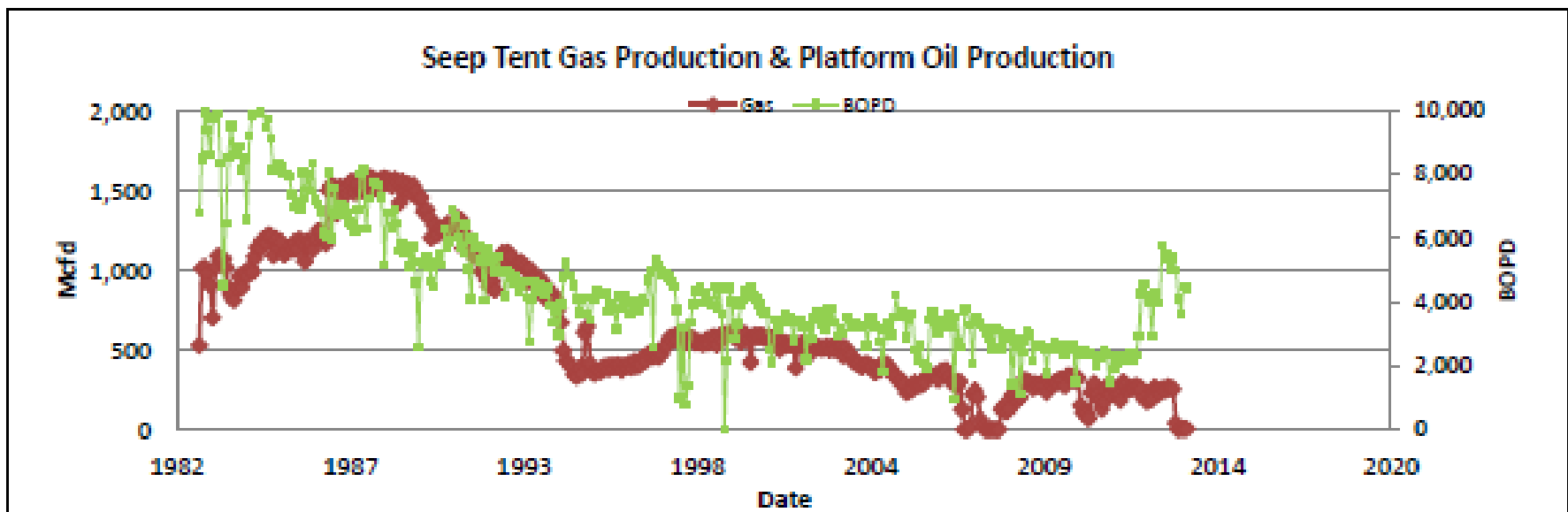


(Quigley et al., 1999)

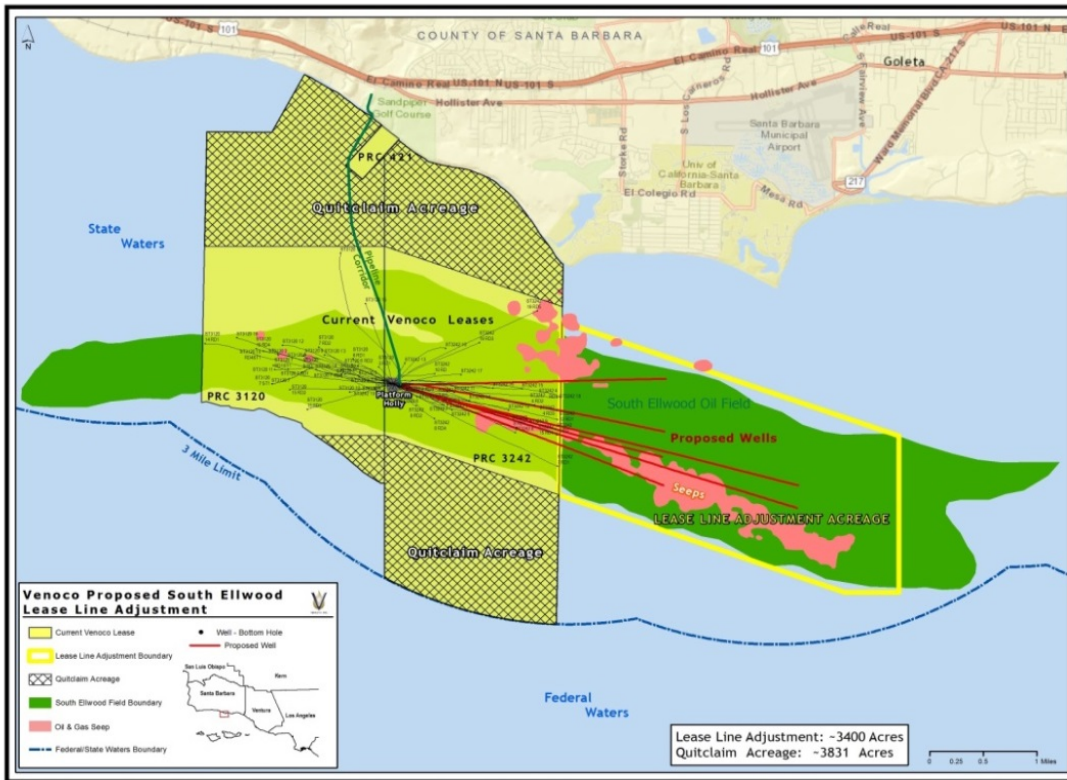
Seep Reduction/Cessation



- Decades of production led to significant reduction in reservoir pressure ultimately resulting in the cessation of seep activity measured within the tents in late 2013.
- The decline in seep gas production from the tents generally correlates with the decline in oil production from Platform Holly.
- At peak, the tents captured over 1,500Mcf of seeping gas per day. This is equal to the amount of air pollution associated with tens of thousands of automobiles. To date the seep tents have captured 7.6Bcf of gas.
- Future production at platform will result in continued lowering of reservoir pressure and continued decrease in seep activity.
- Production at Platform Holly has resulted in significant improvement to local air quality



Future Development



California Public Resource Code 6872.5

“The commission may adjust the boundaries of existing leases to encompass all of a field partially contained within the existing lease...”

Lease Line Adjustment

- Lease Line Adjustment refers to Venoco's application with the State of California to move the existing easterly border of its lease (PRC 3242) to encompass known oil and gas reserves that lie within the South Ellwood oil field, but just outside the current lease boundary.
- ERD wells will be re-drilled on Platform Holly to develop the oil and gas reserves. Oil, gas and water will be processed onshore at the Ellwood Onshore Facility (EOF) within current permit limits. The project does not require any modifications at the EOF nor does it extend the life of the onshore facility.
- Drilling into the Lease Line Adjustment area would result in better recovery and ultimately accelerate production of this resource.
- Upon approval of this project, Venoco will quitclaim a equal portion of acreage to offset the lease line adjustment
- There is a clear and legal path for the lease line adjustment, which includes an EIR and approval by the California State Lands Commission
- But, Politically very complicated!

Conclusions

- Evolution of development of the South Ellwood field has relied on increased exposure in the siliceous members of the Monterey Formation; Upon approval, future development will continue this trend, drilling ERD wells from 16,000' to 22,000 feet MD with over 4000' of on Monterey section completed.
- An estimated 1-2 Billion barrels of oil is in place to the east of existing 3242 boundary. This resource can be reached from existing Platform Holly and processed through existing Ellwood onshore Facilities. Development of this area could add an additional 60MMBO
- Significant environmental and economic benefits to lease line adjustment and continued development:
 - Seep reduction and improved local air quality
 - Every Barrel produced in CA is a barrel we don't import by tanker ship or rail car
 - Generate revenue: ~\$750MM in State Royalties and ~\$150MM in property taxes
- Application submitted with California State Lands Commission. Public notice (NOP) issued last week. Expect decision early 2016.
- Stay tuned!

Thank You!

