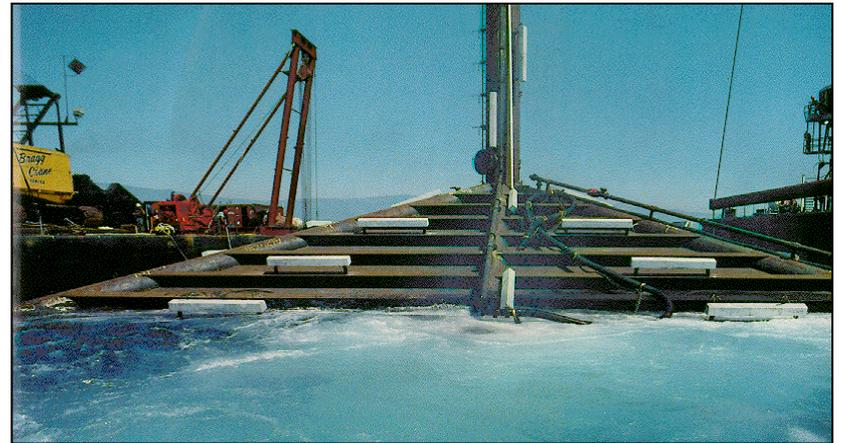


Reduction in Natural Oil and Gas Seeps Due to Hydrocarbon Production at South Ellwood Field - Platform Holly



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October 8, 2014





Abstract



Reduction in natural marine hydrocarbon seepage is occurring in the vicinity of the South Ellwood oil field. 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 and active seep area. The objectives of setting the tents were to capture and produce the natural gas released at the sea floor and to reduce local air emissions related to these seeps. The tents have captured 7.6 billion cubic feet (Bcf) of natural gas to date. This is equivalent to 35,340 tons of ROC's. Decades of production led to significant reduction in reservoir pressure ultimately resulting in the cessation of seep activity measured within the tent structures in late 2013. The decline of seep gas measured in the tents correlates with decrease in reservoir pressure. Future production from platform Holly will result in continued lowering of reservoir pressure and continued decrease in seep activity.

Outline



Platform Holly



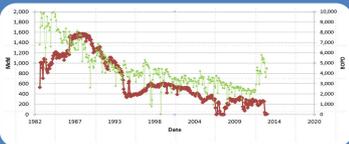
South Ellwood Field



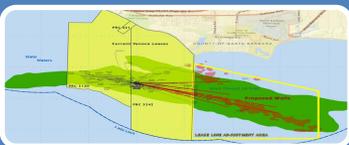
Natural Marine Hydrocarbon Seeps



Seep Containment Project



Seep Tent Reduction/Cessation

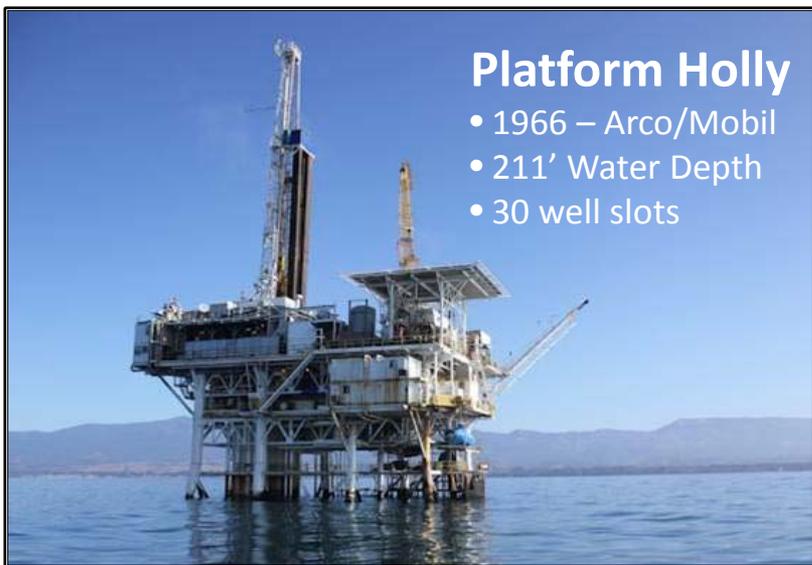


Future Development and Impact

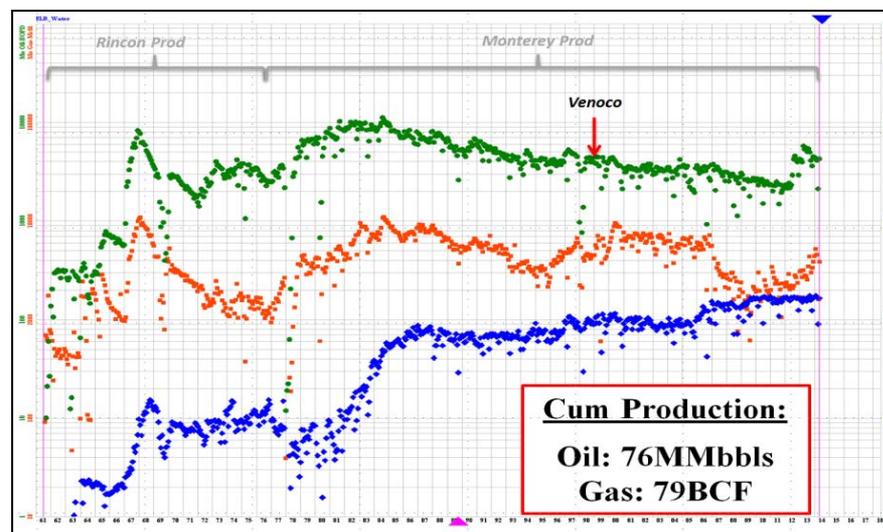
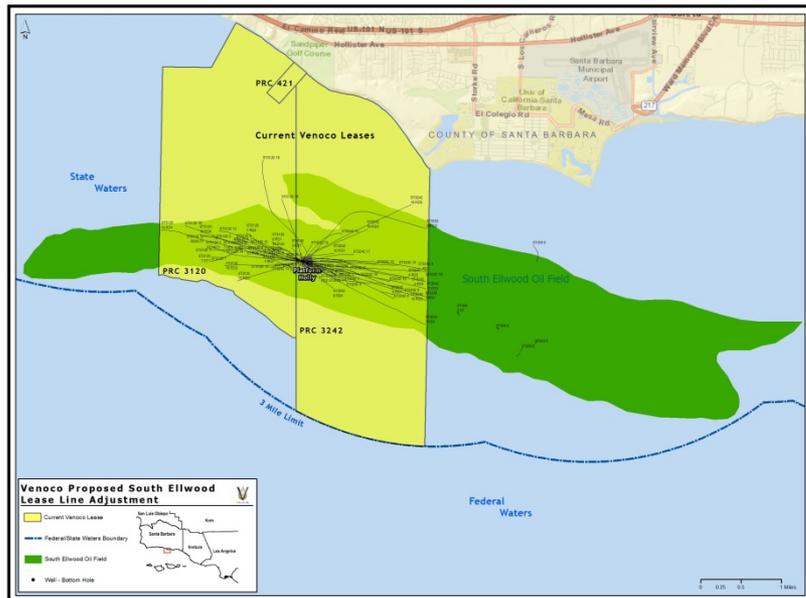
Platform Holly

Platform Holly

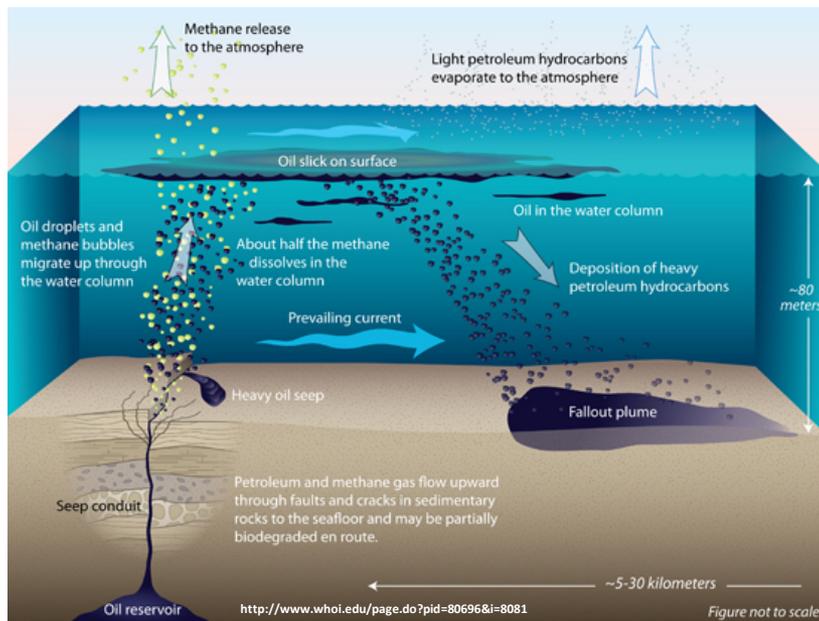
- 1966 – Arco/Mobil
- 211' Water Depth
- 30 well slots



- The South Ellwood Field is located 2 miles offshore along the northern margin of the Santa Barbara Channel. Platform Holly is set 11 miles west of the city of Santa Barbara.
- Only platform in State Waters in the Santa Barbara Channel.
- First offshore California field to produce from the Monterey formation (1969: Well 3120-8: 2100 BOPD)
- 1993-1997 Mobil – Clearview
- 1997 Venoco
- 2012-2014 Venoco – Active development and discovery
- Cum production to date 76MMbbls and 79BCF gas



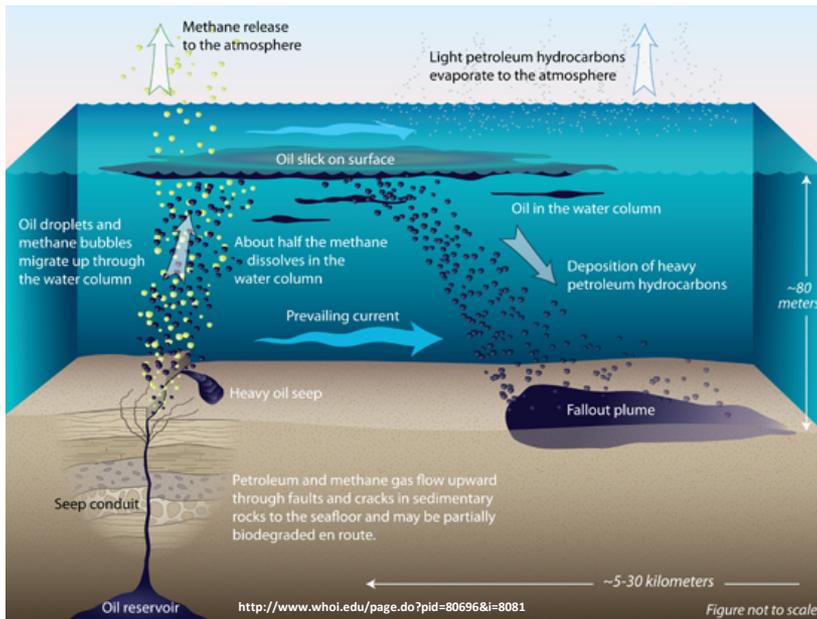
Natural Marine Hydrocarbon Seeps



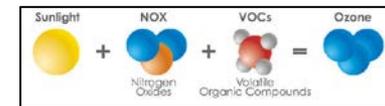
- Simple physics: Oil and natural gas are lighter than water and due to buoyant forces they move upward through the sediment they were generated in, eventually reaching the earth's surface, ocean and atmosphere
- The main source of hydrocarbons is the Monterey Formation, which is a world renowned petroleum source and reservoir rock
- The Santa Barbara Channel has some of the most prolific oil and gas seeps in the world. Second only to Caspian Sea
- There have been more than 1,200 natural seeps charted in the Santa Barbara Channel. Half of them occur within 3 miles of Coal Oil Point



Natural Marine Hydrocarbon Seeps



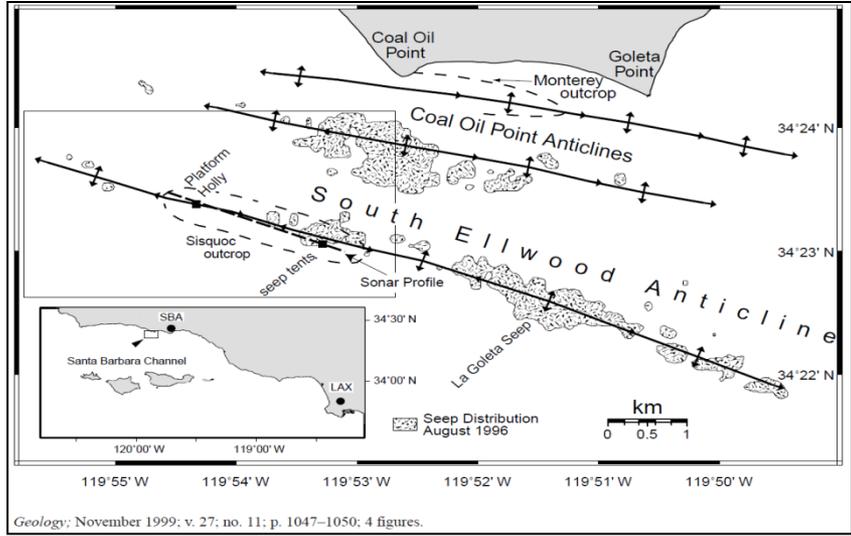
- Santa Barbara Chanel seeps release ~100-175 BO/day and up to 55,000 BO/year
- Santa Barbara Chanel seeps release ~3-7MMCFPD
 - Predominantly methane
- Each day, the natural seeps contribute 29 to 37 tons of reactive organic compounds into the air



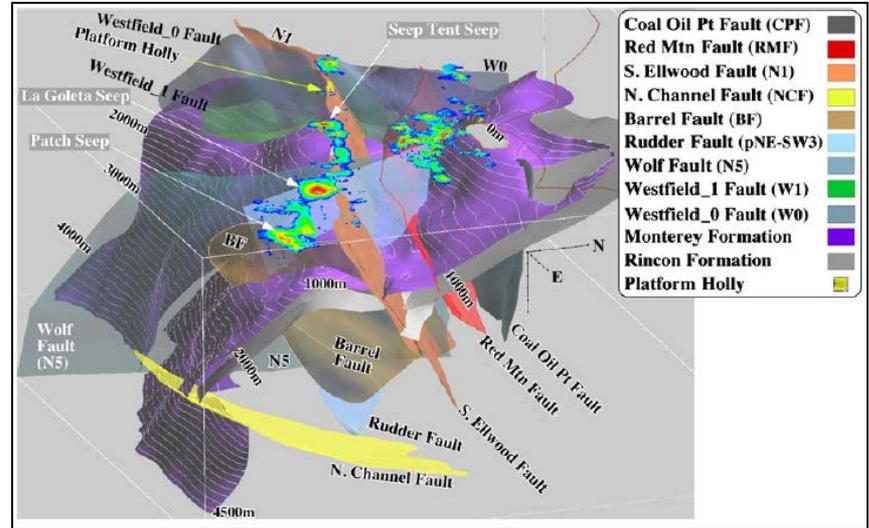
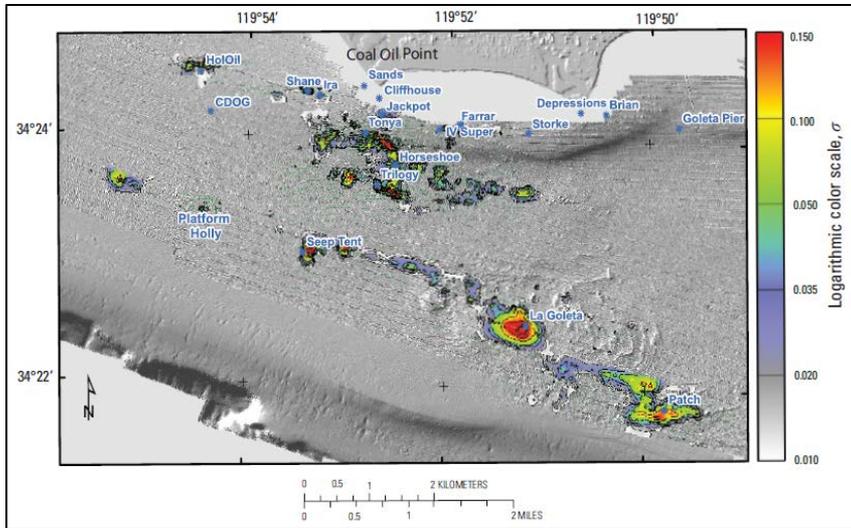
- Initial daily recovery from tents was equal to 50% of SB air pollution or 35,000 cars per day (Gunthrie et al. 1983)



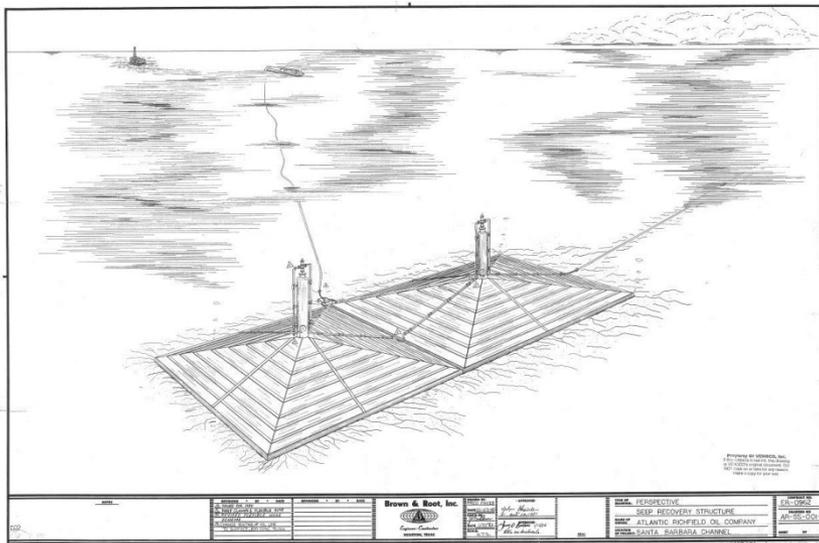
Natural Marine Hydrocarbon Seeps



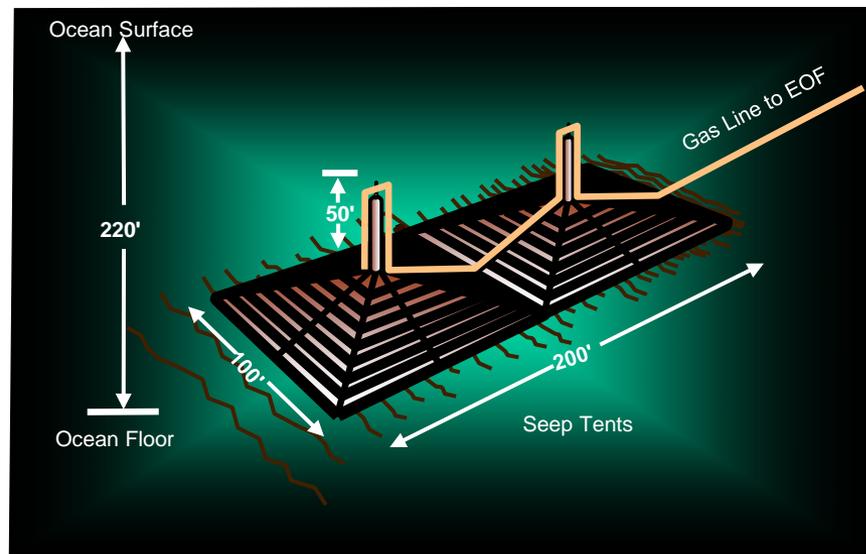
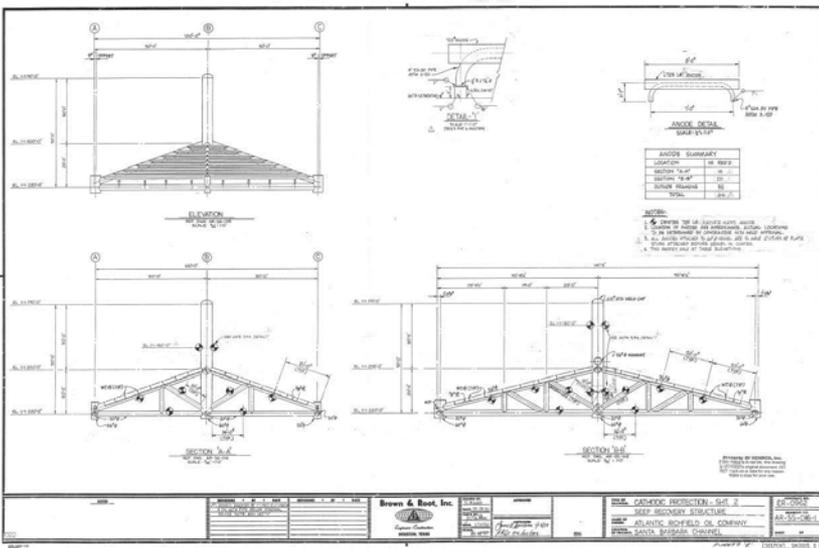
- Tectonics have resulted in significant faulting and uplift in the Santa Barbara Channel. It is this tectonic evolution that has resulted in numerous prolific structural accumulations in the Channel (anticlinal traps)
- Faults and fractures caused by tectonic deformation act as conduits for hydrocarbon migration. Several major reverse faults occur along the crest of the structure
- Independent mapping of seep activity/volume shows clusters of seeps directly above major faults
 - Coil Oil Point Anticline
 - South Ellwood Anticline



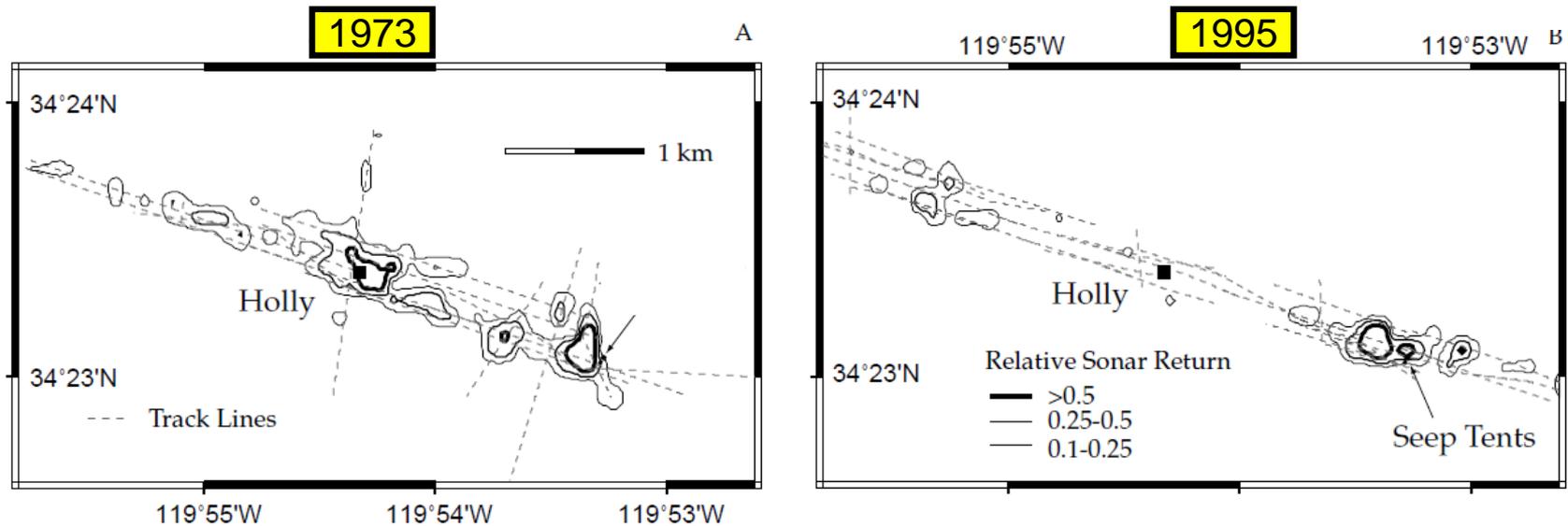
Seep Containment Project



- 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.
- Separate 4 mile, 6" pipeline built to transfer gas to EOF
- Estimated cost of \$7MM and was uneconomic without the incentives offered (emission reduction credits)



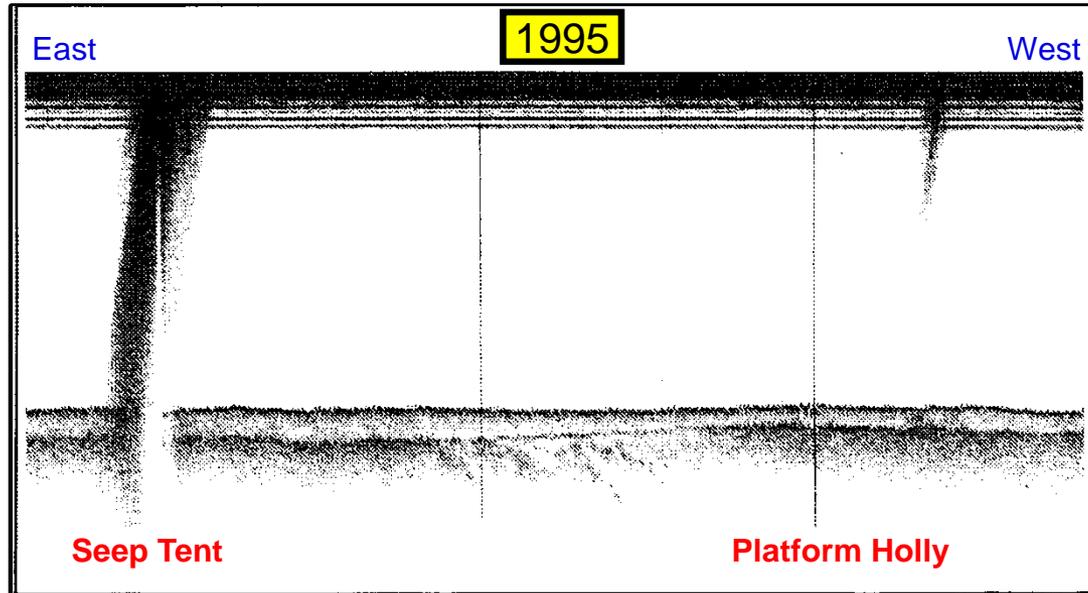
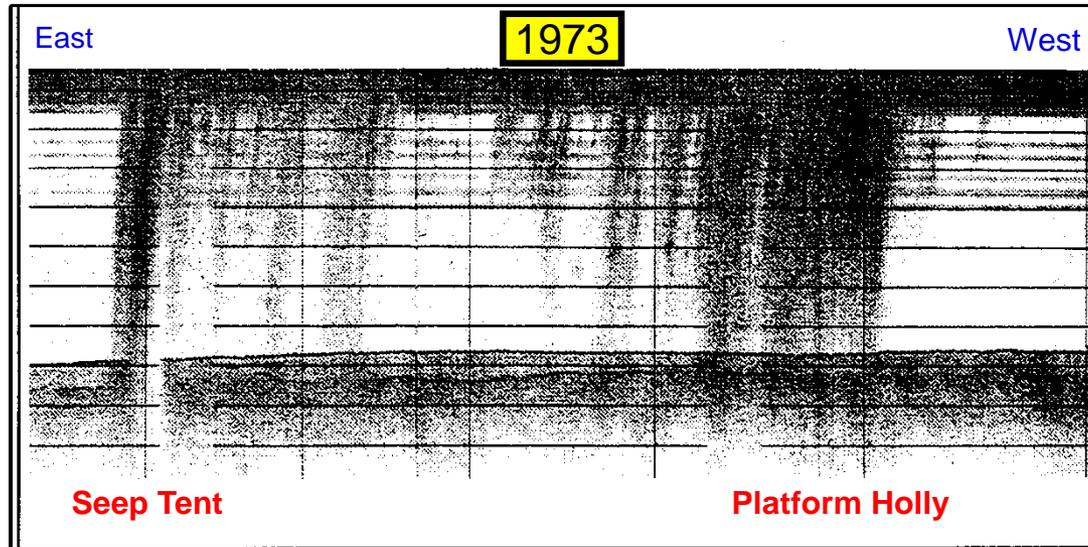
Seep Reduction/Cessation



*“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



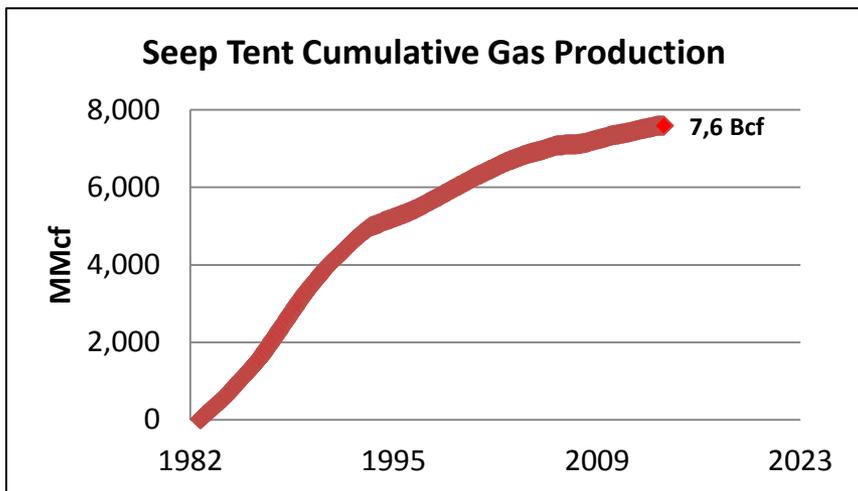


VENOCO, INC.

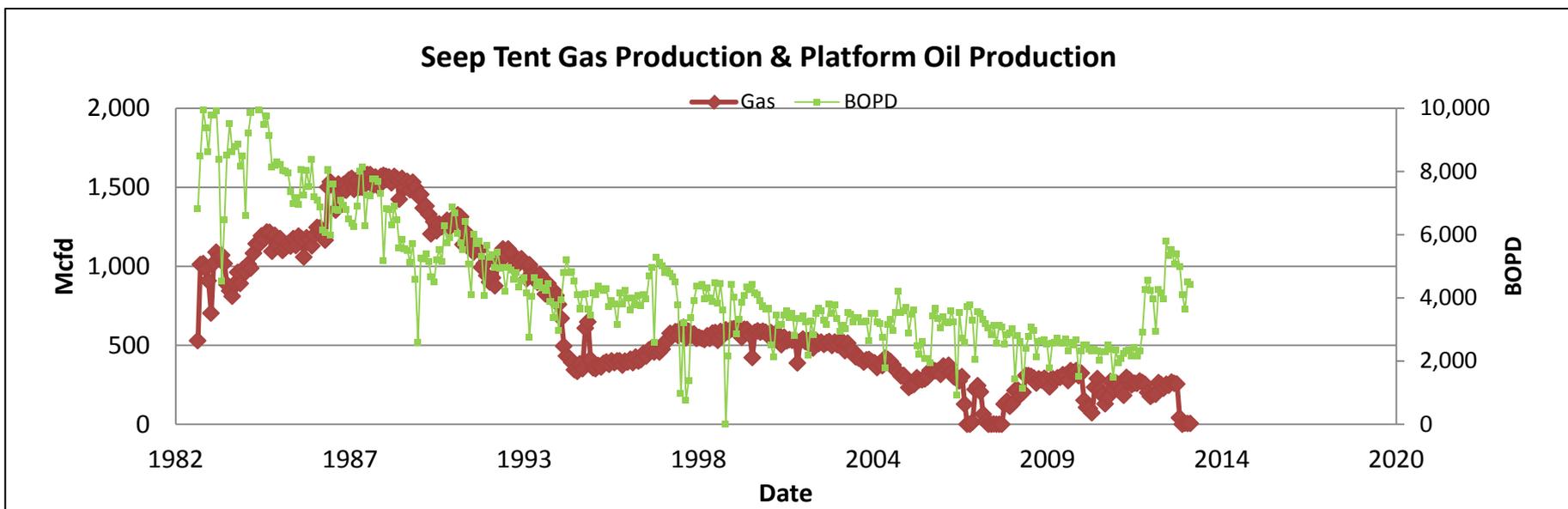
Seep Reduction/Cessation



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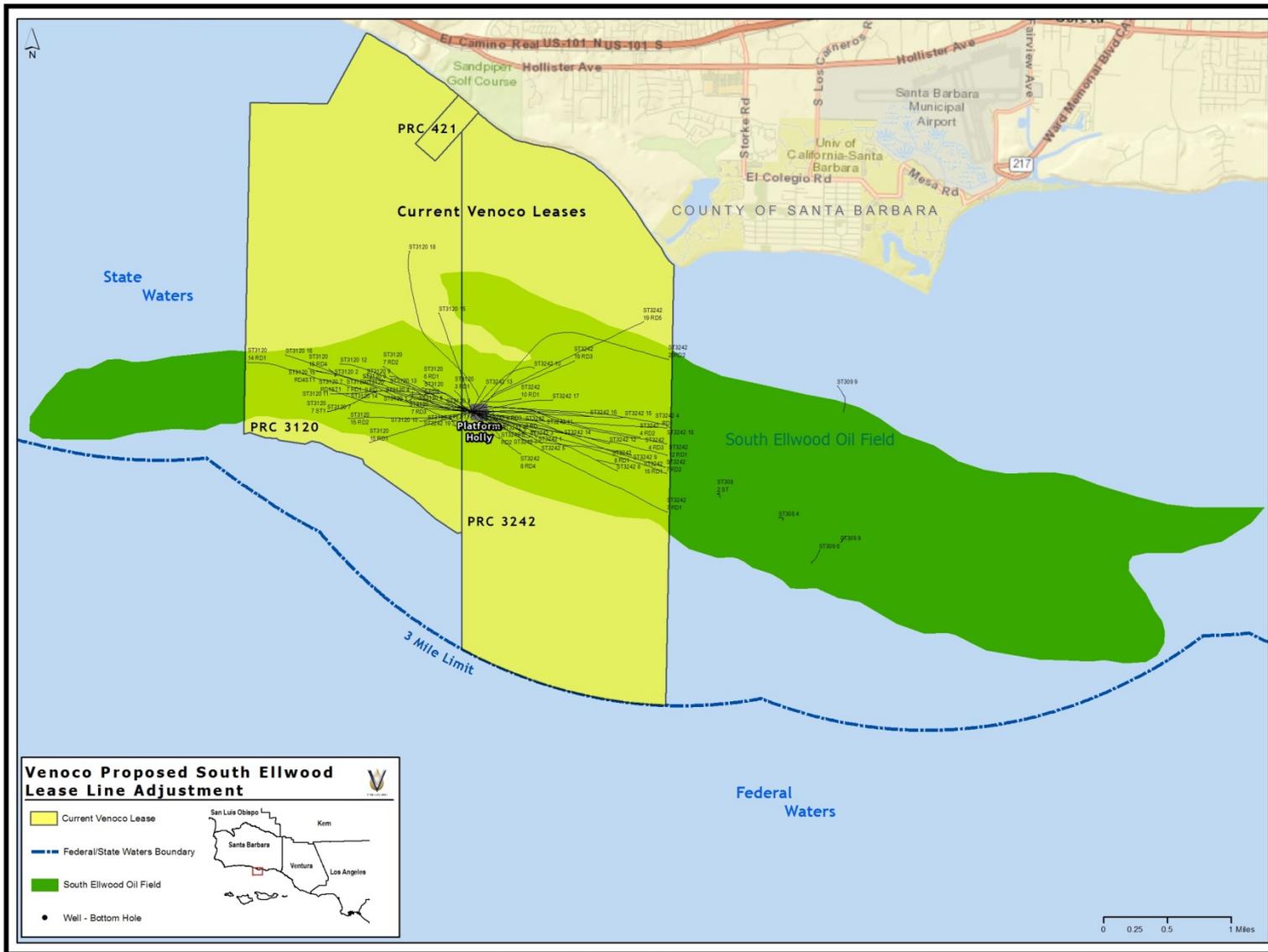


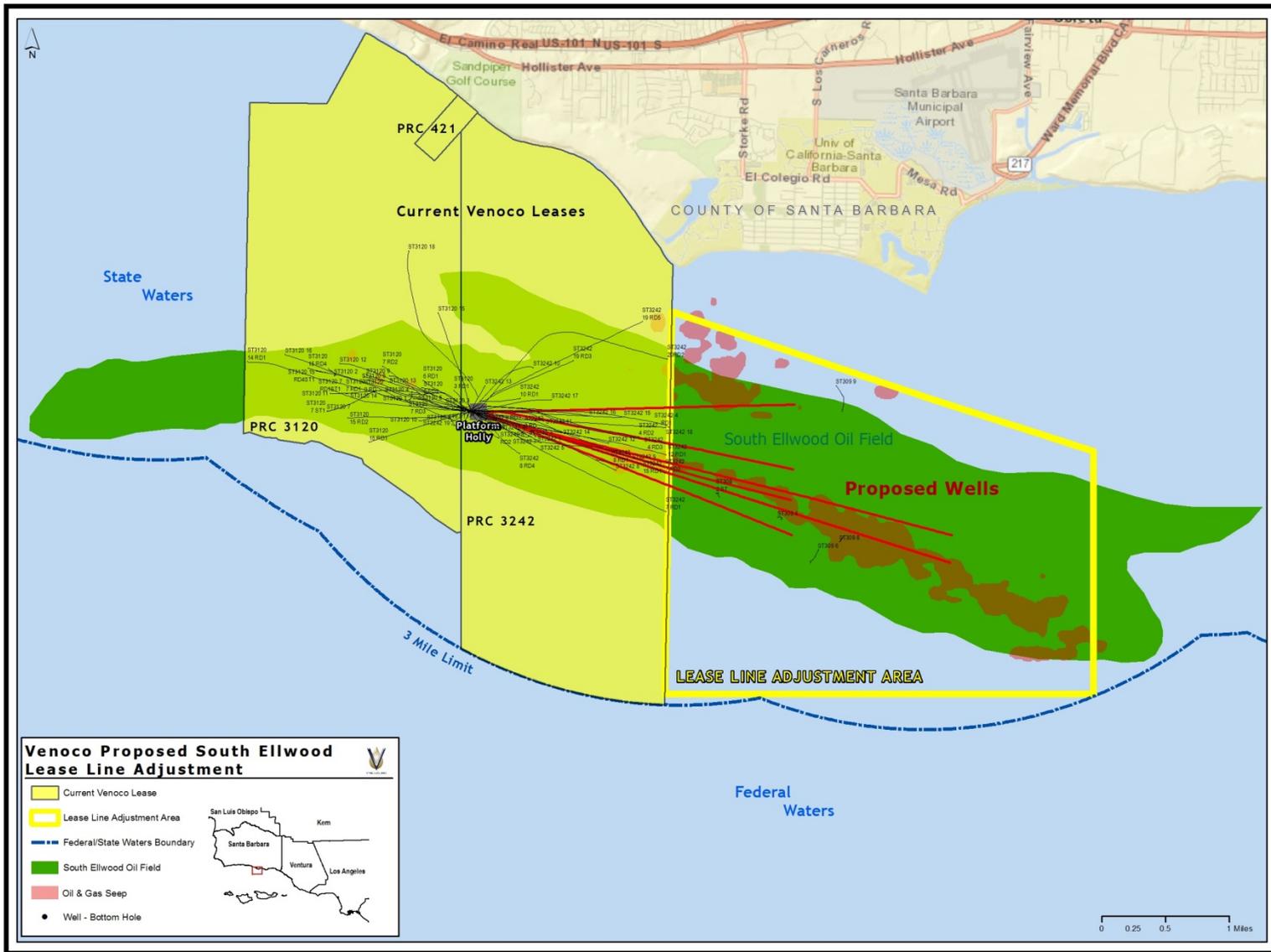
- Decades of production led to significant reduction in reservoir pressure ultimately resulting in the cessation of seep activity measured within the tent structures in late 2013.
- The decline of seep gas measured in the tents correlates with decrease in reservoir pressure.
- Future production from platform Holly will result in continued lowering of reservoir pressure and continued decrease in seep activity.
- At peak, the tents captured over 1,500,000 cubic feet of seeping gas each day -- equal to the amount of air pollution associated with tens of thousands of automobiles. To date, the seep tents have captured 7.6 billion cubic feet of gas.





Future Development & Impact on Seeps







Conclusions



- Production from the seep tents has been steadily declining through the past 30 years and production ceased completely in 2013
- The decline in seep tent production clearly correlates to the overall field decline and cessation coincides with recent increase in production
- To date, the seep tents have captured 7.6 billion cubic feet of gas. This is equivalent to 35,340 tons of ROC's
- The reduction and eventual cessation of seep activity is a direct result from hydrocarbon production and lowering of pore-pressure within the subsurface reservoir directly below this area
- Seep tents cover less than 1 acre (29,200 ft²) in total, which represents a very small fraction of the active seep field that extends for thousands of acres. Actual seep and emission reduction is much greater than measured within the relatively small area covered by the seep tents. Production at Platform Holly has resulted in significant improvement in local air quality
- Significant seeps occur to the east of PRC 3242 along the easterly extent of the South Ellwood and Coal Oil Point anticlines. Extension wells into the undrained portion of this reservoir will result in a reduction of reservoir pressure ultimately leading to less seeps and reduced emissions in that area
- An estimated 1-2 Billion barrels of oil is in place to the east of existing 3242 boundary. This resource can be accessed from existing Platform Holly and processed through existing Ellwood onshore Facilities