Technical Summary

STUDY TITLE: Submarine Oil Seep Study: Southern Santa Maria Basin and Western Santa Barbara Channel-- Source Markers, and Relation to Oil Residues on the Coastline.

REPORT TITLE: Natural Offshore Oil Seepage and Related Tarball Accumulation on the California Coastline – Santa Barbara Channel and the Southern Santa Maria Basin; Source Identification and Inventory

CONTRACT NUMBER: Interagency Agreement # 18985

SPONSORING OCS REGION: Pacific

APPLICABLE PLANNING AREAS: Central and Southern California

FISCAL YEARS OF PROJECT FUNDING: FY2001-FY2010

COMPLETION DATE OF REPORT: January 8, 2010

COSTS: $407,747 from MMS with match of $1,194,895 from USGS and $100,000 from the County of Santa Barbara.

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KEY WORDS: Natural oil and gas seeps, tar seeps, tarballs, southern Santa Maria Basin, Santa Barbara Channel, biomarker, stable carbon isotope ratios, fingerprint oil samples, oil platforms

BACKGROUND: The major goal of this project is to establish the geologic setting, source(s), and ultimate dispersal of natural oil and gas seeps in the offshore southern California within the area between Point Arguello and Ventura. The surveys focus on likely areas of hydrocarbon seepage which are known to occur over the Pt. Arguello oil field, and the area near Santa Barbara where huge amounts of offshore oil seepage occur.

OBJECTIVES: Objectives in reaching this goal are to: 1) Document the locations and geochemically fingerprint natural seeps within the offshore southern Santa Maria and Ventura Basins; 2) Geochemically fingerprint coastal tar residues and potential sources, both onshore and offshore, in this region and compare these data with the existing database from this and other coastal regions of California; 3) Establish chemical correlations between offshore active seeps and coastal residues thus linking seep sources to oil residues; 4)Measure the rate of natural seepage of individual seeps and attempt to assess regional natural oil and gas seepage rates; 5) Attempt to predict transport pathways of oil from seep sources to the coastline; and 6) Interpret the petroleum system history for the natural seeps.

DESCRIPTION: Previous studies of the area were consulted to document the location of natural oil and gas seepage. Field "sniffer" surveys were conducted to locate and measure the concentration of methane in the water column. High resolution seismic and sidescan sonar surveys were also conducted to provide information about potential source rock in areas of high interest. Samples of oil were then collected from platforms, at the source of seep oil on the ocean floor, and on the beach for fingerprinting. Samples of produced crude oil were collected from nine oil and gas platforms in the western Santa Barbara Channel/Southern Santa Maria Basin including Federal OCS Platforms Irene, Hidalgo, Harvest, Hermosa, Heritage, Hondo, Harmony, Platform A and State Platforms Holly. Samples from a decommissioned State platform, Hilda, were also evaluated. Natural tar samples were collected using Remotely Operated Vehicles (ROV's) at a range of depths and locations in the Channel and Santa Maria Basin.

Biomarker and stable carbon isotope ratios were used to infer the age, lithology, organic matter input, and depositional environment of the source rocks for 388 samples of produced crude oil, natural seep oil, and tarballs mainly from coastal California. As these platforms sampled represent only a subset of the 23 Federal and 6 State platforms, the model is not comprehensive and the findings are not conclusive.

SIGNIFICANT RESULTS: Hundreds of samples of highly weathered and fresh oils collected from the seafloor, oil and gas platforms, and beaches were successfully chemically fingerprinted and used to inform a model which will serve to determine the origin of oil samples in the future. In several cases, produced oil samples could be chemically differentiated from neighboring natural tar seeps. In other cases, biomarker analysis is required, in addition to chemical fingerprinting and, in a few cases; the produced oil is too similar to the natural oil to be clearly different unless the samples are fairly fresh. The study has greatly improved our knowledge about the varied types and extent of natural seeps and has already been successfully employed to determine the origin of unknown spills during the spill event.

STUDY RESULTS: The model results with the 388 samples placed them into three groups or "tribes". The oils are further subdivided into "families". Within each tribe, the oil samples have defined characteristics in common, indicating a common geologic origin.

Tribe 1 contains four oil families having geochemical traits of clay-rich marine shale source rock deposited under suboxic conditions with substantial higher-plant input. Tribe 2 contains four oil families with intermediate traits, except for abundant 28,30-bisnorhopane, indicating suboxic to anoxic marine marl source rock with hemipelagic input. Tribe 3 contains five oil families with traits of distal marine carbonate source rock deposited under anoxic conditions with pelagic but little or no higher-plant input. Tribes 1 and 2 occur mainly south of Point Conception in paleogeographic settings where deep burial of the Monterey Formation source rock favored generation from all three members or their equivalents. In this area, oil from the clayey-siliceous and carbonaceous marl members (Tribes 1 and 2) may overwhelm that from the lower calcareous-siliceous member (Tribe 3) because the latter is thinner and less oil-prone than the overlying members. Tribe 3 occurs mainly north of Point Conception, where shallow burial caused preferential generation from the underlying lower calcareous-siliceous member or another unit with similar characteristics.

It is very desirable to be able to clearly distinguish the naturally occurring seep oils from the anthropogenically derived platform oils. Within the “training set” of oils and tars (388 samples), the biomarker parameters are sometimes sufficient to allow unique discrimination of individual platform oils. More often however, platform samples and seep samples with sources geographically close to each other are too similar to each other, with respect to the biomarker parameters, to definitively differentiate them on that basis alone. In some cases other parameters can be helpful. These other parameters are related to the degree of biogeochemical degradation or weathering that the oils or tars have experienced. These components include the typical oil distribution of n-alkane hydrocarbons and isoprenoids pristane and phytane. All of the platform oils in our sample set contain these components. On the other hand, the seep oils or tars have been exposed to significant biodegradation while in the near subsurface. The majority, but not all of seep oils or tars have been biodegraded up to or beyond the loss of n-alkanes and isoprenoids. Seep oils found in the vicinity of Coal Oil Point or Arroyo Burro are apparently the least weathered and are particularly likely to retain significant n-alkanes and isoprenoids. Therefore, the combination of chemometric fingerprinting and the presence or absence of n-alkanes and isoprenoids help to differentiate anthropogenic production oils versus natural seeps oils and tars.

The differentiation is not always definitive because of the close chemical similarity of some samples and the variability in the biodegradation progression. This is the case near Coal Oil Point, and near Platform A (Dos Cuadros Field) where seep oils and Platform Holly and Platform A oils are genetically very

similar and cannot be definitively distinguished after a period of a few days of weathering. In contrast, oils from the Point Conception platforms can be distinguished on the basis of chemometric fingerprinting alone. In the middle of this spectrum are oils from Platforms Harmony, Heritage, and Hondo, where it is expected that oil weathering would take on the order of two weeks to a month to produce tarballs similar to those seen near Point Conception. In this case there is a much greater degree of weathering needed to proceed from produced oil to the biodegraded tar characteristic of tarball stranded on the beach.

Tar deposition on beaches was monitored as part of cooperative with the County of Santa Barbara Energy Division and the U.S. Geological Survey during 2001-2003. We found tar deposition varies on a seasonal basis. In general, tarballs accumulate at a faster rate or remain longer on all beaches during the summer and fall months. The reasons for this are unclear based on our limited observations, however we speculate that factors such as prevailing winds and currents combined with more quiescent wave conditions favors the accumulation and preservation of tarballs on the beach during the summer and fall months. In contrast, winter storms, with much greater wave action remove beach sand and other materials, and stormy seas tend to break up oil that might weather into tarballs. Natural seepage is affected by the spring/neap tidal cycle; however, the link to tar deposition is unclear. Longer periods of monitoring are needed to address the variability in the data and provide a more robust statistical analysis.

STUDY PRODUCT(S):

See the USGS website for more information about cruise reports, peer-reviewed papers and other products.
http://walrus.wr.usgs.gov/research/projects/oilandgasseep.html

Open file Report

Lorenson, T.D, Hostettler, F.D., Rosenbauer, R.J., Peters, K.E., Kvenvolden, K.A., Dougherty, J.A., Gutmacher, C.E., Wong, F.L., and Normark, W.R., 2009, Natural offshore seepage and related tarball accumulation on the California coastline; Santa Barbara Channel and the southern Santa Maria Basin; source identification and inventory: U.S. Geological Survey Open-File Report 2009-1225 and MMS report 2009-030, 116 p. and spreadsheets.
http://pubs.usgs.gov/of/2009/1225/