STUDY TITLE: Environmental Mitigation Monitoring: Determining the Potential Release of Contaminants into the Marine Environment from Pacific OCS Shell Mounds

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BACKGROUND: Offshore oil and gas production platforms have been present off the Southern California coast since 1958. At present, there are 23 offshore platforms located in Federal waters, installed between 1968 and 1989 and operating in water depths ranging between approximately 45 and 365 m). The hard substrate provided by the platform structure provides needed attachment surface for sessile (fixed) invertebrates, especially mussels, barnacles, and rock scallops that settle and grow on its surface, forming a biotic layer. When removed or shed, the organisms, especially their hard parts, create a mound underneath each platform that combines with rock cuttings and muds from drilling operations and normal marine deposition of suspended sediments. The height and areal extent of these shell mounds is dependent on water depth and age of the platform.

Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement (BSEE) regulations require the complete removal of platform structures and associated debris following decommissioning of offshore oil and gas facilities in the Pacific Outer Continental Shelf (POCS). BOEM continues to study the unique physical, chemical and biological environment associated with shell mounds located beneath the platforms to better understand the environmental costs and benefits of removing the mounds or, whether some mounds may be left in place. Shell mounds consist of discharged drilling muds and cuttings interlayered with shells and marine organisms falling from the platform infrastructure.

OBJECTIVES: The purpose of the current study was to assess whether chemical concentrations contained within POCS shell mounds, most notably PAHs, are migrating into the marine environment to the extent of posing a risk to marine organisms. Information from this study will be useful for helping evaluate the effects on the marine environment of the potential abandonment or removal of shell mounds following decommissioning of offshore oil and gas facilities, and the development of mitigation measures designed to minimize any adverse effects.

DESCRIPTION: Shell mounds associated with many of the POCS oil and gas production platforms contain sources of polycyclic aromatic hydrocarbons (PAHs) that could potentially migrate through mound sediments and pose a risk to marine biota.

PAHs are complex organic molecules consisting of various number of carbon rings (predominantly benzene and sometimes pentene rings) formed from carbon atoms with other atoms attached to the ring carbons and extending outside the rings. Consequently, the preponderance of PAHs with different numbers of rings can provide clues about how fresh or weathered the PAHs mixtures are. Moreover, within a class of PAH (e.g., naphthalene) are different forms (homologs) that are differentiated by the numbers of carbons attached to the ring(s), referred to as alkyl. As the PAHs are partially combusted or degraded by microbes, the extra-ring carbons are removed, leaving behind only hydrogen atoms and eventually leave only the C-0, or parent compounds.

This study utilized Semipermeable Membrane Devices (SPMDs) to assess PAH concentrations in the water column that were deployed at different locations immediately above the shell mounds at two POCS platforms and at two control sites. Study data provided insight into the chemical source of the PAHs and their weathering patterns, spatial patterns in their concentrations and compositions, and a comparison of total PAH concentrations detected at study platforms to water quality criteria for gauging potential harm to marine life and humans.

SIGNIFICANT CONCLUSIONS: The current study was developed to assess whether PAHs in POCS shell mounds were migrating into the marine environment and posing a risk to marine organisms. The approach utilized multiple PAH-absorbing SPMDs deployed over the shell mounds of two nearshore POCS platforms and at one control/background location sited near each platform. The individual SPMDs at each platform were placed over both the thin margins and the thickest section of the shell mound where the lowest and highest concentrations of PAHs were expected to be located, respectively. Based on study results and analyses, the following study conclusions can be made: 1) The SPMDs at both the platform sites and control sites detected very low concentrations of PAHs in the water column. 2) The abundances of C-1, C-2, C-3 and C-4 homologs of 2–4 ringed PAHs relative to their C-0 parent compounds (naphthalenes, fluorenes. phenanthrenes/anthracenes, dibenzothiophenes, fluoranthenes/pyrenes, and chrysenes) in the SPMD samples are chemically consistent with a crude oil source rather than a combusted hydrocarbon source. 3) Detected PAHs at all stations are consistent with relatively fresh sources of petroleum rather than an older weathered hydrocarbon source, as would be expected from the 30-40 year old drill cuttings buried in the shell mounds. 4) Although the shell mounds can not be entirely ruled out as a source of some of the PAHs reported in this study, the fact that the SPMDs deployed over the thicker areas of each shell mound at Platforms A and B, where the highest concentration of hydrocarbon-containing drill cuttings have been reported, did not detect higher PAH concentrations than those deployed over the fringes of the mounds suggests that the shell mounds are not the primary source of detected PAHs. 5) Although this study was able to accurately detect very low (part per trillion) concentrations of PAHs in the water adjacent to Platforms A and B, as well as at the two control sites, the proximity of natural hydrocarbon seeps to the study area and their contribution to detected PAH concentrations prevented this study from definitively differentiating the contribution, if any, made by the shell mounds to those PAH concentrations. 6) Based on observed PAH concentrations at the two control sites and the dominance of un-weathered crude oil PAHs in study results, the potential contribution of any shell mound PAHs to observed PAHs can be assumed to be very low. 7) The most likely source of PAHs is natural oil seepage, which is prevalent throughout the Santa Barbara Channel. This appears especially true at near Platform A where seepage has been previously reported since 1969. 8) Finally, PAH concentrations observed in the water column, regardless of the source of the PAHs, were more than an order of magnitude lower than regulatory water quality objectives established by the State of California to protect marine biota and human health. Consequently, any potential contribution of PAHs from platform

shell mounds to observed water concentrations of PAHs is likely very small and probably poses no appreciable risk to area marine biota.

STUDY RESULTS: Recovered SPMD PAH data was condensed into the six dominant compound groups consisting of 2–4 ringed PAHs, which constituted more than 94% of the total resolved PAHs and included naphthalenes, fluorenes, phenanthrenes/anthracenes, dibenzothiophenes, fluoranthenes/pyrenes, and chrysenes.

There were several patterns in the SPMD-derived water PAH concentration data. First, the concentrations of nearly all PAH groups were higher at the platforms than at the controls sites, especially at Platform A. The one exception to this pattern at Platform A was naphthalenes, which for some unknown reason were highest at the control A site. Second, at the Platform B control site, only dibenzothiophenes and fluoranthenes/pyrenes were detected at concentrations below (outside) the 95% confidence intervals of the reported concentrations for the same PAH compounds in Platform B samples. The 95% confidence intervals are a standard statistical measure for reporting the spread of the data and are used to estimate the range within which the true mean of a set of data is expected to occur with a probability of 0.95. Finally, Platform A had significantly higher concentrations of PAHs than Platform B across the entire major PAH groups

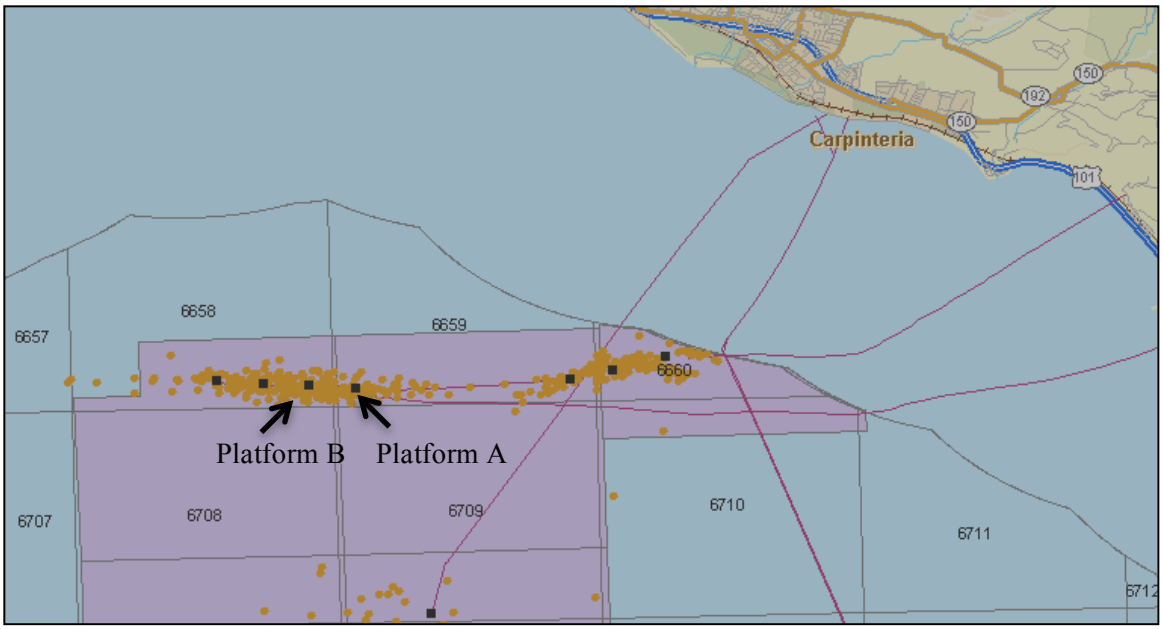
Samples from within each platform were relatively consistent in the composition of PAHs, and the relative contributions of naphthalenes, dibenzothiophenes and fluoranthenes/pyrenes suggested that the PAHs collected at Platform A and Platform B had different hydrocarbon sources. Additionally, the relative abundances of parent PAHs to their C-1, C-2, C-3 and C-4 homologs in all of the samples are consistent with an un-weathered crude oil source. Most crude oil has higher abundances of alkylated homologs (C-1 to C-4) than the parent compound (i.e., no side chains on the aromatic rings) than combusted or weathered hydrocarbon.. In study samples, alkylated PAHs were abundant and dominant indicating that the sources of PAHs in water sampled for this study were un-weathered crude oil that had not been refined or combusted.

SPMD arrays deployed at the topographic high point of the shell mound at each platform did not exhibit higher concentrations of PAHs than SPMDs deployed on the mound fringes where little to no hydrocarbon containing drill cuttings have been reported to be present. Therefore, it appears that proximity of an array to thicker regions of the shell mounds did not result in noticeably higher PAH concentrations.

Measured PAH concentrations did not suggest a risk to wildlife or humans. Calculation of Total PAH concentrations, as outlined in the Ocean Plan water quality objective for determined that the maximum PAH concentrations measured in any of the study samples were less than 10% of the established water quality objective.

STUDY PRODUCT(S):
Bemis, B. E., R.B. Spies, D.D. Hardin and J.A. Johnson. 2014. Determining the Potential Release of Contaminants into the Marine Environment from Pacific OCS Shell Mounds. Prepared by Applied Marine Sciences, Inc. for the U.S. Department of the Interior, Bureau of Ocean Energy Management. Camarillo, CA. OCS Study BOEM 2013-208. 33 pages + Appendices.

Map showing area of study:



Study Location in the Santa Barbara Channel, CA.