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STUDY TITLE: Impacts of Outer Continental Shelf (OCS) Related Activities on Sensitive Coastal Habitats

REPORT TITLE: Produced Waters in Sensitive Coastal Habitats: An Analysis of Impacts, Central Coastal Gulf of Mexico

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APPLICABLE PLANNING AREAS: Central and Western Gulf of Mexico

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BACKGROUND: During the production of oil or gas, water that is trapped within permeable sedimentary rock may also be brought to the surface. This produced water may have a salinity in excess of that of ambient sea water. In addition, produced waters may contain elevated levels of various inorganic and organic substances. The discharge of produced waters into brackish and marine waters is widespread in the northwestern Gulf of Mexico. Large volumes of produced water generated in the Federal OCS are piped ashore with the oil or gas streams and separated at shore-based or nearshore facilities located in state waters. The resulting produced waters are either discharged into nearshore continental shelf waters or estuarine waters or reinjected into disposal wells. The environmental effects of OCS-generated produced water discharges, and especially these large volume discharges into shallow state coastal waters, have received little attention.

OBJECTIVES: (1) to quantify the location and characteristics of discharges of OCS-generated produced waters into coastal environments of the Gulf of Mexico; (2) to provide an assessment of the environmental fate and effects of selected discharges.

DESCRIPTION: The objectives were addressed through an inventory of OCS-generated produced water discharges in coastal environments based on records of regulatory agencies and a field assessment.

Applications submitted to the Louisiana Department of Environmental Quality for permits for discharges of produced waters into surface waters of the state and the data base of the Texas Railroad Commission which permits produced water discharges in the state of Texas were the bases for the inventory.

Three study sites were selected for chemical and biological reconnaissance of the impacts of produced water discharges into coastal waters: Bayou Rigaud, behind Grand Isle; Pass Fourchon; and the bay side of East Timbalier Island. At each site, produced waters from the discharge point were sampled for hydrocarbon and trace metal analyses. The water column overlying the bottom and bottom sediments were sampled for similar analyses along a gradient away from the discharge point. Water column depth, temperature, and salinity were measured and benthic macroinfauna were sampled along the same gradient. Oysters and ribbed mussels were sampled for chemical body burdens. Sediment cores from the marsh were collected at one of the study sites for vertical profiles of hydrocarbons and trace metals.

SIGNIFICANT CONCLUSIONS: The total emissions of produced water into estuarine, coastal and continental shelf environments of the Gulf of Mexico region are estimated at 3.4 million barrels per day. This emission rate is considerably greater than previous estimates. The discharged produced water flows to the bottom because of its high density, and the rate of its dispersion depends on tidal currents. Sediments up to one kilometer from the produced water discharges studied exhibited evidence of petroleum contamination. At locations closest to the discharge where bottom sediments were heavily contaminated, the macrobenthic fauna was essentially eliminated. Low densities of organisms and few species were found under conditions of moderate hydrocarbon contamination of sediments.

STUDY RESULTS: The total emissions of produced water into coastal and offshore environments in the Gulf of Mexico region is estimated at 3.4 million barrels per day. Approximately 70% of these discharges enter the estuarine systems of Louisiana and Texas. [The other Gulf States (Mississippi, Alabama and Florida) do not permit the discharge of produced water into surface waters.] The distribution of these discharges is widespread throughout the coastal zones of both states, but produced water discharges are more numerous and voluminous in southeastern Louisiana and on the upper Texas coast. Produced water discharges from coastal separation facilities handling oil-gas-water streams from the OCS contribute approximately 434,772 bbl/day and are located mainly along the southeastern Louisiana coast from Atchafalaya Bay to the Mississippi River delta. The discharge of OCS produced waters into Louisiana coastal waters represents 22% of all produced waters discharged there. The facilities discharging OCS-generated produced water are few in number, but generally handle

very large volumes. Several of these facilities have reported daily discharges which exceed 20,000 bbl/day and two facilities discharge in excess of 100,000 bbl/day.

Produced water discharges contained high concentrations of organic acids, phenols, volatile aromatics, saturated alkanes, low moleoular weight polynuclear aromatic hydrocarbons and some trace metals. Concentrations of alkanes and aromatic hydrocarbons were similar to previous studies; however, the produced waters analyzed in this study had generally higher concentrations of naphthalene and its alkylated homologs than in most other studies. Concentrations of the organic constituents may depend on the separation and treatment technologies employed.

Produced water effluents act as a dense plume which sinks to the bottom. The rate of its dispersion depends on the receiving environment, tidal currents, and turbulence. Where bottom currents are swift, elevated salinities and volatile organics in overlying waters were not observed beyond the immediate vicinity of the discharge. On the other hand, where tidal flows are much less energetic, a dense near-bottom plume extended 800 m from the discharge.

Substantial contamination of fine-grained sediments with petroleum hydrocarbons was observed near the discharges at the three sites studied. Concentrations of polynuclear aromatic hydrocarbons in sediments exceeded apparent background levels by over an order of magnitude. Hydrocarbon contamination of sediments from produced water discharges extended several hundred meters to over one kilometer from the point of discharge.

This effect was more extensive than reported for other produced water discharges which have been studied, because of the lower physical dispersion in the bayous and canals into which the discharges take place and the larger volumes of produced water discharged. The degree of contamination of bottom sediments by trace metals contained in the produced waters was far less than that for petroleum hydrocarbons.

General surveys of the benthic fauna showed evidence of biological effects in reduced density and diversity of macrobenthic organisms in contaminated sediments. At locations closest to the discharge where bottom sediments were heavily contaminated, the macrobenthic fauna was essentially eliminated. Low densities of organisms and few species were found under conditions of moderate hydrocarbon contamination of sediments. Although some relatively uncontaminated sediments had a sparse benthic fauna, high polynuclear aromatic hydrocarbon levels in sediments were always associated with a depauperate benthos. Results from hydrocarbon analyses demonstrated the potential for uptake of produced water associated hydrocarbons by filter feeding molluscs in the vicinity of the discharge. Total polynuclear aromatic hydrocarbons and total saturated hydrocarbons were both at least three times more concentrated in oysters and mussels near the produced water discharges than those at reference sites. Moreover, the fossil fuel pollution index was greater than 0.7 in the molluscs from near discharge sites, while it was much lower or near zero at the reference sites.

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