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SPONSORING OCS REGION: Alaska.

APPLICABLE PLANNING AREA(S): North Aleutian Basin; St. George Basin; Navarin Basin; Norton Basin.

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KEY WORDS: North Aleutian Basin; St. George Basin; Navarin Basin; Norton Basin; Bering Sea; transportation economics; technology assessments; development scenarios; ice; marine traffic.

BACKGROUND: The Alaska Outer Continental Shelf (OCS) Social and Economic Studies Program was initiated by the Minerals Management Service to evaluate and predict the effect of OCS petroleum development on the unique physical, social, and economic environments within Alaska. This study evaluates and compares technology and costs associated with crude oil transportation alternatives from Bering Sea lease sale areas. No offshore field development has occurred in an environment similar to the Bering Sea. The North Sea environment, where approximately 10 years of petroleum development and operating experience is available, is similar but has significant differences. The most important difference is the presence of ice floes and large ice features in the Bering Sea.

OBJECTIVES: (1) To identify and evaluate technology for loading crude oil tankers given severe Bering Sea environmental constraints; (2) To identify and evaluate technology for transporting crude oil by marine and land pipeline; and (3) To evaluate and compare various transportation alternatives, illustrating advantages and disadvantages of each system and analyzing contributing key variables.

DESCRIPTION: In order to complete technological and cost analyses of systems for transporting crude oil from the Bering Sea, a number of assumptions had to be made and parameters established. Three representative scenarios (northern, central, and southern Bering Sea) were developed based on ice cover, which is considered the most significant difference within the Bering Sea. All relevant scenario parameters were defined and the potential range of critical parameter values was established for sensitivity analysis purposes. Environmental parameters were based on information in the public domain. Forces exerted on various offshore structure types were determined based on state-of-the-art procedures. Details were developed for each major transportation system element, including offshore loading systems, onshore storage facilities, transshipment terminals, marine pipelines, land pipelines, ice-strengthened tankers, conventional tankers, and icebreakers. These elements were combined to formulate all reasonable transportation alternatives. Total life cycle costs were developed. Alternatives were compared based on construction logistics, reliability, environmental considerations, and other factors. Base case scenario values and ranges of all relevant parameters were defined including environmental factors, crude oil production parameters and crude oil destinations. Each scenario was analyzed separately assuming no linking with OCS development elsewhere. When comparing crude oil

transportion alternatives, the total system from production platforms to refinery was considered and the ultimate destination to a U.S. West Coast port was assumed.

SIGNIFICANT CONCLUSIONS: For base case parameters of all three scenarios, the optimum crude oil transportation alternative consists of an offshore loading terminal for loading two ice-strengthened tankers traveling directly between the terminal and the U.S. West Coast. The sensitivity evaluation indicates that average crude oil transportation cost is sensitive to the quantity of total recoverable reserves for reserves less than approximately one billion barrels. The base case crude oil is suitable for either tanker or pipeline transportation but would be impractical to transport through a long marine pipeline.

STUDY RESULTS: For base case parameters of all three scenarios, the optimum crude oil transportation alternative consists of an offshore loading terminal for loading two ice-strengthened tankers traveling directly between the terminal and the U.S. West Coast. For the northern Bering Sea (Scenario 1), the offshore terminal consists of a crude oil storage structure, a separate tanker loading structure and, interconnecting pipelines. The storage structure is a self-contained, cylindrical, concrete structure and has a 1.5 million barrel storage capacity. The loading facility is a self-contained, rigid, gravity-stabilized, cylindrical tower, with a conical surface at the waterline, a large base for stability, and a rotating mooring boom. Both structures are brought to the site and ballasted to the seabed. Two 169,000 deadweight ton (DWT), ice-strengthened, and Class 4 powered tankers shuttle between the loading facility and the U.S. West Coast. Two Class 5 icebreakers provide assistance in tanker maneuvering and mooring and general operation, supply, and maintenance of the terminal. For the central Bering Sea (Scenario 2), the offshore terminal consists of a combined storage/loading facility connected by pipeline to the production platform. The facility consists of a 1.7 million barrel floating storage vessel, permanently moored by a rigid yoke to a catenary, chain- stabilized, articulated column. The storage vessel is self-contained, ice- strengthened, and equipped with a mooring boom for the shuttle tanker. Two 160,000 DWT, ice-strengthened, and Class 2 powered tankers shuttle between the offshore loading terminal and the U.S. West Coast. Two Class 3 icebreakers assist the tankers and operate the terminal. For the southern Bering Sea (Scenario 3), the offshore loading terminal consists of a combined storage/loading facility connected by pipeline to the production platform. The storage/loading facility consists of a 1.3 million barrel floating storage vessel, permanently moored by a rigid yoke to a buoyancy-stabilized, articulated column. The storage vessel is self-contained, ice-strengthened, and equipped with a mooring boom for the shuttle tanker. Two 137,000 DWT, ice-strengthened, and Class 1 powered tankers shuttle between the offshore terminal and the U.S. West Coast. Two Class 2 icebreakers assist the tankers and operate the terminal.

STUDY PRODUCT(S): Han-Padron Associates. 1984. Evaluation of Bering Sea Crude Oil Transportation Systems. Vol. I: Technical Report. A final report for the U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, Anchorage, AK. Social and Economic Studies Program Technical Report No. 110. Contract No. 14-12-0001-30077. 326 pp.

Han-Padron Associates. 1984. Evaluation of Bering Sea Crude Oil Transportation Systems. Vol. II: Appendices. A final report for the U.S. Department of the Interior, Minerals Management Service Alaska OCS Region, Anchorage, AK. Social and Economic Studies Program Technical Report No. 110. Contract No. 14-12-0001-30077. 158 pp.

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