ABSTRACT

The Outer Continental Shelf Environmental Assessment Program (OCSEAP) is a multidisciplinary program established to provide timely environmental information for decisions on offshore oil and gas development. One of OCSEAP's primary tasks is to provide information on the transport of pollutants in the marine environment. OCSEAP's science program is reviewed in relation to this task. Utilization of OCSEAP's extensive physical oceanographic data base to develop numerical models for calculation of spilled oil trajectories is discussed. Present and planned physical oceanographic studies and their goals are described.

INTRODUCTION

Two legislative acts: The Outer Continental Shelf (OCS) Lands Act of 1953 and the OCS Lands Act Amendments of 1978 call for the orderly development of the nation's outer continental shelf. As designated manager of the OCS leasing program, the Department of the Interior (DOI) is responsible for ensuring that the management of the outer continental shelf will be conducted in a manner which considers the economic, social, and environmental values of the renewable and non-renewable resources of the shelf as well as the potential impacts on those resources. Additionally, as part of the Environmental Impact Statement (EIS) analysis required under the National Environmental Policy Act of 1969, DOI is further responsible for ensuring that proposed OCS development and production activities will not irreparably damage the marine environment and its resources.

The Outer Continental Shelf Environmental Assessment Program (OCSEAP) was established by interagency agreement between DOI's Bureau of Land Management (now, following reorganization, the Minerals Management Service (MMS)) and the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) in 1974. This multi-disciplinary program was created to provide MMS and other agencies involved in the OCS leasing decisions the scientific data and information needed to predict environmental disturbances and to resolve multiple-use conflicts associated with offshore oil and gas exploration and development in Alaska.

The specific program objectives of OCSEAP are:

1. To provide information about the OCS environment that will enable DOI to make sound management decisions regarding the development of mineral resources on the OCS.

2. To acquire information that will enable DOI to identify those aspects of the environment that might be affected by oil and gas exploration and development.

3. To establish a basis for predicting the effects of OCS oil and gas activities on the environment.

4. To acquire data that may result in modification of leasing stipulations, operating regulations, and OCS operating orders in order to permit more efficient resource recovery with adequate environmental protection.

THE OCSEAP SCIENCE PROGRAM

There are some thirteen different OCS planning areas for oil and gas development on the Alaskan continental shelf and slope. In each area extensive environmental studies must be conducted before such development is allowed. The studies program must develop meaningful data in a usable form and in a timely
manner, so that any required mitigative actions can be taken to avoid serious or irreversible impacts to the marine environment. To meet the OCSEAP program objectives and to respond to the environmental issues identified for each leasing area, the scientific objectives of the science program are planned according to combinations or subdivisions of the following general study elements:

1. Contaminant Distribution - Determination of the predevelopment distribution and concentrations of potential contaminants commonly associated with oil and gas development.

2. Environmental Hazards - Identification and estimation of the potential hazards posed by the environment to petroleum exploration and development.

3. Pollutant Transport, Weathering and Fate - Determination of the ways in which possible contaminant discharges would move through the environment and how they would be altered by physical, chemical, and biological processes.

4. Living resources - Determination and characterization of the biological populations, communities, and ecosystems that are subject to impact from petroleum exploration and development.

5. Effects - Determination of the potential effects of contaminants and other insults on individuals, populations, and ecological systems.

To address the above tasks and meet the program objectives the science program is divided approximately equally between physical and biologically oriented studies. The biological program includes studies on: marine ecosystems and habitats, the abundance, distribution and feeding ecology of selected species including the endangered species, industrial noise effects, and effects of oil on the food chain. The physical program includes: geology and marine hazards, sediment/oil/ice interactions, oil weathering, Arctic and Sub-Arctic meteorology, circulation and oceanographic processes, and numerical modeling.

THE OCEANOGRAPHY PROGRAM

The transport and transformation of accidental or regulated discharges of contaminants associated with OCS oil and gas development are of key significance. The potential for a large oil spill is considered the aspect of petroleum development most detrimental to the regional environment. One of OCSEAP’s primary tasks is to provide information on pollutant transport in the marine environment. Physical oceanographic measurements are inherent in this task. The general goal of the physical oceanography program is to quantify the paths that OCS contaminants will follow, and the extent and character of the exposure of contaminants to biota along and at the ends of the transport.

The basic approach of the physical oceanography program has been to numerically model the OCS using models driven by observations from past and ongoing studies. OCSEAP has sponsored the development of an oil spill trajectory model to predict the behavior and distribution of spilled oil and to simulate the movement of spills from a planned OCS development area. The model also serves to integrate oceanographic data from various field projects into a holistic description of tidal and net circulation in a given region.

The amount of oceanographic data available from Alaskan OCS leasing areas in 1974 was quite limited. Initial OCSEAP studies described offshore circulation [1,2,3,4] in the Gulf of Alaska, Bering, Chukchi, and Beaufort Seas. These studies provided data on water mass characteristics, mean currents, tidal velocities, etc. and established important boundary conditions for the modeling studies. Subsequent transport studies focused on site-specific processes and included special efforts to describe the behavior of oil in water and ice [5,6,7].

Oil spill trajectory modeling has undergone a relatively rapid evolution as more data become available and additional areas are proposed for development. The initial modeling effort was used to describe the circulation in the Gulf of Alaska. The modeling effort was subsequently extended to computing circulation and trajectories in the Bering Sea. The modeling has now evolved to the extent that the entire Alaskan OCS is described by three regional models covering the Beaufort and Chukchi Seas, the Chukchi and Bering Seas, and the Gulf of Alaska. Since ice dominates the entire Arctic OCS area, the processes by which oil is constrained to move in, and with, ice has been studied by OCSEAP. These studies have shown that large quantities of oil can be trapped in the under-ice roughness cavities and that there is a typical threshold current-ice velocity differential of 15-20 cm/s.
that must exist before the oil will be stripped from the bottom of the ice [8]. The results of these studies have been incorporated into the oil trajectory model for the subarctic and arctic lease areas. Studies of the weathering of oil in the open ocean have been completed [9] and integrated into the trajectory model such that oil-component concentrations around a hypothetical trajectory can be computed. Additional studies of the interaction of oil, ice, and suspended particulates are underway and their data will be incorporated into the model allowing computation of trajectories during the sea ice freeze-up and break-up periods. Investigations of the weathering of oil actually incorporated into ice are underway and can be expected to be included in the trajectory model.

In open water areas, wind is the dominant force in moving and dispersing an oil spill. A storm-track submodel was incorporated into the trajectory model to allow a more realistic wind field computation during a trajectory run. This is especially important in the Bering Sea and Gulf of Alaska where there is an average of three to four storms a month each lasting several days.

The evolution of the trajectory model has been steady in response to continual input of new results from OCSEAP and non-OCSEAP studies. The model presently consists of a suite of submodels capable of addressing many of the questions associated with pollutant transport in the marine environment and will continue to evolve as results from new and on going investigations are incorporated.

PRESENT STUDIES

Since 1974, OCSEAP sponsored investigations have compiled a significant amount of data on the general circulation on the Alaskan OCS. The available OCSEAP and non-OCSEAP data are thought to be sufficient to adequately model and compute three dimensional pollutant transport trajectories in the Gulf of Alaska, Bering, Chukchi and nearshore regions of the western Beaufort Seas. Ongoing OCSEAP studies in pollutant transport are providing data for verification of the model outputs and data to serve as interior test points for model calculations.

The current state of knowledge of coastal circulation, including that in the coastal lagoons and embayments, in the western Beaufort Sea is fairly good. Surface circulation data over the mid and outer shelf regions are very limited and generally, inadequate. Oceanographic measurements elsewhere on the shelf and in the eastern Beaufort have been sporadic, encompassing only small portions of the inner and outer shelf regions. Little information is available for the inner shelf, at depths ranging from 20 to 50 m. OCSEAP is currently sponsoring a study in this region to investigate and describe the circulation over the inner and outer shelf regimes in both open water and ice-covered conditions. The study results should explain in the dynamics of the alongshore low frequency flows observed in earlier current meter records and also, the cross-shelf exchanges indicated by the few available hydrographic records. Study elements are included to observe a hypothesized downslope current along the bottom caused by high salinity water formed during freezing and to verify the circulation model developed for this area.

Because sea ice is potentially a dominant factor affecting the transport of spilled oil in the Beaufort, Chukchi and Bering Seas, OCSEAP is sponsoring studies on the motion of pack ice and the interaction of oil, suspended particulates, and ice. One study involves the placement of instrumented buoys on the ice pack and monitoring their positions via satellite. Up to 30 buoys are deployed and provide valuable ice/meteorological data in near real-time. Understanding the interaction of ice, suspended particulate materials (spm), and oil is very important in trying to model pollutant transport in the Arctic. Periods of high turbulence associated with storms and windy weather during freeze up are involved in entraining and concentrating fine grained sediments in nearshore ice. The entrained sediments are of a size and composition (fine grained silt) and clays that are particularly efficient at scavenging petroleum components such as the higher molecular weight aliphatic, acyclic and polynuclear aromatic hydrocarbons, dissolved or dispersed in the water column. The oil/ice/spm study is attempting to develop a model which can be used to describe and quantify the physical and chemical interactions of oil, ice, and sediments since these interactions could influence the entrainment and concentration of sediments, as well as the weathering, transport, and deposition of the oil. Study results will allow more detailed, year-round analyses of pollutant transport when combined with the existing trajectory and weathering models.

A more site-specific transport study is underway in Norton Sound. The Yukon River Delta is located in the vicinity of planned OCS development; it is also considered a biologically important area. The gently sloping topography, extensive
saltwater intrusion, frequently occurring storm surges, strong diurnal sea breezes, and heavy sediment loads make the delta extremely susceptible to pollutant impingement over large areas. The study elements include resolving the extent, persistence and velocity of land and sea breezes near the delta, determine the river flow parameters and the currents in the nearshore area of the delta, estimating the extent of saltwater intrusion upstream to determine what distance a pollutant could be advected from within the salt wedge, and obtain and analyze suspended sediment data to determine its affinity to accommodate and transport OCS pollutants.

The completion of on going studies and the integration of their results into the extensive OCSEAP data base will allow detailed descriptions of the trajectories of OCS derived pollutants from all lease areas on the Alaskan OCS. This description will include modeling of surface trajectories, sub-surface plumes, ice transport, sediment incorporation and transport, and many phases of the actual weathering of oil.

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REFERENCES


