Chapter 7

Environmental Considerations

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Chapter 7
Environmental Considerations

OVERVIEW

The development of petroleum resources in frontier areas of the Outer Continental Shelf (OCS) has become an important strategy in meeting the Nation's future energy needs. At the same time, a national consensus exists that protecting the environment from the effects of OCS development is equally important. Several laws are in force which address the potentially conflicting goals of environmental protection and resource development:

- ***The Outer Continental Shelf Lands Act (OCS Lands Act) of 1953*** (amended in 1978) mandates, among other things, that environmental studies be done "in order to establish information needed for assessment and management of environmental impacts on the human, marine, and coastal environments of the Outer Continental Shelf and the coastal areas which may be affected by oil and gas development."[1]
- ***The National Environmental Policy Act (NEPA) of 1969*** requires that all Federal agencies "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact upon man's environment. The NEPA requires that an Environmental Impact Statement be prepared for major Federal actions.
- ***The Marine Protection, Research and Sanctuaries Act*** prohibits the unregulated dumping of waste materials into coastal and ocean waters and authorizes the Secretary of Commerce to designate offshore marine sanctuaries.[3]
- ***The Endangered Species Act*** requires that endangered and threatened species of fish, wildlife, and plants (and the ecosystems on which they depend) be determined and conserved, and it authorizes issuance of regulations necessary for protection of these species.[4]
- ***The Marine Mammal Protection Act*** provides for the conservation and management of marine mammals.[5]
- ***The Coastal Zone Management Act (CZMA)*** provides for management and protection of the coastal zone in cooperation with states.[6] Under the CZMA Federal actions must be consistent with approved state coastal zone management programs.
- ***The Federal Water Pollution Control Act (FWPCA)*** provides for the restoration and maintenance of the quality of the Nation's waters.[7] Among other things, the FWPCA requires discharge permits for OCS activities.

Several important environmental concerns are related to oil and gas development in frontier areas. If OCS exploration and development is to proceed with due regard for environmental protection and if sound lease management decisions are to be made, a large quantity of environmental information is needed. This is particularly true in Arctic frontier areas where relatively less is known about marine ecosystems and the manner in which they may be affected by OCS activities. Given funding constraints for environmental research, it is particularly important that such information be based on sound scientific procedures, provided in a timely manner, available to all interested parties, and rele-

[1] Public Law 83-212, 67 Stat. 462 (1953), 43 USC 1331-1356, as amended by Pub. Law 93-627, 88 Stat. 2126 (1975), and Pub, Law. 95-372, 92 Stat. 629 (1978). Section 20 (a)(l),

[2] Public Law 91-90, 83 Stat. 852 (1970), 42 USC 4321-4347, as amended by Pub. Law 94-52, 89 Stat. 258 (1975) and Pub. Law 94-83, 89 Stat. 424 (1975). Section 102 (2)(A).

[3] Public Law 92-532, 86 Stat, 1052 (1972), 33 USC 1401- 1444; 16 USC 1431-1434, as amended by Public Laws 93-254 (1974), 93-472 (1974), 94-62 (1975), 94-326 (1976), and 95-153 (1977).

[4] Public Law 93-205, 87 Stat. 884 (1973), 16 USC 1531-1543, as amended by Public Laws 94-325 (1976), 94-359 (1976), 95-212 (1977), 95-632 (1978), and 96-159 (1979).

[5] Public Law 92-522, 86 Stat. 1027 (1972), 16 USC 1361-1407, as amended by Public Laws 93-205 (1973), 94-265 (1976), 95- 136(1977), and 95-316 (1978).

[6] Public Law 92-583, 86 Stat. 1280 (1972), as amended by Public Laws 93-612 (1975), 94-370 (1976), and 95-372 (1978).

[7] Public Law 845, 62 Stat. 1155 (1948), 33 USC 1251-1367, as amended.

vant to the pre-and post-lease decisions that must be made. The major program for developing the information necessary for predicting, assessing, and managing the effects of OCS development is the Department of the Interior's Environmental Studies Program (ESP).

It is beyond the scope of this assessment to do an exhaustive study of all biological resources that potentially may be affected by OCS oil and gas development. Some endangered species and some species of commercial importance which may be affected by oil and gas activities in Arctic areas are briefly considered. In lieu of a thorough analysis of all species, a detailed case study of bowhead whales is presented. Although not the only Arctic marine mammal listed as endangered, this species has received considerable attention in recent years. The possible vulnerability of bowhead whales to oil and gas activities has been the subject of intense debate among groups with different values and different objectives for Arctic development. Organizations including the Minerals Management Service (MMS), the National Marine Fisheries Service (NMFS), the Alaska Eskimo Whaling Commission, and the oil and gas industry have funded bowhead whale research in an effort to better understand the life history of the species and to determine the potential effects of OCS oil and gas activities on the species' behavior, survival, and reproduction.

Technology and techniques for oil spill containment and clean up in frontier areas are an important environmental consideration. While the oil and gas industry is genuinely concerned with preventing oil spills, the industry's capability to contain and clean up spilled oil in hostile environments has not been proven under actual conditions. This assessment focuses on the evaluation of the state-of-the-art of Arctic oil spill countermeasures. Less attention is given to deepwater spills. Although some deepwater oil spills may occur as the oil and gas industry moves further offshore, and although current capability to clean up such spills is limited, the equipment and methods for combating deepwater spills are essentially no different than those used for nearshore areas. Most deepwater spills will likely be of less concern than shallow water, nearshore spills because: 1) they generally occur in less biologically sensitive areas; 2) natural processes may often work to dissipate and degrade deepwater spills before significant damage can be done; and 3) greater distance from shore allows more lead time in which to consider what (if anything) is to be done.

ENVIRONMENTAL INFORMATION

Overview

The Department of the Interior (DOI) is responsible for leasing and managing OCS lands. As manager of the OCS leasing program, it is DOI's responsibility to ensure that environmental safeguards are employed. Specifically, DOI must ensure that OCS operations are

> . . . conducted in a safe manner by well-trained personnel using technology, precautions and techniques sufficient to prevent or minimize the liklihood of blowouts, loss of well control, fires, spillages, physical obstruction to other users of the waters or subsoil and seabed, or other occurrences which may cause damage to the environment or property, or endanger life or health.[8]

[8]Section 3(6), Supra note 1.

In order to meet this responsibility, DOI must be able to assess the environmental impacts of proposed offshore development, to delineate sensitive and unique areas, and to determine environmental hazards. The need for scientific information to accomplish these tasks led to the establishment of the Environmental Studies Program in 1973. This is the major scientific program designed to acquire information for OCS leasing.

ESP was initially administered by the Bureau of Land Management (BLM). However, in 1982, then Secretary of the Interior James Watt created MMS in order to streamline the administration of the leasing process, and the responsibility for the ESP was transferred to MMS. The environmental information generated by ESP research projects is used by the Secretary of the Interior and by the environmental assessment and leasing management divisions of the MMS in order to carry out their responsibilities under the NEPA and the OCS Lands Act. The Secretary of the Interior uses ESP information (as presented in NEPA documents and in the Secretarial Issue Document for each sale) for sale-related decisions.

The studies program is divided among the four MMS regional offices—the Alaska, the Atlantic, the Gulf of Mexico, and the Pacific regions—and the headquarters office. Alaska studies have received the most attention because the Alaska OCS is the largest OCS area (comprising about 74 percent of OCS lands) as well as the least explored and least studied area.

Relatively little information was available prior to 1973 to assess the potential impacts of oil and gas development, and data gaps were especially large for the Alaskan OCS. Moreover, BLM—primarily a western land management agency—initially did not have the inhouse capability to extend its environmental studies program to the Alaskan OCS. Therefore, in 1974, BLM contracted with the National Oceanic and Atmospheric Administration (NOAA) to design and manage an environmental studies program for the Alaskan region. NOAA initiated the Outer Continental Shelf Environmental Assessment Program (OCSEAP) for Alaskan studies, OCSEAP has become one of the most comprehensive programs for the collection and evaluation of Arctic environmental information. It is also the largest single segment of the environmental studies programs funded by the MMS.

MMS directly manages all environmental studies in the Atlantic, Gulf, and Pacific OCS regions and some of the Alaskan OCS studies (including some transport studies and endangered species and monitoring studies). MMS also manages the Alaska Social and Economic Studies Program. This program, begun in 1976, funds studies which investigate the impact of offshore oil and gas development on economic, social, and cultural systems of coastal residents, communities, and regions. Seventy-five percent of MMS funds for social and economic studies have been spent in Alaska.

The assessment of environmental information needs and the development of environmental studies occur annually through the MMS Regional Studies Plans. Assistance in developing Regional Studies Plans is given by Regional Technical Working Groups in each OCS area. In the Alaska region, this group is composed of representatives from the MMS, the State of Alaska, the Fish and Wildlife Service, the NMFS, the U.S. Coast Guard, the Environmental Protection Agency, industry, and private groups. The OCS Advisory Board Scientific Committee also comments on the plans during development.

Studies are ranked according to: 1) the importance of the research to decision-makers; 2) the date of the decision for which the study results are to be used; 3) the generic applicability of results or techniques from the study; 4) the availability and completeness of existing information; and 5) the applicability of the information to issues of regional or programmatic concern.[9]

With respect to the Alaskan OCS, information needs identified by MMS are utilized by NOAA to prepare an annual Technical Development Plan for OCSEAP research.[10] OCSEAP research is performed at universities, State and Federal agencies, private firms, and research institutions. Private firms currently receive the greatest proportion of ESP funding in Alaska, and that proportion has been increasing.

The results of research projects are utilized in the OCS leasing decision process at various stages. The steps in which scientific information is incorporated into leasing decisions are described in table 7-1. Results from the studies program and other scientific information are also utilized in post-lease permitting, post-lease environmental analyses, and (if necessary) development environmental impact statements.

Expenditures

MMS spent approximately $370 million on the ESP between 1973, the year in which the program was initiated, and 1984, the latest year for which data are available (see figure 7-l). About half of

[9]Minerals Management Service, Alaska Outer Continental Shelf Region, *FY1985 Alaska Regional Studies Plan: Final (October 1983)*.

[10]National Oceanic and Atmospheric Administration, *Outer Continental Shelf Environmental Assessment Program: FY 84 Technical Development Plan* (August 1983).

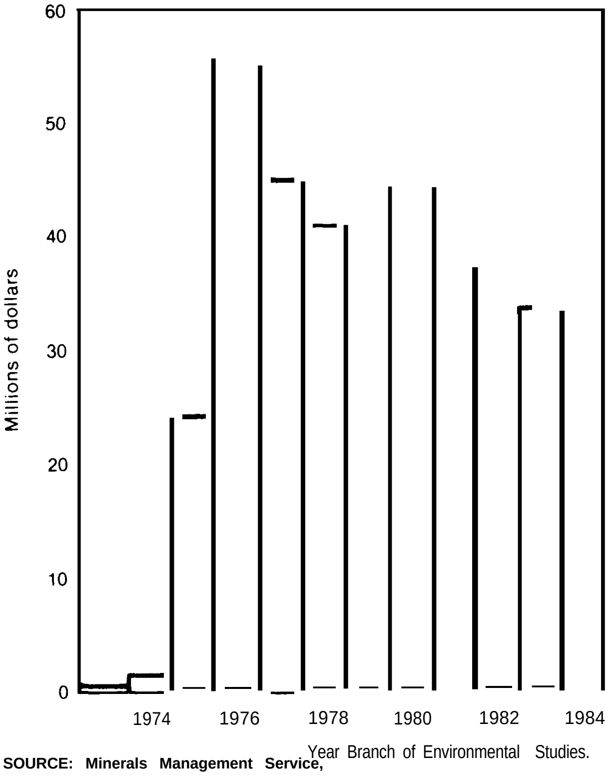
Table 7-1 .—Use of Environmental Information in Leasing Process

Area Identification MMS analyzes recommendations based on environmental information from FWS, DOI, the public, and affected States.	**MMS Scoping Meeting** Issues concerning proposed lease areas identified. Attended by MMS, other Federal and State agencies, oil and gas industry, environmental groups, a-rid citizen representatives.
MMS/OCSEAP Synthesis Meeting Primary management tool for incorporation of scientific results into OCS leasing process. Scientists and science managers discuss research results, identify data gaps, determine how results answered OCS management questions. Full synthesis meeting now held only for first generation lease sales. Smaller meetings held for second or third sales in an area,	**Synthesis Report** Synthesis Report prepared by NOAA (for Alaska OCS regions) used by MMS in preparation of Draft Environmental Impact Statement (DEIS).
Draft Environmental Impact Statement MMS prepares the Draft Environmental Impact Statement based upon available research results from a variety of sources, including, when applicable, the OCSEAP Synthesis Report (or results from the Synthesis Meeting if report not yet available). DEIS must address major issues related to the proposed action.	**Endangered Species Consultation** MMS required to consult with NMFS for formal biological opinion.
Final Environmental Impact Statement Required to address proposed alternatives discussed in DEIS; incorporates public comment received on DEIS.	**Secretarial Issue Document** Addresses economic, industry, social, and environmental concerns. Used by Secretary of Interior in lease tract sale decision.
Final Notice of Sale Decision to lease, approved by Secretary of Interior. Any changes in bidding systems, lease stipulations, **lease** blocks incorporated here.	

SOURCE: Office of Technology Assessment.

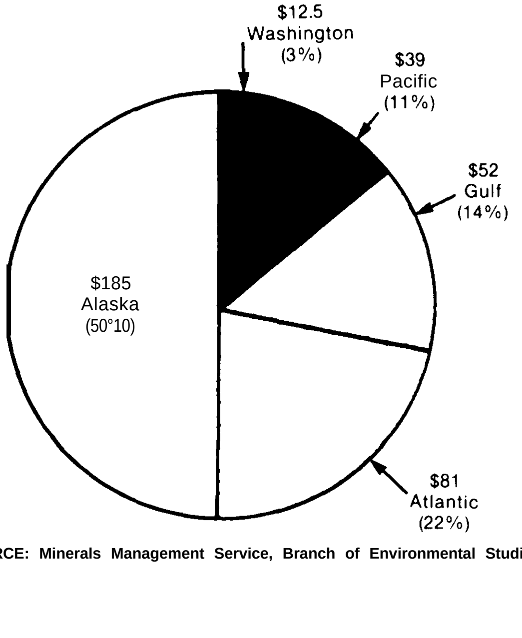
these funds have been expended in the Alaska OCS region (see figures 7-2). The other half of the budget has funded studies in the Atlantic, Gulf, and Pacific regions and in the Washington headquarters office. Program expenditures increased dramatically in 1975 and doubled again in 1976, in response to the decision to lease offshore areas for oil and gas exploration in Alaska.

Figure 7-1 .—Expenditures for Environmental Studies
(1973-84)



SOURCE: Minerals Management Service, Branch of Environmental Studies.

Figure 7-2.— Expenditures for Environmental Studies by Region (1973-84) (millions **of dollars)**



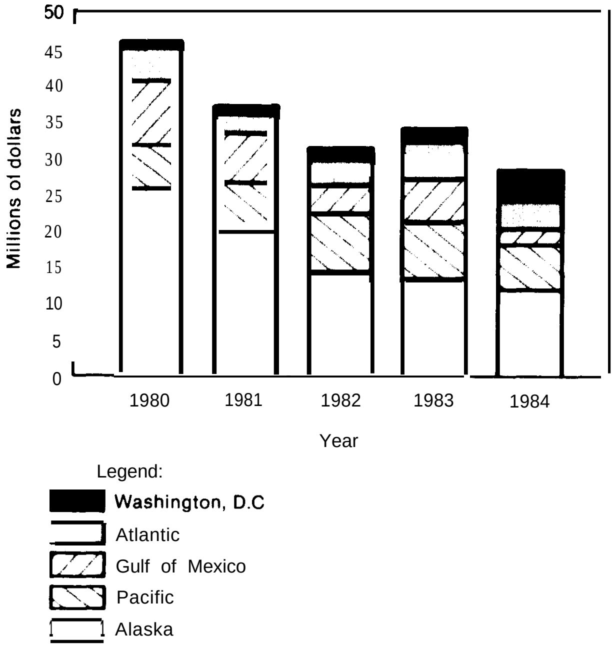
SOURCE: Minerals Management Service, Branch of Environmental Studies

However, since 1980, when expenditures for environmental studies totaled more than $45 million, budgets for the program have declined, and, in 1984, yearly funding dropped below $30 million (without accounting for inflation) for the first time since 1975. This trend is consistent with reduced non-defense spending throughout government under the 1981 through 1984 budgets.

Since 1980, ESP funds for the Alaska region have decreased more rapidly than funding for studies in other areas (see figure 7-3). Although the Alaska region budget is still the largest, it has decreased from 55 percent of the budget in 1980 to 45 percent in 1984, Funds for Alaska OCS studies have been reduced some 49 percent since 1980, from $25.3 million to $12.9 million in 1984 (see figure 7-4). Funding for Gulf of Mexico studies has also decreased, from 19 percent of the budget in 1980 to less than 14 percent in 1984. The proportion of the total budget spent for Atlantic and Pacific region studies has increased since 1980, although total dollar amounts have declined. Funding for the Washington, D.C. headquarters office also increased in this period, and in 1984 accounted for 5.3 percent of the total ESP budget.

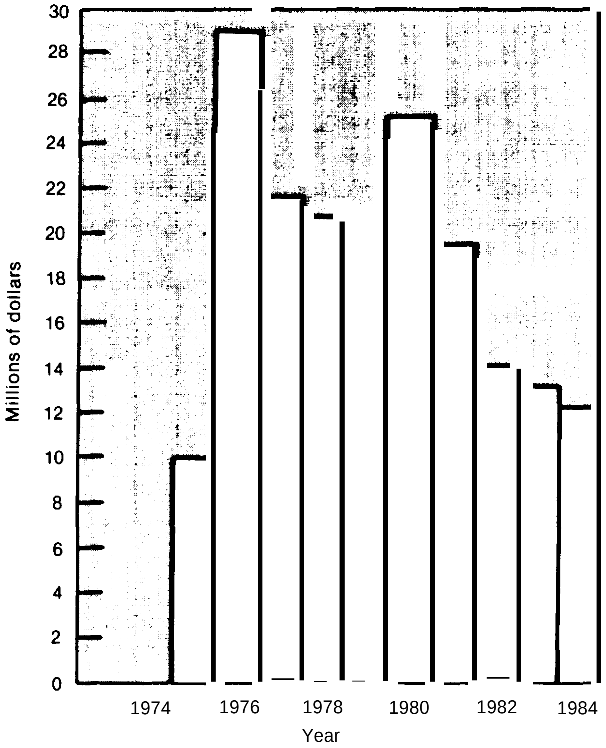
Over the 1 l-year period from 1973 through 1983 about 86 percent ($148 million) of Alaska environmental studies funds have been used for NOAA/OCSEAP studies. The relationship between NOAA and MMS has changed in recent years. MMS has gradually upgraded its technical capabilities which it lacked in the early years of the program, and has assumed more responsibility for managing Alaskan environmental research. The budget for MMS (non-OCSEAP) Alaskan studies has increased–but not dramatically— since 1980, but funding for OCSEAP studies has decreased more than 50 percent, from just over $21 million in 1980 to less than $8 million in 1984. Thus, the ***relative*** importance of MMS inhouse and directly contracted environmental studies has increased significantly.

Figure 7-3.—Recent Trends in Environmental Studies Funding (1980-84)



SOURCE: Minerals Management Service, Branch of Environmental Studies.

Figure 7-4.—Funding for Alaskan Environmental Studies



SOURCE: Minerals Management Service, Branch of Environmental Studies.

Types of Studies

ESP and OCSEAP studies maybe classified into seven categories. These are:

Contaminant Distribution Baseline Studies

These studies were designed to learn more about the background levels of hydrocarbons and heavy metals in the Alaskan OCS in order to establish a baseline for predicting changes if these kinds of contaminants were released during oil and gas development. Funding for baseline studies in the Alaska region was greatest in 1976, 1977, and 1978 (see figure 7-5).

Biological Studies

Biological studies have investigated the distribution and population dynamics of birds, mammals, fish, littoral biota, benthic biota, and plankton. These studies have received the largest total amount of funding since the inception of the program.

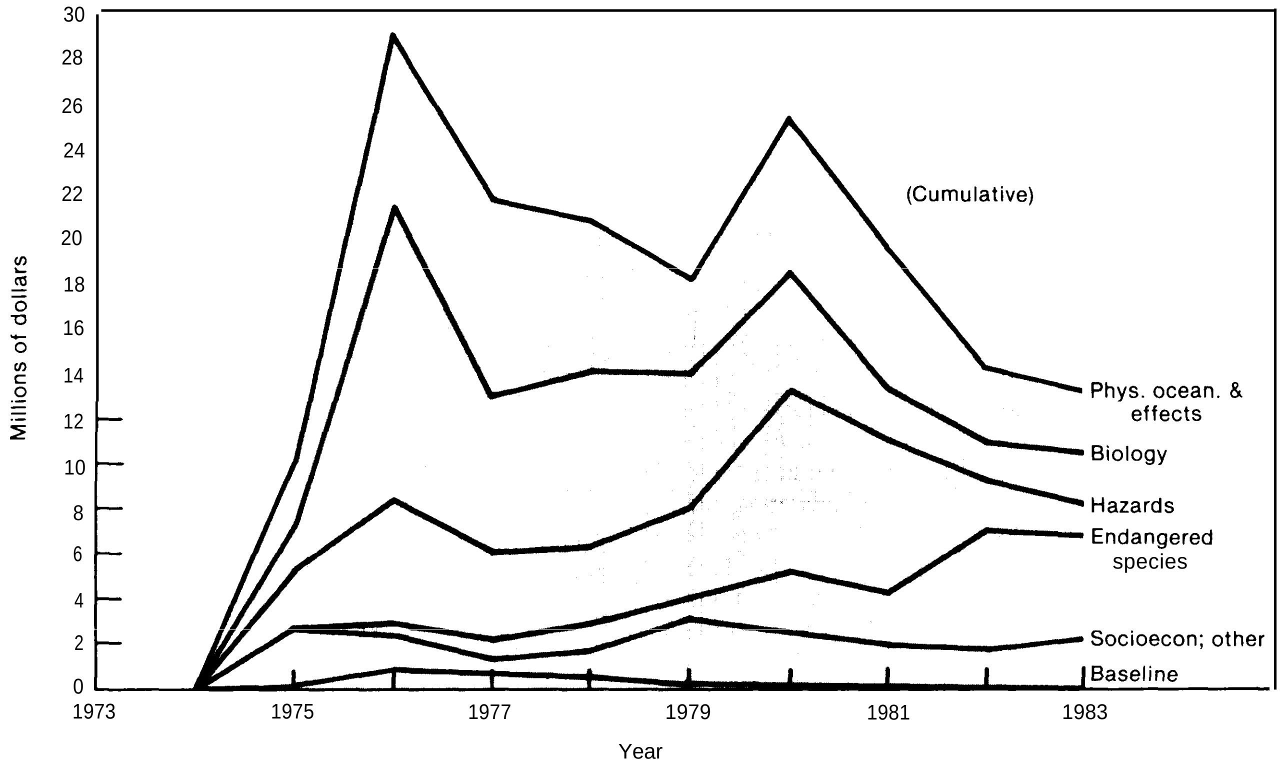
Hazards Studies

Environmental hazards studies encompassed investigation of seismicity and volcanicity; determination of the character of bottom sediments and subsea permafrost; quantification of the nature, intensity, and frequency of sea ice hazards; and determination of wave heights. The objective of these studies has been to acquire information useful for determining hazards to drill ships, platforms, and pipelines, and for determining the probability of accidents caused by environmental hazards.

Transport Mechanisms

The objective of transport studies has been to determine the mechanisms involved in transport, weathering, and dispersion of spilled oil, oiled sediments, and other contaminants. A major part of this program has involved physical oceanography studies, including development of a sophisti-

Figure 7-5.—Funding for Alaskan Environmental Studies by Type (1973-83)



SOURCE **Minerals Management Service, Branch of Environmental Studies.**

cated oceanic circulation model, a simplified version of which the MMS now uses for risk analysis. Such models are important because they help to focus impact assessment on identified vulnerable coastlines and marine biological resources at risk. They also can lead to local site-specific models which could allow assessment of OCS activities affecting circulation patterns, or whose impact is distributed regionally by circulation (e. g., causeway construction, sand and gravel extraction, hydrocarbon production byproducts, and marine construction siting).

Effects Studies

Effects studies investigate the interactions of spilled oil and other contaminants on individual species and ecosystems. For example, effects studies have been done for salmon, herring, and king and tanner crabs.

Ecosystem Processes

The purpose of process studies is to investigate and understand aspects of community structure and function. Although some biological process studies have been undertaken in specific ecosystems, there are still other ecosystems for which processes need to be better understood. Studies of ecosystem structure and processes tend to involve many scientists in different disciplines, all collecting field data concurrently. Thus, these studies are expensive and site specific. Ecosystem studies have been conducted at Simpson Lagoon and Pearl Bay, and studies of the Yukon Delta and the North Aleutian Shelf are in progress.

Socioeconomic Studies

The objective of these studies is to assess the social costs of OCS operations, e.g. , the impacts of coastal development, tanker traffic, and marine pollution associated with OCS development; effects on local cultural systems; damages to personal property and property values; and costs to recreational and/or subsistence uses.

Trends in the Environmental Studies Program

Scope and Direction

Baseline studies. Baseline characteristics and contaminants in Arctic regions have been extensively studied. However, this class of background study was criticized by scientists in the 1978 National Research Council ESP review because the natural geographic and temporal variability of the marine environment is so great, both in space and time, that useful baselines could not be established without prior information on the types and specific locations of the development to be undertaken. Thus, the studies would be of little use either for predicting changes or for quantifying change during and after development. Consequently, funding for these studies was cut significantly in 1979, and, beginning in 1982, no funds were allocated for baseline studies. Now that development in specific Arctic OCS areas may occur, concern about monitoring the effects of OCS activities has increased, and more site-specific work will be necessary.

Biological ***studies.*** Funding for biological studies has decreased in the last several years by a greater proportion than decreases for the ESP as a whole. Basic information about Arctic biota is now relatively well known. However, data are still lacking for many geographic and subject areas (e. g., areas outside the fast ice zone in the Beaufort Sea). The Interagency Committee on Ocean Pollution Research, Development, and Monitoring considers the Beaufort Sea living resources studies important because they are process oriented. " These studies have proven more effective than studies which simply enumerate and catalog biota. For example, the results of ecological process studies in Simpson Lagoon provided the nucleus for biological stipulations attached to the joint State/Federal Beaufort Sea lease sale in 1979 and for other lease sales.

Funding for endangered species studies has increased significantly since the beginning of the ESP. In fiscal years 1982 and 1983, endangered species studies accounted for the largest percentage (about 35 percent) of Alaska ESP expenditures. The endangered species most studied have been bowhead and gray whales. The Endangered Species Act is a major reason that studies of endangered whales have been emphasized. Federal agencies must ensure that actions which they authorize, fund, or carry out are not likely to jeopardize the existence of any endangered "or threatened species. The emphasis on bowhead whale studies, in particular, is also motivated by regional political concerns. Several interest groups have important, but not necessarily compatible, interests concerning the species.

Hazards studies. In the early stages of the ESP, there was a large geological hazards assessment program. Funding for environmental hazards studies peaked in 1980 at $12.6 million per year (of which two-thirds was allocated to Alaska OCS studies). Since then, funding has been reduced significantly. In 1983, total ESP funding amounted to only $1.4 million. The decrease in funding has corresponded to an evolution in DOI policy concerning the appropriate scope of the Federal Government's research responsibilities relative to those expected of the private sector. It is the MMS position that most hazards studies should be undertaken by industry. In particular, industry must undertake site-specific hazards studies in order to properly design offshore structures, pipelines, etc., and must provide the data to the MMS Offshore Field Operations for exploration plan and permit approvals.

Reduced ESP funding for geological hazards studies has been controversial. Some groups believe that the government should have an independently acquired, public body of information in order to properly perform its oversight role of assessing the performance of the industry in their proposed future OCS activities, and that the current program does not provide the government with this capability. Thus, it is contended that government needs a stronger capability to evaluate offshore hazards and the measures that industry is developing to respond to them. This would require more Federal involvement in hazards studies and more funding.

111~teragency Committee on Ocean Pollution Research, Development, and Monitoring, ***Marine Oil Pollution: Federal Program Review*** (April 1981).

Transport mechanism studies. Transport studies generally have been of high quality, especially in Alaska where relatively less was known. Nevertheless, regional gaps remain, such as the need for better information about sediment transport in the Bering Sea (e. g., for designing gathering pipelines and subsea completions) and the need for weather and ice data in the Bering and Chukchi Seas. Most transport studies require data acquisition over periods of years, requiring many instruments and repetitive surveys. However, risk analysis is conducted using simulation models which project probable transport based on physical and chemical properties and available field data.

Effects ***studies.*** Although research needs remain, funding for effects studies has decreased by more than 50 percent since 1980. Knowledge of effects of offshore development (e. g., the effects of oil spills, the effects of artificial structures on living organisms, the effects of coastal modifications on the natural movement of fishes, and the effects of noise) is currently deemed by some to be inadequate, Others take the view that such effects (with the possible exception of noise) would be too localized to play a major part in formulating large-scale research policy. Several effects studies have been completed or are underway.

Socioeconomic studies. In comparison to other studies areas, relatively little money has been spent by MMS on socioeconomic studies (e. g., $2.0 million in 1983), Social and economic studies are often less expensive than equipment-intensive environmental studies. Hence, although less money has been spent, the number of socioeconomic studies funded through 1983 (133) is large relative to the numbers of studies funded in other categories. Most of these funds have been spent in Alaska. On the other hand, the 1981 report of the Interagency Committee on Ocean Pollution Research, Development, and Monitoring notes that higher priority is generally assigned to studies which are legally mandated or which are designed to avoid lawsuits or to accommodate political concerns. Thus, studies addressing economic and social issues may have greater difficulty meeting the criteria for funding.

Management

Funds allocated to the OCSEAP program have decreased since 1980, and MMS has increased its capability to manage environmental studies. The relationship between OCSEAP and MMS is changing, and some critics have argued that the larger role for MMS in directly managing Alaskan environmental studies may not be the optimum situation. The argument against MMS's involvement is that the agency responsible for OCS leasing should not also be in charge of determining what environmental research is necessary and of supervising subsequent research efforts. Thus, a continuing OCSEAP role is seen by some as desirable in order to help ensure that scientific knowledge is produced which is needed to achieve a balance between offshore oil and gas development and environmental protection, thus safeguarding the public interest. Conversely, the OCSEAP program has always been supported by interagency transfer of BLM/MMS funds, and OCSEAP managers have worked under the guidance of the MMS. MMS is legally required by the OCS Lands Act and NEPA to acquire information relevant to potential environmental impacts, and is increasing its capability to do this itself.

In 1978, a National Research Council review of the ESP concluded that the program at that time did not effectively contribute to leasing decisions or to the accrual of sound scientific information adequate for OCS management. The National Research Council cited several reasons for poor program design, including low priority within DOI and the paucity of professional experience within the staff.[12] Many of the important issues raised by the NRC have been addressed, and, in particular, the creation of MMS, improvements in staff, and redesign of the program have produced information more directly related to the management of OCS activity. However, despite the fact that MMS is now conducting the post-lease monitoring required by the OCS Lands Act, MMS's research efforts—given its leasing mission—have mostly been focused on immediate rather than long-range information needs. Approaches should be considered that help ensure that important longer term studies, not motivated by near-term leasing decisions, are undertaken.

[12] National ***Research Council, OCS Oil and Gas: An Assessment of the Department of the Interior Environmental Studies Program*** (Washington, DC: National Academy of Science, 1978).

Funding

Each year less money is available for environmental studies, and fewer such studies are funded. This raises the fundamental question of what level of funding is adequate for OCS decision making and management, and, related to this, what information base is adequate for decision making. On the one hand, a large body of OCS environmental information has been acquired in the past 10 years. The current information base is increasingly sufficient for most pre-lease decisions in all OCS regions. This is a major reason why MMS is now shifting the focus of environmental studies toward research designed to answer operational questions.

Nevertheless, the stated national objective is to increase reliance upon domestic petroleum resources, and at the same time minimize environmental disturbance. To do this properly, a significant research effort is still required—particularly for post-lease studies and in Arctic and deepwater areas—and research in OCS frontier areas is expensive. Adding to the expense of Arctic and deepwater studies is the fact that opportunities for conducting research are constrained by weather and other variables.

The Federal budget is under scrutiny, and it may be difficult to increase funding for OCS environmental studies. However, the size of the Alaskan OCS and the amount of estimated oil and gas reserves, the frontier character of the Alaska region, and the high costs of logistics and support operations may warrant the continued emphasis on funding for this area relative to the other OCS areas. It is not necessary, however, to rely entirely on research funded by the ESP/OCSEAP program to answer all important research questions. Some results from other research programs, both Arctic and non-Arctic (e. g., the National Science Foundation's Arctic Research Program, MMS's Technology Assessment and Research Program, etc.) may be useful.

Emphasis

The main thrust of the ESP, until recently, has been to gather information useful primarily for the leasing decision itself. In 1978, the National Research Council criticized BLM's (now MMS) inadequate program design for post-lease environmental studies. Increasing emphasis is now being placed on post-lease management and monitoring studies. For instance, in 1984, MMS implemented a long-term monitoring program for the Beaufort Sea to determine if any trends can be observed in concentrations of heavy metals and other contaminants. Such studies are expensive and require continuous funding.

Both the MMS and NOAA are chartered to do ocean monitoring studies. MMS is specifically charged with monitoring the effects of OCS operations while NOAA has a more general mandate to study long-range effects of pollution and man-induced changes of ocean ecosystems. This overlap of responsibilities is sometimes confusing and has fostered occasional competition between MMS and NOAA. In this regard, the Biological Task Forces that have been organized for the Bering and Beaufort Seas may be able to play a larger role in fostering coordination and cooperation among the Federal environmental monitoring programs. These task forces are composed of agency representatives from MMS, the Environmental Protection Agency (EPA), Fish and Wildlife Service, and NMFS (State and local observers participate as well in Alaska). They were created to give these agencies an opportunity to advise MMS's Regional Supervisor of Field Operations on the biological aspects of the lessee's proposed activities and to recommend appropriate actions for protecting biological resources.

Public Participation

Environmental groups are concerned that public input to the decisionmaking process has decreased since 1981. Environmentalists perceive that less scientific information related to the oil and gas leasing program is being disseminated, and that the public is therefore less informed than it was immediately after the OCS Lands Act Amendments were implemented in 1978. For example, environmentalists contend that Synthesis Reports, which are helpful to the public in evaluating environmental impact statements, are not available sufficiently in advance of lease sales. DOI is attempting to respond to the criticisms of the environmental groups with regard to dissemination of study results. Beginning in July, 1984, for instance, DOI began publishing a list of offshore scientific and technical publications available to the public. A list of OCSEAP-supported publications has been available since 1980, In addition, the ESP has begun a project to make available abstracts of most prior environmental studies, and MMS now conducts annual Information Transfer meetings to help disseminate the results of studies. Nevertheless, funding for publication of research results has declined, and it does take longer to get information published.

Public participation and input to the process of determining research needs has also decreased, according to environmental groups monitoring DOI's OCS program, and it has thus become more difficult for the public to participate in framing the research questions to be addressed by the environmental studies program. The MMS argues that there are ample opportunities for public participation, including Scoping Meetings, which are held at an early stage in the lease process to give citizens a chance to express their concerns. However, another useful forum for involving the public at an early stage of the research planning process, the OCSEAP Users Panel, no longer exists, and the Regional Technical Working Group in Alaska has been meeting less frequently.

BIOLOGICAL RESOURCES

Overview

Since the Torrey Canyon and Santa Barbara oil spills in 1967 and 1969, the effects of oil spill accidents have been studied intensively.[13] Despite this study, there is still a great deal of controversy regarding the effects of oil in the marine environment. A major problem in assessing the effects of pollution is that natural variation of biological populations and water quality in the ocean is very great and poorly understood. It is difficult to detect changes and to relate these changes to a specific pollution event. MMS has made some attempt to rank the OCS planning areas in terms of their potential vulnerability to spilled oil (see box).

There have been few documented effects of oil in the water column, even from such massive spills as Amoco Cadiz and Ixtoc I. On the other hand, oil regularly reaches bottom sediments after a spill, and may persist in these sediments for years. When fresh oil reaches the bottom, effects including death among sensitive benthic species may occur. Sublethal contamination of zooplankton and benthic invertebrates is common. Studies have shown (e. g., of the Arrow spill off the coast of Nova Scotia) that

Relative Environmental Sensitivity of the OCS Planning Areas[a]

Planning area	Overall total score
St. Matthew-Hall	345
Norton Basin	307
	303
Kodiak	
Gulf of Alaska	283
St. George Basin	278
	278
North Aleutian Basin	264
Cook Inlet	255
Central Gulf of Mexico	253
North Atlantic	245
Central California	244
Northern California	234
Hope Basin	231
Southern California	222
Chukchi Sea	212
South Atlantic	208
Eastern Gulf of Mexic o	
Washington-Oregon	203
Mid-Atlantic	185
Beaufort Sea	183
Navarin Basin	
Aleutian Basin	

[a]Based largely on extent of coastal and marine habitats In planning area and sensitivity to effects of spilled oil.

SOURCE: Minerals Management Service, Draft Proposed Program, *5-Year Outer Continental Shelf Oil and Gas Leasing Program* for *Mid-1986 Through Mid-1991*, March 1985.

[13] John M. Teal and Robert M. Howarth, "oi] Spill Studies: A Review of Ecological Effects," Environmental Management (1984), 8(1):27-44.

oil contamination can decrease the abundance of organisms and the diversity of species of benthic communities. However, there are striking differences in sensitivities among these species. Persistent effects have been found in soft sediments in shallow, protected waters, where natural recovery may take 6 to 12 years or more. Rocky headlands are much more quickly cleansed, and generally recover within a few years, at least to the extent of recolonization of the substrate. Where initial recolonization is not by the normal dominant species, however, time for return to initial conditions through succession may be much greater.

Affected Species

Fish

The commercial fish stocks of the Bering Sea and Georges Bank are world-renowned. Important commercial fisheries exist in most other U.S. OCS areas as well, and subsistence fishing is important in the Beaufort, Chukchi, and Bering Seas and the Gulf of Alaska. In the Bering Sea, for example, lease sales have been held or are being planned in such productive fishing grounds as the North Aleutian Shelf, St. George Basin, and Navarin Basin. Important commercial fish species in these areas include: sockeye, chinook, chum, Pacific, pink, and coho salmon; Tanner and king crabs; Pacific herring; Pacific halibut; yellowfin, flathead, and rock sole; walleye pollack; Pacific cod; Greenland turbot; sablefish; Pacific Ocean perch; atka mackerel; arrowtooth flounder; sidestripe, pink, and humpy shrimp; and Alaska plaice. In addition to the United States, Japan, the Soviet Union, South Korea and several other nations regularly fish these waters. The 1983 ex-vessel (before processing) commercial value of the Bering Sea catch was about $409 million dollars.

The regional effects of oil spills on most species of fish are likely to be minor. It has been noted that:

> . . . although there is a widespread public perception of impending environmental degradation and resulting loss to harvestable populations coinciding with possible oil spills, this does not appear to be justified for relatively small oil spills . . . [b]ecause most species are widely dispersed in the Bering Sea and because stocks exhibit high annual variability in year class strengths. [E]ven the largest estimated oil-induced mortalities from spills occurring under open-water conditions would probably be undetectable in regional fisheries.[14]

However, species which spawn in nearshore areas in relatively few locations—for example, salmon, herring, capelin—could be particularly vulnerable to a large spill. A large oil spill in Bristol Bay, for instance, during a period in which salmon were migrating to their spawning grounds could have substantial effects on a large portion of a year class. Kills of adult fish probably pose less of a threat to commercial fisheries than do damage to eggs and larvae, or changes in the ecosystem supporting the fishery. The greatest potential effect on fish populations would probably occur if oil were spilled in spawning or nursery areas where larvae and eggs were abundant, or if local populations of food species of adults, juveniles, or larvae were reduced or eliminated.

Birds

Birds are particularly susceptible to the effects of oil spills and human interference. Depending on the time of year, large numbers may be present in Arctic areas. For example, at least six million marine birds breed on the Pribilof Islands and on St. Matthew and St. Lawrence Islands adjacent to the Navarin Basin.

Birds most vulnerable to oiling are those which are gregarious, spend much of their time on the surface, and dive rather than fly when disturbed. These include murres, puffins, and diving ducks such as eiders, scoters, and oldsquaws. Oiling of plumage may cause death from hypothermia, shock, or drowning. In addition, death of embryos may result from the transfer of oil on feathers to eggs. The physiological stress accompanying migration may reduce birds' ability to survive the additional stress resulting from oiling. Oil ingestion through preening could possibly reduce reproduction in some birds and causes various pathological conditions.

1+ Fredrik V. Thorsteinson and Lyman K. Thorsteinson, "Fishery Resources, " in Lyman K. Thorsteinson, Ed., ***Proceedings ofa Synthesis Meeting: The North Aleutian Shelf Environment and Possible Consequences of Offshore Oil and Gas Development*** (Juneau, Alaska: Outer Continental Shelf Environment Assessment Program, March 1984), p. 153.

Oil spills occurring near colonies or along migration corridors could have substantial effects on seabirds and waterfowl. Oil reaching coastal wetlands could persist for a long period of time, and large numbers of birds could be contaminated. The MMS estimates, for instance, that important regional seabird populations on St. Matthew and adjacent islands could sustain major losses if spills occur in the area during the breeding season. MMS estimates that seabirds and waterfowl wintering in the Navarin Basin lease area may sustain losses of 10,000 or more birds in each of the several spills projected over the life of the field.[15] A tanker spill in Unimak Pass, one of the major migration corridors for bird and mammal populations entering and leaving the Bering Sea, could be particularly serious, since oil could potentially affect major portions of regional populations of both birds and marine mammals. However, long-term population responses of sea-birds to oil-induced mortalities are uncertain due to incomplete data. For example, Great Britain's seabird populations appear to be increasing in spite of incremental mortalities induced by OCS oil and gas operations in the North Sea.[16]

Marine Mammals

Impacts of potential oil spills on marine mammals have received considerable attention. Effects could include coating of animals with oil, ingestion of oil, and irritation of eyes. Contact with oil may also contribute to or alter susceptibility to existing physiological and/or behavioral stresses. However, "unequivocal evidence for mortality of marine mammals caused by oiling in the wild has not been observed."[17] The potential for adverse effects on most marine mammals from large and small oil spills is perceived to be low. Adverse effects in the immediate vicinity of a spill would be unavoidable, but, given the mobility and widespread distribution of most species, the low occurrence rate of large spills, the relatively small areas affected by spills, and the rapid dispersion and dilution of small spills, significant population losses of most species are unlikely.

Some species are probably more vulnerable than others, and some species may be particularly vulnerable at certain times of the year or while occupying certain habitats. Research to date suggests that the animals most at risk are those vulnerable to oiling of fur, such as furred seals, sea otters, and polar bears. A number of endangered and threatened species occur in prospective OCS development areas. Other cetaceans inhabiting subarctic seas during all or part of the year include right, fin, sei, blue, humpback, gray, and sperm whales. Some of these whales (for example, gray whales) migrate considerable distances, and may potentially come in contact with oil in several OCS regions.

Several examples of areas where marine mammals would be particularly vulnerable include:

St. Matthew Island. In addition to large seasonal concentrations of nesting birds, St. Matthew Island (and nearby Hall Island), is the location of numerous haulout sites for Stellar sea lions, spotted seals, and walruses. Several species of endangered whales also inhabit the vicinity. A support facility for Navarin Basin exploration and development has been proposed for this Bering Sea island; however, recent court action denied the facility. In addition to the possible impact of oil spills, marine mammals and birds in the area may be exposed to fre-

Photo credit: American Petroleum Institute

Offshore energy production must be balanced with protection of seals and other wildlife

[15] Minerals Management Service, *Navarin Basin Lease Offering: Final Environmental Impact Statement* (November 1983).

[16] Laurie Jarvela, Lyman Thorsteinson, and Mauri Pelto, "Oil and Gas Development and Related Issues," in Laurie Jarvela, Ed., *The Navarin Basin Environment and Possible Consequences of Planned Offshore Oil and Gas Development* (Juneau, Alaska: Outer Continental Shelf Environmental Assessment Program, May 1984).

[17] Minerals Management Service, *Navarin Basin Lease Offering: Final Environmental Impact Statement* (November 1983), p. IV-37.

quent vessel movements, helicopter flights, and construction activities.

The ***Prihilof Islands.*** In addition to their importance to nesting birds, from May through August the Pribilof Islands are home to over 70 percent of the world's population of northern fur seals, which breed and bear their pups there. Fur seals may be particularly sensitive to oiling since they rely on their fur for thermal protection, and oil can destroy its insulative properties. Oil spill trajectory models indicate that a St. George Basin spill could possibly reach the Pribilof Islands.[18]

Unimak Pass. Unimak Pass through the Aleutian Islands is a major migration corridor for endangered gray, fin, and humpback whales, northern fur seals, and several species of birds (e. g., shearwaters and tufted puffins). Although it is predicted that strong currents would likely rapidly wash away spilled oil, a spill large enough to significantly oil the pass in early spring or late fall could expose great numbers of whales, birds, and fur seals to hydrocarbons, and could seriously impact regional populations. In the event of oil and gas discoveries in the Bering Sea, increased vessel traffic (including tankers) is expected through the Pass.

Bowhead Whales: A Case Study

Introduction

Bowhead whales are listed as an endangered species and could be adversely affected by offshore oil and gas operations in the Arctic. The degree of their vulnerability remains uncertain at this time; however, bowheads are a subject of concern and the target of several expensive research projects. As a consequence of their endangered status, the Endangered Species Act places specific legal constraints on all Federal agency activity affecting the species. Thus, the potential impacts of offshore oil and gas activities on the bowhead population must be considered fully. If these activities are found to jeopardize the continued existence of bowheads or other endangered species, the law requires that actions be taken to ensure their preservation. Actions to protect bowhead whales could take the form of restrictions on or curtailment of Arctic oil and gas development. Thus, the potential for conflict exists between the competing national objectives of energy production and the preservation of an endangered species.

Bowhead whales are also highly prized by the indigenous people of the Arctic (the Inuit) as a supplementary source of food and as a part of their cultural heritage. Activities which threaten bowhead whales are considered by the Inuit to be a threat to their culture and their subsistence lifestyle. At the same time, the annual bowhead harvest by Inuit whalers may also be a threat to the existence of the species. The national effort to protect endangered marine mammals competes, to some degree, with the local interest in Arctic subsistence hunting. Protection of bowhead whales is thus complicated by competing national interests in the production of domestic energy and the desire to protect endangered species as well as by the interests of Native Alaskans to pursue their traditional lifestyle. The debate surrounding the bowhead whale involves complex scientific, political, and socioeconomic issues for which there are no totally satisfying answers.

Compared to a pre-exploitation whaling stock (estimated by the International Whaling Commission to be approximately 20,000 animals during the 1800s), the minimum population is now believed to be about 3,900, Census taking has improved in recent years, so that this number is larger than the number of whales believed to exist in 1977 (between 800 and 1,200 animals), but the figure is still imprecise. For hundreds of years, until about the turn of the century, bowheads were one of the most important commercial whale species. Commercial exploitation of bowheads has ceased, but whaling in several coastal Arctic native communities is still an important cultural activity.

Bowhead whales winter in the Bering Sea, generally south and west of St. Lawrence Island (the full extent of the area they use is unknown). In March and April they begin their northward migration, using the lead systems that develop in the ice cover. The whales follow nearshore open leads past Point Hope, Cape Lisburne, and Point Barrow and then move further offshore en route to their summer range in the eastern Beaufort Sea off Canada.

[18] H. W. Braham et. al., "Marine Mammals, " in M. J. Hameedi, Ed., ***Proceedings of*** a ***Synthesis Meeting: The St. George Basin Environment and Possible Consequences of Planned Offshore Oil and Gas Development*** (Juneau, Alaska: Outer Continental Shelf Environmental Assessment Program, March 1982).

After about mid-September the whales begin their return migration to the Bering Sea. The migration corridor is bounded on its landward side by approximately the 20-meter isobath and extends on its seaward side to at least the 50-meter isobath. It is during the migration periods when the whales are closest to the coast that they are hunted by Inuit (Eskimo) whalers and, at the same time, may be most vulnerable to potential disturbance by the activities of the oil and gas industry.

Concerned Groups

Among the groups with a stake in the future of the bowhead whale are the indigenous people of the Arctic (the Inuit Eskimos of Alaska), environmentalists, industry, the Federal Government, and the State of Alaska.

Inuit. For the Inuit, the bowhead whale is an important element of cultural identity. Despite the ongoing changes occuring in Alaska whaling villages, many traditional activities remain important, and the annual hunting cycle remains essentially the same as practiced for generations. Currently, ten Inuit villages participate in bowhead hunting. Eight of these ten villages take part in the spring hunt, and three participate in the fall hunt. Barrow, given its strategic location, is the only village to participate in both hunting seasons.

A recent survey indicates that most Inuit continue to value hunting and fishing highly and to view these activities as an important source of food.[19] Data from the same survey also suggest that Inuit still prefer locally harvested foods (especially whale meat, although seal and walrus are probably consumed in greater quantity) despite the influence of western culture. Inuit maintain that the 'Eskimo way of life' would be severely jeopardized if they could no longer hunt bowhead whales. In addition to the food that the whales provide (which is shared among the members of the community), a successful hunt is an occasion for celebration, a symbol of initiation into manhood, and brings prestige to successful whalers.

Inuit are concerned about potential adverse impacts that offshore oil and gas activities could have on bowhead whales. They are concerned about maintaining a pollution-free marine environment, about protecting bowhead feeding and nursery areas, and about preventing seismic survey and other noise-making activities that may interfere with the annual hunt or with the health of the species. Increasing industrial activity in the Arctic highlights the fact that whale hunting now must compete with national, and even international, interests. These concerns have stimulated an active Inuit-sponsored research program to learn more about the factors which affect bowhead whales. This research focuses on bowhead population dynamics (size and growth rates) and on the possible susceptibility to disturbance from various industrial activities.

Photo credit: National *Marine Fisheries Service*

The endangered bowhead whale is important to the Inuit culture

Environmentalists. The primary concern of enviromentalists is for the protection and stewardship of an endangered species and its marine habitat. Environmentalists are particularly concerned that the projected increase in offshore oil and gas activities may be detrimental to the bowhead whale population. Offshore exploration and development introduces increased levels of industrial noise into the marine environment and raises the potential for marine oil pollution, both of which may be harmful to whales. Environmentalists assert that the effects of noise (particularly noise generated by marine seismic exploration) and of oil pollution on bowhead whales should be fully studied, and that steps should be taken to reduce impacts as much as possible.

[19]Alaska Consultants, inc. , ***Subsistence Study of Alaska Eskimo Whaling Villages*** report prepared for the U.S. Department of the Interior ('January 1984).

Most environmental groups are not enthusiastic about subsistence whaling, but tend to view it as a legitimate activity so long as vigilant oversight of bowhead stocks is maintained and traditional methods are used. A few groups have advocated the complete prohibition of native whaling of endangered whales. These groups contend that the result is the same whether the whale is taken by commercial whalers or native whalers. If the species is endangered, they reason, no whaling should be allowed.

Between 1970 and 1977, there was about a threefold increase in the bowhead whale harvest. In 1977, the International Whaling Commission noted this trend with alarm, and established a quota for native whalers which has been in effect since the 1978 harvests, reducing the hunt to approximate historic levels. This quota system is considered an important management tool by environmentalists and by the Federal Government.

Industry. The oil and gas industry acknowledges that under certain circumstances bowhead whales do respond to offshore hydrocarbon activities, but does not believe that normal operational activities constitute a major problem for the health of the whale stock. Even if some limited, localized, short-term impacts (e. g., flight response to nearby seismic activities) are unavoidable, the industry does not believe that long-term effects from oil and gas activities will be significant.

Seasonal drilling restrictions have been imposed and protective buffer zones established to mitigate the possible adverse impacts to bowhead whales. Industry's consistent opposition to these costly restrictions that reduce operating efficiency is based on their belief that they are not warranted by the scientific evidence. However, industry wishes to avoid unnecessary interruptions in its long-term operations, and has therefore participated in some bowhead research projects (for instance, by dedicating geophysical ship time to assess seismic impacts on bowhead whales).

The industry is convinced that, given current technology and personnel training, the possibility of a major blowout in the Arctic is remote, and that even if such an accident were to occur, the capability to recover most spilled oil and thus to avoid harm to whales, is adequate. Since the first stipulations attached to the 1979 joint Federal/State lease sale in the Beaufort Sea, lease stipulations inside the barrier islands have become less stringent. However, industry is still unhappy with seasonal drilling restrictions.

The ***Federal Government.*** The Federal Government is responsible for promoting OCS development, protecting endangered species, and ensuring that Native interests are considered. The desire to stimulate domestic petroleum production was the primary reason for the Administration's decision to accelerate leasing of OCS lands. In addition, the sale of leases for OCS energy exploitation is the second-ranked source of Federal revenues, and OCS resources are seen as insurance against potential international energy supply disruptions.

Federal development and protection objectives are potentially in conflict, particularly since leasing is now taking place at a faster pace in Alaskan offshore areas. However, several Federal laws provide for the protection and management of bowhead whales. The Endangered Species Act of 1973 prohibits the taking, harassing, importing, exporting, or interstate trading of any endangered species, their parts or products. However, the take by Alaska natives is exempted. The Marine Mammal Protection Act of 1972 protects all marine mammals from any undue influence or exploitation by U.S. nationals and forbids importation of any marine mammal products into the country. "Subsistence' hunting is permitted as long as the stocks can support the harvest, and specific conditions are met.

The Endangered Species Act specifies that it is the responsibility of all Federal agencies to conserve endangered species. Each Federal agency is required to ensure, in consultation with the Fish and Wildlife Service or the NMFS (as appropriate, for species under their respective jurisdictions), that any action it authorizes, funds, or conducts is not likely to jeopardize the continued existence of an endangered or threatened species or result in the adverse modification of its critical habitat. Thus, MMS must consult with the NMFS on the probable impacts to bowhead whales that might result from many OCS activities for which it issues permits. NMFS then issues a biological opinion concerning the likelihood that these impacts will jeopardize the survival of the species. If so, NMFS also describes "reasonable and prudent alternatives' to the activity that would avoid jeopardy.

In practice, NMFS also includes in its biological opinions recommendations and suggestions that it feels would help conserve the species, although the Act does not require that they be included. MMS is not legally required to adopt these recommendations, suggestions or alternatives to avoid jeopardy so long as the mitigating measures it does adopt are consistent with the alternatives, would effectively preclude jeopardy, and satisfy the intent of the law.

Some dispute the right of the MMS not to accept all parts of biological opinions. DOI's 'veto power' has been criticized by those who contend that NMFS recommendations should be binding. However, biological opinions carry weight in the courts, so DOI must have good reasons for not implementing every NMFS recommendation or risk being litigated. The biological opinion process has evolved over the years, and NMFS recommendations for avoiding jeopardy to the species are less specific than they once were.

In 1981, the NOAA and the Alaska Eskimo Whaling Commission signed a cooperative agreement to implement the limited bowhead quota allowed by the International Whaling Commission (IWC). For calendar years 1981, 1982, and 1983, a quota was established by the IWC for the Bering/Beaufort/Chukchi Sea stock of 45 bowheads landed and 65 struck, with a maximum of 17 to be landed in any one year.[20] (65 whales were struck, and, of these, 34 were landed). For 1984 and 1985, 43 strikes have been allowed (0.55 percent of the estimated population per year), but no more than 27 can be made in either year. The agreement specifies whaling techniques, monitoring procedures, and division of responsibilities.

Alaska. The State must consider the welfare of its citizens, and, in this particular case, the welfare of those engaged in native whaling. Similarly, the State is concerned with environmental protection. Moreover, since the State derives a major proportion of its revenues from the oil and gas industry (although none at the present time from Federal OCS leases), it has a major stake in fostering responsible oil and gas development. These interests may be conflicting if oil spills or industrial noise associated with development adversely affect the environment or Native hunting.

The State believes that further research should be undertaken. The State also is concerned about the capability of industry to clean up oil spills and about the effects of such spills on bowhead whales. For these reasons, in responding to the Draft Environmental Impact Statement for the 1984 Diapir Field Sale No. 87, the State of Alaska recommended that sensitive blocks in the eastern and western parts of the sale area be deleted and that all proposed stipulations in the DEIS be adopted. In general, the State believes that mitigating measures are preferable to tract deletions if adequate scientific information is available or if existing technological capabilities are adequate; however, it was not felt at that time that these concerns had been adequately studied.

More recently, the State's position regarding bowhead whales was addressed in its decision to allow exploratory drilling in the Beaufort Sea where the capability to clean up oil spills in broken ice can be demonstrated. However, *in* reaching its decision to allow longer drilling periods in certain circumstances, the State reviewed existing bowhead whale and related knowledge and concluded that: 1) the likelihood of a large oil spill from exploratory drilling was small; 2) the probability that migrating bowhead whales would encounter spilled oil was also small; 3) oil spill countermeasures for combating spills from artificial islands are now adequate; and 4) prohibition of exploratory drilling and other downhole activity during whale migrations is an adequate measure to ensure that bowheads are not unduly disturbed by industrial noise. The State recognizes that information gaps still exist and that its decision was based on a large amount of probabilistic data, but it is satisfied that exploratory activities in nearshore areas can be conducted without significant impacts on bowhead whales.

Potential Impacts

The June 1984 Diapir Field Final Environmental Impact Statement for Sale No. 87 and accompanying comments on the Draft Environmental Im-

[20] William F. Gusey, *Bowhead* (Houston, Texas: Shell Oil Company, June 1983), p. 87.

pact Statement provide an overview of the current state of knowledge concerning the impacts of oil and gas development on the bowhead whale.

Noise. Bowheads may react to noise associated with offshore activities. The ocean is naturally noisy owing to sounds created by rain, wind, ice, and the animals themselves. However, noise pollution has been of concern in recent years because some marine mammal species seem to rely heavily upon sound for communications with one another and for acquiring information about their surroundings. Since many offshore industrial activities create intense sounds, there has been concern that such sounds may disturb marine mammals and also mask the "natural' sounds that are apparently important to these mammals. In evaluating the potential effects of noise from industrial operations, it is important to consider ambient noise levels, the characteristics of noise from industry sources and from marine mammals, the propagation of sound in water, hearing by marine mammals, the ' 'zone of influence' of noise from industry sources, and documented reactions of marine mammals to industrial noise.[21]

Sound can be generated by passing boats and ships, by open-water geophysical seismic exploration, and by on-ice activities or onshore installations. The intermittent sound generated by seismic surveys is the most intense type of sound. Short-term behavioral reactions to seismic activity and vessels may include flight from the area, changes in surfacing and dive times, and temporary changes in direction. However, responses of bowheads to seismic activity have been much less clear-cut than responses of bowheads to moving vessels.

Evidence demonstrates that bowheads react to low-flying aircraft by diving suddenly and thus are sensitive to aircraft disturbance. Other sources of noise include drilling activities and dredging and gravel island construction, none of which is expected to be as disturbing to whales as vessel noise. Adding the small effects of all these noise disturbances together, MMS has concluded that during the spring and fall migratory period, noise from seismic activity on leased tracts or from vessels or aircraft could have moderate impacts on bowheads. That is, a portion of the regional population could change in abundance and/or distribution over more than one generation, but is unlikely to affect the regional population. The North Slope Borough and many environmental groups disagree with this overall conclusion, and believe that MMS has tended to downplay evidence suggesting greater effects.

Oil pollution. Few observations of the responses of bowhead and other whales to oil spills have been made. It is unknown whether or not large cetaceans are able to detect hydrocarbon pollution. Dolphins, however, have shown an ability to detect and avoid oil. The rough nature of bowhead whale skin suggests that bowheads maybe more vulnerable to affects of surface contact with oil than most cetaceans. Concern has also been expressed that bowhead skin and eyes may be sensitive to oil contact, but it is unknown whether contact would be harmful. Inhalation of toxic substances and plugging of blowholes by oil have also been cited as possible, but unlikely, threats.

The potential effect of oil on bowhead feeding is another type of adverse impact. Bowheads may not be able to differentiate between hydrocarbon-contaminated and uncontaminated food. If the baleen plates of bowhead whales become fouled by oil, feeding efficiency is decreased, although recent experiments have shown only minor and short-lived reductions in efficiency. Indirectly, bowheads may be adversely affected if food sources are reduced by acute or chronic hydrocarbon pollution, but such pollution would have to be very widespread in order to have a serious effect.

The impact of an oil spill on the bowhead whale population would vary depending upon the volume of oil spilled, the amount of oil in the water column, the extent of weathering of the oil, the proportions of habitat affected, the numbers of whales present, and other factors. The MMS considers the probability that oil from an accidental spill will come in contact with whales in the offshore leads to be very low, particularly "since whales are not present in the lease offerings at all times, and if certain tracts are deleted from lease consideration. '[22]

[21] W. J. Richardson et. al., ***Effects of Offshore Petroleum Operations on Cold Water Marine Mammals*** (American Petroleum Institute, October 1983).

[22] Minerals Management Service, ***Diapir Field Lease Offering: Final Environmental Impact Statement*** (March 1984), p. IV-1OO.

MMS concedes that localized effects of spills could occur, but believes that the probable degree of regional impact from oilspills within the lease area will be minor. Other groups believe the impact could be severe in the case of a major oil spill, and the NMFS, as noted above, has concluded that an uncontrolled blowout or major oil spill could jeopardize the continued existence of the species if whales are present and encounter spilled oil.

In the Final Environmental Impact Statement for the August 1984 Diapir Field lease sale, MMS concluded that the overall regional impact of the combined effects of noise and oilspills resulting from the original proposal was not expected to exceed "moderate. Moreover, if sensitive tracts in the western and eastern portions of the Diapir Field sale area were deleted, the combined potential adverse effects on bowhead whales were expected by MMS to be minor. Both the State of Alaska and the North Slope Borough supported these tract deletions in order to reduce potential disturbances to the whales in the spring ice lead system and during the fall migration offshore of Point Barrow. As a result, a 20-mile buffer zone was established around Barrow, where the Inuit conduct their hunt; and, although no tracts were deleted in the eastern Beaufort Sea, a study has been initiated to determine whether this area is an important habitat where oil and gas exploitation should be restricted. Borough residents believe this is a major improvement over the original lease plan. 23

While the MMS bases its conclusions on the best available information, there are still gaps in knowledge about bowhead whales. Hence, despite the fact that bowhead whales have been one of the most studied of the endangered species, there is still disagreement concerning the probable effects of oil, noise, and other aspects of human intervention on the behavior, survival, and reproduction of individuals and populations.[24]

[23] 'Plans for Oil Leases Would Protect Whales, The New York Times (August 5, 1984), p. 27.

[24] L. Lee Eberhardt and R. J. Hofman, "Existing Programs, Technology, and Requirements Relative to the Conservation and Protection of Marine Mammals in the U. S. Fishery Conservation Zone and in the Southern Ocean, in ***Technology and Oceanography,*** (Washington, DC: Office of Technology Assessment, 1981).

Research Priorities

Four general areas for future research appear to be especially important.

Population studies. There is a continuing need for more precise information about the status of the bowhead whale population. Shore-based censuses, aerial surveys, and/or acoustical detection methods have been employed in bowhead whale population studies for about 8 years, yet scientists still have not satisfactorily defined population parameters. Reliable information is needed about the current and the historic distribution, abundance, and productivity of the population. Currently, it is believed that calves account for at least 7 percent of the population, and that the distribution among age classes is about normal. However, it is not yet known whether the bowhead population is growing, stabilized, or decreasing or what the natural mortality rate is. Such information is important in order to determine population status and trends to aid in conserving the species. It is also important to facilitate setting quotas for Native whalers. Thus, if the yearly increment in the bowhead population can be accurately determined, it will be possible to allocate, with a much larger degree of confidence, a portion (e. g., one-half) of this increment to native hunters.

One hypothesis that has been put forth recently is that the Beaufort Sea bowhead whale population may be a distinct sub-population or feeding group. While feeding groups in the Chukchi and Bering Seas have been decimated, the Beaufort Sea stock may, in fact, be healthy and possibly as numerous as before commercial whaling began. This hypothesis will be difficult to test; however, historical data make it clear that large numbers of bowheads once existed in the Bering and Chukchi Seas in June, July and August. Thus, of an original western Arctic bowhead population of perhaps 20,000 animals, it has been suggested that only one-quarter to one-third of these animals comprised the Beaufort Sea sub-population. Since there are now known to be a minimum of 3,900 bowhead whales, the present stock may be very near historical levels. Thus, as a corollary of this hypothesis, until the Bering and Chukchi stocks can be repopulated, one cannot expect the bowhead population to recover, because it involves distinct sub-populations. If this hypothesis can be proven, rethinking of bowhead whale stock management would be in order.

Effects of noise. Better understanding of these effects will aid in establishing appropriate "zones of influence, thereby enabling better protection of the whales from noise associated with industrial activities. If one knows the noise levels of an industrial activity and the propagation characteristics of the surrounding waters, then it is possible to determine how far the sound travels and its level of impact at various distances from the source. It is much more difficult to determine the effect of noise on the whale, in large part because it is difficult to control all aspects of experiments. Results from the most recent study have shown that whales do not exhibit avoidance behavior beyond four miles from seismic activities, and that behavioral changes between about 2 and 4 miles are only temporary.[25] Although the presence of whales in the vicinity of industrial activities in the Canadian Beaufort has declined since 1980, evidence proving a cause and effect relationship between industrial activities and the decline has not been established. Canadian efforts to address this question are currently underway.

If bowhead whales have a threshold level above which noise causes detrimental effects, then a zone of influence—generally delimited by a circle—can be calculated. The zone delimits the area within which activities (e. g., seismic activity) may be restricted when whales are present. Several zones may be postulated, the size of which vary according to the level of sound and/or the degree of disturbance; however, with currently available information, determining zones of influence may be a theoretical exercise. MMS has established a 5-mile zone of influence, pending receipt of new data. The NMFS concurs with this decision. Both agencies feel that more information is necessary, however, and MMS has established an experimental program with cooperating oil and geophysical exploration companies to obtain more data concerning whale reactions to seismic activities.

Cumulative effects of industrial activities. Such effects are extremely difficult to assess, particularly in the absence of development. However, it is important to know whether whales are likely to permanently vacate oil and gas development areas or whether they might, in fact, become accustomed to development activities as seems to be the case with gray whales in Southern California. In addition, as offshore Arctic development increases, whales are likely to encounter more industrial activity. Thus, it is possible that noise and pollution effects, which, in isolation, may not be detrimental, may have a cumulative impact as whales encounter these effects along their migratory route.

Identification of sensitive habitats, including primary feeding areas and nursery areas within U.S. and Canadian waters. Migrating bowheads in spring do not feed extensively. However, there is new, but as yet unsubstantiated evidence that the area between Barter Island and the Canadian border is an important habitat area where bowhead whales feed on their westward fall migration. Concern has been expressed by the North Slope Borough and other groups that seismic and oil activities in this area may adversely affect bowhead feeding at a critical time and, hence, that the bowhead population may be affected. Scientists would like to be able to correlate the distribution of organisms in these areas with whale feeding habits. In 1985, MMS plans to study the importance of the area east of Barter Island to bowhead whale feeding. Better knowledge of feeding areas will aid understanding of migratory patterns and in conservation of the whale's ecosystem.

Some specific tasks have been identified by the Interorganization Bowhead Whale Research Planning and Technical Coordination Group.[26] The group agreed that the highest priority short-term (1983) research needs included:

- Continuation of studies of recruitment using photography.
- Completion of the evaluation of the sources of bias in census taking and improvement of the accuracy of the census count (at Point Barrow).
- Study of the distribution of bowheads in summer to facilitate estimating total abundance and migratory behavior.

[25] Minerals Management Service, "Observations on the Behavior of Bowhead Whales in the Presence of Operating Seismic Exploration Vessels in the Alaskan Beaufort Sea" (Technical Report, 1985).

[26] National Marine Fisheries Service, "Report of the Second Interorganization Bowhead Whale Research Planning and Technical Coordination Meeting" (Washington, DC: NOAA Technical Memorandum, April 1983).

- Identification and evaluation of possible feeding areas in the Beaufort Sea in summer and autumn.
- Determination of the effects of seismic operations (through a boat-whale interaction study).
- Initiation of a review of the state-of-the-art of bowhead knowledge.

This last task is important because there has been a rapid accumulation of information in the past few years, but a much slower rate of synthesis. Moreover, it could be a very useful exercise in order to reach a scientific consensus on the key issues. Other important but less pressing studies were also identified by the group.

Current Research

Research on bowhead whales is conducted by several organizations, but primarily MMS. MMS is conducting surveys to detect when whales are present in areas where they could be disturbed by seismic activities. They are also doing basic behavior and perturbation studies, and, in the Bering Sea, distribution and abundance studies. Since 1980, MMS has funded four studies related totally or in part to the effects of noise on endangered whales. The funding for these studies through 1983 was about $4.3 million.

NMFS is responsible for the management of bowhead whales. The National Marine Mammal Laboratory in Seattle, Washington, is involved in bowhead whale research. NMFS research focuses on understanding the life history and population dynamics of bowhead whales. During the spring migrations, bowheads are counted from ice camps, and during the summer photo-identification surveys are conducted.

The North Slope Borough and Alaska Eskimo Whaling Commission receive much of their research funds from the Alaska Legislature. Their research focuses on biological studies of animals taken in harvest. They have also conducted population counts of bowheads as they move north in the spring. Recently, hydrophones have been used at the counting stations to try to account for the whales which pass beyond the view of visual counters or travel when the leads are closed. The North Slope Borough has organized and convened several bowhead whale symposia.

The oil industry also has contributed to the bowhead whale research effort. Particularly valuable was the large research effort undertaken in 1981 which led to the discovery of a better means to estimate the rate of calf production.

In comparison to the funds spent on other endangered species, a large proportion of available money has been spent on bowhead research. In large part, this is due to expensive logistical requirements, and to the necessity of using ships and airplanes. Despite the large sums of money that have been spent, most scientists are reluctant to make unqualified statements concerning bowhead whale population, reproduction, or the effects of noise and oil contamination.

The reasons for large bowhead whale research budgets are at least in part political. Native Alaskans hope that research results will help them both to justify a continued, if not expanded, whale hunt and to protect the health of the species. The oil industry hopes that research results may lead to less restrictive stipulations, and the Federal Government must try to balance competing national and international objectives. In addition, the special status of bowhead whale research stems in part from the legal mandate granted by the 1973 Endangered Species Act and the 1972 Marine Mammal Protection Act.

Operational Restrictions

MMS can mitigate potential adverse impacts that oil and gas activities may have on bowheads by deleting tracts or by specifying lease stipulations and conditions in operating permits, some of which NMFS suggests in its biological opinion. These may take the form of drilling restrictions during migration or broken ice periods, restrictions on seismic activities when whales are within the vicinity (e. g., within a 5-mile zone of influence), and/or directions to vessel operators on how to comport themselves in the presence of whales. For instance, in the 1979 Federal/State Beaufort Sea Lease Sale the recommendations of scientists were followed and a 7-month seasonal drilling closure effective for 2 years was proclaimed. In the 1982 Diapir Field lease sale, drilling restrictions were reduced so as to apply only to specified tracts and only during the 2-month fall whale migration. Moreover, MMS did not

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adopt NMFS's recommendations in its biological opinion calling for drilling restriction periods to be extended so as to ensure that areas occupied by migrating whales are free of oil by the time the whales arrive. MMS did not believe that the low level of risk of a major oil blowout or spill during exploration justified such a precaution. In the 1984 sale, drilling and other downhole activity has been restricted in the periods of April 15 through June 15 and September 1 through October 31 in the western blocks and between August 1 and October 31 in the eastern blocks,

MMS may also publish a "notice to lesees and operators. This is advisory and applies to those activities which take place after the lease sale but before development or production plans are submitted. For instance, MMS may advise lessees to use aircraft to ensure that no bowhead whales are within 5 miles of seismic operations.

The findings of bowhead whale researchers have influenced Federal OCS lease decisions and stipulations in the past. Differences of opinion exist, however, concerning whether science or political considerations are more important in determining mitigating measures. Some scientists have suggested that "political issues and [especially] the desire to accelerate development on the OCS predominated over scientific considerations in the [1982] sale. "[27] For instance, bowhead whale migration data were collected between 1979 and 1982, but, in the view of these scientists, the new data did not justify relaxing the seasonal drilling restriction. Conversely, much more data were available by 1982—it was clear by then, for instance, that the spring migration takes places well offshore and that the fall migration corridor lies in water from 20 to 50 meters deep—and restrictions were reduced in light of this new information.

[27] Jacqueline Grebmeier, "The Role of Science in the Alaskan Outer Continental Shelf Oil and Gas Leasing Decision Process' (Master's Thesis, Institute for Marine Studies, University of Washington, August 1983).

Stipulations currently in place to mitigate impacts on bowhead whales are operational in nature, i.e., they affect operating procedures. Alternatively, one might consider stipulations requiring the design of offshore structures and ships aimed at reducing industrial noise to an acceptable level. Rather than being required to curtail activities in the presence of whales, industry could be offered an opportunity to design, for example, quieter ships. This regulatory approach is favored by some environmentalists, but they admit that far too little information is currently available for designing appropriately quiet technology, particularly given the lack of knowledge on the effects of noise on marine mammals. Moreover, designation of this type of stipulation would probably be beyond the current authority of the MMS. However, if such design regulations proved to be less costly to the oil industry than operating restrictions, industry may be receptive.

Current policies regarding protection of bowhead whales from the impacts of oil and gas activities and native whaling include limited and closely controlled Inuit hunting, stipulations controlling drilling and other activities during specified periods, and continuation of relevant scientific research. The aim of these policies has been to balance competing national interests. However, differences of opinion persist concerning their adequacy. Both the North Slope Borough and the environmentalists have pushed for greater bowhead whale protection, while the oil and gas industry believes drilling restrictions to be unwarranted based on the information available concerning whale migrations and on the safety record of OCS operations. Some alteration and/or finetuning of existing policies (e.g., alteration of whale quotas, changes in the radius of the zone of influence, or further tract deletions) may be necessary, depending upon the results of further scientific research. However, no significant changes of policy are likely to be necessary in the near term.

OIL SPILLS

Introduction

As the U.S. oil and gas industry begins exploration of deepwater and Arctic OCS areas, questions are being raised concerning the effectiveness of techniques and equipment for combatting oil spills in frontier areas. Industry argues that it is prepared for the possibility of spills in both Arctic and deepwater areas, and that the risk of catastrophic spills is very low. Although the petroleum industry has not had a drilling or production-related oil spill in U.S. waters as large as the Santa Barbara blowout since 1969, major spills in other parts of the world (for example the 1979 Ixtoc 1 blowout in the Gulf of Mexico) and a number of sizeable tanker casualties have heightened the public's awareness of the risks and consequences of oil spills.

The offshore oil and gas industry has a good oil spill prevention record. However, the industry has little experience producing oil in Arctic and deepwater frontier areas. With the exception of Canadian and North Sea operations and Cook Inlet operations in State waters in Southern Alaska, the industry's offshore operating experience and oil spill data are derived largely from operations in temperate regions, such as the Gulf of Mexico and California. Notwithstanding the oil and gas industry's plans and preparations for oil spills, it is still uncertain whether the industry will be able to make effective use of currently available equipment and countermeasure strategies to recover significant amounts of spilled oil in frontier areas. Although industry has equipment on hand and can airlift additional equipment to a spill site if necessary, this equipment has never been proven under realistic, at-sea conditions.

Most oil spill containment and cleanup technology has been developed for nearshore and temperate regions and may be unsuitable for Arctic or deepwater areas. Arctic oil spill countermeasures may be complicated by extremely cold temperatures, the presence of ice, long periods of darkness, intense storms, and lack of support facilities in most areas. Hence, the risk of oil spills in the Arctic may sometimes be greater than the risk in temperate areas. At least partially offsetting this factor, however, is the higher level of engineering in the Arctic and the significant attention paid to safety factors. Risks have been analyzed and are carefully considered in the planning process, but there is little offshore Arctic operating experience on which to base risk estimates. In deepwater areas, high seastates may be encountered, and the greater distance from shore may create logistical problems for oil spill cleanup. Existing cleanup technologies have proven effective only in placid, protected waters.

The number of frontier area spills that may occur, and, therefore, the total amount of oil that may be spilled is related to the amount of oil that will be found and produced. Predictions concerning the amount of oil frontier areas will yield are considered highly speculative, and thus the possible danger of oil spills is also uncertain. MMS uses oil spill risk analyses to estimate the probability of oil spills occurring in offshore areas it proposes to lease. Based on historic data from the U.S. OCS, MMS has determined that 3.9 spills of 1,000 barrels or greater and 1.8 spills of 10,000 barrels or greater can be expected for each billion barrels of oil produced and transported. Predicted spill types and corresponding rates are shown in table 7-2. Although no oil has yet been produced from the Federal Arctic OCS, and the United States has only recently begun production from areas of about 1,000-foot water depths, the probability that one or more spills of both 1,000 barrels or greater and 10,000 barrels or greater will occur over the productive life of each lease sale area is considered to be very high, based on past statistics.[28]

[28] Minerals Management Service, *Navarin Basin Lease Offering: Final Environmental Impact Statement* (November 1983), p. IV-4.

Table 7-2.—Oil Spill Probabilities (predicted spills per billion barrels of oil produced)

Source of spills	1,000-barrel oil spills	10,000-barrel oil spills
Platforms	1.0	0.44
Pipelines	1.6	0.67
Tankers at sea	0.9	0.50
Tankers in port	0.4	0.15
Total	3.9	1.76

SOURCE: Minerals Management Service, *Navarin Basin Lease Offering: Final Environmental Impact Statement,* November 1983

Industry's capability to effectively deal with spilled oil in the frontier regions depends on two factors: 1) preparedness with regard to countermeasures strategies, logistical support, equipment availability, and planning; and 2) performance, effectiveness, and suitability of the containment and cleanup equipment. Industry has met current State and Federal requirements for pre-spill preparation. The major uncertainty, however, is how equipment which is currently available will actually perform under the conditions commonly encountered in Arctic and deepwater areas. Although the state-of-the-art of cleanup technology has advanced in recent years, for the most part, only rough qualitative measures of its effectiveness exist. Little quantitative data about equipment performance exists, and most of that which does exist is derived from relatively inexpensive and easily controllable simulations and small-scale tank tests rather than from expensive testing under real-life conditions. In many instances, the manufacturer's claims and the vendor's specifications are all the information available to gauge the effectiveness of the equipment.

There are two major types of oil spills: blowouts and tanker spills. The sudden, uncontrolled escape of hydrocarbons from a well is known as a blowout. Oil well blowouts differ from tanker spills in that the discharge rate of a blowout is often slower and usually occurs over a longer period of time. Tanker spills could involve the release of a large amount of oil over a relatively short period of time. The behavior of the discharge, countermeasures strategies, and the potential impact of a blowout spill are thus different than for tanker spills. Countermeasures strategies vary for blowouts depending upon the depth of the blowout (e. g., whether it is a surface blowout from an artificial island or a shallow or deepwater blowout resulting from a drillship accident), the amount and stability of ice cover (e. g., moving pack ice, broken ice, or open water), and the sea state.

If a blowout cannot be controlled quickly, large quantities of oil and gas may be released. If the blowout occurs on the sea floor, the difficulties of control are compounded; and if it occurs underwater and under moving ice, it can be extremely difficult to control. It has been estimated that an uncontrolled sub-sea blowout in the Beaufort Sea lasting one year (although improbable) could release about 500,000 barrels of oil.

Some characteristics of blowouts make them easier to handle than tanker spills. First, potential spill locations are known; thus, spill containment and cleanup equipment can be prepositioned and variables affecting the spill's behavior (currents, wind patterns, etc.) can be studied before the event. Second, the release rates of blowouts are generally lower than release rates of tanker spills. If a blowout can be quickly controlled, relatively less equipment may be needed to clean up this type of spill. And third, oil from a blowout is often initially in a fresh, fluid state. This characteristic makes cleanup easier. However, the oil does not remain fresh for long, and once it has weathered, it is more difficult to recover.[29]

There have been several proposals to transport Arctic hydrocarbons by ice-strengthened or icebreaking tankers. The proponents of these proposals (e.g., Dome Petroleum) have designed tankers to minimize the risk of a spill. Nevertheless, the possibility of a tanker spill in the Arctic—if and when tankering becomes viable—cannot be discounted. It is impossible to predict the exact location of tanker spills. Equipment cannot be positioned in advance, and it is therefore very difficult to implement a fast response before extensive oil spreading and weathering occurs. Tanker spills may result in the release of a large amount of oil during a short period of time. Responses to such spills would require a large amount of equipment and manpower.

Limits to Effective Countermeasures

Environmental Variables

Whether a spill is from a blowout or a tanker accident, a number of environmental variables will affect the response effort. One of the most important is the amount of ice present. Spills may occur either in open water, under conditions of partial ice coverage, or in solid landfast or pack ice. Those which occur in complete ice cover are probably the easiest to control. In such instances, the most practical countermeasures technique currently available

[29]See S. L. Ross Environmental Research Limited, *Potential Large Oil Spills Offshore Canada and Possible Response Strategies* (Environment Canada, March 1982), *Oil Spill Countermeasures: The Beaufort Sea and the Search for Oil* (Canadian Department of Fisheries and the Environment, 1977), and *Evaluation of Industry Oil Spill Countermeasures Capability in Broken Ice Conditions in the Alaskan Beaufort Sea* (Alaskan Department of Environmental Conservation, September 1983).

probably is to burn the oil on the surface of the ice or, if spilled under the ice, to burn it as it accumulates in melt pools during the spring breakup. Open water spills, particularly in the high sea states common in the Bering Sea, are much more difficult to clean up. For instance, contamination from a summer tanker spill is not likely to be significantly reduced using currently available cleanup technology. High sea states would, however, promote natural dispersion.

In many ways, however, the most difficult spills to clean up may be those which occur in partial ice cover. Most oil spill containment and cleanup technology has been developed for temperate region spills and may not be sufficiently effective when used in partial (or broken) ice. Some promising techniques have been developed recently, but all require further development, testing, and integration into an overall response strategy. The broken-ice period varies by year and by location. In the Beaufort Sea and Chukchi Seas, this period lasts approximately 3 to 7 weeks during breakup and 3 to 6 weeks during freezeup. Thus, the most difficult conditions in which to clean up spilled oil last from 6 to 13 weeks each year. A generalization about the Bering Sea is not possible since the Bering varies in climate from north to south. Some areas of the Bering Sea may have broken ice at any time of the year.

Other environmental variables also affect the performance and efficiency of equipment and the overall response effort. The velocity of the ice is important, since it is much more difficult to operate in moving ice than in stationary (or landfast) ice. The characteristics of the ice are also important. Solid ice, for instance, provides an excellent platform from which to stage countermeasures, but it is extremely difficult to maneuver equipment (such as barges or skimmers) when ice coverage is extensive, Conversely, the operation of equipment in old "rotten ice or in thin, early season "grease' ice is probably easier than in solid ice, but these types of ice cannot be used as a countermeasures platform.

Inasmuch as the wind speed, sea state, and current strength affect both the rate at which oil is dispersed and the deployment and operation of countermeasures equipment, cleanup efficiency is also influenced by these variables. Water temperature also plays a role because colder temperatures increase the viscosity of the oil, thus reducing spreading. However, in very viscous oil mechanical cleanup is difficult, and the effectiveness of chemical dispersants is reduced.

Lack of Support Facilities

The absence of roads and support facilities throughout much of the North Slope and Western Alaska will make oil spill countermeasures difficult even if appropriate cleanup technology is available. There are few roads in these areas. Thus, land access to staging areas for offshore spills and/or threatened shorelines is rarely possible, and extensive use of aircraft is required. In addition there are no refineries, little manpower, few housing facilities, and few disposal sites. Some of the resources which could be mobilized in more populated areas in the event of a major spill simply do not exist in the Arctic. Conversely, industry argues that because Arctic areas are so remote, they must be self-sufficient. Located in the Prudhoe Bay area are fixed wing aircraft, helicopters, air cushion vehicles, roligons, trucks, boats, barges and personnel which could be mobilized rapidly in a local emergency.

Difficult Working Conditions

Difficult working conditions pose a general limitation on the capability of industry to clean up offshore Arctic oil spills. Although techniques, equipment, and clothing have been developed to minimize the effects of intense cold, and personnel have received specialized training, human efficiency is reduced in cold climates, and safety is correspondingly more difficult to ensure. Even with the best of protection, it is not possible to work outside for long periods of time. Generally, responses to accidents in cold environments take more time and equipment problems are greater, although little reliable data exists concerning the precise effects of cold on either human or equipment efficiency. The possibility that a spill may occur during the long Arctic night or during times of persistent fog also poses problems of efficiency industry will be able to make effective use of currently available equipment and countermeasure strategies to recover significant amounts of spilled oil in frontier areas.

Response Time

Of all the difficulties associated with containing and cleaning up spilled oil in the Arctic, two appear to be especially troublesome. The first is the problem of response time. Although inventories of oil spill cleanup equipment are located at Prudhoe Bay and at Dutch Harbor, response time is a problem because Arctic spills may occur in remote areas and because human efficiency is less in cold environments. If response to a spill is not prompt, the effectiveness of countermeasures is reduced, sometimes markedly. The response time problem will be particularly difficult in the case of tanker spills, since a spill may occur anywhere. Although tankers are not currently being utilized, their use in the Bering Sea can be foreseen, and their future use in the Beaufort and Chukchi Seas is being considered. It has been suggested that the major countermeasures question in the case of open water spills is how to deliver the technologies to the spill site prior to the oil's spreading and weathering beyond control.

In the Bering Sea, a distressed ship could be 400 or more miles from any point in Alaska and a much greater distance from a base that could support a spill response effort. For instance, it would take a Coast Guard icebreaker stationed at Kodiak Island at least 4 days to reach the site of a Bering Sea spill. It may be possible, if the safety of the crew is not at risk, to use the tanker itself as a working platform for countermeasures operations. A portable response system may be developed to be carried on tankers that would include booms that could be deployed by a small boat, skimmers that could be operated remotely or from the ship, and some kind of vehicle capable of operating in the water and on all kinds of ice. The United States has no requirement at this time that ships be equipped for countermeasures activities.

While the response time problem for remote tanker spills is of particular concern, responses to all Arctic spills will, on average, take more time than responses to temperate spills. The difficulty of detecting oil spills compounds the problem. Detection is most difficult for spills which occur under the ice or in broken ice, but it can also be a problem in more controllable situations, such as in the June 1981 Challenge Island oil spill in the Beaufort Sea. In this case a spill of approximately 3,000 gallons went undetected for an indeterminate length of time because of sustained inclement weather conditions.[30]

The industry treats the response problem seriously. Individual oil companies as well as industry cooperatives have stockpiled spill countermeasures equipment as required by the MMS. The companies prepare oil spill contingency plans for all exploration activities, and they conduct periodic drills to improve their response capability. In addition, the U.S. Coast Guard has established a national strike force equipped to respond to spills on short notice.

The broader countermeasures challenge is to develop a comprehensive and integrated spill response system. Such a system is composed of many components, including detection and surveillance, logistics operations, containment, recovery, storage, and disposal. In addition, the response operation depends upon timely weather and ice information and on other contingency plans (e. g., when conditions become hazardous, evacuation of personnel must be provided). If attention to any of the system components is less than adequate, the effectiveness of the overall response is likely to be limited. Thus, even with the best recovery technology, the response may be ineffective if the equipment can not be transported to the site fast enough or if recovery efforts must be terminated due to unsafe conditions.

Countermeasures Technology

Mechanical Recovery

In some Arctic spill situations oil can be removed from the surface of the water by mechanical skimming devices. Many different types of skimmers have been developed, but few of these have been designed specifically to recover oil from Arctic waters. Moreover, although mechanical oil skimming technology continues to advance, little testing has been done under at-sea Arctic conditions. Even

[30] Sohio Alaska Petroleum Company, *Challenge Island Spill Report* (March 1982).

the most effective skimmers have limited capacities for recovering oil in stormy and/or ice-covered Arctic waters. Considering the relatively low percentage of spilled oil they may be able to recover in most Arctic spill scenarios, skimmers are seen by some to be a second-order countermeasure technique.

The effectiveness of skimming devices depends upon a number of different variables. For one, the thickness of the oil layer to be recovered affects cleanup efficiency. Thus, skimmers are usually used in conjunction with booms which prevent the oil from spreading and becoming too thin to recover. In this respect, ice may sometimes be used to advantage. If ice is present, but not extensive enough to limit skimmer deployment, it may serve as a natural barrier to spreading and thinning. The viscosity of the oil is a second important variable. The mechanical recovery of viscous oil, which may quickly form in cold Arctic waters, is a problem requiring specialized equipment. Skimmer performance is also reduced by high sea states, strong currents, and the presence of debris and/or ice. Skimmers for Arctic spills must be easily maintainable, easy to transport to the spill site, and simple to operate. Skimmer designs which may be useful in certain Arctic spill situations include weir, suction, and sorbent surface devices. Each type of device is available in the Arctic.

Weir skimmers. Weir type skimmers depend on gravity to drain oil off the surface of the water. They operate by allowing the oil to fall over a lip suspended at the surface of the water into a sump placed in the slick. The oil is then pumped out of the sump to a storage facility. The main advantages of this type of skimmer are portability and simplicity. They have proven most useful for recovering light oil in calm water. They are not useful in waves because large volumes of water will enter the sump with the oil (a ratio of 10 percent oil recovery to 90 percent water is not atypical). In larger waves, smaller weir skimmers may be swamped. Weir skimmers can be used in calm, open water Arctic spill situations; however, the presence of ice or other debris may clog the weir openings and render the equipment temporarily inoperative.

Suction devices. Suction devices, if mounted on a suitable operating platform and if used with suitably powerful positive displacement pumps, may prove to be useful in some instances. Since low ambient temperatures predominate in the Arctic, spilled oil is likely to become very viscous; water-in-oil emulsions also may be formed. The main advantage of suction skimmers is their ability to vacuum heavier oil. Even suction pumps, however, will have problems recovering semi-solid oil. Other types of skimmers have difficulty efficiently recovering viscous oil because the oil will not readily flow toward the equipment.

Disc skimmers and rope mops. Sorbent surface devices, including rotating disc skimmers and rope mops, seem to hold promise for efficient operation where small amounts of ice are present. The disc type skimmer collects oil on rotating oleophilic discs. The oil is scraped from the discs, transfered to a screw auger at the axis of the discs, and pumped to storage containers. The advantages of this type of skimmer for Arctic use are its ability to pick up viscous oil and to function amidst limited ice, debris, and waves. However, disc skimmers may become quickly overloaded in heavy oil.

Rope mop skimmers use continuously moving, absorbent, polypropylene ropes to sop up oil. This type of device has relatively good potential as a secondary collection system in broken ice conditions. Rope mop skimmers range in size from very small portable units capable of being mounted on ice-strengthened barges or other platforms to large boats specially designed for skimming operations.

The ARCAT. The largest and most important rope mop skimmer currently on hand in the Arctic is the ARCAT, a 65-foot catamaran dedicated

Photo credit: *EPA OHMSETT facility*

Testing the effectiveness of a rope mop skimmer in cleaning up oil spills in broken ice to spill cleanup in the Beaufort Sea and operated by Alaska Clean Seas. A distance of 6 feet separates the ARCAT's two hulls. However, using diversionary booms and support from two small tow boats, the ARCAT can increase its swath width and thus its oil encounter rate by a factor of 20 or more. By offloading recovered oil into auxiliary oil storage containers, it is hoped that ARCAT will be able to operate continuously for days or even weeks at a time, recovering oil at the average rate of 5 to 30 barrels per hour. Other features of the ARCAT include oil dispersant booms, oil storage capacity, and equipment to break down recovered emulsions.[31]

The maneuverability of the ARCAT has been evaluated in broken ice coverage up to 7 oktas (an okta is equivalent to 12.5 percent—one-eight—coverage). In 2 oktas (25 percent) or less ice coverage, it is able to maneuver through broken ice at speeds of from 5 to 7 knots. In 3 to 5 oktas its speed is reduced to one to 2.5 knots, and, in 6 to 7 oktas to about one-half knot. Industry is satisfied that the ARCAT has been sufficiently tested to demonstrate its utility for recovering oil in broken ice conditions. Industry argues that further testing is not necessary since other skimmers very similar to the ARCAT have been tested with good results in oil, and it is reasonable to conclude that ARCAT mops will behave in the same way. Others are not so sure, since it has not been tested in oil and ice, and believe that the device should be put to the test recovering the type of oil that it will most likely encounter—viscous crude that has weathered for about 3 days in water at 0°C. Even if ARCAT can handle these tests, special operating procedures may have to be developed. Tests may indicate that different types of mops are necessary, or that it may be necessary to adjust wringer speed, rope speed, or even the vessel speed. These operating procedures could be tested and developed before a spill occurs.

The Force Seven type mop. The Force Seven type rope mop has also been considered in connection with Arctic spill response. This system uses a series of mops deployed from the stern of a vessel. It is attractive because: 1) the area covered can be increased by increasing the number of mops; 2) the device is likely to have some utility in broken ice since the mops are drawn over the surface of the ice; 3) there is no problem of a catamaran hull becoming jammed with ice; and 4) the device can be quickly installed on the stern of any available vessel. This last feature is particularly important. The ARCAT is an expensive vessel, and although it may be used for other purposes, it is dedicated solely to oil spill response. When it isn't recovering oil, it sits unused. As a result, only one ARCAT has been built and deployed to date. If a large spill does occur, however, the use of as many vessels as are available probably will be required if a significant amount of oil is to be recovered. Therefore, availability of equipment that can be mounted on vessels of opportunity probably will be more feasible than dedicated single-purpose vessels.

Few skimmers have been independently tested to evaluate how well they perform in broken ice conditions. In most cases it is simply not known how well they will operate in the different ice conditions which could be encountered. Manufacturers have made optimistic statements about the efficiency of their skimmers for Arctic conditions, but what little independent testing has been done has shown many of these claims to be overstated.

Industry has been using conventional barges and tugs for some time for supporting offshore and nearshore oil spill cleanup operations. One innovation would be an icebreaking barge. Barges provide mobile and stable platforms from which to conduct countermeasures operations. Recent industry demonstrations have shown that rope mop skimmers can be effectively deployed from barges in deteriorating heavy pack ice. The recovery capability of barge-mounted skimmers, however, has not been demonstrated. The oil-encounter rate for these skimmers may not be high; nevertheless, this approach constitutes one more countermeasures tool that may be useful in some situations.

Booms. Booms are used to contain oil. They may either be employed in conjunction with skimming operations (in which case their function is to capture and concentrate oil slicks so that recovery can be as efficient as possible) or for deflecting or excluding oil from particularly sensitive areas. Booms work best in calm water, free of ice or other de-

[31] R.E.Williams, S. J. Bowen, and D. H. Glenn, "Field Trials of the ARCAT 11 in Prudhoe Bay, Proceedings of the Seventh annual Arctic Marine Oilspill Technical Seminar (Edmonton, Alberta, June 1984).

bris. However, in strong currents (above one knot) and high sea states, the efficiency of containment booms is impaired. In heavy sea states, for instance, oil may either splash over the top of the boom or escape under the skirt. In addition, scattered ice can cause boom damage. In general, booms do not yet seem to have the endurance necessary for continuing performance during a long-term cleanup operation, and booms used in open ocean conditions have not proved to be very effective. In rough environments, the use of booms and skimmers probably would not make a significant difference in the ultimate environmental impact of a spill.

MMS recommends that booms be able to perform in wave heights of 8 to 10 feet. These performance guidelines have not been met. However, it is still unclear what constitutes adequate boom performance under real conditions, and under high wave conditions, oil will usually be quickly dispersed, Although booms are an indispensable countermeasures tool, their use is clearly limited. A promising addition to containment technology is the high pressure water jet barrier, which currently is being developed. It is used for the same purposes as conventional booms. The water jet system is designed to herd oil in waves, ice, and marsh areas, and can be mounted on and used in conjunction with skimming devices. It has not yet been evaluated in high sea states, however. In addition, the jets create a considerable amount of fine mist. In subfreezing air temperatures, the resulting ice mist could be a health and safety hazard.

Disposal. The ultimate disposal of recovered oil or oiled debris generally takes the form of either landfilling or incinerating the material. Both of these alternatives have drawbacks in a northern application.

The burial or landfilling of oil and oiled debris is possible only if suitable sites are available to construct either subsurface pits or above-grade berms to contain the material. Such sites are not plentiful in the Arctic; where available, they may be difficult to access due to the complete absence of roads and the presence of shallow water at the shore. Ice-rich soils, common in the Arctic, also pose a problem in summer operations since excavation in permafrost can create sloppy, unworkable conditions. Landfilling operations also require the use of heavy equipment which is not plentiful in the North and which would be difficult to transport to specific disposal sites. The major advantage of land filling in the Arctic is the ability to permanently encapsulate the oil and debris in a frozen surrounding.

The state-of-the-art for oil spill disposal by incineration has advanced from earlier attempts at burning oil and debris in oil drums or open pits to a technology including air-transportable incinerators and reciprocating kiln beach cleaners. A transportable flare burner capable of burning 6,000 barrels of light oil per day and 3,000 barrels of heavy oil per day is available in Anchorage. The industry on the North Slope has access to a rental burner that is theoretically capable of incinerating 13,000 barrels of oil per day.[32]

Oiled beach materials such as sand and rock could be cleaned in simple reciprocating kiln devices but such equipment at present has a very low throughput. A larger number of these kilns, along with their manpower and logistical support, would therefore be required to carry out an extensive beach cleaning. It is also apparent that any proposed landfill operation would involve serious logistical problems. This is also the case for any proposed labor-intensive spill control operation in the North, either beach cleaning or debris disposal.

The disposal problem is mainly of concern for large spills. Small spills can be stored until adequate disposal is available. For the Beaufort Sea, the industry points out that it would be technically feasible to transport skimmed oil by barge or possibly over ice to Prudhoe Bay where it could be offloaded into a "slop tank' at one of the flow stations of the Prudhoe Bay Unit. These flow stations have the capability to treat skimmed oil to Trans Alaska Pipeline specifications. Likewise, in the Bering Sea, it may be technically possible to transport skimmed oil in a large oceangoing barge to Kenai, Alaska or Seattle, Washington for deposit into a refinery slop tank.

In Situ Burning

For many Arctic marine oil spills, in ***situ*** burning is considered to be one of the most practical methods available for removing oil from the envi-

[32]Shell Oil Company, Sohio Alaska Petroleum Company, Exxon Company, and Amoco Production Company, *Oil Spill **Response in the Arctic*** (Three parts, April 1984).

ronment. This countermeasure method may be used in combination with other techniques to reduce water pollution. The oil that escapes combustion, either as residue or as a partially burned oil layer, might be recovered downstream with skimmers. When burning can be used as an oil spill countermeasure, the problems of disposal encountered with mechanical recovery techniques may be reduced.

In situ burning may be practical for both contained and uncontained spills. In an uncontained slick, such as one from a tanker spill in open water, burning may be the only feasible method of significantly reducing the amount of oil in the water. Even if mechanical recovery equipment could be deployed to a remote spill site, it probably could not be expected to remove more than a small fraction of the oil from a large batch spill, and the problem of disposal of recovered oil would remain. Dispersants might be used to counteract some of the adverse effects of uncontained spills, but their effectiveness may be reduced in cold environments.

If spilled oil can be contained, ***in situ*** burning may be the most efficient removal technique. Oil may be contained naturally or by man-made, fire resistant booms. Winter tanker accidents or winter subsea blowouts are two situations in which spilled oil would be naturally contained and in which ***in situ*** burning may be successfully used. In either situation, most of the spilled oil would be trapped under the ice for the duration of the winter, and no countermeasures would be possible until breakup begins. Within a very short time, the oil would be encapsulated in the growing ice sheet. If the spill were in the landfast ice zone, the oil would not likely travel very far. However, if the spill were beyond this zone in the moving pack ice, the oil could eventually be spread along a narrow track under the ice for many miles. As the ice begins to decay, the oil would migrate to the surface (where it would emerge in a relatively fresh and unweathered state) and collect in melt pools. Depending upon the size and type of the spill, thousands if not tens of thousands of separate oiled pools could appear. Like spills resulting from open-water tanker accidents, there may be no practical solution other than burning for spills resulting from either winter tanker accidents or winter subsea blowouts.

Photo credit: EPA OHMSETT facility

Testing the effectiveness of *in situ* burning as an oil spill countermeasure

Spills which occur during the broken ice period can also be contained naturally for ***in situ*** burning, if the ice coverage is adequate (the ice edges tend to limit the spreading tendency of the oil). For some open water or broken ice situations, fire resistant containment booms, although still in the development stage, may provide a way for reducing marine oil pollution.

The major technical issue associated with ***in situ*** burning is the problem of igniting the oil and keeping it burning. When oil is allowed to spread and thin, it is difficult to burn efficiently. Oil which is thicker than about 2 or 3 millimeters can be ignited and burned. Since oil thins as it spreads, undue delays in ignition result in reduced burn efficiencies. Moderate wind may be helpful if it works to herd the oil against an ice barrier. However, lower burn efficiencies can normally be expected in high wind and low ice concentrations. Weathered oil which has remained in the water is likely to be unburnable because the lighter fractions quickly evaporate, and the remaining oil breaks into windrows. Minimum conditions for burning are currently unknown.

For ***in situ*** burning of uncontained slicks to be effective, the spreading of the flame must keep up with the spread of the oil itself. The flame spreading velocity is related to the type of oil burned, wind speed, and water temperature. Recent laboratory and test-tank oil burn tests have shown that in most cases the flame spreads as rapidly as the burning oil until the thickness of the leading edge of the slick drops below that necessary to support combustion. Beyond this point, only the thick portions of the slick burn, However, certain ignition patterns, such as igniting the circumference of the slick, may be able to overcome this problem. Combustion efficiencies vary proportionally with spill size, wind speed, amount of ice, water temperature, oil type, ignition delay, and pattern of ignition. Efficiencies of up to 80 percent by volume can be achieved, with lower efficiencies expected, for instance, in high winds and low ice concentrations. If adverse conditions persist, cleanup efficiencies could drop below 20 percent.

The 1983 Alaskan Tier 2 field demonstrations of industry's ability to clean up oil in broken ice included industry demonstrations of ***in situ*** burning. Task 1 consisted of a series of burns of oil in grounded and floating ice. Although the demonstrations were less successful when the ice was floating rather than grounded, they clearly showed that burning is an important component of Arctic oil spill response and cleanup if the oil enters moving broken ice. In its evaluation of the demonstration, the State of Alaska noted that the relatively high efficiency of ***in situ*** burning depended on the crucial assumption that burning must take place close to the spill source while the oil layer is relatively thick and easily combustible. In many situat ions, however, a safe burn near the source of a blowout may be impossible, and therefore the burn efficiency will be significantly reduced. It is suggested that more work on the ignition and ***in situ*** burning of crude oil among **3** to **5** oktas of moving ice is necessary to determine the limits of this countermeasure approach with respect to oil weathering, thickness, and environmental conditions.

Wellhead ignition. When ***in situ*** burning and other countermeasures techniques are not feasible, wellhead ignition is another possibility. This technique has been considered for dealing with blowouts from gravel islands. Combustion and skimming techniques employed in the vicinity of an unignited blowout can be dangerous and countermeasures taken far downstream of a blowout may not be very effective, Therefore, well ignition may be the only way that artificial island blowouts can be rapidly and effectively controlled. It has been roughly estimated that if the wellhead is ignited, approximately **95** percent of the oil would be burned immediately and another three percent could be removed by other cleanup processes, regardless of whether the blowout occurred in broken ice, landfast ice or open water.

However, there are some important unanswered questions concerning the feasibility of wellhead ignition as an oil spill countermeasures technique. Oil companies may be reluctant to ignite blowouts and thus destroy their wells unless there is no alternative. When possible, rapid control of the well may be more effective in minimizing pollution than early ignition of the blowout. Wellhead ignition prevents the use of equipment which could otherwise be used to reduce the flow.

If a blowout were to occur, wellhead ignition would probably not be ordered immediately. There would inevitably be some delay as experts evaluated the best course of action to take, during which time oil would continue to flow. It has been suggested that 24 to 48 hours would be required to analyze the blowout situation. If experts determined that the well could be brought under control within a ' 'reasonable' time period, the well would not be purposely ignited, and alternative well control efforts would commence. The decision would depend on the rate of flow, the likely damage to the rig and equipment if the well were purposely ignited, the potential environmental damage with and without well ignition, and the safety, cost, and efficiency of cleanup options.

The State of Alaska's decision to grant year-round exploratory drilling on and inside the barrier islands to qualified lessees (the Tier 2 decision), was based, in part, on the viability of wellhead ignition as a countermeasures option. A major question, however, is whether government authorities (either the Alaska Department of Environmental Conservation or the United States Coast Guard) would be willing to order a blowout ignited, recognizing the possible legal problems which might ensue if industry claimed that the well could have been saved and that other techniques could have been used. If ignition is ordered by these authorities, it ***is*** not altogether clear who would pay for the damage to equipment. There is also some concern about the safety of ignition. On offshore structures, for instance, it is possible that igniting a blowout could destroy blowout preventers which might be used to bring the blowout under control. In this situation, the capability to drill a relief well becomes very important. Depending upon the area in question and the availability of rigs, a relief well could take from one to three months to drill. Hence, a buffer period would be required so that relief well drilling could be completed before the fall freezeup. Wellhead ignition should probably not be considered a preferred countermeasure, but rather as a last resort to use in the absence of any better technique.

Ah--deployable igniters. Any approach to dealing with spills beneath ice must take into account that the size of the area that might have to be cleaned could be extremely large, that there could be numerous unconnected pools of oil to clean up, and that putting cleanup personnel on the ice surface is potentially unsafe. To overcome these problems, a considerable amount of effort has gone into developing igniters which are inexpensive and safe for use from helicopters. One of the requirements specified by Alaska's Department of Environmental Conservation in order for a lessee to obtain approval of its contingency plan is that the lessee must be able to obtain 500 ***in situ*** igniters within 6 hours of a spill and an additional 1,000 igniters within 48 hours of a spill. Still, this number of igniters might be inadequate for certain types of spills. It has been estimated, for instance, that up to 30,000 igniters could be needed to ignite the oil from a large spill from a tanker. Research is continuing on developing more efficient igniters, and one of the more promising techniques currently under investigation is that of airborne laser ignition. 33

Collection and disposal of residue. Although ***in situ*** burning is considered the most practical countermeasure for oil spills on solid or in broken ice, little attention has been given to collection and disposal of the residue from a burn, which could be as much as 35 percent of the volume of the oil spilled. Such residue will be viscous and difficult to handle. While flare burners could be used to dispose of oil and oil/water mixtures recovered by mechanical devices, residue from ***in situ*** burning may be too viscous to burn. Field tests have shown that burn residue can be removed using sorbents. However, burn residue and sorbent material must first be collected and then transported to an incineration site, which may not be an easy task if the spill is distant from onshore facilities.

Air pollution. In situ burning in many places in the United States would be considered unacceptable because of the smoke and products of combustion. On the North Slope it may be less objectionable because it is remote from populated areas. Environment Canada conducted a brief study of the characteristics of atmospheric emissions from ***in situ*** burning in 1979 and concluded that "in the immediate vicinity of the fire, the concentration of particulate (soot) will be undesirably high and such areas should be avoided. The concentrations at distances of 10 to 40 km and beyond are judged to be sufficiently low that no adverse air quality problem exists. '[34] The study further notes that poly-nuclear aromatic hydrocarbons in the oil soot have been established as potent carcinogens and are regarded as being only slowly biodegradable. The toxicity of the amounts of these substances likely to be present in the soot has not yet been established, but the Canadian report recommends that it is prudent to minimize human exposure to these substances. This could probably be accomplished by careful planning of the burning operations, taking into account short range weather forecasts.

More recently, the Alaska Department of Environmental Conservation and the Alaska Department of Natural Resources have noted that it is unlikely, given the remoteness from population centers of Arctic oil and gas activities, that concentrations of the byproducts of ***in situ*** burning of oil will reach levels in which a hazard to humans and wildlife will be present. They plan to use a dispersion model to analyze the air quality impact before deciding to order a blowout ignited or burn large quantities of oil ***in situ.*** Despite possible air contamination, it is generally believed that in balance it may be more advantageous to burn the oil rather than allow it to remain in the marine environment.

[33] I. A. Buist, R. C. Belore, and L. B. Solsberg, "Countermeasures for a Major Oil Spill from a Tanker in Arctic Waters, 'Proceedings of the Seventh Annual Arctic Marine Oilspill Technical Seminar (Edmonton, Alberta, June 1984).

[34] Tom Day, et. al., *Characteristics **of Atmospheric Emissions from an In-Situ Crude Oil Fire*** (Ottawa: Environment Canada, October 1979), p. 58.

Finally, although it will be possible to burn oil that surfaces in melt pools in the spring, if large quantities of oil are involved, it may be desirable to take action sooner. The Alaskan Beaufort Sea Oilspill Response Body (ABSORB) has sponsored research investigating the possibility of drilling through the ice to reach oil pooled beneath. Since oil from a winter subsea blowout would be trapped in cavities under the ice, it may be possible to put personnel and heavy equipment on the ice in winter to drill down to oil trapped in the larger pools—if it can be located—and pump it out. This approach would not require developing any new equipment.

Dispersants

Dispersants are chemical agents used to eliminate oil from the surface of the water and distribute it though the upper few meters of the water column. Used on an oil slick, dispersants decrease the interracial tension between oil and water, thus reducing the cohesiveness of the slick and promoting the formation of small droplets, which, with the aid of wind and waves, move downward into the water column. Natural degradation by oil consuming bacteria and other processes eventually takes place. The use of dispersants as an oil spill countermeasure may be appropriate if: 1) sea conditions are too rough for deployment and/or efficient operation of collection and recovery equipment; 2) the spill is too large; 3) the spill site is too remote for efficient mechanical recovery or in ***situ*** burning; 4) it is necessary to stop the movement of a slick toward shore; 5) the oil slick presents a fire hazard; or 6) the probability of contaminating wildfowl is high. 35

There are several problems associated with the use of dispersants. For one, dispersants may adversely affect marine organisms. The first dispersants used for oil spills were hydrocarbon-base solvents. In response to the Torrey Canyon spill it was found that, when applied in large doses, these first-generation dispersants were lethal to marine organisms. Dispersants thus acquired the reputation of being compounds too harmful to marine life to be used as an oil spill countermeasure. More recently, "third-generation" dispersants have been developed. For these dispersants, the water on which the oil is floating serves as the reactant in the dispersing process. This eliminates the need for hydrocarbon solvents, and greatly reduces the biological toxicity. The most effective dispersants are those which maximize dispersal of oil at sea but have a minimal impact on key organisms living in the water column and sediments. Although the most recent generation of dispersants are relatively nontoxic, there may still be problems associated with placing dissolved and particulate oil in the water column. It is believed that sub-lethal effects (e. g., tainting of marine species) are the main biological concern.

The decision to use or not to use chemical dispersants relates to the expected severity of oil spill impacts on wildfowl, beaches, or wildlife. The safe use of dispersants requires an understanding of the fate, behavior, and effects of treated and untreated oil spills. Since the potential exists for improper use, dispersants must be thoroughly tested before being placed on the EPA approved list.

A second problem concerns the effectiveness of dispersants in cold climates. Dispersants formulated for use in temperate regions may not be well-suited for use in the Arctic, since cold temperatures increase the oil's viscosity, thereby reducing the ability of the dispersant to break down the slick. Since dispersants require relatively high surface mixing, their use would probably not be effective in broken ice conditions. Currently available dispersants are less effective in acting on water-in-oil emulsions. Another temperature-related problem is the potential for the dispersant to separate, freeze, or gel at low temperatures which might cause problems in spraying. Also, the amount of mixing, the degree of weathering of the oil, the dispersant-to-oil ratio, uniformity of coverage, the size of the oil droplets (they must be small enough to create a permanent dispersion), the presence of slush ice, and the degree of salinity affect dispersion. For instance, dispersants require mixing to be effective, and sufficient wave energy is often not present off the North Slope. In addition, since current oil and gas operations in the Alaskan Beaufort Sea are in very shallow water, the use of dispersants may not be an effective way to degrade the oil and may not be desirable from an environmental point of view.

[35]American Petroleum Institute, *Oil Spill **Cleanup: A Primer (Washington, DC, 1982).***

On the other hand, dispersants could be effective in the Navarin Basin, where there is more wave energy and deeper water, and where marine life and wildfowl are more dispersed.

Dispersants have been developed in the last few years which apparently require little mixing ***in addition to*** normal wave action, and this development has stimulated research and development in aerial application techniques. Dispersant effectiveness, toxicity, and logistics support requirements probably should be examined in light of the much greater slick thicknesses associated with fresh oil films in the Arctic. Ultimately, it could be possible to rank dispersants according to their effectiveness in specific types of situations.

The effectiveness of dispersants as a countermeasure in Arctic waters has yet to be adequately demonstrated under cold marine conditions. Questions remain, for instance, about whether aerially applied dispersants work the way they are supposed to or merely 'herd' the oil to either side of the spray path. The two largest dispersant manufacturers, British Petroleum and Exxon, are actively involved in developing chemical dispersants that will be more effective in treating Arctic oil spills, or other viscous spills.

Logistics problems and high costs of using dispersants as a countermeasure for large, remote Arctic spills may ultimately prove to be the factors most limiting their use. Since dispersants must be applied from either ships or aircraft, their use depends upon the availability of expensive equipment. Moreover, for major spills, large quantities of dispersants will be required. Long distances require large amounts of fuel. However, aerial dispersant operations could be carried out in all Alaska OCS areas from existing aircraft landing facilities.

For use in remote Arctic locations (e. g., to apply to oil from a tanker spill), aircraft may be the only practical means of delivery, because for dispersants to be effective, they must be applied as soon as possible after a spill. It has been estimated that a response effort for remote spills could require three to four days to mount. By this time, however, the increased viscosity of the oil would make currently available dispersants much less effective. Thus, until more effective dispersants are developed, aerial applications will not likely be a useful countermeasures technique for remote tanker spills. Moreover, expensive stockpiling of sufficient quantities of dispersants at strategic locations and a well-rehearsed logistics plan for delivering the chemical to the spill site probably will be crucial if future applications are to be successful. More promising, perhaps, is the use of dispersants to combat oil from blowouts which is thin and fresh, and for fresh spills in choppy seas which can be reached quickly. Other applications might include small batch spills and protection of nearshore areas.

Shoreline Cleanup

Conventional shoreline cleanup in the south involves the containment of oil at shore, the removal of oil and oiled debris by manual and mechanized means, and the cleaning of rocks and man-made structures by high-pressure water and steam. Northern cleanup and restoration operations will utilize techniques and equipment much as in the south. The northern shoreline cleanup operation will, however, likely be complicated by several factors.

Outside the Prudhoe Bay area, a large work force is not available in the Arctic. Since many cleanup steps require manual labor, responses to northern spills may face labor shortages. Heavy equipment will have to be used sparingly due to the sensitive nature of the northern shorelines and their slow recuperative abilities. In many instances, beach material will not support heavy loads. In addition, the presence of boulders and other irregular features on the surface preclude the use of any large mechanized vehicle. The lack of road access in the Arctic means personnel and equipment will have to be transported to the spill site by water or air. Cold temperatures much of the year and periods of prolonged darkness will also complicate northern shoreline cleanup operations. While all of the southern shoreline cleanup techniques are generally applicable to the Arctic study area, the remote nature and harsh but fragile environment of the North will make their application more difficult and less efficient. In most cases, beaches and shorelines will likely be left to regenerate by natural means.

Conversely, shoreline response may not be as time sensitive as offshore or nearshore cleanup; thus, there would be more time to import additional labor from Fairbanks, Anchorage, or elsewhere. In the northernmost areas, the shoreline would be in a frozen or semi-frozen condition most of the year, which would limit the amount of oil that would penetrate the surface. Industry expects that most shoreline cleanup operations would take place during the summer when there is much more daylight than in the lower latitudes.

Monitoring and Surveillance

The effectiveness of many control operations depends on the ability to monitor the position, direction of drift, and size of oil slicks. The vast areas and remoteness of the Arctic, as well as long periods of darkness, complicate this task. The most obvious method of tracking the oil is by visual observation from aircraft. In many cases this will not be possible in the Arctic because of prolonged periods of poor visibility due to either weather or seasonal daylight conditions. Many other methods have been developed for this purpose which will improve surveillance under northern conditions.

Radio tracking buoys monitored from land, ships or aircraft have been constructed to simulate the behavior of specific oil types. Tracking distances of 15 kilometers from the water and 45 kilometers from the air for periods of up to three weeks are possible with the present equipment.

The use of both passive and active airborne remote-sensing packages for tracking and locating purposes has been advanced in recent years. Pictures of spill extent and location can be made through color or filtered black and white photographs. Low-light television systems can differentiate oil slicks from wind and wave patterns but are ineffective in the dark and are unable to discriminate oil from foam, slush ice or brash ice, A day or night system—the laser fluorosensor-is able to detect oil on water, on ice, and in ice-infested conditions. It is limited to the detection of oil at, or very near the surface of the water or ice. Dual, infrared/ultraviolet, line scanners have been successful in locating oil on a real-time basis during the day. Side Looking Airborne Radar (SLAR) is able to cover a larger area in one pass from an airplane or satellite. These SLAR systems are effective, day or night, in detecting oil only in ice-free waters. None of the sensors currently available have been proven to detect oil in broken ice, with the exception of the laser fluorsensor, which is still being tested.

Satellite imagery is another means of locating and tracking oil slicks during daylight hours. Currently, the LANDSAT series of satellites scan the Arctic with sensors in the red, green, and near infrared. This information can be used to identify the position and extent of an oil slick. Plans to mount improved sensors in these orbiting stations will undoubtedly enhance the use of satellites for future monitoring.

Government/Industry Responsibilities

Primary responsibility to cleanup oil spills rests with industry, and, although industry has treated the oil spill issue seriously, it has developed only limited capability to contain or clean up a spill in the Arctic. It is the responsibility of Federal and State governments to ensure that industry is adequately prepared to respond to oil spills and to provide backup assistance when necessary.

Federal Government

Since the Santa Barbara blowout, improvements in the regulations governing OCS oil and gas exploration and development have been made by the Department of the Interior. New regulations regarding subsea blowout preventers, worker training programs, oil spill contingency plans, and inspections have been implemented since 1970. In addition, several laws establish penalties for spilling oil and assess liability for polluters. For example, amendments to the FWPCA in 1972, 1977, and 1978 have increased civil and criminal penalties that may be incurred for polluting. Polluters may now be fined up to $10,000 for failure to report an incident, and up to $50,000 for each offense (and more if willful misconduct or negligence can be proved). Under the FWPCA, vessel owners are liable for cleanup costs of up to $150 per gross ton and owners of offshore facilities may be liable for cleanup costs up to $50 million. The Administration supported recent congressional attempts to further increase pollution penalties and liability limits.

Federal responsibilities in the event of offshore oil spills are specified in the National Oil and Hazardous Substances Pollution Contingency Plan, developed in response to the FWPCA. The plan designates the Coast Guard and the MMS as the lead government agencies with responsibilities for offshore oil spill mitigation and cleanup. The respective responsibilities of these two agencies have been clarified in several memoranda of understanding.

In general, the Coast Guard is responsible for coordinating and directing measures to contain and remove pollutants from the water, while the MMS is responsible for coordinating and directing measures to abate the source of the pollution. In the Alaska coastal region, responsibilities are further delineated by the Alaska Coastal Region Multi-Agency Oil and Hazardous Substances Pollution Contingency Plan. Although the primary responsibility for pollution response lies with the Coast Guard, the MMS does have the authority to suspend response operations within a 500-meter radius of the pollution source to facilitate abatement measures.

Supervising and monitoring is the Coast Guard's normal role in managing a cleanup operation. It is Coast Guard policy to encourage the responsible operator to undertake proper removal actions. However, the Coast Guard is prepared to direct the response if the responsible operator is either unknown or not taking satisfactory action. When the Coast Guard is simply monitoring the cleanup operation, removal is done by commercial cleanup contractors and industry cooperatives. Historically, the Coast Guard has been directly involved in only one out of five removal operations. When this happens, the Coast Guard uses its pollution revolving fund ($35 million, established by the FWPCA).[36]

In the event of an offshore spill, the Coast Guard provides an On-Scene Coordinator (OSC) (the Captain of the Port within a specific area of the coastal zone). The OSC coordinates or directs the Federal response to actual or potential pollution incidents. If the OSC decides that cleanup is inadequate or cannot find anyone to immediately assume responsibility for directing an action which is considered necessary, he or she will declare a Federal response and take over actual management of the cleanup. Commercial contractors are used whenever possible, since it is the Coast Guard's policy not to compete with private industry. However, the Coast Guard has developed a modest inventory of equipment for use where commercial sources are either not available or do not have the necessary amount or type of equipment. Much of the Coast Guard's equipment is for use to combat open water spills and was designed specifically for its use, since there are fewer commercial sources for this type of equipment.

The OSC has a number of resources available to expand the amount of equipment, personnel, and expertise available. The Regional Response Team (RRT) can be convened at the request of the OSC for advice or assistance in obtaining equipment or other support. The RRT is also responsible for planning and preparedness prior to spills. The team consists of regional representatives of the Departments of Agriculture, Commerce (NOAA), Defense, Energy, Health and Human Services, Interior, Justice, Labor, State, and Transportation, EPA, the Federal Emergency Management Agency, and representatives of State governments. The National Response Team (NRT), composed of Federal agency representatives at the national level, is also available to assist the OSC. The NRT is consulted for major policy decisions or when large scale or specialized support not available to the RRT is needed.

The National Strike Force (NSF) is a key Coast Guard resource available to the OSC. When commercial resources are not adequate, the NSF is employed. The Strike Force consists of several teams specially trained and equipped to respond to oil spills. The Pacific Strike Team of the NSF, located in Marin County, California, is the unit charged with responding to spills in the Arctic. The NSF maintains a stock of specialized equipment that can be deployed anywhere in nation. It is also involved in testing and evaluation of equipment and response methods. Other resources upon which the OSC can draw are the Scientific Support Coordinator provided by NOAA, EPA, State and local governments, and the academic community.

The Coast Guard has developed regional and local contingency plans in preparation for spills. These plans include data on possible pollution

[36] *Coast Guard Capabilities for Oilspill Cleanup*, Hearing before the House Committee on Government Operations (August 26, 1982).

sources, location of environmentally sensitive areas, available contractors/cooperatives and their equipment, and plans for protecting vulnerable resources within the area. An Environmental Atlas for the Alaskan Beaufort Sea, which contains information concerning general oceanography, meteorology, ice, and climatology recently has been compiled for use by the OSC. By compiling available information on environmental conditions and variables, the OSC is better able to understand the environmental conditions one could expect to encounter in the event of a spill. If the atlas proves useful, the Coast Guard plans to develop atlases for other lease sale areas of the Alaskan OCS.

Industry

The offshore oil and gas industry must comply with OCS regulations and orders. Regulations are general rules applicable to OCS operations everywhere. OCS orders are published by the MMS and refer to particular areas. These orders expand upon the regulations and provide more detailed guidance on regulatory requirements. OCS Order No. 7 stipulates the pollution prevention and control measures required of industry. This order specifies that lessees shall submit a description of procedures, personnel, and equipment to be used in reporting, cleaning up, and preventing oil spills which may occur during exploration or development activities. The order also requires lessees to maintain (or to have readily available) pollution control equipment, including booms, skimmers, cleanup materials, and chemical agents. In addition, requirements for drills and training procedures are also stipulated.

In addition to other requirements, OCS Order No. 7 requires that all companies that propose to do work in the Arctic submit an oil spill contingency plan. Contingency plans are reviewed annually and must contain information concerning: 1) amount, type, and location of all countermeasures equipment and time required for its deployment; 2) alternative responses for spills of varying severity; 3) plans for protection of areas of special biological sensitivity; 4) procedures for early detection and timely notification of an oil spill, including names and telephone numbers of people to notify; and 5) the necessary steps to be taken to assess the seriousness of the spill, plan the response, and begin cleanup actions. Oil companies must specify an oil spill response operating team consisting of trained, prepared, and available operating personnel; an oil spill response coordinator; a response operations center and reliable communications system for coordinating the response; and provisions for disposal of recovered spill materials.

The Coast Guard reviews and advises the MMS as to the adequacy of industry oil spill contingency plans submitted to MMS. Criteria for evaluating plans have been defined jointly by the two agencies. The Coast Guard and MMS consider: 1) the adequacy of the risk analysis; 2) the adequacy of recovery equipment; 3) equipment availability; 4) the estimated response time; 5) provisions for periodic practice drills; 6) adequacy of support vessels; 7) dispersant equipment; 8) decision procedure for ordering ignition of an uncontrollable well; 9) disposal methods and sites; and 10) detection and monitoring provisions.

Oil spill contingency planning efforts of individual companies are supplemented by a statewide cooperative organization, Alaska Clean Seas (ACS). ACS has been organized to assist member companies in dealing with the possibility of a major spill. ACS maintains spill response equipment and supplies, provides staff assistance for contingency planning and training, and conducts research and development projects to advance the state of the art of oil spill containment and cleanup. ACS is divided into five cost-participation areas: the Beaufort Sea, Norton Sound, St. George Basin, the Gulf of Alaska, and the Navarin Basin. In all, sixteen companies have joined ACS, although memberships of each area vary according to company interests.

ABSORB, the Alaskan Beaufort Sea Oilspill Response Body, is under the ACS umbrella, and is the regional response organization for the Beaufort Sea. Equipment for use by members has been stockpiled at ABSORB's main warehouse in Prudhoe Bay. As far as equipment staging is concerned, industry preparations seem to be very good. In addition to providing supplemental equipment and expertise, ABSORB has studied the biology and shoreline characteristics of the Beaufort Sea, and has recently assembled an oil spill response considerations manual which synthesizes knowledge of the biological resources of the area. Industry points out, with some pride, that it has not yet been necessary to use ABSORB equipment. However, since there have not been any spill incidents, the capability of personnel to respond to spills under realistic conditions, remains unknown. Moreover, for large Arctic spills, it is likely that contractors from outside the region would have to be used. The Cook Inlet Response Organization could possibly also provide support for spills in the Arctic.

The Alaska Cooperative Oilspill Response Planning Committee functions in addition to the industry cooperative organizations. It consists of both industry (ACS) and government (State and Federal) representatives. Its purpose is to foster sharing of resources and technical expertise and to facilitate cooperative oil spill response.

State of Alaska

The Alaskan Department of Environmental Conservation requires that an oil spill contingency plan be approved (and renewed at least once every three years) for operations within State waters. Moreover, concurrence of the State in the adequacy of oil spill contingency plans must be obtained to the extent required the CZMA. Like the Coast Guard, if the State determines that containment and cleanup activities are not adequate, the department may undertake cleanup itself and/or may issue a contract for the cleanup. Where the Coast Guard has primary authority, the State may still authorize supplemental cleanup or containment efforts.

State contingency plans are similar in most respects to Federal requirements. Of special note, for Tier 2 approval the State requires that 500 in situ igniters be available within 6 hours of a spill, and that an additional 1,000 be obtainable within 48 hours of spill. The state also requires that 1,000 feet of fire resistent boom be stored on site, and that an additional 2,500 feet be available within six hours. In addition, plans must be submitted for drilling a relief well, and the decision process necessary to ignite a well must be outlined .37

[37] Alaska Departments of Environmental Conservation and Natural Resources, ' 'Final Finding and Decision of the Commissioners Regarding the Oil Industry's Capability to Clean Up Spilled Oil During Broken Ice Periods in the Alaskan Beaufort Sea' (June 1984).

Technology Development

Under the OCS Lands Act, the Federal government requires that the oil industry use the best available and safest technologies (BAST) in their drilling and production operations. Criteria exist for evaluating the adequacy of most equipment or processes, but there are as yet no standards for evaluating offshore oil spill cleanup technology. One problem is that it is difficult to determine what proportion of spilled oil is "adequate" to clean up or how much can reasonably be expected to be cleaned up in spill situations. The definition of "adequacy " is as much a political issue as a technological one. Neither the government nor the oil and gas industry is currently required to demonstrate which oil spill technology is best.

Three Federal agencies have small inhouse oil spill research and development programs: the MMS, the Coast Guard, and EPA. Total Federal funding for oil spill technology research has averaged less than $1 million per year over the past five years, One million dollars per year is considered small in view of: a) the unknown and/or inadequate capabilities of oil spill containment and cleanup technologies for frontier areas; b) the Administration's objective of accelerating OCS development; and c) the fact that the total economic costs of major spills may reach several hundred million dollars. Suggestions of the kinds of oil spill technology research needed are given in table 7-3.

Representatives from the U.S. agencies, along with the U.S. Navy and the Environmental Protection Service (EPS) of Canada, comprise the OHMSETT (Oil and Hazardous Materials Simulated Environmental Test Tank) Interagency Technical Committee (OITC). Although the Coast Guard has funded some Arctic and offshore spill technology research since the early 1970s, the OITC did not become involved in Arctic or offshore oil spill technology research until 1984. The objective of the OITC program is to evaluate oil spill countermeasures equipment and methods for OCS conditions. The OHMSETT test tank, located in Leonardo, New Jersey, has been used to evaluate Arctic oil spill technology. However, because this program is new and because there have

Table 7-3.—Oil Spill Technology Research Needs

Assessment of capabilities of existing oil spill equipment and techniques under realistic conditions
Field or large-scale tank tests of behavior of North Slope crude oil in cold water and in ice
Assessment of behavior of oil in a moving, broken ice field
Development of a portable oil spill response system to be used on tankers
Development of a containment boom that can be used in broken ice conditions
Development of better techniques for oil spill cleanup in shallow, nearshore waters
Development of better techniques for containing oil in scattered ice floes outside the protection of the barrier islands
Development of more effective igniters
Development of an oil spill recovery system that can be used on vessels-of-opportunity (vessels used to supply offshore operations)
Determine and record the properties of air and water-borne residues of in situ burning
Determine minimum boundary conditions for effective in situ burning (thickness, degree of weathering, containment requirements)
Refine fire resistant containment booms
Review dispersants for cold and open water applications

SOURCE: Office of Technology Assessment

been funding limitations, little testing of equipment for use in Arctic or deepwater areas has been accomplished to date.

The OITC has recently proposed a 5-year program for testing OCS booms and skimmers. This program would consist of three phases: 1) tank testing; 2) assessment of equipment capability at sea for seakeeping and durability (in accordance with a rigorous, pre-determined test protocol); and 3) exposure of the equipment under OCS conditions to intentional oil spills. The OITC also proposes to continue tests, begun in 1984, on the potential for mechanical recovery and ***in situ*** burning of oil in broken ice as a mitigation measure; to continue investigation of new technologies; and to take advantage, when possible, of spills-of-opportunity to gather equipment performance data.

The OITC program has been level-funded at $400,000 per year with the MMS, Coast Guard, and EPA each contributing about $125,000, and EPS contributing about $25,000. Continued funding at this level is considered unlikely in light of the budget constraints of the participating agencies. EPS participation is considered very important, since the Canadian agency also conducts spill research, the results of which are available to the OITC. The Coast Guard also contributes logistical support. Although the MMS has spent about $372 million (or an average of approximately $31 million per year) for OCS environmental studies since 1973, none of this money has been allocated for oil spill equipment research.

Since the 1970s, little industry or government effort has been given to developing technology or methods for the specific purpose of combatting oil spills in deepwater. As oil and gas activities increase in deeper and more distant waters, the continued use of conventional recovery equipment in these areas may need further analysis. In particular, technologies for open-ocean rough sea recovery and deepwater sea floor containment may need further development. However, the major difference between countermeasures problems in deepwater and spill problems nearshore is logistical rather than technological. Logistical concerns include how to transport the equipment needed to contain, recover, store, and dispose of oil to the spill site in a timely way.

The MMS is currently funding two engineering studies to deal specifically with deepwater subsea blowouts: 1) the feasibility of deploying a large self-contained collection ship capable of remaining on-station while collecting oil and gas from a blowing well using a subsea collector similar to that used in the Ixtoc 1 blowout (the ' 'sombrero' '); and 2) the feasibility of deploying a collection ship equipped with skimming booms to collect and separate oil in close proximity to a blowing well. Such a ship would have to be large enough to remain on-station in heavy weather and to store two to three weeks of recovered oil. The availability of such self-contained ships could possibly overcome many of the logistics problems related to deepwater spills; however, costs may be extremely high.