

REPORT
to
THE SECRETARY OF THE INTERIOR
from the
NORTH CAROLINA
ENVIRONMENTAL SCIENCES
REVIEW PANEL
as
MANDATED BY THE OIL
POLLUTION ACT OF 1990

JANUARY 22, 1992

**NORTH CAROLINA
ENVIRONMENTAL SCIENCES REVIEW PANEL**

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EXECUTIVE SUMMARY

INTRODUCTION

Background

The Oil Pollution Act of 1990, in a section cited as the Outer Banks Protection Act, prohibits the Secretary of the Interior from proceeding with a number of actions relative to development of oil and gas resources offshore North Carolina for which he is responsible under the Outer Continental Shelf Lands Act (OCSLA). Actions prohibited include: (1) conducting a lease sale; (2) issuing any new lease; (3) approving any exploration plan; (4) approving any development and production plan; (5) approving any application for permit to drill; and (6) permitting any drilling. The prohibition on these actions is mandated to remain in effect until the later of: (1) October 1, 1991 or (2) 45 days of continuous session of the Congress following the submission of a written report from the Secretary certifying that the information available to him is sufficient to carry out his responsibilities under the OCSLA.

In his report, the Secretary is required to take into consideration findings and recommendations of a panel established by the Outer Banks Protection Act, the North Carolina Environmental Sciences Review Panel, and to include a detailed explanation of any differences between his certification of sufficient information and the findings and recommendations of this group. The Panel is charged by the Act with: (1) assessing the adequacy of the available physical oceanographic, ecological, and socioeconomic information to enable the Secretary to fulfill his responsibilities under OCSLA and (2) identifying any additional information deemed essential to enable the Secretary to carry out these responsibilities. The Panel's response to this charge is the subject of this document.

Organization of the Review Process

As provided by the Outer Banks Protection Act, the North Carolina Environmental Sciences Review Panel is composed of five members, a marine scientist selected by the Secretary of the Interior, a marine scientist selected by the Governor of North Carolina, and three scientists, one each from the disciplines of physical

oceanography, ecology, and social sciences, selected jointly by the Secretary and the Governor from a list developed by the National Academy of Sciences.

The first meeting of the Panel was on January 28, 1991. This and subsequent Panel meetings were devoted to discussing and reaching agreement on the functioning of the group, an appropriate definition for adequacy of information, the scope and structure of the required report, conclusions regarding adequacy of information, and recommendations for implementing additional studies. To develop the report, individual Panel members carried out extensive reviews of available information, developed draft sections, and contributed to detailed discussions regarding revisions. All conclusions presented in the report were thoroughly considered at one or more Panel meetings. Unless specifically indicated in the text, the conclusions and recommendations presented in the report represent the unanimous decision of the Panel members. All meetings were announced in the Federal Register and were open to the public.

Geographic Area Considered

The Panel is directed to consider the adequacy of information for making decisions regarding oil and gas leasing, exploration, and development on the lands of the Outer Continental Shelf (OCS) offshore of North Carolina. There are presently 53 lease blocks in this area for which there are active leases for oil and gas resource identification and development. These leases were sold in 1981, 1982, and 1983 by the Department of the Interior's Minerals Management Service (MMS) and the Bureau of Land Management (BLM), MMS's predecessor organization.

Additional lease blocks are currently under consideration for leasing as part of a proposed 5-year (1992-1997) program of lease sales (U.S. DOI, 1991b). There is also one request presently pending which seeks approval of a plan for drilling one exploratory well in Manteo Area Block 467 (the Manteo site). This site is being proposed for drilling to test for oil and gas resources, not only in Block 467, but also in a wider, unitized Exploration Unit which includes this block and 20 other contiguous leased blocks (the Manteo Unit). Given the strong interest and public concern regarding this proposed exploratory well, the Panel especially focused on assessing the adequacy of information in the documents (U.S. DOI, 1990a; 1990b) which were developed by MMS specifically to support decision-making regarding oil and gas resource development for this site.

However, the Panel's report also includes a separate, broader and more general, consideration of the adequacy of information for the other parts of the OCS offshore of North Carolina, especially areas south of Cape Hatteras.

Adequacy of Existing and Need for Additional Information

A recent National Research Council (NRC, 1989) report evaluates the adequacy of the existing environmental information to support decision-making regarding development of oil and gas resources on the OCS of Florida and California. This NRC report uses a definition which judges adequacy on the basis of the completeness and scientific rigor of the available information. The Panel concluded that it was appropriate to adopt a consistent definition that judges adequacy using the same two elements.

The Panel notes and endorses recent changes in the focus of the Environmental Studies Program of MMS, which were catalyzed in part by a NRC review conducted some time ago (NRC, 1978). However, the Panel also concurs with a more recent NRC evaluation (NRC, 1989) which emphasizes the continuing need for a still greater commitment to the support of process-oriented studies by this program to assess potential impacts of OCS activities.

CONCLUSIONS

Area of Manteo Block 467

General information relating to the physical oceanography and ecology in the vicinity of Manteo Block 467 has been presented in the DOI decision documents for oil and/or gas resource development at this site. However this information is not sufficiently quantitative or process-oriented to provide an adequate understanding of potential impacts related to such development. Socioeconomic information for all phases of developmental activity ranges from inadequate to non-existent.

Although adequate in many respects for providing needed physical oceanography information, the present OSRA model is deficient in several aspects, including the failure to account for effects of short-term fluctuations in Gulf Stream dynamics. Simple estimates of errors associated with known current variability can make OSRA adequate for decision-making for exploration, however. Information

is inadequate relating to flow over the shelf north of Cape Hatteras, how oil from a spill at the Manteo Site may tend to concentrate along the Gulf Stream front, and how oil would disperse from the site of a potential pipeline rupture or tanker accident away from the drill site. With regard to the behavior of oil within the surf zone, the inlets, or the estuarine systems enclosed within the barrier islands, information is not as good as desirable, but it is adequate to assume that oil which approaches the coast will either beach or enter an estuary. Adequate information is presented on the fates and effects of drilling muds and cuttings as well as the secondary release of small amounts of contaminants from platforms or vessels.

A number of inadequacies of ecological information were identified in the DOI decision documents relating to all phases of exploitation of oil and gas resources. These result from incomplete ecological information and flawed interpretations rather than from failure to incorporate available information within the documents. Major inadequacies include absence of understanding of: (1) how physical/biological couplings drive intense utilization by top carnivores near the Manteo site, especially in the highly productive area identified as "the Point"; (2) the role of the Gulf Stream *Sargassum* community as vital habitat, not only for the reproduction and young of a number of recreationally and commercially important fishes, but also for juveniles of the five species of turtles identified in the Endangered Species Act; (3) the potential impacts of development on the benthic community adjacent to the Manteo Site; (4) impacts of an oil spill on the overwintering striped bass populations along the shallow waters off the Outer Banks; and (5) the mechanisms of transport, deposition, and impact of spills on the large offshore shoals found at the North Carolina capes.

Within the socioeconomic presentations in the DOI decision documents, there is little or no attempt to establish connections among social scientific variables or between these and physical and natural scientific properties or to analyze such relationships. For example, the effect of OCS-related activities on specific fish stocks, specific recreational or commercial fishermen who exploit such fish stocks, and the communities and industries that are dependent upon such activity are not fully characterized or analyzed. The potential impact of changing perceptions and attitudes concerning the marine and coastal environment on behavior patterns are another example of such relationships that are not fully characterized or analyzed. The general assumption contained within the DOI decision documents is one of "no significant impact", a

conclusion which may be warranted for certain aspects of the exploration/delineation phase, but is not justified beyond this for the development/production phase nor, for that matter, for the exploration/delineation phase as a whole. All OCS activity, especially during development and production such as has occurred in Alaska, Louisiana, and California, has a significant impact on the human environment including socioeconomic systems (Pettersen *et al.*, 1983; Wolf, 1991; Yarle, 1983). Whether or not we judge this impact to be, on balance, positive or negative is not the point here; the point is that there are significant impacts which must be adequately characterized and analyzed. Virtually all of the analyses relating to the costs and benefits of the proposed OCS activities do not warrant the conclusions presented in the DOI documents.

North Carolina OCS

Within the broad area of the North Carolina OCS, information on the physical oceanographic, ecological, and socioeconomic aspects is generally less adequate than that available for the Manteo site, largely because these areas are less well studied and the DOI decision documents were not developed with these areas as the primary focus. Physical oceanographic information was deemed inadequate relative to accidents and the possible distribution of oil spills.

Although much of the ecological information available regarding development at Manteo Block 467 is applicable to leasing in the North Carolina OCS area, inadequacies identified for that site are equally relevant to the North Carolina OCS. Additionally the available information is deemed inadequate to support leasing on the North Carolina OCS with regard to: (1) the role of ocean physics in determining the reproductive success of fish and shellfish in this region, (2) inventories of the seabirds present and the mechanisms controlling their abundances; (3) the distributions of cetaceans and turtles, especially the threatened and endangered ones; and (4), particularly for the area south of Cape Hatteras, information concerning primary and secondary production. Additionally, site-specific issues, including questions concerning appropriate monitoring studies, can be expected to arise, but these cannot be identified in advance of completion and analysis of recommended studies associated with the leasing phase and of further information on specific sites.

Conclusions relating to the adequacy of socioeconomic information within the the Manteo site decision documents also apply to the entire North Carolina OCS. However, there are considerably less data and information available that pertain to this broader region and thus, an even greater need exists for developing comparable data and information.

RECOMMENDED STUDIES

Area of Manteo Block 467

Specific studies are identified within the physical oceanographic, ecological, and socioeconomic areas for each of the four phases of operation.

Recommended studies in physical oceanography include the following:

(1) Development of improvements in OSRA specifically designed to provide better current field estimation and to better account for the effects of Gulf Stream meanders and cold dome eddies. Such improvements are currently under development.

(2) Development of OSRA submodels focusing on the nearshore regions of barrier islands, inlets, and estuarine regions inshore of the Outer Banks. Such an improvement is desirable, but not likely to be available in the near future.

(3) Major field efforts to characterize the current fields of the northern North Carolina shelf and of the region south of Cape Hatteras between the shelf and the Gulf Stream. The former study is underway and the second is only required if oil and gas developmental activities are to take place south of the Manteo block.

Also, in the event that it is demonstrated that the Gulf Stream frontal regions are critical habitats, it will be desirable to conduct studies of frontal convergence. These studies are needed only for development at the Manteo site as the presently available information is adequate for decision-making regarding exploration at this site. For the exploration phase at the Manteo site, the field studies called for in Item #3 above will not be required if OSRA can be shown to include realistic time-varying subsurface currents.

Recommended studies in the area of ecology include the following:

(1) Development of an understanding of the oceanographic and ecological processes acting on the North Carolina continental shelf and slope, largely to explain the functional basis for the distinctively intense use in the area of "the Point" by higher trophic level consumers. These studies should be initiated immediately and completed before delineation, but the initial exploration need not be delayed.

(2) An investigation on the dynamics of the *Sargassum* community focusing on the degree to which it represents a major habitat for sea turtles and in the recruitment of commercially and recreationally important pelagic fishes. This study should begin immediately and be completed before delineation.

(3) A survey of the benthic community in the area of the Manteo site to determine the geographic extent of the unusual aggregation of organisms in this region and, depending upon the extent, further studies to determine the recovery rate of these organism if covered by drilling discharges. The survey portion should be undertaken immediately and should be completed before exploration begins.

(4) Monitoring studies to determine possible increases in hydrocarbon levels within several indicator organisms, including *Sargassum*, one or two associated animals, and the Wilson's storm petrels.

The following studies dealing with the socioeconomics area should each require about one year and all should be completed before further permits are issued:

(1) Base case characterization analyses for the Manteo area. These should include not only standard aggregate data base analyses, but also characterization of the structure of relevant industries and the relationships among the private and public sector entities potentially affected by development of oil and gas resources in this area.

(2) Community studies involving the communities most likely to be affected by development at the Manteo site. These studies should cover the sociocultural variables

necessary for developing a contextual understanding of the role and effect of potential OCS activities in these communities.

(3) Pre-OCS activity perceptions of environmental conditions and values associated with potential oil and gas development at the Manteo site.

(4) Infrastructural impacts of development at the Manteo site including consideration of the impacts on all potentially affected areas related to revenue sources, distribution of financial burdens, and certain sociopolitical variables.

(5) Design of a comprehensive, longitudinal socioeconomic monitoring program which should be implemented prior to the issuance of drilling permits.

These recommended studies are focused primarily on the needs for socioeconomic information to support the leasing and exploration phases. For the development/production phase, similar studies will be needed, but ones that are significantly increased in the breadth and depth of the geographical areas and magnitude of impacts considered.

Socioeconomic studies are also recommended specifically for the post-production phase; these should be designed to consider questions about the maintenance of the infrastructure developed because of OCS production, the displacement effects for employees of related industries, and the restoration or replacement of pre-developmental activities and human environments.

North Carolina OCS

In light of the fact that there is much less information available for Panel review pertaining to the potential impacts of development on the North Carolina OCS than for the specific area of the Manteo site, expanded versions of most of the studies recommended for that site would be required to provide adequate information on physical oceanography, ecology, and socioeconomics over the North Carolina OCS.

The additional physical oceanographic studies should include the following:

(1) Detailed assessments using OSRA calculations and an evaluation of their potential errors for all sites under consideration for leasing (required for leasing phase);

(2) Current meter measurements at potential drilling sites and at locations away from these sites that will provide improved information with which to estimate the fate of spills both at the sites and from service vessels along their paths to the sites (required for exploration phase); and

(3) Expanded shelf circulation studies of the region through which gas and/or oil will be transported from producing wells (required for development phase). (This item may be unnecessary if OSRA is proven to incorporate realistic time-varying subsurface currents.)

Additional studies involving ecology should include the following:

(1) The development of a better understanding of the relation between cross-shelf water movements and the reproductive success of estuarine-dependent fishes and shellfish that use the shelf for reproduction;

(2) A survey of the seasonal patterns in distribution and abundance of seabirds in relation to circulation patterns; and

(3) An expansion of the ongoing South Atlantic assessment of the occurrence of marine mammals and sea turtles to include all of the area offshore North Carolina.

Other ecological studies will likely be required, but these can only be defined after specific sites for drilling have been proposed.

The recommended socioeconomic studies all involve expansion of the studies that have already been recommended for the Manteo site. These expanded studies will need to be tailored to the specific sites and socioeconomic systems involved with the OCS activities under consideration.

It is also recommended that MMS obtain and use a Geographic Information System for the area of the North Carolina OCS to facilitate the identification, assemblage, review, and analysis of the considerable body of scattered information and data available for this area.

A summary of the studies recommended by the Panel to initiate decision-making at each of the four phases is presented for the Manteo Site and for the North Carolina OCS in Table 1.

Table 1. A Summary of the Studies Recommended to Obtain Adequate Information to Initiate Decision-making at Each of the Four Phases of Oil and Gas Exploitation for the Manteo Site and on the North Carolina OCS.

<u>PHASE</u>	<u>MANTEO SITE</u>	<u>NORTH CAROLINA OCS</u>
Leasing	<p>(As leasing has already been carried out for the area of the Manteo site, it is not pertinent to recommend studies to support this phase in this area.)</p> <p><u>Physical Oceanography</u> No Studies Required (p. 30)</p> <p><u>Ecology</u> No Studies Required (p. 46)</p> <p><u>Socioeconomics</u> No Studies Required (p. 60)</p>	<p><u>Physical Oceanography</u> OSRA (p. 33)</p> <p><u>Ecology</u> <i>Sargassum</i>, Community Dynamics (p. 55) Use of NC Shelf for Fish Reproduction (p. 55) Seabird Survey (p. 56) Cetacean and Turtle Assessment (p. 56)</p> <p><u>Socioeconomics</u> Base Case Characterization (p. 66, a) Community Studies (p. 66, a) Aesthetic & Perceptual Issues (p. 66, a) Infrastructural Issues (p. 66, a) Socioeconomic Monitoring (p. 66, a & d)</p>
Exploration/Delineation	<p><u>Physical Oceanography (f)</u> No Studies Required (p. 30)</p> <p><u>Ecology</u> Benthic Community Survey & Recovery (p. 48, c) Ecosystem Dynamics at the "Point" (p. 47, c) <i>Sargassum</i> Community Dynamics (p. 47, c)</p> <p><u>Socioeconomics</u> Base Case Characterization (p. 63, b) Community Studies (p. 64, b) Aesthetic & Perceptual Issues (p. 64, b) Infrastructural Issues (p. 64, b) Socioeconomic Monitoring (p. 64, b & d)</p>	<p><u>Physical Oceanography</u> OSRA Error Assessments (p. 33)</p> <p><u>Ecology</u> No Studies Identified (p. 60)</p> <p><u>Socioeconomics</u> Base Case Characterization (p. 66, b) Community Studies (p. 66, b) Aesthetic & Perceptual Issues (p. 66, b) Infrastructural Issues (p. 66, b) Socioeconomic Monitoring (p. 66, b & d)</p>

PHASE	MANTEO SITE	NORTH CAROLINA OCS
Development/Production	<u>Physical Oceanography</u> Shelf Circulation (p. 31) <u>Ecology</u> Monitoring of <i>Sargassum</i> Community Contamination (p. 49, d) Oil on Cape Shoals (p. 49) Aggregations of Striped Bass (p. 49) <u>Socioeconomics</u> Base Characterization (p. 64, a) Community Studies (p. 64, a) Aesthetic & Perceptual Issues (p. 64, a) Infrastructural Issues (p. 64, a) Socioeconomic Monitoring (p. 64, a & d)	<u>Physical Oceanography</u> Shelf Circulation/Moorings (p. 34) <u>Ecology</u> No Studies Identified (p. 57) <u>Socioeconomics</u> Base Characterization (p. 66, a) Community Studies (p. 66, a) Aesthetic & Perceptual Issues (p. 66, a) Infrastructural Issues (p. 66, a) Socioeconomic Monitoring (p. 66, a & d)
Post-production (e)	<u>Physical Oceanography</u> No Studies Identified <u>Ecology</u> Sea Turtle Attraction Study (p. 50) <u>Socioeconomics</u> Post-production study (p. 65)	<u>Physical Oceanography</u> No Studies Identified <u>Ecology</u> Sea Turtle Attraction Study (p. 57) <u>Socioeconomics</u> Post-production study (p. 66)
All Phases		<u>General</u> Geographic Information System (p. 66)

- (a) Regional in scope
- (b) Site-specific in scope
- (c) Studies should be initiated immediately and should be completed before delineation is approved
- (d) Monitoring design completed before identified phase but activity continued through post-production phase.
- (e) Required before approval of production phase
- (f) Although no specific new studies are recommended, further analyses and interpretation of OSRA results are needed in the decision documents (p. 30).

INTRODUCTION

BACKGROUND

The Oil Pollution Act of 1990 contains a section, cited as the Outer Banks Protection Act, which prohibits the Secretary of the Interior from taking a number of actions under the Outer Continental Shelf Lands Act (OCSLA) regarding oil and gas resource development on lands offshore of North Carolina. These prohibited actions are: (1) conducting a lease sale, (2) issuing any new lease, (3) approving any exploration plan, (4) approving any development and production plan, (5) approving any application for permit to drill, and (6) permitting any drilling. The prohibition on these actions is mandated to remain in effect until the later of: (1) October 1, 1991 or (2) 45 days of continuous session of the Congress after the submission of a written report to the Congress from the Secretary of the Interior certifying that the information available is sufficient to enable the Secretary to carry out his responsibilities under OCSLA with respect to the actions listed above. The Outer Banks Protection Act mandates that the report from the Secretary shall take into consideration the findings and recommendations of a panel established by the Act, the North Carolina Environmental Sciences Review Panel, and shall include a detailed explanation of any differences between the findings and recommendations of this panel and the Secretary's certification of sufficient available information.

The Act charges the North Carolina Environmental Sciences Review Panel with: (1) assessing the adequacy of the available physical oceanographic, ecological, and socioeconomic information for enabling the Secretary to carry out his responsibilities under OCSLA with respect to the actions listed above and (2) recommending studies to obtain the additional information required to enable the Secretary to carry out these responsibilities if the available information is judged inadequate. The following presents the report of this Panel as called for under the Outer Banks Protection Act.

ORGANIZATION OF THE REVIEW PROCESS

The Outer Banks Protection Act specifies that the North Carolina Environmental Sciences Review Panel shall consist of the following five members: (1) a marine scientist selected by the Secretary of the Interior; (2) a marine scientist selected by the Governor of the State of North Carolina; and (3) one scientist from each of the disciplines of physical oceanography, ecology, and social science selected jointly by the Secretary of the Interior and the Governor of North Carolina from a list nominated by the National Academy of Sciences. The members selected to serve on the Panel were: (1) Dr. John Teal, Woods Hole Oceanographic Institution; (2) Dr. John Costlow, Duke University Marine Laboratory; (3) Dr. Kenneth Brink, Woods Hole Oceanographic Institution; (4) Dr. Charles Peterson, Institute of Marine Sciences, University of North Carolina - Chapel Hill; and (5) Dr. Michael Orbach, East Carolina University. Dr. Costlow was elected by the Panel at its first meeting to serve as chair.

This Panel met a number of times to discuss how the group should function, the scope and structure of the Panel's report to the Secretary, the appropriate primary sources of information, and to reach agreement on the conclusions and recommended studies that should be included in the report. All meetings were announced in the Federal Register and open to the public. The Panel members accepted responsibility for writing initial drafts of specific sections of the report. Each Panel member carried out an extensive review of the available information and then wrote draft sections that were discussed at the the Panel meetings and then revised. All the conclusions reached in this report were thoroughly considered at one or more Panel meetings. They represent the collective judgement of the Panel, except in the few instances, identified in the text, where the Panel members did not reach complete consensus.

The Outer Banks Protection Act directs that the report of the North Carolina Environmental Sciences Review Panel be submitted to the Secretary of the Interior not later than six months after its enactment, which was on August 18, 1990. However, the Panel was not established until December 28, 1990 and was not able to hold its first meeting until January 28, 1991. At this meeting it was determined that it would not be possible to develop a satisfactory report within the schedule called for by the Act and that the Panel

would proceed to develop the report for submission as soon as reasonably possible.

GEOGRAPHIC AREA CONSIDERED

The Outer Banks Protection Act directs the Panel to assess the adequacy of the available information for making decisions regarding oil and gas leasing, exploration, and development, "on any lands of the Outer Continental Shelf offshore North Carolina" (Sec. 6003, Oil Pollution Act of 1990). It includes in these lands the area within the lateral seaward boundaries that separate offshore North Carolina from areas offshore Virginia on the north and from areas offshore South Carolina on the south, as already specified by bilateral state agreements, ratified by the U.S. Congress.

There are presently 53 lease blocks within this area for which active leases for identification and development of oil and gas resources have been issued by the Department of the Interior's Minerals Management Service (MMS) or its predecessor, the Bureau of Land Management. These blocks were leased in 1981 (Lease Sale 56), 1982 (Resale 2 of Lease Sale 56), or 1983 (Lease Sale 78). Additional lease blocks are on the list for consideration for leasing under the proposed 1992-1997 5-year program for lease sales (U.S. DOI, 1990b). Presently there is one request pending for approval of a plan for drilling one exploratory well in Manteo Area Block 467 (hereafter referred to as the Manteo site). This site is being proposed for drilling to test for hydrocarbon potential not only in Block 467, but also in a wider unitized Exploration Unit including this block and 20 other leased blocks (hereafter referred to as the Manteo Unit) in the vicinity of this site (U.S. DOI, 1990b).

Because of the proposal for drilling at this location, there has been a great deal of interest and public concern focused on this area, and a large amount of information has been acquired and synthesized to aid in assessing the potential impact of the discovery and development of exploitable hydrocarbon resources at this location. Given this interest and the fact that decisions regarding exploratory drilling at the Manteo site are presently under consideration, the Panel decided to direct its attention especially to assessing the adequacy of information for making decisions regarding oil and gas development in this area. This report considers the adequacy of information for the Manteo site, assessing the specific reports developed by MMS and others to evaluate potential impacts from drilling at this site, separately from much broader consideration of

the adequacy of information to support oil and gas development for the whole of the outer continental shelf (OCS) offshore of North Carolina.

The information available for areas away from the Manteo Unit has not been gathered together and synthesized by MMS to anywhere near the extent as has been done for the Manteo area. Thus, it is a more difficult task to judge the adequacy of this diffuse body of information that is scattered throughout the scientific literature as well as in unpublished reports and data sets than to judge the adequacy of the Manteo information.

SOURCES OF INFORMATION

A large body of reports, articles, and other documents was reviewed by the Panel during the development of this report. Some of these are referenced in the text, and all are listed in Appendix A.

During its deliberations, the Panel especially focused its attention on the proposed exploratory drilling at the Manteo site and on the adequacy of the information contained in the two primary documents developed by MMS to support decision-making with regard to exploratory drilling at this site. The first of these documents, the *Final Environmental Report on Proposed Exploratory Drilling Offshore North Carolina* (U.S. DOI, 1990a), was developed by MMS in response to a Memorandum of Understanding (MOU) that this agency signed in July 1989 with the State of North Carolina and Mobil Oil Exploration & Producing Southeast Inc. It provides an in-depth analysis of the issues and concerns, as identified in the MOU, regarding the proposed exploratory drilling at the Manteo site. The second document, *Environmental Assessment of Exploration Plan for Manteo Area Block 467* (U.S. DOI, 1990b), provides the information needed to decide, as required by the National Environmental Policy Act, whether the exploratory drilling proposed by Mobil at the Manteo site is a major Federal action that will significantly affect the quality of the human environment. The Environmental Report contains an immense amount of material and is the primary document integrating and synthesizing the information available with regard to the Manteo site. The Environmental Assessment is a much shorter document that summarizes the Environmental Report information and refers the reader to the appropriate sections of the Environmental Report for more specific information on various aspects. A third document, the *Mobil Exploration Plan: Manteo Area Block 467 Offshore Atlantic* (MOEPSI, 1990), also contains a detailed

review of the data and information available for the Manteo site and was drawn on extensively by the Panel in its evaluation of the adequacy of the available information.

ADEQUACY OF INFORMATION

A recent National Research Council (NRC, 1989) report that reviews the adequacy of environmental information for OCS oil and gas decisions off Florida and California chose a definition for adequacy that was comprised of two components: the completeness of the information and the scientific rigor of the information. While there is no requirement that the North Carolina Environmental Sciences Review Panel adopt an identical working definition of adequacy, the Panel concluded that consistency with this report was appropriate and that a definition for adequacy should involve both of these components of scope and quality.

It is entirely logical to argue that different types and escalating levels of information are required for adequate environmental review and decision-making at each subsequent stage in the process: leasing, exploration and delineation, development and production, and post-production. Each stage implies different types and intensities of activity as well as different potential environmental impacts. Impacts are difficult to assess in the absence of specific information on the extent and type(s) of petroleum resources present, as this requires exploring and evaluating extensive and elaborate hypothetical scenarios to cover all feasible alternatives. The geophysical information available prior to exploratory drilling does not permit accurate prediction of the types and extents of the petroleum reserves present. Furthermore, the costs of much of this hypothetical evaluation and additional information gathering are not insignificant and may represent unnecessary expenditures if the petroleum reserves discovered prove inadequate to develop economically. In addition, the process of weighing potential environmental impacts against the economic and strategic benefits of developing the reservoir is difficult to conduct in the absence of reliable information on the size of the petroleum reserves. All these considerations speak in support of a phased, accumulative process of information gathering and decision-making.

Despite the logic supporting a phasing of the OCS information-gathering and decision-making process, there exists widespread perception that once a lease is sold all subsequent phases of exploitation, *i.e.*, exploration, delineation, development, and

production, will necessarily follow if the lessee requests the appropriate permits. There is little evidence in the historical record of DOI decision-making to contradict this perception. Drilling plans and procedures have indeed been modified upon review of environmental issues, but the Panel is not aware of any instance where a development and production plan has been ultimately rejected by DOI. The very act of leasing carries with it presumption of rights to explore, and subsequently to develop and produce from that tract. The large sums of money paid for the leases and the high costs of the exploratory drilling, especially in OCS areas, render difficult, costly, and inefficient any revocation of exploration, development, or production rights after the initial leasing decision. If this perception of the decision-making process is correct, this implies a need for much more intensive and extensive information gathering and impact analysis at the preleasing stage than if stop-or-go decisions about development and production are truly made later by DOI.

The Panel devoted substantial effort to reaching a working definition of what constitutes adequacy of information to permit informed decision-making during the OCS process. Some considerations that have bearing on this are discussed in Appendix B. Despite these efforts, the definition of adequacy remains somewhat subjective. The Panel's definition is based upon the mandate for the MMS Environmental Studies Program, as provided in the OCSLA as amended in 1978, and upon various precedents provided by other review panels and standards of practice by MMS in other geographical regions. The application of precedents applied elsewhere is the most defensible means of reaching an objective standard definition of adequacy of environmental information. Consistency across regions also implies fairness of equal treatment.

Under OCSLA the Environmental Studies Program of MMS has two primary objectives. First, it must acquire information needed for the "assessment and management of environmental impacts on the human, marine, and coastal environments of the OCS and the coastal areas that may be affected by oil and gas development" (OCSLA Amendments of 1978, Section 208) in any proposed leasing area. Studies must be "designed to predict impacts on the marine biota which may result from chronic low-level pollution or large spills associated with OCS production, from the introduction of drill cuttings and drilling muds in the area, and from the laying of pipe to serve the offshore production area, and the impacts of development offshore on the affected coastal areas" (OCSLA Amendments of 1978, Section 208). The second objective of the Environmental

Studies Program is to "monitor the human, marine, and coastal environments" (OCSLA Amendments of 1978, Section 208) of leased areas "to provide time-series and data-trend information which can be used for comparison with any previously collected data for the purpose of identifying any significant changes in the quality and productivity of such environments, for establishing trends in the areas studied and monitored, and for designing experiments to identify the causes of such changes" (OCSLA Amendments of 1978, Section 208).

The OCSLA also requires that OCS activities be carried out in distinct phases - leasing, exploration, and development. The North Carolina Environmental Sciences Review Panel recognizes this phased nature of the OCS process and has realized that the amount and types of information required will likely change at each successive stage.

The Panel's primary source of precedent-setting standards for an operational definition of informational adequacy was the NRC (1989) report on *The Adequacy of Environmental Information for Outer Continental Shelf Oil and Gas Decisions: Florida and California*. Because of the broad geographic and conceptual mandates for this report and because of the repute of the NRC, the working definitions of adequacy it contains seem likely to be generally applied. Indeed, the subsequent presidential moratorium on leasing and other OCS activities in many OCS areas for the purpose of assemblage of needed additional environmental information is one demonstration that these standards are being broadly applied. A major motivation for the establishment of this North Carolina Environmental Sciences Review Panel was to assess the degree to which these standards of informational adequacy were appropriately applied to the North Carolina OCS area when North Carolina was not included within the areas covered by the moratorium. The Panel took further note of the MMS studies planned prior to leasing of the Oregon and Washington OCS area as another indication of the extent of the information on the environment being produced in advance of OCS activities elsewhere.

DEFINITION OF OPERATIONAL PHASES

Throughout this document the overall process of identifying and utilizing petroleum hydrocarbon resources on the OCS is considered to be divided into four phases. These phases are steps in a sequential process with additional business and regulatory decisions

being required in order to initiate and carry out each of these phases. The adequacy of available information has been judged separately for each of these phases. They are defined below largely following U.S. DOI (1986, 1987) documents.

Leasing--The process by which a contractual agreement is reached between the Federal Government and industrial concerns granting the privilege for those concerns to explore for, develop, and produce oil and gas on given areas of U.S. OCS lands. The leases are granted for periods of five years or for up to ten years where, because of deep water or other unusually adverse conditions, it is judged necessary in order to encourage exploration and development.

Exploration/delineation--The process of searching for and determining the extent of oil and gas resources in a lease area in order to allow the lessee to decide whether to proceed with development and production in that area. During this phase geophysical surveys may be conducted and exploratory wells drilled to identify oil and gas resources and additional wells may be drilled to delineate these reservoirs.

Development/production--This is the process during which commercially exploitable oil and gas resources are extracted from OCS lease areas and are transported from the lease areas to land-based receiving facilities. This phase includes the drilling and completion of producing wells and then the extraction, separation, treatment, storage, measurement, and transport of the petroleum hydrocarbon and associated fluids from these wells.

Post-production--This is the process of closing down production facilities after extraction of oil and gas resources has ended. It includes dismantling and removal of production facilities on the OCS and the shutting down or redirection of activities at associated sea- and land-based facilities.

EVOLVING FOCUS OF THE MMS ENVIRONMENTAL STUDIES PROGRAM

The focus of the ecological studies of the MMS OCS Environmental Studies Program has changed over time and will continue to change. Its early emphasis was the collection of extensive baseline survey information on the distribution and abundance of the biological resources of the continental shelf environments. These efforts have produced substantial contributions to marine ecology by: (1) improving dramatically the existing knowledge of the distribution and abundance of pelagic seabirds and of marine mammals; (2) characterizing the benthic communities of the shelf; and (3)

discovering and cataloguing the previously undescribed phylogenetic richness of benthic invertebrates on the continental shelves and slopes of the United States. While Federal research programs within the National Science Foundation have only recently been developed to describe the biodiversity of global ecosystems, oriented primarily towards tropical rain forests, MMS has long been funding projects that collect and describe new species of benthic invertebrates from the continental margins. For example, the benthic studies of Blake *et al.* (1987) off the Carolinas recorded 1202 species of infaunal invertebrates, of which 520 were new to science. These achievements of this program are substantive and important.

In part because of the success of these surveys and in part because of maturation of the sciences of ecology and environmental assessment, the Environmental Studies Program of MMS has changed in a direction of becoming more process-oriented. This change was catalyzed by a NRC review in 1978, which recommended an emphasis on the prediction of impacts of OCS activities and on establishment of cause-effect experiments to establish the vulnerability of key species and communities (NRC, 1978). The most recent NRC review of OCS activities (NRC, 1989) calls for a much greater commitment to process studies by MMS.

The Panel endorses this further change in focus of MMS's Environmental Studies Program. However, the aims of MMS can and should remain explicitly focused on gaining understanding of those processes of most critical significance to predicting impacts of OCS activities. In the absence of a basic scientific appreciation of the fundamental environmental processes, the knowledge required for reliable prediction of impacts is inadequate. Because this need for process understanding overlaps the purview of other agencies, MMS should be encouraged to take advantage of a variety of ongoing and planned programs by those agencies. Collaboration with those programs through augmentation of studies so as to provide missing elements that serve the specific goals of MMS would seem cost-effective and likely to achieve a more rigorous and complete understanding of ecological relationships. This would also mean a change in operating procedure from the traditional short-term contracting mode to one in which longer-term collaboration with basic research scientists in universities and Federal laboratories is employed. This is in fact one recommendation of the task force for OCS activities on the Oregon and Washington area, and this panel concurs.

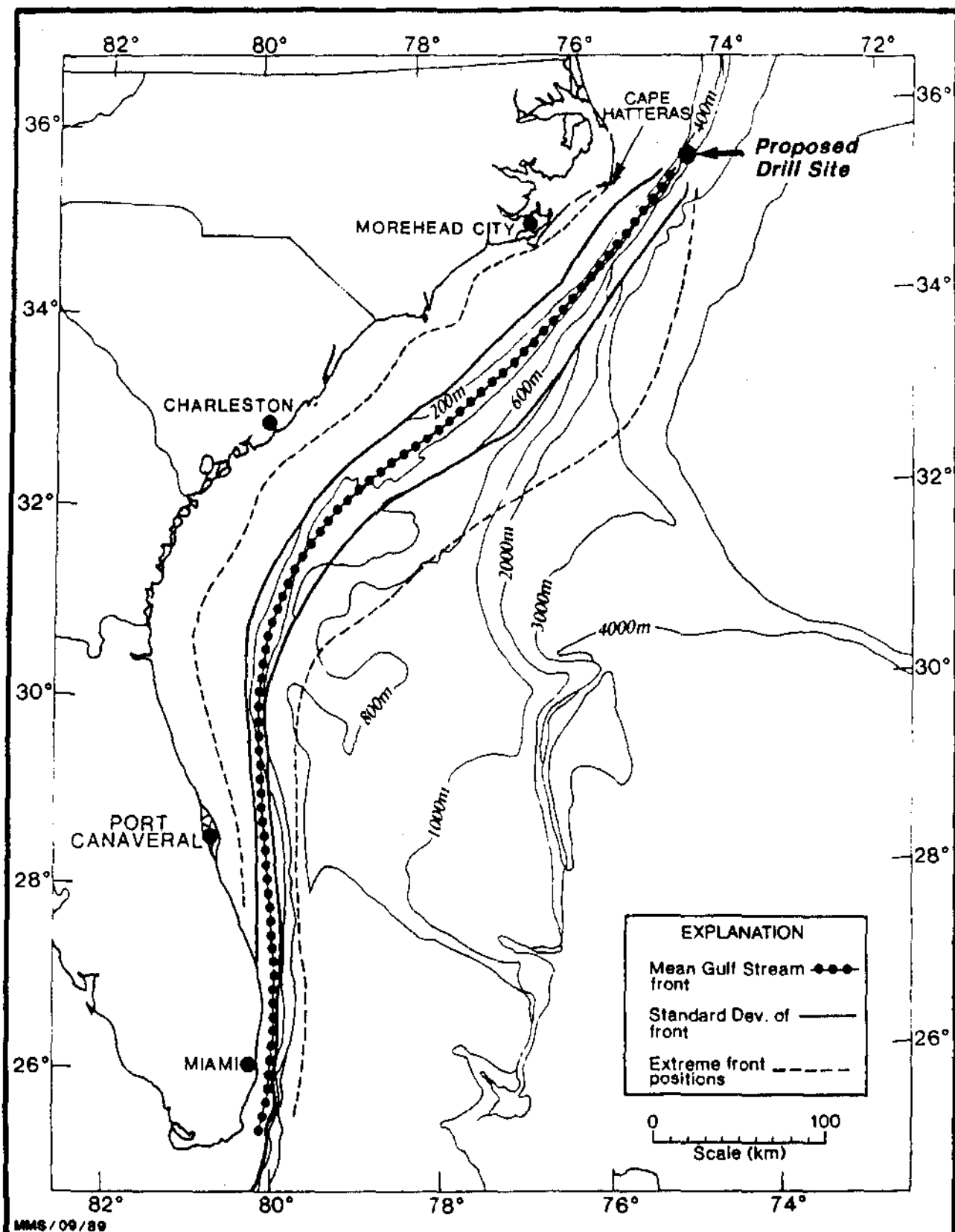
SUBJECT OVERVIEW

PHYSICAL OCEANOGRAPHY

Area of Manteo Block 467

The dominant oceanographic factor in this region is the Gulf Stream, a strong (>100 cm/sec), persistent western boundary current. Although its exact location can vary, it is typically found somewhere offshore of the 100 m isobath off the Carolinas (Figure 1). Using the MMS Oil Spill Risk Assessment (OSRA) model assumption that oil moves with the current plus 3.5% of the wind speed, the mean current (140 cm/sec based on SAIC (Science Applications International Corporation), 1990) at the Manteo site is equivalent to a hurricane-strength 40 m/sec wind. Thus, oil spill transport at the Manteo site will be dominated by the Gulf Stream currents.

The OSRA model is the main tool used by MMS in the decision documents for the Manteo site to estimate the probability of an oil spill encountering resources, both on the coast and offshore. It uses seasonal-average currents derived from a diagnostic numerical model, where the main inputs are historical, seasonally averaged, hydrographic (temperature, salinity, and density) data and seasonal mean wind fields. In running the model, these nearly constant currents, along with the time-varying wind fields which move the oil at an additional 3.5% of the instantaneous wind, advect the model oil spill. The wind field can either be a synthetic field (based on the statistics of locally observed winds) or actually observed winds from the area (as used for the North Carolina case). The approach is simple, but it is reasonable. The main problem with the approach is that the current fields used are necessarily heavily smoothed in space and time, and hence tend to give currents that are much slower and less richly structured than those observed at any given time. Creating accurate and proven models is a difficult task. However, MMS is presently making a considerable effort to improve their ocean current models, and there is reason to believe that these may prove to be useful inputs to OSRA within the next several years. A lack in the MMS decision documents is that they do not specifically address the probability of long-duration spills encountering the coast. However, these probabilities are readily treated using OSRA outputs.



Source: Adapted from General Oceanics, 1986

Location of the mean, standard deviation, and extreme positions of the Gulf Stream front

Two factors mitigate the dominant presence of the Gulf Stream off of North Carolina. First, cold dome eddies (associated with Gulf Stream "filaments") propagate alongshore from the southwest, at a speed of about 40 cm/sec, about every 5 days (see Atkinson *et al.*, 1989 for greater detail). These eddies cause brief periods of onshore flow at the shelf break of about 20 cm/sec. These features become less frequent toward the northeast, appearing only about 9-15% of the time near the Manteo site. A second important aspect of the variability is meanders, where the Gulf Stream shifts offshore, leaving behind weak currents which allow winds to dominate the oil spill transport. A recent SAIC (1990) report demonstrates that satellite data have only partial skill at detecting these meanders. At the Manteo site, these displacements occur about 20% of the time. In either case, it seems unlikely that an oil spill originating from the Manteo site would reach the coast in less than about one day, and then only in extreme circumstances.

Both the cold dome eddies and the meanders act to enhance the probability of shoreward (and offshore) transport in comparison to the situation when the undisturbed Gulf Stream is present. Neither of these phenomena is represented in the OSRA model calculations summarized in the Environmental Report (U.S. DOI, 1990a). If onshore winds are blowing (which occurs 28% of the time) at the time of a spill and at the same time one of the above phenomena is occurring and if the onshore winds are sustained long enough, it is likely that the spill will encounter the coast. Assuming that the winds are, in fact, sustained for long enough, the instantaneous probability of the appropriate conditions can be estimated at about 10% ($=28\% \times (15\% + 20\%)$). This is a conservative estimate, partly because it is not clear that the probabilities of meanders and eddies are additive, and partly because of the assumption that any onshore wind in these circumstances is adequate to get an oil spill to the coast. The point about the wind can be readily addressed by running OSRA with no currents to improve (decrease) the 28% estimate. Similar sorts of refined risk assessments can be made for other "target" areas used in the OSRA calculations. The OSRA results presented in the Environmental Report are likely too optimistic, although they can be readily refined as described above.

Adequacy of All Information

Adequate information exists in terms of general physical oceanographic knowledge to support decision-making concerning leasing for the Manteo area. However, it would have been desirable

to do OSRA runs before conducting lease sales to gain a rough idea of what potential lease sites might pose particular environmental dangers to valuable resources. This desirability is somewhat tempered by the fact that the present OSRA model excludes important time variability in the currents, especially cold dome eddies and Gulf Stream meanders. In addition, the current inputs for the OSRA model include a time-averaged Gulf Stream which is much slower (typical peak speeds of about 50 cm/sec) than the true currents.

When the exploration/delineation phase is considered, the issue of mud and cutting discharges becomes pertinent. The fate of these discharges depends on local currents, which are now well-characterized for the Manteo site. Physical information in relation to these discharges is adequate, in that measurable deposition is likely to be confined to within a few kilometers of the drill site.

The available information is also generally adequate to estimate encounter probabilities for spills that may occur during the exploration/delineation phase. This conclusion is based on the assumptions that an oil spill during this phase will likely occur only at the drill site platform and that the errors for the OSRA calculation (as performed for the Manteo site) are well enough understood to make these estimates. This is not to say that the information is as good as would be desirable. For example, the present understanding of how the oil from a spill at the Manteo site, either during this phase or during development and production, might tend to concentrate along the Gulf Stream front is inadequate. Better understanding of this process is important if the front proves to be a preferred site for *Sargassum*-related communities and endangered sea turtles. This weakness reflects a general lack of quantitative physical knowledge on the tendency for frontal convergence. Drifter studies could provide some useful information on this subject.

Information is also adequate both for estimating the risks involved if a service vessel accident should occur near the drill site and for a service vessel accident near the coast, where it seems fair to assume a 100% probability of damage to local environmental assets.

However, should a pipeline rupture or tanker wreck occur over the continental shelf and away from the site, especially north of Cape Hatteras, the existing knowledge of the physical oceanographic features is so limited that no useful risk assessment could be made. A recent report by Atkinson *et al.* (Anonymous, 1991) makes specific recommendations for oceanographic studies to address this problem

for the area north of the Manteo site. These studies will be initiated by February 1992.

The main issue related to the routine operations of the development/production phase at the Manteo site is the release of muds and cuttings. In this regard, the existing physical knowledge is adequate. A secondary issue is the release of small amounts of contaminants from platforms or from vessels serving the platforms. The physical problems associated with these are essentially those presented by spills. In terms of releases at a Manteo 467 platform, the OSRA results, combined with an assessment of their errors, represent adequate knowledge to characterize the area of measurable deposition.

For discharges from ships serving the platform during routine operations, the physical knowledge is not adequate in that there is not enough information to evaluate the performance of OSRA over the continental shelf and in other locations away from the drill site. Although high levels of contaminants are presumably not involved, more should be known about the physical oceanography of sites away from the platform, especially north of Cape Hatteras because of the potential for Norfolk to be a staging area for drilling operations.

The physical oceanographic information related to accidents at the drilling site during production, although quite limited, is generally adequate for decision-making. The Panel recognizes that, in most cases, an oil spill at the Manteo site would be rapidly advected offshore in the Gulf Stream, while the instantaneous probability of the conditions occurring that may result in a spill reaching the coast is less than about 10%. Moored current meter observations, obtained by SAIC (1990), establish approximately how often strong Gulf Stream currents exist at the site. This information can be used to improve on the OSRA risk assessments. However, should an accident (such as a pipeline rupture, service vessel collision or fire, or tanker wreck) occur away from the site, especially inshore or to the north, far too little is known about the currents over these areas to make a reasonable risk assessment. Completion of the study recommended by Atkinson *et al.* (Anonymous, 1991) will make the information base adequate if Norfolk is used as a staging area, but a comparable study will be required focusing farther south if a more southern port, such as Wilmington or Charleston, is chosen as the staging area. Further, as pointed out before, frontal convergence issues could be a problem if it is demonstrated that fronts are important habitats for endangered species.

Adequacy of DOI Decision Documents

The Environmental Report (U.S. DOI, 1990a) and the Environmental Assessment (U.S. DOI, 1990b) give good general descriptions of the physical phenomenology in the region of the Manteo site. The descriptions are not, however, very quantitative with regard to physical oceanography.

The documents are not adequate in that the physical risk assessment is based on a literal interpretation of OSRA results. Specifically, time variability of the currents is not included. The errors associated with this have been discussed and crudely quantified above. Further, the reports do not discuss risk enhancement associated with a prolonged spill. Again, addressing this problem involves a straight forward extension of existing results. Although the documents are judged inadequate for these reasons, information is readily available to make the information base for decision-making adequate for the exploration phase.

Recommended Studies

Leasing

The Panel strongly endorses the improvements in OSRA (specifically, improved current field estimation through numerical models) which MMS is presently pursuing. In addition, OSRA does not include submodels specifically for the nearshore region or for inlets in the coastline. It would be desirable to develop and include such improvements to the models (which will not be simple), especially for situations, such as that for North Carolina, where there are significant resources in the estuarine regions inshore of barrier islands.

Exploration and Delineation

While it would be desirable to carry out studies to parameterize and quantify frontal convergence, the state of physical knowledge and instrumentation is such that it seems unlikely that any major progress will be made in this area within the next five years. Thus, it is not clear that it is reasonable to expect MMS to address this shortcoming in the near future.

It would also be desirable, although not critical for this stage, to have a better understanding of how oil behaves as it enters the surf zone. Further, it would be desirable to understand how much oil would enter the estuarine system and what its residence time would be under various spill scenarios. For the time being, though, it is adequate to assume the worst. However, it should be noted that there is no discussion of these issues in the Environmental Report.

Development and Production

To help predict the fate and effects of oil spills associated with development at the Manteo site, studies of the physical oceanography over the North Carolina shelf are needed as outlined in the Atkinson *et al.* (Anonymous, 1991) report. Carrying out these studies will lead to adequate information if Norfolk is the staging area, but comparable studies farther south will be required if a more southerly port is used. Assuming Norfolk as the staging area, a major field study of the northern North Carolina shelf and the region between the shelf and the Gulf Stream is especially called for. This is planned to be initiated in the near future and should be completed and analyzed before any decision is made about allowing development and production to take place. (It may be possible to delete these measurements if OSRA can be demonstrated to include realistic subsurface currents.) Further, as with the exploration/delineation phase, it is desirable to extend the understanding of how much of a spill would penetrate inshore of the barrier islands and what its fate there would be before production is allowed.

Even more than for the exploration/delineation phase, studies of frontal convergence would be needed before this development/production phase is approved, if it is demonstrated that the Gulf Stream frontal regions are critical habitats. However, as it seems unlikely that meaningful physical results concerning these convergences can be obtained in the near future, the worst, *i.e.*, any discharge will lead to a concentration in the frontal zones, should be assumed for the purposes of assessing risk to communities in these zones.

North Carolina OCS Area

The same considerations as for the Manteo site (see above) are valid at other locations over the continental slope. Since the

frequencies of cold dome eddies and of meanders are site-specific, information to make assessments of the potential error in the OSRA model is not readily available. For drilling sites over the continental shelf, the Gulf Stream is not a direct factor, although currents associated with cold dome eddies are still a concern. In addition, wind-driven and buoyancy-driven shelf currents also act to complicate the picture. Since the shelf currents can be quite energetic (>50 cm/sec), they are of serious importance in risk assessment.

Adequacy of All Information

The information available for the physical oceanography of the North Carolina OCS away from the Manteo site is generally less adequate than that available for the vicinity of the site. Thus, the physical oceanographic aspects that were identified as inadequate in the discussion above concerning that site also apply more generally here for the entire North Carolina OCS. However, because the areas away from the Manteo site are less well studied, there are additional concerns regarding adequacy for these areas.

For lease sales of areas on the shelf, a better characterization of shelf currents would be desirable. At a minimum, currents should be well enough characterized to estimate the likely error bounds on the OSRA results.

As for the Manteo site, the primary issue for routine exploratory and production drilling operations on the North Carolina OCS is that of the distribution of discharged muds and cuttings. Since it is expected that the impact of this material will be local, physical information is regarded as adequate, in that it is understood where the measurable deposition of these materials will occur.

The physical oceanographic information for considering accidents in areas on the North Carolina OCS away from the Manteo site is judged inadequate as only the general oceanographic features for these areas have been described. Not enough is known about the frequency and duration of Gulf Stream meanders at any given site without making lengthy moored current meter measurements and, because of this lack, a reasonable assessment of the OSRA results for these areas can not be made. Most companies holding leases will likely make such current meter measurements before exploration in order to gather engineering data, and information about the local frequency of cold dome eddies can be obtained through studying historical satellite remote sensing records. However, knowledge of

the detailed kinematics of these features is not adequate for situations where they occur frequently, such as off the coast of southern North Carolina.

Although the existing knowledge of the physical behavior of oil spills as they approach the coast is not extensive, it is reasonable to assume that a spill that gets to within a couple of kilometers of the coast will come ashore and find its way into an estuary. Based on this assumption, the information available is generally adequate, provided that OSRA risk assessments are revised (as described above) to account for known variability.

Recommended Studies

Leasing

In addition to the recommendations already included for the Manteo site above, it would be desirable to have an OSRA model which resolves the important current variability, since this can substantially increase the probability of an oil spill reaching coastal resources. MMS is currently pursuing the development of such improvements. At a minimum, OSRA should be run for potential lease sites before lease sales, and its probable errors (due to unresolved variability) estimated.

Exploration and Delineation

The recommendations for studies at this stage included for the Manteo site above also apply here. In addition, long-term (*i.e.*, greater than one-year) current measurements should be made to estimate the frequency of Gulf Stream meanders and for engineering purposes at each potential exploratory drilling site over the slope and shelf. For all such locations, further studies of the historical frequency of cold dome eddies should be conducted. The kinematics of cold dome eddies (specifically with regard to the onshore flow ahead of the eddy) should be quantified. For shelf locations, information on other flow features is sometimes adequate, depending on location. For locations on the shelf north of Cape Hatteras, characterization of flow over the shelf is entirely inadequate. This information is needed to make improvements in the OSRA risk assessment. All of these studies should be completed before decisions are made to allow exploratory drilling at any site

other than Manteo 467. However, they can be simplified if OSRA can be demonstrated to include realistic time-varying subsurface currents.

Development and Production

As recommended above, measurements of Gulf Stream strength and occurrence at proposed drill sites should be made prior to the preliminary exploratory stage to gather engineering information. Provided these records are sufficiently long (more than about 12 months), adequate information on these measurements should exist by the time of the production phase. The Gulf Stream position is not a major issue for drilling taking place over the mid to inner shelf, where the Gulf Stream does not directly influence currents.

In contrast to the situation for the proposed drilling sites, measurements from long-term moorings and drifter deployments will not, in general, be available from the exploratory phase for locations away from these sites. Yet such information is needed to estimate the fate of spills as they spread. Thus, for drilling locations in or near the Gulf Stream, long-term moorings strategically placed away from the site may have to be deployed in order to estimate how frequently the Gulf Stream is not present at these locations. For locations on the shelf, a general physical oceanographic field program is warranted, with special focus on the upper ocean and the role of Gulf Stream cold dome eddies. This field study should be completed and analyzed before development begins and could be modeled after the study suggested in the Atkinson *et al.* (Anonymous, 1991) report. It may be possible to simplify this study considerably if OSRA can be proven to include realistic time-varying subsurface currents.

ECOLOGY

The 1989 NRC report maintains that "to make an informed leasing decision, a characterization of the environment, including its biological resources, and a basic knowledge of ecological relationships are needed. The desired information includes: (1) a characterization of major habitat types; (2) a catalog of representative species (or major species groups) present in the lease area; and (3) seasonal patterns of distribution and abundance. For exploration, more site-specific information is needed, including

(4) basic ecological information (e.g., habitat, feeding behavior, and reproduction); (5) basic information on factors determining vulnerability of various species; and (6) the potential effects of various agents of impact (e.g., spilled oil, noise and disturbance, and other discharges)." This final point must be considered in the context of the large anthropogenic impacts already occurring, especially those related to fishing. "Where unique habitats or endangered and rare species exist, more extensive characterization of the sensitivity of biota to OCS activities, recovery rates, and identification of mitigating measures may be required before leasing; in such cases, information on all six factors could be needed for a leasing decision." The Panel agrees with these statements and has used them as guidelines in judging the adequacy of ecological information for offshore North Carolina.

Area of Manteo Block 467

Adequacy of All Information

The Environmental Assessment (U.S. DOI, 1990b), the Environmental Report (U.S. DOI, 1990a), and the Mobil Exploration Plan for Manteo Block 467 (MOEPSI, 1990) extensively address the specific issues that must be considered prior to decision-making by the Department of the Interior on OCS oil and gas activity in offshore North Carolina. Although the treatment of the majority of these issues is adequate, the Panel has identified a number of scientific inadequacies in the ecological arena, sufficient to render the ecological information inadequate for the Manteo Unit at every stage in the decision chain (leasing, exploration/delineation, and development/production). These inadequacies result from incomplete ecological information, not from any failure to incorporate available information into the decision documents. Thus, the decision documents are necessarily inadequate until that new information is provided and incorporated into the evaluations of potential impacts. The decision documents are also flawed by some general problems in their interpretations. Although these flaws alone may not have been sufficient to render the decision documents inadequate, they should be addressed in any revisions done to incorporate new information.

Leasing

Although leasing of the Manteo Unit took place more than a decade ago, the North Carolina Environmental Sciences Review Panel recognizes two broad areas of ecological information that are judged, by today's standards of scientific adequacy to be inadequate: *i.e.*, (1) understanding the physical/biological coupling at "the Point" region that induces its high utilization by top predators and (2) understanding the functioning of the *Sargassum* community.

The Panel was unable to reach unanimity as to whether studies in both of these areas should be required before approval of exploration on the Manteo Unit, where leases have already been granted. The majority, by a vote of four to one, held that, because these leases were duly granted and because the studies needed to address the information voids relate to impacts that are unlikely to apply until the development and production phase, the exploration activities should not be delayed to await completion of these studies. However, the majority (four to one) agreed that these studies should be initiated immediately to provide information that may be required to modify certain exploration procedures; and all five Panel members agreed that the proposed leasing studies are necessary to provide, prior to delineation drilling, the ecological knowledge needed to permit decision-making on development and production plans.

The minority opinion holds that any study that the panel agrees is needed to render the ecological information base adequate to allow leasing in this Manteo Block region should then logically be completed prior to making decisions on any and all exploration plans. Even though the minority opinion concurs with the majority that the studies in question relate to ecological impacts that are postulated to occur mostly during development and production, the minority view argues (1) that failure to complete and evaluate these issues before exploration effectively precludes any option of Federal buyback of the leases, which may conceivably be called for based on results of the studies, (2) that results of the studies could be needed to modify exploration drilling plans, and (3) that the failure to conduct one of the two studies prior to exploration drilling, that on the *Sargassum* community which includes hatchling endangered sea turtles, is inconsistent with DOI's responsibilities under the Federal Endangered Species Act.

a). Roles of physical-chemical coupling in ecosystem dynamics in "the Point" region--The Panel considers the available information on

use of the area by organisms to be adequate to characterize the communities in the vicinity of Cape Hatteras, and especially those in "the Point" region, as unusual and valuable. The area is a major biogeographic transition zone, where species from tropical and subtropical provinces overlap with species from temperate and boreal provinces, presumably due to the complex physical oceanographic conditions. "The Point" is renowned for seasonal abundances of large predatory fishes including king mackerel, dolphin, tunas, wahoo, sharks, and billfishes. Unusually large numbers of seabirds and sea mammals feed here. The benthic communities on the slope in this region have a much higher density than in other areas and a distinctive species composition (Blake *et al.*, 1987). The Panel does not believe the basic ecological information available for this region is sufficient for leasing decisions because of the lack of understanding of how physics and biology are coupled to maintain the higher trophic levels of these abundant and diverse communities.

b). Sargassum community dynamics--The Panel also considers the scientific understanding of the Gulf Stream *Sargassum* community to be inadequate to support leasing decisions of blocks in and near the Gulf Stream, an area which includes the Manteo Unit as well as North Carolina OCS sites farther south. The ecological information is inadequate in three areas. First, knowledge of the spatial and temporal abundance of hatchling sea turtles in the *Sargassum* community of the western wall of the Gulf Stream is inadequate to evaluate the risks of oil and gas activities on these endangered and threatened species. Second, the use of the *Sargassum* community for reproduction of commercially and recreationally important fishes is inadequately known to allow prediction of risk from OCS activities within the Gulf Stream off North Carolina. Third, the importance of amount and quality of *Sargassum* and the role of biological interactions in structuring the diverse and distinctive *Sargassum* community is not well enough understood.

Although some observations of hatchling sea turtles in the *Sargassum* community of the western wall of the Gulf Stream off North Carolina suggest that the Gulf Stream may be the primary or even sole habitat for developmental stages of juvenile sea turtles, especially loggerheads and Kemp's ridleys, during this least known portion of their life cycle (from hatching to age 2 or 3), this possibility has not been adequately studied. The Federal Endangered Species Act implies that an effort to illuminate what once was

called the mystery stage for sea turtles is necessary to evaluate the potential risks of OCS activities to sea turtle populations.

Sargassum plants collect in the convergence zone that is the western wall of the Gulf Stream. These convergences are likely to concentrate the eggs, larvae, and early juvenile stages with limited mobility of many marine fishes that inhabit or spawn in the Gulf Stream system, as well as spilled oil. Insufficient quantitative sampling of the western wall of the Gulf Stream has been conducted off North Carolina, and specifically off Cape Hatteras, to describe adequately the important biological resources potentially at risk and to formulate decisions on discharge limitations or possible mitigation requirements.

The Panel agrees with a recent report of the National Marine Fisheries Service (Coston-Clements *et al.*, 1991) which states:

"It has been well established that the *Sargassum* habitat is utilized by many different organisms. It provides vertebrates and invertebrates a source of food, shelter from predation, and a substrate for spawning and attachment. The species that live in the *Sargassum* are fairly well known, especially the juvenile and adult stages. There is relatively little known, however, about utilization by egg and larval stages of associated fishes. Functional relationships between the animals and the habitat have not been elucidated (e.g., we do not know the effect of loss of *Sargassum* on fish and sea turtle populations). We also do not have a clear picture of the population dynamics of the *Sargassum* habitat, i.e., what is the standing crop, the productivity and the effect of harvesting on living marine resources?"

An enhanced understanding of the processes that control the function and production of this *Sargassum* system, especially the role of the amount and health of the *Sargassum* to the biological community dynamics is needed.

Exploration and Delineation

The Panel believes that a relatively low-cost, short-term survey of the seafloor in the vicinity of the Manteo Unit should be completed prior to initiation of exploratory drilling.

MMS-funded surveys (Blake *et al.*, 1981; 1987) and recent studies by North Carolina State University (Schaaf *et al.*, 1992) characterize the seafloor on the continental slope off Cape Hatteras, in the very

region of the Manteo Block 467 where an exploratory well is proposed, as having the extremely high densities of benthic animals that are more typical of the most highly productive shallow shelf environments. Associated with these high-density, soft-bottom infaunal communities are large numbers of eelpouts, a demersal fish, and dense accumulations of a giant protozoan, *Bathysiphon filliformis*, that lives epifaunally in white tubes. In addition, the complex bottom topography of the slope in the proposed drill site provides high-relief habitat for unusually concentrated assemblages of sabellid polychaetes, brittle stars, and various suites of hard-bottom benthic organisms. Although not fine-tuned to reflect the three-dimensional flow fields at the Manteo Unit, the sedimentological model used to predict the fate of drilling muds and cuttings (NRC, 1983) is sufficient to suggest that depositional effects will not extend beyond about 1 km from the well source. However, the limited knowledge of the geographical extent of the unusual benthic community around the Manteo drill site is inadequate to describe what fraction of this system would be at risk during deposition of muds and cuttings.

Development and Production

Adequate ecological information is available on many topics to be able to assess the potential biological impacts of oil and gas development and production from the Manteo Unit. However, the ecological information gaps that are discussed under the earlier leasing and exploration/delineation phases also apply at the development/production phase. Also additional ecological information and analysis is required before decision-making because of the escalation of drilling activity from the small number of exploration and delineation wells to a larger number with attendant greater risks of accident; the increased amounts and kinds of discharges, including especially the production waters; the added consequences of producing a product which must be landed; and the need to establish monitoring programs during this phase of activity. In as much as studies on "the Point" ecosystem and on *Sargassum* dynamics should have most appropriately been completed prior to leasing, the Panel assumes that the review of development and production plans for the Manteo Block will involve a thorough ecological analysis for decision-making. The inability to complete the prospective analyses of site suitability and likely impacts of development and production prior to leasing because results of these

two studies were unavailable leads the Panel to believe that this complete evaluation is necessary for decision-making with regard to development and production.

At the present stage--in the absence of knowledge of the type of product (oil, gas, or wet gas); of the locations of drilling platforms, pipelines, and land facilities; and of the results of the environmental studies that the Panel is recommending for earlier phases--it is impossible for the Panel to anticipate all the additional environmental studies that will be required. However, a need to elaborate on certain aspects of previous studies and analyses to address the question of how cumulative effects of multiple wells and their support activities will impact ecological resources can be envisioned. Also the potential ecological impacts of land-based processing activities during the production phase will require evaluation. Information will be required to identify potential effects not only on the coastal margins (*i.e.*, barrier islands), but also on the North Carolina and/or Virginia estuarine systems, including their wetlands, and the Areas of Environmental Concern (AECs) identified within the Land Use Plans of the twenty coastal counties of North Carolina, as required by the 1974 North Carolina Coastal Area Management Act. Identification of explicit studies, however, should await the provision of information from exploration and delineation and from the completion of studies recommended for earlier phases of the OCS process.

Despite the Panel's reluctance, and in many cases actual inability, to specify the ecological information gaps that will need to be filled prior to development and production on the Manteo Unit, one category of study that will be required and that deserves advance attention to create a sufficient study plan to satisfy its goals can be identified. To discharge the second mission of the Environmental Studies Program of MMS as set forth in OCSLA, namely the environmental monitoring for impacts on potentially affected systems, up-front design of an appropriate monitoring scheme is necessary to establish a scientifically rigorous and statistically powerful design and to ensure that the required pre-disturbance data are properly collected.

The power of a statistical test is a measure of its ability to detect a real effect of a given size, and is thus an important aspect of a test designed to protect a public trust. As a prime example of an important advance in impact test methodology, the BACI test (Before-After-Control-Impact) of Stewart-Oaten *et al.* (1986) provides a well-justified means of testing rigorously for impacts of a point source discharge, even though that source is unreplicated, by

clever use of collections of time series data at control (reference) sites and the impact site both before and after treatments commence. The Panel concurs with the NRC (1989) panel report on the adequacy of environmental information off Florida and California that MMS needs to adopt such modern designs to put into place rigorous and powerful monitoring tests for progressive and cumulative impacts of oil and gas production. The Environmental Report (U.S. DOI, 1990a) and Environmental Assessment (U.S. DOI, 1990b) fail to identify any design or plans to develop any such design for rigorous monitoring and fail to discuss the types of long-term data sets required for such analyses. Given the need for a time series of some length in the "before" period prior to application of the treatment and given the need to develop an adequate explicit statistical monitoring design beforehand, such monitoring programs must be established well in advance of the development and production phase.

Various ecological systems and taxonomic groups provide different opportunities for rigorous monitoring. For example, populations of birds that nest in the open can be completely assessed within each nesting colony. This is possible even if the colony should change its nesting location as a consequence of coastal erosion or some other disturbance. The ideal species of bird for monitoring population-level impacts would nest in the open; be large enough to be counted from aerial surveys; be abundant enough that egg collections could be taken for analysis of hydrocarbon concentration and composition; spend considerable time in contact with the water surface and so be at risk of frequent exposure to oil spills; feed on small fish and crustaceans; stay in inshore waters; and be present year-round. No single species seems ideal. The breeding laughing gull in summer supplemented by herring gulls in winter might be suitable. A monitoring program built around such species would be a valuable addition to the offshore monitoring program suggested for pelagic birds.

Benthic communities are largely comprised of sessile organisms that are therefore useful in detecting spatial scales of impacts. Long-lived suspension feeders, especially bivalve molluscs, are extremely useful as integrators of water quality and as indicators of biologically available pollutants, as evidenced by their use in the NOAA mussel-watch program. These organisms are also useful for detecting sublethal effects on growth or reproduction.

In the absence of more precise information concerning the nature and location of specific proposed development and production activities, the Panel is not prepared to suggest all the specific

studies that should be conducted. However, the Panel does recommend inclusion of the two studies listed below.

The area of potential energy development in the Manteo Unit off North Carolina is rich in seabirds, sea turtles, and the *Sargassum* community. None of these characteristic elements of the region is very well studied, and all three provide a good opportunity to measure the extent of present contamination and to follow any subsequent changes that may occur if and when development and production of OCS oil and/or gas occurs. The data obtained would both help understand the present condition of these target organisms and communities and also warn of impacts from OCS operations that would support decisions on changes in regulations.

The organisms of most concern are endangered or threatened, all five species of sea turtles that occur in the area and the Bermuda and black-capped petrels. Since these cannot legally or ethically be sampled, it is suggested that monitoring for hydrocarbons be conducted with the *Sargassum* community and with an analogous seabird, Wilson's storm petrel.

The Panel recognizes that the *Sargassum* community of the North Atlantic has been widely contaminated with hydrocarbons (Burns and Teal, 1973; Butler *et al.*, 1973). This contamination results from the presence of widespread surface hydrocarbons (mostly tarballs) in the North Atlantic originating from tankers and other ship traffic. Ideally, sampling should be done of the *Sargassum* mat and one or two associated animals with different food habits. The results of Burns and Teal (1973) suggest that a crab and a fish meeting these criteria would be suitable. Sampling should occur both upstream and downstream of the drilling site so that local inputs can be distinguished from contamination derived elsewhere. It would also be desirable to raise *Sargassum* under clean conditions to distinguish the natural hydrocarbons from the contaminants more clearly than can be done with samples collected at sea.

There are data indicating that storm petrels regularly encounter hydrocarbons as they feed on the ocean surface and that their stomach oils are a good indicator of the extent of exposure (Boersma, 1986). Wilson's storm petrels breed in the southern hemisphere but migrate through and inhabit offshore North Carolina waters during the southern winter, our summer. Since these birds are so mobile, effective upstream and downstream contrasts would be difficult to achieve. Comparisons of time series are suggested instead. For both the *Sargassum* system and the storm petrels, the monitoring should begin during the exploratory phase of the operations to provide the adequate pre-production information.

The Panel argues that from past basic research and from the history of oil spills elsewhere, there is probably enough information available to make reasonable predictions of the fate and biological consequences of an oil spill that reaches the beaches of North Carolina. However, there is inadequate basic understanding of the physical mechanisms of transport and deposition and of biology to make such predictions regarding one component of the Outer Banks system, the large offshore shoals that occur at the capes. With regard to the Manteo Unit, this lack is especially important for Diamond Shoals.

Considerable knowledge exists of the dynamic nature of ocean beaches and of man's influences on those sedimentary dynamics. The average erosion rate, for example, along the North Carolina Outer Banks is about 5 feet/yr, with areas near inlets subject to far larger changes (Aubrey, personal communication). This indicates that oil landing on the beach is not likely to remain immobilized there for very long, even if buried initially. Furthermore, considering the large exchanges of water through the inlets and the long-shore transport processes along the banks, much of the oil reaching the coast can reasonably be assumed to enter the sounds. There is some understanding also of the benthic invertebrates and demersal fishes that are so abundant and productive along the ocean beaches of North Carolina.

The large offshore shoals are a part of this system that are not well understood, but that are believed to accumulate sediment and so could also accumulate and store spilled oil. The petroleum and its degradation products would then be released at rates depending upon weather--slowly over longer periods of time when shoal sediments are not being very actively disturbed and more rapidly during major storms. These areas are the only portion of the nearshore ocean where there is insufficient understanding of either the physical dynamics of the natural system or the biological responses once polluted to be able to make adequate predictions of the impact of major oil spill. This subsystem of outer beaches and shoals is not even mentioned and discussed in the DOI decision documents.

A related issue that is also not adequately covered in the decision documents is the potential susceptibility of striped bass to oil spills reaching the beaches of the Outer Banks. Large adult striped bass, and other important exploited fishes, are known to accumulate in high concentrations in shallow coastal waters off the North Carolina Outer Banks during winter. Because of the recreational and commercial importance of striped bass, the

depleted nature of the stock, and the significant portion of the brood stock apparently concentrated off the Outer Banks, the North Carolina Marine Fisheries Commission has been compelled to enact regulations in the past (1984-90) prohibiting possession of trawl-caught striped bass in the winter trawl fishery. The risk faced by these overwintering fish from processes that may contaminate the beaches and shoals is not addressed in the decision documents. This lack is especially important for striped bass, but is also of concern regarding the other important species that overwinter in large numbers in small areas off the North Carolina Outer Banks, including summer flounder, bluefish, red drum, croakers, and grey trout.

Although it would be most useful to have more information on the physical dynamics and the ecology of cape shoals at the time of rendering decisions on development and production plans for the Manteo Unit, provided the discovery of oil or wet gas, limitations to technology prevent the Panel from recommending that such a study be carried out prior to development and production. These areas are extremely difficult to study. It is impossible to work on site during severe weather, and probably also impossible, at present, to ensure reliable installation of recording instruments. Such a study has to receive a low priority now, although this should be reassessed as the development and production phase approaches. The related issue of susceptibility of overwintering striped bass does need to be adequately evaluated prior to development and production, however.

Post-production

The post-production phase lies even further away with even greater uncertainties about the needs for ecological study than the development and production phase. The Panel was still was able to identify explicitly one important ecological problem for the post-production phase--sea turtle attraction to drilling platforms.

There are reports in the literature of aggregations of sea turtles around oil production platforms in the Gulf of Mexico. If such a behavior is general and strong, turtles would suffer substantial risk during platform removal in the post-production phase when explosive charges are ordinarily deployed. The attraction of drilling platforms for each of the five species of sea turtles should be evaluated.

Adequacy of DOI Decision Documents

The Environmental Report (U.S. DOI, 1990a), the Environmental Assessment (U.S. DOI, 1990b), and the Mobil Exploration Plan (MOEPI, 1990) are all compromised and made inadequate by the absence of ecological information: (1) that should have been available prior to leasing, namely the information on the functional dynamics of "the Point" ecosystem and on the *Sargassum* community dynamics and (2) that is needed before exploration, namely information on the geographic extent and degree of uniqueness of the unusual benthic community at the proposed drill site. This missing information can only be supplied by conducting additional scientific investigations and then incorporating the results into modified analyses of potential impacts in the decision documents. This added information would be sufficient to elevate the ecological knowledge base for the Manteo OCS region of North Carolina to a level consistent with the guidelines presented in the NRC panel report (1989) on the adequacy of scientific information to permit OCS leasing off South Florida and California and consistent with the agreement between MMS and the states of Oregon and Washington on what additional environmental information is required to evaluate their OCS areas for potential leasing.

In addition to identifying these information gaps, the Panel also recognizes two general flaws in the interpretation of available information that run through the decision documents and appear in multiple analyses. These flaws may not be sufficient in themselves to require revision of the documents, but should be addressed if revision is required for other reasons (such as conducting an adequate analysis and interpretation of the physical transport data or incorporating analysis and interpretations of necessary socioeconomic information). These flaws are 1) a failure to appreciate the importance of power in statistical testing for environmental assessments and 2) a misconception of the ecological significance of natural variability.

The power of a statistical test is its ability to detect a real effect of a certain size. Whenever tests for effects are conducted with inadequate power, the conclusion that no effect exists is unjustified. The proper inference is that the test employed was unable to detect any significant response or difference. Only if power of detection is high, can this nonsignificant test result be used to conclude that the treatment has no important impact. This perhaps subtle statistical point is not adequately appreciated in the

presentations and discussions of environmental information in the DOI decision documents.

The decision documents also misconstrue the ecological significance of natural variability. The documents imply that if a parameter shows naturally large variability, then an impact of some treatment that creates a small change relative to the natural variation is of no ecological significance. For example, just because a fisherman's catch varies over a period of years by a factor of two because of natural variations in fish populations, it is not appropriate to argue that an average reduction in his catch of say 10% is both tolerable to him and consistent with environmental protection. Similarly, a small average change in some driving physical variable might often have extreme ecological implications even though that physical variable fluctuates greatly under natural conditions. For example, light limitation on the seafloor sets the lower limit of the distribution of important habitat-providing plants such as kelps and seagrasses. Even though light varies tremendously, falling to virtual zero every night, a small average reduction in irradiance reaching the seafloor could readily eliminate occupation of otherwise suitable habitat in deeper areas where light was marginally sufficient for plant survival. Purging from the decision documents the unjustified argument that variable ecological resources and variable driving forces do not deserve the same level of protection from environmental impacts as more invariant parameters is needed to render the interpretations and conclusions adequately defensible.

Recommended Studies

This section specifies the ecological studies the Panel recommends be undertaken to provide adequate information for decision-making regarding the Manteo Unit.

Leasing

No studies recommended.

Exploration and Delineation

In the case of the Manteo Unit in particular, where adequate prelease studies were not done, it is the majority opinion of the Panel that under the present circumstances of the Memorandum of Understanding, and with the subsequent materials produced by MMS and Mobil, the studies indicated below are adequate background information for the exploration phase.

a). Roles of physical-biological coupling in ecosystem dynamics in "the Point" region--The purpose of this study is to develop sufficient understanding of the reasons for the abundance and diversity of the higher trophic levels at "the Point" so that decisions can be made about how these properties might be affected by proposed OCS activities in the area. Fishermen believe that large fishes are concentrated at the boundaries between currents and/or water masses. A reasonable hypothesis is that the physical circulation of the region concentrates food at these fronts which in turn attract the large animals. It is also possible that local productivity is stimulated by these same environmental features. There are other hypotheses, especially with regard to the immediate cues used by the animals to locate themselves in a particularly suitable area. While it will ultimately be necessary to study the interactions between biology and physics at every level at "the Point" to gain a complete understanding of the abundance and diversity of animals in this ecosystem, what is required for the necessary decisions is to understand the mechanisms that concentrate the animals and the links in the food chain that supports them. The physical circulation will not be affected by OCS activities. But the quality of food that supports the predators could be affected by OCS activities and conceivably the chemical and visual cues used by the fishes could be locally modified by discharges. We need a better understanding of both the immediate cues by which the predators locate themselves in relation to the presumed prey concentrations (for the large fishes) and of the possibilities of contamination of the food supplies for all the large predators. The latter study is more critical than the former.

The Panel recommends that this project be initiated immediately, and completed prior to delineation, but that the drilling of the initial exploratory well not be delayed to await results.

b). *Sargassum* community dynamics--The purpose of this recommended study is to provide enhanced understanding of the functioning of the *Sargassum* community of the western wall of the

Gulf Stream so as to improve our ability to make predictions about anthropogenic effects on this diverse, persistent, and distinctive assemblage. The study should have three separate components: (1) sampling and experimentation to assess the degree to which recently hatched sea turtles of each of the five threatened or endangered species found off the east coast of the United States utilize and depend upon this *Sargassum* habitat during their early life history; (2) sampling to describe the role that the *Sargassum* community plays in the recruitment of commercially and recreationally important pelagic fishes; and (3) developing an understanding of how interactions between the plants and animals and among the animals influence the structure and dynamics of the *Sargassum* community.

This three-part *Sargassum* study should ideally have been conducted prior to leasing in the vicinity of the Gulf Stream off North Carolina to provide the information needed to restrict drilling to seasons when hatchling sea turtles are not present. All five panel members agree that this *Sargassum* study should be initiated immediately and that it should be completed prior to the delineation phase. The majority (four to one) maintains that exploration drilling should not be held up awaiting the outcome of any part of this study, but that, if it is established that the area is an important habitat for the developmental stages of Kemp's ridley sea turtles, then measures should be initiated immediately to reduce risk of impact to these animals. The minority opinion maintains that this course of action is inconsistent with the Panel's determination that this study should have preceded leasing and so violates the mandates of the Endangered Species Act as it applies to sea turtles and that initiation of exploratory drilling effectively precludes any remaining option for Federal repurchase of the Manteo Unit leases. Such repurchase may conceivably be called for should the recommended studies demonstrate both high utilization of the Gulf Stream by hatchling sea turtles and also no effective means of conducting development and production drilling in a fashion that implies acceptably low risk to sea turtles from oil spills.

c). Benthic community survey and possible recovery study--The purpose of this study is to survey the seafloor in the vicinity of the Manteo Block to determine the geographic extent of the unusual benthic community of this region and then, if that area is so small that drilling at the Manteo Unit could bury more than about 5% of it with muds and cuttings, to determine the recovery rate of this community. Benthic surveys by Blake *et al.* (1981, 1987) and Schaaf *et al.* (1992) have been adequate to raise, but not to answer, these

questions. The survey portion of this benthic study could be completed within about a 6-month time frame, ensuring that sampling was conducted at a time consistent with previous sampling of this community by Blake *et al.* To complete this study within such a short time period would, however, require the resources to employ enough personnel to analyze photographs and videotapes and to sort and identify invertebrates from a number of box core samples--a tedious process that often limits the rate of completion of such benthic studies. The Panel maintains that this survey portion should be completed and analyzed before any exploration drilling at the Manteo Unit. The recovery portion of the study, if required, would take an indefinite period of time, as determined by the rate of recovery of the community in question.

Development and Production

a). Monitoring of *Sargassum* community contamination--This study is designed to be conducted during the period of drilling of the exploration and delineation wells so as to test empirically whether any detectable increase in hydrocarbon contamination appears in the *Sargassum*, in one or two associated animals, and in the Wilson's storm petrels. Should development and production go forward in the Manteo Unit, this study should be continued as a monitoring study with information collected during exploration serving as baseline data against which to compare later temporal change in hydrocarbon levels. The monitoring is directed towards the *Sargassum* community because of its biological significance in this region and because the physical convergence that concentrates the floating plants would also be expected to concentrate spilled oil. The Wilson's storm petrel is meant to serve as a proxy for the endangered Bermuda and black-capped petrels that cannot be sampled.

b). Fate and effects of oil spilled on cape shoals--If and when technological developments have advanced sufficiently to permit a meaningful study of physical dynamics on the cape shoals and on their productivity and the interrelationships among their benthic organisms and the sedimentary environment, then such a study should be carried out to evaluate the potential impacts associated with development and production.

c). Effects of oil spills on winter aggregations of striped bass--The Panel maintains that the DOI decision documents need to be revised based on existing, but not included, information to develop a

rigorous evaluation of the risks from an oil spill reaching the Outer Banks during the winter to the large numbers of striped bass that aggregate on the North Carolina shelf during that time. This question is critical because of the poor condition of the striped bass stock and the recreational and commercial value that this fish has. This revision should also include more complete evaluation of the population risk for other commercially and recreationally important fishes that overwinter off the Outer Banks, explicitly red drum, summer flounder, croaker, and grey trout.

Post-production

a). Behavioral responses of sea turtles to drilling platforms--This study should test whether any or all of the five species of endangered and threatened sea turtles are attracted to drilling platforms and, if so, estimate the quantitative degree of enhanced abundance around drilling platforms. This goal is probably best achieved in the Gulf of Mexico, where all five species of sea turtles are found and where operating drilling platforms already exist. In addition, some evaluation of sea turtle behavior should be conducted in North Carolina after installation of drilling platforms to learn whether the platforms are vacated by sea turtles during any or all of the winter season. Seasonality of occupation could conceivably provide a window in time during which the removal of the platform could be achieved without risk to sea turtles.

Estimation of the degree of attraction of sea turtles to drilling platforms is not an especially easy chore. It could probably best be done for the most abundant species of sea turtles, the loggerheads, by utilizing otter trawls in a design that sampled concentric rings around one or more platforms. This method would require Federal approval from NOAA to deploy an otter trawl without a TED (turtle excluder device) and would necessitate use of short enough tow times to insure survival of the turtles that are captured. It is possible to employ visual sampling from airplanes to conduct this same sampling of sea turtles in concentric rings around platforms, but even under ideal viewing conditions only a very small fraction of the sea turtles actually present is counted by this method because they spend little time at the sea surface. The sampling results should be augmented by results of a study component that monitors the movements and thus the behavior of turtles to which radio transmitters have been attached. The methods of deploying these tools are now being developed and improved by a MMS study of sea turtles conducted in the Mid-Atlantic region. Results will be available to improve

the use of this technique to address the issues of whether and to what degree the sea turtles aggregate around drilling platforms.

North Carolina OCS Area

Adequacy of All Information

Because the OCS process for all areas outside the Manteo Unit is at an earlier stage and there are no specific documents prepared to evaluate ecological impacts of exploration, the ecological information available for this large area of North Carolina OCS is quite diffuse. Much of the information reviewed in the Environmental Report (U.S. DOI, 1990a) and Environmental Assessment (U.S. DOI, 1990b) for the Manteo Unit is also directly relevant to the wider North Carolina OCS because the studies cited and used are often broad in their geographic coverage and/or generic in their intent so that extrapolation is reasonable. To augment what was brought to the Panel's attention through the Environmental Assessment and the Environmental Report, scientific sources were also solicited from members of the scientific community knowledgeable about this area. Nevertheless, the recommendations of the Panel relative to the larger North Carolina OCS area are necessarily less specific and more generic than the Manteo Block recommendations. The Panel rarely addressed issues specific to particular localities even though some blocks have already been leased and some new areas are proposed for leasing in the new five-year plan that fall within the OCS area of North Carolina.

Leasing

The ecological issues that must be covered to allow leasing in the North Carolina OCS area are, of course, the same as for the Manteo Unit. A large majority of the ecological information prepared for Manteo is applicable to leasing in the North Carolina OCS area and is adequate to that purpose. Nevertheless, the three components of the *Sargassum* study described for the Manteo Unit are equally relevant to the North Carolina OCS area, and the results from these components are needed to render the ecological information base adequate for decision-making for the North Carolina OCS area. There are, however, certain key differences between the Manteo Unit and other OCS sites in North Carolina,

especially those south of Cape Lookout, that create different prelease needs for Manteo and the broader North Carolina OCS area. South of about Cape Lookout, the physics of cross-shelf transport may differ sufficiently from that of the region around the Manteo Unit to increase greatly the importance of this more southerly area for offshore spawning and early development of the productive estuarine-dependent fishes. Certain MMS-supported surveys done north of Cape Hatteras and in other geographic regions have not been conducted as intensively in the South Atlantic planning region of MMS, notably surveys of seabirds, sea mammals, and sea turtles. And finally, basic process information on the patterns and causes of variation in productivity of this region of the ocean are deficient, as compared to other OCS regions.

a). Sargassum community dynamics--The need for this information for the entire North Carolina OCS region is the same as for the Manteo Unit and the study suggested in the section above concerning that site will suffice to satisfy the inadequacies for the entire North Carolina OCS area.

b). Use of the North Carolina shelf for estuarine fish reproduction--The dominant estuarine fishes of the North Carolina sounds, including commercially and recreationally important species especially those of the drum family as well as flounders, menhaden, and important shellfish such as shrimps, use the waters over the continental shelf for spawning. The eggs and larvae produced from those spawns, as well as from blue crabs that spawn near inlets, develop and grow offshore where they are transported by physical processes. For these larvae to survive, this physical transport must eventually return them to the coast and then through an inlet, enabling them to complete development inside the estuaries (Miller et al., 1984). Checkley et al. (1988) showed that menhaden spawn in offshore frontal areas from which the young animals produced are transported into estuarine areas for their postlarval and juvenile stages, during which they experience rapid growth.

The dependence of the reproductive success of these important fish and shellfish species on passive cross-shelf transport by geostrophic ocean currents, surface wind-driven flows, and internal waves (e.g., Shanks, 1987) implies that the different regions of the North Carolina OCS area may vary in suitability as spawning sites for these estuarine-dependent fishes, depending in part on the differing likelihood of physical transport in the required shoreward direction. For example, the shelf waters west of the Gulf Stream in Onslow Bay (south of Cape Lookout) appear to be heavily utilized for spawning by these estuarine-dependent fishes whereas the existing

knowledge, from measurements and OSRA predictions, concerning ocean currents in the area of the Manteo site implies that this area may be less significant for these species.. However, without further study, including evaluation of currents at depth, the significance of cross-shelf transport is uncertain. Such a study is called for prior to further leasing of North Carolina OCS areas and prior to exploration on already granted leases, except for the most southerly leases lying east of the Gulf Stream.

The Panel is aware that the Coastal Ocean Program of NOAA is embarking upon a multi-year project called SABRE (South Atlantic Bight Recruitment Experiment) that is designed to study coupling of fish reproduction with physical dynamics in this geographic region. Because this project is not a directed research program, but rather is generated by the hypotheses developed by the Principal Investigators, there is no way now to predict exactly what this program will ultimately address. It will certainly be relevant to the MMS needs as described here, but may need augmentation to address the otherwise unmet needs for assessing potential impacts of OCS activities relative to cross-shelf larval transport. This study should be initiated soon to take proper advantage of the opportunity for coordination with SABRE field efforts.

c). Seabirds abundance patterns--Quantitative at-sea inventories of seabirds off the North Carolina (and South Atlantic generally) coast are lacking. The information gathered by the North Carolina Biological Survey and published by Lee and his colleagues (e.g., Lee and Parnell, 1990; Lee and Socci, 1989) are focused on the Cape Hatteras region and do not provide rigorous quantitative information south of Cape Lookout. Such surveys need to be done in combination with basic information on at-sea biological and physical processes to derive a general understanding of mechanisms that create use patterns. For example, a large fraction of the common loon population is hypothesized to overwinter in a relatively small geographic region over the nearshore shelf north of Cape Hatteras. Similarly, during certain seasons, a large fraction of the total populations of Bermuda and black-capped petrels might be present foraging over OCS areas off North Carolina. Testing such hypotheses by gathering systematic quantitative survey data on seabirds is necessary to be able to conduct initial risk analyses prior to selection of areas for leasing in the OCS region off North Carolina.

d). Cetacean and turtle abundances--Surveying for marine mammals in the South Atlantic and Gulf of Mexico OCS planning regions is much less complete than in other OCS regions. MMS's

Cetacean and Turtle Assessment Program (CETAP), which was conducted in the Mid- and North Atlantic OCS regions from 1978-1982, stopped at Cape Hatteras, leaving the South Atlantic region largely undescribed. CETAP helped confirm the function of the Great South Channel off Cape Cod as a critical feeding ground for many marine mammals. Subsequently, a large interdisciplinary oceanographic program called SCOPEX has been going on for several years to derive a process-based understanding of what conditions serve to make this region so special and valuable for sea mammals. In the absence of a CETAP-like program for the South Atlantic, the Panel lacks sufficient information to know whether there exists any similarly critical area for cetaceans and other endangered marine mammals off North (and South) Carolina. An ongoing project supported by MMS is providing most of the information required to ultimately fill this need. That study is focusing, quite properly, on the narrow shelf region between about Jacksonville, Florida and Savannah, Georgia, where the endangered North Atlantic right whales appear to overwinter and perhaps also where they give birth to and initially raise their calves. Only some modest additional support is required for this project to make adequate its now too sporadic coverage of the region from Savannah to Cape Hatteras. This augmentation of effort should be initiated immediately to take advantage of the potential for augmentation of the ongoing project.

Exploration and Delineation

The Panel agrees that inadequate information is available relative to a number of issues within the North Carolina OCS area outside the Manteo Unit. These include:

- a). Information on benthos in areas around the proposed drill sites and potential anchor sites with special reference to the locations of "live bottoms", reef areas, and concentrations of fishery resources such as scallops, shrimps, and demersal fishes;
- b). Information on the importance of proposed drill sites and their immediate vicinity to significant fish stocks and the organisms on which they forage. Assuming completion of a comprehensive, preleasing study on the relationships of physical, cross-shelf transport processes to reproductive success of important estuarine-dependent fishes and completion of the Manteo study on the role of the *Sargassum* community for Gulf Stream fishes, the required additional evaluation for fishes can probably be

obtained through a survey of the fishing fleets and some site-specific sampling.

c). Information on usage of specific sites by sea turtles, sea mammals, and seabirds.

Development and Production

The generic comments about information needs for the Manteo Unit prior to development and production apply as well to the entire North Carolina OCS region. Site-specific issues will doubtless arise and require both environmental information gathering and analysis, but those problems cannot be explicitly identified in advance of completion and analysis of the recommended prelease studies and further information on specific sites and development plans.

Post-production

These issues are covered by the comments made in the comparable section above dealing with the Manteo Unit.

Recommended Studies

Leasing

a) Sargassum community dynamics--The study as described under the section above containing recommended studies for the Manteo Unit is appropriate to fill the generic need for ecological information on this system.

b). Use of the North Carolina shelf for estuarine fish reproduction--The purpose of this study is to develop an adequate understanding of the importance of the continental shelf off North and South Carolina for the reproductive success of the major stocks of estuarine-dependent fish and shellfish that use the shelf system for reproduction. Such a study would have two integrated components, one documenting the spatio-temporal patterns of abundance of reproductive products of the fish and shellfish and the other evaluating the fate of those reproductive products as a function of site- and time-specific physical transport mechanisms. The species of significance should include sciaenids (the drum family), such as croaker and spot, and paralichthyds, such as

southern and summer flounder, as well as menhaden, blue crabs, and penaeid shrimps. These species are of critical importance to the fisheries and ecology of the North Carolina and southeast estuaries, yet their recruitment is thought to be dependent upon events occurring on the continental shelf.

This study could conceivably be conducted within a single year with an extensive effort covering all three latitudes, but a three-year program that moves successively from one latitude to the next seems more appropriate. This study should be coordinated with the SABRE project of NOAA's Coastal Ocean Program, which has some of the same objectives as those outlined here. This would be cost-effective and would help insure rigor of the study, given the level of review applied to the SABRE program. The Panel contends that this study should start soon and that the results should be available prior to decision-making on additional leasing or exploration of present leases in the North Carolina OCS region outside of the Manteo Unit and outside of the area to the extreme south that lies east of the Gulf Stream.

c). Seabird survey--This study is intended to represent a systematic and quantitative survey of the seasonal pattern of seabird distribution and abundance in relation to ocean circulation over the continental shelf and slope from Cape Hatteras south. The Panel recommends that this seabird survey be initiated soon and that the results be available prior to any additional leasing of OCS areas off North Carolina and prior to exploration on those leases already granted outside the Manteo Unit. The study should encompass two years of observation for all transect lines so as to identify the level of interannual variability in abundance and distribution patterns.

d). Cetacean and turtle assessment--An ongoing MMS study, which is focusing on the winter distribution of the endangered North Atlantic right whale, but is also documenting all sightings of marine mammals and sea turtles, will provide adequate sea mammal and sea turtle information for the South Atlantic OCS planning area from Miami to Savannah. However, this South Atlantic program needs some augmentation of coverage for the region from Savannah to Cape Hatteras. This area was covered by one set of aerial transects in the winter of 1985 and some additional coverage in the winter of 1989. However, the other seasons of the year are not adequately sampled. Additionally, the right whale is thought to move through the waters offshore of the Carolinas in autumn and spring on route to and from its wintering grounds, respectively, and further information on this species in this area is also needed.

This augmentation of the sea mammal and sea turtle observational data base should be achieved before further leasing in the North Carolina OCS area and before exploration on those leases already granted outside of the Manteo Unit. This implies that planning for this work should be done soon.

Exploration and Delineation

Although the Panel has identified several generic studies that it anticipates will be required at this stage, more specific information arising from the recommended prelease studies will be needed to be able to outline explicit study plans. Consequently, no further elaboration beyond that contained above is provided.

Development and Production

The Panel is similarly unwilling to attempt to recommend specific studies for this phase given the absence of information from the prelease studies. However, it may be necessary to consider monitoring programs to assess potential changes in contaminant levels in sediments, water, and biota associated with areas of North Carolina OCS activity.

Post-production

The Panel cannot anticipate any need for ecological information at this stage except for the sea turtle behavior study already presented under the Manteo Unit section above.

SOCIOECONOMICS

Area of Manteo Block 467

Adequacy of All Information

"Human environment" is defined as "the physical, social, and economic components, conditions, and factors which interactively determine the state, condition, and quality of living conditions,

employment, and health of those affected, directly or indirectly, by activities on the OCS..."(43 USC 1331(i), quoted in NRC, 1989). The Panel further construes "human environment" in a social systems sense, to be all patterns of behavior and interaction, on water or land, which may be affected by OCS activity.

In general, socioeconomics is the most neglected area in the primary documents dealing with exploratory drilling at the Manteo site, *i.e.*, the Environmental Report (DOI, 1990a), the Environmental Assessment (DOI, 1990b), and the Mobil Exploration Plan (MOEPSI, 1990), and is the area in which the greatest need exists for more data and analysis. The review provided in this report will be limited to evaluation of the adequacy of existing data and information concerning direct and indirect socioeconomic impacts of OCS activity on coastal populations and communities. The Panel concluded that larger issues such as the socioeconomic aspects of national energy policy were beyond its purview.

The human environment potentially affected by OCS activity offshore North Carolina runs from Charleston, South Carolina to the Delmarva Peninsula north of the mouth of the Chesapeake Bay, and includes the areas offshore of these locations. Generally, the potential location of supply bases for leases in the southern portion of the North Carolina OCS defines the southern boundary, the potential for petrochemical spills defines the northern boundary, and the furthest offshore leases define the eastern boundary.

The socioeconomic data and information contained in the Manteo Unit lease sale documents and in the Exploration Plan (MOEPSI, 1990) and the associated Environmental Report (U.S. DOI, 1990a) and Environmental Assessment (U.S. DOI, 1990b) are from aggregate data bases. Data on general demographic and economic activity variables concerning the coastal counties of North Carolina and standard data summaries for specific industries (*i.e.*, poundage and value of commercial fishery landings) and sector (*i.e.*, aggregate value of leisure, including retirement, and tourism) are generally adequate, although the comparability of the data (*i.e.*, to what extent are 'multiplier effects' reflected in the data?) is not fully explained.

The general conclusions of other analysts concerning social scientific data and information and OCS impact analysis apply also to the North Carolina situation:

"Few data have been collected by MMS or anyone else to address the social and economic impacts of OCS activities.....Although the practice of social and economic impact assessment has a relatively long history (Finsterbush *et al.*, 1983; Freudenburg, 1986), MMS has made little or no attempt to apply those

techniques systematically or to do follow-up studies.....Even the few socioeconomic data that have been collected were not collected in a systematic, scientific program or in concert with the scientific community." (NRC, 1989)

Comments such as these are even more applicable to North Carolina and its coastal environs and adjacent states than they are to Florida and California, about which the above quote was written, because of the lack of comprehensive socioeconomic studies in North Carolina compared to, for example Alaska (Minerals Management Service, 1991) or California (NRC, 1989).

As noted above, issues of national energy policy have been excluded from this analysis. Although the Panel did not treat these issues, they are critically important for consideration of both overall OCS policy and the question of the costs and benefits of OCS development to any specific region, such as eastern North Carolina. The Panel strongly urges that increased analytical attention be given to these issues within the MMS OCS program.

Adequacy of DOI Decision Documents

In general, the adequacy of the socioeconomic data and information decrease as the scenarios progress from exploration and delineation to post-production. The information is largely inadequate, even in the exploration and delineation phase. The following are general comments on the socioeconomic information in the DOI documents:

- 1) Few of the relevant specialized socioeconomic studies of the North Carolina area (*e.g.*, Johnson and Purdue, 1986) or relevant case studies of other areas (*e.g.*, Petterson, 1990; Mitchell, 1976) were referenced or used.
- 2) Because of the reliance on standard aggregate data bases, there is little or no attempt to establish and analyze connections or relationships among social scientific variables or between these and physical and natural scientific properties. For example, the effect of OCS-related activities on specific fish stocks, specific recreational or commercial fishermen who exploit such fish stocks, and on the communities and industries that are dependent upon such activity are not fully characterized or analyzed. The potential impact of changing perceptions and attitudes concerning the marine and coastal environment on behavior patterns are another example of such relationships that are not fully characterized or analyzed.

3) There is virtually no reference to attitudinal or perceptual data or information or to sociocultural variables beyond simple demographics.

4) OCS activity in the Manteo Unit has the potential to affect human populations from at least the Beaufort-Morehead City area to the Delmarva Peninsula. The reviewed documents, however, refer almost exclusively in the socioeconomic analysis to northeastern North Carolina. The important omission is southeastern Virginia (Norfolk-Hampton Roads-Newport News) and the Delmarva Peninsula, where there is a high probability of shore-side development and impact in any of the advanced (i.e., development and production) scenarios.

5) The general assumption which runs as a thread through the DOI documents is one of 'no significant impact.' While this may be warranted in some portions of the socioeconomic assessment because these documents focus primarily on the exploration and delineation phase, this assumption is certainly not warranted for the phases beyond exploration and delineation nor even for this phase as a whole. All OCS activity, especially in advanced phases such as has occurred in Alaska, Louisiana, and California, has a significant impact on the human environment including socioeconomic systems (Pettersen, 1983; Wolf, 1991; Yarle, 1983). Whether or not we judge this impact to be, on balance, positive or negative is not the point here; the point is that there are significant impacts which must be adequately characterized and analyzed.

6) The analysis of the overall costs and benefits of the proposed OCS activity to eastern North Carolina is deficient, in particular as it relates to the potential for increased availability and presumed reduced cost of petrochemical products within the region resulting from such activity. The assumptions and analyses concerning the location of transportation and processing facilities and the potential supply routes and end markets for these products are incomplete and, as presented, do not warrant the conclusions reached.

Recommended Studies

Leasing

If it is assumed that success in the exploration and delineation phase pursuant to a lease sale has a high probability of leading to

development and production, then the data and information requirements for the leasing phase should encompass all categories of information and analysis for all subsequent phases of OCS development, albeit to a lesser level of detail than that required at the actual points of subsequent activity. Since the leases for the Manteo Unit are already in place, the following recommended studies are presented as a comment on what would have constituted adequate data and information at this stage for the Manteo Unit. All of these studies should be initiated as soon as possible.

a) Base case characterization analysis--This should include not only the standard aggregate data base analyses on such variables as population, employment, and economic activity, but also characterization of the structure of relevant industries (*e.g.*, fishing and leisure, including retirement, and tourism) and the relationships among the private and public sector entities at all levels in the affected areas. Such analyses should take a "social systems" approach (Palinkas *et al.*, 1983) rather than a simple listing of statistics. Through such a systems approach, the human activities on the water in the OCS area of potential development should be traced back to their shore bases. For example, the residence, home port, and embarkation locations for recreational fishermen and boaters should be identified. In addition, the potential shore bases for OCS activity through all potential phases of lease-related activity should be identified. Finally, those locations where the results of potential spills or accidents would be evident should be specified, including in particular leisure, retirement, and tourism locations. Once these locations are identified, more detailed demographic and economic analyses should be done for these specific locations, indicating how they each might fit into the total picture of OCS development and what potential changes might occur. Prior to the leasing phase such studies, which could be performed largely via secondary sources and existing data bases, would take approximately two years to complete.

b) Community studies--Detailed community studies similar to those done in other OCS areas (Pettersen *et al.*, 1983; Minerals Management Service, 1991) should be done on the communities most likely to be affected by OCS development as identified by the work set out in paragraph (a) above. These studies should cover the range of sociocultural variables necessary to a contextual understanding of the role and effect of potential OCS activities in these communities, including such variables as cultural traditions (*i.e.*, occupational continuity or formal religious organization) and psychosocial conditions (*i.e.*, mental health). The central purpose of

these communities studies would be to gain an understanding of how these communities function as coherent social, economic, cultural, and political systems; in essence, to identify the "cultural ecology" of the human communities in a way similar to the identification of the ecological structure of the OCS system. These studies should have a significant on-site, ethnographic research component performed by professional ethnographers. These data and information are necessary to adequately evaluate how the communities might respond to OCS development-induced changes. These community studies would require about two years during a prelease phase.

c) Aesthetic and perceptual issues--Studies concerning perceptions of environmental conditions and values associated with potential OCS activities and their impacts should be performed for representative portions of the potentially affected populations prior to lease sale activity (NRC, 1989). These studies, which could be performed through a combination of on-site and telephone interviews, should include such subjects as perceived priority uses of various portions of the environment and perceived risks of various OCS activities. They will require about one year.

d) Infrastructure issues--Studies should be done on the potential infrastructural impacts of OCS development through all scenarios, including revenue sources, distribution of financial burdens, and sociopolitical variables affecting infrastructure development and use for all potentially affected areas. Such studies should focus on the locations and communities identified in paragraphs (a) and (b) above, and should focus on the potential for changes in local and regional economic and political relationships as a result of OCS-related development as well as the fiscal impacts of that development. These should include a complete analysis, based on empirical data and comparative case studies, of the potential availability and cost of petrochemical products, both within the eastern North Carolina region and to the nation as a whole, as a result of the proposed OCS development. These studies will require about one year for completion.

e) Socioeconomic Monitoring--Once the base case characterizations are established, socioeconomic variables (economic, sociopolitical, and sociocultural) should be included as part of a comprehensive, longitudinal OCS monitoring program associated with the Manteo Unit through all phases from exploration to post-production. This monitoring should be built into the basic environmental studies program based on a clearly defined set of variables, allowing for additions to such variables and other

alterations in the monitoring process as OCS activity progresses, and should be performed by professionally qualified social scientists with adequate resources to establish longitudinal data bases. In general, the variables for such a monitoring program should cover all of the above issue categories--socioeconomic characterization, community systems, aesthetic and perceptual, and infrastructural. Changes in all of these arenas should be monitored.

Exploration and Delineation

The studies required for the exploration and delineation phase are the same as those set out in the previous section, especially since those studies were not done at the leasing phase for the Manteo Unit. For exploration and delineation, however, these studies should be focused on the use of the Manteo Unit itself by commercial and recreational fishermen and boaters, the locations and communities with which these fishermen and boaters are connected, those shore locations referenced in the Exploration Plan, and those areas at risk from accidents. The major inadequacies are in the areas of: 1) the impact of OCS activities on commercial and recreational fishing and boating in the area of the drilling and on the communities and industries connected with that fishing and boating; 2) the impact of onshore OCS-related activities on local communities; 3) perceptions and attitudes toward OCS activities in this phase; 4) the interactions among local, state, and Federal governments in planning for possible future OCS development scenarios; and 5) the need for a thorough socioeconomic monitoring program to be in place prior to the initiation of any OCS activity. For the purposes of this phase, studies of the required depth could be accomplished in the areas cited above within a time frame of approximately one year. The modest time requirements recommended for this phase are based on the presumed existence of pertinent data, which have presumably been collected at the prelease phase, and the modest scale of the OCS activity itself during this phase. In the case of the Manteo Unit in particular, where adequate prelease studies were not done, it is the majority opinion of the Panel that under the present circumstances of the Memorandum of Understanding, and with the subsequent materials produced by MMS and Mobil, the studies indicated below are adequate background information for the exploration phase.

a) Base case characterization analysis--These studies, as described in the previous section, should be done for: 1) the

commercial and recreational fishing and boating activity that uses the Manteo Unit area; 2) the coastal communities from which this fishing and boating occurs (see (b) below); 3) coastal communities adjacent or related to the area of the Manteo Unit which might be affected by either normal OCS activity or accidents (generally, from Norfolk/Hampton Roads to Ocracoke Island, Roanoke Island, and the Beaufort/Morehead City area).

b) Community studies--These studies, as described in the previous section, should be performed for Outer Banks communities from Virginia Beach to Ocracoke Village, Roanoke Island (Wanchese), Englehard, Belhaven, Vandemere, Hobucken, Lowland, Oriental, Atlantic, and Beaufort/Morehead City.

c) Aesthetic and perceptual issues--A study of attitudes and perceptions as described in the previous section should be done for an overall sample of the residents of eastern North Carolina and southeastern Virginia, with subsamples of: 1) commercial fishermen; 2) recreational fishermen and boaters; and 3) residents of Dare, Hyde, Pamlico, and Carteret Counties. The studies should also collect as much data on the social and economic value of the use of OCS-related environments as possible.

d) Infrastructural issues--These studies should focus on Beaufort/Morehead City and the location of the oil spill response activity and should cover the items set out in the Infrastructural Issues discussion for leasing above.

e) Socioeconomic monitoring--The system of monitoring described in the Socioeconomic Monitoring discussion for leasing above should be set up before the exploration and delineation activity begins.

Development and Production

With development and production, the socioeconomic information requirements increase significantly due to the large increase in the breadth and scale of OCS activities and their attendant impacts in this phase. The categories of data and information needed remain the same as noted above, but the geographic area and magnitude of impacts--and thus the breadth and depth of the studies required--increase significantly. For the development and production phase, socioeconomic data and information are inadequate in virtually all areas, in particular in the areas of economics and infrastructure; community, household, and family sociocultural impacts; and psychosocial, aesthetic, and perceptual issues. In general, such

expanded socioeconomic studies would take approximately two years to complete once the detailed alternatives for the development and production phase have been developed.

Post-production

There is an extreme paucity of data and information on the socioeconomic impacts of the post-production phase of OCS operations in general, and the subject was not treated in the reviewed documents. Generally, the categories of information needed are those identified in the above sections. Within these categories, the question is that of the effects of the withdrawal of the physical and economic activities associated with OCS production. How will infrastructure developed for OCS activities be maintained? What will be the displacement effects for employees of OCS-related industries? Can pre-OCS development activities and human environments be "restored" or can replacement activities and environments be developed?

The key to effective planning and data-gathering for the post-production phase of OCS operations off North Carolina at this point is effective socioeconomic monitoring and analysis of OCS activities in other locations that are nearing, in, or past their post-production phase. That information and analysis must then be applied to the North Carolina situation.

North Carolina OCS Area.

Adequacy of All Information

The comments concerning adequacy of socioeconomic information contained in the comparable section above related to the Manteo area also apply to the whole of the North Carolina OCS. In fact, there is even less data and information available concerning the North Carolina OCS outside of the Manteo area than there is for the vicinity of the site. Therefore, there is an even greater need for such data and information for OCS activities proposed for areas beyond the region of the Manteo site than is identified for the Manteo area.

Recommended Studies

The recommended studies for the North Carolina OCS are the same as those referenced above for the Manteo site, with the studies tailored to the specific sites and socioeconomic systems involved in the particular proposal for OCS activity. Such studies might, depending on the particular proposal, have to be extended to offshore tracts south of Cape Hatteras and to onshore locations south to the vicinity of Charleston, South Carolina.

ADDITIONAL RECOMMENDATION: GEOGRAPHIC INFORMATION SYSTEM

The Panel in carrying out its responsibilities has found it necessary to identify, assemble, review, and analyze a large amount of scattered information and data pertaining to the physical oceanography, ecology, and socioeconomics of the area of the Manteo site and more generally to all of the North Carolina OCS. Based on this experience, the Panel recommends that MMS promote and use a Geographic Information System (GIS) program to provide the necessary information for all future leasing on the North Carolina OCS. The program should be initiated immediately and so designed that new information and data can be added as these become available.

IMPLICATIONS OF FOLLOWING THESE RECOMMENDATIONS

It is recognized that to fill all the information deficiencies that the Panel has identified may require resources in excess of those the Environmental Studies Program of MMS now has in its budget to allocate. The Panel also recognizes that the MMS budget for the Environmental Studies Program has declined substantially over the past decade in real dollars. It is thus possible that, if it is decided to conduct the studies recommended in this report, new funds will need to be allocated by Congress.

APPENDICES

APPENDIX A: LITERATURE REVIEWED

- Abel, P. D. 1974. Toxicity of synthetic detergents to fish and aquatic invertebrates. *J. Fish Biol.* 6: 279-298.
- Abernathy, S. A. (ed.). 1989. Drilling and Production Discharges and Oil Spills in the Marine Environment. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA. OCS EIS/EA MMS 89-0065, 39 pp. + Appendix.
- Anderson & Associates, Inc. 1982. Coal Train Movements through the City of Wilmington, North Carolina. North Carolina Department of Natural Resources, Office of Coastal Management. Coastal Energy Impact Program. CEIP Rept. No. 26, 114 pp.
- Anonymous. 1991. North Carolina Physical Oceanography Report. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region. OCS Study MMS 91-0011, 45 pp.
- ARCO Exploration Company. 1982. Exploration Plan: Critical Operations and Curtailment Plan. Offshore South Atlantic, Russell Area, OCS-A-0247 and OCS-A-0248, Block 709 and Block 710. ARCO Exploration Company, Dallas, TX. pp. 124.
- Atkinson, L. P. et al. 1989. Frontal eddy dynamics (FRED) experiment off North Carolina. Volume II. Technical report (C. C. Ebbesmeyer, ed.). U.S. Department of the Interior, Minerals Management Service, Herndon, VA. MMS 89-0028, 325 pp.
- Baird, P. H. 1990. Concentrations of seabirds at oil-drilling rigs. *The Condor*. 92: 768-771.
- Blake, J. A., B. Hecker, J. F. Grassle, N. Maciolek-Blake, B. Brown, M. Curran, B. Dade, S. Freitas, and R. E. Ruff. 1985. Studies of biological processes on the U.S. South Atlantic slope and rise. Phase 1. Benthic characterization study. Final Report. Prepared for U.S. Department of the Interior, Minerals Management Service, Washington, DC. Contract No. 14-12-0001-30064. 142 pp.
- Blake, J. A., B. Hecker, J. F. Grassle, B. Brown, M. Wade, P. D. Boehm, E. Baptiste, B. Hilbig, N. Maciolek, R. Petrecca, R. E. Ruff, V. Starczak, and L. Watling. 1987. Study of biological processes on the U.S. South Atlantic slope and rise. Phase 2. Final report. Prepared for U.S. Department of the Interior, Minerals Management Service, Washington, DC. OCS Study MMS 86-0096. 414 pp.

- Bobra, A., D. Mackay, and W. Y. Shiu. 1979. Distribution of hydrocarbons among oil, water and vapor phases during oil dispersant toxicity tests. *Bull. Environ. Contam. Toxicol.* 23: 558-565.
- Bodin, P. 1988. Results of ecological monitoring of three beaches polluted by the 'Amoco Cadiz' oil spill: Development of meiofauna from 1978 to 1984. *Mar. Ecol. Prog. Ser.* 42: 105-123.
- Boehm, P. D., M. S. Steinhauer, D. R. Green, B. Fowler, B. Humphrey, D. L. Fiest, and W. J. Cretney. 1987. Comparative fate of chemically dispersed and beached crude oil in subtidal sediments of the Arctic nearshore. *Arctic*. 40 (Suppl. 1): 133-148.
- Boersma, P. D. 1986. Ingestion of petroleum by seabirds can serve as a monitor of water quality. *Science*. 231: 373-376.
- Burns, K. A. and J. M. Teal. 1973. Hydrocarbons in the pelagic *Sargassum* community. *Deep Sea Res.* 20: 207-211.
- Burton, G. A., Jr., J. M. Lazorchak, W. T. Waller, and G. R. Lanza. 1987. Arsenic toxicity changes in the presence of sediment. *Bull. Environ. Contam. Toxicol.* 38: 491-499.
- Butler, J. N., B. F. Morris, and J. Sass. 1973. Pelagic tar from Bermuda and the Sargasso Sea. Bermuda Biological Station for Research, Spec. Publ. No. 10.
- Carraway, R. J. and L. J. Priddy. 1983. Mapping of Submerged Grass Beds in Core and Bogue Sounds, Carteret County, North Carolina, by Conventional Aerial Photography. North Carolina Department of Natural Resources and Community Development, Office of Coastal Management, North Carolina Coastal Energy Impact Program. CEIP Rept. No. 20, 86 pp.
- Chevron U.S.A., Inc. 1982. Exploration Plan: Manteo NI 18-2, UTM Zone 18, Block 510. Chevron U.S.A., Inc.
- Checkley, D. M., Jr., S. Raman, G. L. Maillet, and K. M. Mason. 1988. Winter storm effects on the spawning and larval drift of a pelagic fish. *Nature*. 335: 346-348.
- Continental Shelf Associates, Inc. 1989a. Draft Final Live-bottom Survey Report for Manteo Area Block 467. Prepared by Continental Shelf Associates, Inc., Jupiter, FL for Mobil Oil Exploration & Producing Southeast Inc., New Orleans, LA. 66 pp. + Appendices A-B.
- Continental Shelf Associates, Inc. 1989b. Appendix N of the Mobil Draft Exploration Plan, Manteo Area, Block 467, Offshore Atlantic (Revised). Prepared by Continental Shelf Associates,

- Inc., Jupiter, FL for Mobil Oil Exploration & Producing Southeast Inc., New Orleans, LA.
- Continental Shelf Associates, Inc. 1990. A Comparison of Marine Productivity among Outer Continental Shelf Planning Areas. A final report for the U.S. Department of the Interior, Minerals Management Service. OCS Study MMS 90-0070. Contract 14-35-0001-30487. 243 pp. + Appendices
- Continental Shelf Associates, Inc. 1991. Ichthyoplankton in the Vicinity of Manteo Area Block 467 from June to November 1990. Final Report. Prepared for Mobil Oil Exploration & Producing Southeast Inc., Dallas, TX by Continental Shelf Associates, Inc., Jupiter, FL. 65 pp. + Appendix.
- Coston-Clements, L., L. R. Settle, D. E. Hoss, and F. A. Cross. 1991. Utilization of *Sargassum* Habitat by Marine Invertebrates and Vertebrates (Final Report). Prepared by NOAA, National Marine Fisheries Service, Southeast Fisheries Science Center, Beaufort Laboratory, Beaufort, NC for South Atlantic Fishery Management Council, Charleston, SC. 22 pp. + Figures.
- Cribbins, P. D. 1981. Coastal Energy Transportation Study. Phase II, Volume I. A Study of OCS Onshore Support Bases and Coal Export Terminals. North Carolina Department of Natural Resources and Community Development, Office of Coastal Management, Coastal Energy Impact Program. CEIP Rept. 2, 73 pp.
- Cribbins, P. D. 1982. Coastal Energy Transportation Study. Phase III, Volume 4. The Potential for Wide-Beam Shallow-Draft Ships to Serve Coal and Other Bulk Commodity Terminals Along the Cape Fear. North Carolina Department of Natural Resources and Community Development, Office of Coastal Management, Coastal Energy Impact Program. CEIP Rept. 35, 43 pp.
- Cribbins, P. D. and R. D. Latta. 1982. Coastal Energy Transportation Study: Alternative Technologies for Transporting and Handling Export Coal. North Carolina Department of Natural Resources and Community Development, Office of Coastal Management, Coastal Energy Impact Program. CEIP Rept. 12, 63 pp.
- Dames & Moore. 1982a. Environmental Report: Exploration South Atlantic Outer Continental Shelf Lease Blocks NI 18-5-709 and 710, Lease Sale Area No. 56. Prepared by Dames & Moore, Cranford, NJ for Arco Exploration Company, Dallas TX. 105 pp. + Appendices A-D.
- Dames & Moore. 1982b. Environmental Report: Exploration Mid-Atlantic Lease Block 587, Lease Sale Area No. 59. Prepared by Dames & Moore, Cranford, NJ for Shell Offshore Inc., New Orleans, LA. 107 pp. + Appendices A-J.

- Dames & Moore. 1983a. Environmental Report: Exploration Mid-Atlantic Lease Block 586, Lease Sale Area No. 59. Prepared by Dames & Moore, Cranford, NJ for Shell Offshore Inc., New Orleans, LA. 56 pp. + Appendices A-J.
- Dames & Moore. 1983b. Environmental Report: Exploration Mid-Atlantic Lease Block 93, Lease Sale Area No. 59. Prepared by Dames & Moore, Cranford, NJ for Shell Offshore Inc., Atlantic Coast Production Group, Houston, TX. 61 pp. + Appendices A-J.
- Dames & Moore. 1983c. Environmental Report: Exploration Mid-Atlantic Lease Block 372, Lease Sale Area No. 59. Prepared by Dames & Moore, Cranford, NJ for Shell Offshore Inc., New Orleans, LA. 55 pp. Appendices A-J.
- Depledge, M. H. 1984. Changes in cardiac activity, oxygen uptake and perfusion indices in *Carcinus maenas* (L.) exposed to crude oil and dispersant. Comp. Biochem. Physiol. 78C: 461-466.
- Duke, T. W. and G. Petrazzuolo (eds.). 1989. Oil and Dispersant Toxicity Testing, Proceedings of a Workshop on Technical Specifications Held in New Orleans, January 17-19, 1989. Prepared by Technical Resources, Inc. U.S. Department of the Interior, Minerals Management Service. OCS Study MMS 89-0042, 139 pp.
- Dutka, B. J. and K. K. Kwan. 1984. Study of long term effects of oil and oil-dispersant mixtures on freshwater microbial populations in man made ponds. Sci. Total Environ. 35: 135-148.
- Espey, Huston & Associates, Inc. 1990. A Review of Drilling Mud Research. Prepared by Espey, Huston & Associates Inc., Austin, TX for Mobil Oil Exploration & Producing Southeast Inc., New Orleans, LA.
- Fabregas, J., C. Herrero, and M. Veiga. 1984. Effect of oil and dispersant on growth and chlorophyll *a* content of marine microalga *Tetraselmis suecica*. Appl. Environ. Microbiol. 47: 445-447.
- Fang, C. S. 1990. Petroleum drilling and production operations in the Gulf of Mexico. Estuaries. 13: 89-97.
- Finsterbush, K., L. G. Llewellyn, and C. P. Wolf (eds.). 1983. Social Impact Assessment. Sage Press, Beverly Hills, CA.
- Freudenburg, W. R. 1986. Social impact assessment. Ann. Rev. Sociol. 12: 451-478.
- Gilfillan, E. S., D. S. Page, S. A. Hanson, J. C. Foster, J. Hotham, D. Vallas, E. Pendergast, S. Hebert, S. D. Pratt, and R. Gerber. 1985. Tidal area dispersant experiment, Searsport Maine: An overview. Proceedings 1985 Oil Spill Conference, pp. 553-569.

- Haim, A., B. Nicolaisen, and N. A. Øritsland. 1984. Crude oil--its impact on the rat's heat balance. *Comp. Biochem. Physiol.* 78A: 259-261.
- Hodgson, B. 1990. Alaska's big spill--Can the wilderness heal? *Nat. Geog.* 177: 5-43.
- Humphrey, B., P. D. Boehm, M. C. Hamilton, and R. J. Norstrom. 1987. The fate of chemically dispersed and untreated crude oil in Arctic benthic biota. *Arctic.* 40 (Suppl 1): 149-161.
- Interstate Electronics Corporation. 1982. Environmental Report--Exploration Blocks 422, 466, 510 (Manteo), South Atlantic OCS. Prepared by Interstate Electronics Corporation, Oceanic Engineering, Anaheim, CA for Chevron U.S.A., Inc.
- Johnson, W. C., II, D. J. DiCristoforo, and N. W. Clayton. 1989. Environmental Studies Program Bibliography 1973-1987. U.S. Department of the Interior, Minerals Management Service, Branch of Environmental Studies. OCS Study MMS 89-0087, 318 pp.
- Johnson, J. C. and R. Purdue. 1986. Marine Recreational Fishing, Marinas, and Marine Manufacturing in North Carolina: An Economic Characterization. University of North Carolina Sea Grant College Program. UNC-8G-SP-86-3. 58 pp.
- Kasschau, M. R. and C. L. Howard. 1984. Free amino acid pool of a sea anemone: Exposure and recovery after an oil spill. *Bull. Environ. Contam. Toxicol.* 33: 56-62.
- Kravetz, L., H. Chung, K. F. Guin, W. T. Shebs, L. S. Smith, and H. Stupel. 1982. Ultimate biodegradation of an alcohol ethoxylate and a nonylphenol ethoxylate under realistic conditions. Shell Chemical Co. Tech. Bull. SC:714-82. 19 pp.
- Lal, H., V. Misra, P. N. Viswanthan, and C. R. Krashna Murti. 1983. Comparative studies on ecotoxicology of synthetic detergents. *Ecotoxicol. Environ. Safe.* 7: 538-545.
- Lee, D. S. and J. F. Parnell (ed.). 1990. Endangered, Threatened, and Rare Fauna of North Carolina. Part III. Birds. Occ. Pap. North Carolina Biol. Surv. 1990. 48 pp.
- Lee, D. S. and M. C. Socci. 1989. Potential Effects of Oil Spills on Seabirds and Selected Other Oceanic Vertebrates off the North Carolina Coast. Occ. Pap. North Carolina Biol. Surv. 1989-1, 64 pp.
- Lewis, M. A. and D. Suprenant. 1983. Comparative acute toxicities of surfactants to aquatic invertebrates. *Ecotoxicol. Environ. Safe.* 7: 313-322.
- LGL Ecological Research Associates Inc. 1991a. Effects of Noise on Marine Mammals: Executive Summary. Prepared by LGL

- Ecological Research Associates Inc., Bryan, TX for U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA. OCS Study MMS 90-0093A. 22 pp.
- LGL Ecological Research Associates Inc. 1991b. Effects of Noise on Marine Mammals. Prepared by LGL Ecological Research Associates Inc., Bryan, TX for U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA. OCS Study MMS 90-0093. 462 pp.
- Mageau, C., F. R. Engelhardt, E. S. Gilfillan, and P. D. Boehm. 1987. Effects of short-term exposure to dispersed oil in Arctic invertebrates. *Arctic*. 40 (Suppl. 1): 162-171.
- Maki, A. W. 1979. Correlations between *Daphnia magna* and fathead minnow (*Pimephales promelas*) chronic toxicity values for several classes test substances. *J. Fish. Res. Bd. Canada*. 36: 411-421.
- Mann, A. H. and V. W. Reid. 1971a. Biodegradation of synthetic detergents, evaluation by community trials. Part 2: Alcohol and alkylphenol ethoxylates. *J. Amer. Oil Chem. Soc.* 48: 794-797.
- Mann, A. H. and V. W. Reid. 1971b. Biodegradation of synthetic detergents, evaluation by community trials. Part 3. Primary alcohol sulphates. *J. Amer. Oil Chem. Soc.* 48: 798-799.
- Miller, J. M., J. P. Reed, and L. J. Pietrafesa. 1984. Patterns, mechanisms, and approaches to the study of migrations of estuarine-dependent fish larvae and juveniles, pp. 209-225. In: *Mechanisms of Migration in Fishes* (J. D. McCleave, G. P. Arnold, J. J. Dodson, and W. H. Neill, eds.). Plenum, New York, NY.
- Minerals Management Service. 1991. Alaska OCS Region: Social and Economic Studies Technical Reports. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK.
- Mitchell, J. K. 1976. Onshore impacts of Scottish offshore oil: Planning implications for Middle Atlantic states. *J. Amer. Inst. Plan.* 42: 6386-398.
- MOEPSI (Mobil Oil Exploration & Producing Southeast Inc.). 1990. Mobil Exploration Plan: Manteo Area Block 467 Offshore Atlantic. Mobil Oil Exploration & Producing Southeast Inc. Vols. 1-3.
- Nagy, E., B. F. Scott, and J. Hart. 1984. The fate of oil and oil-dispersant mixtures in freshwater ponds. *Sci. Total Environ.* 35: 115-133.
- NRC (National Research Council). 1978. OCS Oil and Gas--An Assessment of the Department of the Interior Environmental

- Studies Program. National Academy of Sciences, Washington, DC.
- NRC (National Research Council). 1983. Drilling Discharges in the Marine Environment. National Academy Press, Washington, DC. 180 pp.
- NRC (National Research Council). 1989. The Adequacy of Environmental Information for Outer Continental Shelf Oil and Gas Decisions: Florida and California. National Academy Press, Washington, DC. 86 pp.
- NRC (National Research Council). 1990a. Decline of the Sea Turtles: Causes and Prevention. National Academy Press, Washington, DC. 259 pp.
- NRC (National Research Council). 1990b. Assessment of the U.S. Outer Continental Shelf Environmental Studies Program. I. Physical Oceanography. National Academy Press, Washington, DC. 143 pp.
- NRC (National Research Council). 1991. The Adequacy of Environmental Information for Outer Continental Shelf Oil and Gas Decisions: Georges Bank. National Academy Press, Washington, DC. 83 pp.
- Palinkas, L. A., B. M. Harris, and J. S. Petterson. 1983. A Systems Approach to Social Impact Assessment: Two Alaska Case Studies. Westview Press, Boulder, CO.
- Payne, J. R. 1982. Metabolism of complex mixtures of oil spill surfactant compounds by a representative teleost (*Salmo gairdneri*), crustacean (*Cancer irroratus*), and mollusc (*Chlamys islandicus*). Bull. Environ. Contam. Toxicol. 28: 277-280.
- Petterson, J. S., L. A. Palinkas, B. M. Harris, M. A. Downs, and B. Holmes. Alaska OCS Social and Economic Studies Program, Executive Summary. Unalaska: Ethnographic Study and Impact Analysis. Prepared by Impact Assessment, Inc. for U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region. Technical Report 92.
- Petterson, J. S. 1990. Economic, Social and Psychological Impact Assessment of the Exxon Valdez Oil Spill. Prepared by Impact Assessment, Inc., for the Oiled Mayors' Subcommittee, Alaska Conference of Mayors. 4 Volumes.
- Rabalais, N. N., B. A. McKee, D. J. Reed, and J. C. Means. 1991a. Fate and Effects of Nearshore Discharges of OCS Produced Waters. Volume I: Executive Summary. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. OCS Study MMS 91-0004, 48 pp.

- Rabalais, N. N., B. A. McKee, D. J. Reed, and J. C. Means. 1991b. Fate and Effects of Nearshore Discharges of OCS Produced Waters. Volume II: Technical Report. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. OCS Study MMS 91-0005, 337 pp.
- Rabalais, N. N., B. A. McKee, D. J. Reed, and J. C. Means. 1991c. Fate and Effects of Nearshore Discharges of OCS Produced Waters. Volume III: Appendices. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. OCS Study MMS 91-0006, 225 pp.
- Roberts and Eichler Associates, Inc. 1982. Area Development Plan for Radio Island. North Carolina Department of Natural Resources, Office of Coastal Management, Coastal Energy Impact Program. CEIP Rept. No. 34, 100 pp.
- Rogers, Golden & Halpern. 1982. The Design of a Planning Program to Help Mitigate Energy Facility-related Air Quality Impacts in the Washington County, North Carolina Area. North Carolina Department of Natural Resources, Office of Coastal Management, Coastal Energy Impact Program. CEIP Rept. No. 14, 94 pp.
- Sadiq, M. and T. H. Zaidi. 1984. Vanadium and nickel content of Nowruz spill tar flakes on the Saudi Arabian coastline and their probable environmental impact. Bull. Environ. Contam. Toxicol. 32: 635-639.
- SAIC (Science Applications International Corporation). 1990. Characterization of currents at Manteo Block 467 off Cape Hatteras, NC.--Final report. Science Applications International Corporation, Raleigh, NC. SAIC Rept. No. 90/1131, 152 pp.
- Salazar, S. M. 1985. Toxicity of aqueous filmforming foams to marine organisms: Literature review and biological assessment. Naval Ocean Systems Center, San Diego, CA. Tech. Doc. 825, 17 pp. ++ Appendices A-B.
- Schaaf, T. J., L. A. Levin, N. Blair, F. DeMaster, R. Pope, and S. Boehme. 1992. Spatial heterogeneity of benthos on the North Carolina continental slope: Large (100-km) scale variation. Mar. Ecol. Prog. Ser. (in review).
- Scott, B. F. 1984. Impact of oil and oil-dispersant mixtures on the fauna of freshwater ponds. Sci. Total Environ. 35: 191-206.
- Scott, B. F. and V. Glooschenko. 1984. Impact of oil and oil-dispersant mixtures on flora and water chemistry parameters in freshwater ponds. Sci. Total Environ. 35: 169-190.
- Scott, B. F., E. Nagy, B. J. Dutka, J. P. Sherry, W. D. Taylor, V. Glooschenko, P. J. Wade, and J. Hart. 1984. The fate and impact

- of oil and oil-dispersant mixtures in freshwater pond ecosystems: Introduction. *Sci. Total Environ.* 35: 105-113.
- Scott, W. S. Use of oil sorbent materials for small herbicide spills. *Bull. Environ. Contam. Toxicol.* 23: 123-128.
- Shafer, T. H. and C. t. Hackney. 1987. Variation of adenylate energy charge and phosphoadenylate pool size in estuarine organisms after an oil spill. *Bull. Environ. Contam. Toxicol.* 38: 753-761.
- Shanks, A. L. 1983. Surface slicks associated with tidally forced internal waves may transport pelagic larvae of benthic invertebrates and fishes shoreward. *Mar. Ecol. Prog. Ser.* 13: 331- 315.
- Shell Offshore Inc. 1982. Exploration Plan: Wilmington Canyon Block 587. Shell Offshore Inc.
- Shell Offshore Inc. 1983a. Exploration Plan: Wilmington Canyon Block 372. Shell Offshore Inc. 53 pp.
- Shell Offshore Inc. 1983b. Exploration Plan: Wilmington Canyon Block 586. Shell Offshore Inc. 55 pp.
- Shell Offshore Inc. 1983c. Exploration Plan: Baltimore Rise Block 93. Shell Offshore Inc. 43 pp.
- Sherry, J. P. 1984. The impact of oil and oil-dispersant mixtures on fungi in freshwater ponds. *Sci. Total Environ.* 35: 149-167.
- Slade, G. J. 1982. Effect of Ixtoc I crude oil and Corexit 9527 dispersant on spot (*Leiostomus xanthurus*) egg mortality. *Bull. Environ. Contam. Toxicol.* 29: 525-530.
- Stewart-Oaten, A., W. W. Murdoch, and K. Parker. 1986. Environmental impact assessment: "Pseudoreplication" in time? *Ecology.* 67: 929-940.
- Stone, J. R., M. T. Stanley, and P. T. Tschetter. 1982. Coastal Energy Transportation Study. Phase III, Volume 3. Impacts of Increased Rail Traffic on Communities in Eastern North Carolina. North Carolina Department of Natural Resources, Office of Coastal Management, Coastal Energy Impact Program. CEIP Rept. No. 17, 119 pp.
- Stoner, A. W. 1983. Pelagic *Sargassum*: Evidence for a major decrease in biomass. *Deep-Sea Res.* 30: 469-474.
- Telfer, T. C., J. L. Sincock, G. V. Byrd, and J. R. Reed. 1987. Attraction of Hawaiian seabirds to light: Conservation efforts and effects of moon phase. *Wildl. Soc. Bull.* 15: 406-413.
- U.S. DOI (U.S. Department of the Interior). 1981. Final Environmental Impact Statement: Proposed 1981 Outer Continental Shelf Oil and Gas Lease Sale 56. U.S. Department of the Interior, Bureau of Land Management. 576 pp.

- U.S. DOI (U.S. Department of the Interior). 1982a. Environmental Assessment: Arco Exploration Company as Operator, Plan of Operation (Exploration), Atlantic OCS NI 18-5 Blocks 709 and 710, OCS-A Leases 0247 and 0248. U.S. Department of the Interior, Mineral Management Service, Northfield, NJ.
- U.S. DOI (U.S. Department of the Interior). 1982b. Environmental Assessment: Chevron U.S.A. Inc. as Operator, Plan of Operation (Exploration), Atlantic OCS NI 18-2 Block 510 OCS-A Lease 0237. U.S. Department of the Interior, Minerals Management Service, Northfield, NJ.
- U.S. DOI (U.S. Department of the Interior). 1983a. Environmental Assessment: Shell Offshore Inc. as Operator, Plan of Operation (Exploration), Mid-Atlantic OCS NJ 18-6 Block 587. U.S. Department of the Interior, Minerals Management Service, Vienna, VA.
- U.S. DOI (U.S. Department of the Interior). 1983b. Environmental Assessment: Shell Offshore, Inc. as Operator, Plan of Operation (Exploration), Mid-Atlantic OCS NJ 18-6 Block 586. U.S. Department of the Interior, Minerals Management Service, Vienna, VA.
- U.S. DOI (U.S. Department of the Interior). 1983c. Environmental Assessment: Shell Offshore, Inc. as Operator, Plan of Operation (Exploration), Mid-Atlantic OCS NJ 18-6 Block 372. U.S. Department of the Interior, Minerals Management Service, Vienna, VA.
- U.S. DOI (U.S. Department of the Interior). 1983d. Environmental Assessment: Shell Offshore Inc. as Operator, Plan of Operation (Exploration) Mid-Atlantic OCS NJ 18-9 Block 93. U.S. Department of the Interior, Minerals Management Service, Vienna, VA.
- U.S. DOI (U.S. Department of the Interior). 1983e. Final Environmental Impact Statement, Proposed 1983 Outer Continental Shelf Oil and Gas Lease Sale Offshore the South-Atlantic States. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, New York Office. 355 pp. + Appendices A-H.
- U.S. DOI (U.S. Department of the Interior). 1985. Final Environmental Impact Statement, Proposed 1985 Outer Continental Shelf Oil and Gas Lease Sale Offshore the Mid-Atlantic States. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Vienna, VA. 476 pp. + Appendices A-H.
- U.S. DOI (U.S. Department of the Interior). 1986. Managing oil and gas operations on the Outer Continental Shelf. U.S. Department

- of the Interior, Minerals Management Service, Washington, DC. MS 646, 60 pp.
- U.S. DOI (U.S. Department of the Interior). 1987. Leasing energy resources on the Outer Continental Shelf. U.S. Department of the Interior, Minerals Management Service, Washington, DC. MS 645. 49 pp.
- U.S. DOI (U.S. Department of the Interior). 1990a. Final Environmental Report on Proposed Exploratory Drilling Offshore North Carolina. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA. Vols. I-III.
- U.S. DOI (U.S. Department of the Interior). 1990b. Environmental Assessment of Exploration Plan for Manteo Area Block 467. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA. 113 pp. + Appendices A-G.
- U.S. DOI (U.S. Department of the Interior). 1990c. Comprehensive Program 1992-1997 (Draft Proposal). U.S. Department of the Interior, Minerals Management Service, Herndon, VA. 147 pp. + Appendices 1-11.
- U.S. DOI (U.S. Department of the Interior). 1990d. The Offshore Environmental Studies Program (1973-1989): A Summary of Minerals Management Service Research Conducted on the U.S. Outer Continental Shelf. U.S. Department of the Interior, Minerals Management Service, Environmental Policy and Programs Division. OCS Report MMS 90-0095.
- U.S. DOI (U.S. Department of the Interior). 1991a. Comprehensive Program 1992-1997: Summary and Decision (Draft Proposal). U.S. Department of the Interior, Minerals Management Service, Herndon, VA., 43 pp.
- U.S. DOI (U.S. Department of the Interior). 1991b. Comprehensive Program 1992-1997, Decision Documents (Proposal). U.S. Department of the Interior, Minerals Management Service, Herndon, VA. 186 pp. + Appendices 1-10.
- U.S. DOI (U.S. Department of the Interior). 1991c. Comprehensive Program 1992-1997, Draft Environmental Impact Statement. U.S. Department of the Interior, Minerals Management Service, Herndon, VA. Vols. I-II. OCS EIS/EA MMS 91-0044.
- U.S. DOI. (U.S. Department of the Interior). 1991d. Atlantic OCS Region Regional Studies Plan Fiscal Years 1991-1992. U.S. Department of the Interior, Minerals Management Service, Herndon, VA.
- U.S. DOI (U.S. Department of the Interior). 1991e. Estimating the Environmental Costs of OCS Oil and Gas Development and Marine

- Oil Spills: A General Purpose Model, Overview and Summary. Prepared by A. T. Kearney, Inc. for U.S. Department of the Interior, Minerals Management Service, OCS Study MMS 91-043.
- U.S. DOI (U.S. Department of the Interior). 1991f. Estimating the Environmental Costs of OCS Oil and Gas Development and Marine Oil Spills: A General Purpose Model, Economic Analysis of Environmental Costs. Prepared by A. T. Kearney, Inc. for U.S. Department of the Interior, Minerals Management Service, OCS Study MMS 91-043.
- Verriopoulos, G., M. Moraitou-Apostolopoulou, and E. Milliou. 1987. Combined toxicity of four toxicants (Cu, Cr, oil dispersant) to *Artemia salina*. Bull. Environ. Contam. Toxicol. 38: 483-490.
- Wagner, J. C., D. M. Griffiths, and D. E. Munday. 1987. Experimental studies with palygorskite dusts. Brit. J. Ind. Med. 44: 749-763.
- Wang Engineering Co., Inc. 1982. Analysis of the Impact of Coal Trains Moving through Morehead City, North Carolina. North Carolina Department of Natural Resources and Community Development, Office of Coastal Management, Coastal Energy Impact Program. CEIP Rept. No. 25, 46 pp.
- White, I. C. 1985. An organization to help combat oil spills. Sea Frontiers 31: 15-21.
- Wolf, C. P. 1991. Socioeconomic Impact Assessment of OCS Oil and Gas: A Preliminary Bibliography. Social Impact Assessment Center, New York, NY. 20 pp.
- Yarle, S. (ed.). 1983. Alaska Symposium on the Social, Economic and Cultural Impacts of Natural Resource Development. University of Alaska, Department of Conferences and Institutes, Fairbanks, AK.

APPENDIX B: FACTORS INFLUENCING THE DEFINITION OF ADEQUACY OF INFORMATION

In order to respond to the charge of assessing the adequacy of available environmental information, the Panel found it necessary to consider the factors that may influence adequacy. The results of these considerations are summarized in this appendix. It should be noted that the factors listed here do not represent the definition of adequacy adopted by the Panel; this is presented in the text.

Fairness and Equal Treatment of the States.

The failure to include the North Carolina OCS in the wide-reaching presidential moratorium on OCS oil and gas activities declared in the wake of release of the NRC (1989) report on the adequacy of environmental information for OCS oil and gas decisions off Florida and California implies that the North Carolina Environmental Sciences Review Panel should contrast available OCS environmental information off North Carolina to that available for the areas included in the moratorium. The purpose of the 10-year presidential moratorium is to allow collection of the additional information necessary to make informed judgements on leasing, exploration, and development and production of OCS tracts. This suggests that for fairness and consistency the same standards of adequacy should be applied to North Carolina.

Dependence Upon the Estimated Size of the Oil and Gas Reservoirs.

Perhaps the funding levels for environmental studies of OCS areas by MMS should vary in proportion to the economic value of the estimated reserves. This may seem to make good business sense, but it would carry the consequences that the level of information available for OCS oil and gas decision-making would probably vary from place to place and thus the quality of the decisions would also vary. This factor, the estimated size of the hydrocarbon reserves, should appropriately enter into deciding whether environmental risks are outweighed by economic and strategic benefits of developing the tract in question, but it seems an inappropriate contributor to setting standards for adequacy of environmental information.

Dependence on Environmental Value.

It would seem possible to argue that the amount of environmental information required to make sound decisions on OCS oil and gas proposals should vary to some degree with the value of the environmental resources present. This concept is in part codified by the requirements of the Endangered Species Act, which implies that more extensive information on potential impacts of oil and gas activities be gathered on endangered and threatened species than on others. Thus, the standards of adequacy of environmental information differ for different sets of species. In that same spirit, it seems appropriate that more complete information also be required for economically important species, such as important fish stocks if present, and for socially valued species, such as sea mammals and birds, than for species of plankton, for example. Nevertheless, this concept needs cautious application, given the realization that the success and health of all important species depend in complex ways on the physical, chemical, and biological environment in which they live. Thus, impacts on prey species, predators, competitors, or habitat providers could have substantial effects on the species deemed important. Consequently, some knowledge of the ecosystem structure and function is necessary to make adequate predictions of impact on the species deemed important. To some degree, this limits the development of different criteria of adequacy of environmental information as a function of value of the environmental resource.

Dependence on Public Opinion.

The NRC report on the adequacy of environmental information for OCS oil and gas decisions off Florida and California notes that the amount of information gathered varies widely among states as a function of the intensity of public demand, urgency, and protest. This raises the question of whether it is appropriate that standards of adequacy vary with local public demand. To the degree that this demand itself represents one measure of social impact of the proposed oil and gas activity, it does not seem unreasonable that evaluation effort should be influenced by it.

Dependence on Likelihood of Scenario of Impact.

It seems reasonable to argue that the scope and intensity of information gathering should be influenced to some degree by the probabilities of the scenarios that may lead to impacts. A scenario of impact that is exceedingly unlikely presumably does not justify the same level of environmental evaluation as an alternative scenario that is probable. However, the problem of how to define what is sufficiently improbable to justify inattention yet still be responsive to the mandate of environmental evaluation is a vexing one with no unequivocal answer. Generally too, the level of uncertainty of prediction rises with decreasing probability, which also complicates setting a standard of likelihood that triggers need for complete environmental evaluation. Risk assessment clearly and appropriately requires application of probability theory to permit proper evaluation of proposed OCS activities, but the use of probability in determining standards of completeness of environmental information gathering should be largely limited to exclusion of exceedingly improbable events from extensive evaluation.

Dependence on History of OCS Activity in the Area.

It is reasonable to suggest that more complete study and review of environmental issues should be conducted for "frontier" areas where no previous OCS oil and gas activity has taken place. Extension of OCS oil and gas activities to new areas distant from those previously leased and explored probably does imply that MMS will usually need to fund more environmental studies just because there will generally be less previous information available on which to judge environmental issues. However, this should not affect the standards for adequacy of that environmental information: standards should not vary as a function of the history of prior OCS oil and gas activities in the area. Clearly, the existence of a record of previous nearby OCS activities does affect the environmental evaluation process in other ways. For example, the issue of cumulative impacts becomes more germane to areas with ongoing OCS activity. Furthermore, the existence of ongoing or historical OCS activity implies opportunity to evaluate explicit and site-specific hypotheses concerning potential environmental impacts. Such evaluations should be made a part of the information review process

for areas with prior OCS activities and even for frontier areas where extrapolation can be justified.

Dependence on Federal/State Revenue Allocation.

It is possible to argue that the adequacy of environmental information required for OCS decisions may depend upon the relative allocation of revenues derived from the OCS oil and gas activities, in an indirect fashion, acting through political processes at the level of the states. With the current formula for payments of lease sales and production revenues from OCS areas outside of the Gulf of Mexico, one can argue that the Federal government collects virtually all the revenues while the individual states stand to suffer all the potential environmental impacts, if any. The perceived lack of equity in this arrangement may stimulate greater resistance to OCS activity than if those states were receiving greater direct payments, which could compensate for any ultimate negative environmental impacts.

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