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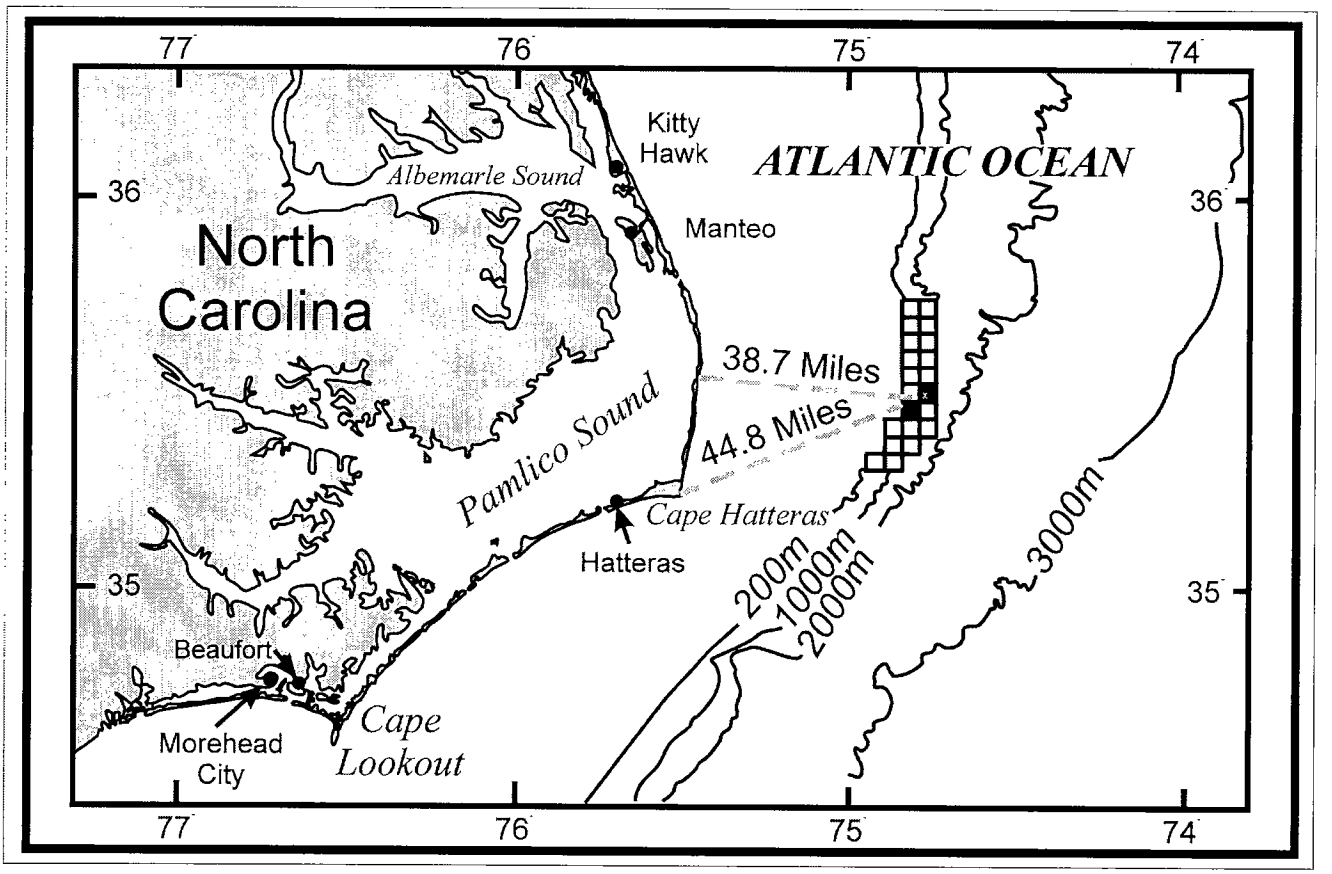
North Carolina/ Minerals Management Service Technical Workshop on Manteo Unit Exploration

February 4-5, 1998



U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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ABOUT THE COVER

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ACKNOWLEDGMENTS

This meeting was a joint effort between the North Carolina Department of Environment and Natural Resources (DENR) and the U.S. Department of the Interior's Minerals Management Service. Ms. Kim Crawford, Ocean Resources Specialist, DENR, and Mr. Mike Lopazanski, Coastal Program Analyst, DENR set up the agenda, contacted speakers, and established a list of participants. Staff of the MMS Gulf of Mexico OCS Region, Environmental Studies Section, provided logistics support for the workshop.

Walter Clark and Larry Cahoon did an excellent job of moderating the general session. Each of the speakers is acknowledged with their presentation printed in this proceedings and a special debt of gratitude is owed to the breakout session chairs for their leadership roles.

INTRODUCTION

Ms. Debra L. Vigil
Leasing and Environment
Minerals Management Service
Gulf of Mexico OCS Region

BACKGROUND

The U.S. Department of the Interior's Minerals Management Service (MMS) has the responsibility of regulating exploration and development by the oil and gas industry on the U.S. Outer Continental Shelf (OCS). There is an area of active leases approximately 45 miles east-northeast of Cape Hatteras, North Carolina, referred to as the Manteo Unit. Chevron U.S.A. may propose to drill a single exploratory well in either Block 467 or 510 of the Manteo Unit with a specially outfitted drilling rig. To review environmental and socioeconomic information known, and needed, on the Manteo Unit, a workshop was conducted on February 4-5, 1998, with the North Carolina Department of Environment and Natural Resources (DENR). The North Carolina DENR established the agenda, and invited speakers and participants.

PURPOSE

The objectives of the workshop were to review the state of knowledge for drilling a single exploratory well in either Block 467 or 510; share scientific information obtained since 1990; distinguish between exploration and development activities; share information on drilling technology and industry experience operating in similar physical environments; address scientific concerns regarding the potential impacts of OCS drilling on biological resources; and address concerns regarding onshore (social and economic) impacts from OCS drilling.

WORKSHOP STRUCTURE

Each participant was provided a briefing book to maintain focus for the workshop--discussion of a single exploratory well being drilled in one of two lease blocks in the Manteo Unit. Background information contained in the briefing book included sale and ownership of Blocks 467 and 510; map of the area; litigation status; status of the OCS leases off North Carolina; plans of exploration on file with MMS; likely scenarios for drilling one exploratory well in the Manteo Unit; environmental assessments; a review of findings of the North Carolina Environmental Sciences Review Panel; 17th Information Transfer Meeting Presentations; MMS publications related to the U.S. Atlantic coast; Gulf of Mexico rigs drilling in deepwater; and the MMS's Regional Director's slide presentation. Most of these background materials provided in the workshop briefing book are provided in this proceedings.

The workshop lasted a day-and-a-half with the first day devoted to general overviews of the area. The MMS's Gulf of Mexico OCS Regional Director gave an MMS perspective on the history and status of the area, and Chevron gave a presentation on how the exploratory well would be drilled. This led into a presentation on the North Carolina response to the Plan of Exploration and the general scientific characterization of Blocks 467 and 510. The scientific characterization was presented in greater detail by a number of scientific experts who spoke on the following disciplines: physical environment; habitat and living resources; seabirds, marine mammals, and sea turtles; and social and economic issues. The day ended with an open discussion, questions and answers, and an introduction to the next morning's breakout sessions.

The second day consisted of five breakout sessions: physical environment; fisheries; benthos; surface biota; and social and economic issues. The breakout groups were tasked with identifying pertinent, exploratory drilling research conducted in the geographic area and with identifying additional efforts needed should development occur. Each breakout session later reported their discussion to the full audience.

Debra Vigil is a program analyst in the Environmental Studies Section of Leasing and Environment. She has worked for MMS for six years and is presently responsible for coordinating outreach efforts and special projects, as well as processing and maintaining environmental study reports. She has a Bachelor of Business Administration degree from Eastern New Mexico University, and most of her career has been spent working as a Special Assistant for Federal officials at the U.S. Departments of Justice, Transportation, Commerce, and Interior.

OPENING REMARKS

Secretary Wayne McDevitt
North Carolina Department of Environment and Natural Resources

On behalf of Governor Jim Hunt and the Department of Environment and Natural Resources, I'd like to welcome you to Raleigh, and to the North Carolina/Minerals Management ServiceTechnical Workshop on Manteo Unit Exploration.

I was looking at your agenda last night, and I know you all know this, but you folks have a big task ahead of you in the next two days.

You're going to be reviewing the knowledge we have now about the Manteo Exploration Unit — the area where Chevron U.S.A. has said it wants to drill an exploratory well as early as the year 2000. You're going to learn about the latest drilling technology, and about Chevron's experience drilling in difficult environments.

You'll discuss scientific concerns about offshore drilling, and what that could mean for biological resources in the area. And you'll talk about how offshore drilling could affect us on shore, both economically and socially.

That's a lot of work, but it is vitally important. So let me thank you now for giving up your time to participate in these important sessions.

I was pleased to learn about this workshop — not just because you will help us identify issues that need further examination, but because this workshop is helping us look at an important issue ahead of time, to do work now so we can conduct the best possible review of Chevron's proposal when it arrives.

That's one of our objectives at the Department of Environment and Natural Resources — to anticipate issues so we can do our work better as an agency.

Today is my six-month anniversary as Secretary of the Department. And it's been a whirlwind, let me tell you.We've accomplished a lot in that time — and a lot of our accomplishments will benefit our coastal environment and economy.

- We saw fisheries reform legislation enacted to protect stocks and habitats, and to require fishery management plans for all significant recreational and commercial species.

- We created a scientific advisory council on water resources and coastal fisheries management.

- We began recreational water quality testing at our coast, in recognition of the importance of assuring the public that our beaches are safe places to be.

- We've also worked hard over the last few months to set our priorities for the remaining three years of this administration. One of those priorities is organizational excellence, and meetings like this one will help us achieve that.

Another DENR priority is stewardship of natural resources. We are stewards of a natural trust that was handed down to us by our ancestors. We are obligated to care for that trust; to make sure that North Carolina's abundant natural resources — air, water, land, animals, birds and fish — are around for our children and grandchildren to enjoy. That includes our resources offshore.

We have seen time and time again that a prosperous economy and a healthy environment can be hand-in-hand. We want North Carolina to grow. We want it to thrive. But we have to make sure that growth is smart, that it's sustainable. That's another priority at our Department. We will work to ensure that North Carolina's growth doesn't come at the heavy price of environmental damage that's hard to repair.

This is our vision: to make North Carolina the best place to live, work and visit. We'll be keeping that in mind as we conduct the Chevron review.

The area where Chevron wants to explore for oil or natural gas is like no other off the North Carolina coast.

This area, known to folks on our coast as The Point, is an unparalleled fishing ground, both for recreational and commercial fishermen. It's become a popular birdwatching site for people from all over, who come to see birds that don't feed anywhere else in the world.

There's a lot we don't know yet about his area and about what offshore drilling would mean — for the fish caught there; the birds that feed there; the geological stability under the ocean floor. That's why it's important that you all are here today. You're going to help us determine what we need to find out.

Still, we know so much more today than we did when Mobil Oil proposed to drill in the late 1980s. We learned a lot from that experience. And what we learned will help us as we review Chevron's plan.

Since the Mobil review, we have been working steadily to improve our ability to review proposals for offshore exploration and drilling.

- Our Coastal Management Division appointed an Ocean Task Force, which examined ocean resources issues and recommended changes to the state's coastal energy policies.

- The Coastal Resources Commission adopted those changes in 1996. They're important changes that clarify the type of information North Carolina needs to review an exploration plan and that will help us do a better job of protecting critical habitat.

- In fact, Governor Hunt thought the amended coastal energy policies were so important that in November, he used his executive order power to put them into immediate effect.

We've also taken some important steps since September, when Chevron announced its desire to explore for offshore oil and natural gas.

- The Division of Coastal Management has just hired two more people to help us coordinate the technical review of Chevron's proposal and to respond to the public's need for information. We believe it is important for people to know as much as they can about this issue. We are committed to keeping this process open, and we will be keeping our citizens informed every step of the way.

- We've also just named a citizen advisory committee to help identify issues of public concern and to help us decide which of those issues we must evaluate first.

The committee includes two members from each of the three environmental commissions, and one each from Dare and Carteret counties. I think most of them are here today, so I'd like to run down the list: Bob Emory and Alton Ballance from the Coastal Resources Commission; Bob Epting and Marion Deerhake from the Environmental Management Commission; and Bob Eakes and Tim Nifong from the Marine Fisheries Commission. Don Kirkman is here from the Carteret County Economic Development Council, and Michael McOwen of LegaSea is here as Dare County's representative. Thank you all for being here today and for agreeing to serve on this important committee.

I'd like to take a minute to also thank the Minerals Management Service for sponsoring this workshop and for being willing to work with us ahead of time, to help us be ready when Chevron's application comes in. And I'd like to thank Chevron for being forthcoming about their plans — months before they give us a formal drilling proposal.

This is an important two days. Each of you in this room is in a position to make a difference for our coastal — and the entire state of North Carolina — by identifying issues that need to be studied before we make a decision on the Chevron proposal.

This review is going to be a big job. And it's one that we at the Department of Environment and Natural Resources have committed to doing to the best of our ability.

We actually have two jobs during the reviews. One is to recognize that our nation needs to find new energy sources. The other is our job as stewards of North Carolina's natural trust. We know how

vitally important our coastal area is to the state's health — both economic and environmental. We are going to protect that coast.

We are going to give this proposal as thorough a review as anything we've ever looked at. Whatever decision we make, we will make certain it is one that will protect our coast — for us and the children will inherit it.

THE MMS PERSPECTIVE: HISTORY/STATUS OF THE MANTEO LEASES

Mr. Chris Oynes
Regional Director
Minerals Management Service
Gulf of Mexico OCS Region

THE MINERALS MANAGEMENT SERVICE—WHO WE ARE

The Secretary of the Interior established the Minerals Management Service (MMS) in 1982 following the independent Commission of Fiscal Accountability's recommendation that proper fiscal accountability and management of the public's mineral resources would best be served by an agency devoted solely to minerals management. Our mission is to manage the mineral resources on the Outer Continental Shelf (OCS) in an environmentally sound and safe manner and to collect, verify, and distribute, in a timely fashion, mineral revenues from Federal (onshore and offshore) and Indian Lands.

The MMS Gulf of Mexico OCS Regional Office strives to be a showcase of careful, safe, and efficient administration of the Nation's oil and gas and other mineral resources. Only close cooperation and consultation with State and local governments and a wide array of industry and other constituencies that exist can make this possible.

The Gulf Regional office has the responsibility for OCS activities from offshore Texas to Maine (Figure 1). Our role in this activity is substantial. We conduct extensive environmental reviews of proposed projects and, by law, must approve every exploration well, every production proposal, the structure design of every platform as well as every pipeline. We issue literally dozens of other approvals for the design and operation of facilities and measurement of product.

A crucial tool in maintaining safe operations is inspection of offshore facilities. We conduct more than 10,000 inspections every year to ensure operational safety and protection of the marine, coastal, and human environment. MMS's petroleum engineering technicians conduct these inspections 365 days per year, weather permitting, evaluating the overall condition of a facility and its operations.

We have an active environmental studies program to examine issues related to OCS development. Currently, MMS Gulf regional scientists administer more than 80 environmental and socioeconomic studies.

These immense tasks are the responsibilities of the almost 500 employees of the Gulf regional office and require their professional training in a host of disciplines. To accomplish this mission, we employee petroleum engineers, geologists, marine biologists, oceanographers, offshore inspectors, geophysicists, and countless other technicians and scientists.

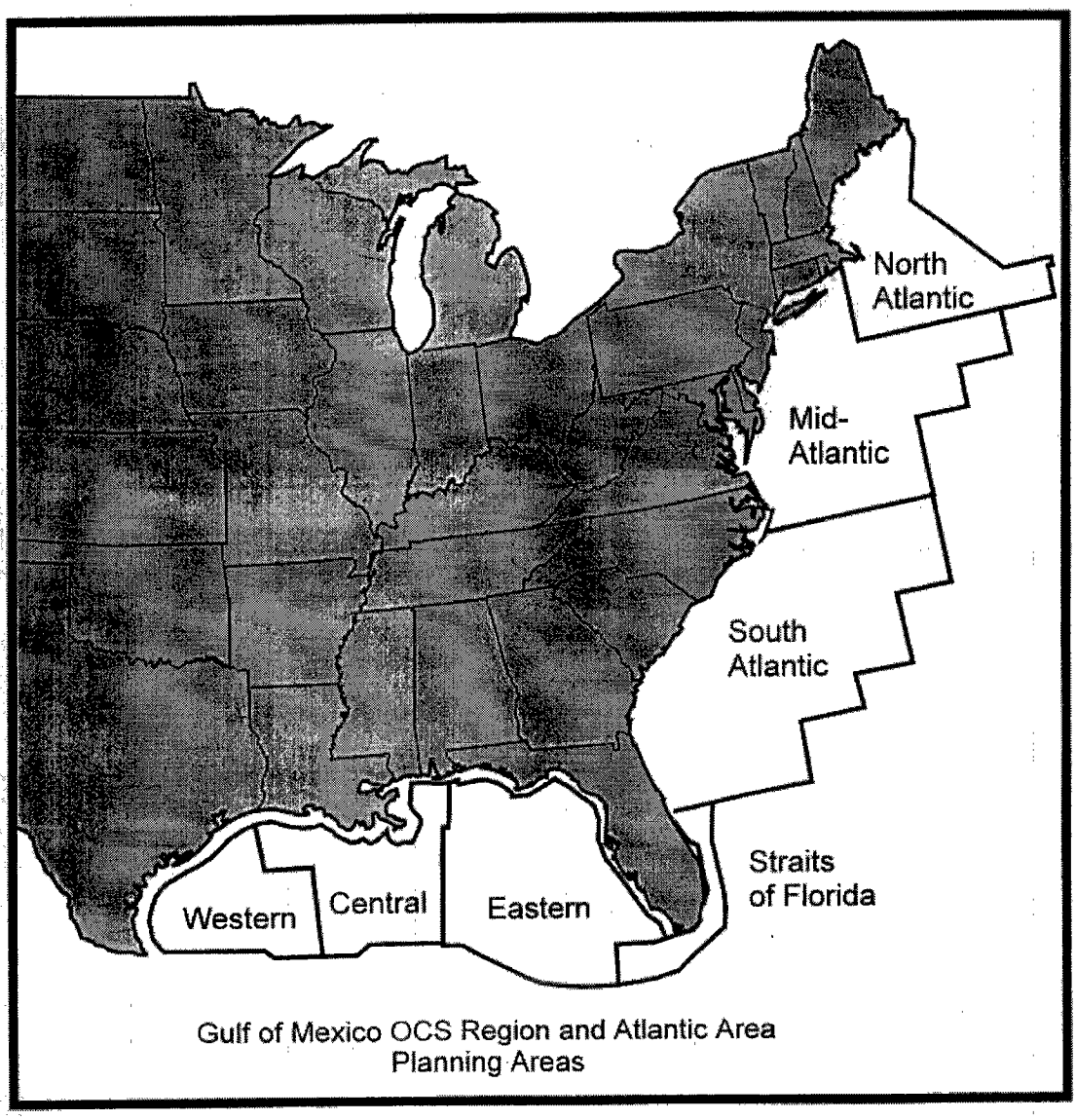

Figure 1. Outer Continental Shelf Planning areas under the administration of the MMS Gulf of Mexico Regional Office.

THE MANTEO LEASES

There have been 10 oil and gas lease sales held for OCS areas along the U.S. Atlantic Coast; 5 have been in the mid-Atlantic area. Twenty-five leases from Sales 56 and 78 are still active; 21 of these are in what is referred to as the Manteo Unit, including Blocks 467 and 510 (Figure 2). The Manteo Unit is located approximately 40 miles due east of North Carolina and approximately 45 miles east-northeast of Cape Hatteras. The water is approximately 2,700 feet deep at the Block 467 site and 2,100 feet at the Block 510 site.

Lease Blocks 467 and 510 are held by multiple interests. Block 467 is jointly held by Mobil (33.4%), Marathon (33.3%), and Amerada Hess (33.3%). Block 510 is held by Chevron (50.0%), Conoco (25.0%), OXY (12.5%), and Shell (12.5%). Our discussions today center around the possibility that Chevron may propose to drill a single exploratory well with a specially outfitted drilling ship in either Block 467 or 510.

EXPLORATION PLANS

There are currently two Plans of Exploration (POE's) on file for Blocks 510 and 467. Chevron submitted a POE for Block 510; it was approved in 1982 by MMS and Coastal Zone Consistency concurrence was given by the State of North Carolina.

Mobil has a POE on file for Block 467 that was "deemed approvable" by MMS in 1990; however, the Outer Banks Protection Act (OBPA) of 1990 prohibited approval of the plan at that time. The State of North Carolina also denied Consistency on both the POE and the U.S. Environmental Protection Agency discharge permit. In 1994, Mobil appealed to the Secretary of Commerce, who held for the State because of a lack of adequate information. Mobil appealed the decision by the Secretary to the Federal District Court in 1996. The judge of the Federal District Court sent the case back to Commerce to decide whether to reopen the appeal; its remand was based on the existence of two MMS studies that were submitted to Commerce late in their decision process but were not considered prior to the issuance of their decision. To date, Commerce has yet to decide whether to reopen the case.

THE NORTH CAROLINA ENVIRONMENTAL SCIENCES REVIEW PANEL

The Outer Banks Protection Act (OBPA) of the Oil Pollution Act (OPA) of 1990 mandated the establishment of a North Carolina Environmental Sciences Review Panel (ESRP) to "prepare and submit to the Secretary of the Interior findings and recommendations assessing the adequacy of available physical oceanography, ecological, and socioeconomic information in enabling the Secretary to carry out responsibilities of the OCS Lands Act...indicating what additional information is required." The Secretary was then to take into consideration the findings of the ESRP in a report to Congress certifying that information available was sufficient for decisions under the OCS Lands Act.

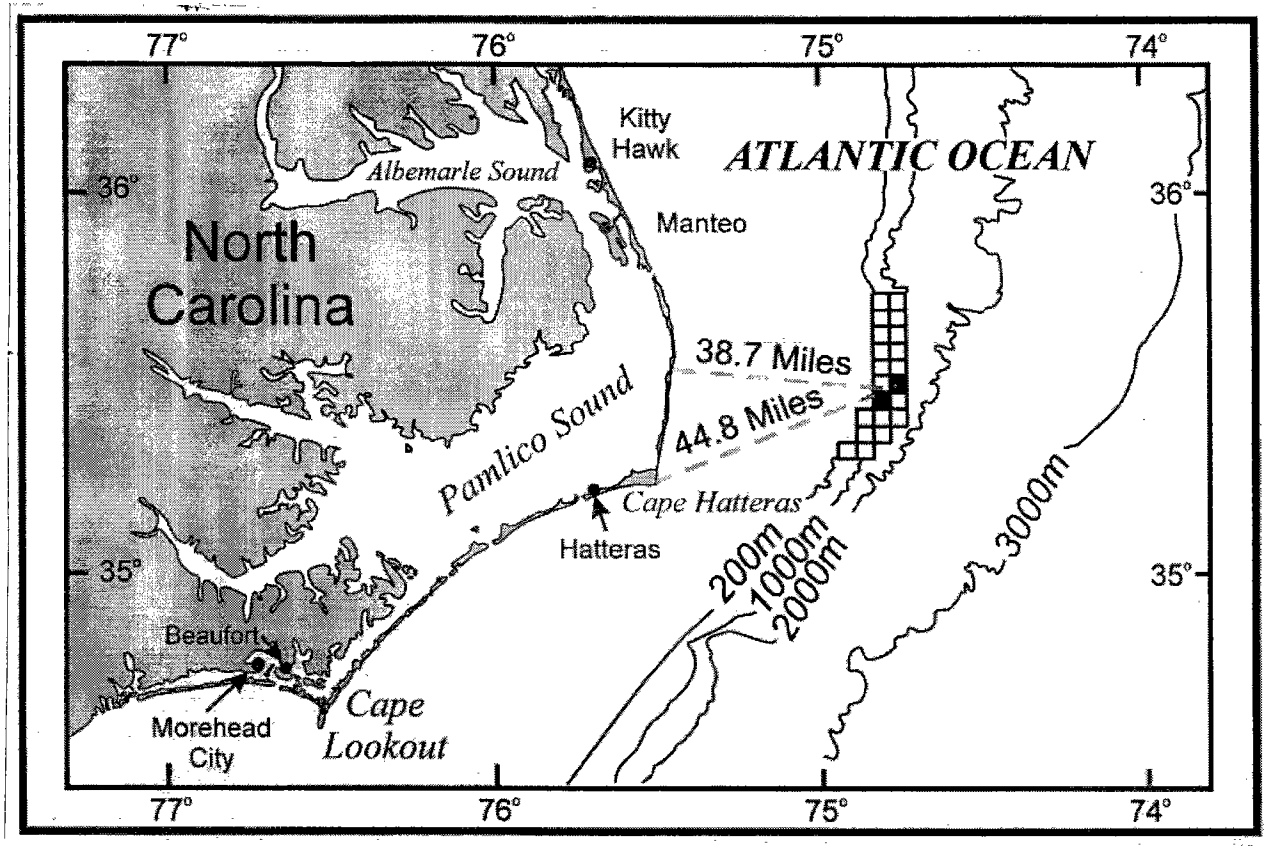

Figure 2. The 21 active leases comprising the Manteo Unit, including Blocks 467 and 510 (the blackened squares). The water is approximately 2,700 feet deep at the Block 467 site and 2,100 feet at the Block 510 site.

Following discussion between the State and Interior Secretary Lujan, the ESRP was composed of Drs. John Costlow, Duke University; John Teal, Woods Hole Oceanographic Institution; Charles eterson, University of North Carolina; Kenneth Brink, Woods Hole Oceanographic Institution; and Michael Orbach, East Carolina University. Dr. Andrew Robertson, Department of Commerce, served as the Federal Coordinator. The panel held its first meeting on January 28, 1991 and submitted its report to Interior on January 23, 1992. Briefly, the ESRP found that the information available was best for exploration at Manteo site; that information needs increased for the phases after exploration and areas other than Manteo; that additional issues could be identified as specific plans develop; and, in general, that physical oceanographic information was most adequate while socioeconomic the least.

On April 2, 1992, the Secretary submitted his report to Congress as required by OPA. In his report the Secretary confirmed that "...in spite of scientific data gaps identified by the ESRP, the information that currently exists is adequate to allow me to make a reasoned decision about the activities presently proposed to take place offshore North Carolina." The Secretary further continued in his report to Congress that "since the ESRP requests for these limited socioeconomic and biological studies are reasonable from a scientific perspective and will undoubtedly add to our information base, I will not issue a permit, approve the exploration plan, or allow any drilling until the studies have been completed." Further, the Secretary went on to say that "the objectives of any future ESRP recommended studies will be reviewed at each phase of development. Specifically, the objectives of these studies will be evaluated after results are available from the first exploratory well."

Shortly thereafter the *Benthic Study of the Continental Slope off Cape Hatteras, North Carolina* (Diaz *et al.* 1993) was conducted for the MMS by the Virginia Institute of Marine Science and the *Coastal North Carolina Socioeconomic Study* (MMS 1993) was conducted by East Carolina University. Data gathering for both studies was completed by December 31, 1992, and the final reports were received in 1993. These two studies, however, are but a small part of the research that the MMS has supported in this OCS area. Cumulatively, MMS has spent over $36,000,000 in support of research in biology, endangered and protected species, fates and effects, geology, physical oceanography, and socioeconomics.

EXPLORATORY DRILLING SCENARIOS—A NUMBER OF POSSIBILITIES

Any future attempts at exploratory drilling at the Manteo site could follow a number of different scenarios. In one scenario, Chevron could elect to prepare a new initial Exploration Plan (EP) for drilling a single well on either Block 510 or Block 467 and submit it to MMS for approval. Such a plan would be subject to North Carolina's Coastal Zone Management (CZM) procedures.

In another scenario, Chevron could propose to drill at Block 510 as approved in the existing EP. Under this scenario, Chevron would submit an Application for Permit to Drill (APD), which would be reviewed by MMS to determine whether to require a revised EP. If MMS determines that a revised EP is not required, the APD can be approved by MMS under the existing EP. If, on the other hand, MMS determines that a revised EP is necessary, Chevron would be required to submit a

revised EP. The MMS would then conduct an analysis to determine whether the revised EP would result in a significant change in the impacts. If MMS determines that it would not result in a significant change in the impacts, the revised EP is not subject to North Carolina CZM procedures. However, if it is determined that it would result in a significant change, the revised EP would be subject to North Carolina CZM procedures.

In a third possible scenario, Chevron proposes to drill as approved in the EP but in a different location in Block 510. Here Chevron submits a revised EP and MMS conducts an analysis to determine whether the revised EP would result in a significant change in the impacts. If it is determined that it would not result in a significant change, the revised EP is not subject to North Carolina CZM procedures. Chevron could then submit an APD that conforms to the revised EP. The APD can then be approved once the revised EP is approved. If it is determined that the revised EP would result in a significant change in the impacts, the revised EP would again be subject to North Carolina CZM procedures.

In a possible fourth scenario, Chevron proposes to drill in Block 467 as proposed in the EP. However, under this scenario a number or issues would have to be resolved. These issues include (a) Conoco losing the "buy-back lawsuit" so that the lease remains in effect; (b) Chevron requesting MMS to approve the EP since the conditions under which it could not be approved are now satisfied and MMS approves it; and (c) the problem with CZM consistency denial being resolved. Finally, if (a), (b), and (c) are satisfied, Chevron could submit an APD; if these are not satisfied, Chevron would have to prepare a new initial EP.

These alternative scenarios are presented as a starting point for discussion. At this point no single scenario is more preferred than another nor more likely.

SOME PERSPECTIVES ON EXPLORATORY DRILLING

To consider the drilling of an exploratory well off North Carolina properly, it might be helpful to consider other history. Exploratory drilling for oil and gas along the U.S. Atlantic OCS is not something new. Some 49 wells have been drilled: 8 in the North Atlantic, 32 in the Mid-Atlantic, 6 in the South Atlantic, and 3 in the Straits of Florida. However, none of these resulted in commercial production.

In the Gulf of Mexico, over 12,000 exploratory wells have been drilled over the past 50 years, approximately 500 alone in 1997. Today, with recent advances in deepwater drilling technology there are between 20 and 25 wells being drilled in the Gulf at water depths greater than 1,000 feet in any given week. Yet, even with this level of OCS activity, the Gulf of Mexico remains a highly productive fisheries resource yielding the Nation's second largest regional commercial fishery by both weight and value.

As for drilling in what may be considered sensitive frontier areas, there have also been 47 exploratory wells drilled offshore Florida. As part of the MMS mission to monitor the effects of the OCS program on the natural and human environment, the USGS conducted two studies for the MMS

to document any environmental impact of drilling exploratory wells on 14 of these sites (Shinn *et al.* 1989; Shinn *et al.* 1993). These studies documented no wide-spread, long-term deleterious effects.

WORKSHOP OBJECTIVES

Since the completion of the two MMS studies in 1993, other studies conducted by the State and its academic institutions have improved the information available today for the North Carolina OCS. Advances in deepwater drilling technology have also made amazing advances working in this difficult environment. It is thus hoped that during the next day-and-half the participants of this workshop will work together to accomplish the following objectives: review the state of knowledge for exploratory drilling, share scientific information obtained since 1990, share information on drilling technology, address any concerns with the experts attending in light of the information available, and distinguish between a single exploratory well and any development activities in the future.

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A SCIENTIFIC OVERVIEW OF THE REGION SURROUNDING LEASE BLOCKS 467 AND 510

Dr. Neal Blair
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North Carolina State University

The continental margin offshore Cape Hatteras, NC has been the focus of numerous oceanographic studies. The objective of this report is to provide an overview of the physical, biological, geological and chemical processes that operate in the region so that the results from individual disciplinary studies can be placed in a system-wide context.

THE HYDROCARBON POTENTIAL

The accumulation of fossil fuel hydrocarbons requires both a source and a reservoir. A potential reservoir exists offshore of Cape Hatteras as the result of the burial of a barrier reef that bounded the shelf edge of the North American continent 140 million years ago. Such carbonate formations form prolific traps in many parts of the world because of their porosity. This particular reef trend rims the east coast of the U.S. and extends into the Gulf of Mexico where it is associated with the major Mexican Oil Fields (Reforma Trend and Poza Rica), the onshore Cretaceous of Texas (Stewart City), and the big gas producers of Louisiana (The Smackover Trend). The Manteo Lease Blocks 467 and 510 (Figure 3) are located over a high point of the structure thus increasing its accessibility. It is also the most logical place to look for hydrocarbons because of their low densities.

Reservoir structures do not guarantee the presence of economically recoverable hydrocarbons. Sedimentary organic matter of sufficient quality (usually rapidly buried water column detrital material) and concentration must be deposited in large volumes near the reservoir. A thick sedimentary sequence containing potential source rock fills a nearby ancient basin, the Carolina Trough. The sedimentary organic matter must be heated at the appropriate temperature (50-100°C) for the necessary period of time (3-300 MY). This is accomplished typically by burial to depths 1-7 km. The age and depth of burial of sedimentary sequences in the Carolina Trough places material within the oil production window.

WATER COLUMN OBSERVATIONS AND PROCESSES

One of the most notable and plainly visible characteristics of this region is the presence of the biologically productive area known as The Point (Figure 3). The Point is the perceived center of a variety of commercial and recreational fisheries and is a foraging habitat for numerous seabirds, both common and rare. Information concerning the fisheries and seabirds is largely anecdotal and qualitative.

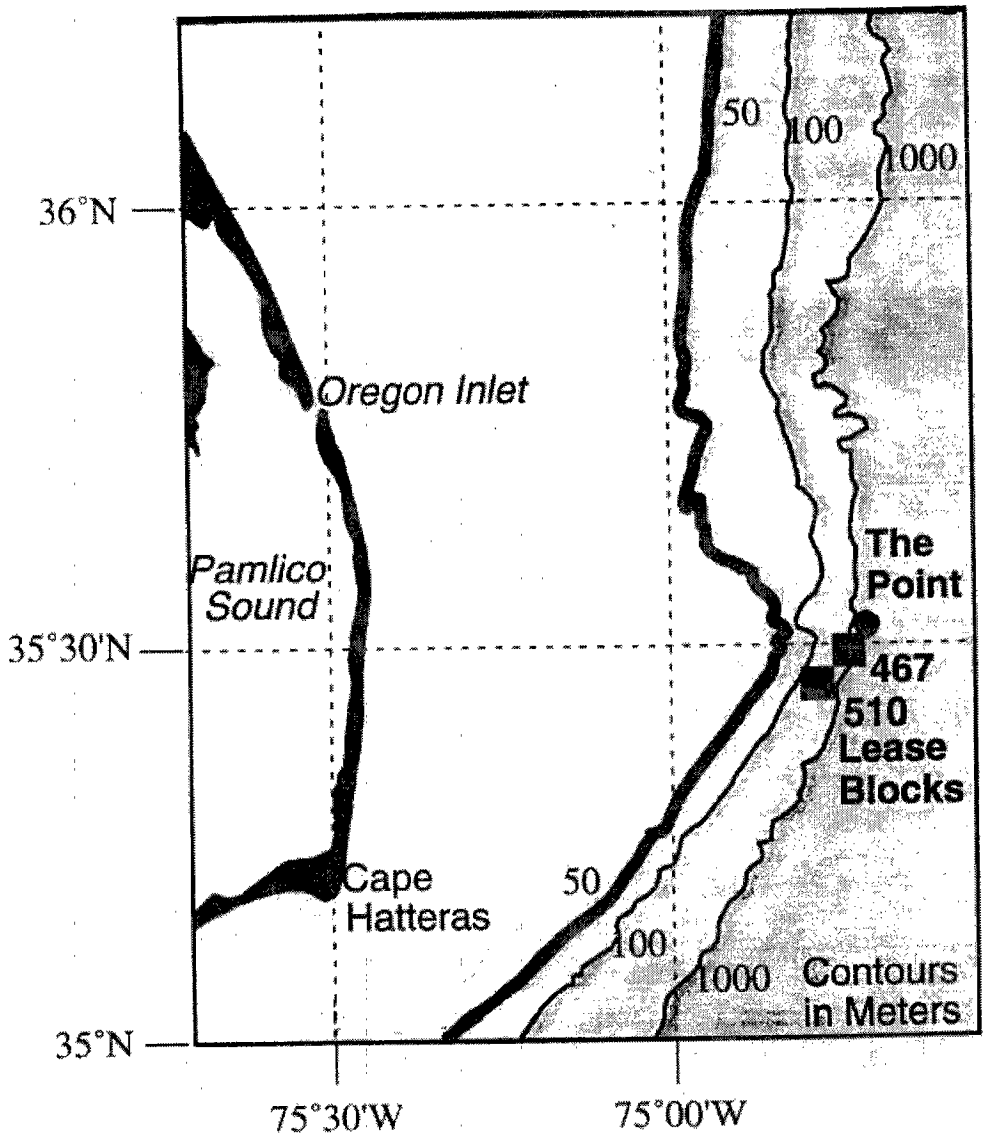

Figure 3. The locations of The Point and Manteo Lease Blocks 467 and 510. The 50 meter isobath is highlighted to illustrate the bathymetric high inshore of the Point.

The Point has an approximate location of 35° 31' N, 74° 45' W. The name refers to a bathymetric feature at about 50 meters water depth (Figure 3). The exact position of The Point, as defined by the biology, is mobile and the radius of the most productive area is uncertain. This is probably a reflection of the dynamic nature of the physical oceanographic processes that support the productivity.

Several potential physical oceanographic mechanisms have been invoked to explain the congregation of animals and apparent elevated productivity around The Point but to date the relative importance of each has not been assessed quantitatively. The Point is at the confluence of the Gulf Stream with slope and shelf waters that transport and focus shelf-derived particulate organic matter into the area. Gulf Stream meanders periodically advect coastal waters seaward with particulate organic carbon and upwell nutrient-rich water. Interaction between the Gulf Stream and the bathymetric high inshore of The Point may also induce intense localized upwelling. The front associated with the western wall of the Gulf Stream is a zone of enhanced productivity as indicated by its weedlines of sargassum that support communities of fish, crustaceans, small turtles and seabirds. In all probability no single mechanism drives the productivity in the region. Instead, the nexus of productivity-supporting processes in a relatively small geographic area may be the most important characteristic of The Point.

The Cape Hatteras area has long enjoyed a reputation for it's recreational deep-sea fishing. The Atlantic bluefin tuna fishery has been highly publicized in recent years. The estimated economic impact on Dare County, NC by this species ranges from $30-70 million in revenue generated over a two year period. The species has been in decline in the Western Atlantic for two decades. It is unclear whether current management strategies are adequate, in part, because the bluefin tuna breeding and migration patterns are poorly understood.

The accessibility of mature fish close to shore and the cooperation between scientists and local fishers has resulted in the Cape Hatteras fishery becoming a scientific center for bluefin tuna research. A coalition of university, federal and private groups is presently studying the migration of the tuna. The major objective of the study is to tag adult bluefin tunas with electronic monitoring devices that will provide information on their migration routes, determine to what extent western and eastern Atlantic populations mix, and discover where they breed.

BENTHIC OBSERVATIONS AND PROCESSES

The steeply sloping seafloor in this region is extensively carved with canyons and gulleys. Rapid sediment deposition, ~ 0.1-1 cm/yr, as well as mass wasting occur. On the slope, fine-grained sediment appears to accumulate primarily on ridges. Gulley bottoms have been under sampled, however, thus our view of the depositional regime may be biased.

Rapid delivery of organic carbon accompanies sediment deposition. Much of the carbon is marine in origin and > 20% is of food quality. Radiotracer studies and visual observations indicate the organic carbon arrives as a steady snow. Pulsed inputs associated with storms or other events superimpose the quasi-steady state delivery. The source of the particulates is no doubt tied to the same water column processes that control surface productivities. Currently, it is felt that the

convergence of the Gulf Stream with the Virginia Current over a quiescent bottom focuses particulate deposition on the slope. The most rapid organic carbon deposition rate determined to date occurs just south of The Point in Lease Block 467.

The rapid flux of carbon is thought to be the primary control on the dense benthic animal populations found in this area. Both infauna and megafauna exhibit elevated densities relative to other areas on the east coast. Deep-burrowing deposit feeders are important constituents of the infauna. Species distributions are patchy.

Demersal fish sizes and species suggest that bottom water O_2 levels are episodically depleted. Sluggish bottom water motion coupled with rapid benthic respiration rates may drive O_2 levels low. A large depletion of O_2 (>30-40%) in the water column appears unlikely based on a preliminary assessment of hydrographic data from the Department of Energy's Ocean Margins Program. There is little information for the benthic boundary layer.

The breakdown of organic debris in the sediments is largely anaerobic. Microbial sulfate reduction is an important, if not dominant, mode of respiration within the seabed. Biogenic methane is produced in the upper 1-2 meters of seabed in some locations between 400-700 meters water depth. The near-surface production of gas, along with the steep slope and high porosity fluid mud (due to rapid sediment accumulation), contribute to the instability of the seafloor and may be important controls on topography. Correlations between known sediment slumps and theoretical limits to gas hydrate occurrences suggest that deeper methane (hydrate) deposits are important controls on topography as well.

SUMMARY AND THE FUTURE

The region of the Manteo Lease blocks is best characterized by its complex physical oceanography, high animal densities and rugged seafloor. The convergence of water masses over the shelf break creates a dynamic combination of fronts that fuel the pelagic and benthic ecosystems. It may also indirectly influence the seafloor geology.

Because of recent multi-disciplinary studies sponsored by DOE, MMS, NOAA- NURC and NSF, we are on the verge of a significant breakthrough in our level of understanding of the processes operating on the Cape Hatteras continental margin. Studies are needed that quantitatively link fisheries with basic oceanographic processes.

The availability of remote sensing platforms, such as SeaWifs, will provide a much needed synoptic time-series of surface water properties as well as animal populations. The continued development of *in situ* technology, such as that delivered by submersible platforms, is needed for the study of this seafloor.

MANTEO PROSPECT: HOW IT CAN BE DONE?

Mr. David Duplantier
Chevron, U. S. A.

Chevron participated in the MMS Information Transfer Meeting on December 18, 1997 in New Orleans and a Technical Workshop in North Carolina on February 4, 1998 to explain how a well would be drilled off the coast of North Carolina. The focus of Chevron's presentations was the geologic nature of the prospect. Participants in these two proceedings included state and federal agencies as well as members of the scientific community.

PLAN OF ACTIVITY FOR THE MANTEO PROSPECT

Chevron plans to drill one exploratory well, likely at the Manteo Block 510 site, a location and activity previously approved by North Carolina when a Plan of Exploration was submitted in 1982. The exploratory well will be drilled using a dynamically positioned drilling vessel. The activity will take approximately 110 days and will be located in about 2,200 feet of water nearly 40 miles from the North Carolina coast. The prospect is a Late Jurassic - Early Cretaceous shelf-edge carbonate reef that lies between 11,000 and 15,000 feet below the seafloor. Chevron would like to spud the well in spring/summer of the year 2000 and use the port of Morehead City as a shorebase for its activity.

Chevron's Deep Water Group out of New Orleans, Louisiana will manage the activity with all the necessary professional disciplines working together as a team. While this activity will be the first well drilled by an oil company in the federal waters off the coast of North Carolina, oil exploration is not new to the state. In addition, the state has previously reviewed other exploratory wells. One such activity was proposed by Mobil in 1990 approximately 5,900 feet away from the Chevron location. This proposal was the subject of intense review by state and federal agencies.

Chevron met with the state on two occasions in 1997 and participated in the two forums noted above. Chevron now plans to submit written documentation in late 1998 (November/December) to allow the MMS to issue the necessary permits for the drilling of one exploratory well at the Manteo Site. If any discovery of commercial hydrocarbons is encountered, it will open an entirely new process of regulatory review which must be completed before any gas or oil is produced. Such production can only happen if the exploratory phase is allowed to go forward and is successful.

GEOLOGIC PROSPECT

The Manteo Prospect is a Late Jurassic - Early Cretaceous barrier reef and platform carbonate complex that was deposited on the paleo shelf-edge roughly 130 to 140 million years ago. This shelf margin carbonate trend rims the North American continent from Newfoundland to Yucatan and has produced numerous fields around the Gulf of Mexico. These fields, which include MP 253/254, Waveland, Black Lake, Fairway, Alabama Ferry, and Stuart City in the U.S. and Golden Lane, Poza

Rica, Reforma, and Campeche in Mexico have estimated recoverable reserves of over 17 billion barrels of oil or equivalent gas. The Manteo prospect consists of three target reef facies: reef core, fore-reef, and back-reef, with most of the reserves expected in the reef core facies.

The Manteo prospect is defined by a 0.5 mile (dip) by 1.5 mile (strike) seismic data grid consisting of five separate 2-D speculative and proprietary seismic surveys that were recorded between 1976 and 1981. This data identifies a large structural culmination of the shelf margin carbonate trend that encompasses several OCS blocks, including Manteo blocks 510 and 467. The prospective reef complex lies below the present day shelf break at a depth of approximately 11,500' subsea. Water depths vary dramatically across Manteo block 510, from less than 300' in the northwest to over 3800' in the southeast. The proposed well is located in the northeastern portion of block 510 in 2132' of water. From this location we anticipate encountering the reef complex at or near its structural crest.

A similar barrier reef and platform carbonate complex was tested by Shell in the mid 1980s in the Wilmington Canyon area approximately 250 miles NNE of the Manteo prospect. Shell's back-reef facies test found poor quality reservoir rock while its reef core facies test found almost 2000' of good quality reservoir rock. Neither well encountered hydrocarbons; thus, it is widely believed that in the Wilmington Canyon area the Lower Cretaceous - Jurassic source rocks were probably immature. This hydrocarbon maturation problem is less likely to exist in the Manteo area where the potential source rocks are buried nearly 5000' deeper than in the Wilmington Canyon area.

The Manteo Prospect is a true wildcat. When one considers the four key elements of risk for finding hydrocarbons (reservoir, trap, source rock, and migration pathways), the existing data and information show that the probability of finding hydrocarbons, in any amount, is roughly 1 in 15 or 7%. When this probability is coupled with the expected reserves distribution, it further reduces the chance of a commercial discovery by a factor of two. Risky as it may be, the Manteo prospect is very important because of the enormity of the prospect's reserves potential. Manteo's expected value reserves of nearly 1.5 billion barrels of oil or equivalent gas would make it the largest domestic hydrocarbon discovery since Prudhoe Bay and more than twice the size of the largest field discovered in recent times in the deep waters of the Gulf of Mexico. Source rock studies are inconclusive, as to the type of hydrocarbons that may be present in the Manteo prospect; therefore, reserve numbers are quoted in barrels of oil or equivalent gas terms.

The expected reservoir conditions (i.e., formation pressure, temperature, and depth) of the Manteo prospect are well within the conventional drilling realm. The expected bottom hole conditions of this well will be very similar to many wells that are currently being drilled with existing technology. The Manteo block 510 well is designed to reach a total vertical depth of at least 15,000 feet subsea, and withstand bottom hole temperature and pressure conditions of 200° F and 7,000 psi, respectively. This compares to wells currently being drilled in the Gulf of Mexico to depths greater than 25,000 feet subsea, with bottom hole temperatures and pressures in excess of 425° F and 12,000 psi, respectively.

DRILLING TECHNOLOGY

The major factors that will affect Chevron's exploratory drilling activity are physical oceanography (current, wind and waves) and drilling vessel capability. The technology that exists and the activity of industry today in areas all over the world support Chevron's ability to perform the exploratory activity proposed for the Manteo Prospect with minimal impact on any land or water resources. A great deal of data has been collected on the physical and oceanographic conditions constituting the area of the Manteo Prospect. This work has been done by various state and federal agencies in conjunction with the academic and scientific communities.

Drilling vessels in operation today have station keeping ability to withstand winds as high as 65 knots, currents up to 4 knots, and tremendous wave forcing. The next generation of drilling vessels being built will have even greater operational capabilities. Most importantly, drilling activities can be shut down within a short period of time and a rig can be moved to a less hostile environment until working conditions improve. This ability to suspend or commence operations in the same location at various times based on operating conditions can be performed with minimal impact.

Chevron and others in the industry must explore in deep water and in previously untested areas to replenish reserves. Some of these areas, such as Manteo, experience high currents for which riser technology has developed dramatically. Special tools keep drilling assembly in place so that work can continue during periods of high current. Special equipment on board the drilling rig allows the proper position to be maintained for continuous drilling operations. The station keeping is provided by the latest dynamic positioning technology that utilizes satellite navigation and onboard thrusters to position the vessel. This technology eliminates the need to anchor the vessel to the seafloor. Conditions similar to the Manteo Area exist off Brazil, in the Gulf of Mexico and in the North Sea, where industry has successfully explored for and produced oil and gas resources.

Advances in drilling technology have allowed drilling ships to evolve in a manner that reduces environmental impacts. These ships have grown to allow for drilling in remote areas with minimal support needed from onshore. Most supplies and equipment required to drill the Manteo exploratory prospect will be on the vessel when it arrives on location. The only significant support needed will be to transfer crews working extended shifts of up to 14 days duration. This ability reduces the need for (crew or work) boat support, thereby eliminating additional boat traffic in the area.

All discharges will take place in compliance with strict guidelines for permits developed by MMS and EPA and other federal agencies. Chevron will need an operating drilling permit issued by MMS as well as an NPDES (National Pollutant Discharge Elimination System) permit and air permit issued by EPA. The permitted activity will be performed in conjunction with consultation by lead agencies with all other state and federal agencies.

Chevron, the Federal Government and the State of North Carolina have invested considerable resources in evaluating the Manteo Area. Chevron believes the drilling of one exploratory well in this area and the minimal impact expected from that activity necessitates this activity go forward.

David Duplantier has been employed by Chevron in its Law Department for the past 12 years and is currently Senior Counsel in the New Orleans Office. Since 1991, he has been actively involved in Chevron's permitting and regulatory process in areas off the coasts of Alabama, Florida, and North Carolina. Before working at Chevron, Mr. Duplantier served a three-year term as a Schedule C White House appointee to Commissioner Oliver G. Richard at the Federal Energy Regulatory Commission as a policy and legal advisor. Mr. Duplantier received a Bachelor of Science in finance from Louisiana State University in 1975, and a law degree from Loyola University in New Orleans in 1978.

NORTH CAROLINA'S COASTAL ENERGY POLICIES: A FRAMEWORK FOR REVIEWING OCS PROPOSALS

Ms. Kim Crawford
N. C. Division of Coastal Management

WHAT THE STATE LEARNED FROM MOBIL'S DRILLING PROPOSAL

Mobil Exploration & Producing U.S. Inc. notified North Carolina in 1988 that it intended to drill up to seven exploration wells in the Manteo Exploration Unit, an area off the state's coast comprising 21 blocks leased by eight oil companies in 1981 and 1983. Although Chevron U.S.A. Production Company, one of the companies holding leases, had submitted a plan of exploration for Manteo Block 510 in 1982, the state made no efforts in the intervening years—from 1982 to 1988— to address possible weaknesses in its enforceable policies to review an exploration proposal.

North Carolina geared up quickly in late 1988 to early 1989 to review Mobil's exploration proposal by hiring legal and policy specialists to research issues and develop policy options for responding to the proposal. Although the state successfully negotiated a Memorandum of Understanding with Mobil and the Department of Interior's Minerals Management Service (MMS) for an expanded environmental review of the proposal, there was some confusion over which components of the N. C. Coastal Management Program would be used to review Mobil's exploration plan for federal consistency.

In 1990 the state found Mobil's exploration plan and discharge permit for Block 467 inconsistent with its coastal program due to inadequate information. Neither Mobil nor the federal government provided information to address the state's concerns regarding potential environmental and socio-economic impacts. The proposal for Block 467 is still under federal appeal and in litigation.

THE N. C. COASTAL MANAGEMENT PROGRAM AND COASTAL ENERGY POLICIES

The applicable components of the N. C. Coastal Management Program for reviewing OCS activities for federal consistency include: goals set forth in the N. C. Coastal Area Management Act; administrative rules found in Title 15, Chapter 7 (approved by the Department of Commerce, NOAA); a network of other state agencies' enforceable policies; and the latest federally approved local land use plans for any coastal towns or counties where energy facilities might be sited.

The N. C. Coastal Resources Commission, which has rule-making authority to implement the goals of the N. C. Coastal Area Management Act, adopted coastal energy policies, as rules, in 1979. These policies defined "major energy facilities" and identified areas that should be avoided to the "maximum extent practicable." One area of confusion was that there were additional criteria for determining federal consistency cited in the state's 1979 amendments to its coastal program that had

not been codified, although the commission clearly intended these policies to be enforceable for federal consistency.

The energy policies adopted in 1979 did not expressly define major energy facilities to include drill ships, platforms, or onshore support structures—structures that have the potential to cause environmental and/or economic impacts due to their size and/or function. Nor did the policies require locating onshore facilities in a manner to protect the scenic and visual qualities of coastal areas, although this is a primary goal stated in the N. C. Coastal Area Management Act.

STRENGTHENING THE STATE'S COASTAL ENERGY POLICIES

In 1991 the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) established the Coastal Zone Enhancement Grants Program to enable states to improve their coastal programs in several areas, including ocean resources planning. The N. C. Division of Coastal Management received funding through this program from 1992 to 1997.

The division formed the N. C. Ocean Resources Task Force in 1993 to review a range of ocean issues and to provide recommendations to the division and the Coastal Resources Commission. The state also contracted with the N. C. Sea Grant College Program to conduct an independent analysis of the state's ocean policies. The task force used Sea Grant's ocean management study as the basis for many of its recommendations.

The task force recommended that the Coastal Resources Commission amend the coastal energy policies to provide greater protection to sensitive natural resources of the coastal area and to clarify the state's information needs for consistency reviews of OCS proposals. The task force's recommendations also included draft language for the commission's consideration.

The Coastal Resources Commission adopted amendments to the energy policies in November 1996. Due to new administrative procedures adopted by the state legislature in 1995, which provide for additional legislative review and oversight, the rules would not have become effective until August 1998. However, because of heightened concern over Chevron's announcement earlier this year that it intended to submit a new exploration proposal for the Manteo Unit, Governor James Hunt signed Executive Order 121 on November 3, 1997, putting the rules into effect immediately. The rules have been formally submitted to NOAA for inclusion in the N. C. Coastal Management Program.

The amended rules clarify for the applicant the information necessary for the state to conduct a consistency review. The rules identify specific sensitive areas (such as wildlife refuges, offshore reefs, hard bottom areas, submerged aquatic vegetation beds, anadromous fish spawning and nursery areas, and sea turtle nesting beaches) that should be avoided when locating energy facilities, require mitigation where impacts to coastal resources cannot be avoided, and restoration of sites when facilities are abandoned. Support facilities, drill ships, and platforms are defined as "major energy facilities" and must, therefore, meet the siting requirements that are listed.

The N. C. Coastal Management Program also incorporates local land use plans that have been approved for consistency by the Department of Commerce/NOAA. During the Mobil review, two oceanfront counties closest to the Manteo Unit—Dare and Hyde —expressed strong concerns about the possible impacts of processing facilities, refineries, drilling platforms, or support bases along pristine areas of the Outer Banks, an area that is renowned for fishing and tourism. Both counties amended their land use plans in 1989 to specifically prohibit the siting of energy facilities. (Hyde County amended its plan to prohibit energy facilities on the outer banks portion of the county; the prohibition does not apply to inland areas.) These land use plan amendments were approved by NOAA, which concurred that energy facilities would not be compatible uses in these two particular areas. Any new OCS proposals would have to be consistent with these amended land use plans.

N. C.'s PROCESS FOR REVIEWING CHEVRON'S EXPLORATION PROPOSAL

Chevron has notified the state that it would like to submit a plan of exploration to drill by the summer of 2000 on either Block 467 or 510 in the Manteo Unit. The N. C. Department of Environment and Natural Resources is preparing to conduct a rigorous review of a new exploration proposal. The consistency review will be coordinated by the Division of Coastal Management, using the amended coastal energy policies as the primary guide.

In coordination with the Minerals Management Service, the state has invited a number of key university scientists, federal and state agency experts to participate in a technical workshop in February 1998 to help identifying scientific information and studies that the state will need for reviewing an OCS exploration proposal. In addition, the department will form an advisory group to the secretary and the governor comprising several members from the three environmental regulatory commissions (Marine Fisheries, Coastal Resources and Environmental Management), as well as representatives from Dare and Carteret Counties.

Once an exploration plan is formally filed by Chevron, there will be deadlines for the state to comment and review the proposal. The state is committed to conducting a very public and thorough review of the proposal. The state has asked the federal government and Chevron to provide the same level of information that it requested during the Mobil plan review.

COMPONENTS OF THE NC CMP FOR REVIEWING OCS ACTIVITIES

NC Coastal Area Management Act (NCGS 113A-100)

Examples of applicable goals:

- Protect beaches, dunes and estuarine systems
- Preserve and enhance water quality
- Insure orderly and balanced use of coastal resources
- Protect natural resources, water use, scenic vistas, fish and wildlife
- Preserve historic, cultural and scientific aspects of the coastal area

Administrative Rules Found in Title 15, Chapter 7 (NC Administrative Code)

Some highlights of Coastal Energy Policies:

- Defines major energy facilities
- Lists information to be included in an impact assessment
- Lists sensitive areas to be avoided to maximum extent practicable: areas with high biological or recreational value, offshore reefs, rock outcrops, wetlands, primary nursery areas, anadromous fish spawning areas, submerged archaeological resources, etc.
- Requires avoidance of nesting and spawning periods
- Requires specific information to be included in an Oil Spill Contingency Plan (pursuant to federal regulations)
- Protects scenic and visual qualities of coastal areas
- Requires restoration of coastal areas when facilities are abandoned

Network of other state agencies' applicable, enforceable policies and guidelines referenced in program documents

Examples:

- Divisions of Air and Water Quality (e.g. air and water quality standards)
- Division of Marine Fisheries (e.g., rules protecting fish spawning areas/life cycles)
- Division of Cultural Resources (e.g., rules to protect archaeological resources)

Federally approved local land use plans for coastal towns or counties

- For Chevron/Mobil Proposals: Dare, Hyde, and Carteret County Land Use Plans; Beaufort, Morehead City Land Use Plans)

Kim Crawford, ocean policy specialist for the North Carolina Division of Coastal Management, has represented North Carolina on the MMS OCS Policy Committee since 1993. She has worked on OCS oil and gas issues for over eight years, and has coordinated the development of the state's ocean resources management plan. She received her bachelor's degree from Wake Forest University and a Master of Public Administration degree from the University of North Carolina at Chapel Hill.

LOOKING FOR THE LODESTAR IN THE SHIFTING SANDS OF THE MANTEO UNIT

Mr. Daniel F. McLawhorn
North Carolina Department of Justice[1]

The pending proposal by Chevron to drill an exploratory well offshore North Carolina presents several extraordinary legal issues. These new legal issues, the unresolved legal issues pending from the Mobil proposal to drill, and the two potential drilling scenarios presented by Chevron, make it even more difficult to define the legal position of the State vis-a-vis the present proposal. Because the factors that can influence the State's policy decision are regularly shifting, it is impossible to find a legal lodestar by which the State can prevail with its position decision—a source of constant quest for the State's attorneys in the Mobil/Chevron case.

CURRENT LEGAL STATUS

North Carolina denied the CZMA (Coastal Zone Management Act) consistency certifications submitted by Mobil for its exploration plan and for its NPDES permit application on November 19, 1990, and July 17, 1990, respectively. As a consequence, the exploration plan and NPDES permit application, and the accompanying environmental documentation, were never made the subject of final agency decisions by the respective federal agencies. The state founded its consistency certification denials on a lack of adequate information. For the NPDES permit, the findings were made pursuant to 15 CFR §§ 930.54(e), -.58, -.60(a), and -.64(d). For the Plan of Exploration, the findings were made pursuant to 15 CFR §§ 930.56(b), -.58, -.75(b), -.77(b), and -.79(c).

Mobil sought Secretarial review of the consistency denials. While the Secretarial review was being conducted, the Secretary of Interior was conducting studies which responded to two of the information topics cited by North Carolina in its denials. The Secretary of Interior determined that studies on the remaining topics could be delayed until during and after the drilling of the exploration well. By the time the studies were released, the Administrative Record (AR) had been closed. While no party to the dispute requested the studies be added to the AR, the Secretary of Interior delivered a copy of the studies to the Secretary of Commerce about six weeks before the final agency decisions issued.

The Secretary of Commerce upheld North Carolina's consistency denials but narrowed the grounds for the denials. The Secretary's bases for upholding the denials relied on the lack of information for two subjects. These were the same issues addressed in the studies conducted by the Minerals Management Service after the consistency appeals were filed. On judicial review, Chevron and Conoco intervened and joined in the motion by Mobil to supplement the AR with these two studies.

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[1]Any opinions expressed in this paper are solely those of the author and not his employer, the North Carolina Department of Justice. This paper does not represent, and may not be cited as, an opinion of the Attorney General's Office of the North Carolina Department of Justice.

In April 1996, the district court entered an order requiring the Secretary of Commerce to determine whether the AR should be enlarged to include the two studies. The parties to the litigation agreed to a delay in responding to the court so the potential for resolution by settlement could be discussed. No formal response has been filed, and the litigation remains on hold.

NEW LEGAL ISSUES

The Chevron proposal to drill an exploratory well will presumably present several new legal issues. In the first instance, Chevron cannot state with certainty the lease block on which it intends to submit an application for an exploration well. The two potential blocks are 467 and 510. Block 467 was the subject of the Mobil application. Block 510 is adjacent to Block 467; the two blocks touch at a corner. The potential drilling locations are approximately one mile to one and a half miles apart. Chevron is the lessee of Block 510, but not of 467. The question of whether 467 will be available will be determined, in part, on the outcome of a litigation now on appeal between Mobil and the United States.

Regardless of the block, North Carolina will insist on a comprehensive analysis of the potential impacts from the exploration and delineation phase of the activities. At the outset, it must be understood that the Manteo Block is a frontier area in all senses, including the State's level of understanding of potential impacts of drilling. There being no history of offshore drilling in the vicinity of the Outer Banks, the information base and level of public discourse needed to reach assurance of consistency with the North Carolina coastal management plan is probably deeper and larger than might be customary off other coasts. North Carolina's Secretary of Environment and Natural Resources has put Chevron on notice that Chevron will be held to the same level of information deemed necessary for a state decision on the merits of consistency certifications as was applied to the Mobil applications. Those information requirements were specified in rules adopted by the Coastal Resources Commission in November 1996 and put into effect by Executive Order of the Governor on November 3, 1997. The rules generally reflect the information required from Mobil through the Memorandum of Understanding.

The separate legal issues presented by the two blocks are the subject of the remainder of this paper.

BLOCK 467

The pending judicial review is concerned with the adequacy of the information submitted by Mobil in conjunction with its coastal consistency certifications. That information was pertinent to the particular exploration plan and NPDES permit application submitted by Mobil. It is particularly significant to note that neither of those documents has been found consistent with the North Carolina coastal zone management plan. Thus, from a legal perspective, Block 467 offers no benefit to Chevron unless and until the consistency objections are removed or overcome.

A second set of issues will be raised should Chevron submit modifications to the exploration plan and NPDES permit application as presented by Mobil. Since the consistency certifications were for a different, albeit related proposal, the consistency certifications will at a minimum require supplementation. However, the OCRM rules do not provide for supplementation of consistency determinations. It will be North Carolina's position that supplementation causes the State again to

have an opportunity to review the projects for consistency and to issue a new consistency certification decision.

The Block 467 issues can also be addressed through a settlement of the pending lawsuit. In those discussions, North Carolina has demanded a new opportunity to make its consistency decision. In addition to the information developed through the Environmental Report issued before the consistency decisions were made, a substantial volume of additional information was developed afterwards and much of it was made a part of the AR. This will be an especially important issue should the court or the parties, through the settlement, decide to make the two MMS studies a part of the AR, as Mobil and Chevron have requested. Of course, the expanded record for a new drilling proposal by Chevron would also have to address any modifications made to the existing applications by Chevron.

For Block 467, another set of issues exists regarding the adequacy of the existing NEPA documentation. Shortly after the project was announced as an exploration well plus the delineation wells, Mobil scaled it down to the exploration well only. Mobil contended, with the concurrence of the MMS, that it could segment the project and submit a second application for the delineation wells. Nothing prevents segmentation of the permits, but the NEPA doctrine against piece-mealing should prevent the environmental assessment from being so narrow. The EA prepared by MMS for the Mobil proposal was limited to the exploration well and did not address the delineation phase of exploration. Because the Record of Decision (ROD) for the EA was not issued, North Carolina was not able to challenge the EA. Under the Council of Environmental Quality regulations, a NEPA decision is not final until the ROD issues. 40 C.F.R. §1505.2. Additionally, the MMS has been barred from issuing the permit by the consistency objection. A challenge to the EA/FONSI will be premature until the ROD for the EA and the permit decision are issued by MMS.

A second NEPA issue is raised by the potential for a Secretarial override of the North Carolina consistency objections. To override consistency determinations by the state, the Secretary exercises executive power and may override for reasons other than an error by the state in its decision. Because of that independent power, North Carolina concludes the Secretary must comply with NEPA before he can override the state's consistency determinations. The AR does not include a NEPA document, the state is not aware of any NEPA document prepared in conjunction with the consistency certification review. Thus, another potential issue is whether the Secretary has met his NEPA responsibilities if he undertakes to override the state's consistency determinations.

BLOCK 510

In 1982, Chevron submitted a consistency certification for an exploration plan for Block 510. North Carolina approved the certification. The OCRM has opined that once consistency certification has been issued, it cannot be revoked or withdrawn. This agency interpretation by NOAA has not been the subject of a judicial construction and may provide an opportunity for challenge. In addition, North Carolina considers the prior consistency certification to have been limited to the plan submitted and to the approved state coastal zone management plan then existing. North Carolina contends the certifications would not apply to modified versions of those previously submitted plans. Thus, the first legal issue is the value or benefit that Chevron can obtain from the prior consistency certifications for its new proposal to drill an exploratory well in the same block.

A second set of issues is presented by the NEPA documentation. That will surely require a supplement. It is unclear whether the exploration plan approval and NPDES permit were ever issued. If they were not issued or the prior NPDES and POE approvals have expired, then new applications as well as NEPA documentation will be required. If they were issued, supplementation may be required. If so, North Carolina should be expected to contend that a new consistency certification is required for the revised applications.

SUMMARY

There are relatively few legal tools available to states in their review of oil and gas exploration and delineation plans. The unusual legal circumstances surrounding the two blocks where Chevron wishes to drill off-shore North Carolina have created variations on the normal themes encountered for such approvals. The factual variables make it difficult, if not impossible, to predict what legal issues will ultimately confront the parties to this matter. Given the history of the case, chances are they will be intriguing regardless of which issues sift out as the sands shift. The task for the author and other members of the Attorney General's staff continues to be finding the legal lodestar in these shifting sands which will guide the State's consistency determination and other actions towards a fair, effective resolution of the Chevron proposal—a resolution that truly accords with the coastal management policies of the state.

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PHYSICAL ENVIRONMENT REVIEW: AN OVERVIEW OF THE METEOROLOGY AND PHYSICAL OCEANOGRAPHY SURROUNDING LEASE BLOCKS 467 AND 510

Dr. Leonard J. Pietrafesa
North Carolina State University

1. The Atmospheric Weather and Climatology

   a. Highs, Lows, Fronts and the Hatteras Effect
   b. Tropical Cyclones
   c. Mid Latitude Extratropical Cyclones

   The area is a region of occasional intense storm activity during all months of the year and both decadal and representative individual storms are described.

2. Physical Oceanography

   a. Gravity Wave Field
   b. Internal-Inertial Wave Field
   c. Subinertial Frequency Events
   d. Sand Waves
   e. Gulf Stream Influence

3. Recent Findings

   The Hatteras Confluence region, specifically the region of The Point serves as the preferred exit pathway for offshelf transport of Mid-Atlantic estuarine and shelf water masses. In the lee (north side) of the "Point," localized upwelling can occur. The steeply sloping outer continental margin seaward and downstream of Diamond Shoals provides a damping mechanism for south to north advecting Gulf Stream frontal waves and also induces robust upwelling of nutrient rich waters.

4. Issues

   a. Ability to predict oil spill trajectories in the region.
   b. Ability of drill rigs to withstand tropical and subtropical cyclone forcing.
   c. Ability of drill ship to evacuate site during the genesis of Atmospheric Bombs.
   d. Role of Physical Oceanography in Biological Productivity.

   - One of our early findings in the Ocean Margins Program (OMP) study is that there is significant lateral (generally offshore) transport through the Bottom/Benthic Boundary Layer (BBL).

   - It is likely that the BBL, which had been undersampled in many previous studies and arguably still has been, could be a conduit through which significant quantities of materials

(particulate organic carbon and colloidal organic carbon) are carried off the Hatteras continental shelf.

- The dominant mechanism by which shelf sediments near Cape Hatteras are resuspended and transported in the BBL include storm-induced flow (principally wave motions superimposed wind driven currents), internal waves and the Gulf Stream. Storm induced waves and currents are dominant in resuspending sediments over the inner and middle shelf, whereas internal waves and Gulf Stream currents are important in mobilizing sediment at the shelf-edge and upper slope. The degree of Gulf Stream penetration onto the Hatteras shelf appears to vary on a seasonal scale. This is suggested both by velocity records from moored current meter data, sea surface temperature data and altimeter data suggest that deep and persistent penetration of the Gulf Stream onto the Cape Hatteras shelf is mainly a summertime phenomenon. However, variations of the Gulf Stream position short of penetration onto the shelf may also be important to lateral transport in this area.

- Distribution of salinity, temperature, and velocity suggest lateral transport and detached bottom (nepheloid) layers in slope waters of the study area. Reportedly high suspended particulate matter concentrations in the bottom waters are indicative of resuspension and formation of a bottom nepheloid layer (BNL) while intermediate nepheloid layers could have been caused by advection of detached bottom nepheloid layers.

- While it is true that boundary currents are primarily along-shore (the Gulf Stream and the Mid-Atlantic Bight) this does not imply that there cannot be any off-shore movement of benthic boundary layer particles and aggregates. Currents rotate along the axis of net water movement in the BBL making it possible that BNL particles are transported off-shore.

- So, episodic lateral exchange processes below 200 m depth responsible for a substantial offshore export of organic carbon are likely related to shifts in the lateral movements of BNL material relative to the position of the Gulf Stream in the Hatteras region.

PHYSICAL ENVIRONMENT REVIEW: SLOPE STABILITY AND OTHER SHALLOW HAZARDS FOR DRILLING AND PRODUCTION IN THE MANTEO 467 AND 510 LEASE BLOCKS

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SHALLOW HAZARDS

Although rare, major drilling and production problems can occur because of sea floor stability problems or because gas pockets are encountered at shallow sub-bottom depths. The potential for sea floor failures is an obvious concern, especially if development operations are to proceed. Sea floor failures are most likely around natural sea floor weaknesses (such as slumps and faults). The presence of gas pockets at shallow sub-bottom depths can result in blow-outs before the riser is set and also indicates an increased potential for sea floor failure during development operations. Such features are called shallow hazards.

Standards for conducting shallow hazard surveys have been developed based on the oil industry's extensive experience working in relatively shallow water (<300 m). Potential hazards are identified by conducting high-resolution surveys (i.e., seismic reflection and side-scan sonar) of the sea floor. Of particular concern are recent sea floor failures (slide scars), subsurface faults, and acoustic indications of shallow gas pockets (Prior and Coleman, 1984; Hovland and Judd, 1988). Areas around past failures and areas where current sediment weakness is inferred are avoided. The frequency of natural failures is also a qualitative indicator of how much of a development challenge a region offers and provides information to guide the design of production infrastructure. Acoustic survey data are commonly augmented by geotechnical measurements made on actual sediment samples. However, the geotechnical sampling needs to focus on the particular potential zones of weakness identified in the acoustic surveys, not just on the background conditions.

The presence of shallow gas bubbles is a concern because interstitial gas bubbles typically act to weaken sediment strength. Moreover, drilling into shallow gas pockets before the riser is in place can result in uncontrolled gas releases. Because potential shallow gas pockets are usually composed of methane, uncontrolled releases are flammable and may also affect the buoyancy of the drilling platform. The standard techniques used for detecting shallow subsurface gas hazards on the continental shelf are based on the acoustic detection of gas bubbles. The presence of a gas phase produces distinct changes in the acoustic properties of the sediment that are easily recognized.

At water depths greater than about 500 meters the pressure and temperature conditions are high enough that methane gas bubbles are not stable. Instead, a crystalline solid, called a gas hydrate, incorporates the excess methane (Sloan, 1990). The environment is appropriate for the existence of gas hydrate at and within the near sea floor sediments off the coast of North Carolina (Booth et al., 1994). With increasing sediment burial temperatures increase and gas bubbles again become a stable phase. Because of the pressure increase with water depth, the thickness of the gas hydrate bearing zone increases with increasing water depth. Gas hydrate itself cannot be identified by the same acoustic techniques used to identify gas bubbles (Dillon et al., 1993). However, the base of a

substantial gas hydrate bearing zone often can be detected by a type of seismic reflector, called a bottom simulating reflector (BSR). A BSR occurs where there is an interface between gas-hydrate-bearing sediments above and gas-bearing sediments below.

The presence of methane gas hydrate within the sediments will also fill the sediment pore space and affect the sediment properties. In recent years, increasing interest has been focused on the potential effect that the decomposition gas hydrate exerts on sea floor sediment stability. Many large slide scars seem to be associated with gas-hydrate-bearing sediments. This potential problem is especially relevant on the margin off Cape Hatteras, because gas hydrates are known to occur close to the Manteo lease area (Booth et al., 1994) and because the near surface sediments contain methane (Blair et al., 1994). There is also concern that the decomposition of gas hydrates in the upper sediment column, during hydrocarbon production, may led to sea floor instability after production has started (Borowski and Paull, 1997; Schofield et al., 1997).

SHALLOW HAZARDS SURVEYS IN THE MANTEO AREA.

Shallow hazard surveys were conducted in both the 467 and 510 Lease Block areas during the 1980Õs. A report summarizing the Block 510 survey was prepared for Chevron by Ocean Sciences Department, Oceanic Engineering Operations, Interstate Electronics Corporation (Anonymous, 1982). The report concludes that there are no identified hazards at either of the sites proposed for exploratory drilling in Block 510. Unfortunately, the actual data to substantiate this conclusion are not contained in the report.

The Block 467 survey data are summarized in a Mobil report (Hoffman, 1989). No hazards are reported at the specific site Mobil had proposed for an exploratory well. The data for these surveys were deposited in the National Geophysical Data Center. Examination of copies of these data relevant to the specific exploration site support Hoffman's conclusion about the specific sites. However, much of the sea floor in the 467 Lease Block area is heavily scarred, indicating recent sea floor erosion and/or slumping (Mellor, in prep.).

Multibeam bathymetry also exists for the 467 Lease Block (Mellor and Paull, 1994) which shows that submarine canyons originate in this area. The flanks of the ridges between the canyon axes are steep (up to 35¡) and are cut with many gullies that coalesce down slope into canyons. Similar bathymetry does not currently exist for Lease Block 510, nor for the rest of the Manteo Area.

GLORIA side-scan sonar data are available along the entire U.S Atlantic Margin (EEZ-Scan-87, 1991). These data show numerous large tongues of distinctly reflective sea floor that originate in the Manteo area. Such reflective areas are interpreted as being large slide scars and debris flow deposits (Dillon et al., 1993).

COMMENTS ON THE STATUS OF SHALLOW HAZARDS IN THE MANTEO AREA

Specific hazards have not been identified directly at the proposed drill sites in either the 467 or 510 Lease Blocks. Thus, there are no identified hazards that would preclude drilling the exploratory holes at the currently proposed sites.

However, the data show that the sea floor in the region is heavily scarred indicating that both sea floor erosion and/or sediment failures are very common in this area. Thus, this region would offer a substantial challenge for placing any semi-permanent structures in the area if development operations were to proceed.

The sediments in the Manteo area are known to be gas-charged and are adjacent to a documented gas hydrate field. Thus, significant amounts of gas hydrate may occur in the near sea floor sediments in the Manteo Area. Before any development infrastructure is designed for this area, the potential role of gas hydrates on sea floor stability needs to be fully assessed.

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HABITAT AND LIVING RESOURCES REVIEW: SCIENTIFIC DATA FOR FISHERIES AND SARGASSUM AT THE HATTERAS MIDDLE SLOPE (INCLUDING "The Point" AND MANTEO EXPLORATION UNIT)

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The purpose of this review is to provide a brief summary of the state of fisheries and Sargassum knowledge in and near to the geographic region proposed for oil exploration activities off of North Carolina (referred to here as the Hatteras Middle Slope, HMS). This will result in a basic listing of what we know about the subjects and what we still need to know. This treatment is restricted to the HMS area and thus is not be a complete description of the North Carolina ichthyofauna. Time and space constraints imposed by the North Carolina/Minerals Management Service Technical Workshop do not allow a full treatment of this subject nor a detailed presentation of the data that support various conclusions. Prioritizing and expanding the list of data needs will require additional discussions, some completed at this meeting, with input from a variety of scientists, managers, and the public. Since the last such summaries (1989 and 1991), considerable data have been collected (much of it published) related to the HMS. Ironically, the major impetus (upper water column fishery concerns around "The Point") for the increased research here resulted in most studies being conducted on or near the bottom close to the proposed drill site rather than studies about the processes driving fisheries at "The Point".

Other presentations during this workshop described the physical/chemical characteristics of the HMS region; therefore, the physical setting will not be covered here. However, since the unique physics of this region probably has the most influence on structuring the biological communities, it must be considered in any discussions. This region is one of multiple transitions between the deep-sea and continental shelf faunas (depth related), between temperate and tropical faunas (latitude related), and between Blake Plateau and Mid-Atlantic canyon faunas (structure related). From physics and chemistry to biology the HMS has proven to be atypical compared to other areas of similar depth and latitude.

For convenience I divided the following discussion into water column or topic sections. While this simplifies the subject, it should not imply that the water column is disconnected. In fact, one of the more interesting, and as yet unexplored, research areas is the degree to which the bottom, middle, and surface biota are connected and the mechanisms facilitating that connection.

BENTHIC SLOPE

(Data from S.W. Ross, K.J. Sulak, M.L. Moser, and J.V. Gartner)

Coming from an historical perspective of almost no data on the demersal HMS ichthyofauna, we are now relatively data rich for describing such basic attributes as relative species importance, habitat associations, some basic physiology, general behaviors, and size structure. The attached figure indicates the spread of data used for our basic bottom fish characterizations. Even with this improved database, I must note that these data resulted from a variety of disconnected programs and are not

ideal for many purposes. One important methodological consideration is that the best technique for assessing the benthic fishes in this very rugged HMS terrain is via submersible employing video/photographic methods. These data have resulted in the following conclusions on the HMS demersal ichthyofauna: 1) Of the 33 fish species so far identified from the HMS, only a few very abundant species are dominant. These are, in order of importance, *Lycenchelys verillii* (wolf eelpout), *Glyptocephalus cynoglossus* (witch flounder), *Myxine glutinosa* (hagfish), *Nezumia bairdii* (marlinspike). 2) Nearly all fish species exhibit smaller sizes at the HMS than recorded for other similar depth locations. 3) The fauna is dominated by sedentary, relatively inactive species with expected, more mobile, benthopelagic species being rare or absent. It is noteworthy that such large differences in fish community structure have occurred on a very small geographic scale. One broad hypothesis proposed to explain these faunal anomalies is that the unique physical/chemical environment of the HMS has created conditions (such as hypoxia) that limit the size structure and species composition of the bottom ichthyofauna. Obvious structural characteristics of the HMS benthic habitat are very low current velocities, a persistent nepheloid layer, rugged canyons and very soft substrate. These attributes are also likely to play a role in controlling the benthic community.

Having basic data on the HMS bottom fish community, we now need to address questions that refine our understanding of this area. Our impression is that the region of faunal anomaly is small and related to unique physics. Although the upper boundary of this fish community is probably near the 200 m isobath, we do not know the lower depth nor latitudinal boundaries. A description of relevant physics and chemistry (e.g., currents, water clarity, dissolved oxygen, sediments) are needed along with this description of fish community coverage to determine the degree to which the biology and physics are associated. Three basic components of life history data are needed for the dominant fishes of the HMS in order to help determine what factors constrain this community: age/growth, reproduction, and trophodynamics. Because hypoxia (either chronic or episodic) has been hypothesized as a structuring mechanism, various experiments are needed to clarify whether low dissolved oxygen plays a role at the HMS benthic boundary. Likewise the role and influence of the persistent nepheloid layer at this site needs to be investigated.

MID-WATER, MESOPELAGIC

(Data from J. Gartner, K. Sulak, S.W. Ross, & others)

Data on the mesopelagic fishes are meager and were mostly collected as an aside to other projects. Even so, some very interesting observations are available on the mesopelagic fishes in the HMS region, and they suggest unique aspects of community structure, paralleling those of the bottom fauna. The HMS mesopelagic fish community documented so far is dominated by two very abundant species (*Ceratoscopelus maderensis* and *Maurolicus muelleri*). These two species along with other mesopelagic fauna exhibit the unusual behavior of migrating in mass to the bottom. Other common mesopelagic species (e.g., *Benthosema glaciale*) behave more as expected, remaining in mid-water and migrating toward the surface diurnally. Preliminary analysis indicates that these bottom associations may be long term at the HMS and that these species may feed on bottom invertebrates. They are also preyed upon while at the bottom by various predators. This abundant mid-water community could represent an important food resource for the upper water column fishes congregating around "The Point". These observations suggest a potential mechanism by which some components of the mesopelagic community conduct energy through the water column linking surface to bottom.

Because these observations on HMS mesopelagic fauna are so limited, more descriptive information is required on species composition, relative abundance, size structure, water column migration behavior, and general life history characteristics. A thorough study of the trophodynamics of the mesopelagic community is required, and this would complement similar studies recommended for other MHS fauna.

SURFACE-UPPER WATER COLUMN
(Data from K. Sulak, S.W. Ross, J. Ross, & others)

Despite the fact that most of the public interest in the HMS region was initially focused on upper water column (< 200 m) pelagic fisheries of "The Point", this is an area with little data. Our understanding of what constitutes "The Point" is based on anecdotal information. There are no written summaries of the fishing seasons, dominant species caught, fishing effort, economics, nor areas fished based on objectively collected data. The limited data on fishes occupying this region come from summary studies conducted for broader topics and incidental collections made during various research cruises. Particularly lacking are data on the non-economically important species that constitute important parts of the food chain (e.g., flying fishes, squids). Despite a lack of specifics, it is clear that a multitude of pelagic fishes occupy, migrate through, and seem even to preferentially congregate around the HMS area. These include several tuna species (yellowfin, bluefin, blackfin, and bigeye), swordfish, marlins, sharks (several species), dolphins, flying fishes (many species), and members of the Sargassum community (see below). All aspects of data are needed to characterize the biota of the upper water column ranging from basic species composition, to life history data, to mechanisms that attract these animals to this area.

While larvae of various fishes can be found at all depths depending on life style, most of the commercially and recreationally important fishes have their eggs and larvae in the upper water column. Most of the data on larval fishes of this region came from broad area surveys (by National Marine Fisheries Service (NMFS)) or very specific (narrowly focused) studies and concentrated inshore of the 200 m depth zone. The one study conducted on the oceanic larval fishes of the HMS area unfortunately has proven to be inadequate and does not substantially add to the existing data base. Problems with that study, including lack of specific identification of eggs and larvae and no depth discrete data, could have been avoided with better coordination of the study plan with the management agencies and scientific community. Because the general distributions of eggs and larvae are controlled by currents, depth discrete data on larval fishes are still needed for this area and should be coupled with appropriate data on physical oceanography.

SARGASSUM COMMUNITY
(Data from L. Settle, M. Moser, and others)

Basic descriptions of the fish community associated with the floating brown algae Sargassum spp., including species lists and relative abundances, are available, but mostly from areas south of Cape Hatteras. Since these communities are linked to a drifting habitat, they pass through the HMS region in route to other destinations. Also, the influences of current and wind patterns tend to congregate the habitat into compact windrows that appears to concentrate trophic activity in time and space. This mobile assemblage is fed on from below by numerous fishes and invertebrates (especially squids), from above by seabirds, as well as harboring its own internal trophodynamic pathways. Sargassum drift lines are also used as cues for fishermen who fish along the edges of these windrows.

This community shares some traits with reef communities in that it is a diverse assemblage of species tightly tied to the habitat. Jacks and filefishes seem to dominate this habitat in most locations and seasons. Numbers and biomass of fishes are positively correlated with algae mat density and size. Sargassum appears to be an essential link in the life history of several animals. Juvenile seaturtles (listed as endangered or threatened) may require it during part of their life. A number of invertebrates and fishes are endemic to this ecosystem. Available data give the impression that the Sargassum habitat is mostly used by fishes as a nursery for juveniles. To some extent this may be an artifact of net collections that have not well sampled the larger, more mobile, deeper segments of this ecosystem. Recent video recordings under Sargassum mats reveal a complicated structure and layering of animals that extends well below the mats with extensive associations by larger fishes (such as dolphins and large jacks).

Since specific data are lacking on the Sargassum habitat moving around Cape Hatteras, basic collections, including traditional netting and newer video techniques, are needed to assess basic characteristics of the community. Similar to other communities of the HMS, a detailed study of trophodynamics is very important. In addition to the fishes and invertebrates this should also include an analysis of how the important bird groups of the HMS use this habitat. Basic life history data are lacking for many of the Sargassum inhabitants. Also lacking is an analysis of how essential this habitat may be to the survival of several groups of animals and how this habitat may respond to various sources of mortality or degradation.

COMMERCIAL/RECREATIONAL FISHERIES

Since the last reviews related to this issue, very little progress has been made in documenting any offshore fisheries around the HMS. Previous North Carolina fishery summaries concentrated on inshore activities. While the majority of North Carolina's diverse and productive fisheries occur in the estuaries and on the continental shelf (< 200 m), there are some fisheries operating in deep water. Most of these concern pelagic species in the upper water column (e.g., tunas, swordfish, billfishes, sharks, dolphin). Sociological, economic, and biological data are lacking for the fisheries beyond 200 m off of North Carolina. Several unpublished or unanalyzed data bases exist (NMFS Woods Hole surveys, North Carolina Dan Moore surveys) that could clarify distributions of commercially/recreationally important groundfish even though these are mostly inshore of 200 m. There has been no evaluation of the potential for new fisheries. Some candidates for new or expanded fisheries could include rosefish, hagfish (i.e., eel skin), squids, and various crabs.

OIL EXPLORATION/DEVELOPMENT CONCERNS

In my view the issues surrounding oil exploration off North Carolina should not be isolated only to the drilling of one or more exploratory wells, but should be expanded to include any environmental and natural resource concerns related to the larger context of oil or gas field development. This expanded view would require environmental assessments from a broader area, including the continental shelf (< 200 m) and some estuaries. The lack of data on a variety of topics (described above and summarized below) prevents a thorough evaluation of many aspects of potential environmental impact from oil exploration or later development. It is important to fill as many of these data gaps as possible. In addition to providing general basic data, there are several specific areas that may be of concern. These include (but are not limited to) the following:

- Discharge effects: This topic has been discussed extensively during the last decade and the potential impacts from discharges may be less likely now (partly due to improved technology). Nevertheless, a complete review of this issue is necessary at some point in this process.

- Lighting effects: The extensive lighting surrounding the drilling operation could be a major environmental hazard that has been underestimated so far. All manner of biota are attracted to lights at night, resulting in some mortality (especially to flying fishes and sea birds). I am unaware of any research on the possible effects of long term lighting. Disruptions to the food chain and to migrations are possible noteworthy impacts from lighting.

- Noise effects: Drilling operations can generate significant amounts of underwater noise. While noise effects tend to be overlooked for fishes, these animals are very sensitive to underwater vibration (i.e., noise). Since oil rigs harbor large fish communities, it is unclear that noise levels have any effect on these fishes. However, since fishes use sound extensively and sounds can either attract (e.g., sharks leading to increased predation) or repel, this topic deserves some attention at least in the form of a short review.

SUMMARY OF DATA/STUDY NEEDS

From some perspectives it seems that large amounts of money have been spent in the HMS area and that data on hand should be sufficient for environmental assessments. While this may be true in some disciplines, one must realize that research (especially oceanographic and submersible) is very expensive. Also, many of the HMS biological studies were quite limited either in geographic/ temporal scope, conceptual scope or both. Projects undertaken in this area should be more cooperative ventures than in the past, with all agencies, industries, and scientists collaborating to solve problems. It is important when filling many basic data needs for the HMS/Point area that nearby comparative areas are included to allow an evaluation of the degree to which the HMS differs. Research submersibles seem to provide much better data for projects near the bottom and in mid-water than more traditional surface maneuvered methods. The following is a summary from the above sections that attempts to prioritize and consolidate data needs related to an ecological assessment of the HMS area.

Trophodynamic/Energetic Pathways
(Plus Other Life History Data)

The need for this type of data is apparent in all areas and species groupings related to the HMS. It is feasible and desirable to conduct an overall water column (top to bottom) and habitat (soft substrate to Sargassum) related study of trophic patterns and linkages during a single project. This would elucidate the degree to which different sections of the HMS water column are linked or isolated and their degree of interdependence. An analysis of basic nutrient inputs to the system should accompany such a study. The advantage of this type of study is that other basic life history data (reproduction, age/growth) can be collected at the same time for no additional field costs. Life history data would allow a much better evaluation of which seasons, habitats, and general conditions are important.

Fisheries at "The Point"

A basic description of the seasonality, effort, catches, economics, and geography of commercial and recreational fisheries operating around "The Point" is required, and this can be conducted for very little costs. The first approach at this study could be to collect intercept data from local fishing operations, and these data could then be used to evaluate the need for future studies as well as guide their designs. Eventually we need to know what the oceanographic mechanisms are that control the large biotic concentrations around this area.

Data Inventory Around HMS and "The Point"

A basic mapping effort listing all studies from all disciplines (published, unpublished, and ongoing) is needed and is feasible for low costs. This would not require new field effort and only a limited descriptive view of the datasets. This would not substitute for a full Environmental Impact Assessment but would be a valuable precursor to that activity. This inventory should be geospatially related in a Geographic Information System with appropriate metadata, and that should be ArcInfo/ArcView.

Larval Fish Data

Basic depth and species specific data are still lacking on this topic. This critical life history phase continues to need basic research attention, especially in describing temporal and spatial distributions.

Lighting Effects

Of all the potential anthropogenic effects, this appears to have the highest probability of negatively impacting the largest array of fauna. Many animals from fishes to birds and larvae to adults are attracted to (or confused by) light at sea, and the impacts of concentrating predators as well as other sources of mortality by lighting are unknown.

Mechanisms Structuring Benthic and Mid-water Fish Communities of the HMS

Various hypotheses about how these communities are organized need to be tested. This should be coupled with a description of the geographic limits of the HMS faunal anomaly. This work would complement the recommended trophic studies.

Physical Oceanography and Productivity at the HMS

While expensive, it is important to collect fishery independent data about what animals are using this area, why/how they use it, when they use it, and what mechanisms (currents, winds, upwelling, etc.) control these apparent concentrations (especially with reference to "The Point"). Such studies would build on the basic descriptions recommended above.

HABITAT AND LIVING RESOURCES REVIEW: BENTHIC ECOLOGY OF THE CAPE HATTERAS CONTINENTAL SLOPE

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INTRODUCTION

The benthic communities of the continental slope off the Carolinas has been described as part of extensive surveys conducted by the Minerals Management Service to assess potential impacts due to exploratory drilling for oil and gas. The initial effort was the Atlantic Continental Slope and Rise (ACSAR) Program, which included transects across the Carolina slope from Cape Hatteras in the north to off the Charleston Bump in the south (Blake *et al.* 1985, 1987; Blake and Grassle 1994). Out of 15 stations sampled for benthic infauna, the most unusual were found off Cape Hatteras in Manteo Lease Block 510 at a depth of 550 m. The benthic fauna at this site included unusually high densities of infauna, epifaunal invertebrates, and fish (Blake and Grassle 1994; Hecker 1994). Much of the surface was seen to be carpeted with white tubes that later proved to be a giant foraminiferan, *Bathysiphon filiformis*. A control site at 2000 m down slope from the 550 m station also exhibited unusually high densities of infauna for the depth range. Overall, the abundance and biomass of the benthos was found to be about 6 to 10 times higher than other areas of the Carolina slope.

In the early 1990s a series of focused research investigations were performed using submersibles and deployments (Schaff 1991; Schaff *et al.* 1992; Ross and Sulak 1992; Sulak 1992). These studies confirmed the existence of a highly productive benthos. In response to concerns about the potential impacts of oil exploration on the Cape Hatteras fauna, additional studies were conducted by the Minerals Management Service in 1992. The objectives these studies were to extend the aerial surveys to encompass larger areas of the slope, especially Block 467 which at the time was being considered by the oil industry for exploration. Six cross-shelf transects were established for box coring and sediment profile imaging. The ACSAR stations were also resampled. Camera sled transects were conducted at each site.

The results of the MMS program and other relevant studies were published in a special issue of Deep-Sea Research (Diaz *et al.* 1994a that also included a CD-ROM with data and selected bottom images (Cutter *et al*, 1994a).

MMS FIELD SURVEYS AND METHODS

The field surveys of the ACSAR program and those conducted in 1992 used more or less similar methodology in terms of field and laboratory techniques. A larger array of sediment parameters were collected in the 1992 samples. Sediment profile images and X-rays of selected subcores was included in the 1992 studies, but had not been employed in the ACSAR program.

The study site and stations are shown in Figure 4. Stations SA9 and SA10 represent the original ACSAR stations. SA9 is located in Block 510. The remaining stations are from the 1992 program. The cross slope camera transects are indicated by transverse lines. The array of stations sampled in 1992 was intended to determine the aerial extent of benthic assemblages and distributions of different sediment parameters.

Data for sediment chemistry, physical parameters, and benthic infauna in 1992 were collected using a 0.16 m^2 BX-640 Box Core, the box of which was subdivided into 16 separate subcores of 10 × 10 × 40 cm. The sampler used in the ACSAR program was the larger 0.25 m^2 Sandia Box Core, but equipped with the same type of subcores. The field samples were therefore collected in the same manner with the data being fully comparable. Details of the field methods may be found in Blake and Grassle (1994) and Blake and Hilbig (1994). The types of samples removed from the 1992 box cores are listed in Table 1 along with references to publications.

Three types of photographic data were collected: (1) Sediment profile images (SPI), collected only in 1992; (2) Vertical plan-view photographs from a camera mounted on the SPI frame; and (3) images of megafauna and geological features taken from towed camera sleds (both programs). Summaries of these samples are listed in Table 1.

At sea, some refinement of the sampling array was done after viewing images from the sediment profile images and plan view images which were developed immediately after the film was removed from the camera. This method allowed us to take maximal advantage of ship time in order to provide the greatest coverage of the study area and sediment types.

Laboratory and data analysis methods for each of the parameters listed in Table 1 are presented in the various references in the same table.

RESULTS AND DISCUSSION

Sedimentology

Sedimentation rates on the Cape Hatteras slope were variable and ranged from 0.3 to 1.8 cm yr^{-1}. These rates are 25-100 times higher than the holocene sedimentation rates estimated for the U.S. Atlantic slope (Emery and Uchupi 1972).

The topographical features revealed in the cross-slope camera sled transects included a wide diversity of bottom types including bare outcrops, sediment-draped outcrops, and erosional and depositional surfaces. Areas on the slope with high rates of sediment input would be expected to experience local over steepening and periodic slope failure. Evidence for this was present on all of the towed camera transects. Many steeply sloping outcrops were observed with an apparently thin cover of soft sediment. Some of these surfaces showed evidence of recent soft sediment flows in the form of erosional "rivulets." Depositional sites for turbidites, debris flows, and massive slump blocks were recognized in bottom photographs by their undulating topography, mud clasts projecting above an otherwise planar depositional surface of fine sediment, and the presence of relatively featureless sediment surfaces that have not had a chance to be disturbed by organisms.

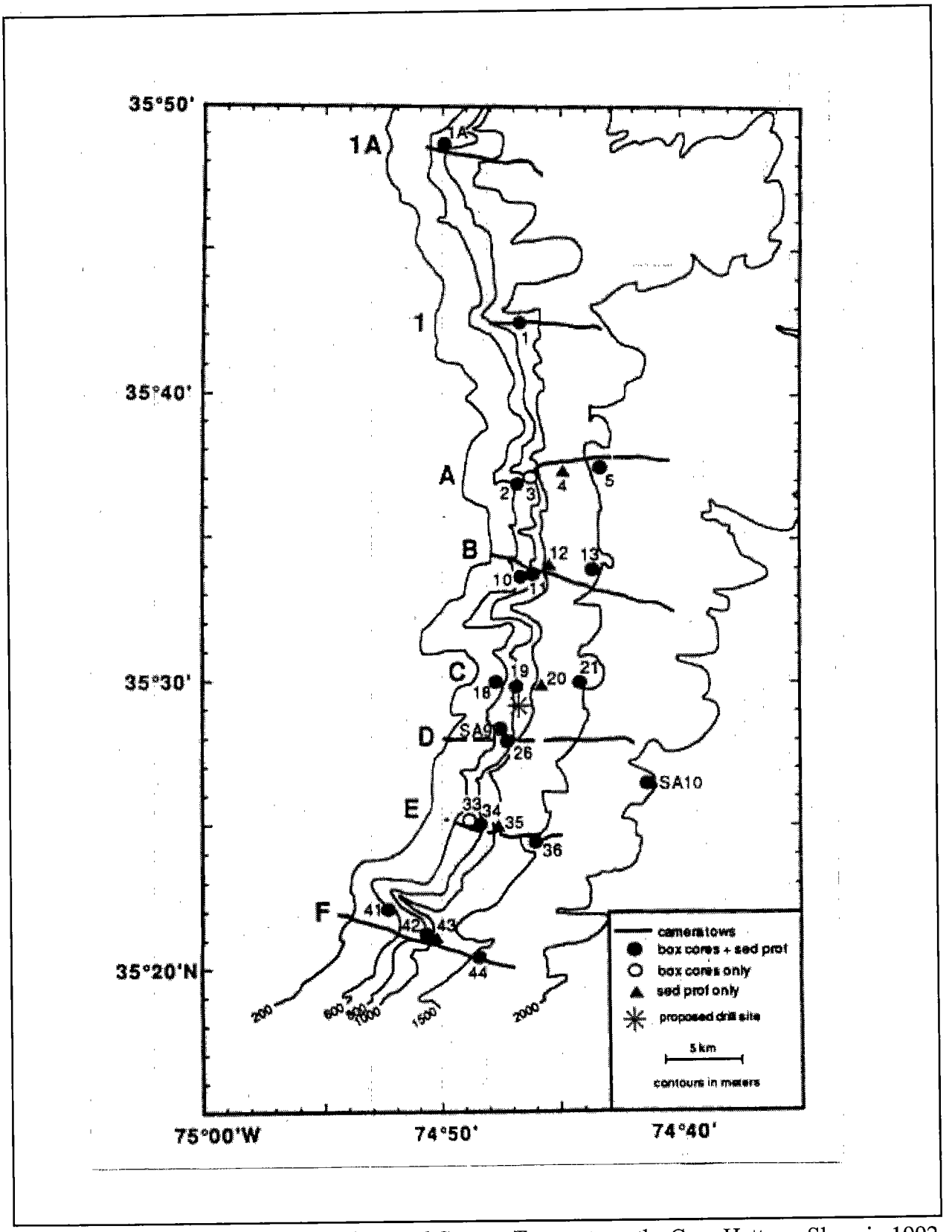

Figure 4. Location of Benthic Stations and Camera Transects on the Cape Hatteras Slope in 1992.

Table 1. Summary of types of data and published references to results of data collected on the Cape Hatteras Continental Slope in the Manteo Area on R/V *Endeavor* Cruise EN-241, 26 August to 6 September 1992.

Box-core: BX-640 (0.16 m²) Ocean Instruments, divided into 16 (10 × 10) subcores	
Chlorophyll *a*	Cahoon *et al.* 1994
Viable diatoms	Cahoon *et al.* 1994
Fatty acids	Harvey 1994
Inorganic carbon	Blair *et al.* 1994
Sediment grain-size	Blair *et al.* 1994
Carbonate	Diaz *et al.* 1994b
Nitrogen	Diaz *et al.* 1994b
Pb-210	Blair *et al.* 1994
X-Rays	DeMaster *et al.* 1994; Diaz *et al.* 1994b
Macrofauna (300 μm)	Blake and Hilbig 1994
Foraminifera	Cutter *et al.* 1994b
Sediment Profile and Vertical Surface (Planview) Cameras - Benthos Models 3731 and 372	
Surface features	Diaz *et al.* 1994b
Subsurface features	Diaz *et al.* 1994b
Apparent mixed layer depth	Diaz *et al.* 1994b
Towed Camera Sled - Oblique Surface Images - Benthos Model 377 Survey Camera	
Megafauna	Hecker 1994
Geological features	Hecker 1994

Sediment parameter results are provided in Table 2. The average rate of organic carbon accumulation was estimated to be 67 g C m^{-2} yr^{-1}, comparable to that found by Schaff *et al.* (1992) at a nearby site. This flux of organic matter is about 35 to 85% lower than that found in productive estuaries (Welsh *et al.* 1982). Annual phytoplankton productivity for 45 estuarine systems had a mean of 190 g C m-2 yr^{-1} (Boynton *et al.* 1982). The average concentration of fatty acids in slope sediments off Cape Hatteras (27 mg g^{-1} dry wt.) falls within the range reported for estuarine sediments (10-35 mg g^{-1} dry wt., Farrington *et al.* 1977) but is less than concentrations found in sediments underlying the more intensive and persistent upwelling zones (765 mg g^{-1} dry wt., Smith *et al.* 1983).

The concentration of chlorophyll *a* in the sediments at the study site appeared to be higher than average for slope sediments that do not underlie upwelling regions. The values were intermediate between those recorded for sediments underlying persistent upwelling zones (Blake *et al.* 1992) and estuarine values (Boynton *et al.* 1982). Because the decomposition rates of chlorophyll *a* are high, the supply of plant cells to the bottom must be very high to support the observed concentrations.

Table 2. Summary of Sedimentary Characteristics on the Continental Slope off Cape Hatteras, North Carolina, in the Manteo Area. Estimated sediment accumulation for Station SA10 was an outlier, possibly related to a recent sediment disturbance, and is presented searately (as values in parentheses).

Parameter	**Mean ± Standard Error**
Fine Sand-Coarse Silt	33.0±2.0%
Sediment Accumulation Rate	0.98±0.14 cm yr^{-1} (0.05 SA10)
Sediment Mixed Layer Depth	12±1 cm
Carbonate	16.6±0.7%
Carbonate Flux	1133±305 g $C0_2$ m^2 yr^{-1} (58 SA10)
Organic Carbon	1.04±0.04%
Organic Carbon flux	66.7±12.8g Cm^2 yr^{-1} (4 SA10)
Organic Nitrogen	0.13±0.01%
C:N Ratio	9.5±0.1
Chlorophyll *a*	0.75±0.15 mg g^{-1} dry wt.
Total Fatty Acids	18.7±3.5 mg g^{-1} dry wt. (5.6±1.0 SA10)
Polyunsaturate Fatty Acids	1.5±0.6 mg g^{-1} dry wt. (0.4±0.2 SA10)

Benthic Communities

Analysis the infauna from the box cores reveals that unusually dense assemblages of benthic infaunal invertebrates are present on the continental slope off Cape Hatteras. Benthic community parameters are provided in Table 3. Densities were highest on the upper slope and ranged from 24,055 to 61,244 ($\bar{x}$=46,255) individuals m^{-2} from nine samples taken at a 600 site in 1984 and 1985 and from 15,522 to 89,566 ($\bar{x}$=37,282) individuals m^{-2} from single samples at 15 stations over a wider depth range of 530 to 1535 m in 1992. A lower slope station at 2000 m (SA10) was sampled six times in 1984-1985 and again in 1992, with densities consistently higher than 8,500 individuals m^{-2}. However, the faunal composition in 1992 differed from the 1984-1985 results in that six of the dominant species had been replaced. This faunal differences observed at SA10 between November 1985 and September 1992 might be the result of a turbidity flow that occurred between the two sampling events (Diaz *et al.* 1994b Rhoads and Hecker 1994). Overall, species richness and diversity patterns are consistently lower on the Cape Hatteras slope than at other locations off North Carolina and elsewhere in the western North Atlantic (Blake and Grassle 1994; Blake and Hilbig 1994).

The 1992 studies indicated that the upper slope infaunal assemblages (~600 m) were dominated by oligochaetes, while the middle slope (800-1,400 m) was dominated by the polychaete *Scalibregma inflatum*. This latter depth range could be defined into two assemblages based upon suites of less abundant species. At depths of 1,500-2,000 m, a lower slope assemblage dominated by various deposit feeding polychaetes and oligochaetes was found. Results from the 1984-1985 studies suggested seasonal or year-to-year patterns in the dominance of *Scalibregma inflatum* and *Cossura longocirrata*.

Table 3. Summary of Benthic Community Parameters on the Continental Slope off Cape Hatteras, North Carolina. Infaunal summaries are for 16 box cores.

Parameter	Mean± Standard Error
Total Infauna Density	30,968±5,152 individuals m^2
Total Species per 0.09 m^2	63.3±5.0
Species per 750 Individuals	45.7±5.0
H′ Diversity	3.2±0.2
Top Ten Dominant Taxa	64-97% (range)

Unusually high sedimentation rates and organic carbon flux have been recorded from the slope off Cape Hatteras and likely account for the high infaunal productivity in the area. Most of the dominant infaunal organisms are species that are more typical of shallow, near coastal habitats. It is postulated that the dominance of these species over more typical deep-sea organisms is the result of high inventories of refractory organic matter in the sediments. The organic matter has been found to consist of a mixture of both marine and terrestrially derived carbon, but only a small percentage is composed of the smaller molecular weight polyunsaturated fatty acids that is more typical of adjacent continental slope sediments. The high percentage of refractory organic matter would favor the survival of preadapted shelf species over those from adjacent slope environments that receive the more typical marine organic carbon flux derived from nearshore or offshore marine phytoplankton.

The benthic megafauna revealed in the camera transects included approximately 35 species of fish, 18 species of alcyonarians and anemones, 17 species of echinoderms, and a variety of crustaceans, worms, molluscs, and other organisms. The most characteristic of the megafauna organisms were the foraminiferan *Bathysiphon filiformis*, the eelpouts *Lycenchelys verrilli* and *Lycodes atlanticus*, the witch flounder *Glyptocephalus cynoglossus*, and the anemone *Actinauge verrilli*. The quill worm *Hyalinoecia artifex* was locally abundant, especially in the upper slope of the two northern transects. Burrowing anemones were locally abundant at depths above 1,000 m. The fauna on the lower slope (>1,600 m) was dominated by brittlestars and sea pens. Most of the photographs also showed numerous biogenic structures including tracks and trails, burrow openings and pits caused by deep-burrowing deposit feeders, excavations caused by fish and crustaceans, and the surficial tubes of infauna organisms.

The high densities of predators, such as eelpouts, witch flounder, and quill worms are likely related to the high densities of potential prey. High abundances of filter feeding megafauna, such as *Actinauge verrilli, Bathysiphon filiformis,* and burrowing anemones, are probably related to the high concentrations of suspended solids seen in many bottom images. High densities of the surface deposit feeding holothurian *Peniagone* sp., is found on the lower slope of Transect D and is also indicative of high organic flux. This species is known to occur in dense aggregations that migrate toward organically rich areas. Large deep-burrowing polychaetes were found in the box cores, and evidence of their activity dominated the sediment surface and profile images.

Geographically, the results of the 1992 survey suggested that the area encompassed by the dense fauna assemblages extends along most of the continental slope off Cape Hatteras. The distance

between Transects 1A in the north and F in the south is approximately 50 km (Figure 4). While the fauna was patchy and exhibited some depth zonation, community structure parameters were similar over the entire length of the study area. These assemblages, however, are not found in the vicinity of the Hatteras Canyon (Blake *et al.* 1995; Blake and Grassle 1994).

The results from traditional benthic analysis, sediment profile images, X-Ray profiles, and bottom photographs revealed that extensive sediment reworking by deep burrowing deposit feeders is an active process on the Cape Hatteras slope despite the high sedimentation rates (Diaz *et al.* 1994b. The surface photographs reveal a complete domination by biogenic structure. The mean apparent RPD (redox potential discontinuity) is 5.3 cm, suggesting aeration of the sediments by deep burrowing deposit feeders. Cross sectional analysis of sediment profile images indicate that sedimentary structure has been replaced by biogenic structure to depths of up to 30 cm, with the most active bioturbation occurring in depths of 5-20 cm. In contrast, bioturbation off Cape Lookout appears to be concentrated in the upper 5 cm and is limited to small near-surface infauna (Blake 1994), a situation that is typical of most slope environments along the U.S. Atlantic coast. Experiments by Blair *et al.* (1996) demonstrate that phytal detritus deposited on the surface of Cape Hatteras slope sediments may be transported to depths of 4-5 cm in a 1.5-d period. These results suggest that newly deposited organic matter will be immediately available to subsurface deposit feeders. Benthic processes at Cape Hatteras, therefore, are unusual for the western North Atlantic, and the deep-sea in general.

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HABITAT AND LIVING RESOURCES REVIEW: WATER COLUMN BIOLOGY AT CAPE HATTERAS

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It is essential in any overview of pelagic food web structure and function to place it in the proper physical perspective. For example, consider the space/time scales for major features of atmospheric and oceanic physical systems. While they share similar spatial scales, ocean physics typically occurs about 100x more slowly than atmospheric physics. In contrast, ecological processes in aquatic systems occur about 100x faster than terrestrial processes. Therefore physics and biology in aquatic environments have similar time/space scales, unlike on land. It thus becomes reasonable to speculate that marine organisms may have evolved to take advantage of the physical variance spectra in their environments. Certainly, we know that long term correlations do exist between physical processes and pelagic food web structure. This knowledge is essential if we are ever to decipher anthropogenic impacts, e.g. an oil or gas pollution effect on seabirds.

In the Carolina Capes region in general, phytoplankton biomass is typically highest in late winter/early spring, associated with a vernal bloom. Higher concentrations occur closer to shore and along shelf/slope fronts. Immediately south of Cape Hatteras is a large area of high upwelling. This massive nitrate flux into the euphotic zone induces substantial plankton development, which advects northward from the South Atlantic Bight (SAB) past Cape Hatteras. The latter is also at the confluence of southward-flowing Mid Atlantic Bight (MAB) water which exits at Cape Hatteras.

The combination of Gulf Stream water, advective SAB and MAB waters, slope water, and estuarine water, make this region a physically active and challenging location for field studies. The Ocean Margins Program (OMP) of the Department of Energy has studies the uptake, transformation, and fate of carbon on the Cape Hatteras shelf for much of the 1990's. A large interdisciplinary field program was conducted in 1996 including over 70 scientists from around the country and a large area of moored biological, physical, and chemical sensors. Numerous research cruises were conducted over the course of several years. These datasets are just now being analyzed, and the process of synthesis will take another year or more (depending upon availability of funds).

Some general conclusions are already apparent. While diatoms contribute significantly to phytoplankton community biomass, especially during the spring bloom, a majority of the total community production comes from small (<8um) photosynthetic nanoplankton. Small protozoan zooplankton ingest more of this primary production than do the larger metazoan zooplankton. Substantial fractions of the total suspended particulate organic carbon (POC) are composed not of living plankton but of nonliving detritus. Such detritus provides a physical and chemical substrate for an active microbial food web, as well as additional food for zooplankton, larval, and juvenile fish. Sampling from a drogued water mass showed changes in phytoplankton and zooplankton biomass and composition as the water advected through the Hatteras region, indicating that productive and consumptive processes are local as well as imported.

These data will hopefully be integrated into increasingly realistic ecological box models and, funding permitting, eventually incorporated into existing 3D circulation models of the Cape Hatteras region.

HABITAT AND LIVING RESOURCES REVIEW: RECENT INFORMATION ON PELAGIC SEABIRDS, MARINE MAMMALS, AND SEA TURTLES OF THE NORTH CAROLINA OUTER CONTINENTAL SHELF AND AN EVALUATION OF EFFECTS OF PROPOSED OFFSHORE OIL & GAS EXPLORATION

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During the late 1980's, the State of North Carolina responded to a proposal by the Mobil Oil Corporation to undertake exploratory gas/oil operations in Federal lease blocks on the Outer Continental Shelf (OCS) known as the Manteo Unit. One of the products resulting from the permit request was a report that addressed potential biological effects from offshore drilling activities as they related to sea birds and other fauna of the region (Lee and Socci 1989). Chevron U.S.A. now proposes to drill an exploratory well on one of the same Manteo blocks originally leased to various oil companies by the Minerals Management Service (MMS). Since 1989, additional information concerning the seabirds, marine mammals, and sea turles on the North Carolina OCS has been obtained, and new research is planned or underway. This paper is intended to highlight recent developments and briefly mention some concerns associated with offshore oil and gas activities that may affect these animals.

PELAGIC SEABIRDS

While offshore oil and gas exploration and the additional ship/air traffic and coastal development that comes with it, creates situations that might impact local seabirds, we will limit the bulk of this discussion to those species and subspecies whose global or regional (Western North Atlantic) conservation status is of concern. Only two of these species are currently listed as *endangered* by the U.S. Fish and Wildlife Service (FWS). Nonetheless, at least five species of global conservation concern occur over the OCS of North Carolina and are seasonally concentrated in the area proposed for exploratory drilling with enough regularity that the potential impacts of offshore drilling need to be addressed. For the most part, these are species whose total world populations are only several hundred pairs or less.

Another nine species also need to be considered. These species are either rare as breeding species in the Western North Atlantic (several being endemic subspecies with extremely small populations

and all number only a few thousand pairs), or birds where a significant percentage of their total population is seasonally concentrated in the State's waters, making their global or regional populations vulnerable to major natural or anthropogenic disasters. Furthermore, the seabirds in both categories are long-lived species, exhibiting protracted adolescence periods, limited reproductive output (typically one egg/successful adult pair/year), and their population stability would be highly vulnerable to increased mortality. For the tropical species in this category all have experienced major population declines as a result of human-induced problems at their breeding sites. Due to the combinations of these factors, the species discussed here are vulnerable, not to just catastrophic events, but to the long-term degradation of their marine habitat. Continued declines in their numbers may eventually lead to irreversible declines.

Nesting pair estimates are based on Croxall *et al.* (1984) or Nettleship *et al.* (1994), and dates and zones of local occurrence in North Carolina are from Lee (1995) unless otherwise credited. Information on species susceptibility to oil pollution and other problems related to offshore drilling are presented by Clapp *et al.* (1982) and summarized by Lee and Socci (1989). Specific information provided here on susceptibility is included only as needed to bring this presentation into context.

Globally Endangered Species

Black-capped Petrel (*Pterodroma hasitata*): This West Indian petrel was once thought to be extinct (see Haney 1987). The discovery of nesting colonies in Haiti in 1961 showed this petrel to still be extant (Wingate 1964). The species is now extirpated, or believed to be extirpated, on four of the five islands on which it was known to nest. Known breeding populations are restricted to the mountains in southern Hispaniola, where this petrel faces a number of serious conservation problems. In the early 1960's, Wingate (1964) estimated the global population to be between 2,000 and 20,000 pairs, yet by 1994, estimates were at less than 2,000 pairs. Subsequently, at a workshop on West Indian seabirds (Society of Caribbean Ornithology, Aruba 1997), biologists from the region estimated the surviving population to be only 1,000-2,000 breeding pairs. Although this species is regularly seen in the Gulf Stream off the southeastern United States (Haney 1987), large concentrations (often 100's of individuals) are known only from the area of "The Point," where the species occurs year-round. The relatively large numbers seen off North Carolina's OCS indicate a large percentage of the total population forages in this region.

Bermuda Petrel (*Pterodroma cahow*): At this time, the only available at-sea records of this rare petrel in U.S. waters are from the North Carolina OCS in the vicinity of "The Point." This suggests that this is an important foraging area for the species. To date there are at least five reports and one confirmed photographic record (NC State Museum). Published reports are from April, May, July, August, and December (summarized in Wingate *et al.* 1998). The only other place where this petrel is known to occur is at its breeding station in Bermuda and an undocumented report of up to 20 individuals at 36.50° N, 66.10° W (Wingate *et al.* 1998). Today the population consists of 53 adult pairs. While this petrel remains one of the most endangered avian species in the world, long-range survival looks promising. Bermuda Petrels are listed as endangered by the FWS and are also listed in the ICBP World Checklist of Threatened Birds.

Herald (Trinidade) Petrel *(Pterodroma (a.) arminjoniana)*: This petrel breeds only on South Trinidade and nearby Martin Vas island groups, where in the first part of this century, Murphy (1936) and others recorded them nesting in vast numbers. The current Atlantic population is small,

with breeding pairs numbering in the 100's; the species conservation status is described as urgent (Williams 1984). Currently, these petrels are regarded as a subspecies of the Pacific herald petrel (*P. a. hearaldi*), and it has been proposed that the Atlantic population is specifically distinct (Olson and Lee in ms). To date, there are over 30 reports of these petrels from North Carolina's OCS, all from the vicinity of "The Point," where the species occurs primarily from May-September. These records represent nearly all of those obtained away from this species' two small tropical South Atlantic breeding islands. This would imply the State's OCS is a key foraging area for this Atlantic endemic.

"Fea's" Petrel (*Pterodroma "feae "*): Currently there are unresolved taxonomic issues as to which species of the eastern Atlantic *Pterodroma* complex occur off North Carolina during the warmer months (see discussions by Tove 1997 and Lee 1995). In addition, a clear understanding of the systematics of breeding populations is lacking. However, from a conservation point of view, species identification is irrelevant. *P. feae* and *P. maderie* are the rarest of European birds. *Pterodroma fea* of the Cape Verde Islands, Bugio in the Desertas, and perhaps the Azores, has an aggregate population estimated at a few hundred pairs. *P. maderie* of Madeira has a total population of less than 50 pairs all nesting in a single colony. The most recent population estimate is from the late 1980's; there were believed to be only 20 pairs (Collar and Andrew 1988). Since the early 1980's, when they were first recorded (Lee 1984), petrels of this species complex have been seen regularly in deep Gulf Stream waters off Cape Hatteras (Tove 1997), the only site away from their breeding areas where this species is known to regularly occur. Both species are listed in the ICBP World Checklist of Threatened Birds (Collar and Andrew 1988).

Roseate Tern (*Sterna dougalli dougalli*): The FWS recognizes the population of these terns in the northeastern North Atlantic as endangered and the disjunct Florida and Caribbean stock as Threatened. The total Atlantic population probably numbers below 8,000 pairs. The species is in decline, and former roseate tern nesting areas such as Bermuda, have been abandoned for decades. Roseate terns are considered to be uncommon migrants in North Carolina waters where they migrate both along the coast and over OCS waters. The vulnerability of this tern to oil pollution is unknown.

Seabirds of Concern

Lee and Socci (1989) listed other species occurring in the region with populations that could be jeopardized by gas/oil exploration on the OCS of North Carolina. For many of these species, the population sizes are now known to be far below the estimates available in the late 1980's. These species are: common loon (*Gavia immer*), greater shearwater (*Puffinus gravis*), sooty shearwater (*Puffinus griseus*), Audubon's shearwater (*Puffinus lherminieri lherminieri*), band-rump storm petrel (*Oceandroma castro*), white-tailed tropicbird (*Phaethon lepturus catesbyi*), red-billed tropicbird (*Phaethon aethereus mesonauta*), masked booby (*Sula dactylatra dratylatra*), northern gannet (*Morus bassanus*), and bridled tern (*Sterna anaethetus melanoptera*).

Other Species of Concern

Lee and Parnell (1990) in their report on species considered to be at risk in North Carolina included nine coastal nesting marine and estuarine birds. The coastal species discussed are listed federally endangered, Threatened, and of special concern. All these species are also protected under North Carolina's endangered species regulations. Subsequently, gull-billed terns have been listed as

threatened, and common terns (*Sterna hirundo*) and least terns (*S. antillarum*) have been added to the state's Special Concern List.

Another federally endangered species, the peregrine falcon (*Falco peregrinus*), is a regular migrant and winter coastal resident in North Carolina. They also migrate over the open ocean and there are records of individual birds from the vicinity of the proposed drilling site. Lee and Socci (1989) review potential problems with oil pollution and note that oiled seabirds could be irresistible targets for migrating peregrines.

MARINE MAMMALS

A number of federally endangered and threatened marine mammals occur in North Carolina waters. Based on naturalist cruise observations, he fin whale (Balaenoptera borealis), humpback whale *(Megaptera novaeangliae*), and sperm whale (*Physeter macrocephalus*) are found with regularity in the vicinity of "The Point."

Fin whales are common in waters of the U.S. Atlantic Exclusive Economic Zone (EEZ) and are appear to be relatively more abundant in waters off New England and Canada. The population is estimated to be about 5,000 from Cape Hatteras to Nova Scotia (Waring *et al.* 1997)

Humpback whales are far less abundant in the U.S. Atlantic EEZ. The same surveys that estimated 5,000 fin whales, calculated approximately 300 humpback whales. Western North Atlantic humpback whales are thought to have distinct summer feeding aggregations in northern waters and then migrate to Caribbean breeding and calving waters in the winter. However, wintertime sightings in southeast coastal waters have increased recently. From 1985-92, humpback whale strandings increased, particularly along the Virginia and North Carolina coasts. Wiley *et al.* (1995) reported on 38 whale strandings, with most animals sexually immature. It was concluded that the North Carolina-Virginia coastal area is becoming an increasingly important habitant for juvenile humpback whales.

Sperm whales generally avoid coastal waters and are thought to be most abundant over the outer shelf and into mid-ocean regions. Waring *et al.* (1993) suggest that this offshore distribution is more commonly associated with the Gulf Stream edge. Of the large whales reported for North Carolina waters, sperm whales may have the strongest 'habitat' association with the proposed drill site in terms of water depth and proximity to the western Gulf Stream edge.

The rarest large whale, the North Atlantic right whale (*Eubalaena glacialis*), is known to migrate nearshore from northern summer feeding grounds in New England and Canadian waters to winter calving areas off the Georgia and Florida coasts. The entire population is only about 300 individuals (Waring *et al.* 1997). Ship strikes by commercial vessels is considered the most dire potential threat to the species (Knowlton, 1997). Very limited mid-Atlantic coast data and historic coastal whaling records indicated right whales migrate through North Carolina waters far inshore of the proposed drill site. However, the distribution of approximately 85% of the winter population and 33% of the summer population are unknown (Waring *et al.* 1997). It is possible that right whales move through North Carolina waters farther offshore, but this has never been documented.

Although not listed as threatened or endangered, the bottlenose dolphin (*Tursiops truncatus*) is of particular concern because of the 1987-88 dolphin die-off that may have decreased coastal populations by as much as 53%. Waring *et al.* (1997) describe two distinct dolphin ecotypes, an

offshore stock and a coastal stock usually found in <25 m depths. Although both stocks appear to have north-south migratory movement, further studies indicate that the coastal stock may have multiple resident components that would respond differently to local population pressures (Hohn, 1997). The coastal stock(s) is listed as depleted under the Marine Mammal Protection Act.

Another species of concern is the harbor porpoise (*Phocoena phocoena*). A summer resident in the Gulf of Maine and Bay of Fundy, the species migrates to the south in winter and is found at "intermediate densities" off North Carolina during January-February (Waring *et al.* 1997). Annual fishery-related mortality and injury to this species is considered significant, and the National Marine Fisheries Service (NMFS) has proposed listing the species as threatened.

In general, the distribution and abundance of cetaceans (whales, dolphins, and porpoises) in waters of North Carolina are not well studied, particularly beyond coastal waters over 3 miles offshore. Other marine mammal species are known to occur in the Manteo area, but there is insufficient information to conclude that they occur there with any regularity. Data that could project probable occurrence and numbers of marine mammals within given distances of the proposed drill site do not exist.

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While survey data are sparse, stranding records and early commercial regional whaling records clearly indicate a particularly rich species diversity for the region. There was active shore-based whaling for humpbacks and right whales on Shackleford Banks and Cape Hatteras. Active stranding and salvage networks were functioning on the Outer Banks as early as the late 1800's. The Smithsonian Institution continued collection efforts into the the early 1990's. Most recently, combined efforts of private and academic groups often coordinated under the NMFS stranding network now compile data for North Carolina (and all coastal states). One author alone (McLellan) has documented over 25 species stranded on the Outer Banks.

A species list of cetaceans that inhabit North Carolina waters can be reasonably generated and would essentially reflect the known U.S. Atlantic cetacean species (Leatherwood and Reeves 1983). In addition to species highlighted in this very brief summary, many species of pelagic dolphins, beaked whales, long- and short-finned pilot whales, dwarf and pygmy sperm whales, and other rare cetaceans have been encountered in Outer Banks waters. Strandings include one melon-headed whale (*Peponcephla electra*), a worldwide species more associated with tropical waters. It is suspected that the "Point" represents an area of notable abundance and diversity for cetaceans.

Dedicated surveys for marine mammals in North Carolina and adjacent waters are increasing in recent years. The University of North Carolina at Wilmington (UNCW) has been conducting aerial surveys for humpback whales in the nearshore waters of the Outer Banks since 1997. Data include all species encountered and their distribution out to 3-5 miles offshore. Vessel survey efforts has been conducted opportunistically on research cruises, mostly in Onslow Bay. UNCW will begin a series of aerial surveys beginning in May 1997, for one year, to cover portions of the OCS off Onslow Bay and the Virginia/ Maryland border.

The Virginia Marine Science Museum (VMSM) at Virgina Beach has been conducting nearshore aerial surveys in the waters from Cape Henry, Virginia to Cape Hatteras, North Carolina. In addition, the VSMS has observed humpback whales from whale watch vessels and survey boats at the mouth

of the Chesapeake Bay. These surveys have been ongoing for 7-8 years. The VMSM also maintains a highly organized stranding program now in its tenth year.

NMFS has conducted several offshore cetacean surveys (also sea turtle observations) that have included North Carolina waters (Waring *et al.* 1997), and another major survey effort is planned for the summer of 1998. The Navy has proposed an offshore weapons testing area either off North Carolina or Virginia. It is anticipated additional offshore biological assessments will result from this project. It is also reasonable to assume that further surface biota studies would be funded by MMS, if the Manteo project proceeded to production plan permitting.

SEA TURTLES

Field observations and naturalist cruises indicate adult Atlantic leatherback (*Dermochelys coriacea*) and Atlantic loggerhead (*Caretta caretta*) turtles are found regularly in the vicinity of The Point. Keinath *et al.* (1996) suggest loggerheads will be most likely near the Manteo area in the spring and fall. It also appears likely that some turtles will overwinter off North Carolina at the western edge of the Gulf Stream.

All Atlantic species of sea turtles occur in North Carolina waters. Loggerhead turtles predominate in number of adults with both coastal nesting and year- round occurrence. Green turtles (*Chelonia mydas*) are second in abundance to loggerheads, followed by leatherbacks, Kemp's ridleys (*Lepidochelys kempi*), and some rare sightings of hawksbills (*Eretmochelys imbricata*).

Preliminary genetic results obtained from in-water studies conducted in North Carolina estuaries indicate that loggerheads originated primarily from two Florida nesting subpopulations. Less than 5% of the sampled turtles belonged to other subpopulations nesting on the Florida panhandle, Mexico, and Brazil (Epperly *et al.* 1995). Initial unpublished results indicate juvenile green turtles originate from at least four different rookeries as distant as Africa.

The coastal area immediately adjacent to Cape Hatteras has long been recognized as a major migratory pathway for loggerhead, leatherback and Kemp's ridley. The north-south movement following warm water was first recognized as a seasonal pattern for these species. Tagging studies and new field observations indicate many variations to this pattern within species including overwintering and onshore-offshore patterns. Spring and fall migration activities tend to increase North Carolina coastal turtle abundance to peaks that exceed summer "resident" populations.

The complexity and variations in turtle migrations and recent genetic studies indicate that turtles moving through the area belong to a number of genetically unique nesting populations throughout the Atlantic, some of which may be experiencing significant declines.

Information on young sea turtles, particularly dispersal of hatchlings and early life as a pelagic phase, is very limited. It is assumed that young turtles are "passive drifters" that inhabit frontal boundaries near major ocean currents and feed upon the surface biota. Young loggerheads and Kemp's ridleys are known to occur in *Sargassum* drift lines, although the association with green turtles may not be the same (Witherington, 1994). The young turtles essentially represent a different animal in terms of behavior, distribution, and techniques needed to study them. The *Sargassum* community is a

major presence in "The Point" area and the pelagic phase turtles are one of the least known aspects of the surface animals dealt with here.

POTENTIAL EFFECTS FROM DRILLSHIP OPERATIONS

This paper will focus on concerns associated with normal exploratory drillship operations. The probability of an exploratory well striking oil is usually well below 50%. Coupled to this would be another very low probability of an oil spill occurring during operations if oil was found. Since commercial tankers travel shipping lanes off North Carolina, the State must deal with a potential large oil spill with or without proposed exploration. It is well recognized that an oil spill is the most catastrophic event associated with oil and gas operations and as demonstrated by results of the *Exxon Valdez* spill, seabirds would be greatly impacted (Piatt *et al.* 1990). Harmful effects could occur to marine mammals as a result of contact with oil, ingestion of oil (or contaminated prey), and inhalation of fumes (Geraci and St. Aubin 1990; Hodgson, 1990). It is assumed sea turtles would have similar problems, particularly with ingestion of oil congealed into globs or tarballs.

Nocturnal seabirds and their prey face the problem of being disoriented by lights from drilling platforms. Lights could cause problems with feeding activities, result in unnatural concentrations of food resources around lights, and on foggy nights cause birds to crash into rigging. Unfortunately, there are no other drilling operations like the one proposed that have similar species at risk. The few deepwater drilling operations are not in regions populated with low-density tropical and subtropical faunas, so it is not possible to obtain data on mortality from other drill sites. The potential for unnatural concentrations of prey and predators that are biologically programmed to exploit patchy shifting resources around a single site has the additional concern of problems of increased magnitude if an operational (vessel-associated) oil spill or similar disaster occurred. Species documented to be affected by lights include all four *Pterodroma*, Audubon's shearwaters and band-rumped storm petrels, and it would be highly unlikely that lights would not affect others species as well.

Lights on drilling platforms may also pose a threat to young pelagic phase sea turtles. It is well known that sea turtle hatchlings emerging from the beach nest cavity exhibit a strong tendency to orient towards the brightest direction. On developed beaches, hatchlings will often crawl toward artificial light sources rather than toward the ocean, resulting in a "light trapping" response (Lohmann *et al.* 1996). Trapped hatchlings, unless rescued, will succumb to predation, dehydration, or exhaustion. It is unknown if bright worklights from a stationary drill platform may elicit a similar reponse from young sea turtles at sea.

It is known that off Florida large numbers of loggerhead hatchlings and juveniles actively feed in *Saragassum* concentrated in convergence zones along the western edge of the Gulf Stream (Witherington, 1994). It is assumed these turtles would also be passively transported through The Point vicinity. Therefore, a brightly lit drilling platform could cause the young turtles to orient toward and congregate under the lights. Recently, hatched turtles from North Carolina nesting sites would be most vulnerable to this possible behavioral response. This response would disrupt normal movement patterns and lead to increased predation.

Drillship operations in the mid-Atlantic "attracted" a small pod of juvenile sperm whales (Doug Beach, NMFS NE Protected Species Coordinator, personal communication). Exact reasons for this are unknown and theories ranged from curiosity to opportunistic feeding on squid attracted to lights

during night operations. While no harm to whales was attributed to this event, it provides an example that lights may alter surface community behavior in many ways.

In addition to young turtles, Haney (1986) and Moser and Lee (in ms) have shown that many of the seabirds occurring in the Gulf Stream use pelagic *Sargassum* reefs as key foraging sites. While this use has been illustrated for at least 21 species, several tropical seabirds are *Sargassum* foraging specialists. Of the birds discussed here, Audubon's shearwaters, masked boobys, and bridled terns rely heavily on a healthy *Sargassum* community. Black-capped petrels and the tropicbirds regularly use this community for feeding. Since large amounts of *Sargassum* pass through the area of "The Point" throughout the summer period, this alone tends to focus the activity of these species of concern into the area. Not only would major spills contaminate the *Sargassum* passing through the area, but minor discharges from ships and boats servicing the drilling operations would concentrate in the same narrow current fronts as the *Sargassum*. Oil and other pollutants would not only directly affect seabirds feeding in *Sargassum*, they would be detrimental to their prey base. This problem would not just be a local one but would affect organisms downstream for considerable distances.

While lights have the potential to attract some animals, noise from drilling operations can have the opposite effect. It is assumed that noise intensity would not be of a magnitude to cause physical damage to hearing, but repeated noise disturbance could induce avoidance behavior. This would be significant only if the sphere of influence was particularly large and animals were "scared" off prime feeding areas (Richardson *et al.* 1995).

Vessels represent a potential collision threat to any animals at the surface and are another source of disturbance. A single drillship, particularly newer designs with most drilling supplies carried onboard, would not generate substantial increased volumes of helicopter and support vessel traffic. Nevertheless, any additional vessel traffic through coastal waters at peak right whale migration periods will be an issue, particularly night traffic at speed.

Because of the storm climate of the Hatteras region, the proposed season of exploratory drilling is between spring and fall. Therefore, except for loons and gannets, all of the species discussed and listed would be present in periods of maximum occurrence during drilling operations. This is also true of other tropical and subtropical species, many with small populations that originate from breeding stations in the West Indies. Additionally, Epperly *et al.* (1995) reported the highest number of sea turtle (adult) sightings from April through June off North Carolina's entire coast and from October through December off North Carolina's northern coast.

Finally, it should be noted that pelagic bird-watching has grown into a significant recreational activity. The area of "The Point" is internationally recognized as one of the prime spots to see seabirds in North America. Interest is not limited to the globally rare species discussed here. This is one of the few areas in the U.S. where dependable concentrations of seabirds occur, and this is one of the best places to access and encounter many of those species. While many of these birds are not rare from a conservation point of view, they are rarely encountered elsewhere in North America. Recreational activities involving birds has become a rapidly growing hobby. In 1991, $5.2 billion was spent nationally on nonconsumptive, bird-related activities ($2.4 million in North Carolina). Figures generated by the FWS show that in the last decade bird-watching has increased as a recreational activity by 155%. In 1998 over 60 commercial trips are scheduled exclusively for observing pelagic seabirds. This would indicate a minimum of 1,800 participants and account for

perhaps as many as 5,000 person-days of ecotourism for the Outer Banks. These figures do not include individuals that schedule their own trips or members of fishing parties that are interested in observing marine life at sea. While it would be difficult to obtain exact figures, a great many of the participants of the commercial offshore bird trips are going specifically to see the very species discussed here.

SUMMARY

Based on existing knowledge and assumptions, a drill platform could negatively impact seabirds, sea turtles, and, least likely, marine mammals. Seabirds are perhaps the primary concern.

Because of the regular occurrence of rare and globally endangered seabirds occurring in the immediate vicinity of the proposed drill site on the OCS of North Carolina, exploratory drilling is an issue of importance to international conservation. Various aspects of the biology of these birds combine to both attract them to the site and to make them vulnerable to man-induced catastrophic events. A secondary concern is the potential effect of disrupting the local marine system and/or further depletion of existing stocks of rare seabirds. Additionally, a growing recreational seabird watching industry has developed on North Carolina's Outer Banks, and offshore gas/oil exploration potentially jeopardizes both the fauna and the aesthetics of the OCS. Despite these concerns, current conservation strategies and the interpretation of existing regulations do not appear to be relevant to the situation.

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HABITAT AND LIVING RESOURCES REVIEW: SOCIAL AND ECONOMIC ISSUES

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INTRODUCTION

The role of social and economic data and information is critical in the OCS exploration process for two reasons. First, all of the alternatives for such exploration have impacts both on the natural environment and on the people who use or are concerned with that environment, and assessing the social and economic impacts of different exploration alternatives on those people is a central part of the planning and evaluation process (Orbach 1984). Second, the basic policy decisions themselves concerning the appropriate tradeoffs that must be made between the impacts to the non-human environment and the costs and benefits accruing to people from the various alternatives which are human value decisions. That is, all costs and benefits must be weighed against some standard or criteria. Those standards and criteria, which are most often expressed as goals and objectives of the planning process, are based on human values with respect to the relationship between humans and the non-human environment (Orbach 1996). It is critical to make those goals and objectives—biological, social and economic—clear and specific. For both of these reasons, adequate social and economic data and information are necessary.

In this brief comment we will cover three topics: 1) the history and results of the Coastal North Carolina Socioeconomic Study, which was initiated as a result of Mobil's submission of an Exploration Plan for the Manteo Unit; 2) the general characteristics of the human environment of "The Point" and associated marine, coastal, and shore locations; and 3) needs with respect to social and economic data and information for further consideration of OCS exploration associated with the Manteo Unit.

THE COASTAL NORTH CAROLINA SOCIOECONOMIC STUDY

As a result of the recommendations of the North Carolina Environmental Science Review Panel mandated by the Outer Banks Protection Act (ESRP 1992), the North Carolina Socioeconomic Study (CNCSS) was commissioned by the Atlantic OCS Region of the Minerals Management Service (MMS). This study, which was completed in 1993, had five objectives: 1) a characterization of base case socioeconomic conditions in the five most potentially affected North Carolina counties, including standard aggregate variables, the structure of related industries, and the relationships among private and public sector entities in the subject areas; 2) detailed community studies on representative communities potentially affected by OCS development, including sociocultural variables necessary to establish the context of the role and effect of potential OCS activities; 3) an aesthetic and perceptual issues study of representative components of the potentially affected populations in the region; 4) infrastructure studies performed in the potentially affected communities, focusing on the potential for changes in local and regional fiscal relationships derived from future OCS activity; and 5) the design of a longitudinal socioeconomic monitoring program that employs

the key variables identified in the base case, community, infrastructure, and risk perception studies. This five-volume study was submitted to MMS in 1993 (CNCSS 1993).

The significant conclusions from this study were that the socioeconomic systems of the study area (the counties of Beaufort, Carteret, Dare, Hyde and Pamlico) are heavily dependent on the use of marine resources and access to a marine environment perceived as relatively pristine. The study also concluded that the character of this dependence varies considerably depending on the mix of a community's or region's reliance on tourism, commercial or recreational fisheries, military activities, retirement, or other transfer income sources. The study further found that the economies and lifestyles of the ocean-adjacent communities are associated with a mix of leisure-tourism and commercial fishing, while commercial fishing is more dominant in communities in the sounds but near the ocean such as Wanchese and Atlantic. The more inland counties such as Beaufort and Pamlico are more dependent on a mix of agriculture, silviculture, commercial fishing, and some manufacturing and other industry. The coastal counties and communities are growing in population, while the inland counties generally are not. In the 1980 to 1990 period, housing values had increased most rapidly in the areas nearest the coast, while the non-white population had decreased as a percentage of total population for all counties in the study area. The general summary indicated a significant trend towards an economy dependent on leisure-tourism, services, second or retirement residences, and migration towards the more coastal locations (CNCSS 1993).

Although various research projects undertaken for other purposes since 1993 have collected various kinds of socioeconomic data on this region and its people, none of these have substantially contributed to the need for socioeconomic data and information beyond that produced by the CNCSS.

THE GENERAL CHARACTERISTICS OF THE HUMAN USE OF "THE POINT" AND ASSOCIATED LOCATIONS

The general characteristics of the human uses of The Point and associated locations are these:

1. Although the potential OCS activity at and the current human uses of The Point occur in the ocean environment, the people and activities associated with these activities and uses connect The Point to a wide range of locations–many tens of miles inland from the ocean itself–in the eastern areas of North Carolina and Virginia. In particular, commercial and recreational fishermen who fish at The Point live and work in a wide range of communities throughout the region. This necessitates the assessment of potential social and economic impacts beyond those of the ocean and shore bases of the OCS activity itself and beyond only areas of direct impact from accidents or spills.

2. Even with the extensive socioeconomic data and information from the CNCSS, the nature and extent of the commercial and recreational use of The Point itself is not well known. The main thrust of the CNCSS was on the shore locations rather than the at-sea activity.

3. The perceptual and attitudinal data collected by the CNCSS indicated a wide range of perceived threats to the human environment in eastern North Carolina, with many of the principal threats coming from activities other than OCS activities, activities such as development or storm events. None of the data collected in the CNCSS constituted a direct

elicitation of opinion regarding the appropriateness or desirability of OCS activity, but was rather intended to place perceptions and attitudes regarding OCS activity in the context of the total set of attributes of, and threats to, the human environment.

THE NEED FOR FURTHER SOCIOECONOMIC DATA AND INFORMATION

Based on the results of the CNCSS and the fact that essentially no directed socioeconomic data collection has occurred with respect to potential OCS activity in the Manteo Unit since the CNCSS, the following are the areas of need with respect to socioeconomic data and information with respect to the consideration of any future OCS activity in the Manteo Unit.

1. Updating of the CNCSS data and information, and continued monitoring of variables identified in that study. Any future OCS activity in the Manteo Unit would occur at least a decade after the date of most of the data references in the CNCSS and should be updated to allow proper assessment of the potential impacts of OCS activity. This could be accompanied by the initiation of the longitudinal socioeconomic monitoring program recommended by the CNCSS.

2. Further data collection should be initiated on the actual commercial and recreational fishing, and other human uses of The Point. This data was not collected under the CNCSS.

3. The conduct of a socioeconomic impact assessment. The data and information collected by the CNCSS resulted in characterization of the identified variables for the study region, but it was not intended to–and did not–include an assessment of the potential socioeconomic impacts of OCS exploration alternatives. Thus, in addition to the updating and monitoring referred to in (1) above, the data and information would have to be used to actually assess the potential socioeconomic impacts of any future OCS activity under the guidelines of the OCSLA, NEPA, and other relevant mandates.

4. The CNCSS was primarily directed at the characterization of socioeconomic variables for the study area, not at the development of analytical tools for better understanding of the relationships among those variables. Thus, work should be initiated in such areas as economic modeling of the relationships among those variables, including such economic relationships as demand curves for the various activities and resources of the region related to, or potentially affected by, OCS activity.

SUMMARY

In summary, significant progress was made on the collection and analysis of socioeconomic data and information regarding the humans and their communities who have some involvement with, and would be potentially affected by, OCS activity in the Manteo Unit. This progress was primarily due to the CNCSS conducted pursuant to the recommendations of the ESRP. However, the data from that study are now dated; some data elements, such as the actual human activity at The Point itself, were not included in the original study; no impact assessments were done with the data and information from the CNCSS; and no adequate socioeconomic monitoring system was established. These points should be addressed, as noted in the above "Needs" section, prior to further OCS activity in the Manteo Unit.

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UNDERSEA SCIENCE AT OCS OIL AND GAS SITES

Mr. Andrew Shepard
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Undersea research is oceanography done by divers using scuba or umbilicals, submersibles or underwater robots. Undersea science plays an important role in studying two OCS oil and gas lease sites—one in the gulf of Mexico and the other off Cape Hatteras, NC.

The National Undersea Research Program is funded by the National Oceanic Atmospheric Administration to conduct underwater research that supports the NOAA's mission to serve as steward of oceanic environments. It does this through regional Centers around the nation.

The southeast center, hosted by the University of North Carolina at Wilmington by a grant from NOAA, supports research from NC to Texas. It is an excellent region for undersea research for two reasons:

1. conditions are conducive to diving; temperate to tropical waters and wide shallow shelf allow us to use a wide variety of technologies, from scuba to submersibles;

2. research needs requiring undersea technology are plentiful, with a range of environments and problems to investigate, including coral, temperate "live bottom" and artificial reefs, and the most productive OCS oil and gas areas in the nation.

One of the most special places to do undersea research lies just within the northern extent of our region at "The Point." I have been going to sea for 20 years and never been in a place quite like it—from the air to the seafloor, The Point is full of life and power and mystery—truly a frontier to explore.

Why do we go under water? First, to explore, to see and experience the world we are studying, and second, to form an accurate and thorough understanding based on fact.

Two places, Green Canyon in the northern Gulf of Mexico and The Point off Cape Hatteras, are similar in some respects:

- both are oil and gas sites
- both lie at similar depths (800 meters) on the continental slope
- both are among the most productive ecosystems in the world's oceans

They are also very different in other respects:

- one is far from shore and the other a short boat ride

- the oil/gas sites at one are or will soon be economically developed, the other is untouched to date

- one ecosystem is fed from below and the other from all directions

We will look at two locations that clearly show why we dive to study the oceans and places like "The Point."

The first site lies a hundred miles off the coast of Louisiana and Texas in an area called Green Canyon, a site first explored using NURP and MMS-sponsored submersibles. The lease block is the only OCS block ever closed to drilling in the Gulf due to its unique biological community.

(At this point a video narrated by Dr. Chuck Fisher of Penn State University was shown.)

Moving north, Cape Hatteras displays, two generalities regarding seep communities that apply to "The Point":

- both communities have evolved and adapted to take advantage of the plentiful food supply, thus, they look very different from the general slope community, however…

- both communities also serve an important functional role to the wider slope community as a source of production and shelter

Whereas the seep communities are limited primarily to the seafloor, from which their food comes, The Point ecosystem is productive from the surface to the seafloor and fed from all directions by the unique hydrography of the region.

The challenges of in situ sampling increase when we try to accurately and completely sample mid-water communities. With our academic and industry partners, we have developed many tools to document and collect mid-water creatures, such as the video bioluminescence recording device, video Fresnel lens for counting plankton and suction sampler and bucket array for collecting delicate individual gelatinous zooplankton.

The first thing to strike you as you enter the dark deep sea below 300 feet is the lights created by bioluminescing plankton of many types, from phytoplankton to fish.

Scientists with thousands of submersible dives around the world are impressed with the abundance and diversity of plankton at The Point, however, quantitative data is rare. Why is that?

- since plankton easily get squashed in nets, they cannot easily be sampled in order to tell them apart

- their behaviors and life habits are unknown and impossible to study with nets

- in situ technologies are the best way to study the mid-water, but they are not cheap, so dives are rarer

Why should we bother to study mid-water communities?

- biodiversity-- one of the best measures of environmental health, but it is useless if biased by sampling artifacts and errors in methodology
- carbon cycle-- zooplankton are the first order processors of the particulates that rain down at The Point [note dense snow at Point]
- the most important food source for economically valuable fish like tuna

The 467 well site is perched on a 600 meter wide plateau. 500 meters across the plateau is a cliff wall leading down into adjacent gulley. Visibility on bottom near The Point ranges from 0 to 20 feet.

The complex bottom makes in situ sampling necessary. Well site/plateau can be sampled from the surface; however, much of the upper Hatteras slope lies at steep angles > 50°. Previous ship-based studies have resulted in a high failure rate (40-75%) of the box cores. Cores that did succeed were biased sampling to flat plateaus only.

During the study the slope angle at the well site, ridge top and gulley was 10-15°.

The infaunal community varies significantly, both in biomass and species composition (see Table 4) between these sites that are only meters apart.

Thirty miles to the north, the snow disappears and visibility increased to > 60 feet; infaunal and megafaunal density drops; note the plastic "reef" with attached anemones.

However, 15 nm to the north, we again see the forams and dense infauna. This suggests that The Point ecosystem extends at least 15 nm north of block 467 and is not just a product of the canyon topography.

Infaunal density in cores from the 467 well site, top of the wall (both on the same plateau) and 15 nm site are significantly higher than the wall, gulley or 30 nm sites. Also apparent is the lack of foram Bathysiphon tubes at the latter three sites.

If we did not use subs to sample The Point we may have mis-represented the community in as much as 50% of the ecosystem (the ridge walls and gulleys).

The presence of "live bottom," hard bottom reef with attached sessile invertebrates and algae, are areas of concern in EIS studies. The Mobil 1989 POE noted that no "live bottom" existed at The Point, and the bottom was characterized by a barren muddy slope. However, we now know that this bottom is far from barren and as alive as any slope ever documented in terms of animals living above and in the seafloor.

For the future, the research report produced by NURC/UNCW, "Past, Present and Future Undersea Research Initiatives on the Upper Hatteras Slope," pursuant to a related workshop involving scientists and managers, cites specific research gaps and recent NURC publications related to the area. In general, we need to go both shallower and deeper.

Since our last sub dives in 1994 we have been back to study

- pelagic fisheries which are driving a local economic boom, e.g. bluefin tuna distribution and life history and
- Sargassum mats and fish recruitment along the water frontal boundaries.

Subs we used to date were limited to 1000 meters. Community downslope where more of the organic material comes to rest is likely to be even more productive and a new frontier.

Table 4. Abundance and species diversity (Shannon-Weiner H' and Evenness J) of macrofauna in 10 cm deep cores from stations visited in 1992. Infaunal abundance and diversity differed significantly (ANOVA, $p < 0.001$) at the stations.

Site (# of 49 cm^2 box subcores)	Subcore Abund.– Mean n ± SE	Mean Density– # m^{-2}	Diversity– Mean H' ± SE	Evenness– Mean J ± SE
Wall (7)	63 ± 07	12,900	1.77 ± .03	0.62 ± .01
30 nm N (11)	75 ± 05	15,300	1.78 ± .08	0.62 ± .01
valley (8)	104 ± 08	21,200	1.55 ± .16	0.70 ± .04
Well (9)	197 ± 13	40,200	1.65 ± .07	0.64 ± .01
Ridge top (9)	219 ± 17	44,700	2.96 ± .04	0.79 ± .01
15 nm N (12)	244 ± 19	49,800	2.86 ± .05	0.87 ± .02

PHYSICAL ENVIRONMENT WORK SESSION RESULTS: PHYSICAL OCEANOGRAPHY/METEOROLOGY

Dr. Leonard J. Pietrafesa
North Carolina State University

Dr. Alexis Lugo-Fernández
Minerals Management Service
Gulf of Mexico OCS Region

The objectives of this session were (1) to identify pertinent research conducted in the geographic area that relates to exploratory drilling, and (2) to identify additional efforts needed should development occur. We defined the physical environment as consisting of geologic, meteorological, and physical oceanographic aspects around the area relating to exploratory drilling. Healthy participation and discussion among the audience were generated, leading to seven major findings. During the final plenary session, a concern pertaining to oil spill trajectories, slumping, and biological-physical interactions was raised and included with our findings.

The session started with a review of available physical oceanographic data for the region. During this time a list of data sources and types was generated. The list is not exhaustive and we recognized that other potential sources exist. The list includes but is not limited to the following:

- National Data Buoy Center
- NDBC Coastal-Marine-Automated (C-MAN) Program
- Satellite AVHHR & Altimetry Data
- Satellite-tracked and other Drifter Data
- Genesis of Atlantic Lows Experiment (GALE) 1986
- Frontal Eddy Dynamics (FRED) Experiment 1987
- Blake Plateau Study 1982
- SYNOP Pilot Study 1986-87
- SYNOP Study 1984-85
- A Physical Oceanographic Field Study off North Carolina 1992-94
- Mid Atlantic Slope and Rise (MASAR) Experiment 1984-86
- Gulf Stream Dynamics Experiment 1982-85
- Chevron 1981-82
- Manteo Block 467 Program (Mobil) 1989-90
- ARM (Met) DOE 1989-96
- SEEP (DOE/NSF) 1988-92
- Mobil 1989

- Wave Information Study (WIS) 1956-75
- Ocean Margin Program (DOE) 1993-98
- COOP (NSF/DOE) 1993

Besides these studies, several other sources of studies completed in this area include an MMS study and a Workshop Report by Mr. A. Shepard and Dr. A. Hulbert.

The discussion then focused on the geological data and the coupling of physical oceanography and fisheries, specially fisheries and primary productivity aspects near the "Point." From these discussions and idea exchanges the Chairs prepared the following summary of findings.

FINDINGS

1. About twenty studies that can provide data on physical oceanography relating to the proposed site were identified in the areas of:
   a. currents
   b. surface waves
   c. meteorology
   d. hydrography
   e. satellite data

   Figure 5 shows most of the sites where current measurement programs have been completed in the geographic area.

2. A compilation of these studies can be made available to interested parties should the need arise.

3. Issues about "shallow hazards" data were raised, i.e., data availability and interpretation of these data from the oil company.

4. There is a good amount of physical oceanography data for purposes of reviewing the exploratory well plans/proposal. This finding supports the conclusions of the North Carolina Environmental Sciences Review Panel of 1992.

5. More data and analyses could be needed and required for evaluation of plans and activities should the company decide to go on with a development phase.

6. Lack of analysis of existing biological-physical oceanography data as it relates to bio-physical coupling and interactions associated with fisheries issues were raised, specifically for development plans and activities. This finding agrees with the conclusions and recommendations of the North Carolina Environmental Sciences Review Panel of 1992.

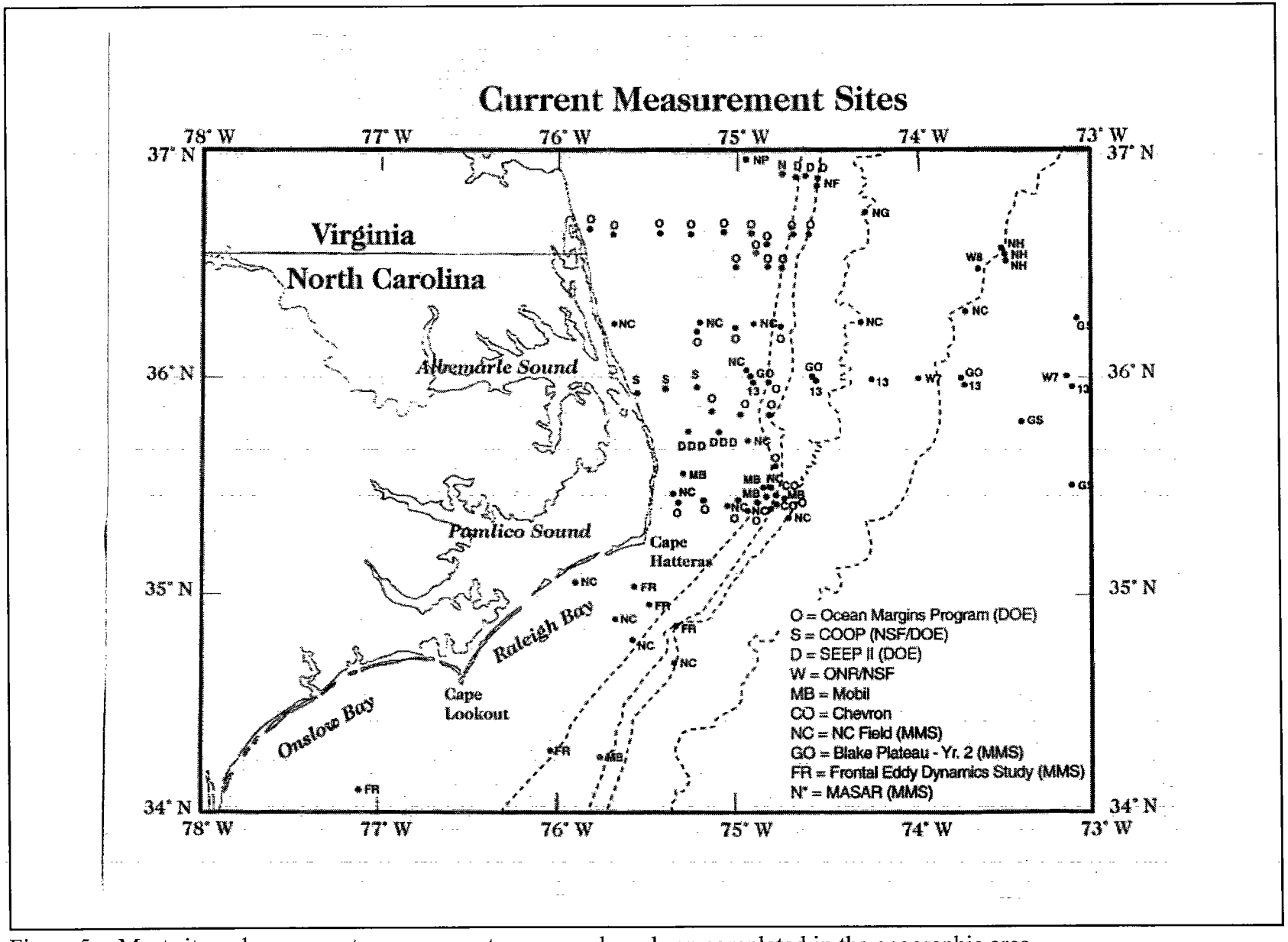

Figure 5. Most sites where current measurement programs have been completed in the geographic area.

7. There may be sufficient information from other sites regarding the impacts of exploratory drilling on marine life, though the application of this information to the NC site may not be direct.

8. Final concerns raised included: the ability to predict oil spill trajectories in the region; ability of drill rigs to evacuate the site during occurrence of intense cyclogenesis; concern regarding slumping; and the role of physical oceanography in the biological productivity including fisheries of the region both through the water column and in the benthic boundary layer.

BIOLOGICAL ENVIRONMENT WORK SESSION RESULTS: FISHERIES

Dr. Steve Ross
North Carolina National Estuaries Research Reserve

Dr. Ann Scarborough-Bull
Minerals Management Service
Gulf of Mexico OCS Region

This session was led by Dr. Steve Ross of North Carolina National Estuaries Research Reserve and Dr. Ann Scarborough-Bull of the Minerals Management Service. There were 50-75 attendees at this break-out session. Attendees included representatives from academia, the offshore oil and gas industry, fishermen, Federal and State agencies, environmental groups, and North Carolina State Commissions. Participants had knowledge specific to the mid-Atlantic area, but came from as far away as Florida and Louisiana. The goal of the session was to raise scientific concerns/issues regarding the potential impacts of OCS drilling on fisheries. The session specifically recommended information needs on a short-term and long-term basis. The short-term was defined as the time period before exploratory drilling would take place in the Manteo Unit offshore North Carolina. The long-term was defined as the time period before development activities took place in the same location. Due to time constraints, the session spent more time on short-term information needs.

ISSUES

Among the issues raised during this session one general recommendation was made that pertains to all subsequent concerns. Projects undertaken in the mid-Atlantic region should be cooperative ventures with agencies, industries, and scientists collaborating to solve problems.

- there should be a team approach to all research
- scientific oversight should be included on any panel or scientific design group

A team approach with scientific oversight would help to ensure that products and information from research are compatible with the information desired.

Short-Term

Two major issues were raised concerning fisheries and oil and gas exploration on a short-term basis. In order of importance:

1. There is a need to define and describe usage of the area known as The Point

   The OCS oil and gas industry is interested in exploration in the Manteo Unit. This interest and the potential for any conflicts or adverse impacts requires knowledge of the geographic location and recreational and commercial fishing done at The Point. This information will help to ensure that decisions regarding development of offshore mineral resources will be compatible with the fishing industry of this specific area.

   The objectives of such information gathering are to

   - provide descriptive geography of The Point
   - describe the seasonality, effort, and catches of commercial and recreational fisheries
   - describe the economics of commercial and recreational fisheries
   - provide data in GIS formats

2. There is a need to synthesize and inventory existing data

   It has been over 10 years since a regional data search and synthesis study was performed that identified important information pertaining to the mid-Atlantic area. Additional and updated information is needed. Any new synthesis effort should be limited to the geographic region known as The Point and immediately adjacent areas.

   The objectives of such information gathering are to

   - identify important published/unpublished information pertaining to The Point
   - identify unpublished/unworked collections of biological material from The Point
   - draft a conceptual model of The Point
   - identify components of The Point that may be uniquely sensitive to impacts

Long-Term

Three major information needs were raised concerning fisheries and oil and gas exploration on a long-term basis. In order of importance:

1. There is a need to better understand the trophodynamics/energetic pathways at The Point

   Published studies indicate that there may be unique trophic patterns in the Hatteras Mid-Slope Region (HMS). Understanding the trophic dynamics and interactions of the HMS entire water column is important to understanding how oil and gas development might impact energetic pathways at The Point.

   The objectives of such information gathering are to

   - describe energetic pathways throughout the HMS water column and habitats
   - elucidate the degree of interdependence between sections of the HMS water column
   - analyze basic nutrient inputs throughout the entire HMS water column

2. There is a need to understand icthyoplankton and it ecological role at The Point

   The study of larval fish can provide information on adult fish populations, spawning, and recruitment among other things. This critical life history phase has barely been studied at The Point. There are no spatial or temporal distribution information.

   The objectives of such information gathering are to

   - provide depth and species specific description of larval fishes at The Point
   - provide the first temporal and spatial distribution data in the HMS

3. There is a need to understand structuring mechanisms

   The objectives of such information gathering are to

   - elucidate mechanisms of both benthic and mid-water fish communities
   - test various hypotheses
   - complement trophic studies

Long-Term

Four additional issues were raised concerning fisheries and oil and gas exploration on a long-term basis. Due to time constraints these concerns were not discussed in any detail. In no order of importance:

1. Concerns related to discharges from both drilling and production

2. Concerns related to the presence of either temporary or permanent structures

3. Concerns related to the effects of noise

4. Concerns related to the presence of lights. Any endeavors on this subject should be tied to the study of the effects of light on the sea birds that feed/roost at The Point.

BIOLOGICAL ENVIRONMENT WORK SESSION RESULTS: BENTHIC ECOLOGY

Dr. James A. Blake
ENSR

Dr. Robert Avent
Minerals Management Service
Gulf of Mexico OCS Region

STATE OF KNOWLEDGE

Numerous isolated studies have been pursued for several decades on the benthic ecology, community structure, and density of the benthic communities of the middle Atlantic continental shelf and slope. Earlier Woods Hole Oceanographic Institution, Virginia Institute of Marine Science, Duke University Marine Laboratory, and others' investigations in the 1960's and 1970's resulted in the development of many of the recent concepts in deep sea ecology, distribution, and diversity. Some of these investigations were conducted off the Cape Hatteras region of North Carolina. The MMS sponsored the U.S. South Atlantic Slope and Rise Program (ACSAR; 1983-1986) which resulted in two large reports (Blake *et al.* 1985; Blake, *et al.* 1987) and presentations at the 1984 and 1985 MMS information Transfer Meetings. The first phase of the "Study of the Biological Processes on the U.S. South Atlantic Slope and Rise" was conducted from a large area from the Georgia Bight northward to the region around Cape Hatteras. The second phase was conducted in a much smaller area off the Carolinas. This effort identified some unique biological conditions and processes off Cape Hatteras including the upper slope in the Manteo leasing area.

A more recent (1992) MMS "Study on Canyon and Slope Processes" and other NOAA and NSF Studies discovered various specific habitats including several canyon type habitats, and areas of high topographic complexity and slope declivity. These studies provided refinements of our understanding of biotic communities the areal extent of faunal assemblages and community patchiness in response to local non-biotic conditions. These studies related biological, physical, chemical and geological processes on the slope.

The results of another recent MMS-sponsored program, "Benthic Study of the Continental Slope off Cape Hatteras, North Carolina" (1992) were published in a final report to MMS (Diaz *et al.* 1993) and in a special Topical Studies in Oceanography issue of Deep-Sea Research (Part II 1994). These geological, geochemical, and faunal studies emphasized various benthic coupled processes in slope sediments, and materially increased our interdisciplinary understanding of the region in depths from 600 to 3,500m. This series of investigations was conducted specifically to make predictions on possible impacts of exploratory drilling, but it added significantly to the scientific literature.

Other recent studies funded by NOAA-NURP, NSF, and DOE have produced data on carbon recycling, biological activity and community structure as they relate to sediments, sedimentation and the oceanographic character of the region.

In regards to the benthic environment on the continental slope, and more specifically the area known as "The Point" (a region coinciding generally with the Manteo Leasing Unit), it is now known that the sediments and fauna are anomalous in a number of ways. The high degree of variability in the area is related to a number of oceanographic features which converge here. Organic input is extraordinarily high and more reminiscent of an estuary than a deep open-water regime. This is reflected in measurements of several types of organics which suggest input from shallow detritus (outwelling and topographic funneling across the slope) and pelagic sources, which supports high standing stocks and biomass in both the infaunal and motile epifaunal sectors. At the same time, the complex combination of more northerly and southerly water mass effects provide local conditions which result in patterns of lower diversity, high numerical dominance, unusual species composition, and predominance of scavenging and deposit feeding guilds. Deep burrowing infauna contribute to high rates of bioturbation and sediment movement downslope. Complex physiographic and topographic conditions (e.g., ridges and valleys, probable erosion and redeposition, and locally high slope declivity) produce faunal and geochemical variability rarely seen on an unconsolidated bottom. In fact these highly variable and dynamic communities probably never approach a "climax community" on the local scale.

DATA GAPS AND FUTURE INVESTIGATIONS

It has been generally agreed that enough background information is available on the benthos to support the drilling of a single exploratory hole in the Manteo Unit.. However some additional information would be needed to monitor the local effects of that event. If future activity included the drilling of additional delineation or production wells, a much larger study effort would be warranted.

A general consensus was reached that although the benthic communities off the Cape Hatteras slope were *generally* well defined, there was insufficient knowledge of the faunal differences over fairly small scales of distance, e.g., between the ridge tops and bottoms of gulleys. The same topographic conditions that seems to influence the "unique" character of the area probably caused the past MMS studies field collections to differentially undersample the gulleys. Clearly, more precise sampling is needed at known sites with well-described topographic attributes. Gulleys were noted to be a likely route for sediment (and possibly pollutant) transport down-slope. It is likely that, in future research, precision sampling of near-by gullies might be given a high priority. Given the anomalies in metallic and organic geochemistry, sediment loads should be measured with high navigational precision and a view toward prudent sampling station selection. An important element of any future investigation at "The Point" would be making comparisons of small-scale heterogeneity in faunal composition and relating these to sediment and topographic character.

The unusual communities raise a number of questions regarding the interactions of the several dominant ("benchmark" or "indicator") species, especially fishes and active infauna responsible for bioturbation. The relationship between bioturbation and sediment oxidation and general chemistry may also be a fruitful line of investigation.

One suggested approach to the detection of biological effects was the investigation of baseline "biological markers" in common local fauna, including stress proteins, e.g., multifunction oxidases (MFO's), levels of bioaccumulation of various chemical species, and relative species abundances (going from the biochemical and cellular levels all the way to the community level).

While the charge of the Benthos Group Discussion Session was instructed to discuss regional benthic ecology, the subject of shallow geological hazards arose. It was recommended that in consideration of local topography, the high sedimentation rates, faulting, and the presence of gas hydrates (CH_4/H_2O clathrate ices), that the research plan could "piggy-back" with geotechnical work.

Finally, all future MMS-supported research in the area be designed with the intent that its results will be useful in future risk analyses employing the best available oil-spill models.

CONSIDERATIONS FOR AN INDUSTRY EXPLORATION PLAN

While not specifically requested to do so, the Benthic Discussion Group made a few recommendations for the preparation of a future Plan of Exploration (POE). Recommendations were that the operators include (if not already required):

A. A thorough and detailed characterization of the benthic environment directly on Block 510.

B. Oil spill modeling, the results to be reviewed in light of the above site characterization.

C. A review of discharge options to ensure that maximal benefit of the Gulf Stream currents be factored into a decision on the depth at which drilling fluids are discharged.

POST-DISCHARGE MONITORING

The Group also strongly recommended that a Post-Discharge Monitoring Plan would be designed and approved by the Minerals Management Service to be implemented before and during the course of exploratory drilling.

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BIOLOGICAL ENVIRONMENT: SURFACE BIOTA

Mr. David S. Lee
North Carolina Museum of Natural Sciences

Dr. William H. Lang
Minerals Management Service
Gulf of Mexico OCS Region

Surface biota during this session was defined as a catch-word phrase to refer to a combination of seabirds, cetaceans (whales and dolphins), and sea turtles. The group was tasked to discuss immediate concerns that could result from one exploratory drillship's activities on the surface biota in the Manteo Unit. Once potential effects of the exploration well were discussed, remaining time was spent on additional concerns, assuming further development and production were to occur.

Fewer than 20 people attended the session. Several marine mammal and sea turtle experts invited to the Raleigh meeting by the State could not attend; thus, representation for issues was limited. Fortunately, the session included Dr. Steve Swartz from the National Marine Fisheries Service and Ms. Ruth Boettcher, Coordinator for North Carolina's Sea Turtle Project. Thus, at least one expert for seabirds (Lee), cetaceans (Swartz), and sea turtles (Boettcher) helped define the issues.

RESOURCES

While the focus of the workshop was on one exploratory well, participants strongly emphasized and advocated *as much information as soon as possible.*

The session focused on concerns for normal drilling operations. It is clearly recognized that an oil spill would be a catastrophic event with its own magnitude of effects and impacts; however, that potential already exists since commercial shipping in the area includes tankers.

The first issue addressed was defining resources at risk in the "Point" vicinity. David Lee's meeting presentation the day before clearly indicated the diversity and concentration of seabirds. The high number of birds in the area is quite noteworthy and is one indication for the "location" of The Point. The session participants reviewed his information and expanded the discussion to marine mammals and sea turtles.

Seabirds concentrate at the "Point" and include a unique assemblage of tropical and subtropical species. Some species are down to 100's of breeding pairs and are known to have significant percentages of their populations seasonally concentrated in the region. With occurrence in the U.S.

essentially isolated to these offshore waters, many of the rare species are not listed by the U.S. Fish and Wildlife Service as threatened or endangered.

All Atlantic species of sea turtles can be found off North Carolina. Kemp's ridleys migrate through the proposed drill site, and young turtles (multiple species) are associated with the floating *Sargassum*. The National Marine Fisheries Service is working on stock determinations for loggerheads and this could redefine the degree local turtle populations are at risk.

Cetacean diversity is high off North Carolina and some endangered species of whales may concentrate off North Carolina. Humpbacks appear to overwinter in the region, and juveniles may use some areas as preferred habitat. Increased strandings of juvenile humpbacks on North Carolina and Virginia beaches is a recent trend. Sperm whales are associated with the western Gulf Stream wall and are expected at the proposed drill site. Juvenile sperm whales were often sighted around mid-Atlantic drillships during past exploratory drilling activities. Right whales are highly endangered and migrate through North Carolina waters. The known migratory route is far inshore of the proposed drill site, but sightings account for only a small proportion of the 300 some remaining whales. The possibility exists for right whales farther offshore but has not been documented. The coastal stock of bottlenose dolphins are listed as depleted under the Marine Mammal Protection Act, a result of massive die-offs in 1987-88 and continued mortalities from fishery interactions. The offshore stock, those expected at the proposed drill site location, appear to have escaped the die-off and are not considered depleted.

The bottom line for these discussions was that from the proposed drill site to shoreline, a particularly rich and abundant surface biota community is present, including many listed species, and for seabirds, some species that are clearly endangered, but unlisted by the United States.

ISSUES

"Short of an oil spill," what potential impacts are of concern?

Although the group did not specifically rank items, drillship lighting appears to be the primary concern. Lights offshore on commercial vessels and smaller boats are already present; any effects from these sources are essentially unknown. A key question in the discussions was whether a stationary drillship with well-lit work areas represents a particular concern. Based on known problems with petrels and land-based lights near nesting sites, the potential for attraction, disorientation, and potential fatal collisions with drillship superstructure, particularly in fog, is a major concern.

Similar problems could exist for turtles. It is well documented that beachfront lighting will disorient turtle hatchlings and nesting adults, resulting in often fatal navigation errors away from the ocean. Substantial numbers of young turtles feed in the *Sargassum* concentrated in convergence zones along the western wall of the Gulf Stream. It is unknown if a brightly lit drilling platform would attract young turtles. If true, the turtles normal movement and feeding patterns would be disrupted. Congregations of turtles around the light source would be highly vulnerable to predators.

Noise disturbance effects would be significant if the drill site coincides with prime feeding areas and if surface/underwater noise displaces biota away from preferred locations. Continued startle effects on seabirds would stress individuals and the same could be true for sea turtles and cetaceans. The potential sphere of influence and intensity of response from disturbed animals are key factors that need to be determined. Any effects are expected to be behavioral as opposed to direct injury from high-intensity sound sources.

Drilling discharges and debris were discussed. Drilling discharges would probably not be significant to surface biota for one well. However, additional drilling would raise concerns on food chain effects. Ocean debris is an international problem for many reasons including beach trash/cleanup, health concerns and direct harm to surface biota through entanglement and/or ingestion. Any "contribution" from a drillship would be considered negative.

Vessel collision is a major concern for large whales and turtles. Increased vessel traffic, particularly in right whale migratory areas, needs to be addressed.

The group had a little time to discuss postexploration activity. The intensity and duration of problems already expressed would be magnified. In addition, any onshore development would introduce new problems not addressed here. For example, coastal dolphins may tend to form distinct local populations, which are highly vulnerable to site-specific depletion.

Some interesting approaches were also discussed. The exploratory drillship could be treated as both a learning experience and at-sea research opportunity. Observations from the ship, or boats using the drillship as home base, would document the degree of actual effects for concerns expressed (seabird interaction with lights, in particular) and improve knowledge of biota at the site. This knowledge would facilitate further permitting for production, if this step became possible.

The global perspective of seabird problems was also discussed. If, in fact, the drillship contributed to some seabird mortality, the money and effort to correct this problem would have far more positive effects applied to nesting site protection in Caribbean islands. Environmental regulatory "offsets" are not a new concept and one this group did not venture any further with in terms of a recommendation, but the perspective is important.

SOCIAL AND ECONOMIC ISSUES WORK SESSION RESULTS: SOCIOECONOMIC ISSUES ASSOCIATED WITH HUMAN USES OF "THE POINT"

Dr. Michael K. Orbach
Duke Marine Laboratory
Nicholas School of the Environment,
Duke University

The discussion session was co-chaired by Dr. Harry Luton of MMS. The group asked the question, "What socioeconomic information is needed for North Carolina and MMS to adequately judge a POE/EA regarding an exploratory well in the Manteo Prospect?" This is the same question that was addressed by the ESRP. Excluded from the group's discussion was whether or not an exploratory well "should" be drilled. The section did not review information availability. Dr. Orbach began the discussion by listing what he considered were information needs:

1. An updated the ECU study data. The information collected is now more than 10 years old. This information should include 1990 Census data as well as document changes to the fishing industry and the continued increase in the tourism and the retirement industry.

2. Establishment of a monitoring program.

3. Detailed assessment of uses and users of "The Point." This might include some kind of cost/benefit analysis of The Point uses.

4. Economic modeling (demand curves, cost/benefit analysis).

Dr. Orbach then discussed the *The Coastal North Carolina Study* Program. As recommended by the ESRP, the Coastal North Carolina Study Program included five elements: (1) a county-level baseline description based on a literature review, publicly available data and key informant interviews; (2) community studies based on the same methods; (3) an aesthetic/perception study based on structured interviews; (4) an infrastructure study based on a literature review and key informant interviews; and, (5) a monitoring design based on a literature review. The Program is a baseline study; it did not address North Carolina's request for economic projections of OCS activities. Dr. Orbach noted that it was a good study, with much useful analysis and data, and made the following observations:

- the baseline description is dated and did not adequately address uses and users of "The Point";

- the Community studies are quite good and, although dated, should be adequate for management decisions for exploration;

- the aesthetic/perception portion of the Study Program examined how people look at their environment and not specifically at concerns about OCS exploration and development;

- the infrastructure portion of the Study Program is dated but adequate. Morehead City is the only likely N.C. shorebase for early exploration; and,

- the monitoring plan provides a good general framework for socioeconomic monitoring.

SUMMARY OF THE BREAKOUT GROUP DISCUSSIONS:

Perception issues were discussed at length. Many in the group thought that oil and gas activities might affect public perceptions of North Carolina's clean beaches and desirability as a tourist and retirement destination. The group discussed possible perception impacts on tourism, recreational and commercial fishing, boating, retirees, second home owners, and regular residents. Heritage-based tourism might be affected. Bird watching at "The Point" may be affected. Regional differences between the upper and lower Outer Banks should be considered. Regional differences between coastal and inland counties should be considered. Several participants noted that some inland residents perceive potential benefits from OCS development including increased employment and gas supplies. Several participants noted that perceptions might be examined in the light of risk assessment—fears balanced against probabilities. Other participants felt that out-of-the-area perceptions of North Carolina rely on images of its pristine Outer Banks and even a movie on the oil industry in the area might have an effect. This observation was followed by a more general one on the perceptions of the broader public regarding the "values" of the OCS process.

The group noted that the *The Coastal North Carolina Study Program* was a baseline study and did not consider the onshore benefits and burdens of OCS activity. Several participants, including a representative from the State of North Carolina, noted that OCS development might conflict with key industries in the area—fishing (including recreational fishing), and recreation (including retirement and second home owners). These industries have expanded since the earlier study and the changes need to be documented. Updates on wildlife observation and diving should be included. Possible conflicts should be assessed and, possibly, modeled. Assessments should consider the possible location of on-shore support facilities. Norfolk was identified as the likely center of such activities, Morehead City is the most likely spot for any on-shore activities located in North Carolina. The costs and location of Spill Response teams is an issue. The geographical coverage of studies should consider differences between coastal and non-coastal counties, northern and southern coastal counties, and coastal counties in North Carolina and Virginia. Studies should draw on what is known about OCS activities in other frontier areas. For the Mantio proposal, little activity would occur in North Carolina.

The group also discussed oil spills. The impacts of oil given various spill scenarios should be examined. These might affect tourism and commercial and recreational fishing.

Several other impact categories were discussed including possible conflicts between the Mantio exploratory rig and boat and ship traffic, conflicts with military air space, helicopter overflights at Cape Lookout National Seashore, effects on beach nourishment projects, and the perception that MMS funding of studies might invalidate their results.

Finally, the group indicated that more public information and education efforts are in order.

SUMMARY

The group made three general suggestions for research related to the Mantio prospect:

1. update current data
2. establish an effective monitoring program
3. strengthen economic modeling efforts

More specific suggestions included the following:

1. conduct perception studies related to potential impacts of OCS activities
2. collect information on uses of, and users of, "The Point"
3. existing data on comparable impacts from other sites should be examined
4. focus on potential user conflicts
5. note differences and relationships among various portions of the study area
6. include all costs and benefits of onshore activities
7. expand the geographic focus to Virginia and South Carolina
8. expand public information and education efforts

APPENDIX A (AGENDA)

NORTH CAROLINA/
MINERALS MANAGEMENT SERVICE
TECHNICAL WORKSHOP ON MANTEO UNIT EXPLORATION

The Raleigh Plaza Hotel
February 4-5, 1998

OBJECTIVES

Review the state of knowledge for exploratory drilling in Blocks 467 and 510.

Share scientific information obtained since 1990.

Distinguish between exploration and development activities.

Share information on drilling technology and industry experience operating in similar physical environments.

Raise/address scientific concerns regarding the potential impacts of OCS drilling on biological resources.

Raise/address concerns regarding onshore (social and economic) impacts from OCS drilling.

NC/MMS Technical Workshop on Manteo Unit Exploration
Wednesday Morning, February 4

7:15	**Registration**
8:00	**Welcome & Introduction** Walter Clark, NC Sea Grant
8:15	**MMS Perspective--History/Status of N.C. OCS Leases** Chris Oynes, Regional Director, Minerals Management Service
8:45	**General Overview of Drilling Technology:** **How a well would be drilled.** David Duplantier/Sandi Fury, Chevron, U.S.A.
9:15	**Questions and Answers with Chevron** Open Discussion
9:45	**General Overview of NC Response** **to the Plan of Exploration** Kim Crawford/Dan McLawhorn, State of North Carolina
10:00	**General Scientific Characterization of** **Manteo Exploration Unit (Blocks 467 and 510)** Neal Blair, NCSU
10:30	**Break**
	Discipline Reviews By Regional Experts Moderator: Larry Cahoon, UNC-Wilmington
10:45	**Physical Environment:** Physical Oceanography/Meteorology Len Pietrafesa, NCSU
11:00	**Physical Environment**: Geological Stability Charles Paull, UNC-CH
11:20	**Habitat & Living Resources:** Fisheries Steve Ross, NC Estuarine Research Reserve, DCM
11:40	**Habitat & Living Resources**: Sargassum Steve Ross, NC Estuarine Research Reserve, DCM

NC/MMS Technical Workshop on Manteo Unit Exploration
Wednesday Afternoon, February 4

12:00	**Lunch/Presentation** Moderator: Larry Cahoon, UNC-Wilmington
	Undersea Research Initiatives Off Cape Hatteras - Past, Present, & Future Andy Shepard, Associate Director National Undersea Research Center UNC-W
1:15	**Habitat & Living Resources (continued):** Benthic Environment Jim Blake, ENSR Consulting & Engineering, Woods Hole
	Habitat & Living Resources: Water-Column Biology Peter Verity, Skidaway Institute of Oceanography
2:15	**Seabirds, Marine Mammals, Turtles** Dave Lee, NC Museum of Natural Sciences
3:00	**Break**
3:15	**Social and Economic Issues:** Human Uses of "The Point": Onshore Impacts Mike Orbach, Duke Marine Lab
4:00	**General Discussion of Issues & Concerns** Mike Orbach, Duke Marine Lab
5:00	**Adjourn for the Day**

NC/MMS Technical Workshop on Manteo Unit Exploration
Thursday, February 5

8:30 **Concurrent Breakout Work Sessions**

Work sessions to identify pertinent research conducted in the geographic area that relates to exploratory drilling; possibly identify additional efforts needed should development occur.

Physical Environment
Len Pietrafesa, NCSU
Alexis Lugo-Fernández, MMS

Biological Environment:
Fisheries: Steve Ross, NCERR; Ann Bull, MMS
Benthos: Jim Blake, ENSR; Robert Avent, MMS
Surface Biota: David Lee, NCMNS; William Lang, MMS

Social & Economic Issues
Mike Orbach, DUML; Harry Luton, MMS

10:00 **Break**

10:30 **Breakout Groups Report to Full Audience (approx. 15 min each)**
Moderator: Larry Cahoon, UNC-Wilmington

12:00 **MMS-Where we go from here?**
Chris Oynes, Regional Director, Minerals Management Service

12:30 **State-Where we go from here?**
Kim Crawford, North Carolina
Department of Environment and Natural Resources

1:00 **Adjourn Meeting**

APPENDIX B

SUMMATION OF CHEVRON'S 510 ENVIRONMENTAL ASSESSMENT (EA)

- The water depth of block 510 ranges from 80 to 1200 meters. The proposed rig is a drillship. The dominant water current is the Gulf Stream. Special protection of the risers will be provided.

- The section on fisheries needs to be updated. Some fisheries may have been latent when the EA was prepared in 1982 but may be operating now. A yellowfin tuna fishery that may have been in the block has possibly moved to much more popular fishing grounds at "The Point" just northeast of Cape Hatteras. Popularity of fishing grounds does guarantee that the grounds have the highest density compared to other areas—only catch-per-unit-effort measurements would show that.

- Information on underwater cables in the area should be updated.

- USFWS and NMFS biological opinions for Section 7 Consultations are in an Appendix.

- Practically no water quality analysis was done. However, no additional analysis may be required if only water-based drilling muds are used (Gail Rainey, pers. comm., 1997)

- The laws and regulations for oil spill contingency plans have changed. A new plan needs to be prepared.

- A photodocumentation report is attached to the Environmental Report

- Weather patterns off Cape Hatteras may disrupt helicopter flights and hinder movement of workers and supplies to and from boats. For occasional heavy seas, drillship operations will be suspended.

- USFWS and NMFS biological opinions for Section 7 Consultations are in an Appendix.

SUMMATION OF MOBIL'S 467 ENVIRONMENTAL ASSESSMENT (EA)

The EA was done in 1990 and does not require extensive updating.

- The depth of water at the proposed drill site is between 800 and 900 meters. The proposed vessel is a drillship.

- Photodocumentation was provided by Mobil with their Plan of Exploration. The benthos section needs to incorporate the new photodocumentation from a study on the uniqueness of the benthic community at the drillsite. The benthos is on the continental slope and does not contribute to the pelagic fishery. The pelagic fishery includes only upper water column fish that feed using their sense of vision. Such fish do not feed off the bottom in total darkness.

- The fish resources section needs to have Mobil's study on ichthyoplankton at "The Point" added to the database. This study addressed ichthyoplankton of estuarine-dependent fish at the drillsite and at the fishing area called "The Point." The fish resources section and the commercial and recreational fisheries section need to address new concern about depletion of bluefin tuna on their northern migration toward the Mid-Atlantic Bight.

- Information on underwater cables in the area should be updated.

- The laws and regulations for Oil Spill Contingency Plans have changed. A new plan needs to be prepared.

- The Environmental Protection Agency (EPA), not MMS, is responsible for air quality issues in Manteo Block 467 (Terry Scholten, pers. comm., 1997).

- The cultural resource stipulation is not in the EA; rather the EA refers to the Environmental Review (ER) for that stipulation. The stipulation for cultural resource protection is presented in a confused way in the ER, where it is discussed in two separate places in the same section.

- No one really knows where blue marlin, tunas, and other continental slope fish spawn. They may spawn mostly in the Gulf of Mexico, at least according to sources in the fishing industry (John Govoni, National Marine Fisheries Service, Beaufort, NC).

APPENDIX C

MMS GULF OF MEXICO OCS REGION
RIGS CURRENTLY DRILLING IN DEEPWATER
WEEK ENDING 1/19/98

THERE ARE 26 RIGS CURRENTLY DRILLING IN WATER DEPTHS GREATER THAN 1,000 FEET

Operator	Area/Block	OCS Lease	Prospect Name	Water Depth
BP	AT 574	G-8035	Neptune	6112'
British Borneo	EW 964	G-12144	Morpeth	1694'
Texaco	VK 786	G-12119	Petronius	1754'
Shell	VK 957	G-8475	Ram Powell	3218'
Amoco	VK 915	G-6894	Marlin	3240'
BP	VK 989	G-6898	Pompano	1295'
Shell	GC 116	G-5904	Popeye	2046'
Texaco	GC 505	G-8879	Fuji	4262'
Shell	MC 194	G-2639	Cognac	1025'
Texaco	MC 247	G-13682	Gemini	3080'
Amoco	MC 476	G-9813	N. Hershel	6627'
Norcen Explorer	MC 584	G-14010	Betelgeuse	2350'
Vastar	MC 764	G-8852	King	3221'
Shell	MC 730	G-7954	Mensa	5292'
Shell	MC 807	G-7963	Mars	2977'
Shell	MC 810	G-9873	Ursa	3948'
BP	MC 899	G-9896	Cosby, Stills, Nash	4394'
Amerada Hess	GB 215	G-9216	Conger	1460'
Shell	GB 248	G-13815	Machette	1448'
British Borneo	GB 258	G-17323	Kilmarnock	2056'
Amerada Hess	GB 260	G-7462	Bald Pate	1646'
Ensearch	GB 386	G-10350	Llano	2610'
Shell	GB 426	G-7493	Auger	2862'
Ensearch	GB 388	G-7486	Cooper-A	2096'
Exxon	GB 785	G-9240	Titan	4640'
Reading & Bates	EB 688	G-9191	East Boomvang	3752'

APPENDIX D

A REVIEW: FINDINGS OF THE NORTH CAROLINA ENVIRONMENTAL SCIENCES REVIEW PANEL (ESRP)

Dr. William H. Lang
Minerals Management Service
Gulf of Mexico OCS Region

INTRODUCTION

Since the initial Outer Continental Shelf (OCS) Lease Sale held on August 4, 1981, the leased group of blocks now known as the Manteo Prospect has been the subject of numerous negotiations, understandings, suspensions, disagreements, prohibitions, and legal actions. During this nearly 17-year period, numerous studies have improved information available for the North Carolina OCS, and deep water drilling technology has made often amazing advances; nevertheless, the fundamental concerns and disagreements remain relatively unchanged.

With this in mind, it is quite appropriate to revisit the findings of a congressionally mandated panel of renowned scientists, the North Carolina Environmental Sciences Review Panel (ESRP). In 1990, they were tasked with assessing the adequacy of information to allow reasoned decisions by the Secretary of Interior on permitting Manteo exploratory drilling and potential development and production phases that could follow. This presentation will highlight the ESRP's report to the Secretary of the Interior and also the Department of the Interior's (DOI's) response to these findings in a report to Congress.

THE PANEL

The Oil Pollution Act of 1990, in a section cited as the Outer Banks Protection Act (OBPA), created the ESRP. The review panel was to be 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 Governor selected Dr. John Costlow, Duke University, and the Secretary selected Dr. John Teal, Woods Hole Oceanographic Institution (WHOI). Joint selections were Dr. Kenneth Brink, WHOI;

Dr. Charles Peterson, University of North Carolina - Chapel Hill; and Dr. Michael Orbach, East Carolina University. Dr. Costlow was elected Chairman of the ESRP at the first meeting, which was on January 28, 1991. The Panel was formed under the Federal Advisory Committee Act and Dr. Andrew Robertson, Department of Commerce, served as the Federal Coordinator.

The Panel was charged by the OBPA with (1) assessing the adequacy of the available physical oceanographic, ecological, and socioeconomic information to enable the Secretary to fulfill his responsibilities under Outer Continental Shelf Lands Act (OCSLA) and (2) identifying any additional information deemed essential to enable the Secretary to carry out these responsibilities.

Fundamental to the panel formation and charge, the OBPA also prohibited 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 OCSLA. Actions prohibited included (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 was 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 the written report, the Secretary was required to take into consideration findings and recommendations of ESRC, and to include a detailed explanation of any differences between his certification of sufficient information and the findings and recommendations of this group.

THE REVIEW PROCESS

The Panel first convened on January 28, 1991. This and six 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, 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.

The Panel was directed to consider the adequacy of information for making decisions regarding oil and gas leasing, exploration, and development on the lands of the OCS offshore North Carolina. In 1991, there were 53 lease blocks in this area with active leases for oil and gas resource identification and development. Additional lease blocks were under consideration for leasing as part of a proposed

5-year (1992-1997) program of lease sales. There was also one request pending for approval of a plan for drilling one exploratory well in Manteo Area Block 467 (the Manteo site). This site proposed drilling to test for oil and gas resources, not only in Block 467, but also in a wider, unitized Exploration Unit that 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) that were developed by MMS specifically to support decision-making regarding oil and gas resource development for this site.

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

The National Research Council (NRC, 1989) evaluated 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 that 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. In addition to the reputation of the NRC, it was also noted that a major motivation for establishing the ESRP was that the North Carolina OCS area was not included in the NRC review. Thus, it was particularly fitting to apply the same standards to North Carolina.

ADEQUACY FINDINGS

In addition to considering adequacy of information for both the Manteo area and the broader North Carolina OCS, the ESRP addressed information needs relative to OCS operational phases. The phases are sequential steps, each requiring additional business and regulatory decisions and are defined in Interior documents (DOI; 1986, 1987):

1) Leasing
2) Exploration/delineation
3) Development/production
4) Post-production

While the Panel readily accepted the logic that different types and escalating levels of information are required at each operational phase, they expressed concern over "the widespread perception that once a lease is sold all subsequent phases of exploitation ...will necessarily follow if the lessee requests the appropriate permits." The Panel ultimately accepted the logic of phased information needs and presented findings within this context. They nevertheless also noted that if the perception were indeed true, this "implies a need for more intensive and extensive information gathering and impact analysis at the preleasing stage ..."

A very generalized summary of the ESRP adequacy findings is that some degree of inadequacy was found in all areas and, depending on the discipline-geographic area-development phase combination, the specific Panel evaluation ranged from readily correctable information needs to totally nonexistent information. By discipline, information was most inadequate for socioeconomics, followed by ecology, and physical oceanography. Not surprisingly, available information was best for the Manteo site. Information needs increased for both the North Carolina OCS and later development phases.

For the Manteo area, the Panel summarized their findings as follows:

> "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 costal 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 activity during development and production such as has occurred in Alaska, Louisiana, and California, has a significant impact on the human environment including socioeconomic systems (Petterson *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."

The ESRP findings continued with additional comments on the broader North Carolina OCS, the essence being that information is generally less adequate because these areas are less well studied. They also noted difficulties in projecting all information needs without results of initial studies and if OCS activities proceeded beyond exploration:

Additionally, site-specific issues, including questions concerning appropriate monitoring studies, can be expected to arise, but these issues cannot be identified in advance of completion and analysis of the recommended studies associated with the leasing phase and of further information on specific sites.

RECOMMENDED STUDIES

The Panel's determination of "additional information deemed essential" to carry out the Secretary's OCS responsibilities logically is mostly a reflection of information found inadequate. Interestingly, they did not list information topics but, in a sense, added an additional step by recommending specific studies.

Repeating language from the Panel's executive summary, recommended studies for the Manteo area are:

Physical Oceanography

(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.

Ecology

(1) 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 organisms if covered by drilling discharges. The survey portion should be undertaken immediately and should be completed before exploration begins.

(2) 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.

(3) 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.

(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.

Socioeconomics

(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 predevelopmental activities and human environments.

For other areas of the North Carolina OCS, the panel made a generic recommendation to initiate expanded versions of most of the studies listed for Manteo. For physical oceanography and ecology six additional studies were specified:

Physical Oceanographic Studies

(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.)

Ecology Studies

(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.

Again, the panel noted that the unknowns of initial study results and future site-specific OCS activities would most likely generate additional study requirements. A final recommendation was for MMS to use a Geographical Information System to manage North Carolina OCS information.

SECRETARY LUJAN'S REPORT TO CONGRESS

On January 27, 1992, MMS issued a news release announcing completion of the ESRP study. Dr. Costlow was quoted, "On the basis of our review the probability of any significant environmental effects from a single well is extremely low." By this press account, only two studies were recommended prior to drilling the first exploratory well. Dr. Costlow's statement was: "We have recommended only socioeconomic studies and an expanded survey of bottom-dwelling organisms in the vicinity of the Manteo drillsite prior to drilling the first exploratory well." Secretary Lujan noted "no exploratory well proposal has been studied as extensively and thoroughly as this one."

A special information attachment to the news release provided details on the recommended socioeconomic studies and benthic survey. MMS noted that other studies were recommended, specifically ecology studies of the "Point" and Saragassum seaweed community studies, but noted that need for these efforts would be evaluated after the results of the first exploratory well became known.

On April 6, 1992, DOI issued a news release announcing submission of Secretary Lujan's report to Congress. The DOI report expanded on the initial MMS assessment of the ESRP report and concurred with the conduct of two studies prior to any exploratory drilling:

> "Baseline socioeconomic data, such as the information requested by this report, is usually not collected until after drilling the first exploration well. However, in this particular case, after reviewing the Panel's findings, I have decided to conduct those studies prior to drilling the proposed Mobil well. I also believe that the Panel's recommendation for a determination of the geographic extent of biological communities in the vicinity of the well site has merit. That study will also be done before any drilling activity."

In his report to Congress, Secretary Lujan noted that "the Panel's definition of adequacy, while defensible from a strictly scientific point of view, was far more restrictive and narrow than my charge under the OCSLA and the more management oriented approach implied in the Outer Banks Protection Act (OBPA)." In spite of scientific gaps identified by the ESRP, "the information that currently exists is adequate to allow me to make a reasoned decision about the activities presently proposed to take place offshore North Carolina [exploratory well]." The Secretary certified, in compliance with Section (c)(3)(A)(ii)(I) of the OBPA, that sufficient information exists at present to consider approval of exploratory activities.

However, after stating that no additional information is legally required, the Secretary added a consideration:

> "...since the ESRP requests for these limited socioeconomic and biological studies are reasonable from a scientific perspective and will undoubtably add to our information base, I will not issue a permit, approve the exploration plan, or allow any drilling until the studies have been completed."

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APPENDIX E

BATHYMETRIC AND PHYSICAL OCEANOGRAPHIC DESCRIPTION OF THE MANTEO LEASE AREA

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The waters off Cape Hatteras exhibit some of the most energetic coastal dynamics anywhere. Here the broad shelves of the Middle and South Atlantic Bight narrow nearly isolating shelf waters north and south of Cape Hatteras from each other. Offshore, one of the strongest current in the ocean, the Gulf Stream, moves northward. In addition to that variability in the large-scale current regime, both winter storms and tropical hurricanes are prevalent in the region. In this paper we discuss the physical oceanographic properties at the Manteo site and their variability.

BATHYMETRY OF THE REGION

The bathymetry of the area (Figure 6) is complex. A key feature of the area is the steep slope rising from the continental rise. The slope shallows to about 50 m where it transitions to the continental shelf at the shelf break. The steepness of the slope and the abruptness and shallowness of the shelf break have some impact on the physical oceanography. This pattern is consistent from Cape Canaveral to well north of Cape Hatteras, with the shelf break gradual deepening from south to north.

The key feature on the shelf is the abrupt change in direction of the coastline at Cape Hatteras. North of Cape Hatteras the coastline trends N/S and is broken only by one large and one small inlet until Chesapeake Bay. South of Cape Hatteras a series of capes break the alongshore patterns. The shoals extending offshore from the Capes nearly reach the shelf break, thus impeding alongshore flow. River inflow to the region occurs at Chesapeake Bay Entrance and at the inlets through the barrier islands where freshwater in the North Carolina Sounds escapes to the ocean. River flow is a minor source of variability in the region.

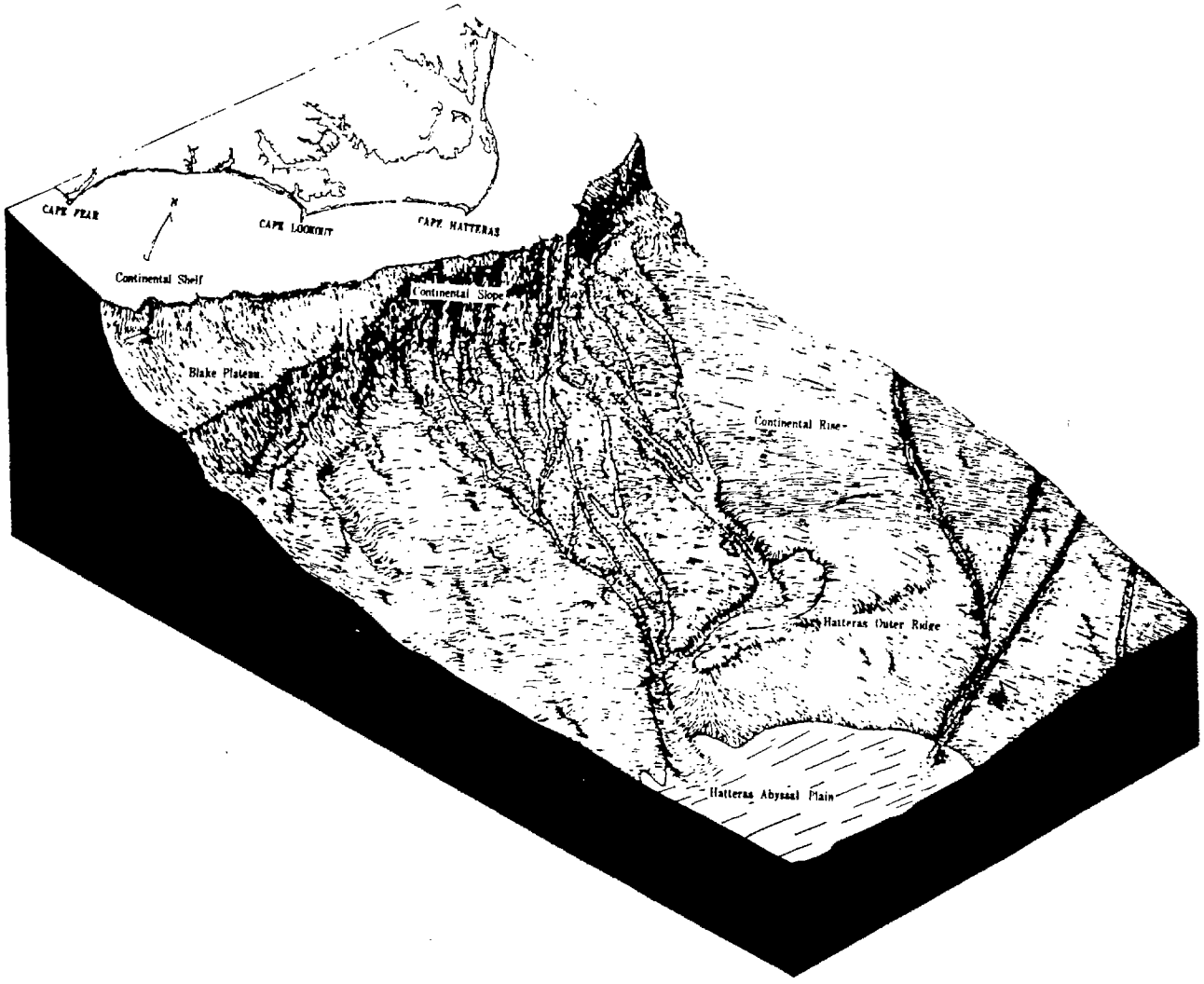

Figure 6. Bathymetry of Cape Hatteras region. From Emery and Uchupi (1972).

PHYSICAL OCEANOGRAPHY

There are two dominant sources of variability in the region: wind and the Gulf Stream. The Gulf Stream, one of the world's largest and fastest open ocean currents, meanders northward along the continental slope shedding eddies and filaments over the shelf. Additionally the area is where extreme atmospheric cyclogenisis occurs when the warm waters of the Gulf Stream provide moisture to developing extra-tropical cyclones. Thus, this area is the confluence of two very large and highly variable forces. The Diamond Shoals Light off Cape Hatteras is near the Manteo site providing an excellent source of weather and climate data.

CLIMATE

Mean monthly data are shown in Figure 7. Mean monthly winds off Cape Hatteras are controlled by the strength of the Bermuda High and the passage of storms. The strengthening and weakening of the Bermuda High in relation to barometric pressure over the continent results in northward winds during the summer and southward winds during the winter. Storms and shorter term variability in the large pressure systems causes the variability we observed. The following statistical summaries are from the Diamond Shoals Light Station. Because this station is on the shelf, nearer land,the summaries are not exactly what one would expect at the Manteo, site but they would be close.

The mean monthly wind reaches a minimum of 12.6 knots in August and a maximum of 18.9 knots in January. Importantly the range in wind speed is highest in August, with September following closely. This is caused by the occurrence of hurricanes, a topic to be discussed later.

The mean monthly averaged air temperatures are no doubt slightly lower in mean and range than what would be observed farther offshore. Nevertheless, the range in mean and the absolute range is rather large: -10C to 30C.

Mean monthly sea water temperature will be much lower in the winter than the Manteo site because of the influence of the Gulf Stream offshore. At DSLS the temperatures range from about 4C to 30C with extreme ranges in the winter months. This range extreme is because of the incursion of both cold nearshore waters and warm offshore water to the DSLS site.

Surface salinity data are not as available as other data. Surface salinity is low in coastal water and the high salinity water of the Gulf Stream. While not necessarily part of the climatology, it should be noted that low salinity water from the SE United States and the Gulf of Mexico is occasionally found off Cape Hatteras in the Gulf Stream front (Atkinson and Wallace 1975; Ortner *et al.* 1995). The drift of buoys from the mouth of the Mississippi River to the region shows the potential for water from the northern Gulf of Mexico to reach the Manteo region (Ortner *et al.* 1995).

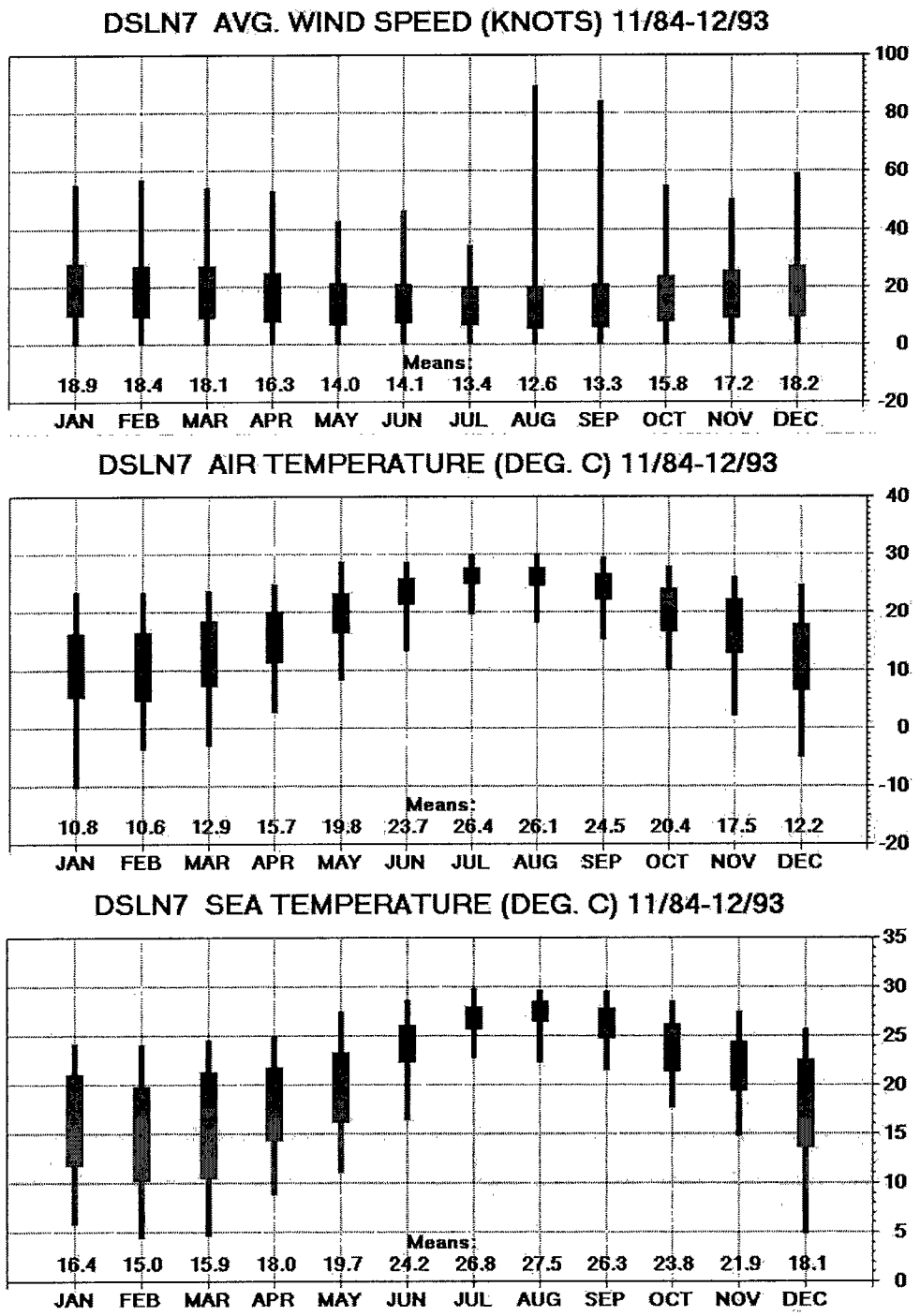

Figure 2. Mean monthly data from Diamond Shoals Light Tower. Data from National Data Buoy Center.

Figure 7. Mean monthly data from Diamond Shoals Light Tower. Data from National Data Buoy Center.

WEATHER

Weather in the region is affected by the passage of cold and warm fronts, lows from either the south or west, and hurricanes. The two forces of concern are the wind stresses and the heat fluxes. Winter storms occur 2 to 5 times per year. Low pressure systems develop in the southeast U.S. and travel northward. When they pass over the warm Gulf Stream waters, water vapor and heat provide the energy for what is called explosive cyclogensis. The strong southwestward winds combined with low air pressure can cause significant storm surge along the coast with accompanying coastal erosion. Sea states during these events are extreme.

Hurricanes pass the area in August and September, following the Gulf Stream northward, and passing very close to the Manteo region.

GULF STREAM

The typical position of the Gulf Stream track is shown in Figure 8. This sea surface temperature image shows the flow of warm water out of the Gulf of Mexico through the Straits of Florida. As the Gulf Stream courses north, it hugs the continental slope except off South Carolina, where a ridge deflects it offshore then onshore again. Off Cape Hatteras the Gulf Stream leaves the coast and begins its trip across the Atlantic. The importance of Cape Hatteras is obvious as it is The Point where the Gulf Stream starts to interact with the colder waters moving southward from Nova Scotia and Labrador.

A more detailed view of the region (Figure 9) shows the southward movement of water along the coast and the northward movement of warm Gulf Stream water to the northeast. Note the penetration of cool shelf water around Cape Hatteras and into Raleigh Bay. Also note the arrows indicating the apparent entrainment of shelf water into the Gulf Stream.

COASTAL CURRENTS

Drifters were released both at the Manteo site and in coastal waters inshore from the site. The drifters followed many different trajectories depending on the release location, and wind direction and speed (Berger *et al.* 1995). Drifters released in the coastal waters tended to stay in coastal waters as would be expected. Drifters released farther offshore followed a variety of tracks with some finally finding the coastal current.

As noted in the SAIC (1990)report "None of the drogued drifters released outside the nearshore region were recovered ashore in the Cape Hatteras region: while seven were found beached in England (1), France (3), the Canary Islands (1), and the Bahamas (2) 14 to 35 months after deployment."

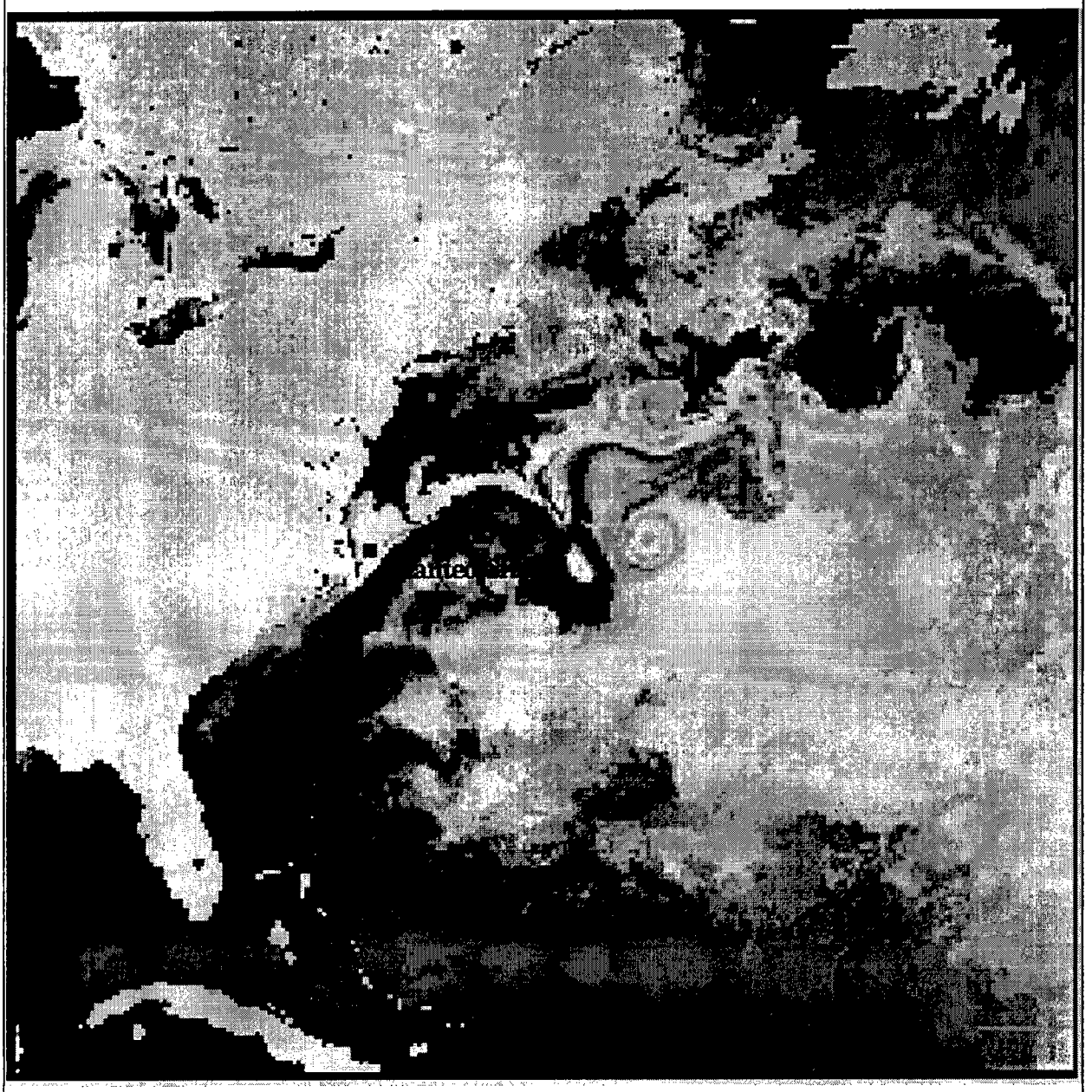

Figure 8. Surface temperatures image in the western North Atlantic showing location of Manteo site. The Gulf Stream shows as dark while cooler waters are lighter greys and cold shelf water is dark again. Figure from NOAA Northeast Coastwatch Center.

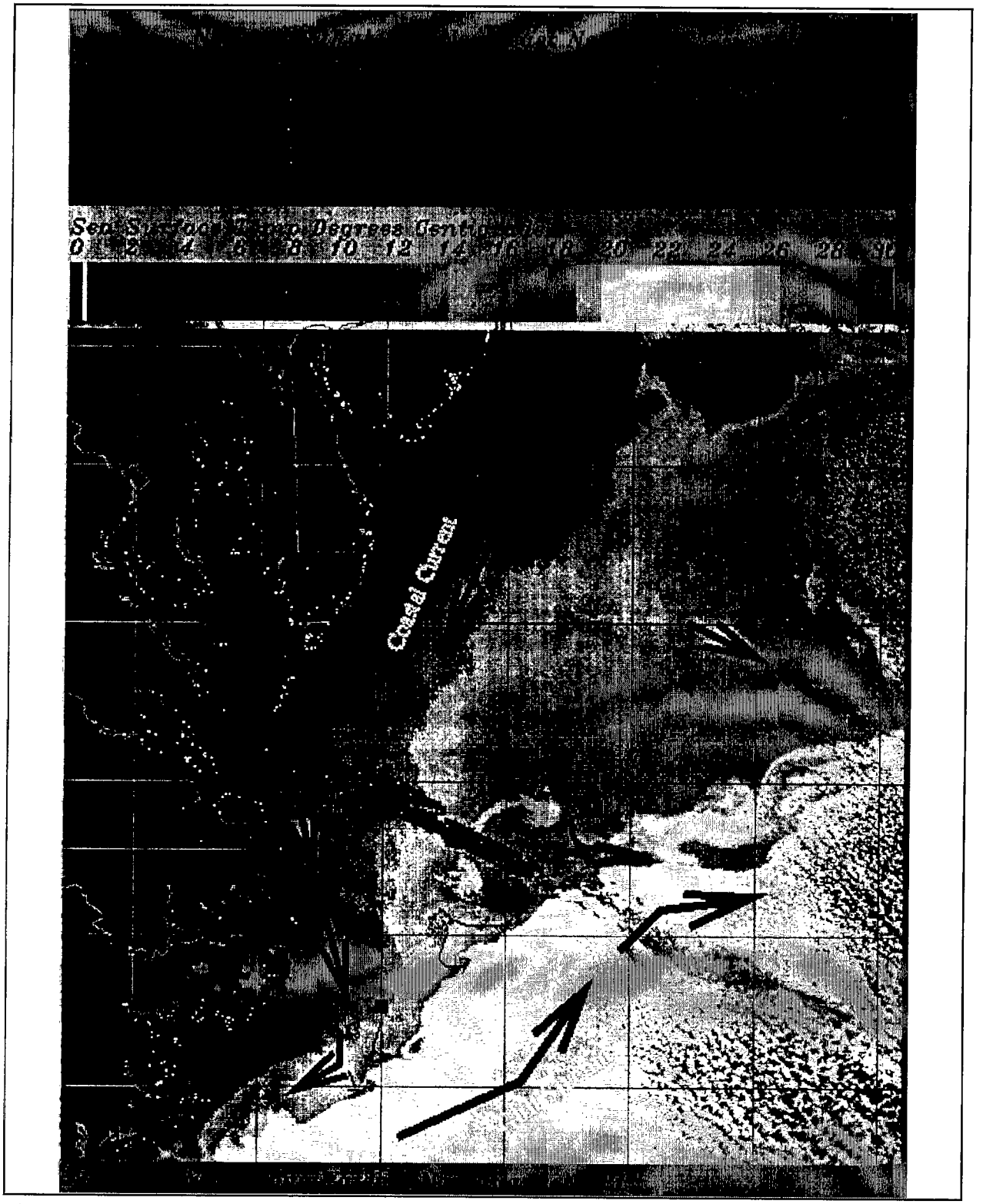

Figure 9. Surface temperature on December 3, 1997 in Cape Hatteras region. Directions of inferred currents indicated. Warm waters are light and cold waters are dark. Figure from NOAA Northeast Coastwatch Center.

SUMMARY

The atmospheric and oceanographic characteristics of the region is quite well known. The principle processes are understood in both conceptual and quantitative ways. The Gulf Stream and its eddies and meanders are the dominate oceanic feature while wind forcing of coastal waters are important further on shore. Atmospheric conditions are controlled by basin scale pressure systems and synoptic scale storms.

ACKNOWLEDGMENTS

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APPENDIX F

A REVIEW: FINDINGS OF THE "BENTHIC STUDY OF THE CONTINENTAL SLOPE OFF CAPE HATTERAS, NORTH CAROLINA"

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INTRODUCTION

The need to develop reliable domestic sources of petroleum and natural gas has led to increasing interest in exploration of the continental shelf and slope off the U.S. East Coast. A number of leased blocks on the continental slope off Cape Hatteras, North Carolina, have been evaluated for their potential as possible petroleum exploration sites with the possibility that exploratory well may be drilled in the near future. The possibility of extracting oil and gas from the continental slope, particularly in the area off Cape Hatteras, has raised a number of environmental concerns that could not be addressed from existing data.

During the MMS Atlantic continental slope and rise program, the benthic fish and invertebrate communities off the Cape Hatteras continental slope were found to be different from others on the Atlantic continental slope. These differences encompass species composition, abundance, and biomass. Blake *et al.* (1985, 1987) surveyed 15 sites on the continental slope and rise off the North Carolina coast and found highest abundances and biomass in the area of Manteo lease block 510, a site adjacent to Manteo 467. Other investigators (Schaff 1991, Schaff *et al.* 1992, Ross and Sulak 1992, Sulak 1992) who concentrated their sampling in this area confirmed these results. Overall, the abundance and biomass of macrobenthic infaunal was about 10 and 6 times higher, respectively, and fish abundance was about 6 times higher than at other slope areas.

Because of the potential environmental impacts associated with development and production activities, the Oil Pollution Act of 1990 mandated that a panel of experts be convened. This panel, North Carolina Environmental Sciences Review Panel (NCESRP), was to consider whether the available scientific information was adequate for making decisions about oil and gas leasing, exploration, and development off North Carolina. The NCESRP (1992) report to the Secretary of the Interior made several recommendations on the information needed to understand the basic ecology

of the leased areas. Among them was the recommendation that the spatial extent of the benthic community found within some of the lease blocks should be determined before any exploration or development activity occurred off Cape Hatteras. The present study was developed by the Minerals Management Service to determine the aerial extent of the community found by Blake *et al.* (1985, 1987). Results of our effort were published as a special issue of Deep-Sea Research Part II (Diaz *et al.* 1994a) which included a CD-ROM with data and selected bottom images (Cutter *et al.* 1994a).

METHODS

The study area (Figure 10) was defined based on output of the Offshore Operators' Committee (OOC) model which predicted the dispersion and accumulation of drilling muds and cuttings over the seafloor (Brandsma 1990). This model predicted areas that would receive as little as 0.1 mm of deposition. After calculating the area of the seafloor that would likely receive any deposition, the initial area to be sampled was expanded 15 km to the north and 15 km to the south of the proposed drill site (Figure 11).

The field work was conducted on the R/V *Endeavor* cruise EN-241 from 26 August to 6 September 1992. The sampling consisted of six cross-shelf transects running approximately east-west nearly perpendicular to the isobaths (Figure 11). We also re-sampled two historical stations (SA9 and SA10), previously sampled by Blake *et al.* (1987), to evaluate long-term changes in the benthic community. On each transect (A through F), a single box core was collected at the 600, 800, and 1,500 m. Surface and sediment profile camera images were taken at these stations and also at a 1,000 m. A camera sled was deployed on each transect starting at the deep (about 1,800 m) end and towed to shallow water (as shallow as 120 m). A summary of data collected, along with references to detailed methods, can be found in Table 5.

Preliminary evaluation of surface and sediment profile camera images at sea allowed us to reevaluate the placement of stations and transects. Data from the preliminary image evaluation, combined with the visual observation on the box cores, indicated that the sediments and benthic community were similar at all the transects that we had established. We replaced the camera sled tow on Transect C with two short transects approximately 10 and 22 km north of Transect A (1 and 1A, Figure 11).

RESULTS AND DISCUSSION

Sediments and Sedimentation Rates

Excluding the 2,000-m station which was likely recently disturbed, the sedimentation rate at the study area was estimated to range from 0.3 to 1.8 cm yr^{-1}. These are 25 to 100 times higher than the holocene sedimentation rates on the slope off the Atlantic coast (Emery and Uchupi 1972). In fact, they are comparable to, or higher than, estuarine rates. However, the rate of sediment accumulation over the entire study site was highly variable. The towed camera sled showed a wide diversity of

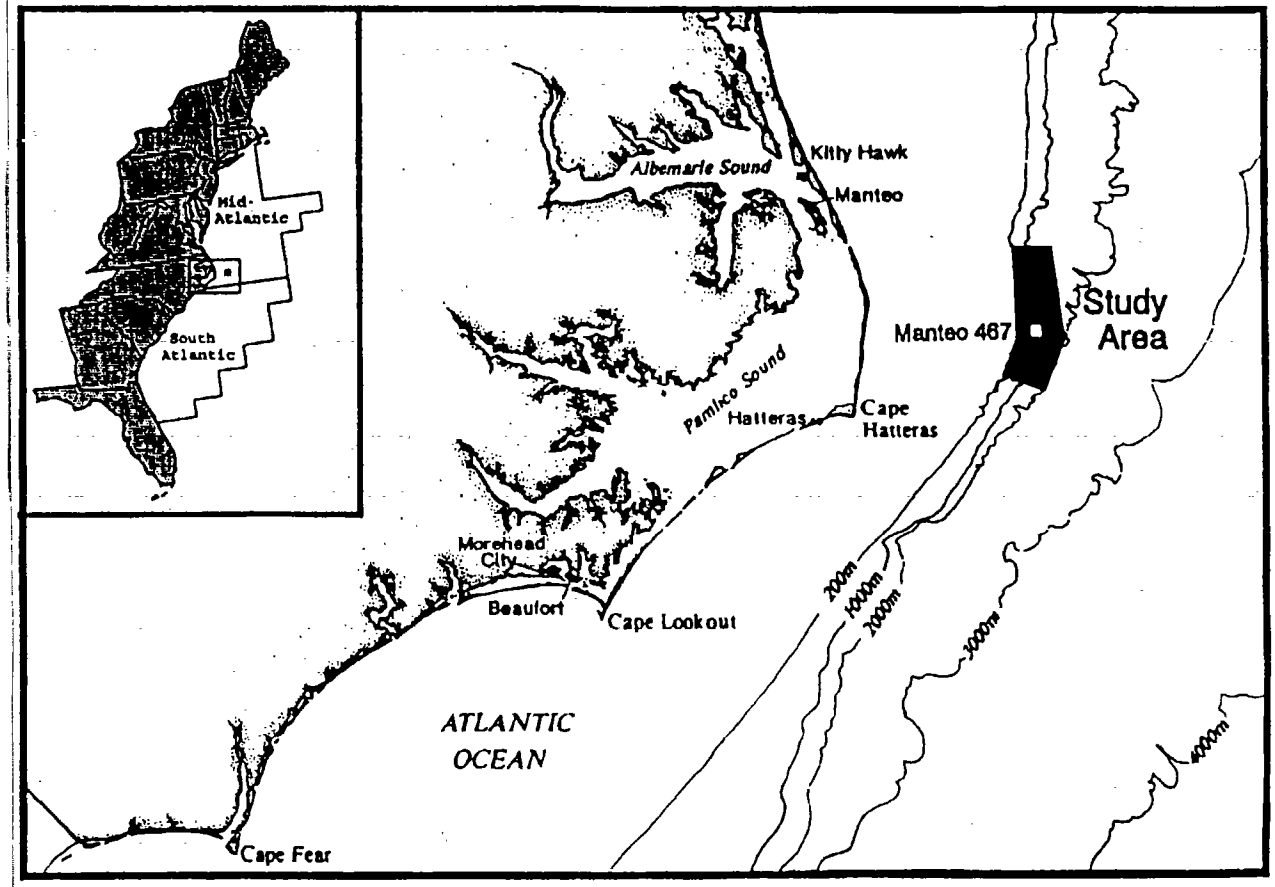

Figure 10. Location of the study area off Cape Hatteras, North Carolina.

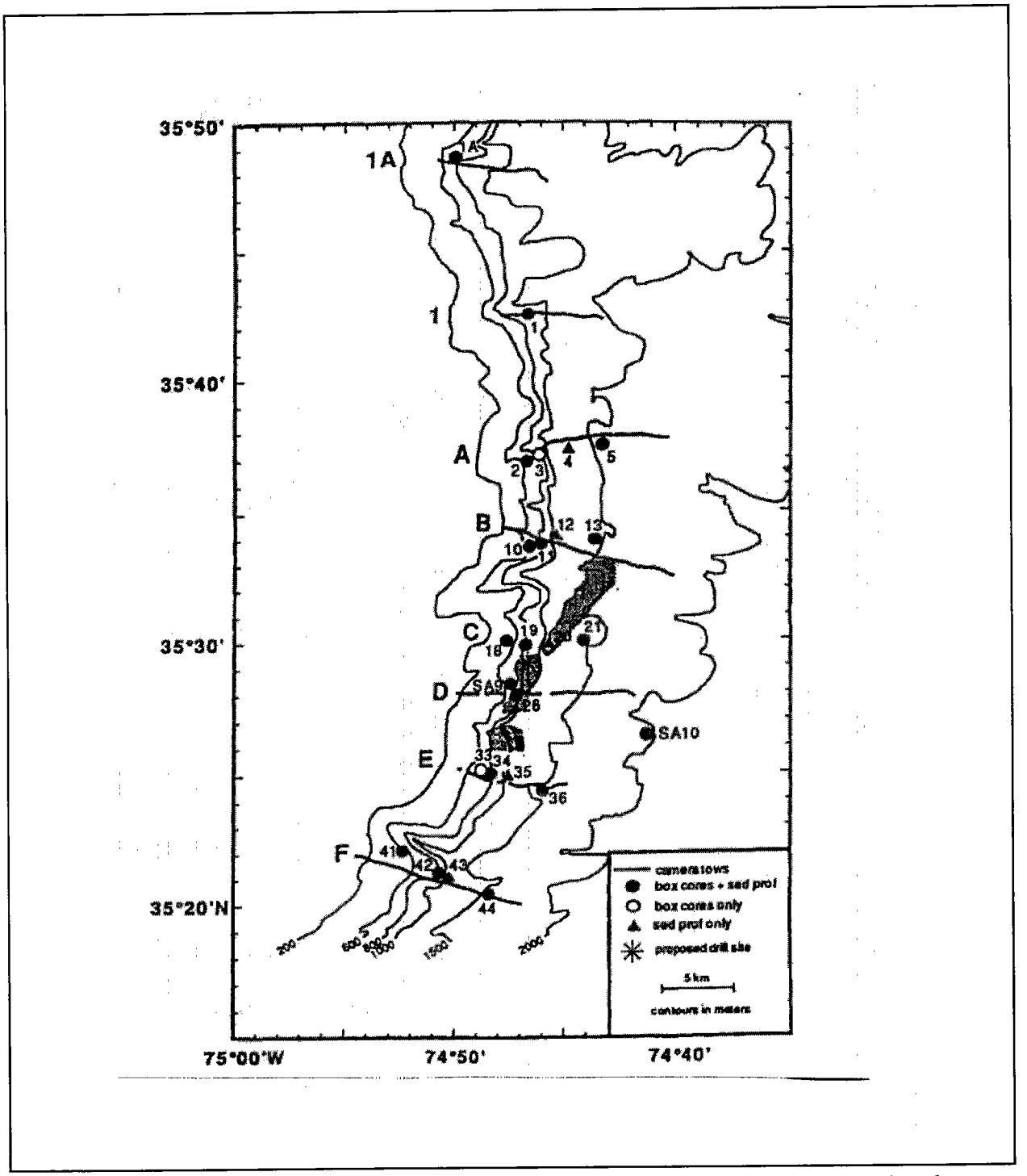

Figure 11. Location of sampling stations on the continental slope off Cape Hatteras. Overlay onto the station locations is the predicted dispersion and deposition patterns (stippled area) from the Offshore Operators' Committee model (Brandsma 1990). The stippled area represents deposition of 67 to 75% of the simulated discharge of 4,000 barrels of drilling muds and cuttings (approximately what the drilling of the exploratory well will generate). The reminder of the material did not settle to the bottom within the model boundaries.

Table 5. Summary of data collected on the continental slope off Cape Hatteras, North Carolina, in the vicinity of Manteo 467 on R/V Endeavor cruise EN-241, 26 August to 6 September 1992.

Box-Core - 0.16 m^2 BX-640 Ocean Instruments, Divided into 16 10x10 subcores.	
Chlorophyll a	Cahoon *et al.* 1994
Viable diatoms	Cahoon *et al.* 1994
Fatty acids	Harvey 1994
Inorganic carbon	Blair *et al.* 1994
Organic carbon	Blair *et al.* 1994
Sediment grain-size	Diaz *et al.* 1994b
Carbonate	Diaz *et al.* 1994b
Nitrogen	Blair *et al.* 1994
Pb-210	DeMaster *et al.* 1994, Diaz *et al.* 1994b
X-Rays	Diaz *et al.* 1994
Macrofauna (300 um)	Blake and Hilbig 1994
Foraminifera	Cutter *et al.* 1994b
Sediment Profile and Vertical Surface Cameras - Benthos Models 3731 and 372	
Surface features	Diaz *et al.* 1994b
Subsurface features	Diaz *et al.* 1994b
Apparent mixed layer depth	Diaz *et al.* 1994b
Towed Camera Sled - Oblique Surface Images - Benthos Model	
Megafauna	Hecker 1994
Geological features	Hecker 1994

bottom types including bare outcrops, sediment-draped outcrops, and erosional and depositional surfaces. Areas on the slope with high rates of sediment input would be expected to experience local oversteepening and periodic slope failure. Evidence for this was present on all of the towed camera transects. Many steeply sloping outcrops were observed with an apparently thin cover of soft sediment. Some of these surfaces showed evidence of recent soft sediment flows in the form of erosional "rivulets." Depositional sites for turbidites, debris flows, and massive slump blocks were recognized in bottom photographs by their undulating topography, mud clasts projecting above an otherwise planar depositional surface of fine sediment, and the presence of relatively featureless sediment surfaces that have not had a chance to be disturbed by organisms.

Average accumulation rate of organic carbon was estimated to be 67 g C m^{-2} yr^{-1}, comparable to that found by Schaff *et al.* (1992) at a nearby site. This flux of organic matter is about 35 to 85% lower than that found in productive estuaries (Welsh *et al.* 1982). Annual phytoplankton productivity for 45 estuarine systems had a mean of 190 g C m^{-2} yr^{-1} (Boynton *et al.* 1982). The average concentration of fatty acids in slope sediments off Cape Hatteras (27 mg g^{-1} dry wt.) falls within the range reported for estuarine sediments (10-35 mg g^{-1} dry wt., Farrington *et al.* 1977) but is less than concentrations found in sediments underlying more intensive and persistent upwelling zones (765 mg g^{-1} dry wt., Smith *et al.* 1983).

The concentration of chlorophyll-*a* in the sediments at the study site appeared to be higher than average for slope sediments that do not underlay upwelling regions. The values were intermediate between those recorded for sediments underlying intensive upwelling regions (Blake *et al.* 1992) and estuarine values (Boynton *et al.* 1982). Because the decomposition rates of chlorophyll-*a* are high, the supply of plant cells to the bottom must be very high to support observed concentrations.

Biological Communities

The infaunal organisms taken from box cores included approximately 280 species of invertebrates, 45% of which were annelid worms. Molluscs (20%), crustaceans (17%), echinoderms (6%), and a variety of miscellaneous taxa comprised the rest of the fauna. The majority of individuals, however, consisted of six taxa: the oligochaetes *Limnodriloides medioporus* and *Tubificoides intermedius,* and the polychaetes *Scalibregma inflatum*, *Aricidea quadrilobata*, *Cossura* spp., and *Tharyx kirkegaardi*. Infauna total density off Cape Hatteras was very high and resembles shallower continental shelf locations such as the mud patch near George's Bank (Neff *et al.* 1989). Blake *et al.* (1987) and Schaff *et al.* (1992) also found infaunal densities on the continental slope to be highest off Cape Hatteras.

Diversity indices at the upper slope (600-800 m) stations were consistently lower than values from upper slope communities recorded elsewhere off North Carolina and Massachusetts (Blake *et al.* 1987, Maciolek *et al.* 1987a,b). One factor which may limit the success of many species on the Cape Hatteras slope is the nature of the carbon supply. The infaunal species most common on the Cape Hatteras slope are typically rare in the deep sea.

The benthic megafauna included at least 35 species of fish, 18 species of alcyonarians and anemones, 17 species of echinoderms, and a variety of crustaceans, worms, molluscs, and other organisms. The species most characteristic of the megafaunal assemblages were the foraminiferan *Bathysiphon filiformis*, the eelpouts *Lycenchelys verrilli* and *Lycodes atlanticus*, the witch flounder *Glyptocephalus cynoglossus*, and the anemone *Actinauge verrilli.* The quill worm *Hyalinoecia artifex* was locally abundant, especially in the upper slope of the two northern transects. Burrowing anemones were locally abundant at depths above 1,000 m. The fauna on the lower slope (>1,600 m) was dominated by brittlestars and sea pens. Most of the photographs also showed numerous instances of Lebensspuren such as tracks and trails, burrow openings and pits caused by deep-burrowing deposit feeders, excavations caused by fish and crustaceans, and the surficial tubes of infaunal organisms.

The high densities of predators, such as eelpouts, witch flounder, and quill worms are likely related to the high densities of potential infaunal prey. High abundances of filter feeding megafauna, such as *Actinauge verrilli*, *Bathysiphon filiformis*, and burrowing anemones, are probably related to high concentrations of suspended solids seen in many bottom images. High densities of the surface deposit feeding holothurian *Peniagone* sp., found on the lower slope of Transect D, also indicate a high organic flux. This species is known to occur in dense aggregations that migrate toward organic rich areas. Large deep-burrowing polychaetes were found in the box cores, and evidence of their activity dominated sediment surface and profile images.

Geographically, results of the 1992 survey suggest that the area encompassed by the dense faunal assemblages extends to most of the continental slope area off Cape Hatteras. The distance between 1A in the north and Transect F in the south is approximately 50 km (Figure 11). While the fauna was patchy and exhibited some depth zonation, community structure parameters were similar over the entire length of the study area. We know, however, that these assemblages are not found in the vicinity of the Hatteras Canyon (Blake *et al.* 1985).

SUMMARY AND CONCLUSIONS

Physical Habitat

The data all point a high input rate of sediment and organic matter of natural origin (Table 6). The location of Cape Hatteras on the Atlantic Coast and its geomorphology combine to funnel material moving southward along the outer shelf onto the slope environment near the study site. Within the study area there were no depth-related gradients in grain-size distributions, sediment chemistry, or sedimentation rates. In part, this was due to topographic irregularities which tend to break-up the bottom into a diverse mosaic of patchy and discontinuous habitats of varying age and stability. Also, the size of the study area was too small to detect broad scale regional gradients.

Table 6. Summary of sedimentary characteristic on the continental slope off Cape Hatteras, North Carolina, in the vicinity of Manteo 467. Estimated sediment accumulation for Station SA-10 was an outlier, possibly related to a recent sediment disturbance, and is presented separately (as values in parentheses).

Parameter	**Mean ± Standard Error**
Fine Sand-Coarse Silt	33.0±2.0%
Sediment Accumulation Rate	0.98±0.14 cm yr^{-1} (0.05 SA-10)
Sediment Mixed Layer Depth	12±1 cm
Carbonate	16.6±0.7%
Carbonate Flux	1133±305 g CO_2 m^2 yr^{-1} (58 SA-10)
Organic Carbon	1.04±0.04%
Organic Carbon Flux	66.7±12.8 g C m^2 yr^{-1} (4 SA-10)
Organic Nitrogen	0.13±0.01%
C:N Ratio	9.5±0.1
Chlorophyll *a*	0.75±0.15 mg g^{-1} dry wt.
Total Fatty Acids	18.7±3.5 mg g^{-1} dry wt. (5.6±1.0 SA-10)
Polyunsaturated Fatty Acids	1.5±0.6 mg g^{-1} dry wt. (0.4±0.2 SA-10)

The organic matter found in the study site's sediments appeared to be derived from both terrestrial and marine sources, and reflected the complicated interactions between sources, degradation pathways, and transport mechanisms. While the supply of organic matter was large, only a small fraction of it was composed of easily digested and highly nutritious smaller molecules (polyunsaturated fatty acids). The majority of the organic matter was refractory which suggests that it is substantially reworked either during transport through the water column or at the sediment-water interface. Subsurface deposit feeders adapted to make use of this more refractory organic matter dominate the infauna in terms of both numbers and biomass. Their unusually high abundance was apparently directly related to the magnitude of carbon flux into the area and the sediment grain size, which was optimal for both tube building and burrowing. The sediments were almost completely reworked biologically, a good indicator of the high level of infaunal activity.

Benthic Community Characterization and Distribution

The infaunal community was characterized by higher-than-average densities and lower-than-average species richness and species diversity for continental slope areas (Table 7). The infaunal community was also numerically dominated by ten species. Densities of total benthic megafauna were only slightly elevated for continental slope areas (Figure 12). However, densities of the four top dominant megafaunal species were much higher than average (Figures 13 and 14). The megafaunal and infaunal communities that populate the continental slope off Cape Hatteras appear well adapted to coping with the dynamic nature of the physical environment. These communities, in turn, provide the trophic base that supports large populations of demersal fish.

The communities were present throughout the study area, but the relative abundances of the major species varied down to the smallest scales measured (meters for the megafauna and kilometers for the infauna). Latitudinal differences were most obvious in the megafauna. The northern part of the study area (1A and 1) differed somewhat from the rest. Depth-related zonation was most obvious in the megafauna with faunal breaks at 400-500 m, between 800 and 1,200 m, and at 1,600 m. For infauna the upper slope (600 m) was dominated by oligochaetes and the middle slope (800-1,400 m) by the polychaete *Scalibregma inflatum*. The boundaries of these unusual communities are at least from 35° 20' to 35° 50' north latitude (about 50 km) and from depths of 600 to 1,500 m, and possibly to 2,000 m depth. The minimum area occupied by these communities, within the study area, is estimated to be about 500 km^2 to the 1,500-m isobath and 900 km^2 to the 2,000-m isobath.

The data indicate that the unusual infauna and megafaunal communities are distributed throughout the study area. Conservatively, these communities occupied a north-south distance of at least 50 km and a depth range of 600 to 1,500 m, and likely to 2,000 m.

Table 7. Summary of benthic community characteristics on the continental slope off Cape Hatteras, North Carolina, in the vicinity of Manteo 467. Infaunal parameters are for 16 box core stations.

Parameter	**Mean ± Standard Error**
Total Infauna Density	30,968±5,152 individuals m^2
Total Species/0.09 m^2	63.3±5.0
Species/750 Individuals	45.7±5.0
H' Diversity	3.2±0.2
Top 10 Dominant Taxa	64-97% (range)

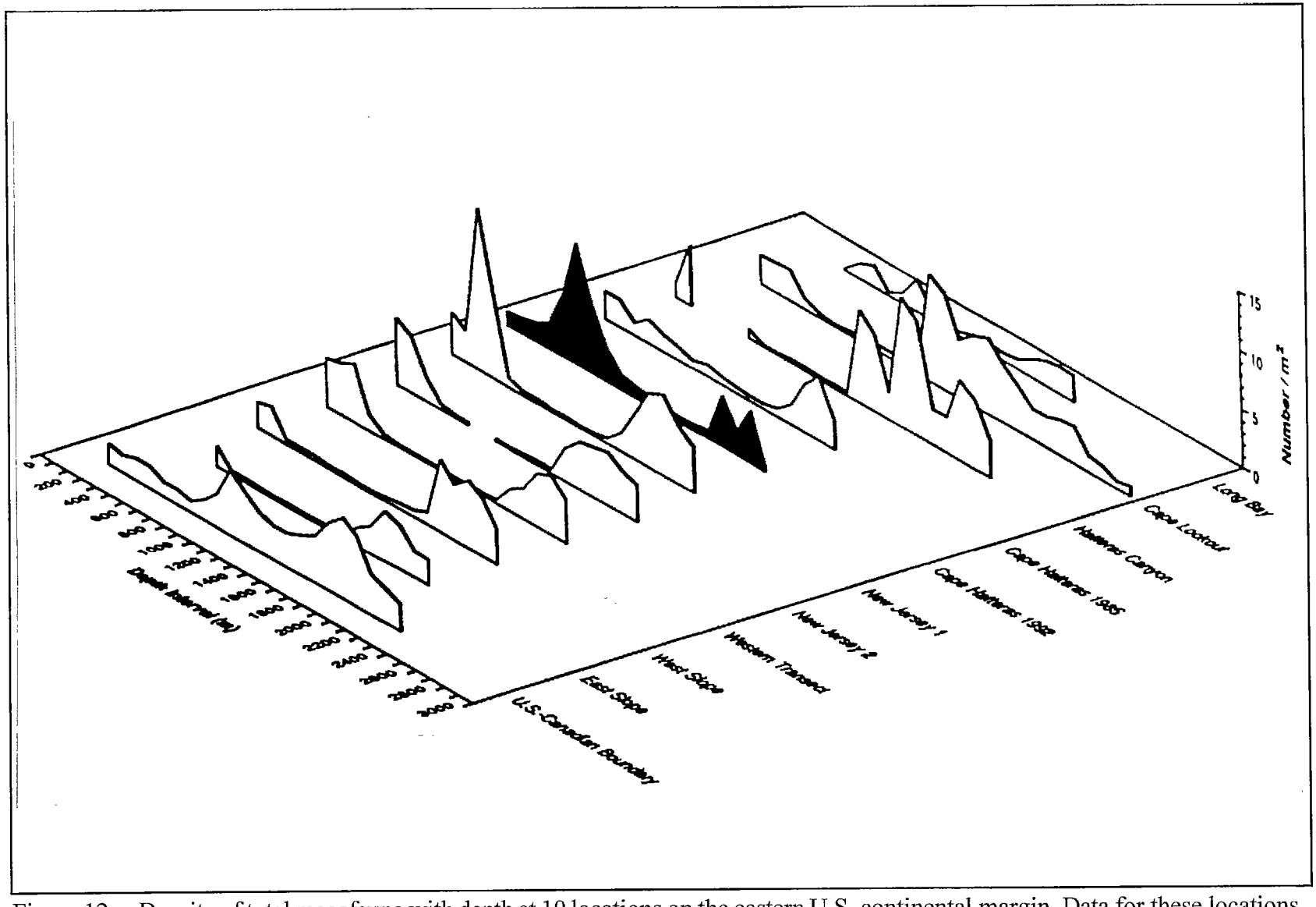

Figure 12. Density of total megafauna with depth at 10 locations on the eastern U.S. continental margin. Data for these locations were collected for studies described in Hecker *et al.* (1983), Hecker (1990), and Blake *et al.* (1985, 1987). Data from the present survey are shaded (Cape Hatteras 1992).

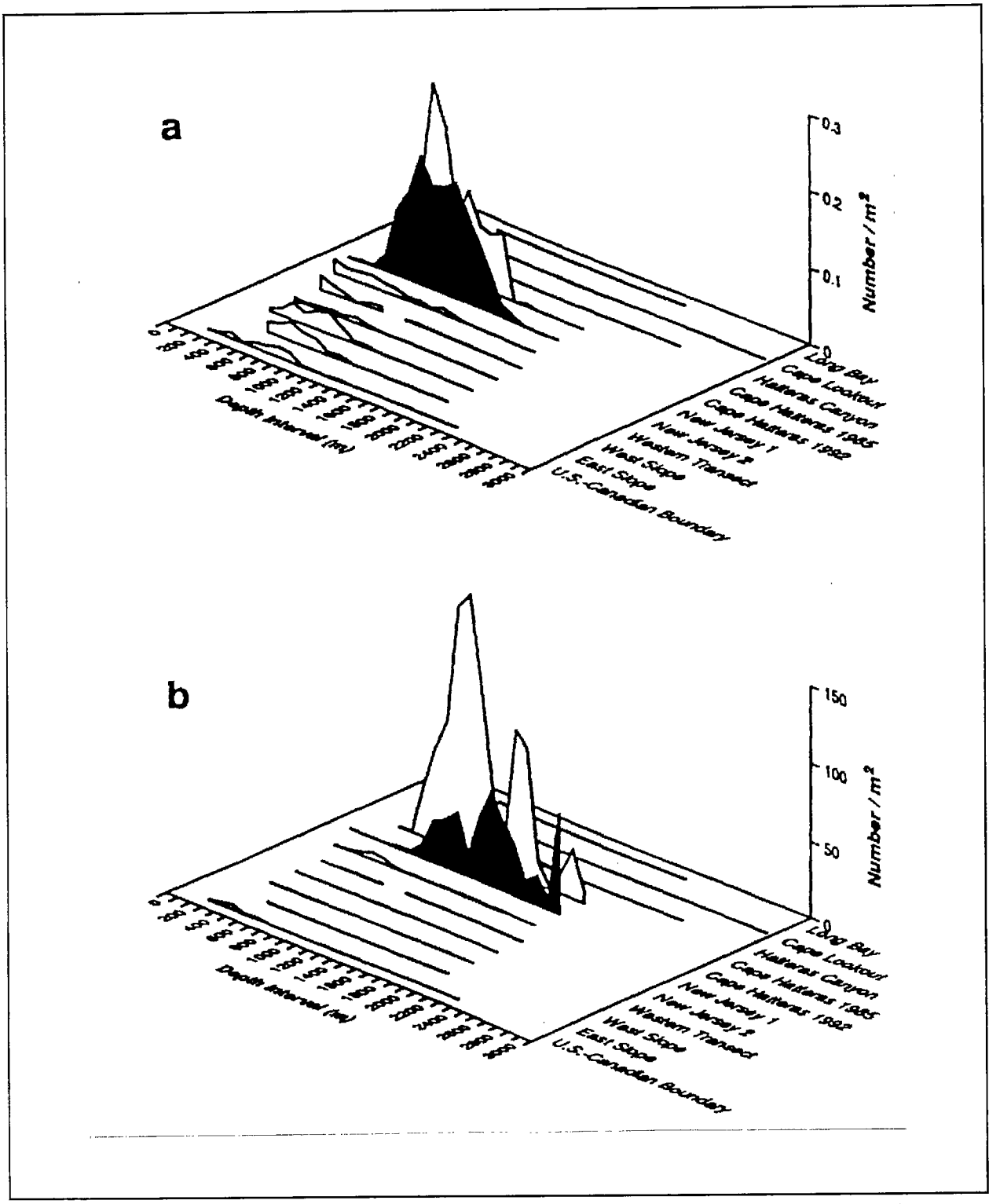

Figure 13. Density of (a) the wolf eelpout *Lycenchelys verrilli* and (b) the anemone *Actinauge verrilli* with depth at 10 locations on the eastern U.S. continental margin. Data for these locations were collected for studies described in Hecker *et al.* (1983), Hecker (1990), and Blake *et al.* (1985, 1987). Data from the present survey are shaded (Cape Hatteras 1992).

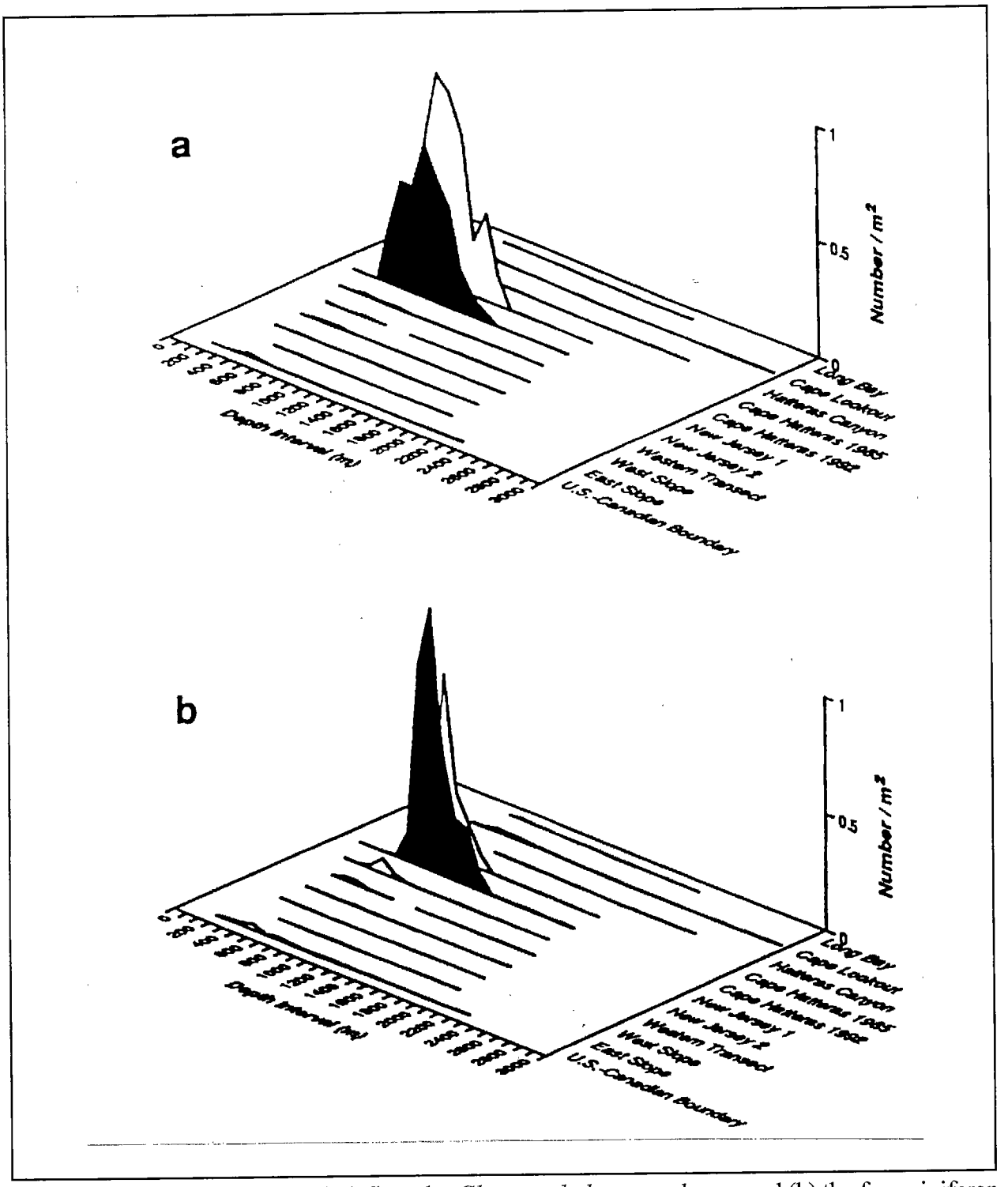

Figure 14. Density of (a) the witch flounder *Glyptocephalus cynoglossus* and (b) the foraminiferan *Bathysiphon filiformis* with depth at 10 locations on the eastern U.S. continental margin. Data for these locations were collected for studies described in Hecker *et al.* (1983), Hecker (1990), and Blake *et al.* (1985, 1987). Data from the present survey are shaded (Cape Hatteras 1992).

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Dr. Robert Diaz, Professor of Marine Science, has been with the Virginia Institute of Marine Science for 30 years. His research interests are in coastal and estuarine benthic pelagic coupling and remote sensing of bottom habitats. Dr. Diaz received his B.S. in biology from LaSalle College and his M.S.

and Ph.D. from the University of Virginia. In 1996 he was awarded a Doctor Honoris Causa from Gothenburg University, Sweden, for his contributions to benthic ecology.

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Dr. James A. Blake is a deep-sea benthic ecologist and marine invertebrate zoologist with an expertise in polychaete systematics and phylogeny with more than 100 published articles on these subjects. He has been both a university professor and consultant with private industry. He has managed previous benthic surveys at Cape Hatteras and elsewhere on the North Carolina coast for MMS.

APPENDIX G

COASTAL NORTH CAROLINA SOCIOECONOMIC STUDY PROGRAM

Dr. John S. Petterson
Impact Assessment, Inc.

INTRODUCTION

The Oil Pollution Act (OPA) of 1990 directed the Secretary of the Interior, in cooperation with the State of North Carolina, to create a panel to assess existing information necessary for the Secretary to make decisions regarding permitting, leasing, exploration and development offshore North Carolina. In response to this requirement, the Environmental Sciences Review Panel (ESRP) was appointed in December 1990. The panel was specifically charged with assessing existing information for its value in determining the potential impacts of offshore oil and gas exploration and production and with identifying areas in which such information is inadequate or absent. After a series of deliberations and public hearings during 1991-1992, this panel submitted its recommendations to the Secretary of Commerce identifying the two areas in greatest need of additional study: (1) benthic oceanographic studies; and (2) socioeconomic studies.

The Minerals Management Service (MMS) initiated, in 1992, a Cooperative Agreement with East Carolina University (ECU) designed to address the socioeconomic shortcomings identified in the ESRP report. The Coastal North Carolina Socioeconomic Study (CNCSS) program was a product of this Agreement. The study was under the lead of ECU (John Maiolo) and implemented by Impact Assessment, Inc. (IAI) under my direction. The study was carried out between August 1992 and September 1993. The project involved the work of 18 researchers, a commitment of over 8 man-years, and a cost of approximately $750,000. Field data collection was carried out from a field headquarters and four satellite field offices (which also served a residences during the study period).

A National Peer Review Committee (consisting of Profs. Russell Bernard, Larry Leistritz, and Robert Trotter) was established to ensure that the study goals were achieved. Designated members of the former ESRP were recruited as oversight to ensure all of the recommendations were addressed (Profs. Michael Orbach and John Costlow).

RESEARCH OBJECTIVES

The Coastal North Carolina Socioeconomic Study was designed to collect, analyze and disseminate information about socioeconomic and sociocultural conditions along those portions of the North Carolina Coast susceptible to the potential effects of exploratory drilling at the Manteo Prospect. The

Manteo Prospect is located in waters some 2,690 feet deep thirty-eight miles east of Salvo in a geologic zone thought to have a reasonable potential for discovery of natural gas or oil.

The objectives of the Coastal North Carolina Socioeconomic Study were to document conditions in the study area for a wide array of variables traditionally used as indicators of socioeconomic and sociocultural status. This information was intended to provide the sponsor with a "snapshot" of current sociocultural and socioeconomic conditions and trends within these areas. The information was to assist decision-making processes undertaken by the federal government, assist county and local governments in planning activities, and provide a means of monitoring and measuring change in the study area should OCS activity in North Carolina proceed.

The North Carolina ESRP was concerned that there was a lack of comprehensive socioeconomic studies in North Carolina. Connections or relationships among social scientific variables or between those and physical and natural scientific properties had not been fully characterized or analyzed. The panel also noted the lack of attitudinal or perceptual data or information. The following recommendations, made by the panel, constitute the study objectives and what the panel considered to be an adequate information supplement for the leasing state at the Manteo Prospect:

(1) Base case characterization analysis should be carried out to include standard aggregate variables as population, employment, and economic activity; characterization and structure of relevant industries; and characterization of the relationships among private and public sector entities in the affected areas.

(2) Detailed community studies should be done on the communities most likely to be affected by OCS development. These studies should include sociocultural variables, such as cultural traditions and psychosocial conditions, necessary to contextualized understanding of the role and effect of potential OCS activities in these communities. The central purpose of this work would be to gain an understanding of how these communities function as coherent social, economic, cultural, and political systems.

(3) Aesthetic and perceptual issues studies should be performed for representative portions of the potentially affected populations. This research should be concerned with the perceptions of environmental conditions and values.

(4) Infrastructure studies should be performed in the potentially affected communities, focusing on the potential for changes in local and regional economic and political relationships.

(5) Comprehensive longitudinal socioeconomic monitoring should be designed based upon base case characterization established socioeconomic variables. The variables should cover all of the above issue categories.

It should be noted that this research effort was explicitly not intended to be an "impact assessment" or "impact analysis." This effort, rather, provides the foundation upon which future impact assessment, if OCS activities proceed, may be based. The County and Communities Studies provide a qualitative and quantitative description of a range of socioeconomic and sociocultural indicators or variables needed to establish the context within which OCS-related changes could occur. The companion Socioeconomic Monitoring Plan provides a template for tracking change in a subset of these variables that, in the informed opinion of research team, will

likely be (1) potentially responsive to OCS-related activities; (2) socioeconomically and socioculturally significant at the community and/or regional level; and, (3) "tractable" (relating to information that is both quantifiable and that can be efficiently obtained).

METHODOLOGY

A combination of research methods was employed to satisfy the informational inadequacies identified by the ESRP. These methods include secondary source research (to assess and compile existing data) and observation and interviews (to compile new data). An interim report entitled Final Research Design/Guide to Field Investigations was prepared to describe the overall technical approach employed to implement the CNCSS including a description of field methods, logistics, analytic approaches, study integration, and study time frame.

Secondary data collection involved traditional literature reviews, including available gray literature, source materials produced by the Sate, counties, and local communities, as well as previously collected materials obtained by the field staff. The principal focus of the data collection effort, given the dearth of available information, was on primary data collection in the potentially affected counties and communities. This information was collected by means of observation (e.g., direct observation, participant observation, non-reactive observation), interviews (e.g., open-ended interviews with key persons or reputational leaders). In addition, a broad array of methods employed to elicit public perception of the key characteristics and risks associated with living in coastal North Carolina communities. These methods included several "free-listing" techniques to establish: (1) quality of place; (2) uses of the environment; and (3) perception of change. Additional data collection techniques employed to provide consistent measures of perceptions included pile-sorting for various environmental and social measures. These data were then subjected to a wide range of analyses, relying on multi-dimensional scaling, hierarchical clustering, cultural consensus modeling, and other statistical approaches.

The resulting final report, Coastal North Carolina Socioeconomic Study Final Technical Report, for the U.S. Department of the Interior, Mineral Management Service, Atlantic OCS Region, by East Carolina University and Impact Assessment, Inc. (1993), consisted of the following five volumes:

Volume I, Executive Summary—MMS 93-0052 (21 pp);

Volume II, Base Case Characterization: County Studies—MMS 93-0053 (290 pp);

Volume III, Base Case Characterization: Community Studies—MMS 93-0054 (408 pp);
Volume IV, Pile Sort Data and Analysis—MMS 93-0055 (630 pp); and
Volume V, Socioeconomic Monitoring Design and Methodology—MMS 93-0056 (31 pp).

CONCLUSIONS AND RECOMMENDATIONS:

A number of conclusions can be drawn and recommendations made from the results of this and earlier MMS socioeconomic studies.

- Small differences in change agent can result in big differences in social effects (e.g., Mobil indication that one potential scenario might result in direct transhipment of discovered oil/gas by underwater pipeline directly to Virginia).

- Unique characteristics of affected community (e.g., size, economic adaptation, occupational orientation, seasonality, etc.) can result in acute sensitivity to particular source of development or change. For example, some communities (or neighborhoods, or regions), by reason of their histories, social, or economic organization,[2] are particularly sensitive to minuscule perturbations of their local social, economic, or physical environment. These highly sensitive populations can suffer disproportionate effects from seemingly minor initial factors. For example, smaller Native villages oiled by the 1989 Exxon Valdez spill continue to suffer the social effects legal turmoil representing one of the more pernicious legacies.

- Socioeconomic and social effects of development-related changes need not be physically contiguous nor contemporaneous. A change in employment, or an active development, in one location could have immediate ramifications for more distant communities that are the sources of employees. The effects of a major development in Beaufort might have a greater impact on Hatteras than on Morehead City. Simply stated, we need to be alert to disproportionate geographic distributional effects.

- One needs to view social change as a process that occurs in gradual steps over an extended period of time—not as synchronous events. One needs carefully to consider preexisting conditions in the particular communities, at particular points in their evolution, in relation to the precise intervening variable (e.g., on shore oil support activities), to evaluate potential effects. The cumulative effect of a particular set of changes (e.g., those associated with on-shore or off-shore oil development) is the result of hundreds of interrelated (sometimes directly, sometimes indirectly related) events that give rise to a particular outcome. At issue

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[2]Socioeconomic systems of this area are heavily dependent upon utilization of marine resources and access to a maritime environment perceived as relatively pristine. The character of this dependence varies considerably depending on the mix of a community's or region's reliance on tourism, commercial or recreational fisheries, military activity, or retirement or other transfer income sources.

isn't simply the construction and operation of an onshore facility (i.e., a synchronic event), but the whole cycle of effects (e.g., associated employment, education, public service, impacts as well as the ultimate termination of the facility and workforce).

- Perceptions of "anticipated" development can have more severe impacts on a community than actual development. The preparatory activities, in advance of any development, can be disturbing to a community, even if, ultimately, none of the actual development occurs.

- Unanticipated and unpredictable future events may dwarf effects predicted in association with OCS development. Hurricanes, floods, recreation/retirement home construction, potable water problems, sewage treatment issues, depending on their timing, can entirely displace (at least for some time) OCS-related risk issues.

- A key focus of future studies should be on threshold effects. At what point does a social change become unacceptable? We know, for example, that some socioeconomic impacts are so small that no effort to measure them would be successful, and that community awareness and concern with these changes is minimal. We are also aware that major developments, especially those where little planning has taken place, will result in a broad range of dramatic impacts to a community—impacts that are obvious to everyone. This is the basic continuum along which all development takes place. Our task, and the task of the MMS and its study program, is to identify those social, psychological, and economic factors that shift the "threshold" in one direction or another. That is, we are looking for those factors that in one community may give rise to adamant public resistance, serious economic dislocation, and political opposition where similar development in another community might be met with enthusiasm and active participation.

- Another key objective should be to develop a clear understanding of the characteristics of causal agents in relationship to the characteristics of the recipient community. Oil development is far from a monolithic process. It is an amalgam of hundreds of separable, sometimes independent, but normally interrelated, events that occur over time. The operation of exploration vessels, support crews, base construction, logistical support operations, transportation, construction and prefabrication sites, and related/ancillary enterprises, etc., all function independently with their own local and larger impacts to communities depending on their unique characteristics—demographic, social, economic, transportation, environmental and other idiosyncratic factors. Moreover, sometimes casual or minor changes in the characteristics of the causal agent can markedly alter the range of potential social impacts. As mentioned above, a decision to transport recovered oil by pipeline to Virginia would radically change the potential impact alternatives that might otherwise need to be considered for coastal North Carolina communities.

- MMS has developed a sufficient understanding of the regional and state-level changes that occur in association with OCS-related activities. These general level social and economic

variables can be routinely and inexpensively maintained. They cannot, however, reflect the actual, sometimes dramatic, changes that can occur in particular locations, communities, or under compressed time schedules. It will be communities that bear the most adverse effects of OCS development. If the unique and particularistic historical and current social organization of a community determines the social impact of OCS development, measures of these social characteristics will serve as: (1) the most accurate and useful indicators of susceptibility and predictors of likely public response (or for planners intent on minimizing impact or maximizing positive effects); and (2) the most accurate measure of impacts that do occur as development proceeds.

- While MMS has done an admirable job of working to broker more acceptable development of U.S. coastal resources, it cannot escape the inherent conflict embedded in its mission statement of both promoting the sale or lease of national resources at the best possible price and its fiduciary obligation to protect the interests of those populations most affected by the activities associated with development of those leases. MMS must always be seen as an agency representing the larger "public" (i.e., "national") interests, while recognizing the fact that the most serious adverse effects of that development are invariably absorbed by the coastal communities that bear the direct effects. It is for this reason that we would encourage closer coordination between proponents (oil companies) and the potentially affected coastal communities and pertinent state agencies—a less adversarial model more akin to the Canadian approach. This approach would go a long way to ensuring more palatable and, in the future, more acceptable forms of development. Creative thinking industry representatives and community representatives, and even outside NGOs, could constructively sit down to discuss issues candidly. This is not to suggest that the fiduciary obligation of the MMS should be, in any way, lifted. As the "experts," they know from experience where the pitfalls are likely to be found, where communities need to be most careful in accepting, or most concerned with understanding, development likely to occur in association with oil development. As a complex process, communities inexperienced in dealing with such development should not be left to their own devices, each time reinventing their responses to problems in a series of predictable confrontations between an experienced proponent and an inexperienced community (where industry strategies have been well tested and the outcome entirely predictable). From this perspective, MMS would then need to be most concerned with ensuring that communities have available the most knowledgeable support staff, committed to the protection of those populations most susceptible to potential impacts.

John S. Petterson received his Ph.D. in anthropology from the University of California, San Diego. He is President of Impact Assessment Inc., and has served as Principal Investigator on the "Economic, Social, and Psychological Impacts of the Exxon Valdez Oil Spill" and the "Socioeconomic Impact Assessment of the Proposed High-Level Nuclear Waste Repository" for

both the Hanford, Washington and Yucca Mountain, Nevada sites. Dr. Petterson has also served in the dual role of project manager and principal investigator on successive social, economic, and cultural studies in support of USDOI, BLM, USFS, North Pacific Fishery Management Council, USFWS socioeconomic impact assessments (SIA), including over a dozen major MMS socioeconomic studies, since the formation of IAI in 1981. Dr. Petterson recently served as co-Principal Investigator on the Congressionally-mandated study, under the Oil Pollution Control Act, which required the Department of the Interior to address specific informational shortcomings in its study program for planned oil development off the coast of North Carolina. The product of this MMS effort was a 4-volume report entitled "Coastal North Carolina Socioeconomic Study" which provided base case and baseline assessments of commercial and recreational fishing conditions and adaptations, as well as infrastructure, social, cultural, and economic conditions in northern coastal North Carolina counties, and detailed community studies of six principal coastal communities.

APPENDIX H

PUBLICATIONS RELATED TO THE ATLANTIC COAST

APRIL 22, 1996

BENTHIC COMMUNITIES

Effects of a Natural Disturbance on a Continental Shelf Live Bottom Community off North Carolina. MMS 85-0055. W.W. Kirby-Smith *et al.* Duke Univ. Marine Laboratory. (1985) 17 p. NTIS PB 86-121712.

Literature Analysis of Benthic Communities in Certain Slope Areas of the South Atlantic Bight, Final Report. MMS 85-0051. D.M. Knott *et al.* Marine Resources Research Institute. (1985) 75 p. NTIS PB 87-213393.

BIRDS

Synthesis of Information on Marine and Coastal Birds of the Atlantic Coast: Abundance, Distribution, and Potential Risks from Oil and Gas Activities: Vol. 1, Executive Summary (MMS 93-0001); Vol. 2, Species Accounts, Abundance, Distribution and Status (MMS 93-0002); Vol. 3, Impacts and Potential Risks from Oil and Gas Activities (MMS 93-0003); and Vol. 4, Bibliography (MMS 93-0004). E.M. Hoopes. Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts. (1994) 7, 178, 127, and 555 p. Available from NTIS: Vol. I: PB 95-183505; Vol. II, PB 95-183513; Vol. III, PB 95-183521; Vol. IV, part 1: PB 95-183539 and part 2: PB 95-183547.

CETACEANS

Effects of Noise on Marine Mammals. MMS 90-0093. W. John Richardson *et al.* LGL Environmental Research Associates. (1991) 2 vol., 490 p. Available from NTIS: Vol. 1, Executive Summary, PB 91-169896; Vol. 2, Final Report, PB 91-168914.

Endangered Right Whales of the Southern North Atlantic, Vol. 1. MMS 90-0079. S. Kraus *et al.* New England Aquarium. (1990) 20 p. Available from NTIS: PB 95-193678.

Endangered Right Whales of the Southwestern North Atlantic. MMS 93-0024. S. D. Kraus *et al.* Edgerton Research Laboratory, New England Aquarium. (1993) 69 p. Available from NTIS: PB 93-215887.

Satellite-monitored Movements and Dive Behavior of the Right Whale, *Eubalaena glacialis,* in the Western North Atlantic, 1991 Results. MMS 93-0049. B. R. Mate *et al.* Hatfield Marine Science Center, Oregon State University. (1992) 80 p. Available from NTIS: PB 93-237428

Synthesis of Effects of Oil on Marine Mammals. MMS 88-0049. J.R. Geraci, ed., *et al.* Battelle Memorial Institute. 1988. 302 p. NTIS: PB 89-117451.

Workshop to Assess Possible Systems for Tracking Large Cetaceans. MMS 87-0029. S. Montgomery ed. Marine Mammal Commission. 1987. 51 p. NTIS: PB 87-182135.

ECOLOGY

Analysis of Trace Metals in Bottom Sediments in Support of Deepwater Biological Processes Studies on the U.S. Mid-Atlantic Continental Slope and Rise, Interim Report. MMS 85-0100. M.H. Bothner *et al.* U.S. Geological Survey. (1986). 59 p. NTIS PB 86-199312.

Analysis of Trace Metals in Bottom Sediments in Support of Deepwater Biological Processes Studies on the U.S. Mid-Atlantic Continental Slope and Rise, Final Report. MMS 86-0102. M.H. Bothner *et al.* U.S. Geological Survey. (1987) 82 p. NTIS: PB 87-194387.

Analysis of Trace Metals in Bottom Sediments in Support of Deepwater Biological Processes Studies on the U.S. North Atlantic Continental Slope and Rise, Interim Report. MMS 86-0008. M.H. Bothner *et al.* U.S. Geological Survey. (1986) 40 p. NTIS PB 86-191467.

Analysis of Trace Metals in Bottom Sediments in Support of Deepwater Biological Processes Studies on the U.S. North Atlantic Continental Slope and Rise, Final Report. MMS 87-0079. M.H. Bothner *et al.* 1987. 52 p. NTIs: PB 88-107560.

Analysis of Trace Metals in Bottom Sediments in Support of Deepwater Biological Processes Studies on the U.S. South Atlantic Continental Slope and Rise, Final Report. MMS 86-0103. M.H. Bothner *et al.* U.S. Geological Survey. (1987) 44 p. NTIS PB 87-200051.

Benthic Study of the Continental Slope off Cape Hatteras, North Carolina. Vol. 1, Executive Summary (MMS 93-0014); Vol. 2, Final Report (MMS 93-0015); and Vol. 3, Appendices (MMS 93-0016). R. J. Diaz *et al.*, Virginia Institute of Marine Science *et al.* (1993) 19, 140, and 132 p. NTIS: Vol. 1, PB 93-186062; Vol. 2, PB 93-186070; and Vol. 3, PB 93-186088.

Description of the Mid-Atlantic Environment. MMS 89-0064. S.A. Abernathy, ed. 1989. 253 p., 1 plate, scale 1:750,000. Reader copy only.

Effects of a Natural Disturbance on a Continental Shelf Live Bottom Community off North Carolina. MMS 85-0055. W.W. Kirby-Smith *et al.* Duke Univ. Marine Laboratory. (1985) 17 p. NTIS PB 86-121712.

Effects of Noise on Marine Mammals. MMS 90-0093. W. John Richardson *et al.* LGL Environmental Research Associates. (1991) 2 vol., 490 p. Available from NTIS: Vol. 1, Executive Summary, PB 91-169896; Vol. 2, Final Report, PB 91-168914.

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Study of Biological Processes on the U.S. Mid-Atlantic Slope and Rise, First Interim Report. MMS 85-0095. N. Maciolek-Blake *et al.* Battelle New England Marine Research Laboratory *et al.* (1985) 125 p. NTIS PB 86-125556.

Study of Biological Processes on the U.S. Mid-Atlantic Slope and Rise, Second Interim Report. MMS 86-0004. N. Maciolek. Battelle New England Marine Research Laboratory *et al.* (1986) 170 p. NTIS PB 86-191046.

Study of Biological Processes on the U.S. Mid-Atlantic Slope and Rise, Final Report. MMS 87-0050. N. Maciolek *et al.* Battelle Ocean Sciences *et al.* (1987) 2 vols., 503 p. NTIS: Vol. 1, Executive Summary, PB 88-182845; Vol. 2, Final Report, PB 88-183090.

Study of Biological Processes on the U.S. North Atlantic Slope and Rise, Interim Report. MMS 86-0022. N. Maciolek *et al.* Battelle New England Marine Research Laboratory *et al.* (1986) 200 p. NTIS PB 86-199320.

Study of Biological Processes on the U.S. North Atlantic Slope and Rise. MMS 87-0051. N. Maciolek *et al.* Battelle Ocean Sciences *et al.* (1987) 2 vols., 582 p. NTIS: Vol. 1, Executive Summary, PB 88-196522; Vol. 2, Final Report, PB 88-196514.

Study of Biological Processes on the U.S. South Atlantic Slope and Rise, Phase 1: Benthic Characterization. Vol. 1, Executive Summary (MMS 85-0096) and Vol. 2, Final Report (MMS 85-0097) J.A. Blake *et al.* Battelle New England Marine Research Laboratory. (1985) 19 and 182 p. NTIS: Vol. 1, PB 86-125531; Vol. 2, PB 86-125549.

Study of Biological Processes on the U.S. South Atlantic Slope and Rise, Phase 2. MMS 86-0096. J.A. Blake *et al.* Battelle Ocean Sciences *et al.* (1987) 2 vols., 586 p. NTIS: Vol. 1, Executive Summary, PB 87-214342; Vol. 2, Final Report, PB 87-214359.

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Synthesis of Available Biological, Geological, Chemical, Socioeconomical, and Cultural Resource Information for the South Florida Area. MMS 90-0019. W. S. Alerizon *et al.* Continental Shelf Associates, Inc. (1990) 746 p. Available from GOM or NTIS: PB 90-266685.

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Synthesis of Information on Marine and Coastal Birds of the Atlantic Coast: Abundance, Distribution, and Potential Risks from Oil and Gas Activities: Vol. 1, Executive Summary (MMS 93-0001); Vol. 2, Species Accounts, Abundance, Distribution and Status (MMS 93-0002); Vol. 3, Impacts and Potential Risks from Oil and Gas Activities (MMS 93-0003); and Vol. 4, Bibliography (MMS 93-0004). E.M. Hoopes. Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts. (1994) 7, 178, 127, and 555 p. Available from NTIS: Vol. I, PB 95-183505; Vol. II, PB 95-183513; Vol. III, PB 95-183521; Vol. IV, part 1: PB 95-183539 and part 2: PB 95-183547.

ECONOMICS

Coastal North Carolina Socioeconomic Study: Vol. 1, Executive Summary (MMS 93-0052); Vol. 2, Base Case Characterization: County Studies (MMS 93-0053); Vol. 3, Base Case

Characterization: Community Studies (MMS 93-0054); Vol. 4, Pile Sort Data and Analysis (MMS 93-0055); and Vol. 5, Socioeconomic Monitoring Design and Methodology (MMS 93-0056). J.R. Maiolo *et al.* East Carolina University. (1995) 21, 291, 306, 674, and 31 p. Available from GOM (limited supply) and NTIS: Vol. I, PB 95-261533; Vol. II, PB 95-261541; Vol. III, PB 95-261558; Vol. IV, PB 95-261566; and Vol. V, PB 95-261574. Complete set: PB 95-261525.

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Mid-Atlantic States Proposed 1985 OCS Oil and Gas Lease Sale 111, Final Environmental Impact Statement. MMS 85-0032. (1985) 476 p., 5 plates. Reading copy only.

North Atlantic Oil and Gas Lease Sale 96, Atlantic Outer Continental Shelf, Draft Environmental Impact Statement. MMS 88-0001. MMS. 1988. 613 p., 1 plate, Scale 1:750,000. Reader copy only.

South Atlantic States Proposed 1985 OCS Oil and Gas Lease Sale 90, Final Environmental Impact Statement. MMS 84-0070. (1984) 642 p., 5 plates. Reading copy only.

EXPLORATION

Exxon Lydonia Canyon 133-1 Well: Geological and Operational Summary. MMS 89-0007. Karen Riccardi, ed. 1989. 46 p. Reader copy only.

Impacts of Oil and Gas Exploration, Development, and Production on the Atlantic Continental Shelf. MMS 90-0080. A. T. Kearney, Inc. (1991) 500 p. NTIS: PB 91-153320.

Murphy Wilmington Canyon 106-1 Well, Geological & Operational Summary. MMS 86-0117. Frederick Adinolfi, ed. (1986) 33 p. Reader copy only.

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The Manteo Unit is an area of active leases approximately 45 miles east-northeast of Cape Hatteras, North Carolina. Chevron U.S.A. may propose to drill a single exploratory well in either Block 467 or 510 of the Manteo Unit with a specially outfitted drilling rig. To review environmental and socioeconomic information known, and needed, on the Manteo Unit, the N.C. Dept. of Environment and Natural Resources and Minerals Management Service conducted a workshop on Feb. 4-5, 1998.

The objectives of the workshop were to review state of knowledge for drilling a single exploratory well in either Block 467 or 510; share scientific info. obtained since 1990; distinguish between exploration and development activities; share info. on drilling technology and industry experience operating in similar physical environments; address scientific concerns regarding the potential impacts of OCS drilling on biological resources; and address concerns regarding onshore (social and economic) impacts from OCS drilling.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.

Minerals Management Service
Gulf of Mexico Region

Managing America's offshore energy resources

Protecting America's coastal and marine environments