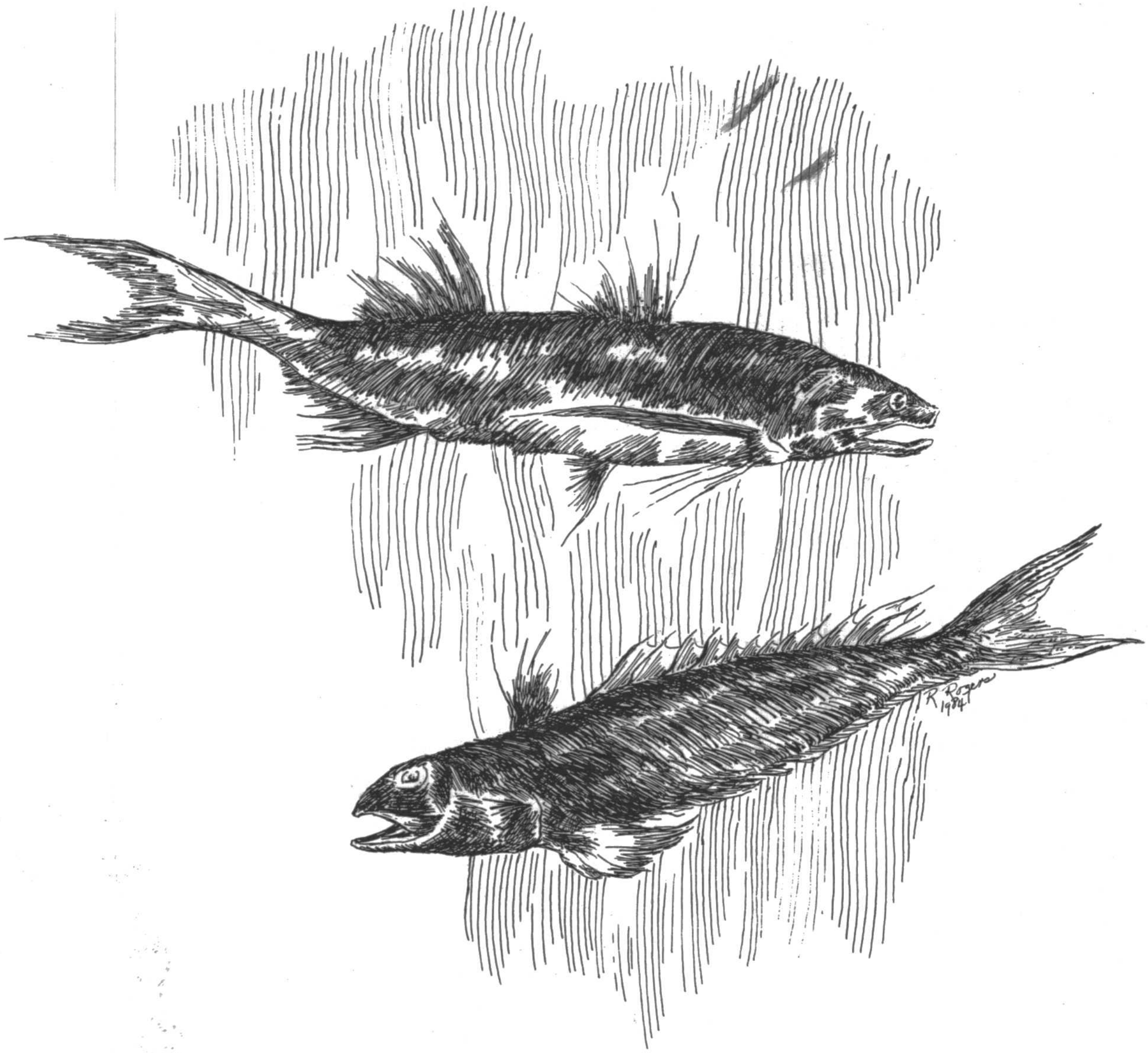
OCS REPORT
MMS 84-0026

PROCEEDINGS

Fourth Annual Gulf of Mexico Information Transfer Meeting



U.S. DEPARTMENT OF THE INTERIOR/MINERALS MANAGEMENT SERVICE

PROCEEDINGS

FOURTH ANNUAL GULF OF MEXICO INFORMATION TRANSFER MEETING

International Hotel
New Orleans, Louisiana
15-17 November 1983

SPONSORED BY

MINERALS MANAGEMENT SERVICE

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PREFACE

The purpose of these Proceedings is to present an overview of major Gulf of Mexico environmental studies programs as presented in the MMS Fourth Annual Information Transfer Meeting held November 15-17, 1983. In order to keep this document to a manageable size, technical descriptions and study results were edited to provide only the briefest description of program objectives. As a result, the Proceedings should be viewed as a reference to studies programs rather than a presentation on their technical content. Further explanations of study objectives and findings should be obtained from either the individual investigator or the responsible government agency. It should be noted that under the presentation titles are the names of the speakers and their respective affiliations. A complete address for all speakers and participants is included in the List of Attendees.

Special thanks are extended to session chairs and speakers, who are responsible for the success of the meeting. The Department of Conferences and Workshops of the University of Southern Mississippi is to be commended for the excellent editorial work done in ensuring the coherence of this document. Special appreciation is also extended to all meeting participants. The active involvement of such an informed group provided the necessary impetus for many stimulating and enlightening exchanges.

Copies of this document are being distributed to all participants in the meeting. A limited number of copies are available from the MMS Gulf of Mexico regional office. Additional copies may be obtained from the National Technical Information Service (NTIS).

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WELCOME

Mr. John Rankin
Regional Manager
MMS, Gulf of Mexico Region

Good morning, ladies and gentlemen. As representative of the Minerals Management Service and, particularly, the Gulf Region, I'd like to welcome you to this Fourth Annual Meeting of the Minerals Management Information Transfer Meeting. It has an impressive agenda and we are most pleased with the attendance.

Tomorrow, Assistant Secretary Designee Perry Pendley will be on hand to address the group. I want to thank all of you for coming. I want to thank, particularly, the participants -- and let me say that I am so impressed by our agenda that I want to impress you with the brevity of my remarks and sit down so we can get to the meat of this meeting.

OCS LEASING AND HISTORIC PRODUCTION

Mr. Harold P. Sieverding
Acting Regional Supervisor for Leasing and Environment
MMS, Gulf of Mexico Region

Let me set the stage for this Fourth Annual Information Transfer Meeting by outlining for you where we are in terms of the oil and gas leasing program in the Gulf of Mexico and how we got there, for the oil and gas leasing program forms the backdrop for all of our studies and environmental activities.

In 1938 the first open water discovery occurred in the Creole Field offshore coastal Louisiana. In 1945 President Truman's proclamation, No. 2667, declared the Outer Continental Shelf (OCS) resources everywhere around the United States a national property. In 1947, we had the first discovery out of sight of land in Ship Shoal Block 32. It was also the first well drilled from a mobile platform. Between 1948 and 1950, there were several discoveries of major fields offshore from Louisiana. In 1953, the Submerged Lands Act was passed and so was the Outer Continental Shelf Lands Act, which forms the basis for the federal involvement in oil and gas development offshore. In 1954, one year later, the first OCS lease sale was held off the State of Louisiana, and a sale has been held in the Gulf of Mexico every year since, except the years 1956, 1957, 1958 and 1961.

In 1975, the President and the Secretary decided to accelerate the offshore leasing program to increase the acreage under lease and enhance the opportunity for finding oil and gas. In 1978, the OCS Lands Act was amended. In 1982, the OCS activities of the then Bureau of Land Management and the U.S. Geological Survey were consolidated into the Minerals Management Service.

In 1983 the first areawide leasing offerings were held in the Gulf of Mexico. The current five-year schedule, dated July 21, 1982, displays all of the sales that will be held around the Outer Continental Shelf of the United States. In 1983, the first one in the Gulf of Mexico was in May (the Central Gulf sale). I'll tell you a little bit about the results of that a little bit later. An August sale was in the Western Gulf of Mexico, and an Eastern Gulf was scheduled for November. That's been postponed and at this instant we're not sure when it will be re-programmed, but it appears it will probably be early next year.

In 1984 there are two sales scheduled, one in the Central Gulf and one in the Western Gulf. In 1985 there are three, one in each of the three planning areas. In 1986, there are two, and in 1987 there will be three. By then, however, the schedule will probably be amended.

We have three planning areas in the Gulf of Mexico: the Western, Central and Eastern Gulf. The Central Planning Area, the portion off Louisiana, was the May sale. The part on the western side of the Gulf was the August sale. Those two sales added a substantial amount of acreage. In order to put what's happened in the recent past into perspective, the Western Gulf has 35.2 million acres total. Between 1954 and 1979 we offered 4.62 million acres and leased 2.28 million acres. In the Western Gulf for the period 1980 to 1983, we offered 32.6 million acres and we leased 3.35 million acres. Currently, there are 4.83 million acres under lease.

The total acreage in the Central Gulf of Mexico is 45.1 million acres. For the period 1954 to 1979 we offered 13.8 million acres and leased 6.84 million acres. Between 1980 and 1983 we offered 39.9 million acres and leased 4.98 million. So currently in the Central Gulf there are 10.27 million acres under lease. In the Eastern Gulf for the period 1954 to 1979 we offered 1.71 million acres and leased .38 million. The total acreage in the Eastern Gulf is 59 million acres. In the '80 to '83 period we offered .5 million acres and leased .15 million acres.

The total number of sales we've held in the Gulf of Mexico to date are 48 oil and gas and 5 salt and sulfur sales. A map of the salt domes in the Gulf of Mexico shows that the Central and Western Gulf have the heaviest accumulations of salt structures. We awarded 4,588 oil and gas leases and 61 salt and sulfur leases. The total number of leases that we had in all OCS areas, including the East Coast, the West Coast and Alaska, was 5,994. Seventy-eight percent of all the leases occur in the Gulf of Mexico. The total number of active leases in Gulf waters as of September 1983 was 3,158 oil and gas, 6 sulfur, and 2 salt.

In the Gulf of Mexico to date, there have been 20,967 wells drilled in the Gulf. We currently have 6,514 producing completions. There are 2,878 platforms as of June 1983. Six hundred and sixteen of those have people aboard them; 2,262 are unmanned. We currently have 83 mobile rigs drilling in the Gulf waters. There are 51 platform rigs drilling, and there are 13,525 miles of pipelines presently in place on the Federal waters of the OCS.

How much money did we make? The total bonuses between '53 and '83 was $36 billion. Production totaled 5.682 billion barrels of oil, 59.8 trillion cubic feet of gas, 4.75 million tons of salt, and 15.3 million tons of sulfur.

The annual rentals, minimum royalties, and shut-in payments for the period 1953 to 1983 were $.3 billion. Production royalties were $18.9 billion, for a total income from the OCS Program in the Gulf of $55.2 billion.

For 1982, Gulf of Mexico OCS production was distributed as follows: the Central Gulf produced 94% of the oil, and 6% of the oil came from the Western Gulf. None came from the Eastern Gulf. The Central Gulf produced 80% of the gas, and the Western Gulf produced 20%.

Approximately 6% of the nation's total oil production comes from the Gulf of Mexico and 24% of the nation's total gas. Of the U. S. OCS, we produced about 94% of the oil and 99-plus percent of OCS gas. The

Gulf of Mexico is a rather important place in terms of the national picture.

The following statistics on employment summarizes our development. In federal waters it is estimated that 30,000 people are directly employed on the offshore. There are 54,000 indirectly employed through service companies, et cetera, for a total of 84,000 people, with a payroll of $1.7 billion per year. State and local taxes generated approximates $48.5 million annually.

The system that we've used in leasing oil and gas has evolved over time from a rather simplistic approach to something that's rather complex. Prior to 1967 we had a call for nominations, and everything that was nominated was put into a sale notice. From 1967 to 1971 a new wrinkle was thrown into the process: tract selection. Nominations were evaluated to determine which of those nominated should be offered for sale.

In 1971 the National Environmental Policy Act came into the picture. Between 1971 and 1975 the process got considerably more complex with environmental data gathering public hearings, document drafting, and the final Environmental Impact Statement all required before sales were held.

In 1975 we decided to bring the states and other interested federal agencies into the process, so we began an effort of coordinating with representatives of the Governors and other federal agencies and the sequence became even more complex. In 1977 the concept of coordinating with state government and the private sector was formalized into the OCS Advisory Board; a move that made the system even more complex. From 1977 to 1982 the system operated with a formalized process and increased the opportunities for input from the state and other people. In 1982 we adopted a streamlined process: we no longer have a tract selection, per se; we have nominations of areas and area identification.

I'd like to give you a few statistics from the last two sales, beginning with the May offering, which was the Central Gulf of Mexico sale. The sum of all the bids received was $4.6 billion. The sum of the high bids was $3.5 billion. There were 7,300 blocks offered in that sale, and 39.9 million acres. Six hundred and fifty-six of those blocks received bids, with 3.3 million acres involved in those 656 blocks. We received 1,015 bids at that sale. Seventy-eight companies participated. The highest bid on any block was $92.4 million. To summarize that sale, we ended up accepting 623 bids for a total of 3.1 million acres and a total bonus of $3.4 billion.

The August sale was the Western Gulf. The sum of all bids received was $2.4 billion and the high bids were $1.5 billion. There were 5,848 blocks offered covering 32.6 million acres. We received bids on 436 blocks. After going through the decision process, we accepted and granted leases on 406 blocks, we leased 2.2 million acres, and we collected $1.5 billion.

This quick and sketchy history of the Gulf of Mexico since 1953, especially the recent past, is the backdrop for the studies and Environmental Impact Statement activities conducted in the Region. As you can see, the contribution of this Region to the total energy picture and the importance of this Region in terms of revenue generation for the Government really can't be over-emphasized. With this perspective, our Studies Program deserves prominence.

OCS ENVIRONMENTAL STUDIES PROGRAM

Dr. Richard Defenbaugh
Chief, Environmental Studies Section
MMS, Gulf of Mexico Region

The OCS Environmental Studies Program is important throughout the leasing process, as studies are either generated or their information used.

We find that the information generated by the Studies Program is used, primarily, in the development of programmatic Environmental Impact Statements (EIS) development of environmental profiles for everyday operations, development of lease stipulations, and development of the preliminary draft and final EIS's, as well as the Secretarial Issue Document (SID). There are two places where studies are generated: pre-sale studies gather information for the EIS and other NEPA documents; post-sale environmental monitor studies. We find that studies information is mostly used in EIS's, in development of stipulations, and, after the sale, in permit application reviews.

The MMS Studies Program was started in 1973 when we were part of the Bureau of Land Management with literature surveys and planning for later field studies. The first major field studies were called baseline studies and benchmark studies and began in the Gulf of Mexico in 1974. The period of '74 to '78 can be characterized as the era of baseline and benchmark studies.

In 1978 the program was re-directed as a result of critical reviews by national panels and by the passage of the OCS Lands Act Amendments, which authorized the program and broadly defined three goals for the program. Briefly, these three program goals were to establish a management information base, to develop a predictive capability, and to monitor for significant changes-all with regard to the effects on the coastal and marine environments as a result of offshore oil and gas activities.

Presently we describe the Environmental Studies Program for the Gulf of Mexico as a group of nine studies series. To date we have awarded 85 contracts for studies in the Gulf of Mexico at a total funding level of approximately $48 million.

In the national history of the program, funding hit a high of $50 to $60 million per year during the years of baseline studies, and has decreased to about $30 million per year more recently. The funding history for the Gulf of Mexico has fluctuated. It was higher during the baseline studies, but more recently it runs about $3 million to $5 million per year. Within the Gulf of Mexico funding by planning area also varies, but in general, we have spent about 33 percent of the money in the Western Gulf, 18 percent in the Central Gulf, 36 percent in the Eastern Gulf and 13 percent on Gulf-wide or generic studies.

PROCESSES OF THE STUDY PROGRAM

Studies are planned by a fairly well-defined process. We, at the Regional level, develop and distribute what we call "study profiles." We convene a Studies Planning workshop with the Regional Technical Working Group (RTWG), an advisory group to the MMS. Based on that workshop, we develop a Draft Regional Studies Plan, which is reviewed and critiqued internally and by the RTWG, then is developed into a Final Regional Studies Plan. This plan is incorporated into a national studies list by our Headquarters Office, which conducts reviews, approvals, and budgetary tuning, and ultimately certain studies are approved for funding.

Our procurement procedure is also fairly well formalized. We develop a procurement package in the Regional Office, which includes a draft request for proposals (RFP), a budget, program notifications, etc. This is sent to Headquarters for reviews and approvals. It is processed and eventually is put on the street by our Branch of Procurement Operations as a formal RFP. All of our RFP's are advertised in the COMMERCE BUSINESS DAILY. Anyone who has the experience and expertise and is willing to apply can respond to the RFP's. We receive proposals, evaluate them, negotiate them, and eventually award a contract, and that's when the work starts.

The division of labor to administer the contracts within the Government is fairly simple. Within our office we have a small staff who carry the title of "CORS," (Contracting Officers Representatives), who monitor all technical aspects of the studies from the time of award through field sampling, laboratory analyses, data reduction, data interpretation, report preparation, and close-out. At the Headquarters level we have a Contracting Officer who administers all the business and legal aspects of the contract, and the Headquarters Branch of Environmental Studies staff provides programmatic overview.

At the end of the contract we receive deliverables in a number of formats, both hard copy and computer tapes, and these are all distributed as needed. All reports the program has generated are available through the National Technical Information Service.

That summarizes how we do studies. Let me now, briefly, describe some of the studies we've done and how we use the information.

THE STUDY PROGRAM SERIES

As I said earlier, we categorize the studies into nine study series. The first one, the **Habitat Mapping Series**, consists of three sub-sets or three programs. The first involves revisions of Topographic Bathymetric Maps with a lease grid overlay, which are used for activities in planning and in operations within the agency. In the second sub-set we funded a Geological Studies Program that included a number of basic geological studies and culminated in some very fine regional geological mapping. And the third program the Ecological Mapping Program which combines habitat mapping with biological characterizations to give us an idea of the regional locations of biological communities.

The next series is the **Physical Oceanography Series,** which includes Field Studies and Data Synthesis as well as Circulation Modeling components. Uses of the physical oceanographic information include feeding into our Oil Spill Risk Analysis Program which supports the EIS's. It's also essential for basic marine science and environmental assessment purposes. A number of other users also benefit from these studies.

Next I'll describe eight sub-sets of the **Marine Ecosystems Series.** The first is the South Texas OCS Program, which studies the extreme Western Gulf. This is one of the first of the major baseline or benchmark programs within the Gulf. As I mentioned earlier, these baseline studies were the beginning of our program and were basically comprehensive programs to sample and analyze everything you could think of in the hope that after development we would be able to recognize any impacts which had occurred. We ran into some problems with these programs for a couple of reasons. One was the inherent natural variability of the regions studied and the statistical problem of trying to pin down the degree of impact which might occur. The other was simply management use of the information. As a result of those problems, the program was re-directed and we went to a different study approach.

Another major program is the Topographic Features Program. These were special studies of offshore banks, mostly offshore Texas/Louisiana, along the continental edge. This program included a variety of sampling and analysis efforts, including geophysical studies, studies of the biological communities and studies of currents adjacent to certain banks. Results of these studies have been widely used for management purposes, including leasing stipulations to protect these banks.

As we proceed from west to east across the Gulf, we next have the Mississippi/Alabama Shelf Program. This was initiated this past funding year with award of a contract for what we call the Offshore Tuscaloosa

Trend Area. The first year of this program is data search and synthesis and initiation of a conceptual model to guide future years in the field.

In the northeastern corner of the Gulf we had the MAFLA Program (an acronym for Mississippi, Alabama and Florida). This program has a special place in our hearts because it was the first baseline study ever awarded, and was awarded as a condition to proceed with a lease sale. It was similar to the South Texas OCS Program in scope. We studied everything possible and did all of the analyses we could think of. We have now a thorough set of reports that characterize the study area.

The last area we presently study that's totally on the continental shelf is the Southwest Florida Shelf Area. This study program has been conducted for a number of years now. It is not exactly a baseline study but is somewhat similar in being a broad regional reconnaissance study. There's not, however, the emphasis on replication and sophisticated chemistry that we formerly put into the baseline studies. We have recently changed direction on this program, and are now getting away from regional characterizations into ecosystem processes, hoping to get a better handle on what goes in that area.

The last set of major field ecosystems studies is the Continental Slope Program. The first year's contract for the field study was just recently awarded, and the first cruise is in a couple of weeks. We are fielding these studies in anticipation of interest from industry in the deeper areas of the Gulf of Mexico, the outer shelf and the upper slope, areas including the major salt structures in the Gulf.

Finally, within this Marine Ecosystem Series, we have the General Program, which includes our original environmental and socioeconomic literature survey and a study of polychaete worms-a sort of quality assurance for a biological program. We also have another assurance program, our Quality Control Program, which was very sophisticated trace metal and hydrocarbon analyses to provide quality assurance functions for our baseline programs.

The fourth series, the **Coastal Studies Series,** primarily on Coastal characterization Studies conducted for us by the U. S. Fish and Wildlife Service. They have conducted these studies throughout the entire Gulf of Mexico coastal area. These studies include development of regional bibliographies for environmental and socio-economic information, synthesis papers based on these bibliographies, habitat mapping at a very fine scale, development of ecosystems models and, finally, narrative reports that tell us what it all means. These are all quite important to us for our coastal impact analyses and assessments, especially anything that has to do with land form or land use changes.

Our **Endangered Species Series** includes both literature syntheses and field studies to date. We have some very fine reports available summarizing available information on birds and mammals and turtles; we have done some supplementary field studies, spoting these creatures in their habitat to gather more information on their distribution and occurrence.

Also, during the past funding year we jointly funded, with our Atlantic OCS Office, a study of the effects of oil and gas activities on marine turtles, so we are now getting away from field studies and field observations, into effect studies for these endangered or vulnerable species.

One of the more important series is our **Cultural Resources Series.** We've conducted only one study within this series and now have an agency policy against studies of this sort. The one study funded was conducted by Dr. Gagliano and his associates in Baton Rouge and was done to assess the probability of locations of historic wrecks and prehistoric early human activity sites. This study has resulted in what we call the "yes/no line." If you have a lease landward of that line then, yes, you'll probably have to do a cultural resources survey, and if you're seaward of that line then, no, you probably won't.

We have a **Socio-economic Study Series** which includes our original socio-economic literature survey and some studies on the effects of oil spills on the Texas Coast. And we have, in planning, studies on the social and economic effects of oil and gas activities throughout the Region.

Our **Ecological Effects Series**, which has four sub-series programs, includes synthesis papers and some studies of, for example, effects on reef-fish if you put a platform next to a submarine bank. We've also conducted studies to look at the effects of exploratory drilling and of production platforms in the Central Gulf of Mexico. We've recently completed a modeling study to provide a mud plume (modeling capability both for discharges of mud) from the surface and for sub-surface blow-out discharges, so that we can get a predictive handle on what can happen in that event. We've also funded studies on the effects of oil spills on the environment, especially along the Texas Coast.

The last series is our **Environmental Information Management Series** which has to do with management of all that information once you get it. The goals are basically to manage the information gathered by our agency and other agencies as effectively as possible. We deal with this at three levels.

The first is data management, involving data archival, making data available to other users, and manipulating data for our own uses. Second is a Reports Management Program, which is production of reports and synthesis of available information into synthesis reports. And, finally, the series includes an information transfer function, the culmination of which, for this year, is this meeting.

That takes us through the Studies Program--program history, use of information produced, planning and administrative processes, and a brief overview of the whole program.

PRE-LEASE ENVIRONMENTAL ASSESSMENT PROGRAM

Mr. Douglas Elvers
Chief, Environmental Assessment Section
MMS, Gulf of Mexico Region

The staff of Leasing and Environment would probably not agree with an earlier picture of a fellow sitting on a high stack of publications wondering what to do with all that information. We have worked effectively over the past ten years getting the new information into environmental impact statements (EIS's) and open file reports (OFR's) published by MMS. These EIS's serve as a record of the data which has been collected that has been most useful for assessing the environmental impacts of this program.

Twenty-five EIS's have been prepared serving 32 oil and gas lease sales in the Gulf of Mexico over the past 14 years. We now add to the number of EIS's with 16 OFR's and a host of new environmental maps. Last year at this meeting we had three open file reports available for the public. This year we have prepared a full rack (sixteen) of open file reports and fact sheets. This newly available information uses MMS studies program reports and data that our cooperating federal and state agencies have made available to us, sometimes free of charge. I think many of you will be pleased with what has been done.

In order to keep current with the very active program we have in the Gulf of Mexico, it is necessary to compare the general list of concerns (see Table 1) with the comments of the latest impact statement, the EIS for 1984 Sales (81/84) that will be available on December 5, 1983.

TABLE 1

GENERAL ENVIRONMENTAL CONCERNS FOR THE GULF OF MEXICO REGION

Sensitive Coastal Habitats	Marine Mammals
Sensitive Offshore Habitats	Coastal and Marine Birds
Endangered and Threatened Species	Water Quality
Commercial Fishing Industry	Water Supply
Offshore Marine Recreational Fishing	Air Quality
Major Shorefront Recreational Beaches	Local Economic Conditions
Designated Environmental Preservation Areas	Community Infrastructure
Cultural Resources	Land Use
Tourist Activity/Industry	Shipping and Navigation
Military Use/Warning Areas	Ports and Harbors

From that list of concerns in Table 1 and the comments in the FEIS 81/84, I have selected three concerns that were recently addressed, and we will inspect the anatomy of these issues.

PROTECTION OF SENSITIVE OFFSHORE HABITAT

The first of these three issues is concern over protection of sensitive offshore habitats, typically known as the "biologic banks issue." The most famous of these banks are the Florida Middle Grounds in the Eastern Gulf of Mexico and the Flower Garden Banks in the Western Gulf. There are some 34 or more sensitive banks that have been mapped and investigated over the past ten years for the MMS Gulf of Mexico Regional Office in cooperation with Texas A&M and other investigators. Table 2 shows the anatomy of this area of concern in terms of who commented, impact factors, and the issues at hand.

TABLE 2

ANATOMY OF AN ISSUE OF CONCERN: SENSITIVE OFFSHORE HABITATS

Areas of Concern:	Sensitive Offshore Habitats/FL Middle Grounds Flower Gardens and Other Sensitive Areas
Commentors:	Federal/State/Public/Industry
Impact Factors:	Muds and Cuttings -Anchor Damage -Blowouts Sediment Plumes Oil Spill
Issue:	Protection of Sensitive Biologic Areas from Oil and Gas Impacts a. Remove tracts or keep stipulations in place b. Do specialized studies of areas
	Biological Stipulation Design Review
	"Deletion" Alternatives/Stipulation Options a. EIS b. Lease Offering Notice
	Future Analysis of Impact Factors
	Open File Reports

The use of environmental studies data to map these banks and to inspect their habitat and the health of the biota in the area played a heavy part in the design of protective stipulations for these banks. Figure 1 shows an example of stipulations designed to protect the West Flower Gardens with a "No Activity Zone" for oil and gas operations. The coral maps for the West Flower Gardens show scattered reefs around a complex structure probably caused by collapse of the central salt dome underlying the bank. The East Flower Gardens (Figure 2) is more regular in shape and has apparently not undergone such extensive deformation. These features were mapped with subbottom profiling, side-scan sonar, submersibles, and using modern navigation accurate to 15 meters or better. This is similar in accuracy to modern oil- and gas-related surveys taking place in the Gulf of Mexico network of navigation stations.

The commentors' concern for these biologic areas ranged from urging MMS to maintain the protective stipulations to concern over anchor damage that is presently unregulated and has a major visible impact. Sixteen commentors compiled approximately 60 pages of comments on this biologic issue -- the protection of sensitive offshore habitats.

AIR QUALITY

In comparison, the second area of concern that we will inspect, air quality, had only one commentor -- the USEPA. Table 3 shows USEPA's issues and requests concerning air quality problems.

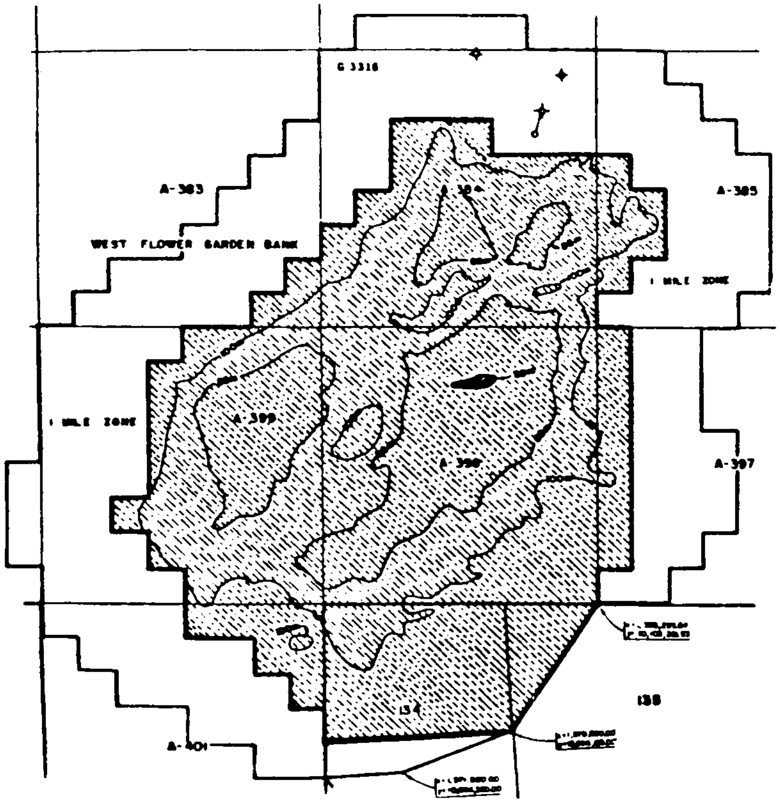


Figure 1. West Flower Garden Bank

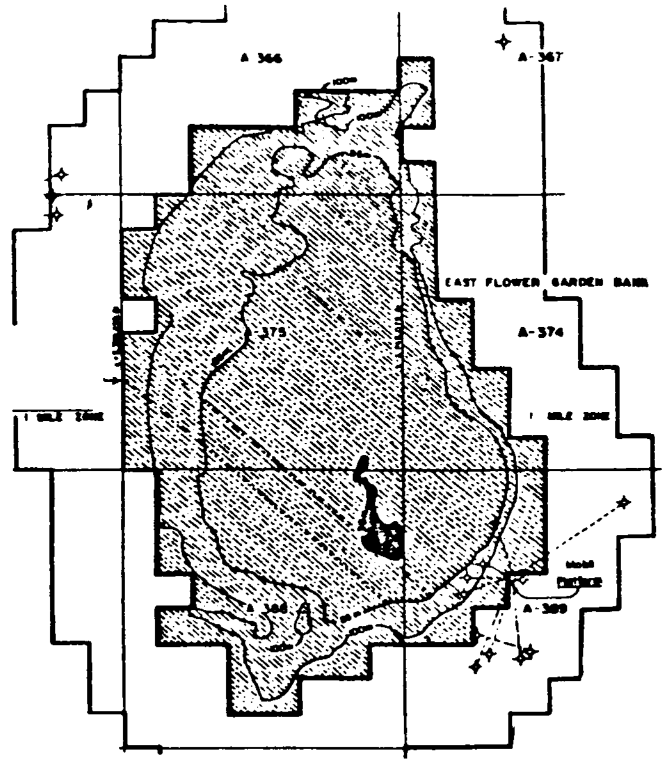


Figure 2. East Flower Garden Bank

TABLE 3

ANATOMY OF AN ISSUE OF CONCERN: AIR QUALITY

Area of Concern: Air Quality Problems

Commentor: Federal, USEPA

Impact Factors:

OCS Air Emissions — Platform, Drilling Rigs

Onshore Air Emissions — Refineries, Other Industry

Refineries — TANKERS

Issue and Requests:

a. MMS monitor the onshore attainment situation.

b. MMS assist coastal attainment objectives now in jeopardy.

c. MMS run USEPA's new Air Quality Model when it becomes available to determine "<u>Cumulative Air Emissions Impact</u>".

d. St. Bernard Parish place OCS NAAQS Information from OCS into State Implementation Plan (Louisiana).

Future Air Quality Studies and Stipulation ??

Future Alternatives/Stipulation Options ??

Future Analysis of Impact Factors

The interesting case here is that we didn't hear a concern from St. Bernard Parish or the State of Louisiana about the area of contention, the impact of air pollution on St. Bernard Parish from offshore operations. You can see Chalmette from the hotel window (International Hotel on Canal Street) and view the air quality problems there. Figure 3 shows the location of Chalmette in St. Bernard Parish in relation to the nearest possible OCS oil and gas leasing and operations. These are some 70 miles to the east of Chalmette in the Chandeleur and Breton Sound Areas and 55 miles to the south in the West Delta Area near Plaquemines Parish.

EPA's concern is caused more by the shape and position of the parish boundaries than air quality, since the air quality problem exists near Chalmette and New Orleans. The parishes are shaped so they extend for miles across open wetlands to the Gulf across areas with no apparent air quality problems. It appears that partitioning of the parishes may be the solution to this OCS air quality conflict rather than extensive and expensive studies as proposed by EPA.

LEASE SALE SIZE

Our third area of concern is involved with the size of the lease sales. We reviewed a number of significant comments from federal and state agencies, the public, and industry on this concern due to the sale of nearly all unleased acreage in the Gulf of Mexico. For this concern the impact producing factors (see Table 4) reach across all factors normally investigated in the EIS process from biology through socio-economics.

A particular concern of Louisiana was the boom in economic activity now with increased leasing and a feared bust later on as activities decline. The request: "Limit the lease offering size to 500,000 acres" was made by the State of Louisiana. Other requests were to keep the leasing program at the present policy so that depressed employment and industry activities have a chance to get back to normal. MMS is

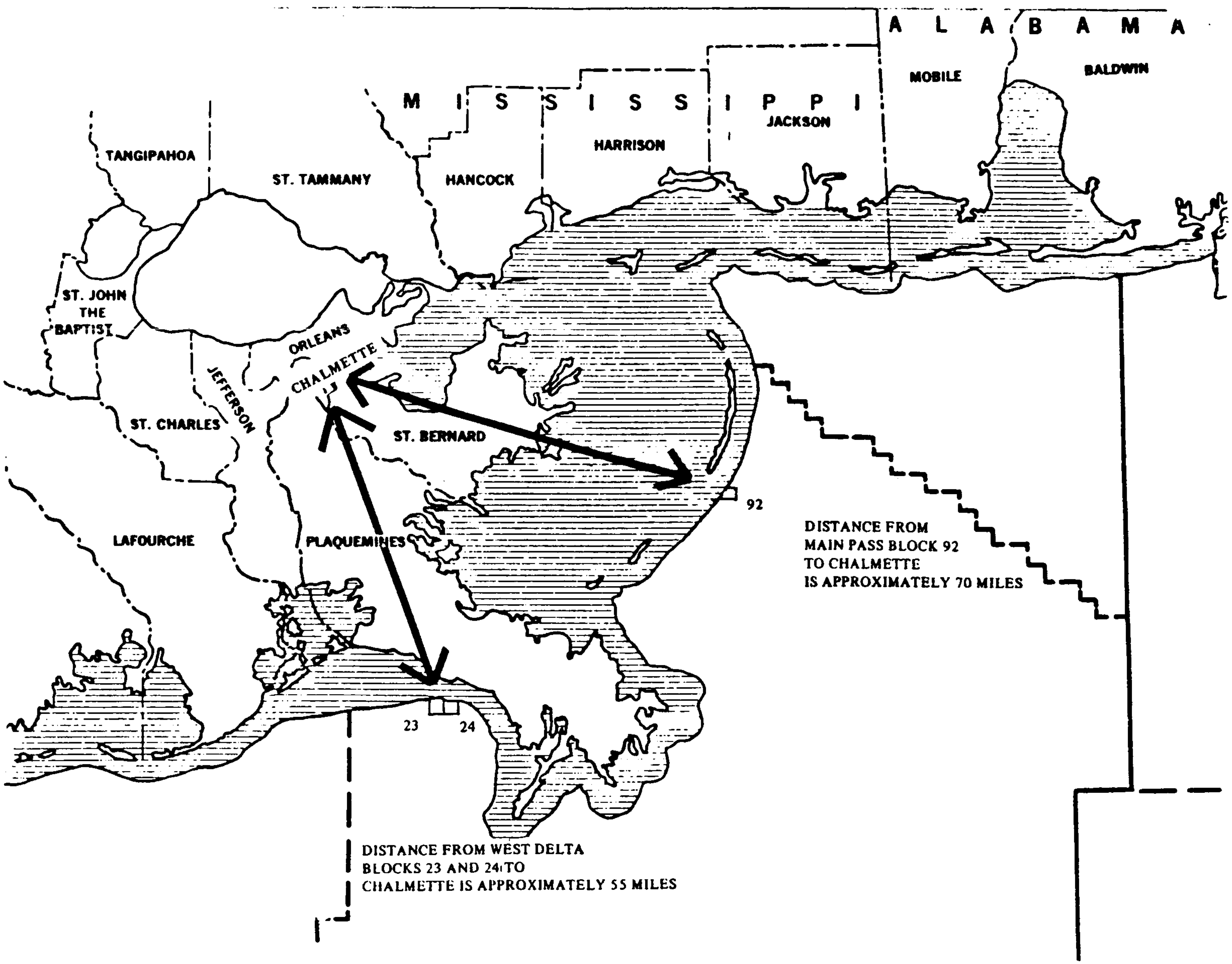


Figure 3. USEPA Air Quality Issue for St. Bernard Parish

TABLE 4

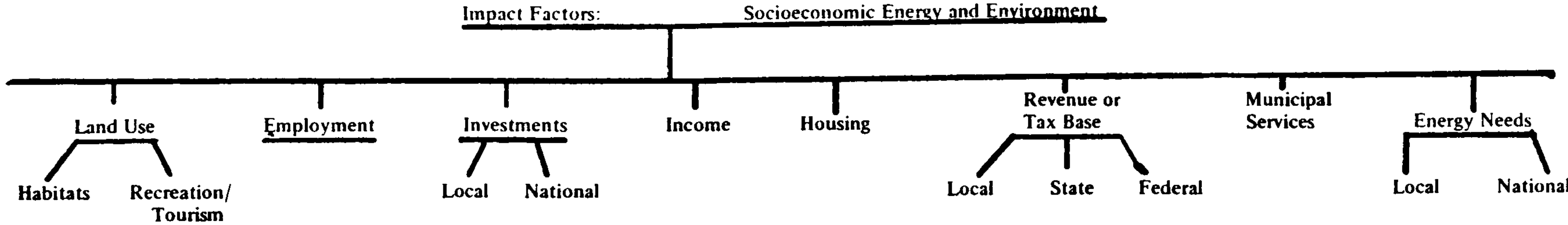
ANATOMY OF AN ISSUE OF CONCERN: LEASE SALE SIZE

Issue of Size of Lease Sales

Commentors: Federal/State/Public/Industry

Area of Concern: Policy on Lease Offering Size/Total List of Concerns on Table S-2

Impact Factors: Socioeconomic Energy and Environment



Issues:
- a. A boom in activity now will create an economic bust in the future./State
- b. Increased leasing is needed for energy, employment, investment, and revenue needs for the national good,/Federal Policy
- c. Environmental degradation will occur at an increased rate,/Public - Environmental Groups
- d. Need for increased activity to bring oil business and associated service companies out of a deep slump./Public and Industry

Requests:
- a. Limit lease offering size to 500,000 acres/year in Central Gulf of Mexico.
- b. Keep the leasing program at the present policy so that depressed employment and industry activities have a chance to get back to normal.

Future Alternative Limiting Offering Size ??

Future Socioeconomic Analysis

Future Environmental Impact Analysis

Future Studies of Socioeconomic and Environmental Effects of Streamlined Leasing obviously going to work on this problem in the future. The studies program will address the needs here for information. My staff will also work on this concern diligently.

In conclusion I will summarize what has happened historically to the OCS program concerning leasing. The FEIS 1984 (Sales 81/84) shows that in the past three years leasing has moved approximately 50 miles farther offshore. One specific effect is that the MMS district inspectors and the industry are now flying or shipping 50 miles farther offshore than they were in 1980. Our studies program is going farther offshore also. We have moved well beyond the high interest area and we're nearly at the base of the moderate interest in the Gulf of Mexico. The question is: What will the next three years bring?

POST-LEASE ENVIRONMENT ASSESSMENT PROGRAM

Mr. Les Dauterive
MMS, Gulf of Mexico Region

The environmental review and assessment record of potential impacts associated with post-lease operation (e.g., geological and geophysical permits, plans of exploration, plans of development and production, and pipeline rights-of-way) is the responsibility of the Environmental Operations Section (EOS). The EOS is one of four sections within the Regional Supervisor's Office for Leasing and Environment. It's work is defined by the Council on Environmental Quality (CEQ). The CEQ regulation for implementing the procedural provisions of the National Environmental Policy Act (NEPA) requires responsible federal agencies to provide a record of environmental review and assessment for actions the agency approves and permits.

Part 1501.4 of the CEQ regulations identifies three classes of actions that require a record of environmental review. The three action classes are:

1. Actions which normally require an Environmental Impact Statement (e.g., Oil and Gas Lease Offerings).

2. Actions which normally require Environmental Assessments but not necessarily an Environmental Impact Statement (e.g., Plans of Exploration and Development in non-mature (frontier) areas of the OCS).

3. Actions which normally do not require either an Environmental Assessment or an Environmental Impact Statement (e.g., Plans of Exploration and Development in mature areas of the OCS).

A large part of the Gulf of Mexico OCS (not the slope) is considered mature in the sense of oil and gas development. Years of environmental operations experience and the extensive environmental data base provided by the environmental studies program has allowed the Minerals Management Service, Gulf of Mexico Region, to adopt the Categorical Exclusion Review (CER) Record. The CER has provided the MMS the means to streamline and avoid unnecessary paperwork and at the same time to fulfill MMS's responsibility of providing an environmental record of potential impacts associated with post-lease operations in the mature areas of the Gulf of Mexico.

Therefore, for post-lease environmental records, a tiering concept is applied. Categorical Exclusion Review determines whether a categorically excluded action represents an exception because of potential impacts associated with such actions. A positive determination requires the preparation of an environmental assessment. The environmental assessment determines whether an action might significantly affect the quality of the human environment in the sense of the National Environmental Policy Act, Section 102(2)(c). A positive determination requires the preparation of an Environmental Impact Statement.

In conclusion, the post-lease environmental assessment program, supported by a multi-disciplinary staff is responsible for the review and approval of surveys and reports related to archaeology, air quality, biology, etc., all of which are part of the post-lease environmental record process.

POST-LEASE OPERATIONS

Mr. Donald Solanas
Regional Supervisor, Offshore Operations Support Group
MMS, Gulf of Mexico Region

Up until a few weeks ago the operations side of the Gulf of Mexico Oil and Gas Operation was called the Offshore Operations Support Group. Now, we've had our name changed and we're called the Office of Rules and Production.

You've heard about the pre-lease studies and the lease sale, and now Jake Lowenhaupt and I will get into the post-lease operation.

Quite a lot of work is carried on by the prospective bidders, their staffs, environmentalists, geologists, geophysicists, and engineers looking toward the big day lease sale that John Rankin holds. After the lease sale, if you were a successful bidder, you spent tens of millions of dollars for which you received a couple of sheets of paper with the Secretary's name and your name on it and rules and regulations that you have to follow. Then your Operations people took over and continued to spend tens of millions of dollars to explore and, if successful, to develop your leases in the Gulf of Mexico.

John Rankin and I work in the same building, and we often talk about the "good old days." Harry Sieverding, earlier in the program, mentioned how it was back at the beginning of the offshore operation. It was simple and easy. The companies would nominate a few tracts out in the shallow area of the Gulf of Mexico because that was the only area for the drilling equipment in those days, about 1953-1954. John would hold his sale. The leases would be awarded and the companies would come in a day or two after the leases were issued by John and the Secretary and present to the U. S. Geological Survey an application to drill. That application was looked at and approved and the operator would move his equipment offshore and drill in 20, 30, 40, 50 feet of water. In those days because of the few leases that were existent, John Rankin had an office for himself and a secretary or a clerk. And we, on the other side of the hallway, had three engineers; a Supervisor, a Deputy Supervisor, and I was the "go-for."

Operations progressed very successfully in the Gulf of Mexico, and now today, in the Minerals Management Service we have some 450 employees. I'm sure that some of the companies feel that at times we are bureaucrats, but John and I would like to say that we're here to assist you to understand the rules and the stipulations that you must operate under in the Gulf of Mexico. I don't consider my staff as regulators; rather, we are your assistants in the development of the natural resources in the Gulf of Mexico.

In my office we begin working with the offshore operator right after the lease sale, and we work with the offshore operator until he abandons his lease, either as a dry hole lease or a productive lease that has come to the abandonment period. This could be five, ten, fifteen, twenty, thirty years of production. All during this time, people in my office are dealing with the operators for the benefit of the resource development. That benefit is not only for the operator and for the Federal Government, who receives royalties, but is mainly for the benefit of the public, who are the consumers of the oil and gas that is developed and produced offshore in the Gulf of Mexico.

My particular function, with my staff, for the Gulf of Mexico is broken up into three sections, mainly engineers or engineering-type people. One section is called Rules, Orders and Standards Section. They assist headquarters in preparing the rules by which the operators must comply offshore and in working with the operators for interpretation of those rules so that the operators can get to their business of exploration and drilling.

Another section is called Plans, Platforms and Pipeline Section. Before an operator can move on to the Outer Continental Shelf after he has successfully purchased a lease, he must comply with the regulation that requires that the operator supply the Minerals Management Service with a plan of his operation -- an Exploration Plan or a Development/Production Plan. This is the kick-off of operations in the Gulf of Mexico. Working together, the operator and our staff develop and adequate Exploration Plan. It is approved in as short a time as we can both work together. We are mandated under the law to approve or disapprove a Plan of Exploration within thirty days after the operator files it with us. So there is no long hassle or bureaucratic delay in the operator moving offshore.

The development plans are more complex because they present plans not only for drilling but also for platform construction and pipeline construction. On these plans, we are mandated under the law to reach a decision within 120 days after the operator files his plan with us. This plan is not merely an engineering plan. It is an environmental plan, also. It shows the Federal Government that the operator has made environmental reviews of his particular lease and believes that he can safely drill and produce on that lease without damaging the offshore environment.

The third section of my staff is called the Production Approval Section. After production is established, this section works with the operators to see that the production gets ashore and is measured properly, that royalty is tendered properly, and that there is no environmental degradation in the Gulf of Mexico or along the coastal areas.

There are over 3,000 effective oil and gas leases in the Gulf of Mexico. I'm sure all of you have read that in the last six months the Department of the Interior has leased 1,000 oil and gas leases in two lease sales. This is going to have a big impact on operations in the Gulf of Mexico for the next five years, as we work with the operators to get them out in the Gulf to drill and eventually to produce. And, of course, the operators will be busy assembling the equipment and getting out and doing the job.

As of today there are 1,300 producing leases in the Gulf of Mexico, and some 8,000 producing oil and gas wells.

In 1978, the regulation on the submission of plans to the Federal Government was expanded, making them more extensive. Since 1978, the operators have filed with us some 4,000 plans of exploration and development and production. We have approved 3,950 of these plans. I think this shows that the operators do comply with the rules and regulations of the Department of the Interior. They are not so difficult or mysterious that an operator must delay his daily operations in order to supply the paperwork and get it approved.

As Harry Sieverding mentioned, there are some 2,900 platforms on the Outer Continental Shelf in the Gulf of Mexico. These platforms up until now have been the conventional steel platforms that you've seen pictures of. Now that leases are being sold in thousands of feet of water depth, these platforms are taking more exotic designs. We have just placed the first guyed tower platform in the Gulf of Mexico. The Shell Oil Company, a few years ago, installed a 1,000-foot water depth platform in the Gulf of Mexico. There are tension-leg platforms which are proposed to be in the Gulf of Mexico in deeper waters. There are platforms on the drawing boards that are floating platforms, that because of the water depth they cannot be installed into the seabed. They must be held on the seabed and will float.

Drilling has been in thousands of feet of water depths. Production is only at the thousand-foot water depth. As the leases are developed and produced in thousands of feet of water depth, there will be many more sophisticated systems to get the production to shore. Operators are working on this and, of course, we'll be working with the operators. There are 14,000 miles of pipeline offshore in the Gulf of Mexico bringing production to shore, and as the leases proceed farther offshore, there will be many more pipelines and larger pipelines.

Together with our regulatory work, it is necessary for my staff to get offshore to inspect these operations. We inspect the platform and the pipeline installations and investigate accidents which occur offshore.

When there are injuries or accidents offshore, the accident reports are submitted by the operators and are reviewed by my staff. If it is considered that the cause of the accident could be a problem for other operators offshore, we publish an OCS Safety Alert, which discusses the accident. It does not name names or places; it simply describes the significant part of the accident and makes recommendations or discusses what the operator will do so that he will not have a recurrence of the accident. This has been a very successful alert program, patterned after the Federal Aviation Authority's program on airplane accidents and problems.

Jake Lowenhaupt, the next speaker, will talk about a more extensive inspection program on a day-to-day basis with a much larger inspection force.

ENFORCEMENT PHASE OCS INSPECTIONS PROGRAM

Mr. Jake Lowenhaupt
Regional Supervisor, District Operations
MMS, Gulf of Mexico Region

As a representative of District Operations, which used to be Offshore Field Operations, I want to talk this morning about organization, drilling and production, safety, and pollution control, and I'll show you some of the details we deal with. [Much of Mr. Lowenhaupt's presentation depended on an extensive slide show.]

Our organization has five districts with approximately 15 to 18 people in each district. We have offices from Metairie to Lake Jackson, Texas. And, of course, as everybody has said, we're spreading farther and farther offshore all the time. Our district takes the paperwork that comes in on plans of exploration and development and on permits to drill, and they look at these things. The District Supervisor is supported by a drilling engineer, a geophysicist, and a geologist. So all the paperwork on drilling gets a pretty close look. And when we get into production, we have a production engineer.

The main thrust of our organization, however, is the drilling unit and the production unit, each headed by a chief technician whose unit technicians go offshore by helicopter seven days a week. Each Drilling and Production Unit has at least three technicians that go offshore. These technicians fly about 480,000 miles a year, and this increases every year. We inspect over 2,800 production structures and we have about 225 drilling rigs.

The top five winning bids in the big May Lease Sale, the top per acre bid, and the five most competitive bids show how we are expanding offshore. Seven of these are outside of the 600-foot contour. This is a change over the years.

While a jack-up rig is under tow, it's under Coast Guard jurisdiction. Once the rig is in position, then it's our responsibility. [Slides show various rigs and drill ships.]

Now we get into some of the things we inspect. Slides show blow-out preventors to illustrate what the technicians look at. These blow-out preventors at the driller's console can be activitiated, if necessary. The driller's console has gotten markedly more complex over the years. He's got pit level indicators for the mud pits, and he's got gas detector indicators. He's got all kinds of things besides the normal drilling operation.

Another slide shows an inside blow-out preventor or a drill string safety valve. By turning the valve 90 degrees, a man can close off the flow. Some safety changes are easily seen. A 1957 picture of a fairly large platform shows very small legs on the platform. A newer production platform has legs that are canted out slightly and a little bigger production facility.

The companies have emergency shut-downs on the platforms at remote locations so that they can be shut-down. If you have a big problem, you are able to shut in the wells and cut off the flow. As the pipelines come into a platform, there are valves that would close off the flow in case of an unwanted event. All elements in this valve system have a requirement for being taken out and tested. [Additional slides show variations on safety and pollution control devices.]

Our technicians test some of the equipment using a pressure sensing device. Our technicians run tests on all of these types of devices and , obviously, this is not the way to win a popularity contest. When we find something wrong, the companies are often written up.

Personnel safety falls more in the purview of the Coast Guard, but we have an interest in safety for the protection of the operation. If the operation is safe, then the people also will be safe. [Slides show unworkmanlike operations.]

We do have requirements for life jackets and fire fighting system, dry chemical or for a sprinkler system, which is tested weekly. [Slides show safety systems and firefighting scenes.]

Statistics we've gathered on some causes of fire and the blow-outs having to do with completions have resulted in some suggestions. Engine fires were further analyzed and diesel engines were found to be a problem. In that regard there's been a recommendation of a change of regulation to have an automatic shut-down on diesel engines. Another statistic on completions and work-overs is noteworthy, and we have a proposed order in that direction to improve on safety of operations.

Our technicians do most of their inspecting during the summer time, but even in winter time they must go out. In December, over 150 inspections on the drilling side and over 100 on the production side were conducted.

MOLLUSKAN FAUNA OF THE LOUISIANA CONTINENTAL SHELF

Dr. Emilio Garcia
University of Southwestern Louisiana

Perhaps my first statements will be rather redundant because many of you are so well-acquainted with the structures off the coast of Louisiana. The bottom of Louisiana's Gulf waters is mostly muddy, and this presents a problem for the molluskan fauna because the majority of the species cannot live in this habitat. The Mississippi River and others bring abundant nutrients to Gulf waters. However, because of the type of bottom that we have, only some very special species of mollusk could inhabit it.

The structures, platforms, pipes, et cetera, attendant to offshore drilling have created an environment that has allowed quite a number of species that were not known before from these waters to flourish. The platforms have created a hard surface for the growth of algae for those mollusks who feed on it; a hard surface for a number of bivalves that need that hard surface to survive. And with the existence of these bivalves, their predators have come along to feed on them. As you can see, if it weren't for the original hard surface provided by the Gulf structures we wouldn't have any of the other.

Here, in one of these platforms, you can see a lot of gooseneck barnacles. Together with them you see a great variety of molluskan fauna, such as this gastropod called *Thais haemastoma*. It is a predator, and if you look right behind them you see the whole structure covered with a type of clam that is probably the most common of them all; it's called *Chama congregata* and serves as food for a number of other mollusks in the chain. A close-up of them shows two species: the *Chama congregata* and *Chama macerophylla*, commonly called "jewel boxes." They come in a variety of colors and their spines serve not only as protection but as camouflage.

Another new inhabitant is called a spiney oyster, but its not at all related to the oyster. Its scientific name is Spondylus americanus and it is an extremely beautiful shell. Again, it would not be nearly as abundant in Louisiana were it not for the platforms. A picture of a spiney oyster with a Chama congregata growing on one of its spines shows how these species compete for hard surface in order to survive.

The spiney oysters of Louisiana are very distinct from those in Florida because they grow on a flat surface, while those from Florida usually live in coral reefs, wrecks, et cetera. In Louisiana they have to create a very flat bottom valve in order not to be dislodged. The bottom valve may even take the shape of the surface on which it grows. Those that grow inside empty pipes are the most spectacular because they are so well protected that they develop a great amount of spines. And they, of course, are much safer from predators there. One spectacular Louisiana spiney oyster measures about ten inches, which is really unusual. For some reason we, in Louisiana, have larger than average specimens of a number of species.

Right next to the platforms the environment is very good for the survival of mollusks. Here you have a type of scallop called Lion's Paw or Lyropecten nodosus. We have a number of fantastic scallops that live off the Louisiana shores, although they camouflage themselves very well. They have to depend on their camouflage for survival. A slide contrasts the living specimen and the clean shell. Of course, it's edible but it's rather rare so you cannot very well do it commercially.

Another scallop that lives abundantly off the Louisiana shores is Pecten muscosus. It has quite a variation of colors and in certain times of the year you find them here by the hundreds. One more type of scallops, Pecten glyptus, is a very rare shell, but it can also be found near the platforms at depths of about a 100 or 150 feet.

A catch out of a dive shows how rich the molluskan fauna is. You can see some Lion's Paws, some of the spiney oysters, a Rock Shell, or a Murex, and the little shiny cowries or Cypraea.

Among abundant algae growth, you might see Latirus infundibulum, one of those gastropods that feed on all of those other little shells. They have been found on just little pieces of pipe showing through the mud; and growing on top of them some more shells, because, again, they need that hard surface.

This shell is called Cypraea cinerea or gray cowry. Cowries are well known for their shiny surface. Most people think they have been polished or varnished, but this is natural. The animal has a membrane, called the mantle, that covers the shell most of the time and keeps it shiny. Louisiana has three species of cowries. This is one of the most common. The Yellow Cowry, Cypraea spurca, is also very common, but you have to hunt for them because they like dark places, particularly inside pipes. A line runs right through the middle of the shell. That is where the two lobes of that mantle, that membrane that keeps the shell shiny, meet.

The Deer Cowry is the largest known species of the family. In Louisiana they have collected specimens as large as seven and a half inches. Again, they prefer the inside of pipes or holes in the platforms and go forging at night. They are algae feeders.

One of the largest predators: Murex fulvescens may be the cause of many of the empty shells you find. It is a very common species in Louisiana. In the same family of shells, the Murexes, is the beautiful Murex beaui, not very common in Louisiana. The Murex hidalgoi is a very rare species in Louisiana. The Murex florifer, or lace murex, is a rather common species and a proficient predator. The Murex bequaerti is very rare; this you will not find but in about 300 to 400 feet of water.

Another family of shells called Volutes are not found on the platforms themselves, but crawling about the bottom. They are called Voluta junonia. Volute, Voluta dubia, a very interesting Louisiana shell, lives in about 70 fathoms of water. It was adopted by the Louisiana Malacological Society, the Louisiana Shell Club, as its emblem because of its rarity and its beauty.

The shell family of cones are well-known to divers because they can inflict serious injuries. They are poisonous, and certain species have been known to kill humans. Those from Louisiana, however, have never caused any harm. The animals of this family generate a neurotoxic substance that is injected in its prey or enemy. This very interesting cone is Conus ermineus. Typical specimens are also found in other parts of the Atlantic and the Caribbean. Others, somewhat narrower and very different in coloration, are Louisiana shells collected in about 100 foot of water by SCUBA divers. Normally they grow to two inches. The Louisiana specimens are about 3 1/2 inches.

Conus elarki, as far as I know, has been found only in Louisiana or very near it. It doesn't live in very deep water, only in some 40 feet of water. Another one of those species that sneaked into Louisiana is a very typical Caribbean cone shell: Conus Mus.

The Architectonica nobilis is a very interesting shell, very primitive. It feeds on algae and is usually associated with sea pansies. The structure of the umbilicus gives it its name Architectonica.

Amaea mitchelli is known as Mitchell's wentletrap. For many years everyone thought Texas was the geographical center for this species, but in the last few years it has been found alive and well living in Louisiana waters in about 17 fathoms.

This specimen of Tellina magna is about five inches long. This slide shows a little hole on the left valve. This is what many predators do. They have a series of teeth called radulae. Together with the teeth and a substance they secrete they soften the shell, which is made of concholin, and bore a little hole sucking the animal right through or killing it and then opening the valves. You will see that hole in many shells you find on the beach.

An extremely rare, very deep water, shell related to the scallop is Amussium dalli. This comes from about 1,200 feet of water. You can see how fragile the shell is.

Gaza superba. When you find this shell alive it glows with a beautiful iridescent green. It likes mud, so it does not need the hardness of the platform for survival. It is a very primitive snail.

This is a Pleurotomella species from a family of shells called turrids. It belongs to a group of families of mollusks that have come into existence in recent geological time. They are distantly related to the cones you saw earlier. This exquisite deep water turrid is Cochlespira elegans, a rare species.

We really don't know very much about the behavior of the living mollusk. Perhaps in the near future we will have a better understanding of this fascinating phylum with the help of many SCUBA divers who are becoming interested in it.

Session:	RECENT PROGRESS IN PHYSICAL OCEANOGRAPHY
Chairman:	Dr. Murray Brown Minerals Management Service
Date:	November 15-17, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Dr. Murray Brown Minerals Management Service

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MMS/Gulf of Mexico/Physical Oceanography Program	Dr. Evans Waddell Science Applications, Inc.
First Results from the MMS Current-Meter Array on the West Florida Shelf	Dr. Tony Sturges Florida State University
MMS Remote Sensing Element/FIO Program Report	Dr. Fred M. Vukovich Research Triangle Inst.
The MMS Drifting Buoy Program in the Gulf of Mexico	Dr. James K. Lewis Science Applications, Inc.
Gulf of Mexico Coastal Zone Color Scanner Studies in 1983 by the National Marine Fisheries Service	Mr. Thomas D. Leming NOAA/NMFS/SEFC Mississippi Laboratories
Florida Current Research	Dr. George A. Maul Atlantic Oceanographic and Meteorological Laboratory, NOAA
Miami Satellite Field Services Station Operations	Dr. Steven Baig Nova University

PART II. REPORTS FROM OTHER PROGRAMS

RECENT PROGRESS IN PHYSICAL OCEANOGRAPHY

PHYSICAL OCEANOGRAPHY SESSION OVERVIEW

Dr. Murray Brown
Minerals Management Service

The National Science Foundation is interested in what we're doing in the Southwest Florida Shelf Area, and it's possible that they might be supplementing our current meter arrays with an additional two current meter moorings near Tampa.

The Minerals Management Service itself is going to have to go deeper in that area because it looks like we're not picking up enough Loop Current signal from our deepest moorings. So we're probably going to go out somewhere around 3200 meters.

The satellite data is really helping and so far it looks like understanding what sort of data we get from the current meters out there is greatly aided by knowing what the top of the water column looked like. The correlations are really excellent.

We're particularly pleased that the Florida Institute of Oceanography has indicated that they would like to enter into a data sharing arrangement with us. They have a Physical Oceanographic Program in the same area, and we're going to set up a Ship-of-Opportunity Program with them. Their data sets, by the way, very greatly complement our own efforts.

The buoys that we've been dropping out there in the Gulf are giving us good results, and several major publications are due to come out from the first set of deployments.

Coastal Zone Color Scanner data is giving very good results in the coordination and planning of hydrographic studies. In fact, anoxic or hypoxic events on the Louisiana Shelf are now reliably predicted by Coastal Zone Color Scanner data.

A program on the east side of Florida called the Sub-Tropical Atlantic Climate Study (STACS), funded completely by NOAA, is going to give us very good boundary conditions for the water masses exiting through the Florida Strait. There is a NOAA data set we've located from the Yucatan Strait that we might incorporate into our own data base, if discussions with the sponsoring agency work out.

It's particularly noteworthy that a recent hydrographic data base analysis completed by George Maul at the Atlantic Oceanographic Meterological Laboratory gives good relative magnitude and general aerial comparison with the Hurlburt-Thompson Model from NORDA.

The GERAF Program broadcasting out of Mobile continues to give good useful products. Their sea service temperature mapping product is no longer available, but the Loop Current analysis from the Satellite Field Service Station in Miami is excellent, and we certainly use it in our own cruise planning.

The National Marine Fisheries Ship-of-Opportunity Program is beginning to utilize a satellite hardware system that allows you to get near-real time, XBT data, and we're considering doing the same thing for the line that we co-sponsor with them in the Gulf of Mexico.

A special presentation on the present state-of-the-art in modelling at the shelf/slope interface told us that much has been accomplished in frontal modelling, but we're certainly not at the point where we can interface deep ocean models with shelf models yet. However, the Minerals Management Service Program, which will probably be going on for another four years in the deep Gulf, is on time. When we finish the Deep Gulf Modelling Program, the state-of-the-art will be such that we'll be ready to try to use these deep Gulf results in providing boundaries conditions for shelf modelling.

At the Waterways Experiment Station in Vicksburg, Mississippi, the Corps of Engineers has added a new laboratory, the Coastal Engineering Laboratory. They'll be doing much of the physical oceanography work up there, but the hydraulics laboratory is also very active in estuarine work and a great deal of data and reports are available via their catalog that perhaps many of you who are active in physical ocaeanography are not aware of. We've certainly been able to obtain good data from them.

The NORDA Geosat Program will probably begin in late 1984 with an 18-month geodetic mission, to be followed with a repeating orbit mission for oceanographic purposes, in cooperation with the Minerals Management Service. The Hurlburt-Thompson/Jaycor Model is a cornerstone of that cooperative effort.

At Texas A&M University a rather elegant tidal model has just been completed for the Waterways Experiment Station by Professor Reid.

At NORDA, frontal studies have just begun with an in-depth workshop, and the agency has received a mandate from the Joint Chiefs of Staff to lead the national military/technological establishment in frontal and eddy studies.

The Minerals Management Service is presently releasing the results of a modelling effort for the West Florida Shelf done by New England Coastal Engineers, a modelling effort for the area out to about 200 meters depth which will be incorporated into our oil spill risk analysis exercises.

At NOAA the Ocean Assessments Division has begun an ambitious effort to model pollution loading in the Gulf. One essential input to that effort, of course, would be a dynamic model that could better simulate actual water motions in the Gulf of Mexico.

NSF, again, has recently funded two modelling efforts relevant to the Minerals Management Service activities in the Gulf. These efforts are taking a closer look at the activities of eddies, particularly when they reach western boundaries currents, activities closely related to the Hurlburt-Thompson model at NORDA.

At the National Data Buoy Center they have ambitious plans for a program called TOGA starting in 1985, wherein they'll keep a resident population of drifting buoys in U. S. coastal waters, perhaps five or six in the Gulf of Mexico.

At Louisiana State University work continues in four general areas: a suspended sediment transport effort, particularly offshore the Atchafalaya Delta Region; frontal work, particularly where river water meets the sea in the near-shelf Region. They are re-examining the old National Marine Fisheries hydrographic data from the Louisiana-Texas Shelf. The Minerals Management Service has recently provided cooperative funding with the Office of Naval Research for current meters offshore the Mississippi River operated by Bill Wiseman.

I think that the most notable accomplishment of the whole meeting, aside from the very excellent presentations which are hastily summarized here, is the fact that we were able to obtain the cooperation of a number of folks from industry. Perhaps one of the brightest signs for physical oceanographic progress in the Gulf of Mexico is the fact that industry scientists are very interested in cooperating with us and we're beginning to generalize some plans for cooperative data compilation and modelling work, perhaps in the framework of 1985 through 1987, involving industry.

I really enjoyed working here in this Information Transfer Meeting this year and I think that the Physical Oceanographic Workshop was a total success, once again.

PART I: MMS PROGRAM REPORT/ INTERAGENCY ADVISORY GROUP REPORTS

MMS/GULF OF MEXICO/PHYSICAL OCEANOGRAPHY PROGRAM

Dr. Evans Waddell
Science Applications, Inc.

In October of 1982, Minerals Management Service initiated a multiyear physical oceanographic (PO) program in the Gulf of Mexico with a twofold objective:

1. Establish a data base that supports both an observational program as well as some of the requirements of a concurrent MMS-funded numerical circulation modeling program,

2. Synthesize these data to develop a clearer understanding and definition of key circulatory patterns and associated physical processes.

Results of this study and the associated numerical modeling should provide a rational basis for management decisions relating to OCS oil and gas exploration and development, such as risk and impact assessment, operational procedures and standards, and transportation. The general approach and many elements of the present program design originated with a BLM workshop convened and supported by BLM in May 1981, which brought together scientists (observationalists and modelers) with recent or relevant experience in the Gulf of Mexico.

The measurement portion of the MMS/Gulf of Mexico/PO study has the following phased regional emphasis:

- Years 1 & 2: Eastern Gulf/Loop Current
- Year 3 : Eastern Gulf/Western Gulf
- Year 4 : Gulf wide

Program elements or tasks during Year 1 include the following:

Subsurface currents/temperature/pressure - Periodically maintained mooring arrays were deployed in January 1983 along a cross-isobath transect extending from the 75 meter isobath seaward to 1700 meters depth offshore of Charlotte Harbor, Florida (26° N). One additional mooring was placed on the 180 meter isobath off of St. Petersburg.

Regional Hydrography - Two cruises have been conducted (March and November 1983) to document temperature, salinity and nutrient distribution in the eastern Gulf.

Satellite Imagery - Daily thermal imagery is obtained during fall, winter and spring (approximately October - June) to define the spatial sequential distribution of the sea surface temperature field which is often closely linked to the regional/Loop Current circulation patterns.

Surface Drifter - Satellite tracked drifting buoys with 200 meter thermistor strings attached were released in Loop Current eddies (2/year). Results of analyses help develop better kinematical and dynamical description of these gyres, which have a very important influence on circulation in the deep portions of the central western Gulf.

Ship of Opportunity Program (SOOP) - The SOOP involves placing equipment aboard a commercial vessel that "reoccupies" a transect of interest on a regular schedule. At regular intervals the ship's crew releases a probe (XBT), which documents the vertical profile. At present, such a transect is maintained between New Orleans and the

Yucatan Straits every 10 to 11 days. In addition, NOAA/NMFS maintains a SOOP line between the Dry Tortugas and Galveston, Texas, every 15 days (approximately). As opportunities arise, e.g., AOML cruises, XBT's are provided to other programs and the resulting data is available to this study.

The above program is managed by Science Applications, Inc., which is also responsible for data management and analyses. Data synthesis and interpretation is done by scientists from various universities and research laboratories as well as from SAI.

Year 2 of this program will expand the subsurface measurement program in the eastern Gulf with the addition of moorings at 40 and 3200 meters depth along the Charlotte Harbor transect. Data from the shallower mooring will better relate shelf-break circulation to that occurring on the shelf proper. The deeper mooring is to provide a more consistent (as compared to the 1700 m mooring) documentation of the Loop Current and related features. In Year 2 a regional hydrographic cruise will involve combined ship and airborne observations. Air deployable XBT's will be used to rapidly document the diagnostic eastern Gulf/Loop Current thermal field. The ship (R/V Cape Florida) will quasi-synoptically sample subregional features more intensively. In addition, the ship will use an Amatek-Straza system to measure current profiles in the upper portion of the water column.

Satellite imagery in Year 2 will be a continuation of Year 1. The drifting buoy program will probably be altered so a larger number of less comprehensive buoys (no thermistor string) will be released and tracked to identify key circulation patterns.

In Year 3 similar types of observations will be made according to a plan that has been defined generally. The goal is to make measurements that document the kinematics and dynamics of Loop Current eddies in the central and western Gulf both in deep/water and as the ring interacts with the continental slope. Program elements in Year 3 include subsurface current measurements ($\sim$ 5 moorings) on the slope on the western basin margin. Locations of moorings will depend on expected eddy trajectories. Two hydrographic cruises will be made on a "fast response" basis to document water mass and the density field associated with Loop Current eddies and related features. One cruise will probably measure conditions in deep water and the other as a ring abutts and interacts with the continental slope.

Satellite imagery will help describe the eddy evolution as indicated by the sea surface temperature field as well as help track the eddy in support of hydrographic and subsurface current measurements. Surface drifters (possibly 4-6/year) will provide information on trajectories of surface-constrained, "tagged" water parcels. Analyses of these data will provide a better understanding and description of ring kinematics and dynamics. The buoys will also help define circulation in the central and western Gulf when no rings are present and provide assistance in locating rings in summer when an absence of sea-surface temperature gradients make it impossible to use remote thermal imagery.

The SOOP is expected to continue through all program years. It is hoped that in Years 2 or 3 an additional transect between New Orleans and Tampico/Vera Cruz can be added to those presently maintained.

Year 4 is to involve many of the same measurements, such as selected current measurements; however, there will probably be a substantially expanded emphasis on several quasi synoptic "pictures" of the conditions and circulation in the deep Gulf. This effort will be closely coordinated with programs funded by several other federal agencies. A Year 5 may be necessary to allow time and support for a complete integration of results from all of the prior program years.

In support of this multiyear effort, the Environmental Studies Staff in the MMS/New Orleans office continues to encourage and seek cooperation with other studies and government agencies. This has resulted and continues to result in cost effective observations being available to support the MMS objectives. Several such cooperative efforts are presently in place, e.g., Louisiana State University, NOAA/NMFS, State of Florida, and NOAA/AOML.

FIRST RESULTS FROM THE MMS CURRENT-METER ARRAY ON THE WEST FLORIDA SHELF

Dr. Tony Sturges
Florida State University

Current-meter data are available from the first 6 months of a two-year array. Three moorings are in a line across the shelf near 26°N, at depth of 75 m, on the shelf; 180 m, at the shelf break; and 1700 m, on the slope. Another mooring is at the shelf break 150 km to the north. The data begin with Jan. 83.

The edge of the Loop Current was inshore of the deepest mooring for two weeks during February. Speeds of 1 knot were recorded at 172 m, the upper-most meter. Similar speeds were observed there during March when a large filament from the Loop Current came over the mooring.

Each record is dominated by the presence of eddy-like features. Some low-frequency "events" are seen only a few times in the records. These large events are the main contibutors to the variance, which is as great as 500 to 700 $(cm/sec)^2$ at some locations.

At resolvable periods, the records show a concentration of energy in the motions near 8 to 15 days. These are coherent in the long-shore direction, but there is very little phase shift over the 150-km separation between the moorings. It seems likely that both moorings are near the source of the forcing. Between the slope and the shelf break, the 8- to 15-day motions are coherent. Between the shelf break and the 75-m mooring, however, little coherence is found, and none in the wind-driven band of 4 to 10 days. Several different mechanisms can contribute to this effect.

The mean values determined from these records have little, if any, significance, because of the high eddy energy. The fluctuating components of the velocity can be compared, however, in different frequency bands. The 40-hr low-passed variance in the records contains 40% of the total, in the onshore component, and 55% in the along-shore component.

The motions tend to be barotropic. However, at the 75-m mooring the current meters at 30 and 60-m are not coherent in the wind-driven band. One reason for this surprising result appears to be the presence of isolated patches of Loop-Current water that break off from time to time and come onto the shelf.

At the upper offshore mooring, the u'v' term has a large negative value, just as found inside the Gulf Stream. Brief excursions as large as -1500 $(cm/sec)^2$ are seen.

MMS REMOTE SENSING ELEMENT/FIO PROGRAM REPORT

Fred M. Vukovich
Research Triangle Institute

Sea-surface temperature analyses using NOAA/AVHRR data were combined with hydrographic and current meter data to study perturbations on the eastern boundary of the Loop Current off the West Florida Shelf in the period March through May, 1983. There were three sources for the hydrographic data: ship of opportunity data, data from the MMS field program, and data from a field program held by the Florida Institute of Oceanography. The current meter data were obtained from an array off the West Florida Shelf that was maintained for the MMS Gulf of Mexico study.

Three cold-core perturbations were noted during the period, two of which were documented in some detail. The current meter data and the calculated geostrophic currents indicated strong southward motion on the Loop Current side of the perturbation and strong northward motion in the warm filament on the shoreward side of the perturbation. The warm filament developed as a result of the cyclonic circulation that was associated with the perturbation. The two principal perturbations appeared to coalesce, creating a large protrusion that nearly linked the eastern boundary of the Loop Current with the western boundary, and separating a warm gyre, from the Loop Current. At the same time the apparent coalescence occurred, dramatic mixing occurred on the West Florida Shelf. Prior to the coalescence, the isotherm pattern on the shelf demonstrated steadily decreasing temperatures toward the Florida coast. After the coalescence, the temperature pattern on the shelf was characterized by isolated lenses of warm and cold water. Some of the warm lenses had temperatures similar to that found in the Loop Current; these may have been remnants of the warm filament associated with the first perturbation. One particular warm lens moved toward the northern coast of Florida and eventually dissipated. The large cold-core perturbation that was a result of the hypothesized coalescence moved southeastward towards the Straits of Florida. As it moved, it began to break up, and portions of it were entrained into the Loop Current. In about two weeks, the cold core perturbation was entirely dissipated.

THE MMS DRIFTING BUOY PROGRAM IN THE GULF OF MEXICO

James K. Lewis
Science Applications, Inc.

PROGRAM HISTORY

In November 1980, the NOAA Data Buoy Center (NDBC) deployed three TzD buoys in a warm core ring which had been shed by the Gulf of Mexico Loop Current. The drifters were deployed at approximately 24 30' N and 92 W, and the ring was tracked until mid-June 1981. During this period, the ring had migrated up against the 1800 m bathymetric curve off the coast of Mexico (Fig. 4).

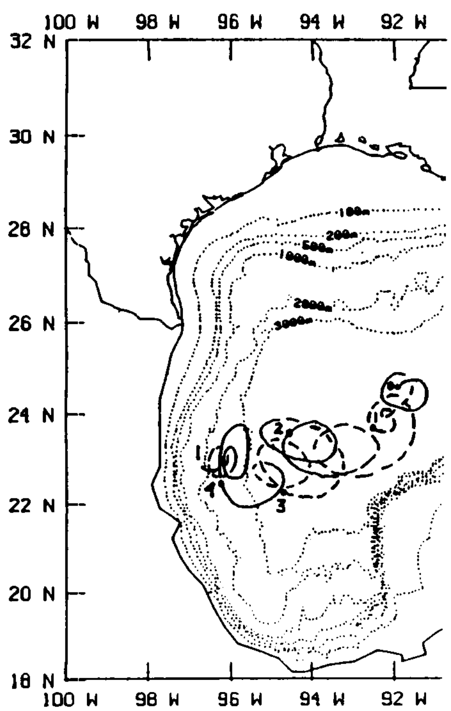


Figure 4. Trajectory for Buoy 1599 Seeded in a Ring on 20 Nov 80 (0 location on trajectory). The location/time legend is 1 for 20 Dec 80, 2 for 20 Jan 81, 3 for 20 Feb 81, and 4 for 20 Mar 81.

Since the drifters tracked the ring for such a long period, their trajectories contained a considerable amount of information on the currents and horizontal velocity gradients that existed in the ring. These features are important considerations in the design for buoy array dispersion measurements in the open ocean since rings can transport large volumes of mass over long distances. NDBC and the MMS supported research to determine the kinematic characteristics of the ring from the drifter trajectories. This research led to the development of a new technique for computing vorticity, divergence, normal deformation rate, and shear deformation rate using only one drifter. The procedure also provides estimates of ring translation rates and ring geometry.

Subsequent deployments consist of a Loop Current ring seeded by one buoy on 6 October 1982 (drifter 3374) and an eddy seeded by one buoy on 22 July 1983 (drifter 3375). Drifter 3374 remained in the ring until July 1983, well after the time the ring hit the Mexican coast. Drifter 3375 showed rotational characteristics for only a short period and then began drifting south. The drifter eventually came under the influence of the ring along the Mexican coast.

PROJECT STATUS AND RESULTS

Trajectories for the various drifter deployments are shown in Figs. 4-6. The paths of the drifters in the rings coincide with one another, and the rings are seen to be relatively persistent after colliding with the Mexican coast. The persistence of an anticyclonic eddy after interacting with the bathymetry of a shelf has been observed in recent numerical experiments and is attributed to dynamics which cause an anticyclone to move offshore as it reaches shallower water. This supports the contention that the anticyclonic pattern that has been observed so often in the western Gulf of Mexico is the result of rings from the Loop Current.

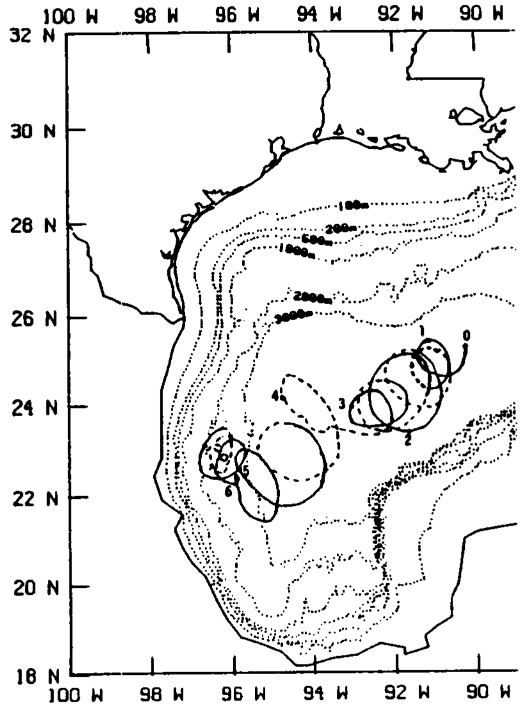


Figure 5a. Trajectory for Buoy 3374 Seeded in a Ring on 6 Oct 82 (0 location on trajectory). The time/location legend is 1 for 15 Nov 82, 2 for 15 Dec 82, 3 for 1 Jan 83, 4 for 1 Feb 83, 5 for 1 Mar 83, and 6 for 1 Apr 83.

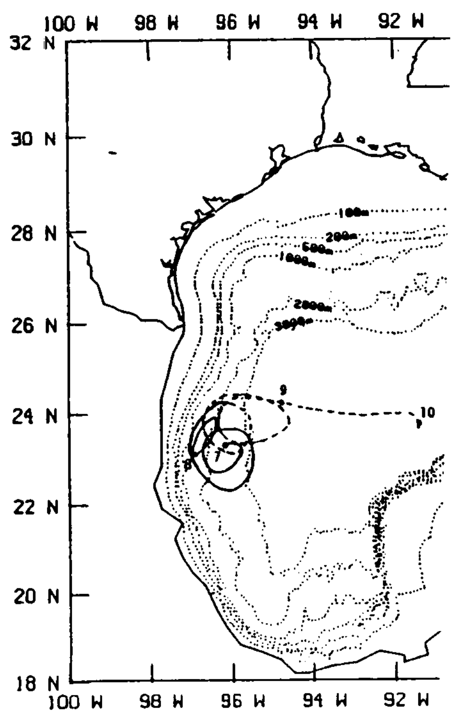


Figure 5b. A Continuation of Trajectory Data for Buoy 3374. The location/time legend is 7 for 1 May 83, 8 for 1 Jun 83, 9 for 1 Jul 83, and 10 for 1 Aug 83.

Ring kinematics have been calculated from ring drifter data. Typical translation speeds are 5 cm/s and typical swirl speeds are 50 cm/s. Also, it was found that smoothing of the position data is required due to an unexpected high frequency mode (with a period of less than a day). It was also found that motion within the rings did not separate the drifters. Vorticity was seen to be the most important kinematic parameter, and there appears to be insignificant separation associated with divergence, normal deformation, and shear deformation.

The rings are seen to undergo substantial modification as they move across the Gulf of Mexico. This modification is reflected in a general increase in area and the development of an east-west elliptical orientation.

Drifter 3374 was deployed in a ring in October 1982 and showed a westward translation, an oscillatory period after coming in contact with the Mexican coast (Fig. 5a), and then a period after July 1983 during which the buoy left the ring and moved toward the east (Fig. 5b). The location at which the drifter left the ring coincides with a region where large eastward transports have been observed. This eastward flow is a result of a combination of the flow pattern of the north limb of the anticyclone and the south limb of a cyclone which is typically found directly north of the anticyclone. Numerical experiments show that a cyclone can be shed from an anticyclone as the latter feels the effects of a western boundary.

Drifter 3375 was seeded in a eddy along the northern Gulf of Mexico shelf, and its trajectory is shown in Fig. 6. After moving south, the vorticity of a strong feature against the Mexican coast carried the drifter around in an anticyclonic loop. This would indicate that the previous ring was still against the coast or that another ring had moved up against the coast by October 1983. By 1 November 1983 the drifter was no longer under the influence of the strong vorticity.

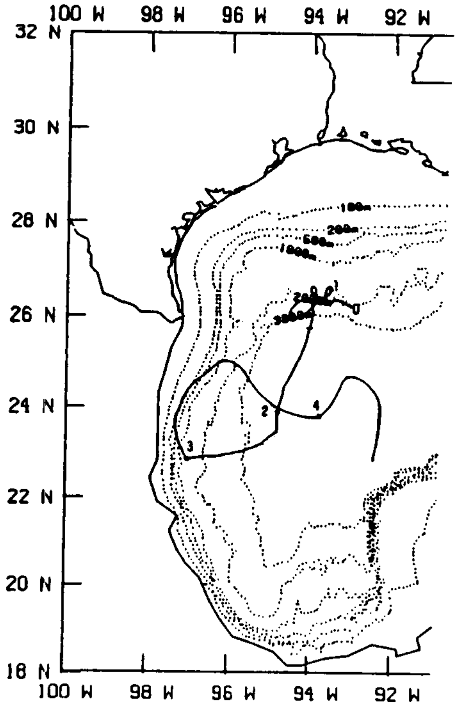


Figure 6. Trajectory for Buoy 3375 Seeded in an Eddy on 22 Jul 83 (0 location on trajectory). The location/time legend is 1 for 1 Aug 83, 2 for 1 Sep 83, 3 for 1 Oct 83, and 4 for 1 Nov 83.

RECOMMENDATIONS

The results of the drifting buoy program have brought to the forefront the following three questions:

1) Do the rings follow almost the same path across the Gulf of Mexico as indicated by the current results, or are there instances in which the rings impact other shelf regions?
2) What is the ring/ring interaction when a more recently-shed ring approaches the Mexican coast where an older ring still exists?
3) How will ring events affect the study of the western Gulf of Mexico?

To address these questions, it is recommended that the number of ring seedings be increased from the planned two deployments per year. This can be accomplished at no additional equipment costs by replacing one of the TzD buoys (a Polar Research Laboratory drifter with a 200 m thermistor chain) with three less expensive buoys which are drougued with a 200 m line.

This would allow for equipment backup and for the seeding of up to four separate oceanic features in the Gulf of Mexico during each year of the project. At the same time, there would still be one TzD buoy deployment per year which would allow for the study of the vertical temperature characteristics as a function of time.

By seeding more rings, we will enhance the statistics of a "normal" trajectory and will increase the possibility of providing initial estimates of variations from the mean. To consider the question of ring/ring interaction, one must have a sufficient number of available buoys to seed consecutive ring-shedding events. Moreover, additional buoys would allow for the option of seeding cyclonic and anticyclonic features in the western Gulf of Mexico. This would provide the first direct observations of the role of cyclones in the movement and fate of the rings shed from the Loop Current. In addition, by seeding more rings, one obtains a greater sampling of ring kinematics, motions, and variations. All this information will aid greatly in the planning of the various physical oceanographic studies for the western Gulf of Mexico.

GULF OF MEXICO COASTAL ZONE COLOR SCANNER STUDIES IN 1983 BY THE NATIONAL MARINE FISHERIES SERVICE

Thomas D. Leming
NOAA/NMFS/SEFC

During the 1983 Southeast Area Monitoring and Assessment Program (SEAMAP) cruises in the northern Gulf of Mexico, Coastal Zone Color Scanner (CZCS) data were collected and processed in near-real-time to produce maps of potentially hypoxic bottom water zones. Up to three orbits per week were collected and dumped by NASA on the west coast. The data received at the Scripp's Satellite Oceanography Laboratory were screened for cloud cover by NMFS personnel and, if the SEAMAP areas were relatively cloud-free, a digital tape was produced and sent by overnight mail to the Mississippi Laboratories.

From 1982 cruises and CZCS data, algorithms have been developed which appear to be successful in delineating potentially hypoxic bottom water areas based on CZCS derived pigment and temperature digital counts. The classification procedure developed at the Mississippi Laboratories relies on a linear discriminant function. The 1982 coefficients of the discriminant function were used to classify the 1983 CZCS scenes to produce predictive charts of potentially hypoxic bottom water area.

Three good CZCS images were used, 9 June, 13 June, and 6 July 1983. The 9 and 13 June images were processed prior to any research vessels reaching the southwest Louisiana coast. Only a small area off Marsh Island, Louisiana was predicted to be potentially hypoxic. Research vessels sampled the area from 13-20 June and essentially confirmed the satellite predictions. Smaller hypoxic areas to the east were predicted from the 6 July image and again were confirmed by a single non-SEAMAP associated vessel during the first week of July. It thus appears that the CZCS may be an important predictive tool for fisheries-related studies.

A small eddy, originally called Eddy G was detected from the CZCS-measured water color on 6 June. It appears now that this eddy was not a true spin-off eddy; however, it does confirm that CZCS water color information may provide a good tool for summer tracking of eddies.

An environmental data atlas for the 1982 SEAMAP cruises is nearing completion. A series of CZCS-derived pigment maps will be included in the atlas.

FLORIDA CURRENT RESEARCH

George A. Maul
Atlantic Oceanographic and Meteorological Laboratory, NOAA

Two research programs which are addressing the flow in the Florida Current between Miami and Jacksonville are of interest to Gulf of Mexico Research. The Subtropical Atlantic Climate Study (STACS) is currently focused on the mass transport of the Florida Current at 27N in the offing of Jupiter, Florida. The Florida Atlantic Coast Transport Study (FACTS) is centered farther downstream at 29N and is addressing the question of water exchange between the Gulf Stream System and Florida coastal water. A brief summary of each program is described below.

STACS began in the spring of 1982 as a precursor to a basin-wide study of the role of the ocean in the climate of the North Atlantic Ocean. The first objective of the study is to establish whether the flow in the Florida Current could be monitored accurately enough for climate research needs. Accordingly, several subprograms were initiated for this purpose: Pegasus measurements of absolute mass transport against which less costly techniques could be compared, current meter moorings to determine the temporal and spatial structure of the flow at discrete points, electromagnetic flux measurements along the Jupiter-Bahamas cable for estimating integrated mass transport, sea level measurements for studying across-stream and down-stream pressure gradients and mean currents, CODAR (coastal dynamics applications radar) measurements of surface currents, acoustic tomography experiments to investigate techniques of determining temperature and mass flux from two-way sound propagation, and modelling studies to study optimum sampling strategies. It appears at this writing that sea level on the western side of the Straits of Florida and the cable voltages each are capable of inferring mass transport to within 1x10**6 m**3/sec.

FACTS will begin deployment of current meter moorings and satellite tracked buoys in March, 1984, and inverted echo sounder/pressure gauges (IES/PGs) in June. The moorings will be along the 75m isobath from Jupiter to Jacksonville at about 100km intervals, and along 29N at the following depths: 15m, 40m, 75m, 200m, 400m, 600m, and 800m. The IES/PGs will be placed along 29N at 300m, 500m, and 700m. Quarterly cruises to make Pegasus absolute velocity and transport measurements along the 29N array will start after the moorings are in place. The instruments are planned to be in place until March 1985 (or longer) for the specific purpose of assessing the role of the Florida Current in water mass exchange between the coast and the Sargasso Sea so to better understand the environmental impact of minerals and/or petroleum mining on the Blake Plateau. In addition, the data will continue to provide mass transport measurements of the Florida Current, and will serve as a southern boundary condition to numerical circulation models of the South Atlantic Bight.

MIAMI SATELLITE FIELD SERVICES STATION OPERATIONS

Steven Baig
Nova University

On 01 October 1983 the functions and personnel of the Miami Satellite Field Services Station (SFSS) were transferred to the National Weather Service at Miami. Meteorological and oceanographic operations of the SFSS are to continue unchanged, at least until a thorough re-organization of the National Hurricane Center and the Miami Weather Service Forecast Office is completed.

Oceanographic operations will continue to be focused on daily frontal analyses of the Gulf Stream Flow System, from the Eastern Gulf of Mexico through the offing of Nova Scotia. Extra effort will be made to describe oceanographic features such as eddies which have broken off of the Loop Current and drifted into the western Gulf of Mexico.

Thrice-weekly charts of the Gulf Stream Flow System from the Yucatan Strait to Cape Hatteras continue to be available via telecopier from the Miami SFSS. Radio station WLO, Mobile, AL, broadcasts the chart on radio-facsimile on the afternoons of the days the chart is produced, Monday, Wednesday, and Friday. Weekly summary charts of the entire analysed area (western Gulf to Nova Scotia) are prepared on Mondays. Copies of these charts are available by special request. The original daily analyses are archived in Miami and are available there for use by the Oceanographic community.

AN AT-SEA AUTOMATED SYSTEM FOR SATELLITE TRANSMISSION OF DATA FROM SHIPS OF OPPORTUNITY

Steven K. Cook
National Marine Fisheries Service
Atlantic Environmental Group

INTRODUCTION

In mid-year 1970, a cooperative expendable bathythermograph (XBT) program was initiated between the National Marine Fisheries Service and the Maritime Administration (MARAD) of the U.S. Department of Commerce.

The program, conducted in support of the Marine Resources Monitoring, Assessment, and Prediction Program of NMFS involved the use of midshipmen trained at the U.S. Merchant Marine Academy, Kings Point, New York; U.S. Coast Guard personnel; and contractors to gather XBT data on board various merchant, Coast Guard, and research vessels along the Atlantic and Gulf coasts of the United States. The objectives of this cooperative program are to identify, describe, and monitor seasonal and year-to-year variations of temperature and circulation in major currents of the Gulf of Maine, Gulf of Mexico, and western North Atlantic, using ships of opportunity as relatively inexpensive platforms for the collection of data.

Presently the AEG operates four XBT transects along the East and Gulf Coasts (Fig. 7). Concurrent with two of the XBT transects, we collect Continuous Plankton Recorder (CPR) data which are provided to and analyzed by the Ocean Ecology Analysis Program. Most of these transects have been occupied for at least five years on a monthly or twice-monthly basis and some for almost ten years, providing a significant time series of subsurface data. From the XBT data collected, we portray, analyze, and synthesize with long-term meteorological and other oceanographic data sets, environmental features, processes, and trends which may influence distribution or abundance of living marine resources.

We also provide information concerning environmental variations to fishery scientists for use in research and management activities, and to commercial or sports fishing interests as an aid to locating concentrations of pelagic fishes or to avoiding hostile conditions for their operations.

We are presently in the process of upgrading our shipboard XBT systems to utilize satellite data transmission. Our goal in this regard is to provide more timely access, by several data users within NOAA, to our SOOP/OMP XBT transect data and for interpretation of satellite IR imagery within the AEG.

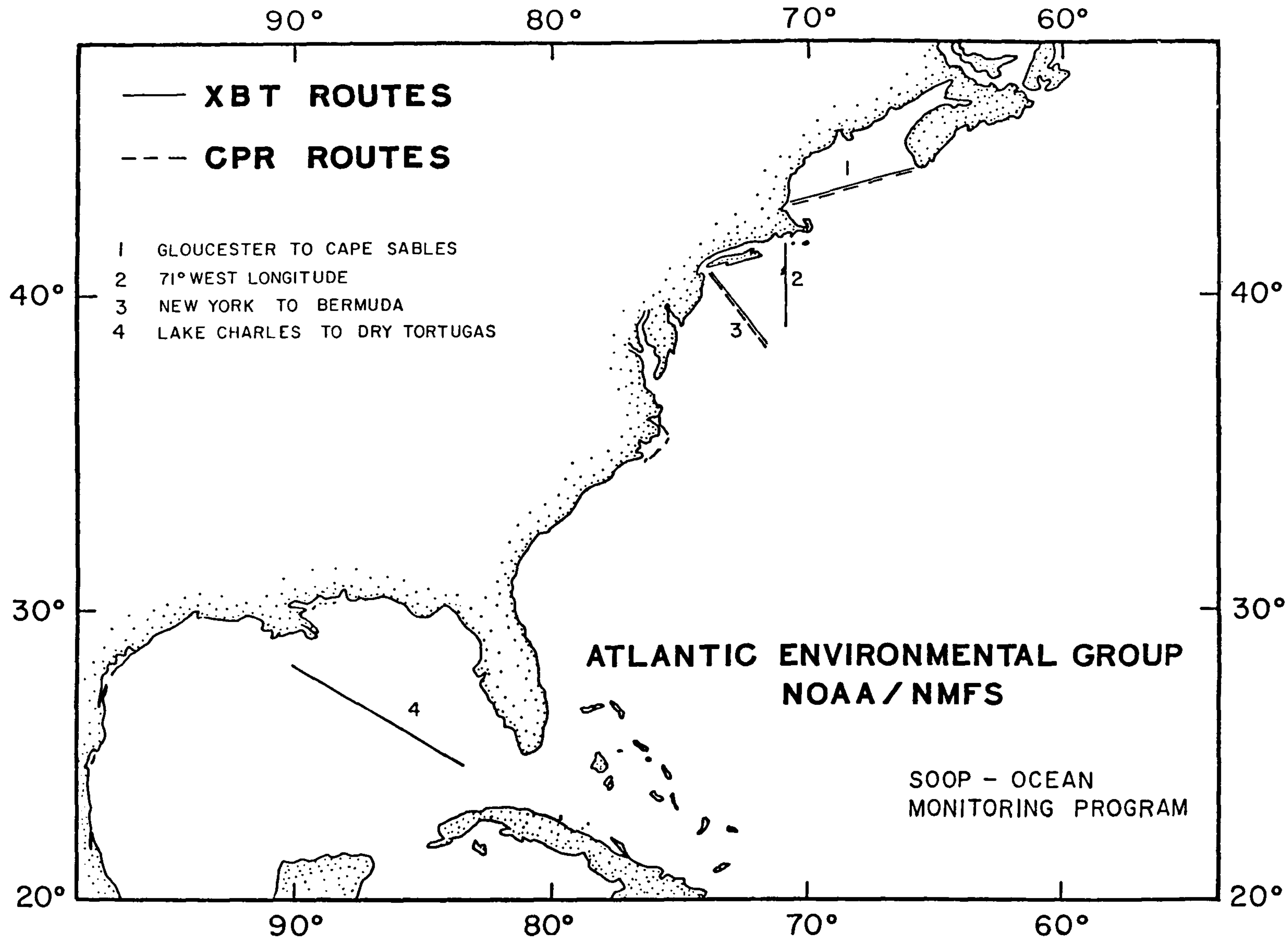


Figure 7. Locator Chart Showing XBT/CPR Routes for the NMFS/AEG Ship of Opportunity-Ocean Monitoring Program

DISCUSSION

In December 1982, we successfully deployed an Expendable Bathythermograph (XBT) Meteorological (MET) Data Collection and Satellite Transmission System onboard the M/V Oleander (Fig. 8), a participating ship of opportunity that operates weekly between Port Newark, New Jersey and Hamilton, Bermuda. Commonly referred to as SEAS (Shipboard Environmental (Data) Acquisition System), this system provides for prompted collection of meteorological and expendable Bathythermograph data, the digitization, compaction, and calculation of inflection points for the XBT data, and finally the timely transmission of these data through a GOES Satellite System in the standard meteorological (World Meteorological Organization (WMO) Ship Synoptic Code No. FM-13-VII) and XBT (JJXX) format. These data are then available in near real time for use in marine synoptic forecasts by the NWS National Meteorological Center (NMC) and to scientists in the Program.

The following is a description of the equipment and its operation.

Equipment

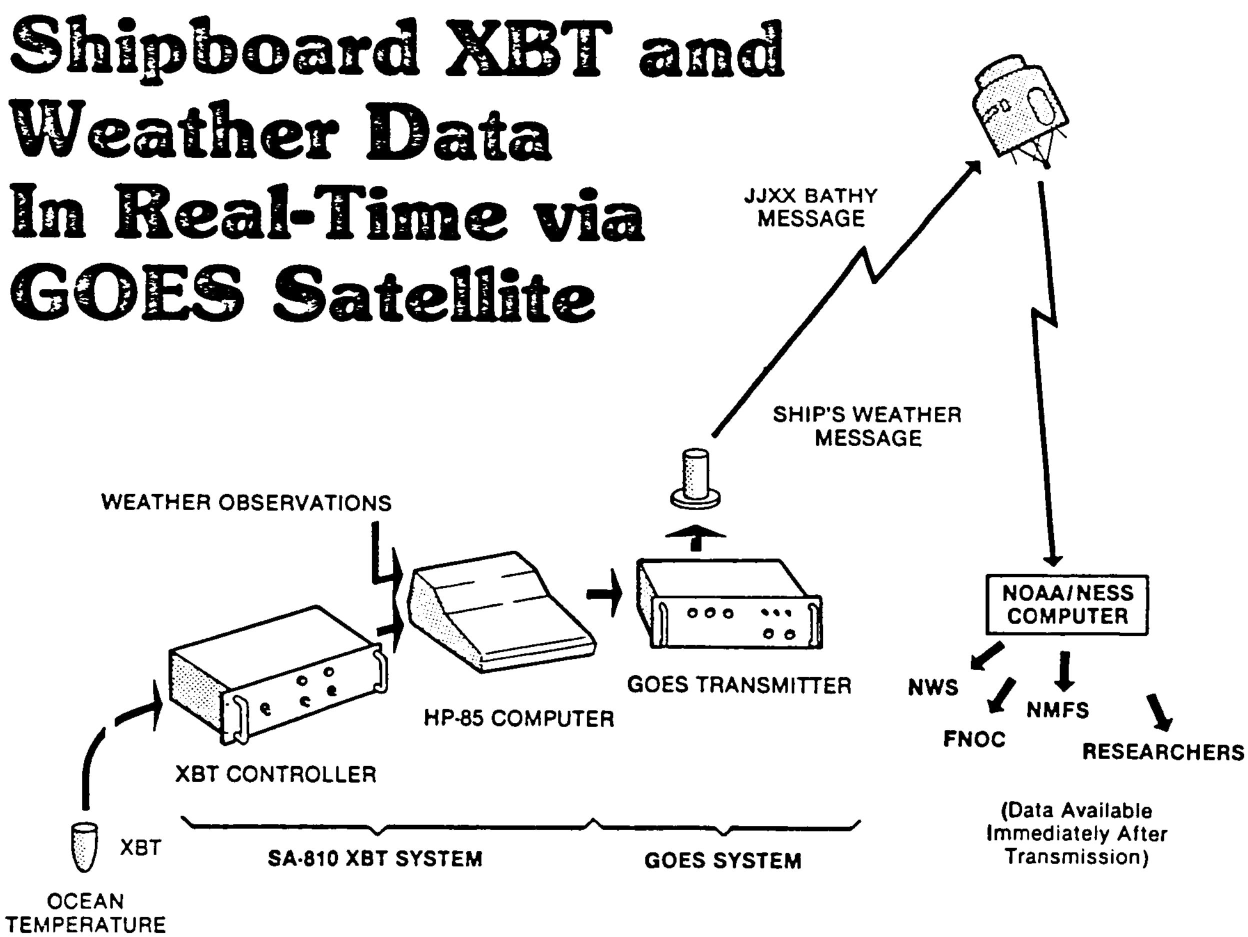
(1) A Bathy Systems XBT Controller provides a direct interface with Sippican XBT probes, a crystal controlled time base (9cm depth error in 1800 m) and RS-232 interface to the HP/85.

(2) HP/85 provides digital recording on magnetic cartridge, a CRT and printer and complete operating system for program development.

(3) A synergetics Data Collection Platform (DCP) including a Master Control Module, a GOES transmitter and uninterruptible power supply.

(4) A Synergetics Omnidirectional Antenna with cable and connectors.

The HP/85 is mounted on top of the XBT controller, making a package measuring 19"x14"x10"; the Data Collection Platform (DCP) is a 10"x10"x10"



XBT Software Features

- Real-Time Plots and Analysis
- Internal Recording
- Data Listings
- Depths of Isotherms
- Inflection Points (JJXX)

Weather Software Features

- Interactive Input Program
- Internal Error Checks for Each Coded Input

GOES Transmission

- Automatic Time Keeping and Transmission
- JJXX Bathy Message
- Ship's Weather Message

Figure 8. Diagrammatic Representation of the XBT/MET Automated Satellite Data Transmission System

cube; the total system weighs approximately 40 pounds. Installation efforts consist of plugging in three 120V wall plugs; positioning the omniantenna in a suitable location and screwing in the antenna lead and XBT launcher cable.

Operation

Expendable Bathythermograph (XBT) Data: To start the XBT program, you turn on the HP/85, and autostart function loads and runs the program automatically. After this point, the program is prompting and will ask that appropriate data be entered, i.e., type of probe, launch number, geographic location, etc.

Following these entries, you receive a message "ready to launch" and an audible "BEEP" signal. The pin is pulled, the probe is launched, and the data is digitized, formatted into a standard Bathy message, and displayed on the HP/85 CRT for real-time viewing to determine a good or bad drop.

The XBT Controller samples the incoming thermistor resistance from the probe ten times per second. The resistance information is then converted to voltages by a 12-bit analog to digital converter. To facilitate data recording and real-time data presentation and analysis, the voltage versus time information is transmitted via an RS232 serial interface to a Hewlett-Packard model 85 desktop computer. When the probe has reached its maximum depth or hit bottom, the data acquisition cycle terminates and the profile data is automatically stored on a magnetic tape cartridge within the HP/85.

Immediately after an XBT temperature profile has been stored on the HP/85 magnetic tape, a BASIC program processes the profile to select the minimum number of depth/temperature pairs necessary to generate an accurate representation of the entire vertical profile (not to exceed 29 depth/temperature pairs). These inflection points are chosen objectively by an algorithm that searches for changes in vertical gradients of temperature.

These depth/temperature pairs are then used to construct a "JJXX Bathy Message" identical in form to that routinely prepared and transmitted via radio from ships at sea.

The data, in the proper digitized format, are then sent to the transmitter, which resides in a buffer awaiting the appropriate transmission time. GOES passwords, I.D. Codes, channel assignments, and time slots have already been automatically entered into the DCP by the program. At the assigned time slot, the message is automatically transmitted and routed through the satellite, Wallops Is., NESDIS, and into the NMC XBT file.

CONCLUSION

Since installing the system on board the M/V Oleander in December 1982, we had to make only one software modification which allowed hand entry of bottom depth. This modification was done to prevent the automatic digitization of spurious data after the XBT probe had hit bottom. Since January 1983, the equipment (both hardware and software) has worked efficiently and reliably. The goal of streamlining accurate and timely data reporting efficiency with improved programming and operator interaction has been met. Indeed, since deployment, over 400 XBT messages and 220 meteorological observations have been collected and transmitted. The project has evolved from experimental to operational, and plans are underway to outfit all ships involved in the AEG SOOP/Ocean Monitoring Program with these systems.

PART II: REPORTS FROM OTHER PROGRAMS

SHELF/SLOPE MODELING

Dong-Ping Wang
Energy and Environmental Systems Division
Argonne National Laboratory

One outstanding problem in ocean modeling is the meshing between shelf (coastal ocean) and open-ocean models. The shelf and open ocean usually are treated as two separated regions in modeling, and the interactions between shelf and open ocean are not considered. On the other hand, because the oceanic processes undergo a rapid change across the continental slope, to extrapolate the slope circulation from the shelf and open-ocean models is difficult. This restriction severly limits the present model ability to predict the particle trajectory across the continental margin.

A most distinct circulation feature in the shelf/slope region is the density front, that is, a narrow zone of rapid density change. Fronts are important in ocean dynamics since they are regions where vertical advection and the exchange of momentum and other properties are locally intense. Fronts are also environmentally important since they are very effective in collecting and concentrating floating detritus and other particulate matter. Indeed, by lining up the oil slicks along the surface convergences, fronts have strong effects on the dispersion of spilled oil.

On the continental margin, there are two major types of the density water mass boundary separating the less saline shelf water from the more saline slope water. The eddy front is a water mass boundary separating eddy or eddy-like meandering current from the shelf/slope water. Both types of fronts are characterized by strong surface convergences, sloping isopycnals, and strong along-frontal currents.

For the shelf/slope front, the equilibrium shape can be modeled from consideration of the geostrophic adjustment between two initially separated water masses. However, the present theory does not include mixing and dissipation; consequently, the cross-frontal circulation cannot be calculated. The frictionless theory also fails to predict a realistic along-frontal current.

For the eddy front, the propagation and dispersion of an isolated eddy can be modeled from consideration of the adjustment of planetary vorticity. The eddy shedding from the Loop Current also can be realistically simulated. However, the present model, which is based on a two-layered density stratification, cannot be applied to the shelf/slope region where the density interface may intercept the bottom topography. The two-layered model also is not adequate for the simulation of the cross-frontal circulation and mixing.

In order to realistically simulate the density front on the continental margin, a three-dimensional model with high spatial resolutions is necessary. On the other hand, because the three-dimensional model has high demand for computer resources, the basin-type model will not have adequate resolutions for the frontal scale motion. At present, the limited-area modeling, that is, ocean models with open domain, appears to be the only feasible approach to the problem of realistic shelf/slope modeling.

Three major areas of research in limited-area modeling must be addressed: open-boundary condition, initialization, and mixing/dissipation. In the open-boundary condition, the research is needed to assure that waves generated inside the model domain will propagate away without reflection at the open boundaries. In the model initialization, it is essential that the large-scale feature, such as a drifting eddy, can be imposed into the model domain without generating significant inertial disturbances. In the mixing and dissipation, the friction time scale for density front and eddy must be determined from the observations.

In summary, the density front in the shelf/sloping region is critical to the prediction of the offshore oil spill risk. Research efforts are required to develop limited-area models for the frontal circulation and eddy-shelf interaction, and to monitor the life cycle for the shelf/slope front, eddy, and meandering current.

A STUDY OF THE EVOLUTION OF ATCHAFALAYA BAY, LOUISIANA

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The U.S. Army Engineer Experiment Station (WES) is engaged in a study of deltaic evolution and associated physical impacts in the Atchafalaya Bay area. Models are being used to address questions about the behavior of the system as it undergoes dynamic changes. Calibration and verification of these models require the collection of tide heights of stages, salinities, currents, winds, waves, and sediment characteristics from the field.

The Atchafalaya Bay complex is located on the south-central Louisiana coast. It consists of five broad, shallow, multiply-connected bays surrounded predominantly by low marshes. Inflows of water and sediment have increased dramatically in this century. Inflow of water is controlled to a great extent by the Old River control structures on the Mississippi River. There was a general infilling of the basin by sediments during the 1950's and 60's. In the early 1970's, subareal land began to appear in Atchafalaya Bay. The U.S. Army Engineer District, New Orleans, began studies of this emerging delta and its impacts on navigation and on local and regional flood control.

WES is applying a number of models (several numerical models and one physical model) to this problem--simulating river flows, sediment transport, salinities, storm surges, and waves. Model results will be integrated and used to predict hydraulic, salinity, and sediment conditions over the next 50 years under present maintenance procedures. The effects of the extension to the Avoca Island levee on backwater flooding and the flows of materials into western Terrebonne Marsh will also be predicted.

Field data collection began in 1980. Tide gages were installed in 1980 and maintained through July 1982, then reinstalled from February until June 1983. Locations are shown in Figure 9. Tidal amplitudes are greatest seaward of the break between the Gulf and the bay, and are attenuated inshore. Current meter deployments were made during July-August 1980, January-March 1981, June-July 1981, June 1982, and March-May 1983 (Figure 10). Many of the tide and current meter data have been subjected to harmonic analysis. Wind and wave measurements were collected in 1980 and 1981 (Figure 11). They have also been subjected to time-series analysis. Winds are comparable to those of other coastal Louisiana locations nearby. Waves are dominated by locally-generated wind waves. Sediment and salinity data were collected at about 30 stations. Suspended sediment concentration and settling velocity measurements imply periodic resuspension of sediments in the bay by tidal currents. Other data are being compiled and analyzed at this time.

Field data reports as well as reports on individual topics are in preparation and scheduled for completion in 1984. They will be published as a WES report series HL-82-15.

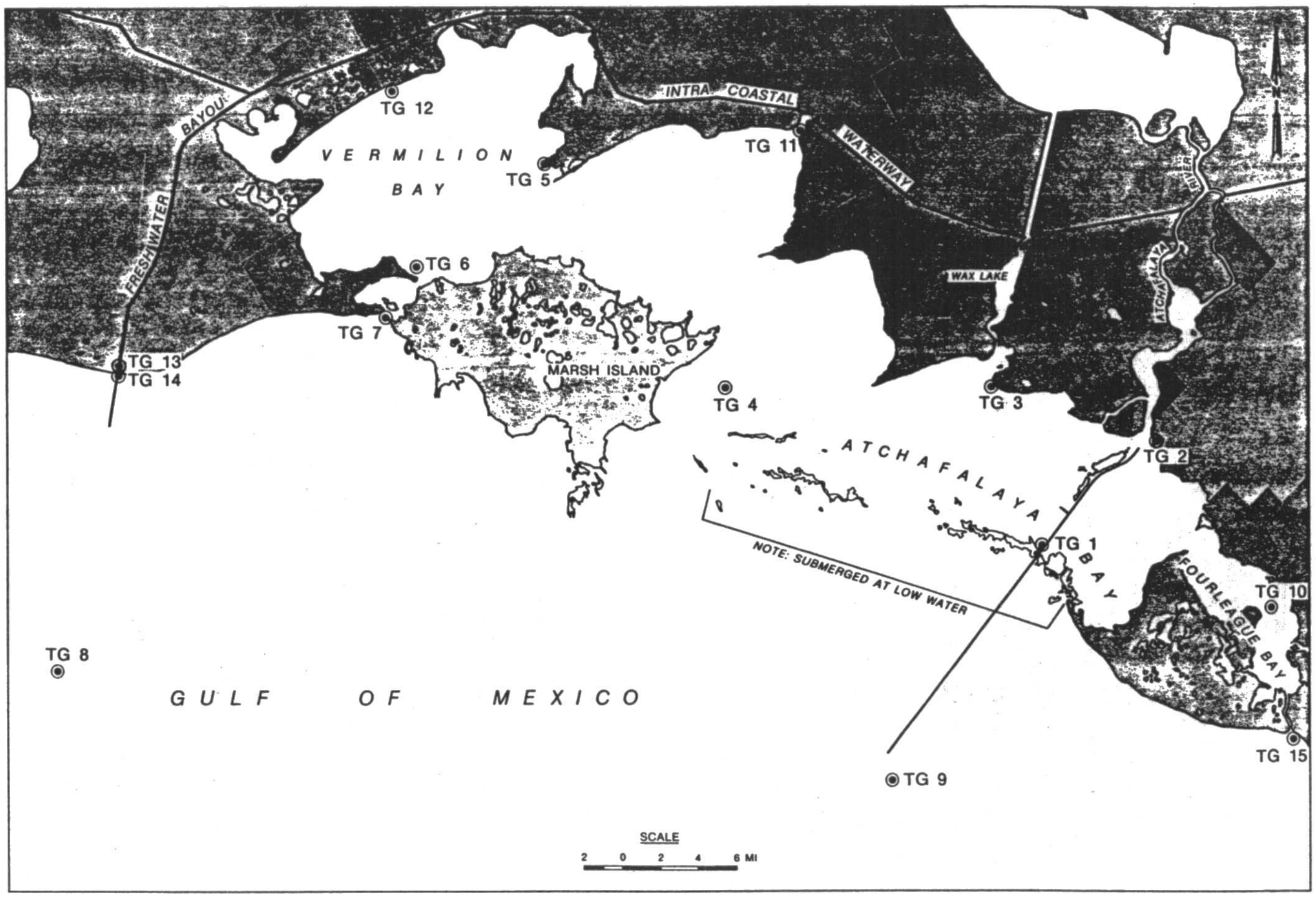

Figure 9. Locations of Tide Gage Installations

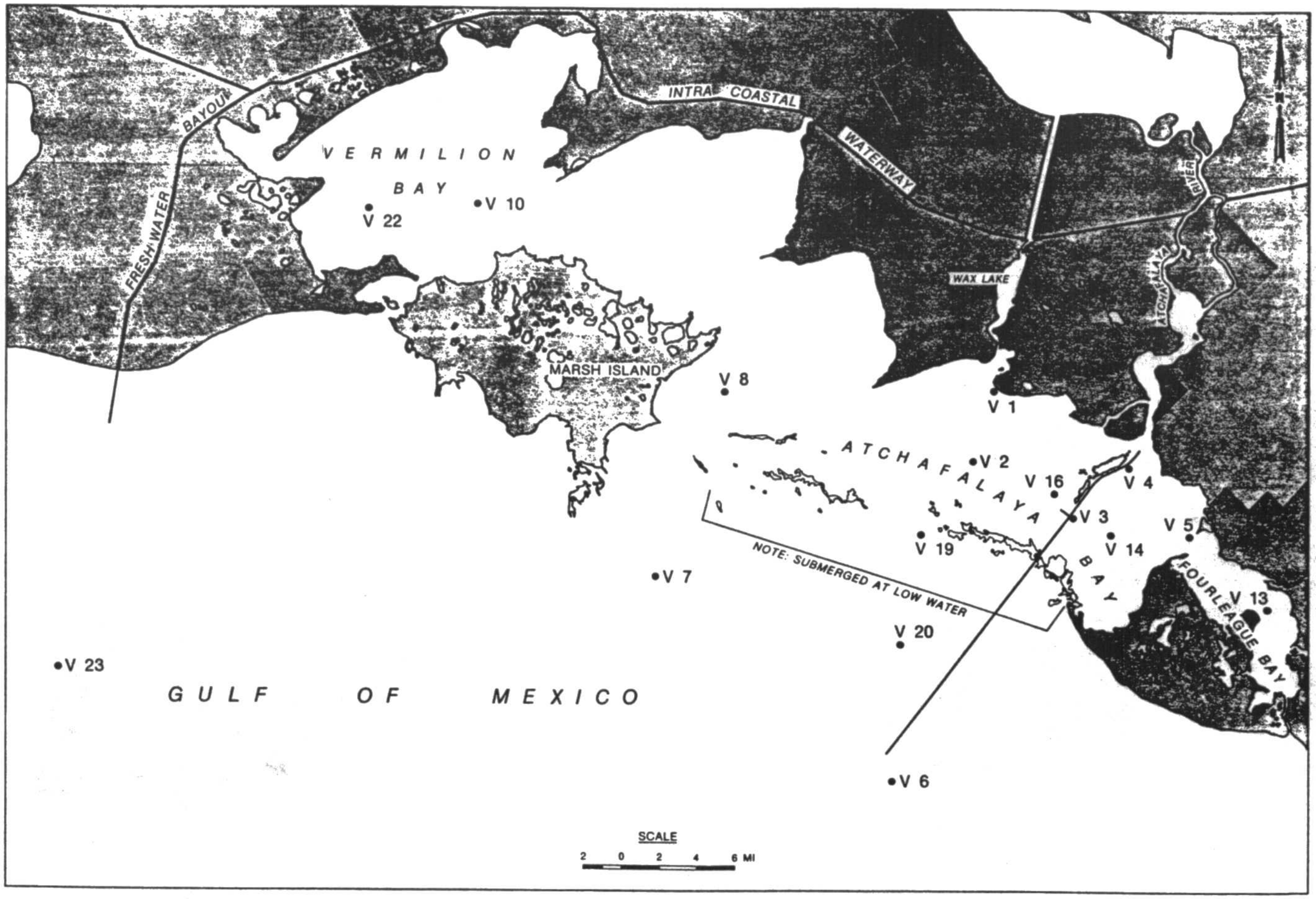

Figure 10. Locations of Velocity Stations

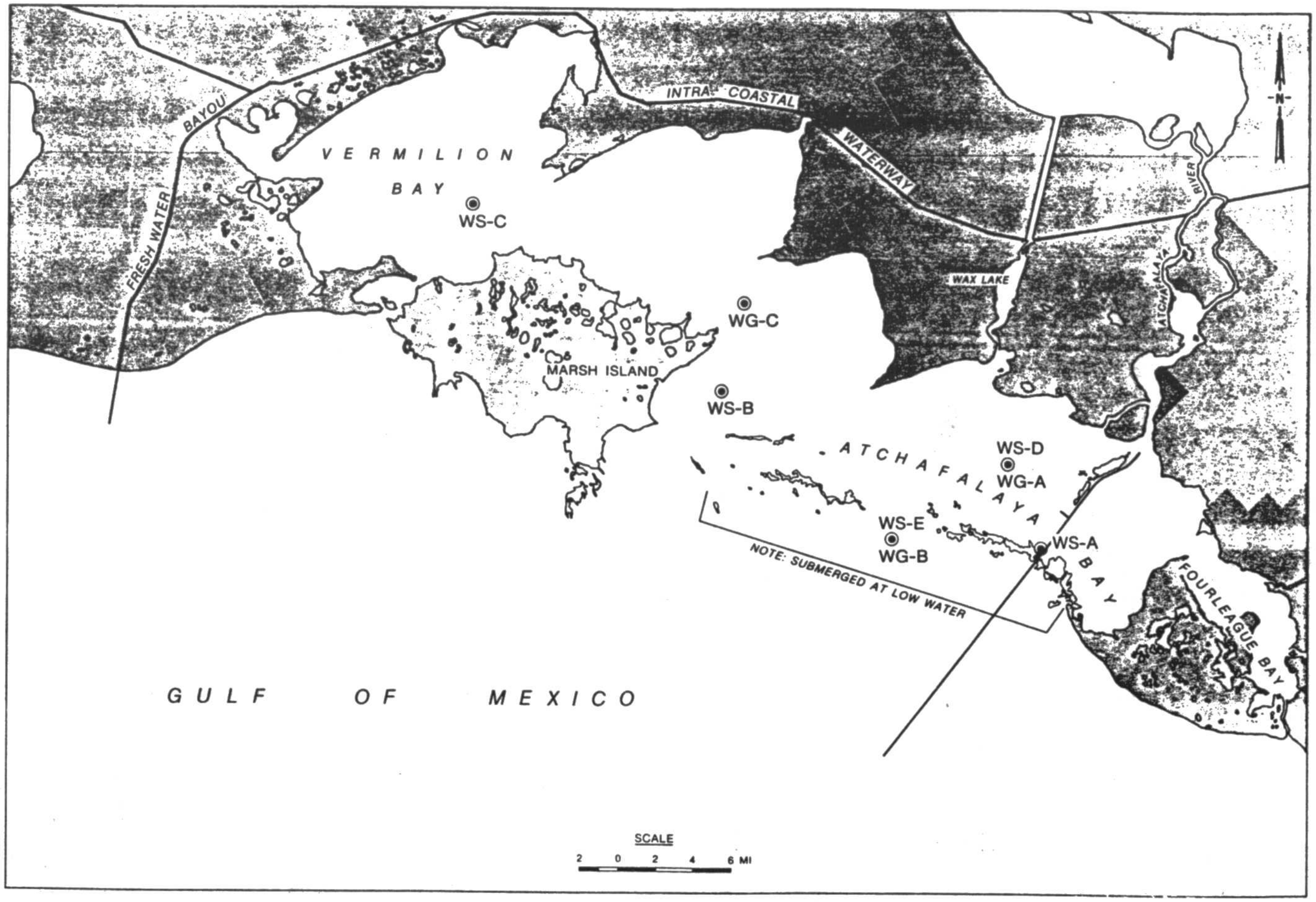

Figure 11. Locations of Weather Stations and Wave Gage Installations

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REGIONAL OCEAN DYNAMICS FROM GEOSAT: PLANS FOR THE GULF OF MEXICO

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Plans for the use of mesoscale topography derived from the U.S. Navy altimetry satellite GEOSAT were discussed in the context of two mesoscale Regional Energetics Experiments (REX). Attention was concentrated on the Gulf of Mexico REX to begin in Spring-Summer, 1986 during which the mechanism of inverse methods will be employed in order to blend the interdependent components of altimetry, geodesy, numerical modelling, and in situ hydrography and acoustic sounding to arrive at an optimal picture of the temporal mean and variable circulation of the Gulf of Mexico.

Topographic inference via altimetry depends upon measurement of the time delay between the satellite transmission and reception of a microwave pulse reflected from the ocean surface and an independent knowledge (obtained via Doppler tracking) of the satellite's height above the earth's center of gravity. Most of the numerous errors inherent in this technique occur on wavelengths much longer than those of the oceanic mesoscale (the water vapor contamination problem sometimes being an exception). The sea surface topography itself is a composite of four major signals with typical amplitudes and wavelengths as summarized below:

Components of the Sea Surface Topography

Source	Typical Amplitude (cm)	Typical Wavelength (km)
Geoid	10^4	10^3
Tides	10 to 10^2	10^3
Quasi-Geostrophic Ocean	10 to 10^2	10^2
Geostrophic Ocean	1 to 10	10^3 to 10^4

Thus, geoid background contamination represents a potentially severe problem to REX plans to derive quasi-geostrophic (i.e., time variable mesoscale) topography from GEOSAT altimetry.

During the initial 1 1/2 years after launch, this problem will be particularly poignant as the satellite will be flying in an orbit whose groundtracks never exactly overlay (in order to carryout its initial primary mission of marine geodesy for the Naval Oceanographic Office and the Naval Surface Weapons Center). During this initial period, NORDA REX will be concentrated in the Northwest Atlantic where the Defense Mapping Agency has agreed to allow use of a classified geoid and the classified GEOSAT heights in order to compute declassified topographic residuals. Studies will focus on Gulf Stream meander and ring dynamics and energetics.

Plans are now being formalized to carry out an extended GEOSAT mission beginning with an orbit change about 1 1/2 years after launch. This second orbit would provide a regular repeating grid of groundtracks approximately every 20 days with an equatorial spacing between closest groundtracks of about 140 km (see Figure 12). Sampling from this orbit begins to approach synopticity for the oceanic mesoscale, particularly for nondispersive dynamic regimes like the Gulf of Mexico.

During this time period the machinery of inverse methods will be called into play. The basic method (Wunsch and Gaposchkin, 1980) allows for the simultaneous improvement of the geoid estimate and the reference velocities which appear as constants in the thermal wind equation. The method hinges on the experimenter's ability to specify conservation constraints on specific parameters (e.g., total mass or mass between two σ_T surfaces) within a region bounded by hydrographic stations and/or physical boundaries.

Obviously, the semi-enclosed Gulf of Mexico represents an excellent opportunity to carry out such a field experiment. Statistics on the circulation in the Gulf as obtained from historical record (Maul, 1983) or

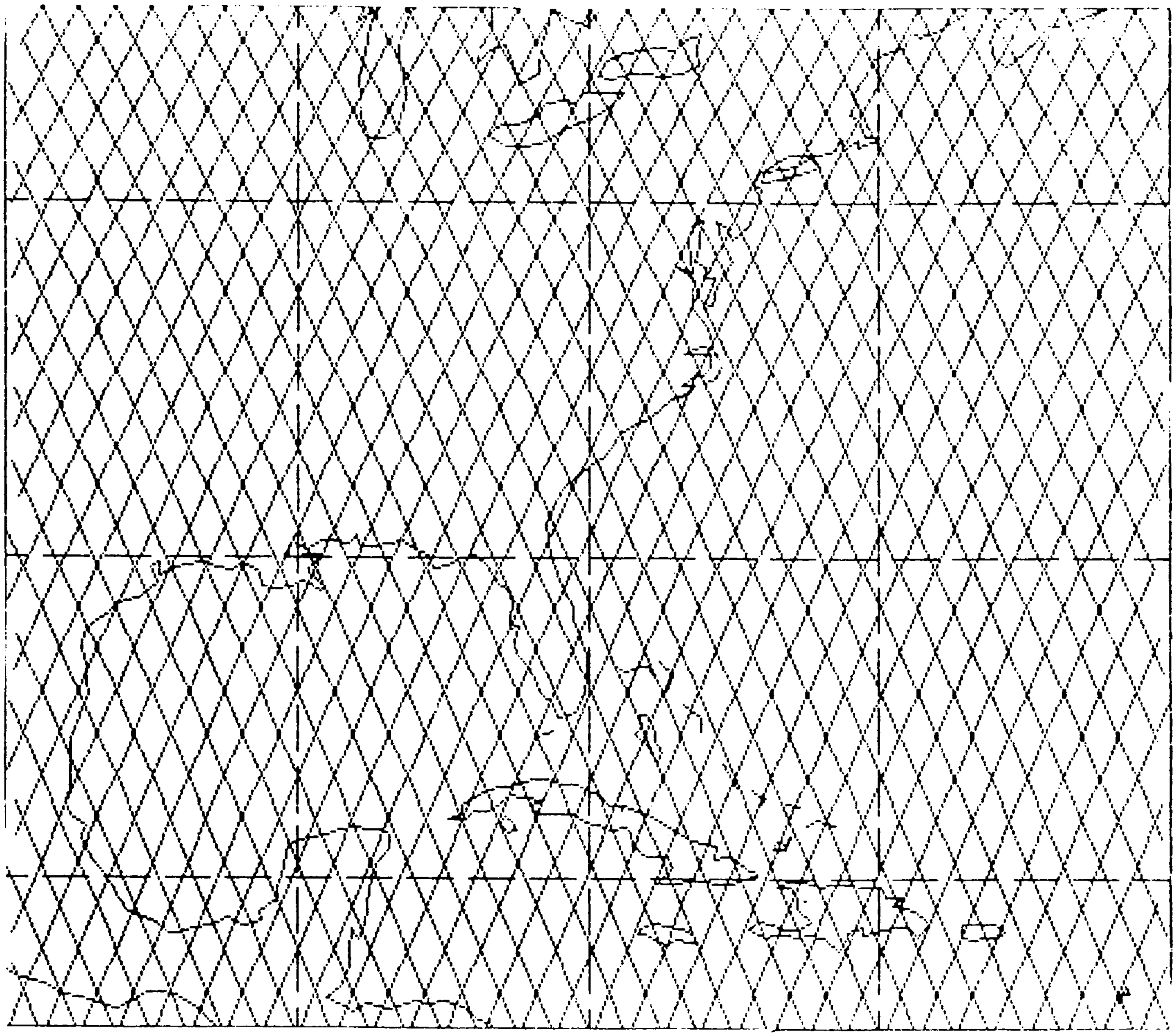

Figure12. GEOSAT Groundtrack Coverage over the Loop Current GulfStream System as Accumulated in 20 Days with the Satellite Flying in an Exact Repeating 20-Day Orbit

Such an orbit will be attained at the end of a nominal 1 1/2 year geodetic mission. Presently, formalization of this extended exact repeat orbit mission (GEOSAT-ERM) is underway.

Longitudinal phasing of the orbit is arbitrary in the above figure. After this orbit is attained, a Regional Experiment (REX) will be initiated in the Gulf of Mexico.

from numerical modelling will aid greatly in the design of both AXBT and CTD surveys to support the Gulf REX for which planning is just beginning. These plans involve the deployment of several Inverted Echo Sounder/Bottom Pressure Gauge arrays near the Yucatan and Florida Straits. The arrays will be used to provide a continuous time series of dynamic topography fluctuations in the Loop Current. These records will aid in the monitoring of gross property excesses associated with any net divergence in the Gulf basin. As well, they will provide a concurrent transect with the altimeter, allowing for meaningful regional extrapolation of fluctuations observed by the later.

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NUMERICAL MODELING OF TIDAL AND METEOROLOGICALLY-INDUCED RESPONSE IN THE GULF OF MEXICO

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TIDES

A numerical model of astronomical tides for the Gulf of Mexico was developed for the U.S. Army Engineer Waterways Experiment Station. The details of this study are contained in a report to be published by the Waterways Experiment Station authored by Reid and Whitaker. Summarized here are some of the unique features of the model and of the findings.

The model employs the depth integrated Laplace tidal equations with linearized bottom stress in sperical coordinates and predicts the evolution of water level and volume flux for given tidal constituents in a finite difference, alternating-direction-implicit (ADI), time-marching mode. Kinematic condition of no flux across the coastal boundaries is employed, such that the model predicts the water level signal at the coast. This is in contrast to "diagnostic" models which employ the observed coastal tide elevational signal as a boundary condition (eg., Schwiderski, 1980).

One of the unique features of the present model is the use of a predictive condition at the open ports. This has the form

$$\frac{\partial}{\partial t}(Q_n - C\xi) \cdot Y\xi = \frac{\partial \Phi}{\partial t},$$

where Q_n is the outward volume flux, ξ the water level anomaly, C and Y are constants, and Φ is a flux potential. Parameter C controls radiation of gravity wave energy at the port, while Y controls inertial effects of the adjoining open sea and helps determine the gravest mode period (which for this system is the Helmholtz mode). Forcing of the tides in the Gulf is via the prescribed volume flux potential Φ for each of the two ports (Yucatan Channel and Florida Strait); in addition forcing via the direct tide producing force (gradient of the tide potential) on the Gulf is included. The prescribed volume flux potential at the ports is determined by a tuning procedure which allows an optimal fit of the predicted amplitudes and phases of the tide at the coastal stations to those observed, for a given tidal constituent. This fitting requires that the model be run for each of three forcing conditions separately (Yucatan forcing, Florida forcing, and direct tide potential forcing). It is the optimal combination of these which is determined in the fitting process. Condition (1) has the feature that while the amplitude and phase of Φ is taken uniform accross the port, the amplitude and phases of the resulting ζ and Qn adjust according to conditions in the interior and are variable across the port.

Previous predictive models of the Gulf of Mexico tides include those of Grace (1932, 1933), Grijalva (1971), and Mungall et al. (1978). Each of these gives a reasonable rendition of the diurnal tides like K_1 and O_1. However, they did a poor job in reproducing the semidiurnal M_2 tide, which on the west Florida shelf is equally energetic to the combined K_1 and O_1 tides. The studies of Grace and Grijalva failed for M_2 because of lack of resolution; Mungall et al. failed because of omission of direct tide potential as a forcing mechanism. These studies make it clear that inclusion of the tide potential forcing as well as good spatial resolution is essential for proper rendition of the M_2 tidal response in the Gulf of Mexico.

The present model, which employs a 15' x 15' grid and includes the direct tide potential, cuts the variance of the residual between observed and predicted tide to less than 10 percent for the M_2 tide and less than 5 percent for the K_1 and O_1. The relative contribution to the variance of water level variation at coastal stations by the different forcing mechanisms is given in the following table.

TABLE 5

PARTIAL VARIANCES (PERCENT) CONTRIBUTED BY DIFFERENT MODES OF FORCING

Constituent Direct	In-phase Residual Port Forcing	Out-of-phase Port forcing	Potential	
K_1	83	1	12	4
O_1	86	1	11	2
M_2	35	1	55	9

It is clear that for the M_2 tide the dominant forcing is by direct tide potential, very much in contrast to the situation with the diurnal tide which respond much like a forced Helmholtz mode to volume flux forcing. Futhermore, for all cases the major mode of port forcing is in-phase for both ports. While the out-of-phase (push-pull) mode of forcing does not contribute significantly to the water level signal within the Gulf, it can influence the phasing of tidal currents in the vicinity of the ports.

Another important conclusion is that the M_2 tide in he Gulf is in near resonance, implying that one of the normal modes of the Gulf must have a period close to 12 hours. A previous study of normal modes in the Gulf of Mexico by Platzman (1972) indicated a period of 21.2 hrs for the gravest mode and 6.7 hrs for the next--neither even close to 12 hrs. The resolution of Platzman's model Gulf was 60' x 60' compared with 15' x 15' in the present study. Apparently the resolution of the bathymetry for regions like the west Florida shelf and slope is critical in the proper rendition of the coupled basin and shelf modes. Some sensitivity tests of the natural periods using a simplified circular basin model confirm this.

METEOROLOGICALLY-INDUCED DISTURBANCES

A study presently in progress under sponsorship of the Coastal Engineering Research Center concerns meteorologically-induced dynamics of the Gulf of Mexico. The tidal model has been generalized to include not only wind stress and atmospheric pressure forcing, but also to allow for a baroclinic (internal) as well as the barotropic (external) mode, via a two-layer model. The operating equations of the model code are cast in external and internal mode form, rather than the primitive two-layer form. The advantage is the ability to employ a combined implicit/explicit system for the external/internal modes respectively, which is not possible for the primitive equations because of strong coupling of the latter. The modal equations are, however, coupled through the effect of variable bottom topography, although this is weak (of order $\epsilon^{1/2}$ where ϵ is the density contrast parameter $\Delta\rho/\rho$).

The study, which is still in progress, focuses on the effects of hurricane response of the system. In particular, some of the questions which we hope to answer are: How much energy goes into baroclinic versus barotropic modes? Can the energy going into baroclinic mode over the central Gulf be transformed into barotropic in the shelf regions via the bottom coupling effect? How important is the circulational modes in the central deep Gulf in influencing the water level on the continental shelf? These are questions which are related to the storm surge problem and an attendant phenomenon known as pre-surge anomaly.

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OCEAN FRONTAL OBSERVATIONS: THE NORDA OCEAN FRONTS PROJECT

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Oceanic fronts are ubitiquious in the surface ocean. Fronts are important in ocean dynamics since they are regions where exchange between different water masses is intense. Large scale fronts traverse entire ocean basins and have important effects on the weather and climate. Fronts are also areas of high biological productivity for all of the food chain from phytoplankton to fish and marine mammals. From a biochemical point of view, oceanic fronts can be viewed as giant chemical reactors fueled by components supplied via water mass transport with the resultant chemical reactions biologically mediated by photosynthesis, respiration, and microbial degradation. While the chemistry of the world oceans is understood on a broad scale, only recently--with the discovery of current spin-off rings and ocean thermal fronts--has a true appreciation of oceanic chemical and biological variability been realized. Chemists no longer view the ocean surface as a homogenous mass with only vertical gradients, all in steady state. Rather, more judicious chemical and biological sampling efforts and the ability to use remote sensing to view large areas has led to the realization that the surface ocean is like a mosaic picture with ocean fronts as the boundaries of the pieces.

In spite of the recognized importance of biological and chemical processes at frontal boundaries, chemical variability in frontal areas is relatively unstudied. The Naval Ocean Research and Development Activity (NORDA) has initiated an interdisciplinary program involving physical and chemical oceanography and remote sensing to address that gap in our knowledge. Chemical and physical variability across selected frontal areas will be examined in detail in an attempt to identify the processes and mechanisms responsible for enhanced chemical variability at frontal boundaries. A deep towed instrument/pumping system will be developed to provide detailed, real-time underway measurement capabilities. Underway measurements will include salinity, temperature, fluorescence, light transmission, pH, nutrients, chlorophyll, and dissolved gases (N_2O, CO_2, and O_2) at a single depth (down to 200 m) along a horizontal transect. Detailed vertical profiles will be made of chlorophyll, suspended particulates, light scattering, fluorescence, pH, nutrients, and dissolved gases. These parameters are chosen as sensitive indicators of both primary biological and microbial activity.

Chemical processes in fronts are, in part, controlled by the physical advection and diffusion of various constituents between different, neighboring water masses. Physical processes will be studied using a profiling, three-component velocimeter/CTD instrument. Through concurrent measurements of the local density, velocity and chemical fields, the interaction of physical processes and rates of change in chemical parameters will be investigated. NORDA's remote sensing capabilities will be used to assess potential study areas beforehand, to provide field experiments with real-time frontal locations, and to correlate the physical and chemical properties with remotely sensed imagery. The association of frontal optical water properites with chemical processes and with remotely sensed data will also be investigated to gain a more complete understanding of frontal effects on bioluminescence and water column optical characteristics. Major field experiments are planned by NORDA during 1985 and 1986.

During December 1982, a preliminary frontal study was undertaken in the Gulf of Mexico. A detailed survey was made of the Mississippi River plume front on 19 December 1982 in an area (28^{o} 53.34'N, 88^{o} 31.17'W) where the surface water was strongly influenced by an anticyclonic Loop Current eddy. This eddy was impinging against the shelf water and jetting the coastal water in a plume toward the east and south. The frontal boundary was very distinct and could be visually observed as a water color change from green (coastal) to deep blue (Gulf). Surface water temperature variations of $2^{o}C$ and salinity changes of $4^{o}/oo$ ($32-36^{o}/oo$) were observed over a horizontal distance of less than 100 m. An XBT survey of the frontal zone showed the Gulf surface water (22.6^{0}C) was well mixed to a depth of 70 m, but was overlaid by a 10-m thick surface layer of lower salinity, cooler (20.6^{0}C) water.

The frontal zone was characterized by large changes in sea surface roughness, chlorophyll (0.66 - 1.42 ug/L), turbidity, and increased interleaving in the vertical temperature profiles. The sharp change in sea surface roughness (white caps on the Gulf side, none on the coastal side) across the front was attributed to the temperature imbalance between the air and surface water. The warmer Gulf water heated the air, causing it to rise and be turbulent, while the colder coastal water cooled the air above. This micrometerological cooling caused the very near-surface atmosphere to be more dense and stable, thus insulating the coastal water from wind action that was producing the white caps a few meters away in the warmer Gulf water. The higher organic content of the coastal water, with consequently higher levels of surface active material, may also have had an effect on the wave damping on the coastal side of the front.

The surface frontal boundary contained large quantities of debris and numerous Physalia physalis, resulting from the sweeping effect of the outflowing coastal plume. Higher fish densities at the front were inferred from increased bird populations, primarily laughing gulls. Thirty + 17 birds were observed in 2-min. counts along the front, compared to 0.7 + 0.6 birds observed on either side of the boundary.

Remote sensing imagery from the NOAA-7 radiometer (AVHRR) and the NIMBUS-7 coastal zone color scanner (CZCS) was used to examine the areal extent and variability of the front. Four AVHRR passes (16, 17, 18 and 20 December) showed the large eddy (diameter=200 km) moved progressively to the northwest. As the edge of the eddy contacted the coastal water, tranfer of momentum resulted in advection of the coastal water east and south in a jet. CZCS data of 21 December showed a plume of water high in chlorophyll associated with the jet. Further analysis of the remote sensing data is in progress.

OPTICAL VARIABILITY IN THE ALBORAN FRONT MONITORED BY CZCS

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The application of visible satellite imagery for assessing the variability of water optical and bio-chemical properties in the Alboran Sea in the Western Mediterranean was demonstrated in the Donde Va? experiment. The Donde Va? experiment, which was conducted during October 1982, was an international experiment with participants from Spain, Germany, France, and United States agencies of NOAA, NEPERF, and NORDA. The overall Donde Va? objective was aimed at the circulation of the Alboran Sea, though considerable interrelationships with the bio-optical parameters were obtained. This work describes results of the bio-optical measurements. Further conclusions with other segments of this experiment are expected within the year. The Coastal Zone Color Scanner aboard Nimbus 7 was used to examine the spatial and temporal variability of absolute concentrations of chlorophyll and calculation of the diffuse attenuation coefficient. A strong inflow of Atlantic water through the Straits of Gibraltar flows westward along the Spanish Coast, forming the Alboran front on the north side. This inflow bends southward toward the North African Coast, where it splits into a east-west flow. The east-west flow completes the anticyclonic Alboran Gyre. Upwelled waters along the Spanish Shelf are responsible for cold shelf and coastal conditions. The spectral water color variations of the water masses--coastal, upwelled, Atlantic inflow, and gyre inflow--can be characterized by CZCS.

METHODS

Grounds truth collected during the course of the experiment was concentrated along a line extending perpendicular from the Spanish coast beginning at Marbella. The line was described to extend across the axis of the inflowing Atlantic water and would therefore, transect several water types: coastal, upwelling, Atlantic, and warm core gyre (Cheney and Doblar, 1982). Water optical stations along this transect were located in each of the water masses and included beam attenuation coefficient and spectral (420-600 nm) upwelling and downwelling diffuse attenuation coefficeint ("k"). Supporting conductivity, temperature and depth profiles were also collected. Coincident water samples for chlorophyll, nutrients, and suspended sediments were also collected but will not be discussed in detail in this report.

CZCS imagery for the western Mediterranean was analyzed for approximately 12 days. A sequence of 6 images (6, 7, 8, 11, 12, 13, October 1982) will be discussed in detail in this paper. The imagery was calibrated and atmospherically corrected in order to obtain absolute upwelling radiance from the ocean surface in three spectral channels (443, 520 and 550 nm). The technique implemented for this correction is a modified version of that described by (Gordon, 1978) and (Gordon and Clark, 1980), in which the 670 nm channel is used as a weighted subtraction of the aerosol concentration. Selection of the angstrom coefficient which determines the optic depth of the aerosols was based on an interactive analysis procedure recently developed (Arnone and Holyer, 1983). In order to accurately describe the temporal variability, each of the images was then registered to a mercator projection. Finally, two algorithms which relate the ratio of the absolute upwelling radiance of the 443 and 550 nm channels to both diffuse attenuation coefficient and chlorophyll concentration were applied (Gordon and Clark, 1980, Austin and Petzold, 1980).

SIGNIFICANT FINDING

The ratioed results of channels 1 to 3 (443/550) for the six-day sequence of CZCS imagery were applied to the algorithms previously described. The spatial distribution of the Alboran front and gyre are clearly observed. North of the inflowing, Atlantic waters appear chlorophyll rich and have high "k" values. These are somewhat distinguished from the coastal water mass which show elevated "k" and chlorophyll values. The temporal variability, which is shown to change on a daily basis, includes both the frontal feature movements and the non-conservative nature of the water mass itself. That is, the temporal bloom or decay of the chlorophyll concentration for a water mass and associated optical properties is shown to change based on the daily gray shade variation. The strongest variations of a single water mass are shown to occur to the north of the inflowing Atlantic waters, and change "k" values form .15 to .07 in a 24-hour period.

Cyclic pulses of cold water features have been shown in thermal IR imagery (LaViolette, 1983) originating at the Straits of Gibraltar and propagating eastward around the gyre. These cold pulsations are shown to coincide with high "k" and chlorophyll and increased turbidity. Results of ground truth analyses confirm the presence of this pulsating water mass. Origin of the pulsations are believed associated with tides, and further analyses are being investigated.

The correlation between sea surface temperature (SST) as measured by thermal IR (NOAA-7) and the diffuse attenuation coefficient as measured by CZCS are also under investigation. An inverse relationship between "SST" and "k" has been illustrated through differences between the position of surface thermal and color fronts, which are presently under investigation.

Calculation of the diffuse attenuation coefficient from CZCS algorithms agreed within 15% with the measured ground truth analyses. Better agreement was observed in the clear deep ocean waters than in the coastal as would be expected (Arnone, 1983). A 10% error in diffuse attenuation coefficient using satellite techniques is considered quite low since error in ground truth instrumentation can attribute 5% and the optical patchiness of the coastal/shelf waters can attribute >10% error for the 800 meter resolution of the satellite.

DISCUSSION AND RECOMMENDATIONS

The dynamic spatial and temporal variability of the bio-optical properties is demonstrated by sequential CZCS imagery. This variability is shown by frontal movements and inherent changes in the bio-optical properties of selective water masses. The processes involved in these substantial changes have not been adequately defined, described, or modeled. The application of quantitative measurements from CZCS imagery has improved our ability to understand our ground truth measurements and expand on the realization that the ocean is more complex and variable than originally surmised.

The use of visible remote sensing techniques for bio-optical quantitative measurements, relies on a thorough understanding of how spectral upwelling radiance results from bio-chemical products and processes within the water column. Future research should encompass modeling radiative transfer in bio-chemical process in order to improve application of visible remote sensing in oceanography.

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SOUTHWEST FLORIDA SHELF CIRCULATION MODEL

Cort Cooper
Conoco

This report summarizes an 18-month study funded by the Minerals Management Service. Motivation for the study arose from the Service's intention to grant leases for oil exploration and the attendant need to estimate the probable destination of water-borne pollutants originating from drilling and production activities. The purpose of the study was to develop a capability for predicting seasonal water circulation on the southwest Florida contintental shelf. Because of modeling considerations, the study area was expanded to include the contiguous West Florida Shelf (WFS), extending from the Florida Keys in the south to Apalachicola in the north, and the 200 m isobath to the west.

The study involved four phases: literature review and data search, model modifications and sensitivity studies, model verification and tuning, and prediction of seasonal circulation patterns. These phases produced the following results:

1. A thorough review of the literature and available data base indicated that there have been very few historical attempts to form a coherent picture of overall circulation on the WFS, and no attempts which have incorporated some of the more recent data bases. In situ data measurements on the shelf were sparse--high quality current data were limited to two studies yielding a total of 6 meter-months of data. Other current measurements exist but they were taken in deeper water near the shelf break. As a result of the limited data base, circulation on the WFS remains poorly understood. Important forcing mechanisms which were identified for inclusion into the model were the Loop Current, winds, and density gradients.

2. The model used in the study was based on a numerical solution of the conservation of momentum and mass equations. The model could predict the temporal and 3-D spatial changes of the horizontal velocity field, and included forcing due to the atmosphere, earth's rotation, inertia, and horizontal pressure gradients. Realistic bottom topography was included. Vertical and horizontal dissipation was modeled via eddy viscosity and bottom friction coefficients. Several improvements to the original model were implemented to better simulate processes of importance on the WFS. These modifications were verified by comparing the model results to analytic solutions of simple flow problems.

3. Following modification and initial sensitivity studies, the model was used to hindcast three data sets in real time. Two of these were about one month in duration taken during the winters of 1973 and 1978. The winter data included in situ current meter and coastal surface elevation data. The third data set was limited to two months of coastal surface elevation data taken during the summer of 1974. A reasonable simulation of the winter 1978 data and surface elevation data for the winter 1973 was obtained.

Summer surface elevations and winter 1973 currents were difficult to simulate largely because available data were inadequate to specify external forcing. In the case of the 1973 data, eddies from the Loop Current strongly influenced current observations but could not be modeled because of insufficient hydrographic data and model limitations.

4. Seasonal descriptions of wind, horizontal density gradients, and the Loop Current were derived from available data.

   Winds were broken into three seasons: fall-winter, spring, and summer. Net resultant wind stresses for each of these seasons were calculated based on five years of data from Key West.

   All available hydrographic data consisting of more than 35,000 measurements were processed and analyzed. The results indicated statistically significant horizontal density gradients only during the summer. It is suspected that the averaging process tended to obscure any gradients which may in fact exist. Averaging was necessary, however, because of the lack of synoptic shelf-wide hydrographic data. Currents resulting from this gradient were less than 1 cm s^{-1}. The hydrographic summary was also used to determine the vertical stratification during the summer, which did prove to have a substantial effect on modeled currents.

   Including Loop Current effects in the seasonal circulation pattern involved a number of serious uncertainties. As a best estimate, the Loop Current effect was modeled using a steady, alongshore velocity applied at the model western boundary. The northern limit of intrusion of the Loop Current into the Gulf of Mexico was varied according to season with maximum penetration occurring in the summer.

   The model results indicated a composite fall-winter circulation with a dominant southerly flow at all levels. Surface currents were on the order of 10 cm s^{-1} on the shelf. The spring and summer currents were generally smaller in magnitude and had a more complicated pattern characterized by northerly surface currents in waters within 50 km of the coast and southerly currents elsewhere. These features were consistent with available drifter observations and in situ current data. The model did not include any effects of migrating Loop Current eddies, as this was not justified by the existing data base and was beyond the present formulation of the model.

Further studies will be severely constrained by the existing data base, but four areas with some potential were suggested. It was recommended that further refinement of the model be performed as soon as additional data became available. The most likely source of future data was the Mineral Management Service's Gulf-wide oceanographic data collection program which was to start in 1982. The proposed program was regarded as appropriate, but based on the data review, it was recommended that the program be augmented by a specific attempt to monitor migrating eddies on the shelf.

DEVELOPING AN OPERATIONAL WATER QUALITY OF THE GULF OF MEXICO

C. John Klein
Ocean Assessments Division, National Oceanic and Atmospheric Administration

This paper briefly describes the rationale for and the development of a simple water quality pollutant transport model to be used in conjunction with other ocean resource assessment methods to analyze resource use conflicts in the Gulf of Mexico. Many types of resource use conflicts occur in the coastal and ocean zones. Since many of the conflicts can result in significant costs to the natural environment and society, there is growing interest in their early identification and development of strategies to reduce their impacts. For the purposes of a strategic assessment in the Gulf of Mexico a model is being developed to serve in the short run as a "first cut" simple quantitative water quality model for use in strategic assessments.

Two schemes for segmenting the Gulf into control volumes will be used. The first tier is to divide the Gulf into a grid of 1/2 by 1/2 cells. The pollutant transport equations developed for this grid scheme will roughly describe the movement of pollution throughout the entire Gulf. The second tier further subdivides selected nearshore regions into smaller square grids covering the remainder of the Gulf. Additional resolution is needed on nearshore waters where many important resource use conflicts occur due to relatively heavy concentration of activities and heavy pollutant loading from land-based sources. The number and location of nearshore regions to be subdivided further will depend on the relative importance of pollution and availability of more refined data in these regions.

The basis for writing the mass balance equations for each control volume will be the well-known, two-dimensional, advection-dispersion, mass transport equation, including a first-order reactive term and external sources and sinks of pollutants:

where C = average concentration of pollutant of interest in control volume,

t = time,

x = longitudinal distance,

y = latitudinal distance,

U_x = average current velocity in the x-direction,

U_y = average current velocity in the y-direction,

k_x = coefficient for dispersion in the x-direction,

k_y = coefficient for disperison in the y-direction,

k_d = first-order decay rate for pollutant of interest, and

S = sum of all external sources, sinks, and interactions among pollutants (when considered).

This equation defines the basic structure of the pollutant transport model to be developed for the Gulf of Mexico. It assumes, and consequently so do the transport equations derived from it, that constituents are instantaneously and homogonously mixed throughout the control volume. When the pollutant is discharged into a control volume, it is dispersed equally throughout the volume and its concentration is the same everywhere in the volume.

In order to fully explain the application of this equation to the control volumes into which the Gulf of Mexico has been segmented, several additional points require explanation: (1) How will the requisite hydrodynamic data and parameter inputs be estimated for each control volume? (2) How will estuaries affect pollutant discharge inputs into nearshore control volumes? and (3) What are the pollutants which will be included in the model?

The hydrodynamics will be based on Geostrophic approximations for a summer and winter season. Other parameters such as dispersion coefficients and decay rates will be developed from field data, if such data are available. Otherwise they will be estimated as empirical values during the process of model calibration.

Most land-based pollution which enters nearshore Gulf of Mexico waters must first pass through estuaries. These estuaries "trap" and/or biochemically decay, to varying degrees, many pollutants before they pass into nearshore waters. The landward boundaries of the control volumes into which the Gulf will be segmented terminate at the mouths of estuaries--that is, no estuaries will be included in a control volume. Consequently, the amount of pollution discharge reduction which takes place in estuaries must be estimated before land-based pollutant discharges can be passed into nearshore waters. Consequently, estuarine retention time determinations will be made and pollutant concentrations inferred from the salinity regime.

Developing a natural system is an exercise in uncertainty. However, developing and using the model will (1) illustrate an important aspect of the analysis framework that is required to generate the information necessary for resource management decision making in coastal and ocean areas; (2) stimulate the collection and integration of information not previously collected or integrated into a single framework; (3) identify major data gaps and priorities for future research, both in terms of data to be developed and specific areas requiring additional detailed analysis; and (4) serve as a basis for developing a more refined pollutant transport model commensurate with the information needs of more detailed regional assessments.

DATA BUOY CENTER PROGRAM PLANS

Mr. Ray Partridge
NOAA Data Buoy Center

The NOAA Data Buoy Center (NDBC) has agressively pursued the development of drifting data buoys to a point so as to render these systems available for operational and routine collection of an assortment of marine environmental data. Largely as a result of the micro-electronic revolution, the capability of these small, air-deployable buoys has increased several fold since the early 70's. Early buoys were used to track near surface oceanic currents by resolving their time-series positions to a set of velocity vectors. Today the drifting buoy can telemeter through the TIROS satellite a suite of data including not only position, but also barametric and hydrostatic pressure, air and sea surface temperatures, wind velocity, and subsurface ocean thermal properties. These data are detailed time-series observations of dynamic environmental responses to natural forces and are relayed to scientists and forecasters in near-real time.

During 1982 and 1983 NDBC has participated in several interdepartmental programs using drifting data buoys. One program with the Minerals Management Service (MMS) has resulted in the deployment of several buoys into anticyclonic rings shed from the Gulf of Mexico Loop Current. The buoys have provided an exciting data base clearly depicting eddy kinematics and significant increase in understanding of the general circulation of the southwestern Gulf of Mexico.

Another joint exercise with the Navy, DRIFTEX, resulted in the deployment of three drifters configured with a complete set of meteorological sensors and subsurface ocean thermal sensors into the central Sargasso Sea. Data from these three buoys clearly depicted ocean internal wave activity generated as a result of the passage of a moderate atmospheric cold front through the vicinity of the buoys.

A third program with drifting data buoys was initiated as a result of an emergency request from the Kingdom of Saudi Arabia for assistance in monitoring and forecasting the impact of a large oil spill occurring in the Arabian Gulf. Thirteen drifting buoys were airlifted to Daharan, KSA and were subsequently deployed by helicopter into the Arabian Gulf. Data from these buoys were input to a numerical model developed by NOAA's Hazardous Materials Response Branch in Seattle that simulates the effects of wind-driven circulation, estuarine circulation, circulation due to fresh water run-off, and oil drift due to wind. Buoy position data were used to obtain a set of velocity vectors separated both in space and time. A linear regression model provides a best fit of buoy data to recorded winds and modeled circulation coefficients. The regression coefficients are used in turn to obtain a better fit of modeled parameters to actual circulation patterns. Variance between the buoy data and the model output yields an indication as to the accuracy of the model.

As a result of the intense wave of interest in the use of drifting data buoys for the acquisition of marine environmental data being generated at the interdepartmental level, a working group for drifting data buoys (WG/DDB) was established by the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) under the Committee for Basic Services (CBS). The first meeting of the working group is scheduled for the week of January 16, 1984.

Future drifting buoy programs that are presently on the drawing board include in addition to the MMS Gulf monitoring study, the establishment of a network of drifters in the northeast Pacific and northwest Atlantic oceans for basic weather data acquisition and the deployment of up to 80 drifting buoys in the southern hemisphere in support of the Tropical Ocean and Global Atmosphere (TOGA) program. Other immediate activites planned in 1984 will include two drifters to be deployed in advance of land falling hurricanes in the Gulf and five drifters for marine data acquistion in the central Atlantic. Data acquired by buoys during these experiments will be made available to operational forecasters via the Global Telecommunications Service (GTS) and to researchers through the appropriate archive centers.

PHYSICAL OCENAOGRAPHIC STUDIES AT LSU OF GULF OF MEXICO SHELVES

William J. Wiseman, Jr.
Coastal Studies Institute, Louisiana State University

All the physical oceanographers at the Coastal Studies Institute have some involvement on the shelves of the northern Gulf of Mexico. The breadth of interest ranges from the effects of river runoff to benthic boundary layer dynamics.

A 2 1/2 year time series of hydrographic cruise data from the Texas-Louisiana shelf has been analyzed to determine the distribution of fresh water on the shelf. A seasonal pattern has been suggested, with fresh water confined near shore in winter/spring and centralized in an isolated peak over the west Louisiana shelf during the summer. Comparison with simultaneous time series of river runoff and estimates of precipitation and evaporation have permitted estimation of refill times for the fresh water on the shelf. These refill times range between about six months to one year.

Monitoring of the Atchafalaya Delta system continues. The growth of the subaerial delta has been tracked for nearly a decade. The distribution of suspended sediment within the effluent plume of the delta is monitored with calibrated LANDSAT images. The subsequent fate of the sediment delivered to the shelf is an area of continuing research. One project is focusing on the dynamics of the muddy coast west of the Atchafalaya Bay system. In particular, this project is describing the seasonal growth and retreat of the mud banks. A second project is investigating the long-term fate of nearshore sediment as a function of sediment size. Comparing field data and model results, it appears that the net drift of fine-grained material is westerly, while the bottom stress is sufficient to resuspend sand-sized particles and transport them only during the strong cold fronts of the winter season. The resultant net drift of sand-sized particles should therefore be easterly. That the existing bottom sediments do not exhibit such a distribution may reflect the effects of extremely aperiodic, high-energy hurricane passages.

Air/sea interactions over the shelf and their effects on circulation are the other areas in which the Institute has active projects. Our remote-sensing group continues to monitor the effects of intense cold-air outbreaks on the surface temperature field of the shelf. Sea-surface temperature frontogenesis and the fate of estuarine effluent plumes following cold-front passage are areas of particular concern.

The effects of mesoscale variability in the surface wind field on the current structure of the shelf are an additional area of interest. Significant variability in both the alongshelf and across-shelf wind field has been observed. Variations in the curl of the wind stress on time scales of a few days can be more than an order of magnitude larger than the long-term mean curl. It is not clear what the consequent effect of such variations may be on the mesoscale flow patterns of the shelf. Measurements to be taken this winter are designed to answer this question.

Session: RIGS-TO-REEFS

Chairmen: Mr. Villere Reggio Jr., MMS
Mr. Dana Larson, NOIA

Scribe: Ms. Carla Langley, MMS

Date: November 15-17, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Mr. Villere Reggio Minerals Management Service

PART I. FINDINGS ON PLATFORM FISHING INVESTIGATIONS IN THE GULF OF MEXICO WITH A FOCUS ON MANAGEMENT IMPLICATIONS AS IT RELATES TO OIL & GAS STRUCTURES

An Analysis of Recreational Fishing Use at 164 Major Offshore Petroleum Structures	Dr. Robert Ditton Texas A&M University
Petroleum Production Structures: Economic Resources for Louisiana Sport Divers	Dr. Kenneth Roberts LSU, Center for Wetland Resources
Comparison of Fish Communities Associated with Natural Hard-Bottom Areas & Offshore Oil & Gas Structures	Mr. Russell Putt Continental Shelf Associates, Inc.

PART II. PLANNING/COOPERATION/INNOVATION- KEY TO EXTENDED PRODUCTION FROM OIL & GAS STRUCTURES

The Role of Artificial Reefs in the Future of the Gulf of Mexico Fishery Management Process	Mr. Ronald Schmied National Marine Fisheries Service

The Artificial Reef Development Center	Mr. Gilbert Radonski Sport Fishing Institute
Adaptive Environmental Assessment and Its Potential Use in the Artificial Reefs Program	Mr. Richard Ellison U. S. Fish & Wildlife Service
Rigs-To-Reefs in the Eastern Gulf: Past Accomplishments & Future Plans	Mr. James Barrett Florida Department of Natural Resources
Innovative Techniques for Economically Removing & Transporting Oil & Gas Structures for Reefs	Dr. Richard Dominguez Woodward Clyde Oceaneering
Japanese Technology & American Resources: Producing Effective Artificial Reefs From Obsolete Platforms	Dr. Daniel Sheehy AQUABIO, Inc.
Enhancing Petroleum Structures for Fish & Fishing: Fact or Fad	Mr. Gregory McIntosh, Jr. McIntosh Marine, Inc.
KEYNOTE ADDRESS	Mr. William Pendley Assistant Secretary for Energy & Minerals, USDI

RIGS-TO-REEFS

RIGS-TO-REEFS SESSION OVERVIEW

Villere C. Reggio, Jr.
Outdoor Recreation Planner, MMS
Gulf of Mexico Region

Over four years ago the Gulf of Mexico region started focusing on the need for information on, and documentation of, the incidental fishing use directly associated with oil and gas structures. Findings from these investigations are now being published through Universities, Sea Grant Institutions, Government reports and in technical journals. Although the value of oil and gas structures to offshore fishing had been reported for years through Gulf of Mexico lease sale environmental impact statements and popular fishing magazines in Louisiana and Texas, only in the last year or two do we have evidence of broad recognition that offshore energy and fisheries developments are more often compatible and mutually supportive than not.

The International Association of Fish and Wildlife Agencies and the Gulf States Marine Fisheries Commission have resolved to support the development of national guidelines and regional planning designed to encourage multiple use of ocean resources and to direct the most effective deployment of artificial reefs for fisheries management and development. Legislative and administrative initiatives aimed at establishing a national artificial reef policy and program are underway in our nation's capitol, and the Secretary of the Interior has established a Recreation, Environmental Enhancement and Fishing in the Seas (REEFS) task force. This task force consists of broad-based representation from key public and private groups which have expressed interest and encouragement for national leadership supporting the development of artificial reefs. Inherent in all these initiatives is recognition of the potential for oil and gas structures to play a major role in the recreational and fisheries development of our nation's offshore marine environments.

In 1983 the Minerals Management Service (MMS) adopted a new policy and issued an interpretive rule directed at encouraging the perpetuation and expansion of the fishery benefits of oil and gas structures and is currently developing procedures which will enable states and other responsible parties to acquire obsolete structures on formerly active leases for fisheries development and enhancement projects.

Rigs-to-Reefs was a timely focus at the Fourth Annual Information Transfer Meeting. Chairmanship of the session was shared with Mr. Dana Larson who is Environmental Conservation and Safety Committee Chairman of the National Ocean Industries Association (NOIA). Mr. Larson was instrumental in the initial conversion of an oil and gas structure to a permanently dedicated artificial reef. NOIA's president, Mr. Charles Matthews, co-chairs the national REEFS task force with the Secretary of the Interior. Six of our session presentors are members of the REEFS task force, and other presentors are represented on the task force by their agencies, industry associations, or institutions.

High interest in agenda topics was evidenced by the standing room only crowds. Audience participation contributed effectively to the session theme. For example, Mr. Rex Alford, from Conoco, related his participation in the International Maritime Organization's (IMO) discussions on platform removals worldwide. Apparently the need for, and wisdom of, complete removals of obsolete oil and gas structures is being reevaluated in other countries as well, a move which could ultimately affect international agreements. Mr. Ben Mostkoff, who coordinates Dade County's very popular artificial reef program, made a strong plea for obsolete oil and gas structures to enhance existing, fully permitted, deep water reef sites off the southeast coast of Florida. Several presentors and audience participants discussed the need for, and value of, artificial reef refuges or sanctuaries where fishing would be discouraged or prohibited. Most of the other discussion was intended to clarify points made by speakers.

The Rigs-to-Reefs session was organized in two distinct parts.

In the first part, we shared information on the results of several studies on fish and fishing associated with oil and gas structures. Moreover, we had a pre-meeting hands-on experience -- we went fishing around active production platforms off Louisiana to help demonstrate to those people who are not natives of the Gulf what we have offshore and often take for granted, and I think we succeeded in doing that.

In part two, we discussed the various planning schemes, techniques, innovations, and governmental leadership likely to make contributions in converting rigs-to-reef rhetoric into new and better fishing opportunities.

We previewed the session with a Tenneco film clip on the Pensacola Reef, a former production platform off Louisiana. This set the stage by very graphically demonstrating that rigs-to-reefs can be more than just a concept.

Professor Ditton from Texas A&M summarized the results of his comprehensive analysis of the fishing use at 164 major offshore petroleum structures. The main purpose of this survey was to get a macro look at fishing patterns from the area offshore of Louisiana which, because of the extensive oil and gas development, has a full range of choices for the fisherman, that is, nearshore/offshore artificial reefs, deep water/shallow water artificial reefs, old/new artificial reefs, big/small artificial reefs, isolated and very accessible artificial reefs. Other than documenting what we already knew--the popularity of offshore structures among all recreational fishing groups--the study did show that there is disproportionate use among nearshore structures. Thus the deployment of structures specifically for recreational fishermen should never be a random undertaking if you're counting on maximizing fishing use, notwithstanding concerns for minimizing conflict among other ocean users.

Next Dr. Ken Roberts, from the L.S.U. Center for Wetland Resources, reported on the findings from a survey of Louisiana scuba divers who utilized petroleum structures. Besides documenting many aspects regarding the motivation and socio-economic profiles of scuba divers, Ken's primary purpose was to evaluate the worth of petroleum platforms to scuba divers and to the economy in general. His findings indicate that the smallest offshore recreational group, scuba divers, say they would be willing to pay approximately $150 a year just for the privilege of scuba diving under these structures. Cumulatively, platform scuba divers contribute over $1 million a year to the Louisiana economy in pursuing this special form of recreational activity provided totally, incidentally, by our national energy development program offshore. His work has been published in a report that is available for distribution from LSU or the U.S. Department of Commerce through Sea Grant Publication No. LSU-TL-83-002.

Mr. Russell Putt, from Continental Shelf Associates, reviewed the findings of a BLM-supported reef fish study shedding some light on fish populations associated with oil and gas structures. Insight into species diversity and environmental effects such as current and depth on the location of specific species in relation to the vertical and horizontal aspects of structures was presented.

Realizing the tremendous fisheries and fishing value incidental to the existing 4,000 petroleum structures or "de facto" reefs cited solely for the purpose of energy development, we moved into part two of our session with the challenge of what could be done or accomplished for fisheries development and fishing should we be able to direct an equivalent amount of artificial reef material soley for the purpose of fisheries management and development.

Gil Radonski, president of the Sports Fishing Institute, commented on the need for a national institutional focus for artificial reefs. The Sports Fishing Institute has taken action to fill that need by establishing the Artificial Reef Development Center. The Center, under the direction of Mr. Bill Dubose, will serve as a national information repository, exchange and clearing house. They will facilitate artificial reef development by matching reef sponsors and material donors, provide data to researchers and managers, and make data on artificial reefs available to other ocean user groups. Specifically, the Sports Fishing Institute Artificial Reef Development Center will focus research, information and solutions on issues in the following areas: the permitting process, siting consideration, suitable materials of opportunity (and they're very, very high on oil and gas structures), liability concerns, long-term maintenance of reefs, appropriate marking devices, and economic considerations relative to reef development and maintenance.

The Center was established by a National Marine Fishery Service, Saltonstall/Kennedy Fisheries Development Grant, and a contribution from Tenneco Oil Company, but intends to become self-supporting. One of the first projects will be to develop a "how to" guide and checklist for prospective artificial reef sponsors.

Ron Schmied, who is Special Assistant to the Regional Director for Recreational Fisheries in the Southeastern Region of the National Marine Fisheries Service, reviewed the legally established fishery management process, related the progress and development of fishery management plans for the Gulf of Mexico, advised of the developing policy and institutional support for habitat conservation and enhancement, and assured us that the National Marine Fisheries Services was high on the fishery development potential of artificial reefs for the Gulf in general, and oil and gas structures in specific.

Ike Ellison, from the Fish and Wildlife Service, advised us on the availability of high tech methods for resolving or making an objective analysis of issues and user conflicts, concerns which must be addressed in planning for artificial reef developments. Specifically, through his

Adaptive Environmental Assessment (AEA) process, which makes use of computer simulation and computer modelling, better planning can be achieved. Industry representatives in the audience who had experience with the AEA process endorsed its value as a valuable planning tool, especially in complex situations where resolution of conflicting uses between and among user groups is required to make progress.

Jim Barrett, from the Florida Department of Natural Resources, voiced his resounding support for a major rigs-to-reef program. He reviewed Florida's past accomplishments to-date in converting two major production platforms to permanently dedicated artificial reefs. He demonstrated the need for many more obsolete oil and gas structures in the Eastern Gulf of Mexico. He expressed a concern about new rules and regulations or interpretations which could lead to the irresponsible abandonment of petroleum structures in-place as artificial reefs even though the Interior's program envisions conversion, not abandonment.

Dr. Dick Domingues, from Woodward Clyde-Oceaneering, described an exciting new flotation methodology developed for removing and transporting the Marathon structure from off the coast of Louisiana to Alabama for an artificial reef. Since the economics of removal and transport of a giant well jacket is a major stumbling block in making the conversion of rigs-to-reef a feasible concept, this new and emerging flotation technology may be a major breakthrough whereby it may become cheaper to give away an oil or gas structure then to throw it away.

Dr. Dan Sheehy, from Aquabio, Incorporated, described the tremendous financial and technological commitment of the Japanese to artificial reefs. Effective reefs require much more than a pile of rubble dumped in the ocean. If we are to make real progress in artificial reef development in this country, he intimated that we have much to learn from others. He commented on the general utility of oil and gas structures as potentially valuable reef material, with proper concern for siting, placement, and management objectives.

Greg McIntosh, from McIntosh Marine, Incorporated, indicated that no matter how good you think oil and gas structures are for attracting fish, you can make them better. He has designed, developed, and marketed a series of FADs, "fish aggregating devices." Through the proper use and deployment of FADs in conjunction with artificial reef projects, he's demonstrated an economically "feasible enhanced enhancement." He went on to propose a research project using oil and gas structures to further evaluate his technology in developing better reef fishing.

A very timely and inspirational presentation by Mr. Perry Pendley, who is Deputy Assistant Secretary for Energy and Minerals for the Department of Interior, assured our session that our government leadership, especially the Department of the Interior and the Department of Commerce, have seen what we've seen and believe what we believe, that is, energy development and fisheries development can, in fact, be mutually supportive and that one thing we can do to achieve a balance between energy development and environmental enhancement is to develop a directed, fully supported and coordinated rigs-to-reef program. Mr. Pendley assured us that the highest level of the federal establishment involved in ocean use, development, and regulation was getting its act together to support the development of a national artificial reef policy and program.

Specifically, he is spearheading the development of a memorandum of understanding among the Departments of the Interior, Commerce, Defense, Transportation, and the Environmental Protection Agency which will lead to a directed national artificial reef program. In addition to the policy, the memorandum of understanding clarifies agency authorities and designates agency functions, thus creating a concerted, planned and aggressive course of action in respect to artificial reef development. Interior and Commerce are already working on the implementation of a framework which envisions a three-tiered approach with federal intervention decreasing with each succeeding level.

Briefly, common sense national guidelines and standards will be established by the cooperating signatory agencies of the MOU with advice and cooperation from the National REEFS Task Force and the coastal states. These documents will be published in the FEDERAL REGISTER for review and comment.

Phase two would focus on the development of regional framework plans through the efforts and leadership of broad-based regional organizations, such as the Marine Fishery Commissions and the Fishery Management Councils.

The Department of Commerce and the Department of the Interior will encourage and support the development of these framework plans. In the Gulf of Mexico, the Gulf States Marine Fisheries Commission, through the encouragement of the International Association of Fish and Wildlife Agencies, has already seen fit to start the ball rolling. They've passed a resolution in 1983 to initiate the development of a Gulf-wide artificial reef plan.

The final phase will involve site selection planning or project planning, led by project sponsors or interested states.

Mr. Pendley also highlighted the prototype Mississippi Delta Recreational Fishing Map prepared by the MMS Gulf Region as an exemplary project of tremendous public utility which could be duplicated in other areas affected by offshore energy development.

In summary, artificial reefs are a potent fishery management tool, and the success of responsible energy development programs, such as we have here in the Gulf, can help us achieve our goals for fishery management and development as well. Perry Pendley assured us that the Washington leadership realizes this and will establish a framework and procedures which will allow our country to take full advantage of the opportunities at hand.

PART I: FINDINGS ON PLATFORM FISHING INVESTIGATIONS IN THE GULF OF MEXICO WITH A FOCUS ON MANAGEMENT IMPLICATIONS AS IT RELATES TO OIL AND GAS STRUCTURES

AN ANALYSIS OF RECREATIONAL AND COMMERCIAL FISHING USE AT 164 MAJOR OFFSHORE PETROLEUM STRUCTURES IN THE CENTRAL GULF OF MEXICO

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BACKGROUND

There are approximately 4,000 petroleum structures in State and Federal waters in the Gulf of Mexico ranging in size and complexity from simple vertical pipes supporting small platforms to major platforms of considerable structural complexity. According to the U. S. Coast Guard list of lighted platform structures, there are 2,035 such structures in Federal waters offshore Louisiana. Of these, 910 are classified as major structures because of their size and are marked with four or more navigation lights. Typically, these major platforms are large, multiwell production platforms.

During 1980 an effort was initiated by the Minerals Management Service (MMS) to evaluate the recreational and commercial fishing use of a sample of major petroleum structures on the federal Outer Continental Shelf (OCS). The study (co-authored with Janice Auyong, Texas A&M University) was to provide a descriptive understanding of fishermen who fish adjacent to petroleum platforms. In particular, there was a need to know which categories of platforms were used most frequently by various boat fishers (recreational and commercial) and, from this, to develop some general criteria defining expected categories of use.

Data collection was accomplished by oil and gas company personnel who recorded daily incidences of fishing activity around the platforms. Initially, an estimated 72,000 daily and/or monthly records from almost 300 offshore platforms or platform complexes in the Central Gulf were obtained. These platforms were not chosen by MMS for their representativeness but rather because the respective companies were willing to involve their personnel in data collection.

An evaluation of reporting consistency and coverage yielded samples of 69, 68, and 27 reporting sources (platform and platform complexes) in the Delta, Bay, and Cameron regions, respectively. An evaluation of the extent to which each sample is representative of the population of major platforms in each region was completed and is useful to the interpretation of study results. From the useable sample of 164 reporting sources, a total of 19,617 records of positive sightings of fishing activity were logged during the study year (April 1980-March 1981):

12,230	(62.3%)	records-positive boat sightings
7,388	(37.7%)	records-cumulative number of days during which platform personnel were obseved fishing
19,618	(100.0%)	records-total

Observations were made of adjacent boat fishing activity (private recreational boats, charter/party boats, scuba boats, and commercial hook-and-line boats) as well as the fishing activity of platform personnel. Data were collected on the following use characteristics: (1) date, (2) day of week, (3) state of origin of boat, (4) number of people per boat, (5) estimated length of boat, (6) type of boat, (7) type of fishing activity, (8) fish species taken, and (9) number of platform personnel fishing. Information about platform reporting sources was obtained from secondary records: (1) distance from shore, (2) depth of water, (3) year installed, (4) number of platforms in complex, (5) type of production, (6) extent that gas flaring occurs, and (7) relative platform size. Weather data for the survey period were obtained from the Office of State Climatology (Baton Rouge).

OVERALL USE PATTERNS

In the Central Gulf OCS study area, private recreational fishing boats were observed most often, followed by charter/party boats, commercial fishing boats, and scuba boats.

Of the three regions considered, the vast majority of boats (regardless of type) were observed in the Delta region. This disproportionate use pattern was expected because of the adjacent major population areas. Boat fishing activity was not evenly distributed along a coast, but rather was dependent on population densities, transportation links, and fishing infrastructure and facilities. Likewise, these factors played a major role in the extent to which petroleum platforms were used for recreational fishing.

Not only did the Delta region receive a disproportionate amount of fishing use, but certain platforms within the region received disproportionate use as well. In the Delta region, one-fifth of the platform reporting sources accounted for 55% of the private boat observations. Further, within ten miles of shore in the Delta region, there were 37 reporting sources. Twenty percent of these, or seven structures, accounted for a majority of observations in this distance zone. This means that within the nearshore range certain platforms have greater value than others for fishing activity. This same pattern held in the other distance categories as well where 20% of the platforms accounted for a majority or near majority of boats observed.

SPATIAL USE PATTERNS

In the Delta region, the majority of private recreational fishing boats were observed within ten miles of shore in depths of 60 feet or less. The majority of charter/party boats were observed within 20 miles of shore in depths of 60-90 feet. The majority of commercial hook-and-line fishing boats were observed between 11 and 30 miles from shore and in depths greater than 90 feet. Even with changes in the slope of the continental shelf, the pattern was consistent as ranges shifted seaward.

In the following table, average distance from shore (platform to shore) and depth values are presented for each boat type and region:

Boat Type	Delta Region	Bay Region	Cameron Region
		Average Distance (miles)	
Private Recreational Fishing Boats	12.1	21.6	29.0
Charter/party Boats	16.3	38.5	40.7
Scuba Boats	19.5	42.5	47.7
Commercial Hook-and-Line Boats	23.2	57.2	72.7
		Average Depth (feet)	
Private Recreational Fishing Boats	89.2	45.6	54.4
Charter/party Boats	113.2	88.3	75.8
Scuba Boats	123.7	95.1	77.4
Commercial Hook-and-Line Boats	164.0	146.0	134.2

Keeping in mind that the vast majority of private recreational fishing boats were observed in the Delta region, there is good support for siting reefs for private boat fishermen within 20 miles of shore where there is adequate onshore access and facility and support systems. There is also support for siting reefs for particular fishing user groups at sequential distance and depth zones from shore.

When distance and depth are taken together, private recreational boat fishermen in the Bay and Cameron regions traded off depth in favor of distance traveled. They apparently were not willing to travel the distances necessary to fish in the depths that Delta fishermen enjoy relatively close to shore.

TEMPORAL USE PATTERNS

In addition to differences in spatial patterns of offshore use, there were temporal differences as well. Recreational craft were observed mostly between May and August on weekends while commercial hook-and-line boats displayed a more uniform monthly use pattern. The various groups of recreational and commercial fishermen appeared to separate themselves in terms of time and space. Platforms at particular locations and times produced either recreational or commercial fishing benefits.

USER GROUP DIFFERENCES

In each of the three regions, private recreational fishing boats constituted a majority of the total boats observed.

As a boat category, charter/party boats carried a disproportionate number of fishermen offshore. For example, in the Delta region, charter/party boats were only one-fifth as numerous as private recreational fishing boats, but they carried 40% of the offshore fishermen. The significance of the charter/party constituency group exceeds the simple number of boats operating in the area.

There was little scuba activity observed offshore Louisiana. Only 274 boats or less than two percent of the total number of boats observed were scuba boats.

Commercial fishing boats were found further offshore than other boat types and displayed a more uniform monthly use pattern. A majority of the commercial hook-and-line boats observed in two of the three Louisiana offshore regions came from Florida. In each region, commercial boats from Louisiana constituted a minority.

Fishing by platform personnel was widespread. Slightly more than one-third of the platform reporting sources noted more than 50 days of personnel fishing. When all major manned platforms are taken into account, this is an important and previously undocumented fishery.

PREDICTING SPATIAL AND TEMPORAL PLATFORM USE LEVELS

In an effort to predict the spatial distributions of boat observations offshore, a regression analysis was conducted for each boating type using actual distance from platform to shore, water depth and age of platform. Generally, these platform characteristics were inadequate predictors of offshore use--we were not able to predict differences in the number of boats seen from platform to platform. There were two reasons for this: (1) actual distances to shore were used rather than travel distance from platform to shoreland access points; and (2) we lacked a random sample of the population of major offshore structures.

Regression analysis was also used to examine the temporal aspects of platform fishery use. Variables in the regression model included weather parameters like wind velocity, precipitation, and temperature, along with the date and day of the week. The variables included in the model proved to be good predictors of the temporal intensity for use of all activity types across the study area. Temperature was important for all activity types. Wind was an important parameter, especially for commercial boats, and platform personnel. Day of the week was an important parameter for recreational boats, less for commercial boats, and least of all for platform personnel fishermen.

A NEW RESEARCH AGENDA

There is now a need for focused studies of fishing activity and participants at those platforms known to receive disproportionate use. In particular, such efforts should be made in behalf of structures scheduled for retirement that were not included in the study sample, or where there is some doubt as to a platform's value as a fishing resource.

The relationship of access (and related fishing pressure) and the surface area capability of platform reefs need to be better understood if fish stocks and yields are to be substained.

Research should continue in an effort to determine if one or more variables can be used to predict spatial patterns of offshore fishing activity.

Currently, there is more known about the biology of petroleum platforms than the fishermen who make use of them. We need to know why fishermen use platforms and with what expectations and how they might react if "their" platforms were removed in favor of newer platforms at locations farther from shore-based access points.

PETROLEUM PRODUCTION STRUCTURES: ECONOMIC RESOURCES FOR LOUISIANA SPORT DIVERS

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The subject of maintaining petroleum structures as recreational sites, either in place or in other accessible areas, involves consideration of international and federal regulations and state policies. Analyses reported in our report (Thompson and Roberts, 1983) show that there is variation within user groups. Variation should be sufficient to inform those interested in the future of structures as providers of recreational services that they should not neglect research on user group characteristics in favor of policy alternatives. The findings from our study on sport divers' use of structures represent a starting point. The study provided insight not only about sport divers but also about the similarities and differences that can arise solely from the origins of the names sampled.

By relying on a sample of the easily obtainable roster of divers belonging to clubs associated with the Louisiana Council of Underwater Dive Clubs, a researcher could make efficient use of funds. A very high percentage (80 percent) of the roster divers depended on the petroleum structures for at least 61 percent of their dive trips. The researcher seeking to get the most interviews out of restricted research funds would have a high rate of success using this roster.

The results reported herein identify the distinct differences between this sample group and the divers contacted through the NAUI, (National Association of Underwater Instructors) and SD (Scuba Divers Magazine) lists. In general, the club roster divers had a higher dependency on structures, invested more funds in equipment, had more years of experience, visited structures primarily for spearfishing alone (62 percent), and had the lowest pretax income of the sampled groups. The low sample group income of roster divers was evidently offset by the fact that their daily trip expenditures were 38 percent below those of other divers sampled. Cost savings by club members when diving were significant enough to allow the highest participation of all divers contacted.

The divers surveyed from the NAUI and SD lists had comparable responses. Similarity was present in:

1. pretax income:	NAUI divers	$26,575
	SD divers	$27,830
2. equipment investment:	NAUI divers	$1,709.44
	SD divers	$1,844.33
3. daily trip expenditures:	NAUI divers	$117
	SD divers	$109
4. number of trips in 1981:	NAUI divers	5.8
	SD divers	6.1
5. percentage of divers taking one to four trips in 1981:	NAUI divers	64%
	SD divers	63%
6. willingness-to-pay value:	NAUI divers	$159.39
	SD divers	$165.87

The research demonstrated that a list of divers selected for sampling from either the NAUI or SD list would yield accurate insights to sport divers who use structures. Caution is needed, though, because the purposes of dive trips varied. Skin Diver-list divers had the highest use of structures for sightseeing, photography, and other combinations not involving spearfishing. While spearfishing was the single largest purpose among all groups sampled, 35 percent of SD-list divers identified it as the sole purpose of a trip compared with 45 and 80 percent of NAUI and club roster divers, respectively.

A procedure for describing a market situation in order to identify the value of structure sport diving off Louisiana was developed. The procedure used randomly selected starting points to initiate a process of bidding. The goal was to identify the annual value of a permit assuring access to diving opportunities around Louisiana petroleum structures. This procedure simply attempted to bring forth an estimated value for a recreational product or service not traded in a market, yet not without value. Mean responses for the three sampled groups (NAUI, SD, club roster divers) reflected a close relationship. The high-value estimate of $165.87 for the 52 SD respondents was very similar to the mean response of $159.39 from 41 NAUI respondents and $163.94 from 33 club roster divers. The results indicate that structures have substantial value in-place to this relatively small population of users. The valuation procedure also was found to be understandable by respondents. There remains the need to initiate research on other users in depicting the sport and commerical value of structures.

COMPARISON OF FISH COMMUNITIES ASSOCIATED WITH NATURAL HARD-BOTTOM AREAS AND OFFSHORE OIL AND GAS STRUCTURES

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The primary purposes of this study were : (1) to collect quantitative data for comparison of reef fish populations associated with natural hard bottom areas and offshore oil and gas structures and (2) to develop fish population sampling methods which can be applied in deep areas that exclude or limit direct observations. The study was designed as a three-phase effort, each phase with specific objectives: (1) Phase I - evaluation of 13 platforms and 12 hard-bottom areas as potential study sites; (2) Phase II - evaluation of equipment and methods (ROV with television, time-lapse movie cameras, television/still camera sled system, and fish traps); and (3) Phase III - generation and evaluation of standing stock estimates for fish species at one hard-bottom and four platforms.

The study area was the northern Gulf of Mexico outer continental shelf (OCS) between 90° and 94°W longitude and the 18 and 200-m isobaths. There are numerous hard bottom areas described as "natural reefs" within this area. Extensive OCS oil and gas activities have taken place near the natural reefs.

During Phase I, 25 sites were surveyed, described, and classified into shallow water (inshore of the 35-m isobath) and deep water (offshore of the 35-m isobath) hard bottom features and platforms. The shallow water hard bottom sites consisted of relatively small, low-relief, outcrop features normally covered by thick growths of ascidians, bryozoans, and hydroids. Atlantic spadefish, gray triggerfish, red snapper, sheepshead, and tomtate were present. The deep water hard bottom sites consisted of large high-relief features rising above a nepheloid layer into clear water. The tops of these features supported warm waters species of corals, crustaceans, fishes, and sponges. The principal faunal characteristic distinguishing both deep water hard bottom and platform sites from shallow water sites was the occurrence of large numbers of tropical reef fishes at the deep water sites. Anglefishes, butterflyfishes, creole-fish, and creole wrasse were common members of the deep water areas while common shallow water species such as Atlantic spadefish and sheepshead were absent.

During Phase II, equipment and methods were evaluated at the deep water hard bottom area of Jackaman's Hole and at the deep water Platform "A", located 2.4 km from each other at the southern edge of East Cameron Area, Block 229. The mobility offered by a ROV was judged a distinct advantage over other visual assessment tools. Based upon the results of Phase II, the primary assessment equipment recommended for Phase III and future studies included a ROV with powerful thrusters, a wide-angle television camera, and a still photographic system. The suggested assessment method consisted of a three-dimensional sampling strategy with observations at fixed positions and along horizontal transects at several depths at each study platform.

During Phase III, the standing stocks of reef fishes were quantitatively assessed and compared at one hard bottom area (Sonnier Bank) and at four platforms. The distributions and abundances of fishes were highly variable. Based on the types of fish species present and their relative abundances, the ichthyocommunity of Sonnier Bank was distinct from those of the platforms. At Sonnier Bank, virtually no fishes were in the water column at the surface and mid-water stations. Most species were directly associated with the hard bottom habitat. The bank was a diversified habitat area, ranging from a high-relief (31 m) rock outcrop at the peak to flat mud bottom at the outer stations. Fish populations varied from platform to platform. Offshore structures were responsible for concentrating fish populations vertically in the water column. There appeared to be a direct relationship between the abundance of small sedentary reef fishes and schooling species that remained near the structure and the amount of available platform habitat. Some hard bottom fishes utilized the relief offered by the platform as a ladder to expand their vertical migratory range.

Quantitative comparisons of fish assemblages associated with hard bottom areas and offshore platforms were complicated by natural variability in the spatial and temporal distribution patterns of fishes. Certain species were closely associated with particular areas of platforms and occurred in patches, groups, or clusters. Other species exhibited a pronounced spatial relationship with depth and water clarity. If a slight water current was flowing past a platform, virtually the entire fish community was positioned up-current from the platform. The abundance and distribution of fishes at Jackaman's Hole changed radically over a period of one month and diurnal variation was noted in the behavior of several species. To evaluate the standing stock of fishes associated with hard bottom of platform areas using remote sampling equipment, such examples of spatial and temporal variations must be considered in the sampling methods.

One previously unidentified high-relief feature (East Cameron Area, Block 293, Hard Bottom, 29 Fathom Place) was described during this study. This rock outcrop feature, rising from a depth of 57 m to within 30 m of the surface, supports extensive invertebrate and fish communities which are typical of those associated with previously described topographic highs. This feature is not presently shown on any bathymetric charts, nor is it included on the BLM, OCS topographic features list.

Based upon the results of this study, the following recommendations were made.

1) Sampling methods must consider the natural spatial and temporal variations in fish assemblages associated with hard bottom and platform areas before accurate stock and impact assessments are possible.

2) Movements of tagged fishes before and after platform placement should be studied to determine if placement and presence of an offshore structure reduces reef fish populations on neighboring hard bottom areas.

Part II: Planning/Cooperation/Innovation--Key to Extended Production from Oil and Gas Structures

THE ROLE OF ARTIFICIAL REEFS IN THE FUTURE OF THE GULF OF MEXICO FISHERY MANAGEMENT PROCESS

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BACKGROUND AND PURPOSE

Artificial reefs, including benthic, mid-water and surface structures are well recognized for their ability to enhance marine habitat, fisheries production, and fishing opportunities. Reef type and location, of course, control the extent to which these functions are served. To date, however, most of the 120 permitted artificial reefs in the Gulf of Mexico, as well as the innumerable unauthorized reefs, have been constructed with a single purpose in mind--to enhance recreational fishing opportunities. Little effort or progress has been made in exploring, in a broader sense, the role that artificial reefs could or should have in Gulf of Mexico fishery conservation and management efforts. Consequently, this presentation described the existing federal fishery management program, both in terms of objectives and process, and provided insights regarding the role that artificial reefs can play in attaining federal fishery management objectives. Of note, the presentation recognized that the estimated 4,000 offshore oil and gas structures in the Gulf currently function as effective artificial reefs - a role which must receive serious consideration in decisions regarding the fate of these structures when their usefulness in offshore oil and gas production ceases.

THE FEDERAL FISHERY MANAGEMENT PROCESS

Passage of the Magnuson Fishery Conservation and Management Act in 1976 was the turning point in federal fisheries management effort. Through the Act, Congress set in motion a national program to conserve and manage U.S. fishery resources. Primary responsibility for accomplishing the purposes of the Act resides with the Secretary of the U. S. Department of Commerce, who acts through the National Marine Fisheries Service.

The discussion of the federal fisheries management program focused on three issues: program objectives, the process used to achieve those objectives, and program accomplishments.

Fishery Management Objectives

The objectives of the federal fishery management program are prescribed by the Magnuson Fishery Conservation and Management Act and include the following:

1. To conserve and manage fishery resources found off the U.S. coasts by establishing a Fishery Conservation Zone (an area extending 200 nautical miles seaward from the U. S. coasts), and exerting exclusive fishery management authority over all fish in the zone (except tunas) and over anadromous species found beyond the zone.

2. To support implementation of international agreements to manage highly migratory species.

3. To promote domestic commercial and recreational fishing.

4. To prepare and implement fishery management plans which adhere to national standards and achieve optimum yield from each fishery on a continuing basis (optimum yield is maximum, sustainable, biological yield adjusted by social, economic and ecological factors).

5. To establish eight Regional Fishery Management Councils to ensure full public participation in the development of fishery management plans (membership prescribed by law).

6. To encourage the development of underutilized or unutilized fisheries.

Management Process

In the presentation, an overview of the fishery management process was presented with particular emphasis on the makeup (membership) of the Gulf of Mexico Fishery Management Council and the national standards used by the Secretary of Commerce to determine the approvability of fishery management plans. The key steps outlined in the process discussion included the following:

1. Scoping process to identify fisheries in need of management and pertinent information.

2. Development of fishery management plans by Fishery Management Councils with public involvement.

3. Review and approval of plans by the Secretary of Commerce. Approval based on compliance with national standards.

4. Development, implementation and enforcement, by the Secretary, of regulations needed to place plans in effect. Civil and criminal penalties may be imposed for violations of regulations.

5. Periodic review and revision of plans by Councils.

Accomplishments

The Gulf of Mexico Fishery Management Council has been in operation since August 1976. Of the 15 plans projected for development in the Gulf of Mexico area, four have been approved and implemented: shrimp, coastal migratory pelagics (king and spanish mackerel), spiny lobster, and stone crab. Two more plans have been approved by the Secretary of Commerce (reef fish and coral), and they will be implemented as soon as final regulations have been developed.

THE ROLE OF ARTIFICIAL REEFS IN THE FISHERY MANAGEMENT PROCESS

Correlation of the various objectives of the federal fisheries management program with research findings and experience regarding artificial reefs reveals at least six major ways in which artificial reef construction can help further fisheries conservation and management efforts in the Gulf of Mexico.

1. Maintaining, Restoring and Enhancing Fishery Habitat

   Artificial reefs can be used to expand habitat locally for habitat-limited species such as snapper, groupers and other fish dependent on coral reefs and bottom outcroppings. Projects conducted with spiny lobster indicate reefs can be used to reduce impact of coastal construction on marine organisms by providing temporary shelter for displaced organisms. Artificial reefs may also be specifically designed to create shelter, spawning, nursery and feeding areas for target species. A new emerging concept is to use artificial reefs to help mitigate habitat loss resulting from coastal perturbations.

2. Rebuilding Fish Stocks

   Research has proven that artificial reefs can actually increase primary production and fish biomass in local areas.

Moreover, the Japanese who currently expend a minimum of $60 million per year on artificial reef development, have demonstrated that reefs can be designed to enhance production of specific target species. Properly designed, sited and constructed artificial reefs, therefore, should be carefully considered in developing fishery management strategies needed to maintain and/or rebuild fish stocks. For example, reef fish stocks in the Gulf, which are currently considered to be overfished and stressed in many nearshore areas, may greatly benefit from artificial reef construction if combined with appropriate catch limitations (minimum size limits).

Establishment of special management areas (marine sanctuaries) for extensive artificial reef complexes could provide an extra measure of protection for stressed fish populations or for vulnerable life stages of various species. For example, fishing could be prohibited selectively around offshore structures and other artificial reefs on a spatial or temporal basis to manage and/or reduce harvest levels.

3. Increasing Food Production and Recreation Opportunities

By carefully analyzing the needs and fishing patterns of various user groups, artificial reefs can be built in a variety of locations and configurations to increase recreational and commercial fishing opportunities and catches. Construction of trolling alleys, fish aggregation systems, and benthic reefs, as well as enhancement of fishing piers, benthic reefs and offshore structures with additional artificial reef units, can lead to increased catches, profits and satisfaction for recreational and commercial users.

Use of artificial reef technology to further the concept of mariculture/aquaculture is an area that deserves additional attention. Offshore structures may be excellent facilities for culturing of shellfish and crustaceans or for hatchery operations.

4. Promoting Efficiency

Utilizing artificial reefs as a means to increase production, concentrate target species and to create recreational fishing opportunities closer to urban populations, can help reduce operating/trip costs for commercial and recreational fishermen. Increased operating costs are the single most important cause of business failure for commercial and recreational fishing businesses. Reduction of travel distance to fishing grounds can also provide an additional margin of safety for fishermen.

5. Reducing User Conflicts

Artificial reefs can be used effectively to provide fishing opportunities for all user groups and to spatially separate users, thereby reducing conflicts. However, proper siting of artificial reefs is essential to avoid creating additional user conflicts.

6. Developing Underutilized Species

Estimates of underutilized marine fishery biomass in the South Atlantic, Gulf of Mexico and Caribbean areas range from 5.2 - 10.3 billion pounds. Wherever the truth lies, it is clear that substantial opportunity exists for increased use of fishery resources in the Gulf for the benefit of recreational and commercial fishery industries and seafood consumers at-large. Artificial reefs can be used to help fishermen selectively target species of interest, particular pelagic species.

RECOMMENDATION

Artificial reefs can help resolve numerous problems confronting both federal and state fishery managers. To capture these benefits, a more reasoned approach is needed regarding the design, location, and management of artificial reefs. In recognition of this need, a major initiative is underway at both national and regional levels to develop a national artifical reef policy and program guidelines.

In the Gulf area, a cooperative state/federal effort is underway to begin development of a Gulf-wide artificial reef siting plan. In addition to developing specific artificial reef siting objectives and criteria, the plan will identify unacceptable and optimum sites for reef construction. Inherent in this process will be a close examination of the role offshore oil and gas structures can and should play in artificial reef and fishery management programs.

THE ARTIFICIAL REEF DEVELOPMENT CENTER

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Although the body of scientific information on the biology of aquatic communities associated with artificial fishing reefs is far from complete, there is sufficient knowledge to encourage and develop management strategies for the design and placement of artificial fishing reefs to increase the social and economic benefits to recreational and commercial fishermen.

Technical sophistication has increased with regard to the materials used for artificial fishing reefs. In general, the technology now exists to create fisheries where fishermen are located (population centers), through design and placement of artificial fishing reefs. The use of artificial reefs is the most effective management tool available to marine fishery managers. However, there exists a need for communication and coordination between all interested an affected parties; specifically, there is a need to provide information on, and coordinate the use of, existing techniques to properly site reefs as part of management strategies to benefit recreational and commericial fishermen.

The single greatest impediment to the expanded incorporation of artificial fishing reef technology to marine fishery management strategies is the absence of a national institutional focus. Therefore, the Sport Fishing Institute intends to create a national focus within an Artificial Reef Development Center (ARDC). As an information repository, exchange and clearinghouse, the ARDC will facilitate artificial fishing reef development by matching potential reef sponsors with donors, provide data to researchers and managers, and make available data on artificial fishing reefs to other ocean and ocean-resource user groups.

Additionally, the ARDC will identify constraints to the implementation of current artificial fishing reef technology and make recommendations to overcome or to accommodate these constraints. Specific concerns to be addressed will include the permitting process, siting considerations, suitable materials of opportunity and their related costs, liability concerns, long-term maintenance of the reefs and appropriate marking devices, and economic considerations relative to artificial fishing reef development and maintenance.

Resulting from the aforementioned investigation will be a How-to Guide and Check-List which will aid interested organizations in the planning and execution of installing an artificial fishing reef. The information contained in these materials will give a potential sponsor an in-depth overview of the development process from the permitting process to procurement of materials to long-term maintenance costs.

Lastly, the ARDC will assess the problems associated with the economic valuation of artificial fishing reefs. Both the economic value and the economic impact of an artificial fishing reef will be examined. Recommendations for assigning potential value to reefs will result. Economic information such as this should aid in developing proper incentives to induce the donation of suitable reef materials and the associated transportation costs.

ADAPTIVE ENVIRONMENTAL ASSESSMENT: A PLANNING SCHEME FOR RIGS-TO-REEFS

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The Division of Biological Services of the U. S. Fish and Wildlife Service has as its mission the development of techniques and information useful in dealing with complex natural resource problems involving fish, wildlife, and their habitats. As a part of this mission, the utility of an approach known as Adaptive Environmental Assessment (AEA) has been under examination for about five years. Developed at the University of British Columbia and the International Institute for Applied Systems Analysis, the AEA process combines some of the techniques of systems analysis, simulation modeling, and group dynamics as a mechanism for focusing on a resource issue. The core of the process is a workshop or series of workshops whose focal point is usually the construction, refinement, and evaluation of a computerized simulation model of the resource problem at hand. Development of a conceptual model is sometimes the goal for problems that are less well defined. The workshops are attended by scientists, managers, policymakers, and interest group representatives with knowledge of the problem. A small staff facilitates the workshops; participants provide the understanding and information concerning the problem, and the staff translate their ideas into the framework of the model.

The process of constructing such a model has several important benefits. First, it helps participants develop a holistic perspective of the problem, its component parts, and how those components interact. Second, it serves to enhance meaningful communication among a variety of interests by providing a common analysis framework (the model). Finally, the explicit nature of a model allows participants to focus on key issues and information needs, and reduces conflict by forcing objectivity.

The AEA approach is currently being used in an analysis of the fate and effects of drilling muds and cuttings discharged in the marine environment. Representatives from a wide variety of State and Federal agencies, universities, and private industries and consulting firms have participated in this effort. The group combines expertise in administration, regulation, physical oceanography, hydrodynamics, sediment dynamics, toxicology, and benthic ecology.

The problem has been approached through a series of workshops and technical meetings aimed at the construction and evaluation of a computerized model simulating the fate and effects of multiple discharges of drilling muds and cuttings from a single drilling operation. The model has three basic components. The discharge and plume fate component calculates how material from discharges is likely to be distributed given its composition and various environmental factors such as current speed and water depth. The sediment dynamics component calculates the accumulation and distribution of material from multiple discharges, taking into account the effects of redistribution of materials due to storms. The benthic community component estimates the response of the benthos as a result of burial, toxicity, growth, and recruitment. While the model is certainly not perfect, it does represent a uniquely comprehensive attempt to integrate what is know about the physical fate and biological effects of drilling muds and cuttings in the marine environment in a quantitative framework.

This project, while not solely responsible, has contributed significantly to a variety of very positive results. First, there is now a much better understanding among effects researchers of the composition and uses of drilling muds, and of the nature and level of potential exposure of marine organisms. This understanding has led to more relevant laboratory research, and especially to greater recognition of the need for protocols that better represent exposure conditions in the environment. Second, there has been a shift of emphasis and concern away from potential water column effects and toward benthic community effects. Third, a cooperative program to obtain used drilling fluids for biological effects investigations has been instituted, once again the result being a more relevant and useful research program. Fourth, there has been a marked shift in the conceptualization of the physical dynamics of discharged materials and a corresponding shift in field sampling procedures. Finally, in the AEA project itself, emphasis has shifted from the objective of improved communication toward the objective of developing a technically credible simulation model that may eventually be useful in the permitting process.

A similar modeling effort would perhaps be useful in examining carefully some of the unresolved questions concerning artificial reefs. In such an effort, the model would probably focus on a single reef and its effects on the relationships between fish populations, productivity, movement, and fishing effort. The objectives would be to synthesize available information and understanding, to focus attention on the unresolved questions, to formulate alternative hypotheses relevant to those questions, and to plan and coordinate research designed to test those hypotheses.

A second application of the AEA process currently underway is directed toward developing a framework for assessing the physical and economic damages to aquatic and nonagricultural terrestrial resources caused by acid precipitation. Participants in this effort include effects researchers, who are examining the physical and biological changes resulting from acidic deposition; economists, who are examining alternative ways of valuing damages due to acidic deposition in monetary terms; and policy analysts, who are attempting to integrate the results of the biological and economic work into a meaningful assessment of alternative decisions and their probable consequences. The work has focused on the development of a conceptual model, rather than a computerized simulation model, of the basic components of the assessment effort and the necessary information exchanges between those components.

This approach for examining components of the assessment and how those components are related through information flows has resulted in a framework that is being used as the basis for an evaluation that will be completed in 1985. More specifically, the framework has a number of important features. These include a precise definition of damage and various ways that it might be measured, a description of the economic methods that will most likely be used to value various kinds of damages, approaches for producing the ecological information required by these economic methods, and a list of areas and species for which this framework was developed was extremely useful in generating a productive dialogue among effects researchers, economists, and policy analysts concerning the ways in which their efforts must interface to produce a meaningful assessment of the damages caused by acidic deposition.

A similar approach might be a very effective means of formulating a framework for developing artificial reefs in an area such as the Gulf of Mexico. Objectives might include identification of types and sources of material suitable for reef construction, identification of areas suitable for reef construction, and definition of criteria and approaches useful in evaluating alternative sites. The resulting framework would likely have broad support from a variety of participating interests and would thus be a useful step in the artificial reefs program.

RIGS-TO-REEFS IN THE EASTERN GULF: PAST ACCOMPLISHMENTS AND FUTURE PLANS

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Division of Marine Resources
Florida Department of Natural Resources

The State of Florida is proud of the role we have been able to play in habitat enhancement through the construction of artificial fishing reefs. We are particularly pleased with the partnership we have been able to join with the petroleum industry, federal agencies, the fisheries constituency and local individuals to pioneer in the conversion of obsolete oil and gas structures into marine habitats.

We have had the successful deployment of two drilling structures off Florida's coast. The first was the experimental submerged production system donated by Exxon in 1980. The second was the Tenneco Ship Shoal platform and jacket which was dropped only a little over a year ago.

I was not with the Department of Natural Resources for the Exxon Template planning and execution, so I missed the pain and perils of first birth. But a record has been established which allowed me to "tiptoe through the tulips" with the Tenneco project.

Dan Tennyson and Mike McGonagill, the Tenneco engineers whose idea this was, and who had to blaze a rocky and uncharted trail in the engineering dynamics of this truly difficult transplanting feat, would surely wince at the rosy description of the project, but from my perspective, it went off without a hitch.

That was not the case with Exxon.

Although the engineering problems were not as perplexing since this was a subsurface structure, it was the first time it had been done. The project director, Charles Futch of our Division of Marine Resources, assembled a representative of every governmental and marine user agency he could imagine. They could have been planning the Normandy invasion. There were representatives of the National Marine Fisheries Service, the United States Army Corps of Engineers, the Environmental Protection Agency, the Florida Department of Environmental Regulation, the U. S. Coast Guard, fishermen, local government representatives, and a requisite assortment of bureaucrats.

At a day long meeting of all these interests, they finally agreed upon a suitable site - all, that is, except the Coast Guard officer, who told them they could not put it there because the water was too shallow. So they picked another site in deeper water, accessible to the Destin and Panama City fishing communities, and achieved unanimity.

The company began final plans for the abandonment project. The Department applied to the Corps of Engineers for the appropriate permit, and all systems appeared to be "go!"

If they had actually been planning the Normandy invasion, the organizers would surely have invited the participation of the United States Air Force. Since this project entailed merely the movement of a little iron around in the Gulf of Mexico, no one had considered that the Air Force would be remotely interested.

That omission almost wrecked the project.

It seems that the site the task force group had chosen was smack-dab in the middle of the Eglin Air Force Base weapons testing range. And the Air Force was more than mildly perturbed by the public relations potential of sending a haywire heat-seeking missile up the exhaust pipe of a boat carrying Joe Six-pack and his family to a day of fun and fishing in the Gulf. The Air Force was very cooperative and helpful and a new site was selected, but the permitting delay caused the project to be put off for a year.

A third site was chosen during this delay, south of the small fishing village of Carrabelle; the site has much to commend it, but access by a substantial population or tourist center is not one of them. Without impugning anyone's motives, I must note that Carrabelle is much closer to Tallahassee, the seat of government and lobbyists, than the Panama City/Destin area. Therefore, I can only conjecture that this site was chosen for purely biological reasons.

Most of you are familiar with the achievement of the Tenneco Reef off Pensacola, so I will not belabor that success story. I do want to remark what a pleasure it was to work with the creative and visionary young engineers at Tenneco who managed the project so well.

The lapse time between my initial contact with them until drop day was less than six months. When you consider that we had to work within the federal, state, and corporate bureaucracies, that is a monumental achievement. A revision of that permitting process is underway which will make that step in the scheme of things even easier.

That is the history of "rigs-to-reefs" in Florida. Let us now explore the future.

The State of Florida is prepared to accept scores of these structures if and when the oil companies are prepared to bring them to us; and therein lies the existing rub.

Following the first meeting with former Interior Secretary James Watt this past summer, I urged all county and municipal governments on the state's Gulf Coast and on the Atlantic to mobilize committees to select sites where reefs might be constructed using this material. Almost every jurisdiction contacted expressed immediate interest, and surveys for locations are now being conducted throughout the area. Some sites are already permitted. As Delta Airlines puts it, "We're ready when you are."

There are problems, however. None of them seem insurmountable, but some are complicated enough that it will take all of the ingenuity and talent assembled here today to develop solutions.

From the industry's perspective, the biggest problem is economics. It costs a great deal of money to pluck these gargantuan jackets and decks from the ocean floor and float them to sites two to six hundred miles away. They want economic incentives. And we, in Florida, believe they should have them.

While it is true they must remove them anyway - and that is expensive - we think that they should be credited for making this investment in the future of our marine resources instead of in a scrap heap. One of our greatest fears is that the industry will simply tow these out to deep water and drop them in a common deep water dump; that would be a tragic waste. We must not let that happen.

Another alternative, which should be unacceptable to most of us and which I have heard a great deal of discussion about at this meeting, is simply leaving the structures in place.

When former Secretary Watt invited a group of us to Washington to discuss "rigs-to-reefs", my antennae immediately went up. "What's this guy up to," I wondered. To give him his due credit, he did bring a focus on this whole problem and its concurrent opportunities. That's why we're here today. But he also confirmed my worst fears when he immediately, through the simple expedient of an interpretative amendment, told the industry that they could leave these objects in place.

The minerals industry made a commitment to other potential users of the marine resources in their promise that when production ceased, these tools would be removed. Except in those rare instances where the States may wish to convert the structures to other on-site uses, this is a commitment which should be kept.

The most difficult problem the states or other agencies face in accepting these structures is the maintenance of aids to navigation. We must reach some agreement through Congressional or Executive action which will either alleviate the stringent Department of Transportation regulations requiring buoys, or we must create a system to finance this long term commitment to improving our fisheries.

All of the Gulf states share a problem that the industry must help us to overcome, perhaps as a part of the economic incentives. We strive to build artificial reefs close to the greatest numbers of people. This is difficult in the Gulf because of the extremely broad Continental Shelf. The water is too shallow or too far. To accommodate structures for such areas as Naples, Fort Myers, Sarasota, St. Petersburg, Clearwater, and elsewhere in the Eastern Gulf, it will be necessary for some dismantling.

I know some of the industry people and the state have been concerned about liability. If they are using that as an excuse for not entering this program, it is clearly a red herring. We are a litigious society and there is no sure way to avoid a lawsuit for whatever reason if some lawyer decides somone has a cause of action. We could probably be sued for merely talking about moving these structures around as we are doing here today.

In the Exxon and Tenneco donations, we had a simple transfer document which indemnifies everybody. Nothing more is needed. It may not protect us from a lawsuit, but if we did everything else right, it should keep us from losing.

Finally, we do need more research. The basic biology has been done. I am convinced that there are more fish in the sea than there would have been if we had not built artificial reefs.

What we do not know is whether we are affecting the behavior of some of these animals. For instance, did all of those large Kingfish we encountered Monday always congregate off Grand Isle? Or did they just start showing up because the oil structures are there?

This is a matter of more than casual concern to fishery managers because that fishery has gone from no appreciable landings a couple of years ago to a million and a half pounds. They are all large, and they are almost all females. And, frankly, we're scared to death of what we may be doing out there.

We need to learn more, and we need money to learn.

I think we have a potential for doing a lot of good in a resource that is coming under increasing pressure. And Florida's experience has demonstrated that the impediments are too insignificant to stand in the way of going forward now.

INNOVATIVE TECHNIQUES FOR ECONOMICALLY REMOVING AND TRANSPORTING OIL AND GAS STRUCTURES FOR REEFS

Steve Haskell
Oceaneering International

Richard P. Dominguez
Woodward Clyde Oceaneering

In June 1983, a four-leg piled platform structure located in 220 feet of water offshore Louisiana was toppled over and refloated using controlled external buoyancy for transport to a site offshore Alabama, where it will begin a new life as a submerged artificial reef. The new method of removal is significant because it is far more efficient, resulting in a considerable savings in the cost of the operation while greatly reducing risks.

As the Gulf Coast offshore oil and gas fields have matured, many structures have exhausted their useful life. The U. S. government's Minerals Management Service requires that disused wells and platforms be cut off below the mudline (seafloor) and the bottom be restored to its original condition. This requirement has eliminated the former option to simply mark and abandon structures.

If the platform structure and deck sections cannot be economically salvaged for reuse, they must be scrapped. The conventional methods are costly and time-consuming, involving the cutting of the structure into pieces of a size and weight that can be lifted onto a barge for transportation to shore.

The scrap value of the materials is minimal because the platform legs and well conductor pipes are cemented internally to the piles and tubing strings. A more cost-effective method of disposing of the platform is to place it in a location where it can serve as a fish haven, resulting in a second beneficial "life" for the structure. The additional fisheries revenue resulting to the coastal states concerned also creates good will to the credit of the oil company donating the structure.

Since there are numerous platforms working offshore Louisiana, the need for aditional artificial reefs there is minimal. However, both Alabama and Florida are highly desirous of obtaining structures for use as artificial reefs to enhance their offshore fishing industries. A site for this particular structure was selected by the State of Alabama, approximately 50 miles south-southeast of Mobile Bay. Marathon Oil Company donated the platform from Ship Shoal Block 272, approximately 60 miles from the Louisiana coast and 130 miles from New Orleans. During the six years as a production platform, SS-272 produced 25.7 billion cubic feet of natural gas.

Marathon contracted Oceaneering International to manage, engineer and perform the platform removal and relocation. The project was carried out on a lump-sum basis, allowing complete predictability of costs for Marathon, a relative rarity in offshore operations. Oceaneering, in effect, took the risks of weather downtime and other unforseeable events common to offshore projects. But the company believed that the "toppling" method they proposed to use for removal of the structure afforded greater predicatbility and reduced weather exposure because of the greater speed at which critical parts of the operation could be accomplished.

The plan to salvage the SS-272 platform involved first removing the deck section of the platform using a derrick barge, then attaching large buoyancy tanks to the platform legs. The platform legs were cut 16 feet below the mudline by explosive shaped charges. Finally, the platform was toppled to a horizontal floating condition.

The four specially-fabricated buoyancy tanks (12 feet in diameter, 81 feet long) were installed on two of the platform's adjacent legs by divers. Deballasting of the tanks was accomplished according to the specified sequence first to topple and then to float the platform horizontally. During the towing of the platform to the reef site offshore Alabama, the tanks supported the completely submerged platform structure.

The size of structure and uniqueness of methods required extensive planning, analysis, and engineering. This attention to detail included a complete computer simulation of the toppling, towing, and launching to establish both operational and contingency procedures. The computer modelling and other engineering services for this project were provided by Woodward Clyde Oceaneering, an Oceaneering affiliate company.

After reaching the reef site, the platform structure was released from the buoyancy tanks explosively, to drop it, still horizontal, to the bottom. The deck section had been placed nearby previously. The buoyancy tanks were recovered for future use in other platform removal projects.

Use of this newly-developed technique permitted Oceaneering to handle the 1,100-ton platform structure in one piece, keeping it in the water and offshore throughout the job. This allowed the project to be carried out using a much smaller, hence less expensive marine spread. An additional benefit of the method was that only one set of explosive charges was used to cut the legs and piling of the platform as compared to the multiple charges necessary to cut the platform into pieces with traditional techniques, thereby reducing the local fish kill associated with the explosive detonation.

As more structures reach the end of their production service life, Oceaneering believes this method of removal can save a great deal of money for the oil companies who are faced with the problem of disposal of these facilities. When this savings can be accompanied by decreased risks and the environmental benefits of artificial reef structures, the results are decidedly positive.

JAPANESE TECHNOLOGY AND AMERICAN RESOURCES: PRODUCING EFFECTIVE ARTIFICIAL REEFS FROM OBSOLETE PLATFORMS

Dr. Daniel J. Sheehy
President, Aquabio, Inc.

The possibility of using obsolete oil and gas platforms to construct artificial reefs represents a dramatic change in the scope and level of effort of American reef building activity. Because of the size of the platforms, the costs involved in moving and placing them as reefs, and the range and scale of their impact on the marine environment, the potential benefits and liabilities involved in any major "rigs to reef" effort are considerably greater than those involved in other artificial reef projects previously undertaken in this country. In order to maximize these benefits, reduce the possible liabilities, and ensure that platform conversions are cost-effective, a comprehensive planning effort on a regional basis is essential.

Such a planning effort should involve evaluating and integrating site-specific data from a number of disciplines such as oceanography, fisheries biology, engineering, resource management, and economics, and, perhaps most important, should be related specifically to the impact of large-scale reef structures. Unfortunately, data developed from experiences with the small-scale and often haphazardly placed scrap material reefs of the sort typically built in the U. S. is simply not adequate to provide the type of information needed to successfully site, configure, and space large-scale structures in any quantity.

These data limitations become clearly apparent when the approach usually taken to reef construction in this country is considered. For the most part, American reef construction has been confined to relatively small-scale projects aimed at enhancing recreational fishing on a localized basis. Typical reef construction materials consist of derelict vessels, rocks, building rubble, tires, and other scrap materials. In fact, solid waste disposal is often a secondary or even a primary objective. Funding for these projects typically ranges from modest and irregular to non-existent. In many cases, construction efforts depend on volunteer or even prison labor.

Predictably, the state-of-the-art for artificial reef technology in the U. S. has developed sporadically, when at all. Post-placement surveys and other scientific research has been minimal. Because of the general lack of oceanographic and biological data related to factors such as siting, stability, fish attraction, and design which help determine a reef's success or failure, it has been necessary to rely on what fundamentally amounts to a trial-and-error approach.

During the past 15 years, I've observed and documented many examples of the errors. Tire reefs, for example, are especially prone to break apart. All too often, tires become "lost" from artificial reefs, only to be "found" when they damage commercial fishing gear, reduce trawling areas, or deface public beaches, sometimes resulting in jurisdictional disputes over responsibility for cleanup. In one county reef program, over a half a million tires are known to have been "lost" from reef sites. In other areas, large steel ships have been moved more than half a mile from their original permitted sites or have disappeared entirely after storms. In still other areas, concrete culvert as well as tires have been observed as they rolled over natural live bottom, crushing or damaging coral and other growth.

While all of these problems and similar mishaps are regretable, they are usually not environmentally or economically disasterous. The environmental impacts are, in most cases, confined to fairly local areas due to the relatively small scale of the reefs involved. Likewise, the economic costs arising from the loss of scrap materials prepared and placed by volunteer labor are usually self-limiting.

The scale of impact produced by an improperly sited platform could be dramatically greater. A single platform of average size may have a void volume greater than the combined total volume of all artificial reefs constructed during a single year by most states with active reef programs. In addition, the costs involved in relocating a single platform may, depending on the situation, far exceed the annual budgets of most state or local reef programs, and perhaps exceed the total budgets for all current U.S. activity combined.

Converting obsolete platforms to artificial reefs constitutes an undertaking which will necessitate the commitment of substantial public and private funds, and which may have a significant long-term impact on the fisheries of the Gulf of Mexico and perhaps other areas. Before beginning a large-scale effort such as this, we need to consider a number of issues that are less crucial for small scrap material reefs, and we need data appropriate to large-scale structures to use in this consideration. The past approach of local trial-and-error tactics is no longer appropriate. Inadequate or inappropriate planning could result in serious problems and drastically reduce the return on investment of the funds spent to relocate platforms.

Due to their size and profile, platforms require deeper water sites than most scrap material reefs. Their aspect ratio also makes them very effective concentrators of pelagic migratory species, as well as of the typical reef fish populations. Thus, in terms of both the basic siting criteria and the target species, they differ significantly from the traditional nearshore low-profile reefs usually built in this country. As a result, there is a relative dearth of information and experience in the U. S. with the type of reef construction and siting necessitated by platform conversion.

However, relevant experience with large-scale reefs does exist in Japan. Like American artificial reef programs, early Japanese reef construction efforts utilized natural materials and scrap items. The Japanese, however, quickly recognized the limitations of these materials and determined that designed units were more cost-effective over the long term. In order to encourage the development and application of the best reef technology, for the past 30 years the Japanese government has funded only those reef projects using designed units.

Because Japan depends so heavily on the sea for food, the Japanese began a major 7-year coastal fisheries development program in 1975 aimed at overcoming the impacts of the 200 mile fishing limits, the 1973 oil crisis, and growing coastal development and pollution. This program was funded at a level of almost one billion dollars from the national government, with matching funds contributed by the prefectures. This program proved so successful that it was recently expanded at almost twice the original level of government funding. A substantial part of these funds are spent on artificial reef research, development, planning, and construction.

As a result, the Japanese have produced a new generation of large-scale reef units which are used to create entire fishing grounds and nursery areas. About 20 to 30 types of these large units have met the fairly stringent standards for stability, damage resistance, life expectancy, and cost-effectiveness required for government funding. These units have been deployed at hundreds of sites along the Japanese coasts.

Among the reef units still undergoing tests and evaluations are a variety of steel structures, some of which resemble small petroleum platforms. Studies performed on earlier, somewhat smaller steel and iron reef unit prototypes indicated a high degree of fish-attracting effectiveness and resistance to impact damage in deep water, but they revealed corrosion problems due to the thin-gauge steel used in the units. Preliminary results on the larger units now being tested show promise in terms of unit cost and damage resistance.

The Japanese have invested considerable effort and funds to develop not only reef unit designs but also a more comprehensive approach to siting, designing, and configuring reef areas, as well as managing and regulating fishing effort on these reefs. Their data shows that even the best unit design will not be cost-effective if improperly sited and grouped. Through both extensive laboratory testing and a wealth of field studies, they have begun to develop criteria related to siting, configuring, and managing large-scale reefs.

In 1976, I began research work in Japan to learn more about their artificial reef technology, and then continued this work by spending most of 1977 and 1978 in Japan and Taiwan, working directly with their national artificial reef programs. Through this valuable experience, I gained access to research data and results from the actual construction of a number of large-scale reefs. Although this information is not generally available in published form even in Japan, at Aquabio we are fortunate to have continuing access to this data through our Japanese colleagues. We have continued to monitor the long-term fisheries, environmental, and economic results of these major reef construction projects.

In projects which we have conducted for various federal, state, municipal, and private industry groups on other aspects of artificial reef technology, we have found technology transfer to be a viable and cost-effective means of applying the results of Japan's considerable investment in this area to American fisheries development. We believe that a similar approach can be productively used to transfer applicable information from the Japanese experience with large-scale artificial reefs to facilitate a successful rigs-to-reefs effort.

Certainly there are differences in the use of large-scale designed reefs and platform reefs in terms of construction motives and usage, but the approaches, which are aimed at maximizing long-term fishing benefits and realizing a good return on investment, are similar. We can greatly benefit from this extensive experience to develop and improve plans for the conversion of obsolete platforms into cost-effective artificial reefs.

It is unlikely that the U. S. will ever expend on artificial reef design and development a level of funding comparable to Japan's investment. Unlike the Japanese, who depend on the sea for more than 50% of their animal protein, Americans are not faced with the same reasons for optimizing the harvest of coastal fishery resources. However, we do have some strong incentives for installing artificial reefs in our coastal waters. These include the enhancement of both recreational and commercial fisheries, the development of extensive aquaculture programs, and the creation or expansion of sanctuary areas or conservation zones. The conversion of a selected number of obsolete platforms into properly sited and designed artificial reefs can certainly serve as part of an effort to meet all of these goals.

Obsolete platforms, which are liabilities for the oil companies faced with their mandated removal, may be converted into assets for fishermen as well as the industries associated with fishing and tourism. This conversion program, if it continues at a reasonable level, will require considerable expenditures. In order to maximize the benefits for everyone concerned and to justify the expenditures needed, a more comprehensive approach to program planning is required.

Although current American experience with such large-scale reefs is inadequate to formulate a siting plan to meet the problems posed by this dramatic change in reef construction and fisheries impacts, we can benefit form the extensive experience, research, and development conducted already in Japan and Taiwan. This technology can be adapted for use here to help ensure the long-term success of the platform conversion program. Through the combination of American platforms and adapted Asian reef technology, we can make judicious long-term investments in American renewable fisheries resources and realize the greatest return in terms of economic, fisheries, and environmental benefits.

ENHANCING PETROLEUM STRUCTURES FOR FISH & FISHING: FACT OR FAD

Gregory S. McIntosh, Jr.
President, McIntosh Marine, Inc.

Until very recently the concept of using non-producing petroleum production platforms as material for artificial reefs was regarded with little merit by the oil and gas industry. The 1980 Exxon Corporation donation of an obsolete subsea production template to the State of Florida for the purpose of enhancing coastal fishery resources (McIntosh, 1981) signaled a departure from traditional thought and practice by industry. A recent ruling by the U.S. Department of the Interior which allows for the retention of non-producing structures as artificial reefs on the outer continental shelf (OCS) is evidence of U. S. Government's recognition of the benefits which may be derived from prudent structure relocation and placement.

The efficacy of these structures as artificial reefs goes unchallenged. Operational, producing structures serve as de facto man-made reefs, which relocated, derelict jackets and platforms ably serve as habitat for benthic fishery resources.

Therefore, the concept of enhancing these structures offers many challenging opportunities. Enhanced petroleum structures may serve as ideal locations for:

- Marine parks and sancturaries
- Mariculture platforms for sea weeds, shrimps, lobsters, and fish
- Abundant supplies of commercially valuable fish stocks
- Improved recreational fishing catch effort
- "Windows" of inclusion/exclusion in Fishery Management Plans (FMPs) promulgated by Regional Fishery Management Councils

Enhancing these structures by means of inexpensive fish aggregating devices (FADs) will not only improve commercial and recreational fishing, it may provide the economic basis necessary to determine if rig relocation for use as an artificial reef is financially acceptable. For the purposes of this paper, FADs may be defined as non-rigid structures rising vertically through the water which are attached to the ocean floor by an anchor (derelict platform) and are suspended by means of a subsurface or surface buoy. Various devices, specifically designed to attract and temporarily retain desired fish species, may be attached to the vertical mooring line.

The concept of enhancing petroleum structures to improve fishing has been demostrated off the coast of Fort Lauderdale, FL, under a cooperative Saltonstall-Kennedy Agreement between McIntosh Marine and the National Marine Fisheries Service (NMFS). Under this contract, identical, obsolete gasoline storage tanks were prepared as artificial reef substrate. Two identical reefs were installed in 25 meters of water and separated by 150 meters. One "patch reef" was selected as a control site, while the second reef was improved with miniature fish aggregating devices.

Each reef was monitored by diver/biologist surveys and time lapse photography efforts. Biological and economic comparsions between the improved and unimproved reef sites conclusively demonstrated the viability of enhancing man-made reefs with fish aggregating devices to improve recreational fishing. An entirely new fishery was created at the reef site improved with mini-FADs. The results of this experiment are listed below and are arranged for reader comparison.

COSTS/BENEFITS OF IMPROVED ARTIFICIAL REEFS

Costs

Each Tank= 1400 sq. ft. surface area	Each FAD= 125 sq. ft. surface area
Each Tank cost $8,900.00 installed	Each FAD cost $200.00 installed
Each benthic reef consisted of nine tanks	Enhancement of benthic reef consisted of twelve FADs
Therefore, each benthic reef consisted of 12,600 sq. ft. of surface area and cost:	Enhancement represented an increase of 1,500 sq. ft. of surface area and cost:
$80,100.00 or $6.40/sq. ft.	$2,400.00 or $1.60/sq. ft.

BENEFITS

	Improved	Unimproved
ABUNDANCE	10,000 FISH	1,000 FISH
DIVERSITY	13 SPECIES	3 SPECIES
FISH PER SQ. FT.	.82	.08
TOTAL COST TO PRODUCE AND INSTALL 20 FEET OF PROFILE/RELIEF	$2,400.00 1.60 SQ. FT.	$80,100.00 6.40 SQ. FT.
COMBINED COSTS	$82,500.00 5.85 SQ. FT.	$160,000.00* 6.40 SQ. FT.

*Estimation, based upon duplicating previous deployment efforts.

The benefits of enhancing petroleum structures with fish aggregating devices are obvious and demonstrable. Directly linking surface and mid-water biological communities to benthic communities by means of FADs appears to produce a more abundant and diverse fishery community than independent benthic or mid-water habitat enhancement efforts produce by themselves.

Experience tells us that the offshore oil and gas industry will not utilitze this technology based upon biology alone. The economics of this method of enhanced enhancement will be the factor which determines future usage. Therefore, the following applications should be investigated:

1. Examine cost effectiveness of relocating structures into areas of deeper water and enhancing resulting reef profile by means

of large and small FADs to improve sport and commercial fishing.

2. Compare value of a structure enhanced by means of FADs to an unenhanced platform. In what way will this value impact mitigation credits?

3. Examine in what way new relocation technology in conjunction with structure enhancement by means of FADs will impact economies of creating artificial reefs.

In conjunction with the above economic considerations, the Department should undertake an experiment, similar to the project described above. Such a study would conclusively demonstrate the applicability of this technology for obsolete oil and gas structures in the Gulf of Mexico.

REFERENCE

McIntosh, Gregory S., Jr. 1981. A concept for Artificial Reefs as Fishery Management Tools in the United States. Proceedings of the Fourth International Coral Reef Symposium, Manila, Vol. I, pp. 99-103.

RIGS-TO-REEFS KEYNOTE ADDRESS

William Perry Pendley
Deputy Assistant Secretary for Energy and Minerals
U. S. Department of the Interior

As you are well aware, fishing in the United States is important to the supply of protein for human consumption and to the economies of shore communities. To improve fishing resources, "man-made" reefs have provided close-to-shore habitat for marine life since the mid-19th century. Because of their great success in attracting and supporting fish and other marine communities, artificial reefs have become centers for recreational opportunities as well as commercial and sport fishing activities. The use of artificial reefs enhances multiple use of the nation's natural resources and promotes our goal of conservation and ecological consciousness by recycling unproductive materials into useful tools.

Despite the benefits that flow from artificial reefs and the willingness of both the States and the private sector to undertake efforts to develop such reefs, unfortunately many opportunities to establish artificial reefs have been lost due to lack of coordination among Federal agencies and the absence of a clear commitment on the part of the Federal Government to implement an artificial reef policy.

Although there has been a great need for a national artificial reef policy, no high-level Federal policymaker had mobilized staff to develop a plan of action. Recognizing the positive qualities possessed by artificial reefs, Secretary James Watt met with a coalition of conservation, industry, and government officials to discuss action needed to establish an aggressive national artificial reef policy. Under his leadership, the Department of the Interior has initiated a coordinated Federal, State and private sector effort to develop an artificial reef policy. With this Secretarial mandate and with the assistance of the aforementioned group, now nicknamed REEFS (standing for Recreational and Environmental Enhancement for Fishing in the Seas), the Federal sector began responding to the need for an organized and effective artificial reef policy. In addition, on July 18 of this year, Secretary Watt testified before the House Merchant Marine Committee's Subcommittee on Fisheries. The Secretary told that Subcommittee that, although he applauded their goals in trying to establish an artificial reef program, recent efforts by the Department in conjunction with other agencies made it unnecessary to legislate such a program.

In order to prevent additional missed opportunities, the Federal family--the Departments of the Interior, Commerce, Defense, Transportation and the Environmental Protection Agency--developed an artificial reef goal. Their objective is to encourage proper placement and use of artificial reefs for the conservation, management, and enhancement of fishery and wildlife resources, thereby improving recreational and commercial fishing opportunities. Through this policy we will encourage construction of artificial reefs with environmentally compatible materials and placement of those reefs in a manner harmonious with other ocean uses. We are deeply committed to multiple use of our natural resources.

To implement our objective, we have developed a Memorandum of Understanding, or MOU, on artificial reefs. In addition to the statement of policy, the MOU clarifies agency authorities and designates agency functions thus creating a concerted, planned and aggressive course of action. But most importantly, this MOU establishes an effective means of ensuring communication on artificial reef policy among the various interested parties. Currently, the MOU is in the final stages of approval. Once signed, we are confident that Federal initiatives on this important environmental issue will be speedy and effective.

Realizing it is time consuming to clear this type of document through the bureaucratic mazes of five Federal agencies, we did not wait for signature to begin working. Interior and Commerce staff have developed the framework for the national policy. Envisioned is a three-tiered approach, with Federal intervention decreasing with each level.

Since planning is the most crucial step in constructing an effective artificial reef, the first tier is devoted to developing commonsense guidelines for artificial reef project sponsors. These guidelines will serve as general rules of thumb to be applied in the initial planning stages of reef construction. Although each artificial reef site is unique, there are basic precepts of which reef sponsors should be made aware. For example, one guideline would restrict the use of toxic substances as construction material for artificial reefs. Using these guidelines will expedite the permit approval process, thus enabling actual reef construction to begin promptly.

Once these guidelines are drafted, they will be forwarded to the REEFS task force, Coastal States, ocean and oil industries and commercial and sport fishing groups for feedback. Additions and deletions offered by these groups will be incorporated into the final version. Once completed, the guidelines will be circulated to interested groups and published in the Federal Register.

Obtaining this feedback and maintaining communication with these user groups is a vital feature of our initiative. To achieve a responsible and successful reef program, we must coordinate with experts on marine environments and artificial reefs from the public and private sectors. We are committed to continued consultation with these experts and with our REEFS task force.

The second tier of the artificial reef framework focuses on regional participation. Through their constituencies, the Departments of the Interior and Commerce will encourage regional planning for reef sites and conditioning. We believe that the Federal Government's role here is one of a "motivator" to plan, not a "developer" of plans. Broad-based regional organizations such as Marine Fisheries Commissions, Fishery Management Councils and Outer Continental Shelf Regional Technical Working Groups should suggest optimal areas for artificial reefs. The expertise is there and must be utilized to coordinate and develop a regional siting plan for artificial reefs.

The third tier centers around the States. Again, the Federal sector will be the "motivator" to encourage the states interested in artificial reefs to develop site plans and criteria. Although some states have mature artificial reef programs, the Federal guidelines and the regional plans will be useful tools to facilitate new state effort to organizing artificial reef planning.

Developing an organized artificial reef program is one facet of the Federal initiative. There are many issues which need to be addressed such as liability, habitat credits and economic incentives. The MOU establishes a working group comprised of the signatory agencies to take action on these problems. This working group will maintain communication with the REEFS task force and other experts to assist in the resolution of these remaining issues.

All in all, our artificial reef plan establishes a means of communication among the many and diverse factions interested in artificial reefs. I believe that our approach will maximize the benefits of artificial reefs through concerted effort by the federal family and consultation with the experts and user groups.

As the Federal Government's offshore oil and gas experts, the Department of the Interior is uniquely qualified to assist in implementing an artificial reef policy utilizing offshore oil and gas structures.

The Department of the Interior, through the Minerals Management Service, oversees the largest "de facto" artificial reef program in the form of the Outer Continental Shelf Leasing Program. Approximately 4,000 "de facto" artificial reefs are found in the Gulf of Mexico alone. In addition to being the most prolific offshore source of oil and gas production for thirty years, the Gulf is the Nation's most productive offshore fisheries zone, accounting for 36% of the Nation's commercial seafood poundage in 1982. Recent findings from Gulf of Mexico studies support the use of petroleum platforms:

- Petroleum platforms enhance fish congregation and dramatically increase fish population.

- Petroleum platforms are the primary focus of offshore recreational fishing. Where oil and gas structures exist, sports fishermen catch more fish, larger fish and fish not otherwise available in the area.

- Petroleum platforms attract commercial fishermen from throughout the Gulf region, especially those seeking snapper, grouper and king mackerel.

- Petroleum platforms are considered so vital to Louisiana scuba divers that they have indicated it is worth a $150 annual fee to maintain platform diving privileges.

- Fishing from petroleum platforms is a source of food and fun for the 40,000 offshore workers employed by the Gulf of Mexico petroleum industry.

The Department has already undertaken policy initiatives to encourage and facilitate the use of appropriate oil and gas platforms as artificial reefs.

On July 8, 1983, the Minerals Management Service published an interpretive rule announcing that selected non-producing platforms may be retained on leaseholder when located in areas of high recreational/commercial fishing use, when reletion on site is compatible with other area users, and where a suitable sponsor is willing and financially capable to assume responsibility for maintenance, navigation aids, and liability for the structure.

We have published a prototype marine recreational fishing map focusing on the Mississippi Delta Region--one of America's oldest and most heavily developed offshore oil and gas provinces and the most popular offshore recreational fishing zone off the Louisiana coast. Copies are available from the Minerals Management Service Gulf of Mexico Regional Office in Metairie, Louisiana.

We have also issued over 1,500 new oil and gas leases, hopefully resulting in the development of approximately 1,200 new "de facto" artificial reefs over the next several years.

I believe that the Department's effort coupled with the Federal initiative will produce a responsive and successful artificial reef program that shows the following benefits:

- Improves fishery production, concentration and habitat
- Enhances the environment and economy of shore communities
- Enriches recreational and fishing opportunities in U.S. waters
- Promotes coordination among Federal, State and local agencies and other artificial reef constituents
- Establishes artificial reef structures which are properly designed, constructed, located and maintained
- Promotes multiple use of natural resources of our Nation's marine environment

By developing an artificial reef policy, we are responding to the increasing demands by fishing organizations, coastal communities and other concerned groups to utilize the Nation's vast ocean resources for the benefit of fisheries and their users.

In 1981, President-elect Ronald Reagan brought to the White House the philosophy of stewardship--taking care of the land, water, and wildlife. With this mandate, we have painstakingly maintained a balance between promoting development and nurturing the environment. Orderly, phased development of our resources provides important protection of the environment. And we are strongly committed to environmental quality.

Our Federal initiative on artificial reef best exemplified this commitment. Concurrent with orderly development of offshore oil and gas resources, the Administration supports the creation of new habitat via the installation of artificial reefs. These structures increase surface area where fish and other marine life congregate and breed. This enhancement of the environment benefits both marine life and those individuals who use these artificial reefs for commercial or recreational activities. This Administration's goal continues to be a clean and improving environment hand-in-hand with the wise use of the nation's natural resources.

Session: GULF POLLUTION CONCERNS

Chairman: Mr. Mark Rouse
Ms. Gail Rainey

Date: November 15-17, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Mr. Mark Rouse Ms. Gail Rainey
PART I: COASTAL CONCERNS	
Water Pollution Problems of Tampa Bay, Florida	Mr. Robin Lewis Mangrove Systems, Inc.
Water Quality in the Houston Ship Channel	Mr. Wayne J. Crouch Texas Dept. of Water Resources
A Study of a Pipeline Spill Within the Lousiana Marsh	Mr. Noel V. Brodtman Environmental Professionals Ltd.
Overview of Corps of Engineers Environmental Effects of Dredging Programs	Mr. Tom Patin U.S. Army Corps of Engineers
Radium in Formation Waters: How Much and Is It of Concern?	Dr. David F. Reid Oregon State University
Superfund Damage Assessment Regulations	Dr. Bruce Blanchard Department of the Interior

PART II: OFFSHORE CONCERNS

GULF POLLUTION CONCERNS

SESSION OVERVIEW

Mark Rouse and Gail Rainey

These two sessions presented the current concerns of both the scientific community and government relative to pollution of the Gulf of Mexico coastal and offshore environments, and shared information on currently recognized pollutant impacted areas.

Such information is needed by the Minerals Management Service in order to meet its mandated objectives of marine resources development and conservation. The Minerals Management Service is mandated through the National Environmental Policy Act to assess the environmental consequences from the exploration, development, and production of offshore oil and gas resources prior to any federal oil and gas lease offering. The Outer Continental Shelf Lands Act mandates that MMS must also provide for protection of the environment concomitant with OCS mineral resources development. In order to accomplish both objectives, this agency must keep abreast of recent information on the impacts to the environment of all actions resulting from resource development activities as well as from unrelated activities and natural phenomenon.

These sessions were organized to provide the following three types of specific information relative to MMS's overall goal of understanding environmental pollution impacts:

The first series of presentations included three presentations which provided specific case histories of oil spill incidents that have occurred in the Gulf of Mexico. Anthony Amos, of the University of Texas (Austin), presented an extremely informative account of his daily surveying of Mustang Island, a Texas Barrier Island, to monitor residual IXTOC spilled oil along the coastline. Of particular interest was his finding of IXTOC oil still present buried in animal burrows. He estimated that as much as 1,500 barrels of the residual oil, originally spilled between June 3, 1979, and March 23, 1980, in the Bay of Campeche, Mexico, could be accounted for in these animal burrows. Noel Brodtman, of Envionmental Professionals Ltd., reported both short-term and long-term damage to three Louisiana oyster areas after a pipeline spill incident. The source of an oil pollution incident that impacted some endangered species along the Texas coast was the subject of a presentation given by Dr. Christian Byrne for Dr. E. Overton, who was unable to attend. A number of dead juvenile sea-turtles washed ashore with associated oil this summer. MMS contracted with the Center for Bio-Organic Studies, University of New Orleans, Louisiana, for chemical analysis of the oily residue samples. The analysis showed that the oil was most probably waxy residues discarded after tanker cleaning operations.

The second type of presentations described the extent of the pollution presently existing in the Gulf. By understanding the current environmental condition of the Gulf, the cumulative impact of oil spilled in connection with the offshore oil industry activites is better evaluated. The long-term contribution of such oil spills is put into perspective with the contribution from all major pollutant sources entering the Gulf. Representatives from Florida (Robin Lewis, Mangrove Systems, Inc.) and Texas (Wayne Crouch, Texas Dept. of Water Resources) provided overviews of Tampa Bay and the Houston/Galveston Ship Channel pollution problems, respectively. Dan Basta, with the Strategic Assessment Branch, NOS, NOAA, described an extremely functional data base for estimating the spatial and temporal patterns of pollutant discharges into the Gulf coastal and ocean waters. An inventory is available from NOAA which provides tables summarizing both point and non-point pollutant discharge data by coastal county, by hydrologic unit, and by specific sources. MMS has already contracted with this group to determine the volume and impact of oil pollution that will be introduced into the Gulf of Mexico due to the marine tankering of the oil resources developed in the Eastern Planning Area.

The third series of presentations described monitoring programs being developed for the Gulf. These can be broken down into two types. One type identifies trends in environmental water quality and determines its potential for contamination. In some instances this effort centers around monitoring changes due to a particular source of contamination. Another type of monitoring program develops procedures and guidelines to be applied to future pollutant incidents for damage assessmenst purposes. NOAA's "Status and Trends" program falls into the first type of effort. This program is being initiated in the Gulf in order to characterize the general environmental condition relative to pollution levels of 20 to 30 regions along the Gulf's coastline. John Calder and Edward Long are heading up this program and are looking for input from interested parties on locations and types of monitoring activities that are most needed in the Gulf area.

Also with NOAA, Charles Ehler and Dan Basta are taking a different approach to monitoring the pollution potential of the Gulf. A data base is being developed which will provide practical information for decision makers for future management of ocean resources. An atlas has been published which provides ready access displays of the temporal and spatial distributions of living marine resources.

David Reid presented a disturbing review of his efforts monitoring the levels of radioactive radium in formation waters. More questions were raised than answered.

Bill Sacket presented the conclusions of a two-year monitoring effort that measured floating oil residues in the Eastern Gulf of Mexico. The study was conducted with T. Van Fleet of the University of South Florida and has received wide-spread publicity. Newspapers have printed such headlines as "Gulf is ranked among Worst Polluted," which has caused some alarm. The study analyzed pelagic tar, often called more of a nuisance than anything else, not all pollution, and found most of the tar associated with the Loop Current. The continental shelf areas around the eastern Gulf were clean with respect to this tar.

Don Boesch of LUMCON is managing a project which encompasses both types of monitoring efforts. The results of his study will develop recommendations for the design of environmental research projects and produce monitoring programs that will evaluate subtle and long-term effects of OCS oil and gas development activities.

The methodology and interpretive guidelines needed to assess the environmental consequences of the Corps of Engineers' dredged material disposal operations are being developed under a new CORPS program called EEDP, according to Tom Patin from Vicksburg, Mississippi. Emphasis is being placed on the determination of long-term as well as sublethal effects.

Clean Gulf Associates' Chemical and Biological Monitoring Proram had as its impetus the need to monitor the effects of the cooperative's oil spill response activities. The need to monitor a real-time spill at the time of its occurrence has been felt for a long time. The CGA efforts are highly applauded.

Finally, Bruce Blanchard outlined the Department of Interior's newly acquired responsibilities in damage assessment. The Comprehensive, Environmental, Response, Compensation, and Liability Act of 1980 mandated that DOI determine the measurement of damages to affected resources and develop the procedures for carrying out such damage assessment.

In summary, the sessions were extremely successful and highly praised by all who attended. The damage assessment and pollution monitoring studies examining the Gulf of Mexico, which were so limited in the past, are now occurring. Today's scientific expertise and methodology are capable of producing results that are holistic in nature and applicable to the decision maker's needs. Research strategies described in the talks showed a new refinement in the level of analysis. Several researchers are presently characterizing the Gulf as a whole and providing results that will allow for a variety of new applications. Not only are immediate effects now being evaluated, but the more subtle, sublethal, and long-term effects will be monitored in the future. Such subleties will provide future prediction capabilities, both on a macro- and meso-scale, for the quantitative and qualitative environmental implications of human activities.

Special emphasis should be placed on a discussion held among Gulf scientists involved in studying residual oil found stranded along the shoreline and/or floating in Gulf waters. This exchange of information allowed a new insight into comprehending the tarball problem. It seems that the vast majority of reports of unusual or heavier than normal strandings of oil occur between May and July each year. The seasonal phenomenon occurs along the entire Gulf coast. Although not proven through scientific study, hypotheses for this seasonal occurrence discussed included increased springtime tankering activity and physical oceanographic circulation patterns. By its recognition, some of the "unknown" spills that occur each spring might be explained, and this knowledge may serve for future resource conservation, such as coastal endangered species protection management plans.

Part I: Coastal Concerns

WATER POLLUTION PROBLEMS OF TAMPA BAY, FLORIDA

Robin Lewis
Mangrove Systems, Inc.

INTRODUCTION

Tampa Bay (Figure 13) is the second largest estuary in the world (400 sq. mi.) and 1.5 million people live in the three counties bordering its shores. This population represents a 45% increase since 1970.

Biologically the bay is a subtropical estuary and supports a wide variety of marine organisms including over 200 species of macroalgae, over 200 species of fish, and over 1200 species of macroinvertebrates (sponges, crabs, etc.). The food chains that support recreational and commercial fisheries in the bay begin with marine plants in the form of mangroves and tidal marsh grasses,[1] microalgae (phytoplankton),[2] macroalgae (seaweeds),[3] and submerged seagrasses.[4] These plants in turn become food for larger fish, birds, marine mammals, reptiles, and eventually human beings (refer to Figure 14).

The health of this biological system depends on a proper balance between the numbers of plants in each of the groups previously mentioned (microalgae, macroalgae, seagrasses, mangroves, and tidal marsh grasses), since each is not only a food source but also habitat for certain animals not generally found in other habitats. An example of this is the preference by shrimp and spotted seatrout for seagrass meadows, while mangrove snapper and many bird species are found associated with mangroves.

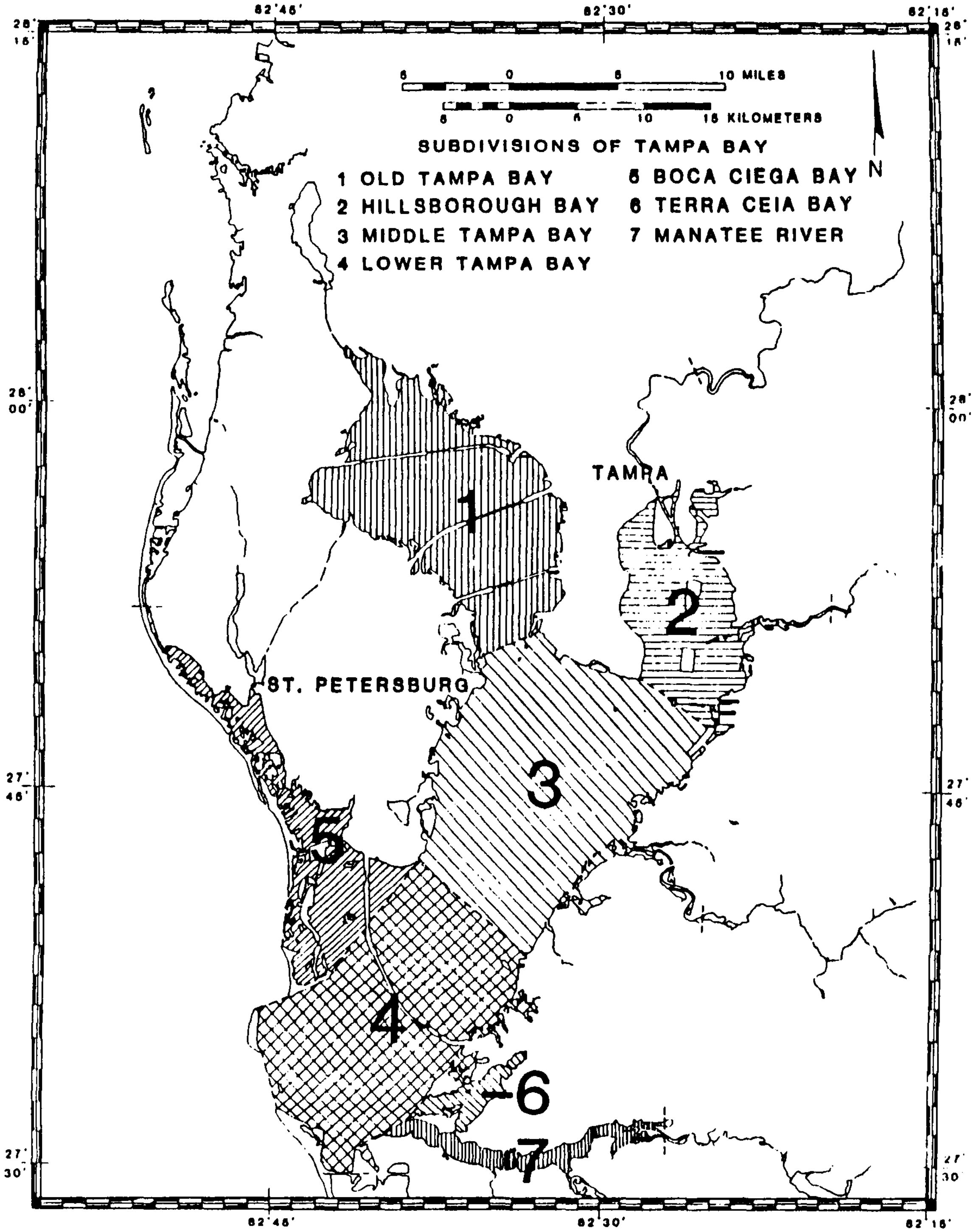

Figure 13. Subdivisions of Tampa Bay
From Lewis and Whitman, 1982.

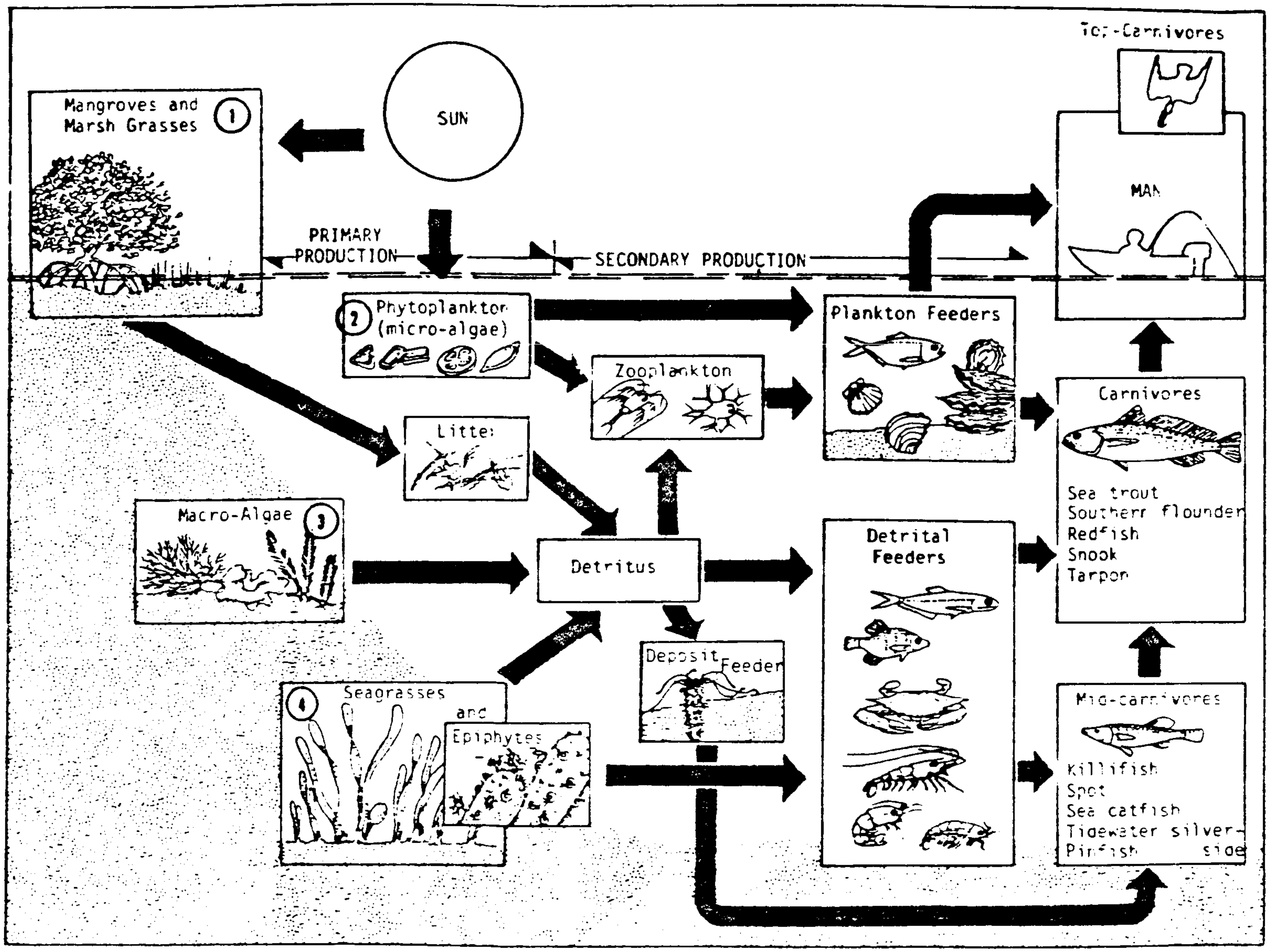

Figure 14. Tampa Bay Food Chain

SUMMARY OF IMPACTS

During the history of human presence along the shores of Tampa Bay, modifications have been made to the bay to "improve" its usefulness to the population. Indians did the first "dredging and filling" of the bay by building shell mounds in mangrove forests, but their impact was very small since their populations were small. Large scale modifications to the bay began in 1880's when the first "improvements" to the natural harbor protection offered by the bay were made by dredging shoals that impeded passage of sailing vessels.

These modifications greatly altered small areas of the bay but generally left the natural systems functioning normally. Beginning in the early 1950's and accelerating during the 1960's, massive dredging and filling and increased untreated sewage discharges altered the balance of plant types and eliminated large areas of important habitat. Recent analyses indicate that 44% of the original 25,000 acres of mangroves and marshes have been destroyed, and 81% of the original 76,500 acres of seagrasses have disappeared. Therefore, it is not surprising that, particularly during the last decade, the commercial harvests of fish and shellfish within the bay have declined; such fisheries as those for scallops and oysters have collapsed completely, and major declines for bait shrimp and spotted seatrout have also occurred.

With the realization that severe environmental damage had been done to the bay, laws and regulations were passed during the late 1960's and early 1970's in an effort to stop the degradaton of the bay. These laws included those to prevent damaging physical alteration of the bay, such as dredging and filling of valuable shoreline areas of mangroves and seagrasses, and those attempting to stop chemical alteration of the bay through control of discharges of industrial wastes and municipal wastes such as partially treated sewage.

Physical alteration of the bay has been largely controlled, although the ongoing Tampa Harbor Deepening Project being conducted by the U.S.

Army Corps of Engineers continues to cause concern, and several large channel dredging projects are now in the planning stage.

It became obvious to the scientific community during the 1970's and early 1980's that control of chemical alterations of bay waters had not been very effective; algal blooms reappeared in 1981-82 after several years without them. In 1980 point source discharges totated 190 billion gallons per year carrying 2.35 and 3.58 million pounds of phosphate and nitrogen respectively into Tampa Bay. The greatest nutrient load was discharged by municipal sewage sources, which contributed 78% of the annual load of phosphate and 84% of the annual load of nitrogen. The blooms of macroalgae, in particular, were the first indicators that the system was still in trouble. In addition, it became obvious that submerged seagrass meadows were continuing to decline, not from being buried by dredge and fill but apparently from the increasing cloudiness of the water which prevented enough light from reaching them. The source of the cloudiness (or turbidity) is poorly understood, but probably reflects historical physical alterations as well as current chemical alterations such as continuing high levels of nutrients which lead to eutrophication or uncontrolled growth of microalgae and macroalgae.

This eutrophication problem is clearly indicated in Figures 15 and 16, which show yearly trends in total phosphate and chlorophyll a. While phosphate has declined due to some point source controls, chlorophyll a is still high. The conclusion is that nitrogen is the limiting nutrient and that significant reductions in nitrogen discharges are still needed.

RECOMMENDATIONS

It is obvious to those familiar with the management of the natural resources of Tampa Bay that many things must be done before we can begin to manage the bay as a single ecosystem. The first of these is to map the natural resources. No single accurate map of the bay's natural resources exists. Some areas such as live bottoms (reefs) in the bay were not even known to cover extensive areas until researchers reported their existence in

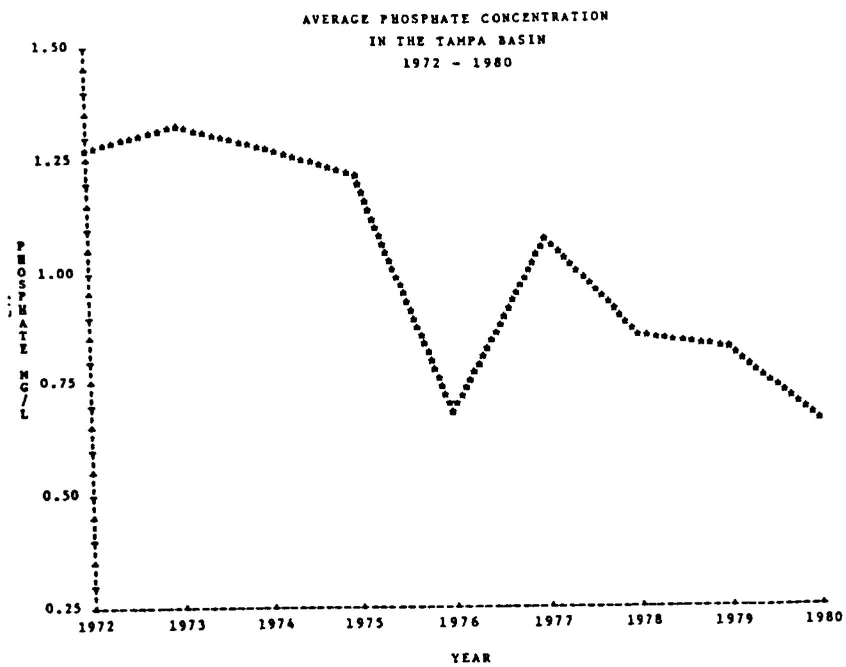

Figure 15. Average Total Phosphate Concentrations in the Tampa Bay Basin (50 Stations). From Hillsborough County Environmental Protection Commission, Annual Report, 1980.

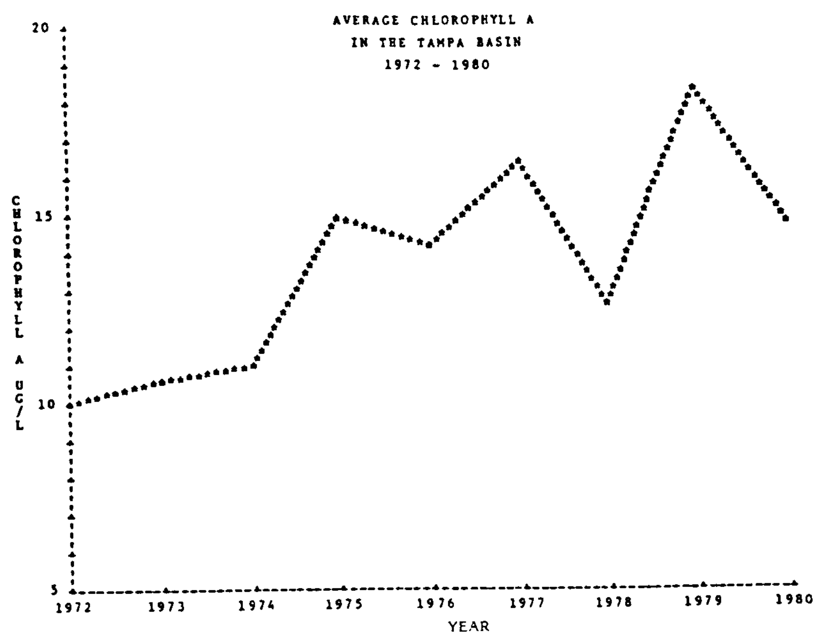

Figure 16. Average Chlorophyll A in the Tampa Bay Basin (50 Stations). From Hillsborough County Environmental Protection Commission, Annual Report, 1980.

1982. This mapping is particularly important in three Aquatic Preserves in the bay. The natural resources of these preserves are under stress and are being modified due to chemical alterations that are initiated in the bay waters outside the boundaries of the Aquatic Preserves, but are carried inside the boundaries by the natural currents of the bay.

The second and concurrent action is the establishment of Tampa Bay Study Committee to examine the present problems in the bay and to make recommendations concerning the best way to manage the bay for the benefit of all the users of the bay including fishermen, the ports, boaters, and industrial and municipal interests needing the bay as a disposal area. Such a committee was established on 10 May 1982. This committee must address the multitude of overlapping, often conflicting, jurisdictional boundaries and interests of user groups which have produced a mismanaged system that can only be expected to show further declines in fish and shellfish productivity, wildlife habitat, and general water quality unless immediate action is taken. In addition, government and industrial users can expect increasing resistance to plans for their use of the bay as the bay is further degraded. It is in the best interest of all user groups to attempt to resolve their sometimes conflicting needs and goals for the future of Tampa Bay.

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WATER QUALITY IN THE HOUSTON SHIP CHANNEL

Wayne J. Crouch
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Texas Department of Water Resources

As Chief of the Biology Section in District 7 of the Texas Department of Water Resources, I'd like to discuss the history of water quality in the Houston Ship Channel and its condition today.

The Houston Ship Channel is a major tributary of the Galveston Bay Complex. The complex consists of Galveston Bay, Trinity Bay, East Bay, and West Bay. It produces 38% of all sport fishing and 80-85% of all shellfishing activities conducted in Texas coastal waters; therefore, water quality in the complex is important to the economy of Texas.

The area around Galveston Bay was inhabitated by Indians and early settlers until the pirate Jean Lafitte and his men settled on Galveston Island. During times of danger, either from approaching storms or from the U.S. Navy, the pirates would take their shallow draft vessels into the various tributaries of the Galveston Bay Complex for shelter. One of these tributaries was Buffalo Bayou, which is today the Houston Ship Channel.

When Stephen F. Austin's colony as well as others began to settle in Texas, they frequently chose waterways, and one of those was the San Jacinto River Basin, which contains Buffalo Bayou. Buffalo Bayou was narrow, shallow, and winding with frequent sand bars and debris jams. Settlers of the time wrote of fabulous hunting and fishing. As they described the area, its water was clear with a sand bottom and contained much aquatic vegetation, non existent today, as well as immense oyster reefs which were scattered throughout the bay complex. An example of just how large the reefs were is illustrated by the story of a rancher in Chambers County who drove his cattle to market by walking them on the reefs across Galveston Bay rather than take them the longer route by land.

Houston grew rapidly after it was established. In 1876, its population was 13,000, and with this increase in area activity, material began to get into Buffalo Bayou and affect its water quality. Primarily, this consisted of papermill waste and runoff from newly cleared land. During the late 1800's, cotton was the primary crop of the area, and shallow draft vessels would sail to the foot of main street to be loaded. People of the period also took sightseeing trips up and down the heavily-wooded bayou, and a sport was to try and shoot one of the many alligators that lived there.

By 1906, Houston had 80 horseless carriages, and by 1910 commerce by water was pretty heavy on Buffalo Bayou. The frequent boat traffic stirred up the bottom sediments and contributed to a declining water quality. In 1913, the ship channel turning basin was dug. By 1930, the Port of Houston was well established and had been widened and deepened by the U.S. Army Corps of Engineers several times.

Population in the area continued to grow, and during World War II there was a rapid growth in petrochemical, munitions, shipbuilding, and other war-related industries. During this period, rapid production was needed and little or no thought was given to water quality. As a result, water quality began to deteriorate at an increased pace.

There are many sources of pollution to the ship channel. A major source of pollution is the sewage plant effluent entering the channel. Approximately 168 sewage plants discharge into the channel; most go into tributaries first and then into the ship channel. It also receives the effluent of 354 industrial discharges. Many storage tanks and lagoons are constructed on or near the shoreline and are potential sources of pollution. Several large grain loading operations located on the channel contribute grain dust to the water during dusty loading operations. There are shipyards for ocean going vessels as well as tugs scattered along the waterway. In the shipyards, hulls are cleaned and repainted, bilges and tanks are cleaned, and solvents and oils are used which potential are further possible pollutants of the water. Subsidence is a pollution problem for the channel. Tabbs Bay is full of oil wells in the water that were on dry land when they were drilled. Now any oil spilled goes directly into the water. The loading and unloading of ships and barges result in occasional spills due to equipment malfunction or operator error. Accidents, such as the tanker hit by lightening several years ago at Shell's dock, can introduce pollutants into the water.

The passage of large ships and tugs up and down the channel with their large props churning the water and resuspending the sediments can cause fishkills if the weather and water conditions are of the necessary quality.

By 1970, the Houston Ship Channel had achieved a nationwide reputation as one of the worst polluted, if not the worst, bodies of water in the nation. A Ralph Nader task force report in 1971 stated, "Fire can erupt anywhere along the crowded channel, in the chemical companies and oil refineries which line its banks, in the ships which ply its waters, and most frightening in its oil and chemical laden waters. The Houston Ship Channel is the most poisoned and potentially the most explosive body of water in the United States. The last 12 miles play host to the partially treated and untreated effluents of hundreds of factories and the domestic sewage of 2 million people."

During the period from 1970-1972, the State of Texas and the U.S. Environmental Protection Agency developed regulations requiring better treatment of effluents. In 1972, the Texas Water Quality Board (now the Texas Department of Water Resources) established four sampling stations along the ship channel where aquatic life would be monitored. One purpose of this sampling was to establish whether there was any aquatic life in the channel, and to monitor it over a period of years to detect trends. Another purpose was to better communicate with the public about the channel water quality. The public, in general, does not understand or care about the chemical parameters that are routinely monitored. However, everyone knows that if a body of water contains lots of fish and a good variety of fish, then the water is probably in good shape. Conversely, if few fish are found, then a possible problem exists that needs to be investigated. These monitoring stations were located at equal distances apart along the channel. The uppermost station was at Houston Lighting & Power Deepwater Plant, just downstream of the turning basin. The second station was at Armco Steel, the third was at Diamond Shamrock Deer Park Plant, and the last station was at Houston Lighting & Power Bertron Plant near Galveston Bay.

The intake screens from all these plants were sampled. An intake screen is simply a loop of wire mesh panels that revolve in and out of the water. Water is drawn from the channel, into the plant to be used for cooling. Trash and aquatic organisms are drawn in with the water and the screens keep them out of the plant. For our collection purposes, we notify the plant the day before we come out. The screens are cleaned at midnight and then not cleaned again until we arrive, which gives us an 8-10 hour collection. The fish collected are identified, weighed, and measured, and records are kept month to month, year to year which give up trends of aquatic life in the channel that can be related to water quality. While the nekton collections are taking place, 10 stations in the channel are sampled by boat. All sampling is done on a monthly basis.

Depending on the time of year, water and weather conditions, and migration patterns, the collections we make will range from very few fish to enormous collections of fish. The collection is usually well mixed with various species of fish; however, occasionally we will collect primarily one species of fish usually in very large numbers, indicating that we have collected a school passing the intake screens.

An interesting sidelight to our collections is that Houston Lighting & Power Deepwater Plant discharges its warm water into Vince Bayou. Since 1975, small Tarpon have spent the winter in this discharge area. The Tarpon fishery was very large along the Texas coast years ago and then virtually disappeared. Lately, reported catches of Tarpon have been increasing. The small Tarpon that winter in the ship channel are an indication that things may be improving for them.

The most populous fish in the ship channel is the Atlantic Croaker (Micropogon undulatus), and the most fragile is the Gulf Menhaden (Brevoortia patronus). The majority of fishkills in the ship channel and the bay complex are composed of menhaden. These fish are very susceptible to any abrupt changes in their environment, such as a temperature, salinity, pH, or dissolved oxygen change.

We get quite a few species of fish now from the channel. We have collected around 150 species so far. In the past few years game fish have been showing up, such as redfish, speckled trout, and flounder. This is another indication that water quality has improved quite a bit. To illustrate what we have found, in 1974 at the Diamond Shamrock station we collected 26 species and 34,000 individuals over a year's time. At the end of 1982, we had collected 30 species and over 500,000 individuals. The increase in the aquatic life in the channel over the past 10 years has been dramatic.

The Houston Ship Channel will never be an area where the public can swim, fish, or ski. Buffalo Bayou no longer exists from the turning basin downstream. It has been widened and deepened to accomodate commercial seagoing vessels.

Many people have written the Ship Channel off, saying that it is polluted and that nothing can be done. The industries and municipalities have done an excellent job of cleaning up their effluents because of the state and federal regulations. Our water quality sampling and sampling of aquatic life in the channel indicate that the water quality is improving and should continue to improve with the new line of City of Houston sewage treatment plants along Buffalo Bayou. Close monitoring and good cooperation between state, federal, industrial, and municipal factions will protect the Galveston Bay complex which is of such importance to the State of Texas.

A STUDY OF A PIPELINE SPILL WITHIN THE LOUISIANA MARSH

Mr. Noel V. Brodtman
Environmental Professionals, Ltd.

Environmental Professionals Ltd. was contracted to determine the impact of a specific oil spill occurring in the Louisiana marsh on the oyster population in the area of the spill. Because this work is currently involved in the litigation surrounding this oil spill, the company is unable to provide the exact location or specific details of the study. The incident occurred when a contractor attempted to dredge a pipeline route across another company's existing 12-inch pipeline. The pipeline flowed for approximately 24 hours, resulting in the loss of a large amount of hydrocarbons which spread into an adjacent lake. The lake covers approximately 168 acres. At the time of the spill the lake was covered 5-8 cm thick with oil. Oil remained in the area for an extended period of time. Environmental Professionals, Ltd. was contracted approximately four months after the incident occurred by the oyster fishermen whose leases were contaminated by the spill. At the time, a large quantity of oil was still noticeable in the bottom sediments.

The following observations were made concerning possible contributing causes for the severity of the oil spill on the oyster leases:

1. The incident occured during the winter months when tidal levels remained fairly low.
2. The area was unable to flush.
3. Efforts were made by the Coast Guard after the spill occurred to contain the oil spill in order to prevent it from contaminating a nearby breeding area for oysters.
4. Dispersants, which have a tendency to sink oil and make a larger amont of hydrocarbons soluable, were used during the clean-up.

For the purposes of this study, oyster samples were obtained from three different bayous. The three oyster leases used for specimen collection contained very hard packed reefs having dense oyster populations. In order to get a large population statistic, a large quantity of oyster samples was collected. Because the legal market length for oysters in Louisiana is greater than 76 mm for adult oysters, this measurement was used for the classification of the specimens into either subadult or adult subgroups. The oyster specimens collected were examined for tissue hydrocarbons by (1) tasting and by (2) lab tissue analysis.

The following observations were made concerning the consequences of the oil spill on the oyster leases:

1. Although the oyster beds used in study have been replenishing themselves for decades, not a single one-year spat was observed throughout two breeding seasons in which a total of 3000 specimens was collected.
2. The oyster leases affected by the spill have experienced an elevated mortality rate since the oil spill occurred.
3. Elevated mortality rates in adult oysters are still evident.

OVERVIEW OF CORPS OF ENGINEERS ENVIRONMENTAL EFFECTS OF DREDGING PROGRAMS

C. C. Calhoun, Jr., T. R. Patin, R. L. Lazor
U.S. Army Engineer Waterways Experiment Station

During the seventies, research emphasis was placed on developing predictive testing procedures to evaluate short-term impacts from dredged material disposal. Today, with a better understanding of short-term impacts, the Army Corps of Engineers is directing its research efforts towards developing predictive techniques and interpretive guidance for assessing chronic and sublethal environmental impacts from dredged material disposal. Research emphasis in the EEDP is directed towards development of laboratory procedures to predict and assess the environmental consequences of dredged material disposal alternatives. The predictive techniques developed in the Long-term Effects of Dredging Operations (LEDO) program and field tested in the Field Verification Program (FVP) will provide field elements with laboratory and field tested predictive techniques. Products of this research will provide predictive techniques and interpretative guidance needed to assist the Corps in meeting its dredging and regulatory missions in an environmentally sound manner. Furthermore, research results will provide technical guidance needed for implementation of the Ocean Dumping Act (Section 103) and Clean Water Act (Section 404).

BACKGROUND

Before the early 1970's, little was known of the environmental effects of dredging and dredged material disposal. As a result, the Congress of the United States recognized that there was no technical or scientific basis for regulating the disposal of dredged material. Consequently, proposed regulations would prove to be excessive and counterproductive. Therefore, the Congress directed the Army Corps of Engineers (Corps) to conduct a comprehensive research program to develop procedures for determining the environmental consequences of dredged material disposal and to develop new or improved methods of minimizing any adverse effects. The Corps was given the lead responsibility for conducting the research since, in the United States, the Corps is responsible for maintaining over 25,000 miles of waterways and 1000 harbors. In addition, Federal legislation requires the Corps to issue permits to regulate disposal of dredge material in waters of the United States.

The Corps initiated the Dredged Material Research Program (DMRP) in 1973 and completed the program in 1978 at a cost approaching $33 million. The DMRP was conducted by the U.S. Army Engineer Waterways Experiment Station (WES). It was designed to be applicable nationally with no major type of dredging activity, region, or environmental setting excluded. The program resulted in first-generation procedures for evaluating the physical, chemical, and biological impacts for a variety of disposal alternatives in water, on uplands, or in wetland areas. The program produced tested, cost-effective methods and guidelines for reducing the impacts of conventional disposal alternatives. At the same time, it demonstrated the viability and limits of new disposal alternatives, including the productive use of dredged material as a natural resource. The results of the DMRP provided the first definitive information on the impacts of dredged material disposal and have been used extensively by the Corps of the U.S. Environmental Protection Agency (EPA) to develop criteria for implementing regulations under Federal legistlation.

In addition to providing the data and information needed to develop criteria and guidelines, two major fundamental conclusions of the DMRP that are important to disposal management were reached. Studies conducted and experience gained in the years since the DMRP was completed support these conclusions. No single disposal alternative is most suited for a region or a type of project. Conversely, there is no single disposal alternative that can be dismissed as environmentally unsatisfactory due to potential impacts. In other words, from a technical standpoint there is no inherent effect or characteristic of an alternative disposal method that precludes its consideration before specific site assessment. This conclusion holds true for ocean disposal, confined disposal, or any other alternative.

To address a variety of environmental factors and considerations adequately, long-range regional planning is required if a lasting effective solution to disposal of dredged material is to be found. Through use of disposal management plans that consider project types, dredged material characteristics, disposal alternatives, and other factors, the best opportunity exists for maximum environmental protection at an acceptable cost.

RADIUM IN FORMATION WATERS: HOW MUCH AND IS IT OF CONCERN?

David F. Reid*

Naval Ocean Research and Development Activity

(Address until Sept. 1984)

College of Oceanography, Oregon State University

Saline formation waters (also called produced water) from regions not associated with known uranium deposits often contain elevated concentrations of the naturally occurring radium isotopes, especially Ra-226 and Ra-228. Numerous measurements of radium in produced and/or geothermal waters from the western and southwestern U.S. and several areas of the Soviet Union have been reported in the published literature.

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*Contents of this presentation are the sole responsibility of the author and do not in any way represent the official opinion or position of the U.S. Naval Ocean Research and Development Activity or any other government agency.

However, few data from the Gulf Coast region of the United States have been reported. This presentation is a synthesis of results from three studies related to Gulf Coast produced and geothermal waters, funded by the U.S. Geological Survey and the Department of Energy (Hanan, 1981; Landa and Reid, 1983; Kraemer and Reid, 1984). The original investigations were not concerned with the question of discharge of radium-bearing solutions to the surface environment, but the resulting data can be used to examine this issue.

A liquid waste would be classified as hazardous due to contained radioactivity with over 50 pCi of total Radium (Ra-226 + Ra-228) per liter under proposed (NOT promulgated at this time) EPA guidelines in connection with the Resource Conservation and Recovery Act of 1976 (RCRA). It should be noted that in 1980 Congress exempted the energy industry from regulation under RCRA, while within the nuclear industry, which comes under the aegis of the Nuclear Regulatory Commission, liquid discharges to unrestricted surface environments may not contain in excess of 30 pCi of Ra-226 per liter. As of 1978, within the State of Louisiana alone, in excess of 35 billion liters of produced water were discharged annually into surface non-potable water supplies such as coastal bays, marshes, canals, and bayous. In spite of the legislative exemption from RCRA, the magnitude of this discharge, the documentation of elevated radium levels in formation waters from other areas, and the continued tight regulation of other sectors of industry will undoubtedly keep open the questions related to Gulf Coast produced water discharges: how much Ra is in the discharges and is it of concern?

Kraemer and Reid (1981) measured Ra-226 and Ra-228 in more than 32 samples of produced waters from Louisiana and Texas. Total Radium (Ra-226 + Ra-228) was found to be positively correlated with the salinity of the water. Over 90% of their samples contained Total Radium in excess of 50 pCi/L, with high salinity samples (>100,000 mg/L) containing several thousand pCi/L. There is some evidence that the relationship between Total Radium and salinity may vary depending on the source-type of the produced water (wells producing gas only, oil only, or water only). However, many more analyses would be required to further refine the general relationship reported by Kraemer and Reid.

Hanan (1981) studied the distribution of Ra-226 in the upper 30-40cm of sediments close to a produced water discharge in a Louisiana tidal marsh. In two control cores taken from this marsh, he observed a relatively uniform down-core Ra-226 distribution (1.1-1.4 pCi/g). Ra-226 concentrations in the cores taken near the produced water discharge ranged from 0.4-7.3 pCi/g, with several of the cores exhibiting subsurface Ra-226 maxima in the upper 30cm. Comparison with other core properties showed that RA-226 was well correlated with clay content and cation exchange capacity (r = +0.74 for both), which suggests that exchange sites on the clays are the primary binding sites for adsorbed Ra-226. Landa and Reid (1983) confirmed this via a laboratory study using sediments from the same discharge site, and showed that the amount adsorbed is salinity dependent, increasing with decreasing salinity.

Based on the proposed EPA/RCRA regulations, over 80% of the formation waters analyzed by Kraemer and Reid (1983) would be classifiable as hazardous due to contained radium isotopes (if the proposed regulations were adopted and applied to these discharges). All of those with salinity >40,000 mg/L clearly exceed the proposed RCRA limits, as well as the parallel limit for Ra-226 enforced by the NRC with regard to the nuclear industry. The average of all the Ra-226 data in the upper 30cm of the cores analyzed by Hanan (1981) is $\approx$3 pCi/g. No Ra-228 data were obtained. If Ra-228 averaged at least 70% of the Ra-226 in these cores, than the proposed EPA/RCRA limit for solid wastes would also be exceeded, and this material would be classifiable as hazardous due to contained radioactivity (if the material were dredged and if the criteria were applicable).

Produced water discharges are presently exempt from regulation under RCRA and are essentially unencumbered by existing regulations. However, it is apparent that the environmental questions related to these discharges have not been properly addressed and are likely to rise again in the near future. Two federal agencies (EPA and NRC) have indicated, by their regulatory actions, the apparent need to limit the discharge of radium to the enviroment to levels significantly below those found in typical saline produced waters. Yet surface discharge of radium-bearing produced waters has been occurring in the Gulf Coast region (and others) for over thirty years. It seems obvious that the applicability of the radium discharge criteria to the naturally occuring radium present in produced water discharges needs to be evaluated: what is the basis for the discharge limits specified in existing criteria; where does the radium in produced waters go--does it accumulate or does it remain mobile and eventually get flushed out to sea? In the case of off-shore discharges, the dilution with seawater combined with natural flushing by currents should eliminate most concerns related to the radium levels--there are other properties of produced waters which will be of much greater concern. With respect to the onshore discharges, the study by Hanan (1981) documented some elevation of Ra-226 in local sediments, but failed to reveal any dramatic local environmental contamination by radium from the discharge of saline produced water. This is in contrast to the severe soil contamination reported by Titayeva et al. (1977) for a produced water discharge site in the Soviet Union. In order to attain a satisfactory degree of confidence in the extrapolation of Hanan's findings to onshore discharges in general, additional studies at several discharge sites, with wider areal coverage, would be required.

In summary, the radium levels observed in most saline produced waters from the Gulf Coast Region exceed proposed and existing radium discharge limits applied to other industrial sectors. Although the energy industry is presently exempt from regulation under these criteria, it is likely that this issue will eventually have to be addressed. At present there are insufficient data with which to properly examine the environmental questions. Blind application of radium discharge limits which may be unnecessarily low would be as inappropriate as continuing to ignore the issue in this industrial sector while enforcing regulation in other industrial sectors. It would be in the best interests of both industry and the government regulatory agencies to pursue the appropriate investigations now, rather than waiting until the regulatory questions and environmental concerns force the issue.

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SUPERFUND DAMAGE ASSESSMENT REGULATIONS

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BACKGROUND

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, also known as Superfund Act) provides that trustees may make claims for damages to natural resources caused by oil spills and hazardous waste releases. Claims may be brought against responsible parties (Section 107) or, in case a responsible party cannot be found, against the Hazardous Substance Trust Fund (Section 111). Claims for damages from oil spills must first be brought against responsible parties and then against oil spill fund (Section 311 of the Clean Water Act). If they are compensable, but unsatisfied by that fund, they may then be brought against the Superfund.

STATUTORY PROVISIONS

CERCLA defines damages and natural resources (Section 101). It provides that trustees are the States and the Federal Government. States are trustees for resources within their borders, including the territorial sea. The Federal Government's trusteeship is limited and pertains only to those resources within the exclusive sovereignty of the United States and those that the Federal Government specifically manages or protects. Thus, in many cases, there will be multiple trustees because of concurrent and contiguous jurisdictions.

In addition, the Act requires the President to promulgate regulations providing protocols and methodologies for assessing damages to natural resources (Section 301c). Once promulgated, Federal trustees must use these regulations in assessing damages. Although the Act does not require State trustees to use the regulations, it does provide that assessments based on the regulations will have a rebuttable presumption in any administrative or judicial proceeding. This will result in a strong incentive for States to use the regulations.

STATUS OF REGULATIONS

In Executive Order 12316 the President identified Federal trustees and assigned the responsibilty for the regulations to the Secretary of the Interior. The Federal trustees were further designated in Subpart G of the National Oil and Hazardous Substances Contingency Plan (40 CFR 300). In FY1982 the Department of the Interior sought funding for this effort from the Superfund but was advised by the Environmental Protection Agency that Superfund monies could not be used for this purpose. This led the Department to decide to initiate the development of the regulations in FY 1983 with existing resources. Advance notices of proposed rulemaking were published in the Federal Register on January 10, 1983 (48 FR 1084) describing the scope of the regulations and requesting advice from interested parties and on August 1, 1983 (48 FR 34768) describing the response to the first notice. For FY1984 the Department has requested and received appropriations for four work-years of effort for the regulations. These resources are not expected to be available until sometime during the second quarter of the fiscal year.

CONCLUSION

The regulations must provide methodologies to assess damages to many different types of resources which may be caused by many types of hazardous substances. Moreover, there is limited data on past damages, especially regarding small incidents, and inherent controversy on methodologies which place economic values on natural resources. Because of this, Interior will probably take the better part of two years to promulgate final regulations.

PART II: OFFSHORE CONCERNS

STATUS OF THE OCS LONG-TERM EFFECTS PROGRAM

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Assessment of Long-Term Effects of OCS Development is a study currently being conducted for the Federal Interagency Committee on Ocean Pollution Research, Development, and Monitoring (COPRDM) with funding from the National Oceanic and Atmospheric Administration and the National Science Foundation. It is a synthetic and interpretative study which involves the evaluation of extant data rather than the development of new results. The assessment is being managed by the Louisiana Universities Marine Consortium but involves experts from throughout the nation.

The issue of the risks of long-term effects which, for example, might result from low-level, chronic contamination created by oil and gas exploration and production has been raised by a number of advisory groups and reports as one meriting better resolution. The Second National Marine Pollution Program Plan prepared by COPRDM pursuant to the National Ocean Pollution Planning Act concluded that a long-term, interagency research program be planned and implemented to investigate the potential long-term, low-level effects of OCS oil and gas development. The present study is the principal planning effort in response to this charge.

The primary objective of the assessment is to develop recommendations for the design of environmental research and monitoring programs to quantify and evaluate the significance of subtle and long-term effects of OCS oil and gas development activities. Intermediate objectives include critically reviewing the current state of relevent knowledge; reviewing the premises, design, and interpretation of field assessment programs; projecting industry trends in development (both in location and technology); developing predictive assessments of realistically potential effects; surveying on-going and planned research and monitoring programs; and designing studies.

The assessment is being directed by a Steering Committee consisting of seven environmental scientists assisted by liaisons from participating federal agencies. In addition, experts have been commissioned to prepare technical papers summarizing the state of knowledge and providing an assessment of issues in such areas as transport and transformation of pollutants, biological effects of oil and drilling production discharges, coastal habitat alterations, and the design of field monitoring.

The study is scheduled to conclude in the spring of 1984. Its conclusions should be particularly important to the Gulf of Mexico region because it has seen the vast majority of OCS development over a long time period. Furthermore, projections indicate that 85% of the OCS wells drilled during the next 10 years will be in the Gulf of Mexico.

A DATA BASE FOR ESTIMATING POLLUTANT DISCHARGES INTO COASTAL AND OCEAN WATERS OF THE UNITED STATES

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NOAA, Strategic Assessment Branch

The data base compiles and assesses all existing information on each individual source of pollutant discharges in the "coastal zone" and is based to the extent possible on monitored data. When completed, this data base will contain an inventory of all land-based sources of pollutant discharges in all ocean coastal areas in the contiguous U.S. (excluding the Great Lakes) and Alaska, as well as ocean-based stationary sources in coastal waters within the 200-mile fishery conservation zone of the U.S. The data base assigns pollutant discharges to individual waterbodies within the coastal zone and along coastline segments and, for ocean-based sources, to 1/2 by 1/2 degree grid cells, based on standard lines of longitude and latitude, into which offshore areas will be divided. Examples of general types of pollutants that will be included are suspended solids, nutrients, organic matter, petroleum hydrocarbons, heavy metals, and synthetic organics.

The development of this data base is an integral part of NOAA's program of strategic assessments of the Nation's coastal and ocean regions. These assessments are intended to identify and evaluate existing and potential ocean resource use conflicts, so that resources can be developed or conserved in an efficient manner, while environmental damages are minimized. The assessments are described as being "strategic" because they are carried out from a comprehensive planning perspective intended to complement, not replace, the necessary detailed "tactical" analyses of coastal and ocean use proposals. Regional assessments have been scheduled which will cover the entire "coastal zone" of the U.S. The National Coastal Pollutant Discharge Data Base is being developed on a similar schedule and will be organized into four separate, but integrated, regional data bases --

one each for the east coast (Region 1), Gulf of Mexico (Region 2), Alaska (Regions 3 and 4), and west coast (Region 5).

The development of detailed information ocean use activities and pollutant discharges is central to formulation and analyzing strategies for mitigating ocean resource use conflicts. Without such information, it is impossible even to approximate the magnitude of potential conflicts or the human activities to which problems, once identified, can be attributed and mitigation strategies formulated. The National Coastal Pollutant Discharge Data Base will provide this type of information in a comprehensive and quantitative form which previously has not been available.

The National Coastal Pollutant Discharge Data Base being developed is comprised of three separate, but closely related, components: (1) an inventory of all land-based and ocean-based point sources and their pollutant discharges; (2) an inventory of all land-based nonpoint sources and their pollutant discharges; and (3) an inventory of pollutant inflows from upstream sources entering estuaries, some portion of which eventually is transported to coastal and ocean waters.

A NATIONAL ENVIRONMENTAL MONITORING EFFORT: NOAA'S STATUS AND TRENDS PROGRAM

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NOAA plans to initiate a new monitoring program in Fiscal Year 1984 that will provide a standardized data base nationwide for identifying the status and trends of environmental quality of the Nation's coastal and estuarine zones. It is apparent that no such data base exists now. Therefore, there is no way to judge confidently if conditions are getting better or worse as consequence of man's activities, including remedial actions, along our Nation's coasts.

The focus of this program will be upon regions known to have or with the potential to have pollution problems. Thus, mostly estuaries, bays, and coastal environments near major urban/industrial areas will be monitored. A few regions considered to be relatively pristine also will be included in the program. Toxic chemicals, pathogenic microorganisms, and bioindicators of toxicant effects will be monitored.

The objective of this program is not to survey and characterize the environmental condition of each and every region of the nation. Rather, it is to select sites which reflect contaminant loadings in selected regions (bays, estuaries, etc.) of the country, and sample those with sufficient replication to ensure adequate statistical rigor to allow identification of trends with time. Selection of sampling sites becomes, then, of critical importance. For example, for that portion of the program that involves sampling sediments for chemical analyses, depositional zones must be found to ensure that the contamination from man's nearby activities is monitored.

This program will likely involve chemical analyses of sediments, bivalves, and fish for organic compounds and metals. It will likely include analyses of bivalves for human pathogens. It will also likely involve testing for some sort of biological indications of contaminant stress, e.g., sediment bioassays for lethality and analyses of fish for lesions of internal organs or enzymatic activity.

This program will not attempt to establish cause/effect relationships, test compliance with discharge permits, measure contaminant metabolites, make projections of future conditions, nor sample specific dumpsites or point sources. It will focus upon monitoring conditions in regions with multiple inputs and a history, of or potential for, contamination.

The program is currently (November, 1983) early in the planning stages. No research laboratory or laboratories have been selected yet to do the work. Regions to be monitored have not been selected yet. Sampling and analytical protocols have not been determined. These protocols will be established through counsel from our expert scientists and negotiation with the researchers selected to perform the work. Researchers will be selected by the end of FY84.

The program will likely start in FY84 by performing a reconnaisance survey of a large number of regions (say, 100) along the three marine coasts. Sediment chemistry, sediment toxicity, and pathogens will likely be measured. Based upon the results of this survey, the monitoring program will likely begin in FY85. Monitoring will be conducted on a three-year rotational basis in which the Atlantic/Gulf/Pacific coasts will be sampled every three years in some as yet undetermined sequence. The monitoring program will likely invlove an analysis of more parameters than included in the initial reconnaisance. In addition, occasional broad contaminant scans and analyses of age-dated stratified sediment cores will be performed in the montoring program.

In addition to collection and analyses of new samples, this program will involve a strong element of acquisition, synthesis, and reporting of data collected by others in local or regional studies and monitoring programs. NOAA will make these synthesis reports widely available on an annual basis along with the results of the monitoring.

This program will be managed by personnel from the National Ocean Service of NOAA in Rockville, Maryland, with assistance from staff in Seattle, Washington, and Stony Brook, New York. We will be seeking help and advice on regions to monitor, locations of depositional zones, biota to sample and test, and locations of existing data sets. At this point we plan to sample about 40 sites within 15 to 20 regions along the Gulf Coast. Which regions should be emphasized? What sites in each should we sample? What sites are likely most representative of man's nearby activities? Please direct your options, ideas and comments to Dr. John Calder or Dr. Adriana Cantillo in Rockville, Maryland, telephone (301) or (FTS) 443-8951.

CLEAN GULF ASSOCIATES' CHEMICAL AND BIOLOGICAL MONITORING PROGRAM

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Clean Gulf Associates (CGA) founded in 1972 is a non-profit organization of 79 energy companies cooperating to provide oil containment and clean-up capabilities in the Gulf of Mexico. The cooperative has more than $5.2 MM worth of equipment in operation or on order. Operating bases in Louisiana are at Grand Isle, Venice, Houma, Cameron, and Intercoastal City and in Texas at Galveston and Rockport.

Clean Gulf Associates' Chemical and Biological Monitoring Program had as its impetus the need seen by many of its member companies to initiate a chemical and/or biological monitoring program as part of an oil spill response. There are many contract firms in the Gulf region which are qualified to conduct biological and chemical programs; however, they generally are not prepared to respond rapidly. The logisitical problems of gathering and transporting sampling equipment to a spill site was seen as the primary cause of delay in a rapid response effort.

A CGA ad hoc committee for selecting and purchasing chemical and biolgical monitoring equipment was formed under its chairman, Dr. Bruce A. Cox of Marathon Oil Company, in late 1982 and given $25 M budget. Other members of the ad hoc committee included Dr. Marion E. Fischel (Shell Oil Company), Dr. Robert E. "Rob" Abbott (Conoco, Inc.), Mr. Bert H. Bates (Sun Exploration and Production Company), and me.

The committee decided to purchase equipment, instruments, and supplies to sample an oil spill's parent oil, the "real time" aromatic hydrocarbon concentration underneath the oil slick at various depths, the water column both below the slick and non-affected areas, the sediments for both chemistry and biology, and various biological specimens to obtain tissue samples for analysis. Equipment purchased included a Turner Field Fluorometer with three submersible pumps and associated hoses, a 4.2 L Kemmerer Water Sampler, YSI Salinity-Conductivity-Temperature and Dissolved O_2 meters, a Hummingbird Depth Sounder Salinity Refractometer, Wisconsin in Plankton Sampler, Wildco Ekman Dredge, Van Veen Dredge, a 12'-1-1/4" Otter Trawl, 30'x6', 1/2" mesh and 30'x6', 1/4" mesh Seines and Oyster Tongs. The equipment with associated deployment materials, sample storage containers, and sample preservation chemicals are stored in an enclosed twin-axled trailer at Grand Isle, Louisiana. The Turner Field Fluorometer is kept at Analysis Laboratories in Metairie, Louisiana so that it can be maintained in proper working order for rapid response. Analysis Laboratories will provide a trained technician to operate the fluorometer in the field during a response.

Dr. Brian Middleitch of the University of Houston-University Park was contracted to provide instructions on how to prepare biological, sediment, and water samples for analysis of volatile and non-volatile hydrocarbons, and Dr. Nick Fotheringham of Dames & Moore provided instructions on the use of purchased sampling equipment and sample collection techniques for chemical and biological analysis. These instructions have been incorporated into a manual to aid a CGA member company in designing a biological and chemical sampling program they may wish to utilize in the event of an oil spill. Individual pieces of sampling equipment are packaged in the response with a laminated instruction sheet for field use.

A field test of the Turner Fluorometer and various field samplers and instruments was held on August 24, 1983 off Grand Isle, Louisiana aboard an oil field service vessel and showed that the equipment tested performed very satisfactorily. The CGA Chemical and Biological Monitoring Program now stands ready for use in any chosen manner by the co-operative's member companies.

GULF OF MEXICO STRATEGIC ASSESSMENT PROJECT

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NOAA, Strategic Assessment Branch

The Strategic Assessment Branch (SAB) of the Ocean Assessments Division, National Ocean Service, has initiated a series of strategic assessments that focus on large coastal ocean regions of the United States. Their purpose is to identify ocean resource use compatibilities or conflicts before they occur, so that resources can be developed or conserved in an effective and efficient manner, while environmental damages are minimized. The assessments are described as "strategic" because they are carried out from a comprehensive planning perspective intended to complement, not replace, the necessary detailed, "tactical" analyses of coastal and ocean use proposals. Five regional assessments have been scheduled that will cover the entire "coastal zone" of the U.S. (excluding the Great Lakes), extending seaward to the 200-mile limit of the fishery conservation zone and including all of the outer continental shelf as defined by the 200-meter isobath.

The Gulf of Mexico project, initiated in October 1980, is SAB's second strategic assessment and focuses on the entire Gulf, including the coasts and ocean waters of the United States and Mexico. For the U.S. the study area includes all coastal counties (as defined by the federal office of Coastal Zone Management), all areas defined by individual Gulf states as their "coastal zone," and the area of the coastal plain (as defined by the 100-meter contour).

For this region the assessment will develop a data base to provide a preliminary basis for identifying and better understanding some of the relationships between and among economic activities and elements of the natural system. The data will be used to (1) identify areas which should be further analyzed for special management consideration because of their biological or ecological importance; (2) evaluate the effects on ambient water quality of alternative economic development scenarios and pollution control strategies in the region; and (3) infer the spatial relationships between economic activities and living resources in the Gulf, particularly the relationship between ambient water quality and areas of special biological importance, such as spawning areas or nursery areas of living marine resources.

SUMMARY OF PROJECT COMPONENTS

The major components of the Gulf of Mexico strategic can be classified into two general types: (1) those related to data base development; and (2) those related to planned analysis and synthesis of the data base.

Planned Analysis: Three types of related analyses are planned. First is a primarily descriptive analysis which will synthesize mapped information on the life history of individual species from the data atlas. This will provide an overall understanding of some of the spatial (and to a lesser extent temporal) relationships among species, their habitats, and potential risks from economic activities. These relationships have not yet been defined in a systematic or comprehensive way. In this analysis, maps containing relevant sets of data will be combined using simple map overlay methods. The study area will be divided into a number of "grid cells" within which the presence or absence of various attributes from sets of individual maps will be recorded. Combining and analysing the mapped data using these methods will develop information for the following uses:

- environmental assessments of major development projects in a specified area, e.g., OCS oil and gas lease sales;
- assessments of alternative locations for onshore and offshore activities, e.g., deepwater ports;
- identification of areas which may require special protection based on biophysical characteristics and inferred environmental stresses, e.g., marine and estuaries sanctuaries;
- preliminary analyses for oil spill contingency planning;
- identification of the spatial dimension needed for coastal and ocean resource management; and
- identification of data gaps and research needs in relation to specific problems.

Second is a simple quantitative analysis of the movement of pollutants and resultant water quality within the Gulf of Mexico. This analysis is being conducted by SAB, NOAA's Environmental Data and Information Service (EDIS), and James H. Duke, a water resources engineer from Austin, Texas. A pollutant transport/water quality model is being developed to compute concentrations of various pollutants throughout the Gulf, given estimates of pollutant discharges inputs from land-based and ocean-based sources (see Data Base Development section). The model is based on the well-known two-dimensional advection dispersion mass transport equation and divides the Gulf into a network of approximately 600 "control volumes" or quarterdegree grid cells, each roughly 30 miles by 30 miles. Depending on the relative importance of pollution or resources in various regions and the availabilty of more refined data, nearshore regions may be divided into smaller grid cells. The model assumes steady state conditions and will be applied for two seasons only--winter and summer. EDIS is developing the oceanographic and hydrodynamic data required to implement the model. In addition, remotely sensed data provided by National Earth Satellite Service on various oceanographic and pollution-related parameters is being investigated.

Third is an analysis which synthesizes the results of the first two analyses to obtain a better understanding of the relative environmental risk to living marine resources (and potential risks from new development) by considering the relationship of two factors: (1) the presence or absence of various marine species and when and where they carry out important life history functions such as spawning, breeding, or nursing; and (2) the distribution of pollutant discharges from land-based and ocean-based sources and their relative effects on water quality in the Gulf of Mexico.

The analysis will not attempt to make quantitative or probabilistic statements of the risks to living marine resources, nor explicitly account for the many factors that vary in time and space and are known to affect these resources. The extent to which this analysis will be developed further depends on the accuracy of the pollutant transport model being developed and cannot be determined at this time.

THE PERSISTENCE OF IXTOC-I OIL ALONG THE SOUTH TEXAS COAST

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Floating oil from the IXTOC-I blowout came ashore in quantity along the South Texas Gulf coastline during August and September 1979. This was a short time-span compared to the 295 days that oil from the IXTOC well flowed into the Gulf of Mexico (June 1979 to March 1980). Within a 12-km long study site on Mustang Island beach, thick deposits of IXTOC oil remained visible also for a comparatively short time due to several factors, among them, seasonal changes in the longshore current system, mechanical oil removal efforts, and two (September 1979) storms that eroded beach, dunes, IXTOC oil, and man-made storage piles of oiled sand and swept them out to sea. IXTOC deposits remained in the form of "tar-reefs" deposited just offshore in the region of the first sandbar and trough. Some effort was made to remove these mechanically in the more popular parts of the beach up until the end of 1979.

The ongoing study, initiated in April 1978, monitors the bird population utilizing this stretch of Gulf coast beach along with sea and weather conditions, beach profile measurements, demographic trends in this rapidly developing area, and the types of beach debris, natural and man-made, including oil and tarballs. The survey is now done on alternate days, and at this writing, 665 have been completed covering 8,000 km of beach, taking 1300 man-hours; 700,000 individual birds of 204 species have been counted. The survey is done by automobile, and distances are measured using a calibrated odometer with a repeatability of 0.03 km to known landmarks. The location of all tar-reefs along the beach has been monitored since 1979. Due to seasonal variations in sea level the tar-reefs remain submerged for much of the year. From late November through February low tides expose the reefs, but at the same time the passage of winter "northers" creates energetic wave systems which erodes them. Fields of characteristic tarballs eroded from the reefs are washed onto the beach and remain there until buried by sand or washed into the foredunes during storms. Figure 17 shows the location of reefs and tarball fields associated with the reefs from September 1979 through June 1983. The last period when the reefs were exposed (in early 1983) revealed several small reefs, the largest being 25 m long by 3 m wide by 25 cm thick, and many tarball fields. It should be noted that due to the limited resources and time available for this project, no effort has been made to locate the tar-reefs when they are submerged. Tar-reef and tarball samples have been collected at intervals throughout the study period and are preserved frozen at UT-MSIPA.

In November 1980 small fields of Callianassa islagrande burrows were discovered that had been filled with IXTOC oil, presumably when the semi-liquid mousse first beached and, mixed with sand, flowed down, and permeated the burrows to form an IXTOC oil burrow cast (Amos et al., 1983). Another event that followed the IXTOC oil beaching was the oiling of shorebirds (Amos, 1980). While gulls and terns and sandpipers occupy the study beach in about equal numbers averaged over a year, the shorebirds were much more vulnerable to oiling than were the gulls and terns. This was particularly so with Sanderling (Crocethia alba). Sanderling feed at the strand-lines where oil and oiled debris are found. Their bills and feet become oiled, and oil is then transferred to the body plumage by preening, by their habit of standing on one foot with the other drawn up to the belly plumage, and by their territorially agressive/submissive postures when they lie flat on the oiled sand or debris. Figure 18 shows the incidence of oiling of Sanderling compared to Piping Plover (Charadrius melodius) from 1978 to the present. Each spring since IXTOC beached (especially during May), numbers of Sanderlings are oiled. While there is some identification of this being a dimishing phenomenon when comparing percentage of birds oiled rather than total numbers oiled, this oiling coincides with a seasonal beaching of fresh tarballs and oiled Sargassum weed. How much of this can be attributed to IXTOC oil and how much to other oil production/transportation spillage or to natural seepage cannot be determined from the present observations. It is interesting to note that

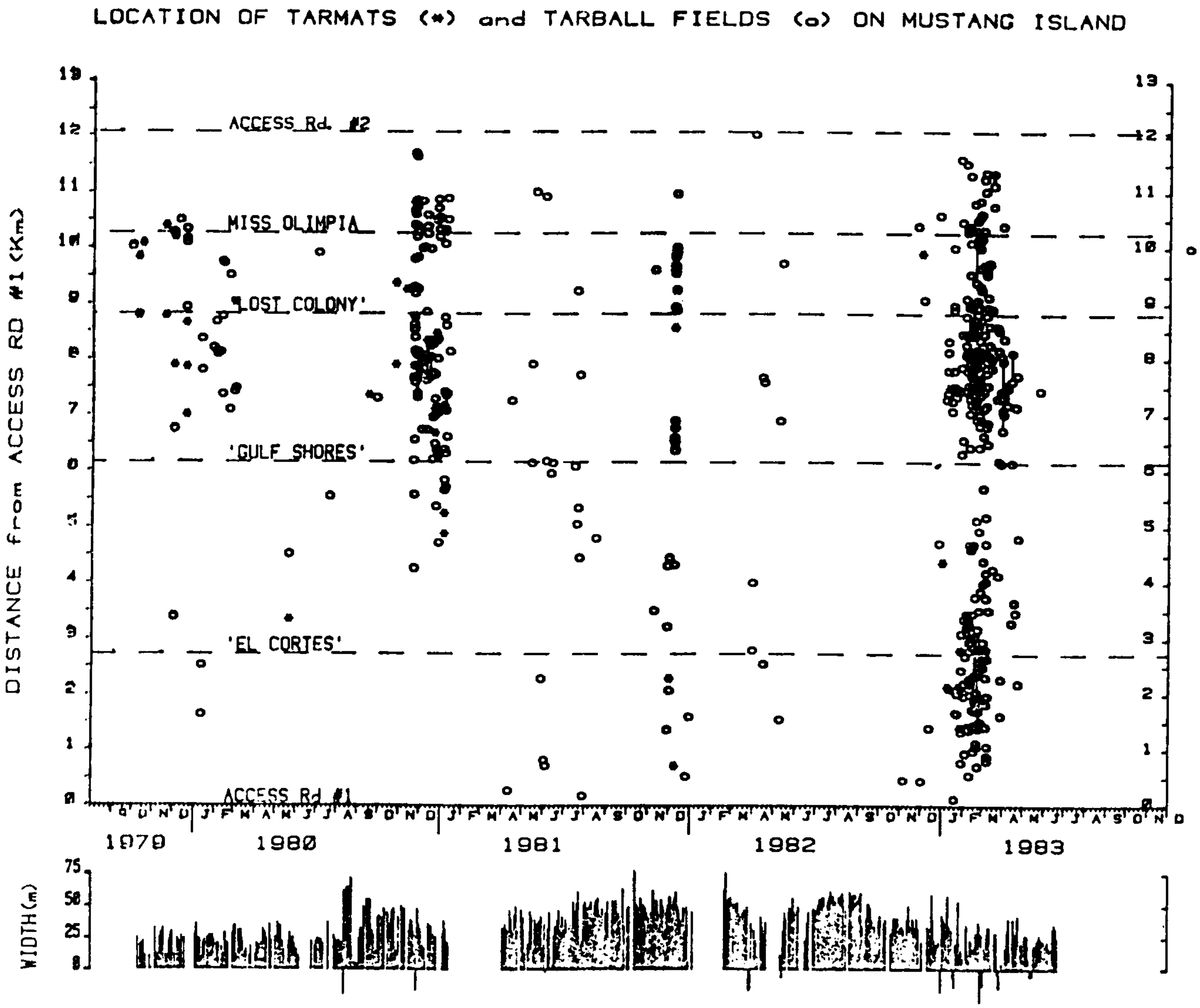
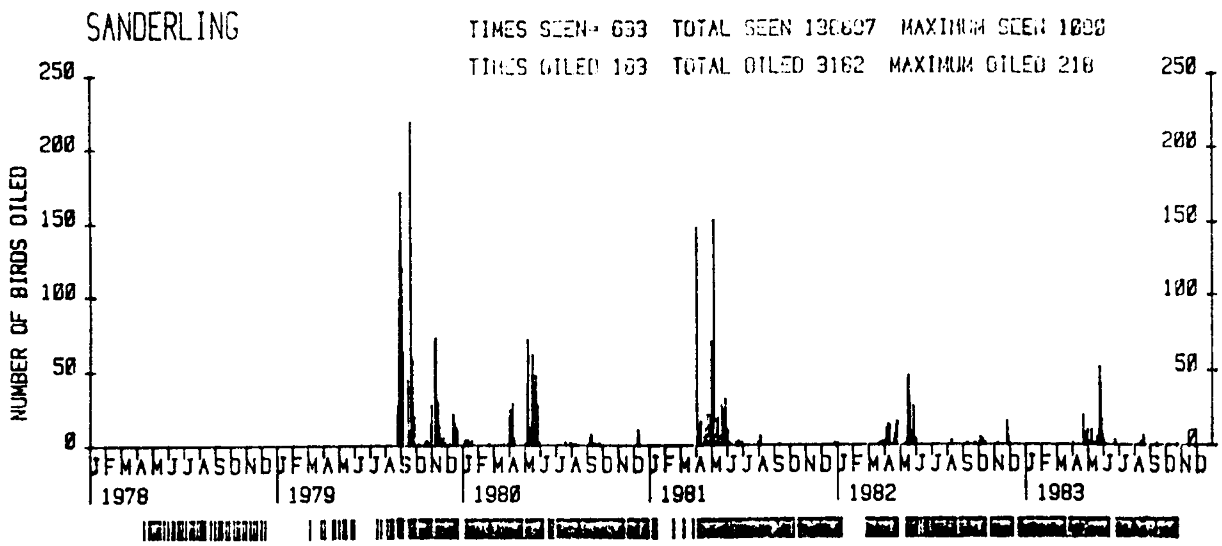


Figure 17. Location of Tarmats (*) and Tarball Fields (o) Associated with Tar-Reefs from September 1979 through June 1983. Frequency of observation can be seen from the beach width (distance from dune line to high-tide line) bars along the bottom of the plot. Location of prominent beach landmarks are shown by the dashed lines.



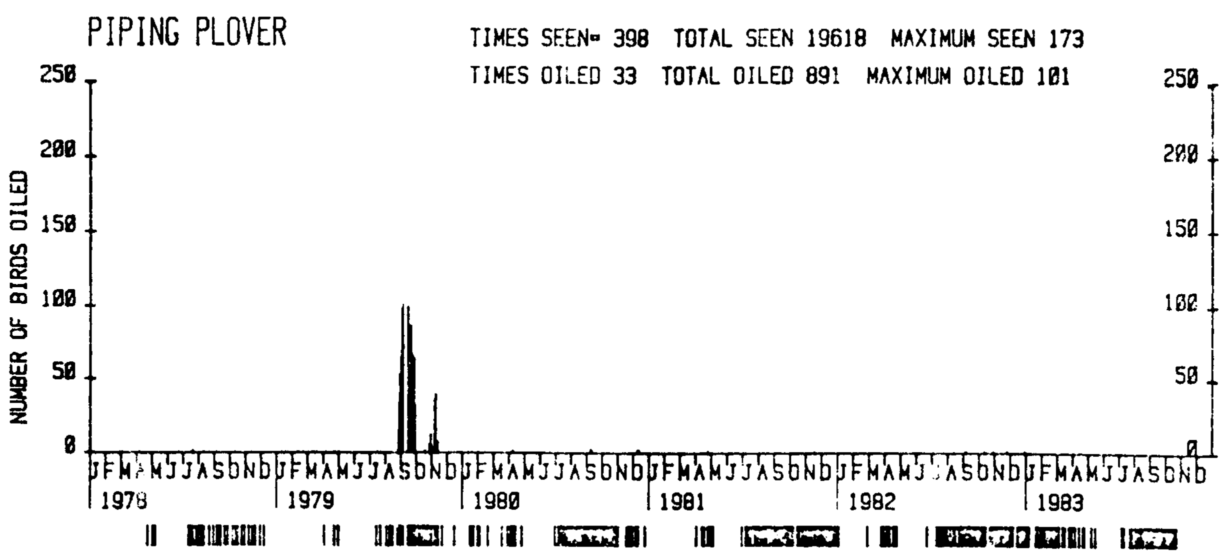


Figure 18. Oiling of Sanderling (Crocethia alba) and Piping Plover (Charadrius melodius) from April 1978 to November 1983
Frequency of observation of each species is given by the vertical bars at the bottom of each plot. Sanderling is the most commonly seen bird on the beach with a sighting frequency of about 99 percent.

Piping Plover and other shorebirds, while initially badly oiled following the IXTOC spill, have not continued to be oiled in the same way that Sanderling has.

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SPATIAL AND TEMPORAL DISTRIBUTION OF FLOATING OIL RESIDUES OFFSHORE WESTERN FLORIDA

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Pelagic tar was monitored over a two-year period in the eastern Gulf of Mexico. A total of 416 surface and subsurface samples were collected during monthly cruises. Conclusions reached during the two-year study are as follows:

(1) Concentrations of pelagic tar found in the eastern Gulf of Mexico are substantially higher than those reported in several other coastal areas around the world.

(2) Pelagic tar found in the eastern Gulf of Mexico is primarily associated with the Gulf Loop Current. The continental shelf areas around the eastern Gulf appear to be quite clean with respect to pelagic tar.

(3) Most of the pelagic tar associated with the Loop Current that ultimately impinges upon the coast of Florida washes ashore between Key West and Fort Pierce.

(4) Pelagic tar transported to the Gulf of Mexico from the Caribbean Sea by the Gulf Loop Current can account for approximately 10-50% of the tar in the eastern Gulf. The remainder appears to originate within the Gulf.

(5) Approximately half of the pelagic tar samples collected during the study appeared to have originated from tanker operations. The remaining tar samples may or may not have come from this source. Natural seeps, Mississippi River discharge, and oil drilling platforms do not appear to contribute a significant portion of the pelagic tar observed in the eastern Gulf of Mexico.

RESULTS FROM THE CHEMICAL ANALYSES OF OILY RESIDUE SAMPLES TAKEN FROM STRANDED JUVENILE SEA TURTLES COLLECTED FROM PADRE AND MUSTANG ISLANDS, TEXAS

E. B. Overton, C. J. Byrne, J. A. McFall, Shelley R. Antoine, and J. L. Laseter

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A joint United States-Mexican project has been initiated with the goal of augmenting the natural breeding stock of the endangered Kemp's Ridley sea turtles (*Lepidochelys kempi*). Eggs were hatched and the hatchlings raised to juveniles by the U.S. National Marine Fisheries Service in Galveston, Texas. The juvenile Kemp's Ridleys were released June 7, 1983, in sargassium patches situated along the 10 fathom depth contour offshore of Padre and Mustang Islands. Between June 8 and 13, 1983, many of the juveniles were found dead or distressed and stranded on Padre and Mustang Islands. Upon inspection, the turtles were found to have small oily residues, with the appearance of tar in the mouth, esophagus, and stomach. Approximately thirty samples of the oily residues from these stranded turtles were collected and sent to the Center for Bio-Organic Studies at the University of New Orleans for chemical analyses.

The chemical analyses included:

a) High resolution gas chromatographic (HRGC) analyses of the saturate fractions.
b) High resolution gas chromatographic-mass spectrometric (HRGC-MS) analyses of the aromatic fractions.
c) Stable carbon and hydrogen isotope analyses.
d) Nickel and vanadium analyses.
e) Specific gravities.

The following observations were made concerning the oily residue samples:

1) Stable isotope carbon and hydrogen analyses do not support a single source for the six oily residue samples.

2) Data on the quantities of nickel and vanadium are similar to those found in heavy crude oils or residues and within the range of reported concentrations found in tarballs collected throughout the Gulf of Mexico.

3) The absence of pronounced chromatographic humps is indicative of the fact that these oily residue samples were not simply heavily weathered crude oils.

4) High resolution gas chromatographic data support the fact that the samples contained elevated levels of "waxy" paraffins in the n-C20 to n-C32 range.

5) Pristane-phytane data and high resolution gas chromatographic profile data provide evidence which indicates that the oily residue samples may have at best three diagenetic sources.

6) Other chromatographic parameters, such as the ratio of saturate to aromatic hydrocarbons, did not provide conclusive evidence to support source identifications of the oily residues.

7) GCMS derived alkyl homolog data support the conclusions that sample NNM101 had a lower sulfur content than the other samples.

8) GCMS analyses revealed only low quantities of the more acutely toxic alkyl benzenes and naphthalenes in the samples.

9) Specific gravities of all samples were low enough to allow the samples to be buoyant in seawater.

Based on these observations, we have reached the following conclusions:

First, the samples were most probably the waxy residues discarded after tanker cleaning operations.

Second, the samples did not contain appreciable quantities of the more acute toxic (to marine organisms) petroleum hydrocarbons such as the alkyl benzenes and naphthalenes.

Third, the samples were buoyant and available to the turtles as foodstuffs.

Session: BIOLOGICAL LEASE STIPULATIONS

Chairman: Dr. Robert Rogers

Date: November 16, 1983

Presentation Title	Speaker/Affiliation
PART I: TOPOGRAPHIC FEATURES PROGRAM COMPLETION SEMINAR	
Session Overview	Dr. Robert Rogers MMS, Gulf of Mexico Region
Northwestern Gulf of Mexico Topographic Features: Their Geological, Biological, and Physical Dynamics	Dr. Richard Rezak, Dr. Thomas Bright, and Dr. David McGrail Department of Oceanography Texas A&M University
An Overview of Biological Lease Stipulations	Charles Hill MMS, Gulf of Mexico Region
PART II: RIG MONITORING STUDIES	
Session Overview	Les Dauterive MMS, Gulf of Mexico Region
Gulf of Mexico Lease Stipulated Rig Monitoring Studies	Les Dauterive MMS, Gulf of Mexico Region
Summary of BLM/MMS Exploratory Rig Monitoring Studies in the Gulf of Mexico	Dr. Richard Defenbaugh, MMS, Gulf of Mexico Region
Georges Bank Benthic Monitoring Program: The First Two Years	Dr. Jerry M. Neff Battelle New England Marine

Pacific OCS Region Rig Monitoring Studies	Dick Wilhelmsen MMS, Pacific OCS Region
Critique of Design of Rig Monitoring Studies	Dr. Donald F. Boesch Louisiana Universities Marine Consortium
Petroleum Industry Overview and Perspective on Rig Monitoring Studies	Dr. James P. Ray Shell Oil Company
API Study of Near-Rig Sediment at Six Drilling Sites in the Gulf of Mexico	Dr. Paul N. Booth College of Geoscience Texas A&M University
Toxicity of "Spent" Drilling Fluids to Selected Marine Organisms	Dr. Thomas W. Duke U.S. EPA Environmental Research Laboratory
National Research Council's Study of Drilling Fluids and Cuttings in the Marine Environment	Dr. Donald F. Boesch Louisiana Universities Marine Consortium

BIOLOGICAL LEASE STIPULATIONS

PART I: TOPOLOGICAL FEATURES PROGRAM COMPLETION SEMINAR

SESSION OVERVIEW

Dr. Robert Rogers
MMS, Gulf of Mexico OCS Region

The purpose of this session was to discuss the completion of the topographic features study and relate this to the development of biological stipulations for the protection of these potentially sensitive submarine banks. The recently completed report "Reefs and Banks of the Northwestern Gulf of Mexico: Their Geological, Biological, and Physical Dynamics" marked the synthesis of nine years of descriptive reconnaissance of these features and was largely sponsored through the Bureau of Land Management's Outer Continental Shelf (OCS) Environmental Studies Program.

As early as 1973, public hearings associated with the first Texas OCS lease sale indicated that there was considerable concern over these potentially sensitive submarine banks. Although it was known there were such features, their location, numbers, and community dynamics were obscure. As a result, the first topographic features study was initiated in 1974 through contract with Texas A&M University. This multidisciplinary program extended for nine years. It included the mapping and geological surveys of 36 banks, biological reconnaissance of 27 of these banks, and description of suspended sediment and current movement about the features. An extensive monitoring program emphasized the East and West Flower Garden Banks. Results of these efforts served as a basis for formulating biological lease stipulations protecting the banks from potential oil and gas exploration and development activities.

Presentations during this session were structured to give an overview of the topographic features studies series and concluded with a discussion of biological stipulations presently in effect. The three principal investigators on the project, Drs. Richard Rezak, Tom Bright, and David McGrail were scheduled to discuss the geology, biology, and current movements of the banks. Unfortunately, Dr. McGrail was detained by previous obligations; Dr. Rezak gave a brief overview of his work. Mr. Charles Hill of MMS discussed the lease stipulations.

Topographic features may be classified into categories based on their general location on the continental shelf and the nature of their geological structure. Details of their geology and biology can further differentiate them into groups by their similar attributes.

RECOMMENDATIONS

Drs. Rezak and Bright agreed that two measures should be implemented for the future protection of the Flower Garden Banks:

(1) The "No Activity Zone" at the East Flower Garden should be returned to the previously stipulated 100 m contour. Recent changes in this biological lease stipulation to an 85 m contour at the High Island, East Addition, South Extension, lease block A-375 are not in accord with recent findings. The release of muds and cuttings at this height on the bank could have potentially deleterious effects on the reef building zones of the bank especially the Algal-Sponge Zone.

(2) The Flower Garden banks should be protected from anchor damage by regulations preventing tankers from anchoring on the banks. Side scan records document the severe mechanical damage produced by the anchoring of large vessels. Efforts to promulgate such regulations through various agencies and thereby indicate such restrictions on navigation charts have thus far proved futile.

NORTHWESTERN GULF OF MEXICO TOPOGRAPHIC FEATURES: THEIR GEOLOGICAL, BIOLOGICAL, AND PHYSICAL DYNAMICS

Drs. Richard Rezak, Thomas Bright, David McGrail
Department of Oceanography, Texas A&M University

SYSTEM OF CLASSIFICATION

Geological categorization is based upon structural expression; that is, did the bank or reef develop on relatively undisturbed strata, like the banks off South Texas, or did it grow on a diapiric structure, like the banks off East Texas and Louisiana? A further subdivision may be made on the basis of the nature of the structure underlying the bank. Is the structure that which we normally associate with salt diapirs or is the stucture inherited from early Jurassic and Triassic tectonic features? The nature of the substrate is also involved in the categorization. Is the substrate made up of bedded Mesozoic and/or Cenozoic sandstones, siltstones, or claystones? Or is the substrate a carbonate cap (reef) that totally conceals the original bedrock substrate? Based on these considerations, the geological classification of the banks identifies two categories: midshelf bedrock banks, and other shelf bedrock banks with carbonate reef caps.

The most appropriate means of categorizing the banks biologically involves recognition of a number of distinct benthic biotic zones characteristic of hard banks in the northwestern Gulf of Mexico, with an indication of the banks on which each zone occurs, and the depth range of each zone on each bank. Seven characteristic benthic biotic zones have been identified. These are classified within four general categories, depending on degree of reef-building activity and primary production as follows:

A. Zones of Major Reef-Building Activity and Primary Production.

I. Diploria-Montastrea-Porites Zone: A zone consisting of living, high-diversity coral reefs. Hermatypic corals dominant. Coralline algae abundant. Leafy algae limited.

II. Madracis Zone and Leafy Algae Zone: The Madracis Zone is dominated by the small branching coral Madracis mirabilis, which produces large amounts of carbonate sediment. In places, large (possibly ephemeral) populations of leafy algae dominate the Madracis gravel substratum (Leafy Algae Zone).

III. Stephanocoenia-Millepora Zone: A zone consisting of living, low diversity coral reefs. Hermatypic corals dominant. Coralline algae abundant. Leafy algae limited.

IV. Algal-Sponge Zone: A zone dominated by crustose coralline algae actively producing large quantities of carbonate substratum, including algal nodules. The zone extends downward, past the depth at which algal nodules diminish in abundance, to the greatest depth at which coralline algal crusts are known to cover a substantial percentage of the hard substratum. This is the largest of the reef-building zones in terms of area of sea bottom. Leafy algae are very abundant.

B. Zone of Minor Reef-Building Activity.

V. Millepora-Sponge Zone: A zone where crusts of the hydrozoan coral Millepora share the tops of siltstone, claystone, or sandstone outcrops with sponges and other epifauna. Isolated scleractinian coral heads may be present, but rare. Coralline algae are rare.

C. Transitional Zones Wherein Reef-Building Activity May Range from Minor to Negligible.

VI. Antipatharian Zone: Limited crusts of coralline algae and several species of coral exist within a zone typified by sizeable populations of antipatharians. Banks supporting Algal-Sponge Zone (A, IV above) generally possess something comparable to an Antipatharian Zone as a "transition" between the Algal-Sponge Zone and the deeper, turbid-water, Nepheloid Zone of the lower bank.

D. Zone of No Reef-Building Activity.

VII. Nepheloid Zone: A zone wherein high turbidity, sedimentation, resuspension of sediments, and resedimentation dominate. Rocks and drowned reefs here are generally covered with veneers of fine sediment. Epifauna are depauperate and variable; deep-water octocorals and solitary stony corals are often conspicuous. This zone occurs in some form on lower parts of all banks below the depths of the Antipatharian or Transitional Zones.

This scheme does not represent a final word on benthic zonation on hard banks in the northwestern Gulf of Mexico. The supposed "Antipatharian Zone" and "Nepheloid Zone" are particularly problematic and may not be valid designations in the biological sense. Each surely represents several biotic assemblages of superficial similarity which could all ultimately be given separate zonal designations. No single bank off Texas-Louisiana possesses all of the zones indicated above, though the East and West Flower Garden Banks lack only the Millepora-Sponge Zone. The two Flower Garden Banks harbor the most diverse and thoroughly developed offshore hard-bottom epibenthic communities in the region. They differ from other shelf-edge carbonate banks primarily in the degree of development of coral reefs. High diversity coral reefs (Diploria-Montastrea-Porites Zone) are not present on any other northern Gulf banks. Lower diversity coral reefs (Stephanocoenia-Millepora Zone) are present at the Flower Gardens and also at two other shelf-edge banks, 18 Fathom and Bright.

The *Millepora*-Sponge Zone, occupying depths comparable to the *Diploria-Montastrea-Porites* Zone, is characteristic of the Tertiary bedrock substrata of the Texas-Louisiana midshelf banks. Interestingly, the zone is present on one shelf-edge carbonate bank (Geyer) but only on a bedrock prominence at the bank's crest.

Upper parts of the relict Pleistocene carbonate reefs of the South Texas midshelf banks and certain midshelf carbonate banks off North Texas and Louisiana are occupied by benthic assemblages comparable to those of the supposed Antipatharian Zone found at somewhat greater depths on the north Texas-Louisiana shelf-edge carbonate banks.

Thus, the basic geological categories of northwestern Gulf OCS banks are also broadly distinguishable from one another in terms of benthic community structure. The biotic differences between bank types are probably explicable in terms of lateral and depth-related variations in substratum type, water temperature, turbidity, and sedimentation.

SOUTH TEXAS RELICT CARBONATE SHELF REEFS

Geology

A line drawn from Matagorda Bay to the shelf break divides the Texas continental shelf into an area of drowned reefs on a relict carbonate shelf and an area of banks situated on salt diapirs.

There is no doubt that the banks on the South Texas shelf are drowned coralgal reefs. Rock dredging by the U.S. Geological Survey and Texas A&M University recovered coralline material from Southern Bank and samples of dead coral from Dream Bank. Radiocarbon (C^{14}) dating yielded ages of 18,000 and 10,580 years B.P., respectively. These banks are dead reefs that were living close to a Late Pleistocene to Early Holocene shoreline.

NORTH TEXAS-LOUISIANA REEFS AND BANKS ON DIAPIRIC STRUCTURES

Midshelf Banks

Midshelf banks are defined as banks rising from depths of 80 m or less and having a relief of 15 m to about 50 m. Banks on the North Texas-Louisiana shelf that fall into this category are Stetson, Claypile, Coffee Lump, Sonnier, and Fishnet. These banks are similar to each other in that they are all associated with salt diapirs and are outcrops of relatively bare, bedded Tertiary limestones, sandstones, claystones, and siltstones.

Shelf-Edge Carbonate Banks and Reefs

The shelf-edge carbonate banks and reefs are located on complex diapiric structures. Although all of the shelf-edge banks have well developed carbonate caps, there are local areas of bare bedded rocks exposed by recent faulting.

Structural Geology

Complexity and variety of a structural style in the banks are due to a number of factors, the most important of which are: 1) the regional stress field; 2) the shape of the dome (circular or elliptical); and 3) structures inherited from Late Triassic to Early Jurassic tectonics.

The influences of outline shape and regional strain on salt dome fault patterns have been amply demonstrated by Withjack and Scheiner (1982), using both experimental and analytical models. They found that circular domes in the absence of regional stresses developed radial fault patterns such as those observed on some of the banks studied. With regional extension, most normal faults on the crests of circular domes trend in a direction perpendicular to the direction of regional extension. Diaphus Bank is a good example of this kind of fracture patten. Diaphus lies close to the shelf edge. The major fault on the bank parallels the shelf edge.

With elliptical domes not involved with external stresses, the pattern of normal faults roughly parallels the long axis of the ellipse, but the faults splay outwards towards the ends of the long axis. With regional extension the normal faults trend perpendicular to the regional extension direction.

Unfortunately, few domes are perfectly circular or elliptical. The shapes of domes may be strongly controlled by pre-existing regional structures. The strongest evidence for the control of shape by pre-existing structures is Rezak-Sidner Bank. Its structure is a rectangular block bounded by normal faults on three sides and an east-facing fault scarp with a displacement of at least 130 m. Trippett and Berryhill (1982) show this bank to be a part of a northwest-southeast trending series of banks formed by a ridge of salt at depth. Many of the banks on the shelf break and the upper slope appear to be parts of complex salt ridges with arcuate patterns. We have demonstrated that the East Flower Garden is located at the intersection of two salt ridges, and that the non-reflective area at the West Flower Garden Bank is linear rather than circular. Geyer and Elvers Banks are also situated on arcuate bathymetric prominences. Their non-reflective cores are also linear rather than circular. The linearity of these cores must be due to the presence of pre-intrusion zones of weakness along which the salt was intruded. These zones of weakness might be joints or fault systems inherited from pre-salt tectonic features. Many of the banks on the upper slope and outer shelf are complicated due to regional extension. Parallel normal faulting, oriented at right angles to the regional extension direction, is common on the East Flower Garden, West Flower Garden, and Geyer Banks. At the East Flower Garden the faulting does not parallel the crests of the intersecting salt ridges but is nearly parallel to the shelf break. At the West Flower Garden and Geyer Banks the faulting is more complex. Some faults parallel the shelf break and some parallel the salt ridge crest.

Consequently, the patterns of faulting will vary depending upon the developmental history of a salt diapir. Those diapirs that are not associated with pre-injection tectonic features will be circular or elliptical in plain view. Those that are associated with pre-injection tectonic features will assume the pattern of those features. These two forms are extreme end members in a spectrum of structural styles that lies between them. These styles are controlled by the history of changes in the regional stress field at a given location on the shelf or slope.

ENVIRONMENTAL CONTROLS

Based on the nature, distribution and degree of development of their epibenthic communities, hard-banks on the Texas-Louisiana Outer Continental Shelf can be divided into five environmental groups as follows:

1. South Texas midshelf relict Pleistocene carbonate reefs bearing turbidity-tolerant Antipatharian Zones and Nepheloid Zones (surrounding depths of 60 to 80 m; crests 56 to 70 m).

2. North Texas-Louisiana midshelf Tertiary outcrop banks bearing clear water, Millepora-Sponge Zones and turbid water-tolerant Nepheloid Zones (surrounding depths of 50 to 62 m; crests 18 to 40m).

3. North Texas-Louisiana midshelf banks bearing turbidity-tolerant assemblages approximating the Antipatharian Zone (surrounding depths of 65 to 78 m; crests 52 to 66 m).

4. North Texas-Louisiana shelf-edge carbonate banks bearing clear-water coral reefs and Algal-Sponge Zones, transitional assemblages approximating the Antipatharian Zone, and Nepheloid Zones (surrounding depths of 84 to 200 m; crests 15 to 75 m).

5. Eastern Louisiana shelf-edge carbonate banks bearing poorly developed elements of the Algal-Sponge Zone, transitional Antipatharian Zone assemblages, and Nepheloid Zones (surrounding depths of 100 to 110 m; crests 67 to 73m).

The clear-water biotic zones on these banks (_Millepora_-Sponge Zone, several coral reef zones, and Algal-Sponge Zone) are distinctly tropical in faunal and floral content. Biota of the Antipatharian and related transitional zones are largely composed of tropical species apparently more tolerant of turbidity. Environmental factors which can be correlated with and probably control regional patterns of community structure, distribution, abundance, and zonation of tropical epibenthos in the northwestern Gulf are distance from shore, regional patterns of substratum type, bottom depth, bank relief, water temperature, salinity, river runoff, turbidity, sedimentation, currents, and seasonal variation in the last six of these.

Conditions at the shelf edge near and beyond the 80 m depth contour on the broad North Texas-Louisiana shelf west of about 91° longitude are favorable for development of tropical reef communities. Current patterns are such that shelf-edge waters come primarily from the southwest and are oceanic, with little admixture of neritic water from the Texas-Louisiana shelf. These currents carry larvae, spores,and juveniles from the Gulf of Campeche, the Yucatan shelf, and the Caribbean.

There is a strong tendency for coastal water masses, highly influenced by outflow from the Mississippi and other rivers in Louisiana and North Texas, to be held onshore and shunted west most of the year (particularly during February to May periods of peak runoff) by the general shelf circulation pattern. As a result, turbidity in the shelf-edge waters is usually nil, and salinity averages 36 ppt. Where high runoff combines with seasonal disruption of the typical counterclockwise current regime on the shelf (such as may occur in late spring or early summer), lower salinities may occur in shelf-edge waters; however, the lowest surface salinity we have ever measured at the Flower Gardens was 32 ppt, and this was accompanied by 34 ppt at 25 m depth.

For most of the year, near-surface water temperatures throughout the Gulf are tropical to sub-tropical (27°to 30 °C). However, near shore in the northern Gulf, temperatures become warm-temperate from December through March. During the coldest months (January to February) temperatures grade from as low as 10°C in the estuaries to 18°C on the outer shelf edge.

Onshore-offshore seasonal movements of the 18° and 16°C surface isotherms probably have very significant influences on distribution of tropical reef biota in the northwestern Gulf. The minimum seasonal temperature limit for vigorous growth of coral reefs is considered to be 18°C. The lower limit, 16° C, is stressful for most reef-building corals. Though reef-building coralline algae and other biotic elements of the tropical reef ecosystem may tolerate somewhat lower temperatures, 16°C is probably near the bottom of their optimal range.

In the northwestern Gulf, the 18°C winter surface isotherm can be expected to occur somewhere between the locations of the 30 and 80 m depth contours, projected upward. The 16°C isotherm occurs between the 20 and 40 m depth contour. The surface isothermal layer during winter extends 50 to 75 m downward, with temperatures only 1° to 3°C less at 100 m. Thus, above 50 m depth off North Texas and Louisiana, and seaward of the general 80 m bottom depth contour, salinities are high and temperatures range annually from approximately 18° to 30°C (Figure 19). Where suitable hard substratum exists in the absence of chronically turbid water, conditions on this part of the shelf are favorable for the growth of tropical reef communities dominated by corals or coralline algae, or both. The degree of light penetration into clear surface waters, and the antagonistic effects of turbidity in bottom nepheloid layers are almost certainly the factors controlling depth ranges for these communities on the various shelf-edge banks. High turbidity decreases light penetration and is therefore inimical to the development of coral and algal reef communities. Sedimentation associated with high turbidity results in smothering of encrusting epibenthos by veneers of silt and clay. Due to the enormous sediment load entering from the rivers, turbidity and sedimentation are major factors limiting development of tropical reef assemblages. It is speculated that reef development at Sackett Bank (Algal-Sponge Zone) is seriously attenuated, due in part to increased turbidity in surface waters from admixed Mississippi River outflow. This influence, accompanied by somewhat reduced salinities, diminishes westward but may extend as far as Diaphus Bank (91°W) during periods of particularly high runoff.

Mid-Shelf banks (Mysterious to Fishnet) arise from surrounding depths of 60 to 80 m. Their tops, which support Antipatharian Zone type assemblages between 56 and 73 m, exist within a depth range which on shelf-edge banks (Flower Gardens to Elvers) is occupied by diverse, clear-water Algal-Sponge Zones. The lack of Algal-Sponge Zones on the midshelf banks, and the occurrence instead of Antipatharian assemblages which are typically found in deeper water at the shelf edge is probably due largely to high turbidity.

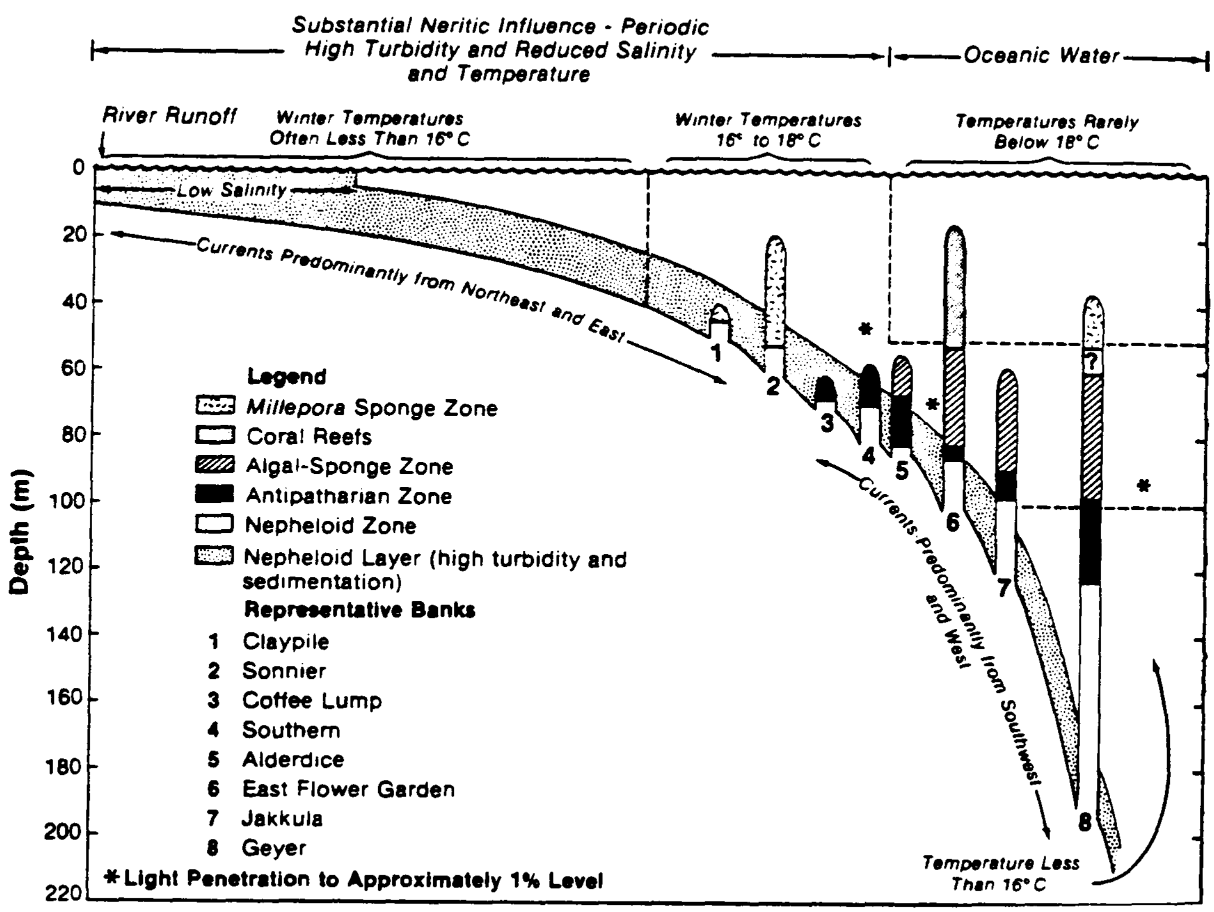

Figure 19. Comparison of Biotic Zones to Temperature, Salinity, Turbidity, and Light Differences at Selected Banks.

The effects of bottom nepheloid layers and associated sedimentation are certainly more pronounced on the midshelf banks than at the shelf-edge banks. We speculate that most or all of the midshelf banks are frequently totally covered by the nepheloid layer, especially during severe wave conditions. At the Flower Garden Banks, a substantial nepheloid layer has not been observed shallower than about 80 m, and usually the water is fairly clear even at that depth. Fine, terrestrial sediments are not found on shelf-edge carbonate banks above the lower limit of their Algal-Sponge Zones. The midshelf banks, however, are generally coated with thin to thick layers of fine sediment, presumably derived from nepheloid layers.

Relief above the surrounding bottom is of considerable importance in alleviating the negative impacts of bottom nepheloid layers and attendant sedimentation on the development of epibenthos. An Algal-Sponge Zone probably will not become established on banks which have less than about 15 m relief above a mud bottom due to the impact of nepheloid layers. At Alderdice Bank, the Algal-Sponge Zone extends downward to only 67 m, which is 17 m above the surrounding mud. Farther offshore, at the East Flower Garden, the Algal-Sponge Zone extends downward to 82 m, about 18 m above the surrounding soft bottom. In even deeper water where surrounding depths are over 180 m (Geyer and Elvers Banks), the vertical extent of the Algal-Sponge Zone is not limited by bottom nepheloid layers because of the high relief. Here, the zone extends down to over 95 m depth.

Thus, on the shelf-edge banks, there is a gradual increase in the maximum depth of expression of coralline algae-dominated communities with increasing surrounding depth. A similar trend is apparent for the Antipatharian Zones on these banks. These observations imply that the bottom nepheloid layers are of great importance as ecological limiting factors on the lower 15 to 20 m of the banks.

Thus, the deeper clear-water reefal communities (Algal-Sponge Zones) are excluded from the midshelf carbonate banks by winter low temperatures, high turbidity, reduced light, and sedimentation. They are limited in downward extent on some of the shelf-edge banks by the effects of nepheloid layers. In their place is a less diverse and less abundant "Antipatharian Zone" assemblage made up of epibenthic forms which, though basically tropical in origin, are tolerant of the stresses imposed.

Hard substratum exists within suitable depths for coral reef development in the form of midshelf claystone-siltstone banks arising from surrounding depths of 52 m and extending upward to 18 m (Sonnier Bank) and 20 m (Stetson). The Millepora-Sponge Zones of these banks are undoubtedly subject to seasonal temperatures somewhat less than the 18°C minimum for vigorous reef growth, but probably not much less than 16°C.

The crests of Stetson and Sonnier Banks may, however, be fairly well isolated from the effects of bottom nepheloid layers due to their relief (40 to 42 m) above the surrounding mud bottom. The other midshelf claystone-siltstone bank, Claypile, with only 10 m relief, is certainly often covered by the nepheloid layer. Consequently, the abundance of dominant epibenthos is least at Claypile (lowest relief) and greatest at Sonnier (highest relief).

Speculation on environmental factors governing the development of the Millepora-Sponge Zone is complicated by the fact that the zone also occurs on shelf-edge bedrock outcrops, protruding from the crest of Geyer Bank between 37 and 52 m depth. The implication here is that development of this zone is dependent upon the presence of newly exposed bedrock outcrops, and vigorous development of the biota is favored by clear water and winter minimum temperatures above 16°C.

The question is why have tropical coral reefs not developed on the claystone-siltstone outcrops on Geyer Bank, which are exposed to the same oceanic conditions as are the coral reefs at the Flower Garden Banks? Hypothetically, the claystone, which is very soft and disintegrates readily upon exposure to water, may be unsuitable substratum for most reef-building corals. Indeed, the epifauna inhabiting the Millepora-Sponge Zone obviously "prefer" the thin beds of rock-hard siltstone which protrude from the softer but more extensive claystone on these outcrops. One can imagine a faunal succession on shelf-edge banks which results in 1) recruitment of reproductively prolific hydrozoan corals (Millepora) to exposed, hard siltstone beds; 2) spreading of these to adjacent claystone to create a carbonate veneer over the outcrop; 3) partial mortality of Millepora and subsequent recruitment of anthozoan hermatypic corals on the carbonate skeletal crust; 4) crowding out of the hydrozoan corals by the more competitive anthozoans; resulting in 5) transformation to a tropical coral reef.

Correlations exist between regional patterns of winter temperature, turbidity, and light penetration in shelf waters and distribution patterns of the recognized biotic zones on Outer Continental Shelf banks. Coral reefs are restricted to clear oceanic water where temperatures rarely drop below 18 °C. Most of the other bank zones may experience lowest winter temperatures of around 16 °C. Neritic seasonal variability in temperature and salinity is greatest along the coast and diminishes offshore to roughly the 80 to 85 m depth contour, beyond which more stable, oceanic conditions predominate. Neritic influences on the midshelf are greatest in the upper 10 m of the water column. Deep tropical reef zones dominated by coralline algae are restricted to the clear, oceanic, shelf-edge waters beyond the 85 m depth contour. Neritic influences extending to the edge of the narrow shelf off the Mississippi Delta limit reefal development on nearby banks.

Chronic turbidity of bottom water (nepheloid layers) and associated sedimentation severely limit epibenthos on the lower 15 to 20 m of most banks. Vigorous reef development is restricted to those parts of banks well above the effects of nepheloid layers. Continual turbidity and sedimentation on low relief banks substantially reduces diversity and abundance of the assemblages present. Penetration of sunlight into the water decreases toward shore due to generally increasing turbidity. This, combined with the light blocking and smothering effects of bottom nepheloid layers and suspended sediment around the bases of the banks, tends to "displace" zones upward on the banks closer to shore.

AN OVERVIEW OF BIOLOGICAL LEASE STIPULATIONS

Charles Hill
MMS, Gulf of Mexico Region

In the Central and Western Gulf, certain biological stipulations are applied to leases for regions on and near topographic features. These banks have been mapped and studied through the previously discussed studies program. The stipulations are founded on the basis that at similar depths, banks in similar hydrographic and sedimentary conditions show similar biological communities. Therefore, stipulations provide for a "No Activity Zone" based on depth, within the 85 m isobath at most banks. In most cases there is a "1-mile zone" within which all discharges must be shunted through a pipe to within 10 m of the bottom, and a "3-mile zone" in which the lessee has the option of shunting or monitoring the impacts of the drilling operations on the bank communities.

These stipulations are more stringent at the East and West Flower Gardens. The "No Activity Zone" is within the 100 m contour; shunting and monitoring are required within the "1-mile zone"; and shunting is also required within a "4-mile zone," rather than the "three-mile zone."

In the eastern Gulf the biologically significant areas tend to be of low relief and patchy in distribution. Thus, lease stipulations require the lessee to determine if there are any "live-bottom" areas near any proposed drilling activities. These stipulations were discussed in more detail in the afternoon session of "Biological Lease Stipulations."

Part II: Rig Monitoring Studies

SESSION OVERVIEW

Mr. Les Dauterive
MMS, Gulf of Mexico Region

The objective of this session was to present an overview of Rig Monitoring Programs and Studies on the Outer Continental Shelf in the Gulf of Mexico Region, Atlantic Region and Pacific Region.

In the Gulf of Mexico, Lease Stipulated Fate and Effects Monitoring Programs date back to 1975. Sixteen such programs have been completed to date and five programs are in various stages of development and/or completion. Stipulated rig monitoring has occurred around 8 of the 30-odd Topographic High Features determined by the Minerals Management Service to be biologically unique and environmentally sensitive.

Dr. Richard Defenbaugh presented the results of two rig monitoring studies in the nothern Gulf of Mexico. The studies, designed as components of large baseline studies, were conducted to assess the environmental impacts of exploration drilling on the marine environment.

Dr. Jerry M. Neff reported on the Georges Bank Benthic Monitoring Program. The objective of the program was to determine the fate of discharges from exploration drilling in Lease Area 42 and to assess the effects of these discharges on benthic species and communities of Georges Bank and potential depositional areas of drilling fluids and cutting in submarine canyons and the OCS south of eastern New England.

Mr. Dick Wilhelmsen reported on a series of long-term monitoring studies in the western Santa Barbara Channel and on the Santa Maria Shelf, offshore California. These studies are being planned in areas where several major OCS oil discoveries have been made in the past few years and in a major new area for OCS oil and gas development off the California coast.

Dr. Donald F. Boesch presented a critique of Design of Rig Monitoring Studies. In his critique Dr. Boesch identified items for emphasis and de-emphasis for understanding environmental effects of OCS oil and gas drilling-related discharges.

Dr. James P. Ray presented an overview of Rig Monitoring Studies from the Petroleum Industry Perspective. Dr. Ray identified and discussed some inherent problems of previous studies and ways to improve the approach and application of rig monitoring studies in the future.

Dr. Paul N. Boothe presented findings of the American Petroleum Institute study of near-rig sediments as six drilling sites in the Gulf of Mexico. The goal of the study was to characterize surface and subsurface sediments within 500 meters of 6 offshore drilling sites in the northwestern Gulf of Mexico.

Dr. Thomas W. Duke presented data obtained by participants of the U.S. Environmental Protection Agency's cooperative research program on the toxicity of spent drilling fluids from the Gulf of Mexico on selected marine oganisms.

Dr. Donald F. Boesch gave the findings of the National Research Council's Study of Drilling Fluids and Cuttings in the Marine Environment. The study suggested, among other things, that research emphasis be based on the broader topics of accumulation and transfer of materials and ecosystem response and that extensive research specifically focused on the fate and effects of drilling fluids is not needed.

GULF OF MEXICO LEASE STIPULATED RIG MONITORING

Les Dauterive
MMS, Gulf of Mexico Regional Office

In the Gulf of Mexico, Lease Stipulated Rig Monitoring has been a requirement on lease blocks surrounding certain topographic highs since 1973. The purpose of the requirement is to determine the fate of drilling discharges and the effects of such discharges on biological communities associated with the topographic highs identified by the Minerals Management Service as biologically unique and sensitive.

Rig monitoring in addition to shunting is required of all drilling discharges that occur within 1 nautical mile of the no-activity zone established for the East and West Flower Garden Banks, and is an optional requirement for drilling discharges that occur beyond 1 nautical mile but within 3 nautical miles of the no-activity Zone established for the clear water shelf break banks. Shunting, a method of diverting the discharge to within 10 meters of the seafloor, has been demonstrated as an effective means of preventing the drilling discharges from impinging on the shallow clear water zone of a topographic high. As an alternative to shunting, the lessee (operator) must demonstrate by monitoring that his non-shunted discharge is not impacting the biological communities of the topographic high for which the monitoring requirement is being applied. The results of a monitoring effort are used by the Minerals Management Service to determine shunting or monitoring requirements of subsequent drilling operations.

As a result of the Topographic High Features Studies Program, 36 features have been geologically mapped and 27 features have been biologically characterized. Eight of these Topographic High Features have had some level of fate or fate and effects monitoring application. These features shown on Figure 20 are:

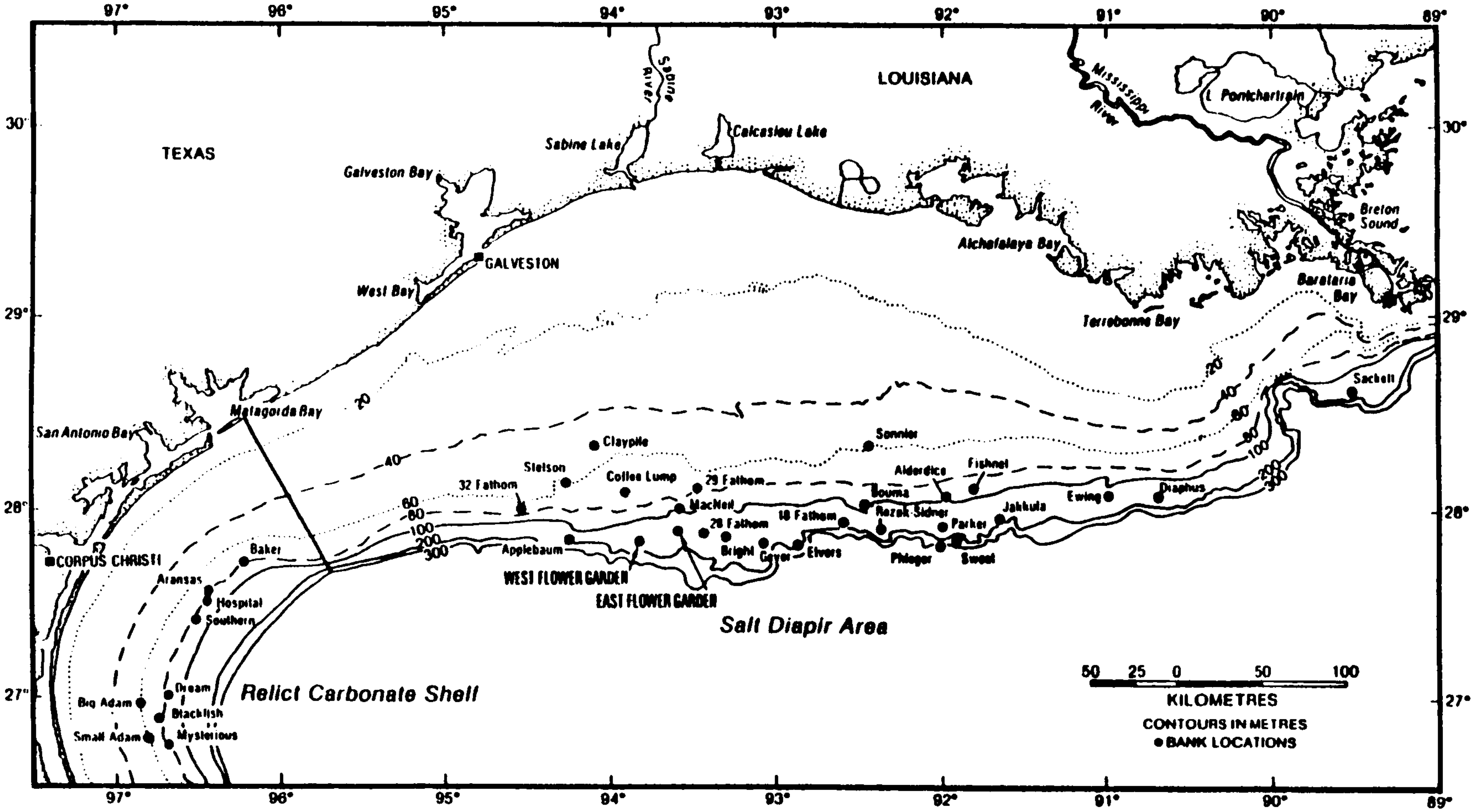

Figure 20. Sites in the Topographic High Features Studies Program

The East Flower Garden Bank
The West Flower Garden Bank
Stetson Bank
29 Fathom Bank
Bouma Bank
Alderdice Bank
Baker Bank
Southern Bank

A total of 15 Rig Monitoring Programs dating back to 1975 have been completed, and 6 such programs are in various stages of development and/or completion.

General conclusions germane to completed rig monitoring programs are as follows:

1. The heavier discharge fraction (drill cuttings) is deposited in the immediate area of the drillsite presenting an impact to the seafloor biota.
2. The less dense fraction (drilling muds) is quickly diluted and dispersed in the water column, presenting no significant impacts to the water column and associated biota.
3. No deleterious effects to the biological communities of the topographic high feature being monitored were observed.

SUMMARY OF BUREAU OF LAND MANAGEMENT/MINERALS MANAGEMENT SERVICE EXPLORATORY RIG MONITORING STUDIES IN THE GULF OF MEXICO

Dr. Richard Defenbaugh
MMS, Gulf of Mexico Regional Office

To date, two studies have been conducted under funding from the Bureau of Land Management (BLM) to assess the environmental impacts of routine exploratory drilling operations on the marine environment of the northern Gulf of Mexico. These two studies were performed during the years 1975-1977; the first of the two studies was performed by the Florida State University System's Institute of Oceanography (SUSIO, 1977), while the second was performed by the Port Aransas Laboratory of the University of Texas' Marine Science Institute, in collaboration with investigators from Texas A&M University, Rice University, and U.S. Geological Survey (UTMSI, 1977).

Each of these studies was designed as a component of the large baseline studies being conducted at the time in the eastern Gulf ("MAFLA" area of Mississippi, Alabama, Florida) and in the western Gulf (the "South Texas OCS" area), and each was to include roughly parallel studies of exploratory drilling operations in the eastern and western Gulf. However, during the contract period there was no drilling activity in the eastern Gulf, so both studies were conducted in the western Gulf, roughly off Corpus Christi, Texas. Sampling designs for the two studies were similar, based on sampling at fixed stations along transects radiating from the drill site. Sampling efforts differed somewhat, in that the SUSIO study included a major benthic sampling effort by SCUBA divers, while the UTMSI study depended solely on sampling from shipboard using grabs, trawls, etc. Relevant study design and site information is presented in Table 6:

TABLE 6: COMPARISON OF "MAFLA" AND "SOUTH TEXAS" STUDIES

	"MAFLA" Study	"South Texas" Study
Drillsite location	27 37'N x 96 58'W (Mustang Island, Block 792)	27 44'N x 96 43'W (Mustang Island, Block 755)
Water depth at drill site	24 m	33 m
Sampling station distances from drill site	0,100,500,1000m	0,100,500,1000,2000m
Sampling periods:		
pre-drilling	November 1975	September 1976
during drilling	January 1976	January 1977
post-drilling	March 1976	February 1984
Parameters studied	Standard sedimentology Clay mineralogy Dissolved LMW-hydrocarbons HMW-hydrocarbons in sediments HMW-hydrocarbons in biota Trace metals in sediments Trace metals in epifauna Histopathology	Salinity, temperature/depth Transmissometry Currents Dissolved LMW-hydrocarbons in water column Particulate trace metals in water column Suspended sedimentology Sediment deposition Sediment texture HMW-hydrocarbons in sediments Trace metals in sediments Meiofauna Macroinfauna Macroepifauna Demersal fishes HMW-hydrocarbons in macroinfauna and fishes Trace metals in macroinfauna and fishes

Significant findings for the MAFLA exploratory rig monitoring study included the following:

- Drill cuttings were observed in the benthic sediments after drilling was completed.

- Some changes in sediment texture/mineralogy were observed, although these may have been due to winter storms which passed through the area.

- High-molecular-weight (HMW) hydrocarbons in the sediments were variable, with the variations not associated with drilling activities or station locations.

- A large high-molecular-weight unresolved complex mixture was observed in sediments, indicative of previous petroleum contamination in the area, probably due to marine transportation.

- Low-molecular-weight (LMW) hydrocarbons in the water column were present, but were attributed to an algal source.

- Post-drilling analyses for high-molecular-weight hydrocarbons in sediments did not indicate any contamination due to drilling activities.

- Post-drilling samples of a penaeid shrimp were contaminated with a petrogenic hydrocarbon, but this was attributed to contamination with fuel oil at the air-sea interface during trawl sample collection.

- An increase in barium in benthic sediments during and after drilling was noted, with the concentration apparently related to distance from the drill site and direction of tidal flow. No trends for other trace metals were noted, however. Concentrations of barium were elevated in an irregularly shaped area which extended to 1000 m from the drill site for the "during-drilling" phase of the study, but the area of high barium contamination receeded to an area less than 500 m from the drill-site for the "post-drilling" phase.

- Foraminiferal communities were typical of stressed environments, throughout the entire study.

- Significant changes noted in the study could not be attributed in toto to drilling operations. The environmental effects which were linked to drilling operations included the post-drilling presence of drill cuttings and increased barium concentrations in benthic sediments, and additional stress on already stressed foraminiferal populations.

  All other effects were attributed to storms and a stressed, but normal environment.

Significant findings for the South Texas exploratory rig monitoring study included the following:

- No significant variations were observed in low-molecular-weight hydrocarbons dissolved in the water column.

- Increases in montmorillonite, a clay mineral, and lead, zinc, barium, and cadmium occurred at the drill site only, following completion of drilling activities.

- There was no evidence of oil contamination to the benthic sediments, based on analyses of high-molecular-weight hydrocarbons in the sediments. One sample from the drill site which showed presence of oil may have been contaminated during the drilling activity, or may have been a drill cutting from oil-bearing ancient shales.

- No meaningful effects were observed from analyses of sediment textures. Observed variations were attributed to sampling procedures, analytic variability, natural variability, or drilling operations.

- Benthic communities were diminished at the drill site, but showed only normal seasonal variations at other stations.

- Oil found in tissues of shrimp and fishes was problematical, since no oil was produced during this exploratory drilling operation, and since all species were highly motile.

- The area of discernible impact was less than 100 m radius from the drill site.

Our overall conclusion, based on the results of these two studies and other information presently available is that when exploratory drilling occurs on the level, soft-bottom habitats of the northwestern Gulf of Mexico, it poses no significant threat either to the environment or to the biological resources of the area.

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THE GEORGES BANK BENTHIC MONITORING PROGRAM: THE FIRST TWO YEARS

Jerry M. Neff
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PURPOSE AND SCOPE OF THE PROGRAM

The major environmental concerns resulting from exploration and development activities for oil and gas on Georges Bank are that intentional discharges of materials (mainly drilling fluids and cuttings) from oil platforms during normal exploratory and development activities may damage the Georges Bank environment, particularly animals living on or in the bottom sediments, upon which commercial fisheries species depend for food. If commercial quantities of oil or gas are found, a major concern during the development and production phases of the Georges Bank field is that accidental spills of crude oil and operational discharges of petroleum hydrocarbon-laden produced water will harm the marine biota, and particularly the floating or pelagic eggs and larvae of commercial fishery species. Other concerns relate to increased ship traffic over the Bank, disruption of the bottom by pipelines, anchors and rig structures, and disturbances of migrating and feeding whales by noise and surface pollution.

The Georges Bank Monitoring Program was designed to address the concerns related to the initial exploratory phase of Georges Bank development. Specifically, the objectives of the Program are to determine the fate of discharges (primarily drilling fluids and cuttings) from exploratory drilling platforms in Lease Area 42 and to assess the effects of these discharges on benthic species and communities of Georges Bank and potential depositional areas for drilling fluids and cuttings in submarine canyons and the Outer Continental Shelf south of eastern New England. The accumulation and distribution of drilling fluid-associated metals, in particular barium and chromium, in bottom sediments in the vicinity of exploratory activities is being used to trace the patterns and quantities of drilling fluid deposition around and downcurrent from drillings rigs. This research is being performed by the U.S. Geological Survey, Woods Hole, Massachusetts (Bothner et al., 1982, 1983). Concentrations of several metals are being analyzed in selected species of bottom-living fish and shellfish, and possible petroleum hydrocarbon contamination of bottom sediments and marine animals of Georges Bank is being investigated by Science Applications, Inc. (Payne et al., 1982, 1983) in a further effort to determine if drilling activities are resulting in contamination of the Georges Bank environment. The major portion of the Monitoring Program is being performed by Battelle New England Marine Research Laboratory and Woods Hole Oceanographic Institution and addresses the question of whether populations of animals living in the bottom sediments (benthic infauna) change in selected regions of the southern Georges Bank and southwestward (downcurrent) along the southern New England Outer Continental Shelf, including Lydonia and Oceanographer Canyons, during various stages of oil and gas exploratory activity in Lease Area 42, and whether these changes can be related to observed changes in the concentrations in the benthic environment of pollutant materials discharged from exploratory platforms (Battelle-Woods Hole, 1983, 1984).

PROGRAM DESIGN AND IMPLEMENTATION

The Benthic Infauna Monitoring Program was designed to determine both the near-field short-term and the regional long-term environmental impacts of oil exploration activities in Lease Area 42. A total of 46 stations were established on and adjacent to Georges Bank. These were of two types. A group of long-term regional stations was established to assess long-term and widespread impacts of drilling activities (Figure 21). Benthic infaunal distributions on the southern flank of the Bank are determined largely by water depth and sediment characteristics. Therefore, three transects of three stations each were established perpendicular to the local depth profiles, approximately in a north-south direction. The three stations on each transect were located at depths of approximately 60, 80, and 100 meters. Because the net movement of water currents over the southern

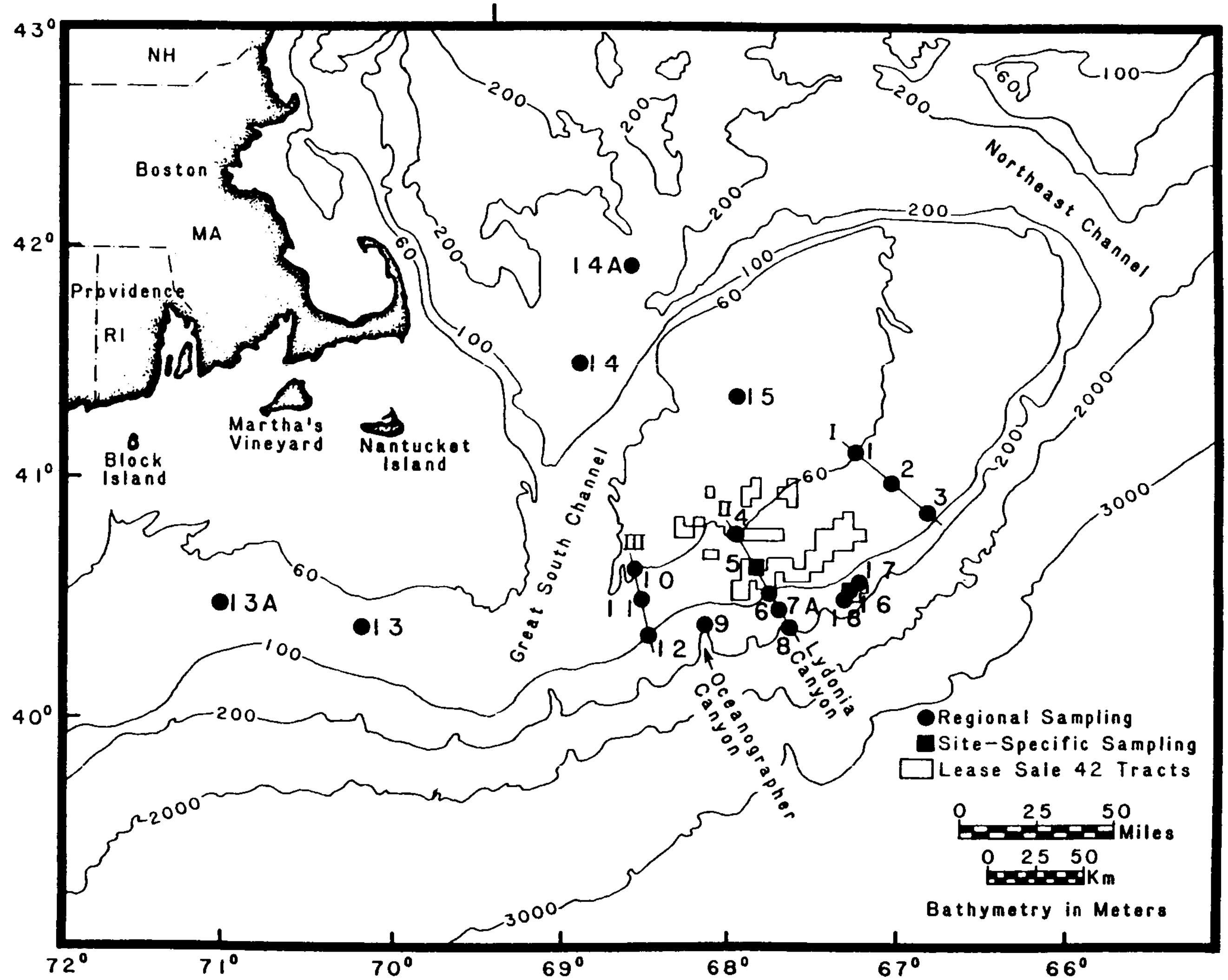

Figure 21. Long-Term Regional Stations

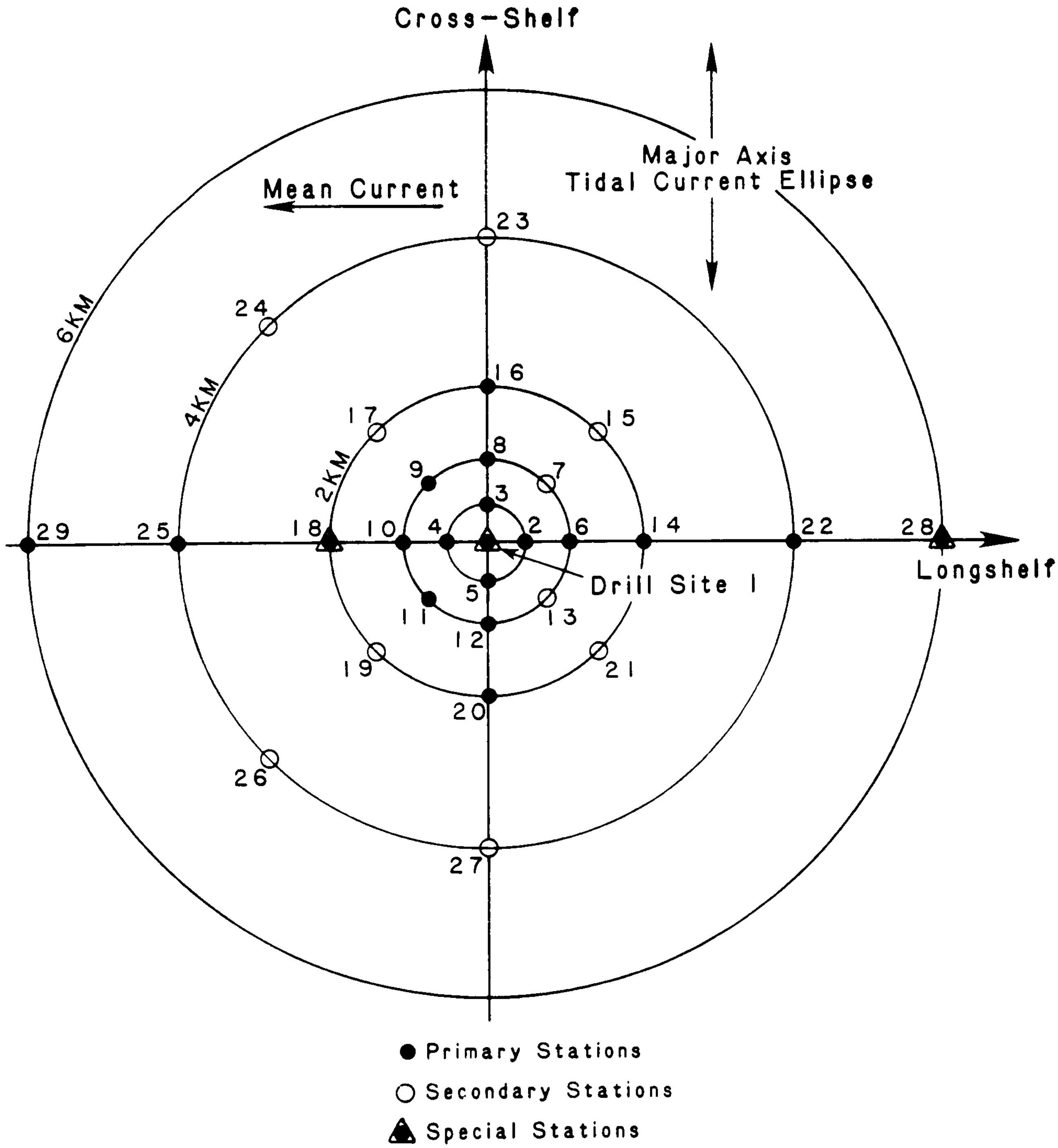

Figure 22. Site-Specific Stations

flank of Georges Bank at all depths and seasons is toward the southwest, the eastern Transect I, lying upstream of the lease area, was considered a reference transect, unlikely to be influenced by drilling activities, with which to compare the other transects. The western Transect III lies downstream of the drilling activity where drilling discharges could accumulate and long-term effects might occur. Additional regional stations were located at sites where drilling fluids and cuttings might accumulate over time. These include the heads of Lydonia and Oceanographer Canyons, the Mud Patch south of Cape Cod and Rhode Island, and just above the edge of the Continental Shelf south of the lease area. Another station was located in a high energy erosional area at the top of the Bank in about 35 meters of water.

In order to detect near-field impacts of drilling discharges on the benthic environment, two groups of sampling stations were established in close proximity to two exploratory drilling operations. A group of three stations was located within 200 meters, and approximately 2,000 meters upcurrent and downcurrent of the drilling site in Block 410 located in about 140 meters of water (Stations 16, 17, and 18 in Figure 1). A larger array of 29 stations was located in a radial pattern around the exploratory rig site in Block 312 in 80 meters of water (Figure 22). This rig site corresponds to Regional Station 5 in Figure 21. Stations were located within 200 meters and at distances of 0.5, 1, 2, 4, and 6 kilometers from the rig site. An over-sampling strategy was used here. Nineteen of the stations were designated as primary stations, and all samples from these stations were analyzed. The other ten stations were secondary stations, and samples from them will be analyzed, if needed, to aid in interpretation of impacts observed at the primary stations.

All stations were sampled four times per year--in July, November, February, and May. At each station, six replicate biology samples and three replicate chemistry samples of undisturbed bottom sediments were collected with 0.04 m^2 and 0.1 m^2 Van Veen grab samplers, respectively. Subsamples of these were taken for analysis of carbon-hydrogen-nitrogen (CHN) and sediment grain size. Biology samples were sieved through 0.5 and 0.3 mm screens and preserved in buffered formalin. Chemistry samples were frozen.

Bottom photographs were taken at each station to document the presence of fish, and in an effort to detect evidence of accumulation of drilling mud and/or cuttings on the bottom. Measurements of water column hydrography (salinity, temperature, dissolved oxygen) were taken at all regional stations. Dredge and trawl samples were collected at up to three regional and three site-specific stations to obtain fish and mollusc (ocean quahog Arctica islandica) samples for chemical analysis.

In the laboratory, each benthic biology sample was completely sorted and identifications then were made to the lowest possible taxon, usually species. Verification of the identity of voucher specimens and problematic species was performed by outside taxonomic experts. Wet-weight biomass was determined separately for each species.

All data from each sampling cruise were coded at Battelle and entered into the VAX 11/780 computer at Woods Hole Oceanographic Institution. Statistical treatment of the data set included an agglomerative clustering technique to determine similarity between samples. The similarity measure was NESS, the Normalized Expected Species Shared, where the comparison of expected species shared is between random samples of 50 or 200 individuals from the initial collection of individuals in each grab. NESS is more sensitive to the less common species than the other commonly used methods. The clustering strategy was flexible sorting with B set at the commonly used value of -0.25. We also have used the Bray-Curtis or percent similarity coefficient as a similarity measure with group average sorting. In addition, the Shannon-Wiener diversity (H') was calculated and Hurlbert's modification of the rarefraction method was used to predict the number of species in a random sample without replacement.

RESULTS AND CONCLUSIONS

The regional stations analyzed for benthic infauna group consistently over all eight sampling periods to date by depth and sediment type. Replicate samples at each station show an exceptionally high degree of homogeneity. Cluster analysis demonstrates that all of the replicates of any one regional station are more similar to each other than to replicates from any other station. When replicates at each station are summed, the samples from each of the eight sampling periods fuse before any separation occurs between stations. This homogeneity should enable us to detect biological changes should they occur at these stations.

Site specific stations in the array around Station 5-1 have a homogeneous community structure, both spatially and temporally over most of the area. The species composition does change with the increase in the proportion of fine sand at stations located 4 and 6 km to the west of Station 5-1.

At all stations sampled, the community structure (i.e., species composition) does not change very much with season. Although average densities of several species were observed to fluctuate seasonally, these changes probably reflect natural cycles in these populations and do not appear to be related to drilling activities.

The only results of the chemical analyses that provide a basis for hypotheses of an impact due to drilling activities are the gradient of barium concentrations (as a marker of accumulation of drilling muds) near the Block 410 Stations 16, 17, and 18, and Site-Specific Station 5-1, and a slight increase in sediment hydrocarbon concentration at Station 5-1.

Drilling began in Block 410 in July, 1981 and continued until March, 1982. With the methods of analysis used thus far, no biological impacts which could be attributed to drilling activities were detected. Differences between stations were always greater than temporal differences at any one of the three stations.

Drilling began in Block 312 on December 8, 1981 and continued until June, 1982. At the site-specific array of stations in this block, the separation of February (M3) and May (M4) samples into discrete clusters may be a result of the decline in total densities at many of the stations in February (M3), followed by a recovery in May (4). The density declines in

February (M3) may be related to changes in sediment composition due to accumulation of drill cuttings or to a severe winter storm shortly before the February cruise, or to normal seasonal population cycles. An analysis of the change in densities over time of 24 infaunal species revealed that at Stations 5-1, 5-2, and 5-8, where greatest increment in barium concentration between July (M1) and May (M4) occurred, the densities of many species declined in November (M2) before drilling began and increased in February (M3). A similar, but less dramatic change, occurred during the second year of the program, after cessation of drilling, indicating that the changes probably were seasonal. In general, no significant changes in benthic community structure which can be related to drilling activities have been detected with the methods of analysis used thus far.

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PACIFIC OCS REGION RIG MONITORING STUDIES

Dick Wilhelmsen
Pacific OCS Region

The Minerals Management Service Pacific OCS Regional Office has planned and is implementing a series of long-term environmental monitoring studies and experiments in the western Santa Barbara Channel and on the Santa Maria Shelf offshore California. The objectives of the studies are to: 1) assess and quantify the long-term chronic effects of OCS oil and gas development and production upon the benthic ecosystem, 2) assess the cumulative effects of platform placement and discharges upon local commercial fisheries, and 3) recommend appropriate, practical mitigating measures to reduce any significant effects observed. These studies are being conducted in an area where several major OCS oil discoveries have been made in the past few years and in a major new area for OCS oil and gas development off the California coast.

The monitoring program includes scientific workshops held to help evaluate and design appropriate monitoring studies; physical oceanographic synthesis, modeling, and observational studies; platform discharge synthesis and modeling studies; long-term benthic assessment studies around production rigs and in control areas; long-term experiments around natural oil seeps; fisheries data base and synthesis studies; and ecological synthesis and interpretive studies. Recent national studies such as the NAS study Drilling Discharges in the Marine Environment and the NOAA, EPA, and MMS-sponsored OCS Long-Term Fates and Effects Study Program will provide additional recommendations to guide the long-term monitoring studies.

To date, two workshops have been held for monitoring and discharge modeling studies, and contracts have been awarded for circulation modeling and observational studies, benthic reconnaissance and characterization of the study area, and a long-term modeling study of platform particulate discharges. Requests for Proposals for future studies will be issued in FY 1984 and 1985 for other studies including the long-term, site-specific benthic rig monitoring studies.

Information from these studies will be used for leasing, exploration, and production environmental assessments and impact statements in the Pacific OCS Region, for decisions on biological stipulations, and for an assessment of the long-term chronic effects of OCS production platforms and discharges on benthic communities and fisheries.

A CRITIQUE OF THE DESIGN OF RIG MONITORING STUDIES

Donald F. Boesch
Louisiana Universities Marine Consortium

Monitoring may be done for a variety of purposes, ranging in orientation from what is often known as compliance monitoring to broader research programs. In any case, careful design is critical to the sensitivity and, consequently, to the reliability of the monitoring program. Although this critique is developed primarily in reference to broader research programs evaluating the fate and effects of pollutants, many of the observations pertain equally well to more limited compliance monitoring.

Perhaps the most fundamental shortcoming of many environmental monitoring programs is the failure to ask a question on which the design can be based. This involves development of some _a priori_ model of potential impacts which considers the susceptibility of the community and its various components and an appraisal of the tractability of assessment. The potential impact for which one wishes to search should be defined as a domain of concern (how much of a change should the monitoring be able to detect) in order to design a program suitably sensitive. Null hypotheses can then be erected for testing. As a corollary, the probability of accepting a null hypothesis incorrectly should be stated, particulary when the risks of being wrong may be relatively unacceptable.

A common practical problem concerns finding suitable controls against which the potentially affected environment and its biota can be compared. A solid understanding of natural environmental patterns and their ecological significance is necessary, but too frequently investigators have tactily assumed environmental homogeneity and have compromised results by selecting inappropriate controls. Pre-monitoring surveys, even if limited in extent, can be very helpful in this regard. Synoptic comparisons between affected areas and well-chosen controls are generally more effective than temporal (before-after) comparisons; however, temporal perspective is necessary for evaluating documented effects. Station sampling designs are frequently insensitive or inefficient, and research in the area of sampling strategy directed to a point source in an omnidirectional flow field, such as the ocean, is urgently needed. Determination of replication is frequently arbitrary and should instead be based on estimates of variance, the degree of change one wishes to be able to detect, the degree of confidence, and the limits of practicality, all considered together.

Analysis of biological results should be ultimately based on population (single species) data for reasons of statistical soundness and interpretability. The use of aggregate or derived parameters (total individuals, diversity indices, etc.) should be only in assessment of gross patterns, not for testing hypotheses about effects. Similarly, multivariate pattern analysis techniques such as cluster analysis should be used primarily for hypothesis generation rather than hypothesis testing.

Almost no monitoring programs are designed to evaluate the consequences of ecosystem change to humanity or to the health of the ecosystem. Consequently, when effects are documented, conclusions about their broader significance are highly subjective. Monitoring studies should seek to document the extent of effects in space and time. Also, expanded research is required on the implications of biotic changes to ecosystems and to humanity.

For the state of understanding of the environmental effects of OCS oil and gas related discharges to significantly advance, I recommend the following emphases and de-emphases.

Emphasize	De-emphasize
Sediment dynamics	Plume tracking
Biogeochemistry	Bulk sample analysis
Efficient sampling design	"Conventional" oceanographic approaches
Life history-population parameters	Derived and aggregate

	parameters
Determination of sequestering and detoxification	Body burden measurements
Ecologically meaningful physiological measures	Histological censusing
Assessments of implications of biological change	Hand waving and wringing

PETROLEUM INDUSTRY OVERVIEW AND PERSPECTIVES ON RIG MONITORING STUDIES

James P. Ray
Shell Oil Company

During the past decade, there has been an ever increasing demand on the petroleum industry to design and conduct offshore rig monitoring programs. The following discussion will provide some personal opinions as to soundness of past programs, some of the inherent problems, and recommendations for future research. Although the title states that this is a petroleum industry overview, it is impossible to prepare such a presentation for review and consensus from the entire industry. The following discussion represents personal opinion, although it probably represents the general opinion of a broad cross-section of the industry.

Over the past several years, there have been increasing demands on the petroleum industry to conduct a broad variety of monitoring programs. Offshore rig monitoring itself has been rather loosely defined and includes everything from classical water quality monitoring approaches to purely academic research programs with little or no regulatory decision making implications. The industry is now conducting a broad variety of studies, including the fate and effects of produced water and drilling fluids and cuttings in environments ranging from the Beaufort Sea in Alaska to California, the Gulf of Mexico, and the Atlantic Coast. Studies have included a broad variety of approaches including physical, chemical, biological and geological oceanography. Study locations have ranged from the intertidal zone to the edges of the continental shelf.

An important part of this discussion is an understanding of the driving mechanisms which result in the petroleum industry being involved in monitoring. It should be noted that the petroleum industry has a primary goal of finding, developing and producing petroleum and its products. The industry is not geared for, nor does it have the necessary disciplines to be engaged in large scale environmental studies.

Quite often, monitoring programs are self-initiated by the industry, sometimes by individual companies, other times by groups of companies through industry trade organizations. Previous programs in this category are the Tanner Bank Drill Muds and Cuttings Study off the coast of California and a drill mud model verification program that is currently in progress off the coast of California.

More frequent are rig monitoring programs initiated by federal action, the two key mechanisms being lease stipulations and NPDES permit requirements. A number of the hard bank studies in the Gulf of Mexico are a result of lease stipulations (e.g., Flower Garden Banks, Baker Banks, etc.). The deep water mid-Atlantic study is an example of NPDES required monitoring programs.

In the past two years, various state agencies have also become very active in requiring monitoring programs. The most pronounced in this category is the State of California which is currently requiring a variety of monitoring (research) programs in state waters. At the present time, the estimated cost of these programs is approximately $1MM . The last major category is that of publicly driven monitoring programs which are usually the result of pressure from environmental groups (e.g., NRDC brought a legal challenge to EPA which resulted in a monitoring program at the Flower Garden Bank off the coast of Texas).

As previously mentioned, the industry is ill-equipped to be designing and carrying out major environmental programs. With this understanding, it is appropriate to discuss some of the problems of previous field studies. The inherent problems to be discussed are not the fault of any one particular group, but in fact the blame is generally shared by all parties--the regulatory agencies, the industry, environmental groups, and the contractors. In one way or the other, they have all had a part in inherent problems to be discussed.

The largest problem is that of poor design. The majority of programs are ill conceived from the start and are forced by individuals who usually do not have the proper oceanographic training nor understanding of marine pollution to be defining the problem to be studied. In addition, quite often the company faced with the monitoring program has limited oceanographic expertise in-house to assist in the monitoring design. Quite often, at both the regulatory agency level within the company and within the contracting organization, people are generally not qualified to be carrying out some of the programs requested. This unfortunately leads to poor study results which are scientifically questionable and provide little useful information for future regulatory decisions.

Another inherent problem in this type of "research" is that there are almost always budget and time constraints. When a major monitoring program is reduced to a two to three month frame to coincide with actual drilling, it is quite often not favorable with regard to weather conditions. Also, the regulatory needs require that the results be available as soon as possible, which does not allow for proper follow-up studies nor interpretation. The most amazing fact for non-industry people to understand is that the petroleum industry does have to operate within certain budgets for any particular project. This sets very specific bounds on what can and cannot be accomplished in any single program. The industry does not have an open checkbook with infinite funds for environmental studies.

Another problem of rig monitoring programs conducted in the past is the general lack of transferability of the data to other geographical regions. Although quite often some part of the data derived is in fact transferable, there is a general unwillingness in different geographical areas to accept this information, a problem called the "our area is unique syndrome."

The final problem area, and probably the most significant, is the lack of publication of the results from these monitoring programs. During the last decade, tens of millions of dollars have been spent on the broad variety of rig monitoring programs mentioned. Unfortunately, very few of the results from these programs have found their way to the peer reviewed scientific literature. It is quite unfortunate that these volumes of oceanographic information are generally unavailable to the scientific community. Although much of the information generated is not of the quality necessary for publication, there is still useful information that is not being disseminated.

So how can we improve our approach to rig monitoring for the future? Having recognized many of the inherent problems of the past programs, I think there are many changes that can be made to minimize nonproductive monitoring programs and to maximize the scientific information derived for the dollar spent. First and foremost, part of the responsibility falls on the regulatory agencies, environmental groups, and the public. It is extremely important for these groups to give serious consideration towards proper identification of "real information needs." The question should always be asked, "Why do we need a particular type of information, and for the money spent, what will we learn and how can we use it in making better regulatory decisions?" If these questions cannot be answered satisfactorily, then serious question should be raised as to the need of the monitoring program. Monitoring should not be done for monitoring's sake and environmental monitoring also should not be lowered to the level of being considered a simple tax for the privilege of operating offshore.

Another way to improve our monitoring programs is to avoid unnecessary repetition. Before deciding on a particular monitoring design, we should evaluate whether or not that particular type of study or monitoring program has already been done. If it has, and if we are comfortable with the information derived, we probably should not continue to repeat those same kind of studies. Another important facet is that only those organizations with the appropriate expertise should really be involved and conduct these monitoring programs. As mentioned earlier, in general the industry does not have the expertise to be fully involved in environmental monitoring programs. There is also a certain problem with credibility for the industry to be involved in self-monitoring. More importantly, the academic institutions or consulting companies that carry out these programs should be staffed with people having the appropriate expertise. In many cases the government agencies which have numerous Ph.D.'s in all fields of oceanography and marine pollution are possibly the best equipped.

A very good way to approach the problem is to make occasional use of external scientific review panels to evaluate the value of information available and to also recommend new directions of research. One very good example of this approach is the recent Federal Interagency Committee on Pollution Research, Development, and Monitoring (COPRDM). This panel reviewed the entire OCS studies program for the Bureau of Land Management and made recommendations for future changes. Another excellent example of this program currently underway, initiated by NOAA, NSF, and MMS, is the Long-Term Effects Program (LTEP), which is doing an indepth analysis of the current state of the knowledge and is making recommendations to the government concerning the feasibility of longterm effects studies that can be conducted over the next decade (i.e., related to offshore oil and gas development).

The last two items are so obvious they should not need mentioning, but for the sake of completeness I will include them. We should be sure that future monitoring programs adhere to good scientific practices and that the results of such programs receive proper review and if worthwhile, publication in the available scientific literature.

In closing, it should be noted that the petroleum industry is very aware that they will be required to conduct a certain number of monitoring programs in the near future. This responsibility is shared by the petroleum industry and the regulatory agencies. If the industry is going to have to conduct such programs, the most important thing is that the programs be well conceived and that the information derived will be of direct regulatory use. Especially in a time when the economics of this industry are at a low ebb, it is more important than ever that we maximize the scientific information derived from the money invested into these programs.

AMERICAN PETROLEUM INSTITUTE STUDY OF NEAR-RIG SEDIMENTS AT SIX DRILLING SITES IN THE GULF OF MEXICO

Dr. Paul N. Booth
Texas A&M University, College of Geoscience

The environmental effects of offshore oil and gas production have received much attention over the past decade. Much of this research has involved field monitoring studies aimed at examining the fate and effects of drilling discharges on the near-site marine environment. None of these studies has been able to quantitatively measure the total accumulation of discharged materials in the surrounding sediments. However, except for short-term events, the magnitude of any environmental effect caused by these discharges is directly determined by their accumulation in the ambient sediments. As with all previous field projects, barium (Ba) was used in this study as a tracer of the major components of the drilling discharges. However, this is the first study in which a mass balance of total excess barium (TEB) in sediments around drilling sites could be accurately calculated. These data, combined with detailed historical data of the drilling mud components used at each site, were used to develop a highly significant multiple regression equation for estimating TEB (the major component of drilling discharges) in the surrounding sediments as a function of water depth and total barium used (TBU) at the site.

The goal of this study was to characterize surface and subsurface sediments within 500 meters (m) of 6 offshore drilling sites in the northwestern Gulf of Mexico. This emphasis is consistent with the current consensus that monitoring studies should focus on the benthic (sedimentary) environment where any measureable impacts from drilling discharges are most likely to occur. The type of sediment at each site was described in terms of sediment texture and concentration of organic carbon, calcium carbonate, aluminum, and iron. The influence of drilling activities on these sediments was characterized by determining sediment concentrations of elements known to be major constituents of drilling fluids (i.e., Ba, Cr) and of bioactive trace elements (i.e., Cd, Cu, Hg, Pb, Zn) and hydrocarbons which may be released during drilling. A major area of emphasis in this study was to establish concentration gradients for many of these parameters as a function of distance from the drilling sites. Locations of the 6 sites studied are shown in Figure 23. Exploration, development and production sites in both shallow and deep water were selected to determine how the amount of drilling, water depth, and elapsed time between cessation of drilling and sampling influence the characteristics of surrounding sediments.

Up to 36 core samples were taken in a regular, circular pattern within a 500 m radius of each drilling site. In addition, 4 core samples were taken 300 m north, east, south and west of each site to serve as comparison samples which were beyond the immediate influence of drilling operations. Both surface (0-2 centimeters, cm) and subsurface sediment samples were analyzed for sediment texture, organic carbon, calcium carbonate, barium chromium, and iron (last 3 by neutron activation analysis). In addition, selected surface samples were analyzed for aluminum, cadmium, copper, lead, zinc (all by atomic absorption spectroscopy, AAS), mercury (by cold vapor AAS), and hydrocarbons (by gas-liquid chromatography). Selected whole cores were X-radiographed and selected sediment samples were subjected to X-ray diffraction analysis to identify barium sulfate. Finally, to determine the age of near surface sediments, lead-210 profiles were measured on 6 selected cores by alpha spectrometry.

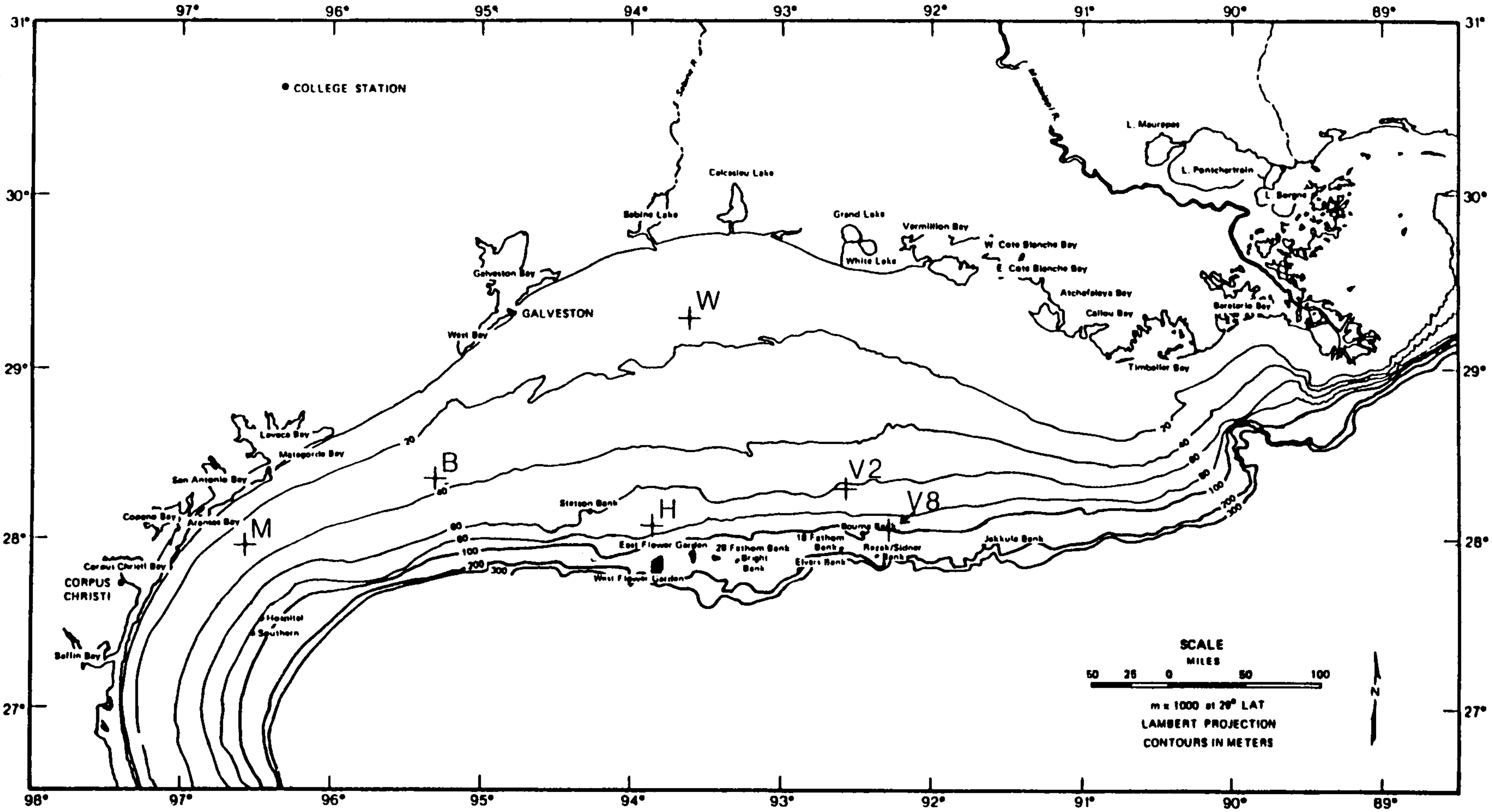

Figure 23. Locations of the 6 Drilling Sites in the Northwestern Gulf of Mexico Used in This Study

Lease areas and block designations for these sites: Exploratory shallow, West Cameron 294 (W); exploratory deep, Vermilion 381 (V8) development shallow, Matagorda 686 (M); development deep, High Island A-341 (H); production shallow, Brazos A-1 (B); production deep, Vermilion 321 (V2).

Since barium is a major component of drilling muds (up to 90% by dry weight) and because of its low water solubility (0.03 ppm in sea water), low levels in undisturbed sediments (< 800 ppm), and chemical inertness, it is an excellent tracer of the major (insoluble) components of discharges from drilling operations. Barium has been used in all previous studies as an indicator of the presence of residual discharged material in the sediments. This study is the first in which sufficient numbers of subsurface as well as surface samples were taken to permit an accurate mass balance of excess barium. An elaborate algorithm was used to estimate the total amount of excess barium (TEB) in sediments within a 500 m radius of each drilling site. This mass balance approach represents a significant advancement over previous studies where surface barium concentrations had to be used as an indicator of the mass of accumulated discharged materials in the near-site sediments. Table 7 shows the results of this barium mass balance at the 6 sites.

SIGNIFICANT FINDINGS

- Only a small fraction (<12%) of the total barium used (TBU) at a site is present in near-site sediments. At nearshore sites 94% of the TBU is transported >3000 m from the drilling site. TBU traces the majority of all materials discharged during drilling operations.

- The percentage of TBU present in near-site sediments (PTBU) is 10 times higher at offshore drilling sites than nearshore ones. Significant resuspension and removal of bottom sediments in the high current nearshore environment appear to be responsible for the low percentage of residual barium at the shallow water sites. The higher barium levels at deep water sites probably come from barite associated with heavier cuttings and other aggregates which settle at a much faster rate than the normal bulk mud. These processes occur rapidly since the length of time between cessation of drilling and sampling had little effect on the PTBU.

TABLE 7
MASS BALANCE OF TOTAL EXCESS SEDIMENT BARIUM SURROUNDING 6 GULF OF MEXICO DRILLING SITES

Drilling Site	Type (1)	Water Depth (m)	Mode of Discharge	Total Barium used (TBU) in drilling activities (10^3 kg)	Mean BAEXAC 0-500m radius (g/m^2) (2)	Total excess Barium (TEB) in sediments (10^3 kg) within radius (m)	Percent of TBU within radius (m)
						500	500
West Cameron 294	ES	13	Surface	2,414	25.8	20.3	0.84
Vermilion 381	ED	102	Surface	229	28.0	22.0	9.6
Matagorda 686	DS	29	Surface	2,334	27.5	21.6	0.93
High Island A-341	DD	76	Surface	1,518	173.	136.	9.0
Brazos A-1	PS	34	Surface	1,041	19.2	15.1	1.5
Vermilion 321	PD	79	Surface	4,964	732.	575.	11.6

(1) Exploratory (E), development (D) or production (P) in shallow (S) or deep (D) water.

(2) Mean total excess barium in the sediment column areal concentration (BAEXAC) within a 500 meter radius of the drilling site= $TEB_{500}/ 2\pi(500)^2$.

• Within each group of drilling sites (nearshore and offshore), the PTBU is strikingly similar despite drastic differences among the sites in terms of well type, sediment type, age of the site, etc.

• TEB is highly correlated with TBU ($p < 0.005$). This means that the amount of discharged materials accumulating in the sediments as a result of multiple wells is directly additive. In previous studies which looked only at sediment barium concentrations, this additive effect of multiple wells was not apparent because barium concentrations are poorly correlated with TBU.

• Despite the large amounts of drilling mud components used at the 6 drillsites, the more pervasive sediment perturbations attributable to drilling activities were largely restricted to deep water development and production sites (High Island and Vermilion 321 in this study). These two sites had by far the largest TEB values among the 6 study sites (Table 7).

• Multiple regression analysis modelling of the barium mass balance data suggests that the distribution of TEB observed around the 6 drilling sites is largely controlled by water depth (as an indicator of current speed) and the total amount of barium used (TBU) in the drilling activities TEB= -41 + 0.00156 (WD) (TBU); $p < 0.0001$, $R^2=0.99$, N=6 . With additional field work, such modelling will allow accurate prediction of those sites which are most susceptible to sediment accumulation of discharged materials and the magnitude of this process. This prediction capability will in turn decrease the need for repetitious field monitoring efforts in the future.

RECOMMENDATIONS

• Future monitoring studies should have a sufficient sampling density (e.g., 1 sample per 25,000 m^2 of seafloor) and analysis regime (including sub-surface samples) to permit the calculation of barium mass balances (TEB) similar to those described here. Using TEB data (including PTBU) is the best way to quantitatively compare the influence of drilling operations among environmentally diverse sites.

• To improve the predictive model described here, future monitoring studies should focus on development and production sites especially in deeper water (> 40 m).

TOXICITY OF "SPENT" DRILLING FLUIDS TO SELECTED MARINE ORGANISMS

Thomas W. Duke
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The Environmental Research Laboratory at Gulf Breeze, Florida (ERL/GB), a part of the U.S. Environmental Protection Agency (EPA), has carried out a cooperative research program to evaluate the potential impact of drilling fluids on the marine environment. This talk presented data obtained by participants of this program on the effect of spent drilling fluids from the Gulf of Mexico on selected marine organisms.

Duplicate samples of drilling fluids were supplied to EPA and the American Petroleum Institute (API) by the Petroleum Equipment Suppliers Association (PESA). Samples were collected randomly from operating rigs in the Gulf of Mexico, and an effort was made to select wells of varying depths and geographical locations. The samples sent to ERL/GB were subsequently used for testing in-house or supplied to extramural contractors. Chemical analyses were performed by Shokes, Science Applications Incorporated, and Barker, New England Aquaria. Biological testing with mysid shrimp, Mysidopsis bahia, by ERL/GB; grass shrimp, Palaemonetes pugio, by Rao, University of West Florida; clams, Mercenaria mercenaria, by Barker, New England Aquaria; minnows, Fundulus *herteroclitus*, and sand dollars including *Echinarachnius parma* by Crawford, Trinity College; and coral, *Acropora cervicornis* by Powell, Texas A&M University.

The biological response of exposure to the drilling fluid was as varied as the chemical composition of the drilling fluids. Mysid shrimp were exposed to whole drilling fluids as well as dissolved and suspended particulate phases (SPP). The lethal concentrations of whole mud required to kill 50% of the test populations (LC_{50}) ranged from 25 to >1500 ppm (volume/volume). When the whole mud was separated into the various phases, SPP was the most toxic, although not as toxic as whole mud. The LC50's for the SPP phase ranged from 386 to >50,000ppm. Studies with grass shrimp were conducted with whole mud and indicate that grass shrimp larvae are less sensitive to whole muds than *mysids* but these organisms are adversely affected by the drilling fluids at relatively low levels of concentration. The LC_{50} values for grass shrimp ranged from 142 to 100,000ppm. Larval *Mercenaria mercenaria* (1 hour fertilized) exposed to liquid and suspended solid phases of the fluids were affected at relatively low levels of concentration and appeared to yield the most sensitive response. The SPP phase of the fluids was slightly more toxic than the liquid phase and LC_{50}'s or SPP varied from 64 to >3000. Effect criteria was the lack of larval development compared with controls. Embryogensis of *Fundulus* and echinoderms was related to exposure to drilling fluids by first establishing a "safe" level of exposure. That level refers to a concentration of 10% of that value having an adverse effect in the most sensitive assay system. This practice permitted the estimation of "safe" dilution levels which might be required in the field. Effects levels, expressed as the dilution of the orginal fluid suspension to achieve the safe concentration, indicated that the most toxic fluid required approximately 10^6 dilution. Sublethal effects of drilling fluids on corals were determined using various metabolic measures such as calcification rate and changes in amino acid and protein content. The stem of the coral was separated into four sections, and the effects on each section were noted after 24-hour exposure to 25ppm of the whole fluid followed by a 48-hour recovery period. Each of the fluids tested elicited an effect, although some were not statistically significant.

A visual inspection of the data indicates, except for corals, a relationship between the toxicity of the drilling fluids and the concentration of Number 2 fuel oil as reported by the New England Aquarium. Spearman Rank Order Correlations of the toxicities of the test organisms and fuel oil content of the mud indicate a significant correlation between these factors, i.e., the greater the concentration of the fuel oil the higher the toxicity (or lower the LC-50). The sign difference with Crawford's data (i.e., Echinoderm embryo) is because a positive relationship existed between the "safe" level and the oil content of the fluids. The correlations are as follows:

Spearman Rank Correlation Coefficients[a]

	No. 2 Fuel Oil
Mysid LC_{50}	
Whole Mud	-.81
Liquid Phase	N.S.
Suspended Phase	-.96
Solid Phase	-.89
Grass Shrimp LC_{50}	
Whole Mud	-.88
Mercenaria EC_{50}	
Liquid Phase	N.S.
Suspended Phase	-.89
Echinoderm Embryo	
Dilution to Safe Concentration	.74

[a] All correlations significant at alpha = .05.

NATIONAL RESEARCH COUNCIL'S STUDY OF DRILLING FLUIDS AND CUTTINGS IN THE MARINE ENVIRONMENT

Donald F. Boesch
Louisiana Universities Marine Consortium

This presentation is a brief summary of the report "Drilling Discharges in the Marine Environment" recently published by the Panel on Assessment of Fates and Effects of Drilling Fluids and Cuttings in the Marine Environment of the National Research Council's Marine Board. The report is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

The Panel was convened by the Marine Board at the request of the Department of the Interior. Dr. John D. Costlow of the Duke University Marine Laboratory served as Chairman of the 13-member group, which included the present author. The Panel was charged with establishing a credible technical basis for decisions about discharging fluids and cuttings, reviewing and critically appraising available knowledge, assessing the adequacy, applicability and transferability of research, and recommending procedures to mitigate environmental effects.

Drilling fluids are required in rotary drilling to remove cuttings, control pressure, cool and lubricate, and seal the well. They must eventually be disposed of because of loss of properties, and cost and operational considerations in offshore drilling favor onsite disposal. The bulk constituents (water, barite, clay minerals, chrome lignosulfonate, lignite, and sodium hydroxide) are essentially nontoxic at concentrations reached quickly after discharge. Minor constituents (including biocides and diesel fuel) may be more toxic, and there is limited information on the composition and quantities used of these additives. Two million metric tons of solid constituents are discharged annually in the U.S. OCS, 90% of this in the Gulf of Mexico. Future discharges are likely to be concentrated in the Gulf of Mexico, Southern and Central California, and Alaska. The total particulate loading from drilling fluids discharged approximates 1% of the annual discharge of the Mississippi River, but the loading of barium may be as much as twice that of the Mississippi.

Greater than 96% of the whole drilling fluids tested in short-term bioassays (44-144 hours) exhibited an LC-50 greater that 1,000 ppm and can be classed as "slightly toxic" to "essentially nontoxic." Over 98% of the tests using the suspended particulate phase had an LC-50 greater than 10,000 ppm. Acute toxicity tests with over 70 different fluids and 60 species of marine animals indicate most water-based fluids are relatively nontoxic. In a few cases where the LC-50 was 100 to 10,000 ppm, the toxicity was probably attributable to diesel oil in the fluid. Tests of sublethal effects are few but generally do not show effects at levels less than one-fifth those exhibiting acute lethal toxicity. The direct application of bioassay results to the prediction of field effects is limited by the fact that these tests generally do not simulate the short and variable exposure conditions actually experienced. Tests of effects on benthic organisms in sediment systems have not separated chemical and physical effects. Studies of bioaccumulation have not considered sequestering and detoxification of metals by organisms; there is no evidence of biomagnification of metals.

There are no clear trends based on toxicity tests that species from one OCS region are more sensitive than another, nor that inshore species are necessarily inappropriate surrogates for offshore counterparts. There exists no evidence that justifies different regulatory policies concerning the use of additives in different OCS regions.

On the continental shelf about 90% of the particulates in the drilling fluid and almost all of the cuttings settle rapidly to the bottom. The upper, visible plume is but a small portion of the discharge but has commanded most attention. Horizontal turbulent diffusion results in a dilution of 10,000 or more of dissolved components within one hour of discharge; greater attenuation can be expected in particulate concentrations as a result of settlement. Despite the inhomogeneities in environmental conditions, observations of upper plume dispersion generally conform with theory. Based on these observations, toxic responses in the water column can only be expected beyond the immediate vicinity of the discharge pipe if they are expressed at concentrations approximating 100 ppm over one hour of exposure. Given this, there is no basis for restrictions of dilutions or rates of discharge for mitigating water column effects.

The extent of contamination of bottom sediments and the resultant effects of the sedimented muds and cuttings depend on sediment dispersal processes which have not been modeled. Effects on benthic communities have been observed in the field under low to moderate regimes within 1,000 m of the discharge. Because residual chemical toxicity of sediments should be low, the recovery of affected communities should be similar to that following other physical disturbances: weeks in frequently disturbed shallow waters, months to a few years in continental shelf environments, and several years in continental slope and deepsea environments. Long-term effects on the benthos resulting from discharges from multiple wells are not well known, but are difficult to separate from other effects. A hard-substrate epibiota may be particularly sensitive to deposition of drilling muds, but most such communities exist in dynamic regimes where sediments are not accumulated.

The notable deficiencies of current knowledge (variable quality of research, limits to the relevence and realism of laboratory experiments, ascribing effects to causes, and poor understanding of ecosystem processes) also pertain to effects of other pollutants in the coastal ocean. Emphasis should be based on research on the broader topics of accumulation and transfer of materials and ecosystem response, and extensive further research specifically focused on the fate and effects of drilling fluids is not needed.

Effects of individual discharges of drilling fluids and cuttings are limited to the benthos, small-scale, and ephemeral; therefore, the risks of exploratory drilling discharges to most OCS communities are small. Discharges from development drilling are greater and more prolonged, but accumulation is less than additive, suggesting that extrapolations can be made from effects observed during exploratory drilling. Uncertainties exist for low energy, depositional environments which experience large inputs over long periods of time.

Effects of drilling discharges can be minimized by avoiding deposition in sensitive benthic environments which are not naturally exposed to significant sediment flux. The use of toxic additives, such as diesel oil, should be monitored or limited. Drilling fluids demonstrating significant toxicity in laboratory experiments should be chemically analyzed to determine the toxic components.

Session: GULF MARINE STUDIES-MMS PROGRAM COMPLETION STUDIES

Chairmen: R. M. Avent
R. M. Darnell

Date: November 15-17, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Rezneat M. Darnell Texas A&M University
Demersal Biological Resources of the Northern Gulf of Mexico Continental Shelf	Rezneat M. Darnell Texas A&M University
Megafaunal Assemblages and Zones of the Deep Gulf of Mexico	Willis E. Pequegnat TerEco Corporation
The Gulf of Mexico Polychaete Taxonomic Standardization Program	Barry A. Vittor and Paul G. Johnson Barry Vittor & Assoc.
Southwest Florida Shelf Hydrography and Productivity	T. Paluszkiewicz, L. Atkinson, J. Yoder
Reformatting MAFLA & STOCS Data for NODC Archiving	Craig Brandt Quantus, Inc.

GULF MARINE STUDIES -- MMS PROGRAM COMPLETION STUDIES

SESSION OVERVIEW

R. M. Darnell
Texas A&M University

The following abstracts report presentations given by investigators while under contract to MMS to conduct a diverse range of studies in the Gulf of Mexico. This session gave each invited author an opportunity to report the final (or near-final) results of his research. Because the presentations were so varied in purpose and scope there was no unifying session theme.

Rezneat M. Darnell presented findings from his Northwest Gulf Shelf Bio-Atlas, the large-format Open File Report 82-04. In this report he delineated distribution and abundance patterns for over 200 fishes and shrimps from the Mississippi Delta to the Rio Grande River. Further, he discussed community ecology and elucidated striking similarities among and dissimilarities between ecological groups of motile megafauna.

Willis E. Pequegnat discussed patterns of animal distribution abundance zonation and zoogeography in the depths of the Gulf of Mexico. His final report dealt with megafauna collected on the R/V *Alaminos* between 1964 and 1973 ranging in depth from the shelf-slope break to the lower abyssal zone. At least seven zones were distinguishable, each of which has characteristic fauna in response to prevailing conditions.

A third biological study was presented by Barry A. Vittor and Paul G. Johnson. They described their Polychaete Taxonomic Standardization Program, which was initiated to resolve problems of taxonomic inconsistencies found in major BLM/MMS-funded baseline studies in the Gulf of Mexico and to produce a taxonomic monograph on this most important group of marine worms. Of the nearly 600 species and 60 families they encountered, about 40% of the species and two families were new to science. An eight-volume series of reports should be available in early 1984, with chapters devoted individually to each family.

A portion of the MMS-funded Southwest Florida Shelf Ecosystems Study Series involved delineation of the dynamics and productivity of the overlying water masses off southwest Florida. A presentation by T. Paluszkiewicz, L. Atkinson, and J. Yoder centered primarily on the dominant Loop Current, its variable penetration into the Gulf, its meanders, filaments, and eddies, and its influence on and interaction with both deeper water masses and the shelf waters. One of the features of the Loop Current is upwelling near the shelf-slope break, which enhances productivity by bringing nutrients into the photic zone. Studies were conducted by satellite infrared imagery and at-sea sampling.

A presentation by C. Brandt demonstrated the inherent difficulties in the handling of major data bases. In an attempt to make data from the South Texas OCS (STOCS) and Mississippi-Alabama-Florida (MAFLA) Studies more widely available to the general public, MMS funded a program to have these data reformatted to National Oceanographic Data Center (NODC) specifications. In all, 160 files representing 38 data types are involved in this program. These contain all manner of chemical, biological, physical, and geological data from these early studies both for the water column and the benthic environment. A major problem stemmed from the lack of NODC codes for nearly a thousand of about 5,300 species encountered. The final task is documenting the types of variables, their spatial and temporal extent, and collection methods, to enable the user to effectively gain access to the information.

DEMERSAL BIOLOGICAL RESOURCES OF THE NORTHERN GULF OF MEXICO CONTINENTAL SHELF

Rezneat M. Darnell
Department of Oceanography, Texas A&M University

In pursuit of its mission to foster the orderly development of subsurface mineral resources of the U.S. Gulf continental shelf, the Minerals Management Service is also concerned with protection of the biological resource base. To this end, through IPA appointments, it supports the present project designed to provide a clear understanding of the distribution patterns of critical demersal species and faunal assemblages of the U.S. Gulf of Mexico continental shelf.

The first major report of this project appeared in July 1983, and is available for distribution (Northwest Gulf Shelf Bio-Atlas, MMS Open File Report 82-04). This report delineates the distribution patterns of 200 fish and 12 penaeid shrimp taxa in the shelf area from the Rio Grande to the Mississippi River Delta. Included are discussions of species and community ecology, as well as management implications.

In continuation, the project now focuses on the continental shelf of the eastern Gulf from the Mississippi River Delta to the Florida Keys. Investigation has revealed that at least a dozen reliable data bases exist which, taken together, provide more or less adequate seasonal coverage for the fishes and shrimp of the genus *Penaeus* on the eastern Gulf shelf. Most of these data bases have been acquired and are being processed for preparation of the Eastern Gulf Shelf Bio-Atlas which should be completed in about a year. Station data locations are provided on the accompanying map (Fig. 24).

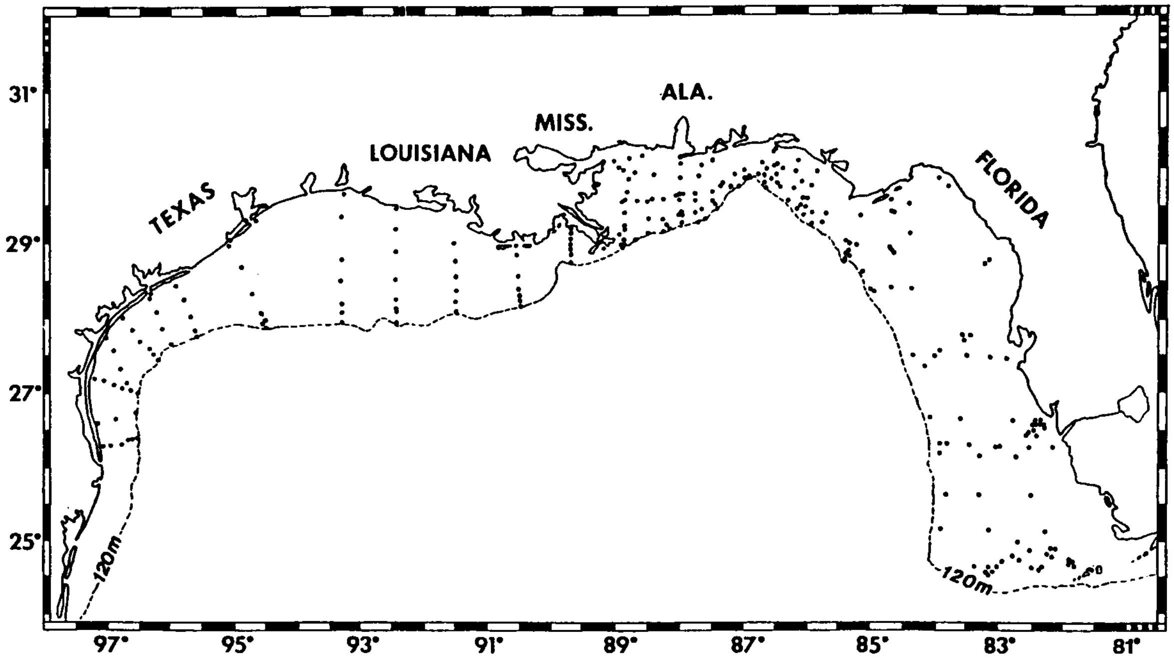

Figure 24. Map of Station Data Locations for the Eastern Gulf Shelf Bio-Atlas

Taken together, these two volumes should provide a clearly enhanced basis for management decisions affecting the biological resources of the Gulf shelf waters. Beyond that, however, these volumes should provide for a deeper scientific understanding of the species and ecological systems which inhabit our shelves. Local studies will appear in perspective, and individual species will be viewed in seasonal detail along 1,500 miles of coastline.

MEGAFAUNAL ASSEMBLAGES AND ZONES OF THE DEEP GULF OF MEXICO

Willis E. Pequegnat
TerEco Corporation

DOMINANT DEEP BENTHIC TAXA

The most important megafaunal groups in the deep sea are the echinoderms, crustaceans, and demersal fishes. This study is based upon 264 stations mounted by R/V ALAMINOS in the Gulf of Mexico between 1964 and 1973 for the study of these groups.

Echinodermata

One hundred eighty-six species of echinoderms were collected between the shelf break and the abyss. Asteroids (61 species) accounted for about one-third of the total, followed by ophiuroids (43 species), holothurians (37 species), echninoids (31 species), and crinoids (14 species). Approximately half (51%) extended their bathymetric range below the 1,000 m isobath. But it is the sea cucumbers that predominate in the deep Gulf, 73 percent occurring below 1,000 m.

Crustacea

One hundred ninety-two species of benthic crustaceans were collected by the ALAMINOS in the offshelf waters of the Gulf. Brachyurans yielded the most species, but they are mostly confined to the shelf and upper slope. Two other diverse groups are the caridean shrimps with 33 species and the galatheid anomurans with 30 species.

Fishes

A total of 206 demersal fish species within 47 families were collected. Seventy-nine species ranged into waters 1,000 m or more in depth, while 59 species had peak populations at 1,000 m or deeper. The Macrouridae was represented by 30 species, followed by Ophidiidae (23 species), Alepocephalidae (12 species), and Gadidae (11 species), which together constitute over one-third of the total number of species. The Gadidae (codfishes) is dominant on the upper continental slope between the shelf break and about 500 m.

DEEP BENTHIC ECOSYSTEMS: ZONATION AND FAUNAL ASSEMBLAGES

In a community one is dealing with populations of organisms that together make up the faunal assemblages of coincidental species that exhibit a high enough degree of recurrence in similar habitats to preclude the conclusion that they are simply randomly assembled collections of species. Accepting these guidelines, we agree with Menzies et al. (1973) when they say "---. Obviously we accept the existence of communities of organisms in the sea as a reality ---."

In the present study we have found, as have others elsewhere, that animal taxa are congregated in such a way that the fauna can be subdivided by statistical criteria into assemblages arranged in vertical depth zones. In fact, we have established five faunal zones from the shelf to the abyss in the northern Gulf. These conform reasonably closely to those established by Menzies et al. (1973) for the Northwest Atlantic Ocean. The principal difference is seen to be in the depth of the shelf break, some 246 m in the Atlantic and 125 to 150 m in the Gulf. Thus, we have established a Shelf/Slope Transition Zone above the Archibenthal Zone. Also, there are reasonably distinctive subdivisions of the Archibenthal and Mesoabyssal Zones that we refer to as horizons.

Shelf/Slope Transition Zone (150-450 m)

Demersal fishes are certainly the hallmark of this zone. Coupling this with the rich group of asteroids and brachyurans, the majority of which are predatory, it appears that this is a very productive part of the benthic environment. Ninety species of demersal fishes were collected here, and over two-thirds of them reach their maximum populations in the zone. Gastropod mollusks and polychaete annelids are also well represented in this zone. Noteworthy for their paucity are the sea cucumbers; contrariwise, the *Brissopsis* group of sea-urchins is extremely abundant.

Archibenthal Zone - Horizon A (475-750 m)

Demersal fishes are abundantly represented here, but there is a reduction in total from 90 to 79 species and those with maximum population from 66 to 45. Asteroids are very well represented and the sea cucumbers have doubled in number. The *Brissopsis* echinoids are almost absent, but their place has been taken by the appearance of *Phormosoma placenta* and *Plesiodiadema antillarum*. Caridean shrimp species have doubled in number here, and among the galatheids the genus *Munidopsis* is beginning to replace *Munida*, which predominates in the shelf areas. Gastropods and polychaetes are still very abundant.

Archibental Zone - Horizon B (775-950 m)

Although the total number of demersal fishes has decreased only moderately, the number of those species that reach maximum populations here is less than half that of Horizon A. This presages a major zonal change. The same is true of asteroids and echinoids. Another remarkable change is the drastic reduction in brachyuran crabs. Gastropod mollusks and polychaetes are still extremely well represented.

Upper Abyssal Zone (975-2,250 m)

Even though the Upper Abyssal Zone's bathymetric range is nearly three times that of the Archibenthal Zone, its demersal ichthyofauna is only half that of the latter zone. This exponential drop in species accelerates more rapidly as one moves into the Mesoabyssal. However, the number of demersal fishes attaining maximum populations in the Upper Abyssal is over twice that of Horizon B. This is indicative of a group uniquely adapted to this environment above the slope's escarpment. Noteworthy is the major increase in the number of species of large sea cucumbers. The galatheids are here represented by 11 species of the genus Munidopsis and only one of Munida. The number of brachyuran crab species continues to drop with only four present here compared with the 35 in the Shelf/Slope Transition. It is perhaps most significant to observe that gastropod and sponge species reach peak numbers here, and polychaete numbers are still at high levels.

Mesoabyssal Zone - Horizon C (2,275-2,700 m)

A very sharp faunal break occurs between the Upper Abyssal Zone and Horizon C of the Mesoabyssal Zone. For instance, the number of demersal fish species having maximum populations in the zone drops from 49 in the Upper Abyssal to 3 in Horizon C. Even if both horizons of the Mesoabyssal are included, the total is only 5. Similar reductions of species are noted in other groups (maximum population species only).

Mesoabyssal Zone - Horizon D (2,725-3,200 m)

This horizon coincides with the lower and steep part of the continental slope in the western Gulf. It encompasses the Sigsbee Escarpment, the lower part of which intersects with the continental rise. In the northeastern Gulf such an escarpment does not exist. Rather, it is dominated by the Mississippi Trough and the Mississippi Fan. Thus, there is a more definitive separation than in faunal assemblages between Horizons C and D in the western Gulf than in the east. This seems to indicate that the degree of slope may play a significant role in species richness, possibly not directly so much as through its contribution to instability of the seabed and the frequency of slumping and related causes of turbidity flows. There are some differences in assemblage constitution between the horizons. For instance, there are nearly twice as many species of demersal fishes in C than in D and four of the species in the former are not found in D. On the other hand, among the Asteroidea there are four species that reach maximum populations in D, whereas none do in C. Other differences are readily apparent in the following analyses of the assemblages.

Lower Abyssal Zone (3,225-3,850 m)

If we assume that the Lower Abyssal Zone begins near the bottom of the slope's escarpments, i.e., at the intersection with the continental rise, its megafauna is depauperate but not to the degree expected by the drop in diversity observed between the Upper Abyssal and Mesoabyssal Zones. Furthermore, this zone has an interesting assemblage of benthic species that do not occur elsewhere.

We have separated the Lower Abyssal Zone into the Active East and Tranquil West subdivisions. This is intended to reflect the fact that bottom currents have been detected in the east but not in the west. Also, there is a marked difference in the sediments between the two subdivisions.

NATURE OF THE DEEP GULF ECOSYSTEM

Although it might appear that the deep ecosystem of the Gulf in the area of this study is quite uniform, in truth there are some remarkable biotal differences. In fact, the biotal differences justify referring to the western Gulf as the "true" Gulf and the eastern part as a divergence of the Atlantic Ocean via the Caribbean Sea.

We have seen that whereas some 187 species among demersal fishes, decapods, and some echinoderms are limited in their distribution to the western Gulf, only 31 species among these occur solely in the eastern Gulf. Some of this discrepancy may be due to sampling artifacts, but the separation might well be even greater had more of the less mobile species been included in the tally. It is not difficult to suggest possible reasons for the relatively high levels of endemism in the western Gulf as compared with the eastern part. For one thing, residence time of water is greater in the west than in the east.

Some of the water entering the Gulf through Yucatan Channel turns westward and becomes incorporated in the southern cyclonic gyre. Moreover, the northern two of the three gyres of the western Gulf are formed by water spinning off from the Loop Current. This water remains sufficiently long here for the development, metamorphosis, and sinking to the bottom of any meroplankters of benthos introduced from the Caribbean. In general this is not so true of the eastern Gulf. Here the Yucatan water often flowing at the rate of 2-4 kts sweeps in and out of the Gulf rather rapidly. Accordingly, holoplankters, meroplankters, and some nekton come into and pass out of the Gulf in a matter of days. Assuming an average transit distance of 576 n miles, water in the Loop Current would remain in the Gulf a maximum of eight days. The effective time for recruitment would be about half of this, simply because to reach the bottom before being carried out of the Gulf, pelagic larvae would have to begin their descent during travel in the ascending (northward) limit of the Loop.

THE GULF OF MEXICO POLYCHAETE TAXONOMIC STANDARDIZATION PROGRAM

Barry A. Vittor and Paul G. Johnson
Barry A. Vittor & Associates, Inc.

The Gulf of Mexico OCS Polychaete Taxonomic Standardization Program was initiated in September, 1979, and will have been completed in early 1984. The purpose of this project was to resolve problems of taxonomic inconsistency in the identification of polychaetes among the several BLM-funded benthic studies in the Gulf and to produce a standardized guide to all taxa encountered in these studies. These objectives have been successfully met. This presentation describes how these goals were attained and what has been produced and discusses how the results of this effort will benefit the regulatory, scientific, and industrial interests in the region.

A total of 591 polychaete species are included in the several Gulf OCS study collections examined by Vittor & Associates. These occur in 60 families, including two families new to science. As many as 233 species (almost 40%) have not previously been described. Each family is assigned a separate chapter in the eight-volume series. Keys to genera and species are provided. Each species is described and its major diagnostic characters are depicted in a series of illustrations.

Family chapters were prepared by a total of 14 specialists, while several additional polychaete taxonomists provided constructive manuscript review and editing. Each chapter was subjected to at least two reviews/revisions. Most chapters have been furnished to the MMS for preliminary examination and testing by other taxonomic laboratories. A complete voucher specimen series has been deposited at the U.S. National Museum (Smithsonian Institution).

Vittor & Associates' work has produced a very valuable tool for accomplishing accurate, consistent benthic ecological analysis of natural resources and environmental impact. For identification of polychaetes from the Gulf of Mexico and neighboring regions, the polychaete atlas will essentially take the place of nearly 1,200 separate taxonomic titles and will also provide diagnoses for taxa which appear in no other literature. Benthic sample analyses from these regions have become less expensive for that reason, resulting in a significant, tangible benefit to environmental managers in government and industry. Other major groups, such as the Crustacea, should be subjected to the same type of taxonomic standardization in order to strengthen further our ability to recognize and interpret ecological impact of OCS activities.

SOUTHWEST FLORIDA SHELF HYDROGRAPHY AND PRODUCTIVITY

T. Paluszkiewicz, L. Atkinson, J. Yoder

The primary goal of the Southwest Florida Ecosystem Study, a three-year, interdisciplinary study, was to obtain environmental data on the impacts of natural resource exploration and development activities on the outer continental shelf. The third phase was aimed at addressing the primary productivity mechanisms on the outer continental shelf and their relationship to the dominant hydrographic distributions during different seasonal periods. A major goal of this phase of the study was to delineate potential driving mechanisms of the ecosystem. Earlier studies indicate that interactions of the bounding current, the Loop Current, with the outer continental shelf could be a major factor in fluxes of heat, salt, nutrients, and momentum and could be the potential driving mechanism of enhanced productivity.

The circulation of the eastern Gulf of Mexico is dominated by the Loop Current which enters through the Yucatan Strait, forms a loop flowing anticycloncially through the Gulf of Mexico, and exiting through the Florida Straits. The northward penetration of the current varies annually and seasonally. Meanders or filaments form on the shoreward boundary of the current, frequently along the west Florida shelf. Some detach and form separate eddies.

Currents on the shelf (50 m and shallower) are coherent with the local wind. Longshore currents over the width of the shelf (calculated from local sea level) are highly coherent with longshore wind during the passage of weather systems. At other times, the coherence of the Loop Current position with sea level indicates the Loop Current drives the longshore currents on the shelf. Momentum transfer occurs at the outer shelf between the current and shelf water largely through eddy-like motions at this boundary.

Another consequence of Loop Current and shelf water interaction is the local modification of water masses. In this respect, the west Florida shelf can be thought of as a transition region between Loop Current water (LCW), waters with fresher, colder T-S characteristics called Continental Edge Water (CEW), and shelf water.

Enhanced primary production has been found associated with the upwelling due to the intrusion of Gulf Stream frontal eddies and meanders off the southeastern continental shelf. The presence of similar frontal eddies along the west Florida shelf indicate that similar effects could be occurring on this outer shelf region.

The two field studies during the third phase of the MMS-sponsored study were designed to study the chances of hydrographic and bilological distributions associated with interactions of the Loop Current and the outer continental shelf. The results of the spring cruise demonstrated the importance of the effects of an intrusion of a Loop Current frontal eddy on the hydrographic structure and primary productivity of the outer shelf. The summer cruise studied the effects of an onshore movement of the Loop Current front.

Hydrographic and enhanced infrared satellite data showed the intrusion of a Loop Current frontal eddy onto the west Florida shelf between April 1 and 7, 1982. T-S characteristics showed that the filament was of LCW uplifted earlier 80 m from the deeper LCW source. The region of cool surface water between the filament of LCW and main body of LCW was identified as CEW by its cooler, fresher T-S characteristics. Sections through this region prior to and during the intrusion showed upwelling beneath this region. Nutrient and oxygen concentrations indicated that the upwelled water was deeper LCW water.

Interleaving occurred along both boundaries of the CEW region indicating that mixing resulted from the intrusion of the LCW filament and front onto the shelf.

The Loop Current frontal eddy had similar characteristics--length scale and speed--to the Gulf Stream frontal eddies described earlier, but the upwelling on the west Florida shelf was less intense and may decrease the impact of intrusions on productivity. This could be due to less energetic current velocities or to loss of energy due to frictional dissipation over the wide shelf area. This one example of a Loop Current frontal eddy may be much stronger or weaker than the mean, and consequently more sampling is needed for a valid comparison.

During September 13 through 18, 1982, hydrographic data were used to study temporal variations associated with fluctuations of the Loop Current. Analysis of a time series of four transects showed a toward-shelf movement of the Loop Current front indicated by an increase in mid-depth salinity maximum characteristic of LCW. During the toward-shelf movement of the current, the thermocline dissipated over the outer slope concurrent with an upslope movement of low-oxygen, high-nutrient water and a progressive doming of isopycnals and isotherms relative to the initally level isolines. These changes could also be due to variations in the alongshelf advection related to the current. A low salinity layer found in the upper 10-20 m is believed to originate in the northern Gulf, possibly from the Mississippi delta. Changes in volume of the low salinity layer were probably related to alongshelf currents, although there are indications that the volume decreased with the toward-shelf movement of the current. Finestructure was present at those stations on the western end of the sampling cross-sections and indicated diffusive mixing at the water mass boundaries between LCW at the outer stations and CEW.

The large degree of hydrographic variability over short time scales (4 to 5 days) at the outer shelf appear to be related to the position of the Loop Current along the shelf break and to cross-shelf and alongshelf currents. Some of the changes appear to correlate with shoreward movements of the Loop Current; however, with the data available we cannot distinguish between effects due to cross-shelf versus alongshelf flow variability.

During both spring and summer cruises, Chl a concentrations in the surface mixed layer were generally very low at about 0.1 $mg \cdot m^{-3}$ or less except within the surface lens of relatively low salinity water (less than 35.5 0/00) where they had higher near-surface Chl a (0.3 $mg \cdot m^{-3}$). Seaward of the 100 m isobath, water was affected by a subsurface intrusion of nutrient-rich, deeper water. The top of the nitracline was located at depths of 40 to 60 m coincident with Chl a concentrations from 0.2 to 1.2 $mg \cdot m^{-3}$.

Enhanced primary production was evident during the summer cruise. Mean primary production of stations influenced by nutrient-rich intruded waters was double that of stations located either seaward or shoreward of the intrusion. Lowest productivity (0.1 $gC \cdot m^{-2} \cdot day^{-1}$) was observed during the spring cruise at a station located off the shelf within the Loop Current. Highest productivity (1.2 $gC \cdot m^{-2} \cdot day^{-1}$) was observed during the summer cruise at the station having the highest concentration of Chl a within the subsurface maximum layer.

On the outer shelf, rates of productivity and euphotic zone Chl a change dramatically in time and space depending on the hydrographic characteristics suggesting upwelling versus non-upwelling conditions may control most of the variability. Since the mean position of the Loop Current varies with the season, this control is probably seasonal and may be more important during upwelling events than during other seasonal effects in the same region.

Based on these studies, dynamics of primary production on the outer southwest Florida continental shelf are similar to those of the outer southeastern shelf. Production rates and biomass are lower on the southwest Florida shelf, probably because the top of the nitracline does not reach as high into the euphotic zone.

REFORMATTING MAFLA & STOCS DATA FOR NODC ARCHIVING

Craig Brandt
Quantus, Inc.

Quantus is reformatting the data from the South Texas Outer Continental Shelf (STOCS) and Mississippi, Alabama and Florida (MAFLA) studies into National Oceanographic Data Center (NODC) formats. Once converted, these data will be available to the public through NODC. The project has been divided into three tasks: (1) data preparation, (2) data reformatting, and (3) data documentation. This presentation summarizes the scope and results of each task.

Approximately 160 files representing 38 data types are involved in this project. These files are being converted into 13 NODC formats as shown in Table 8. As part of the data preparation task, lists of samples, taxa, and chemicals were extracted from the original files. The lists are used to be build cross-reference tables which link the original labels with the NODC-approved labels. We are utilizing the 4th edition of the NODC taxonomic codes (to be released in December 1983) for the taxa and the Chemical Abstract Service names for the chemicals.

TABLE 8

SUMMARY OF THE DATA TYPES, NUMBER OF FILES AND CONVERSION SCHEMA FOR THE MAFLA AND STOCS DATA

Data Type	Number of files MAFLA	STOCS	NODC Format
CHEMISTY			
Demersal fish - hydrocarbons	6		144
Demersal fish - trace metals	2		144
Macroepifauna - hydrocarbons	6	4	144
Macroepifauna - trace metals	2	4	144
Macroinfauna - trace metals		3	144
Mycology - hydrocarbons		2	144
Neuston - hydrocarbons		3	144
Sediment - hydrocarbons	7	8	144
Sediment - total organic carbon	1	1	144
Sediment - trace metals	2	4	144
Water column - hydrocarbons		7	144
Water column - nutrients		3	069
Water column - total organic carbon	1		144
Water column - trace metals	4		144
Zooplankton - hydrocarbons	3	3	144
Zooplankton - trace metals	1		144
TAXONOMY AND ABUNDANCE			
Demersal fish	2	4	123
Macroinfauna	8	4	132
Macroepifauna	1	4	132
Meiofauna	1	4	132
Microbiology		3	009
Microzooplankton and protozoa		1	124
Neuston	1	2	124
Phytoplankton		3	028
Zooplankton	1	3	124

BIOMASS			
Macroinfauna	1		132
Neuston	1		124
Zooplankton	1		124
HISTOPATHOLOGY AND OTHER BIOLOGICAL DATA			
Demersal fish - meristic	1		123
Demersal fish - histopathology		2	013
Macroepifauna - histopathology		2	064
Adenosine triphosphate (ATP)		2	069
Primary productivity		3	069
Chlorophyll-A		3	069
Fluorescence		1	029,049
PHYSICAL DATA			
Marine sediments	3	4	073
Water STD	4	4	022,144
Water column transmissometer profile	1		022

One of the major difficulties encountered in this project was the lack of NODC codes for many of the taxa present in the MAFLA and STOCS biological data. Out of a total of 5,309 taxa, only 3,495 or 66 percent were found in the 3rd edition NODC codes, and an additional 15.5 percent were present in the 4th edition codes. Of the taxa, 991 were not found in the NODC codes, and NODC is currently assigning codes to these taxa. Table 9 summarizes the current status of the NODC code assignments.

TABLE 9

NODC TAXONOMIC CODE ASSIGNMENTS FOR VARIOUS BIOLOGICAL ASSEMBLAGES

Assemblage	Total Taxa	NODC codes assigned 3rd Edition	NODC codes assigned 4th Edition	To be Assigned
Phytoplankton	437	325	88	24
Zooplankton	340	273	58	9
Protozoa	123	8	6	109
Microzooplankton	470	231	30	209
Demersal fish	358	346	3	9
Macroinfauna	3581	2312	638	631
TOTALS	5309	3495	823	991

We are using a relational data management system together with the Statistical Analysis System (SAS) to perform the actual reformatting of the data. Both of these software are implemented on a Digital Equipment Corporation VAX 11/780 interactive minicomputer. The relational data management package is used to generate the sample, taxa, and chemical lists described above, while SAS is used for the actual reformatting task because of its powerful and versatile formatting capabilities.

The final task is the presentation of documentation describing the spatial and temporal extent of the samples, the types of variables measured and the methodologies employed. The purpose of the documentation is to provide the pertinent information which will enable a person to intelligently use the data. We have reviewed cruise reports, progress summaries, and final reports to gather the necessary documentation.

Session: SOCIOECONOMIC EFFECTS OF OFFSHORE OIL AND GAS ACTIVITIES

Chairpersons: Mr. John Rodi
Mrs. Mary R. Bartz
Dr. Carolyn French

Date: November 15-17, 1983

Presentation Title	Speaker/Affiliation
PART I: EMPLOYMENT AND INCOME	
Session Overview	John Rodi MMS, Gulf of Mexico Region
Outlook for Gulf of Mexico Offshore Activity	G. Allen Brooks Offshore Data Services, Inc.
Direct Employment Associated with Gulf of Mexico OCS Oil and Gas Activity	J. R. MacGregor ODECO
The Petroleum Industry in Louisiana	William C. Bailey, Jr. Mid-Continent Oil and Gas Association
Economic Impacts of the Oil- and Gas-Related Industries in Texas	Dr. Jerry Olson University of Texas
A model for Projecting Economic, Demographic, and Fiscal Effects of Resource Development	Dr. F. Larry Leistritz North Dakota State University
The Travel and Residency Patterns of Rig Workers: The Getty Oil Company East Bay Project, Santa Rosa County, Florida	Dr. Thomas Herbert T.A. Herbert and Associates

PART II: COASTAL LAND USE AND COMMUNITY INFRASTRUCTURE REQUIREMENTS

Session Overview	Mary R. Bartz MMS, Gulf of Mexico Region
Industry Methodology for Determining Site Locations	Luther Kelly Placid Oil Company
Actual Land Use for Industry Related Facilities Compared to Estimates Given in the Gulf of Mexico Lease Offering Environmental Impact Statement	Virgil A. Harris Shell Oil Company
State Process of Permitting for OCS-Related Industry Facilities	Dr. Ernest A. Mancini University of Alabama
Florida OCS Facility Siting Studies	Jeffrey L. Kiss Florida Department of Community Affairs
A Comparison of Coastal and Inshore Community Impacts	Ray Quay Rice University
Coordinated Forewarning System for Minimizing Impacts to Sensitive Areas	Mike Hightower Texas General Land Office
Special Management Area Planning for Waterfront Areas	Jerry E. Mitchell Mississippi Bureau of Marine Resources
Offshore Oil and Gas Impacts to Several East St. Mary Parish Communities	Dr. Robert B. Gramling, Jr. University of Southwestern Louisiana

SOCIOECONOMIC EFFECTS OF OFFSHORE OIL AND GAS ACTIVITIES

PART I: EMPLOYMENT AND INCOME

SESSION OVERVIEW

John Rodi
MMS, Gulf of Mexico Region

The 1980's have been and will continue to be a period in which the public's concern over socioeconomic impacts is among the foremost issues addressed in MMS's Environmental Impact Statements. For this reason, it was decided that socioeconomic sessions should be explicitly included in this year's Information Transfer Meeting. Since this is the first time that such sessions have been incorporated, it is pleasing to say that their resounding success on all fronts will ensure their inclusion in any future meetings.

The task of forecasting impacts of Gulf of Mexico OCS oil and gas lease offerings is far from simple. Furthermore, the supply of primary data and related analyses is crucial to any successful attempt at such predictions. The first socioeconomic session provided some extremely valuable data for such employment and income analyses, and the following is a summary of major points.

Everyone can remember the bleak economic outlook for the offshore oil and gas industry which existed as recently as last spring. The industry was operating at about an 86 percent utilization rate and new rigs being delivered were adding to this surplus. The national economic situation, as well as conditions in the oil and gas industry itself, were the primary reasons for this pessimistic outlook. Since then, however, the forecast has changed significantly. The adoption and successful completion of two area-wide offerings in the Gulf in 1983 have provided much economic impetus to this ailing industry. The improvement in national economic conditions, of course, also promises to aid the industry along the path to recovery.

Projections by Offshore Data Services, the first presenter and a highly recognized corporation in the field of oil and gas economics, indicate that the number of wildcat wells to be drilled in the Gulf next year may reach a total of 550, up from the expectation of 300 for 1983. A further increase in such wells is predicted for 1985. While the exploration drilling is certain to increase, a more gradual recovery in development drilling will occur in the next few years. The rate of improvement in development drilling, of course, will rely on conditions within the natural gas market. Based on these projections, the utilization rate of offshore drilling rigs could jump to a level of 92 percent from the recent level of 86 percent by next year. In fact, a possible shortage of deep water drilling rigs and large cantilever jack-up rigs may develop next year, a pleasant change from the past eighteen months.

The beneficial impact of this upturn on Gulf-wide employment and income is obvious. The expected magnitude of this impact, however, may be surprising to many. The direct impact alone of additional oil and gas drilling and subsequent activities can be quite great. For example, an analysis of the Odeco-operated ship Shoal 113 Field, another presentation at this session, which covers 47,500 OCS acres or about eight standard-sized lease blocks, indicated that the direct daily employment has varied between a minimum of 400 people and a maximum of 600 people, depending upon the period you examine from geophysical activity through product sales. This estimate includes such field personnel as geophysical survey teams, mobile rig crews, contract catering crews, permanent surface-based employees, production platform crews, fabrication yard employees, lay barge crews, and employees associated with marine terminals, gas processing plants and refineries. If you add to the list the employees which support OCS activity at Odeco's New Orleans headquarters office, the direct daily employment estimate would be even greater. And, remember, these numbers apply only to one field. If you address all offshore oil and gas activity in Louisiana, the magnitude of employment and income generated thereby becomes quite impressive.

A recent input/output analysis prepared for the Mid-Continent Oil and Gas Association, the third presenter, indicated that there are over 40,000 people directly employed offshore Louisiana in the oil and gas industry with earnings of over $807 million. Furthermore, for every direct job, about two additional jobs in other economic sectors were indirectly created. In total, over 125,000 jobs in Louisiana are directly and indirectly tied to offshore oil and gas activities. In this holistic sense, it's obvious that the OCS oil and gas activity affects more workers in Louisiana than many people realize, including the workers themselves. In addition to these jobs, per se, are the taxes generated for federal, state, and local coffers. Offshore activity results in significant corporate income, franchise and sales tax payments, as well as income and sales tax payments by the workers themselves. The fact that Louisiana currently ranks among the lowest states of our nation in individual tax burdens is clearly resultant from the state and local tax revenues generated by OCS activity.

These impacts of offshore oil and gas activity are not restricted to Louisiana, but are also pronounced in Texas. The strength of the refining sector in that state even further enhances the economic importance of the offshore oil and gas sector. A University of Texas econometric analysis, the fourth presentation, indicated that for every dollar in gross product generated by the refining sector, over $2.50 in gross product were indirectly generated in other economic sectors. Furthermore, for every $1 million in gross product in the refining sector, over 400 people migrated into the region.

Of course, just as these studies indicate the expansion of economic effects of OCS oil and gas activity on the Gulf Region, any reduction in OCS activity in the Gulf would result in equally pronounced direct and indirect economic losses.

Finally, it is well known that while the economic impact at the regional level may be clearly beneficial, the impact at the local level of

OCS oil and gas activity regarding requirements for public facilities and services may be both great and not so clearly beneficial. Fortunately, there has been an increase in the supply of data in recent years which can be used to improve our analysis of this condition. Various rigorous economic models, such as the North Dakota State University economic demographic model, described in one of our presentations, have residential allocations, service requirements, and fiscal impact sub-components built into them. Also, less rigorous but equally important grass root analyses such as the study of commuting patterns for oil and gas workers in the Florida State Water East Bay Field, described by our final presenter, have helped to indicate exactly where the offshore workers live and spend much of their income. For example, despite Getty Oil Company's determined effort to hire locally in the East Bay Field, over two-thirds of the workers lived in Louisiana, Mississippi, and Alabama. The commuting pattern for workers in Louisiana and Texas, much more developed areas, seems to be no less pronounced according to other recent analyses.

In conclusion, it is clear that some important socioeconomic data was disseminated through this year's Information Transfer Meeting. Of course, there are still many existing data gaps. The entire MMS socioeconomic staff in the New Orleans Office looks forward to continued communication with the speakers, as well as with all who attended the socioeconomic session on employment, income, and population.

OUTLOOK FOR GULF OF MEXICO OFFSHORE ACTIVITY

G. Allen Brooks
Vice-President, Offshore Data Services, Inc.

Offshore Data Services performs various studies for companies engaged in operations in the Gulf of Mexico and worldwide, also. In all cases, the studies are designed to answer specific management questions about particular markets and business opportunities. While most of these studies are oriented toward the mobile drilling rig industry, studies are also done for field development markets and other support industries operating in the Gulf.

A study we completed early in 1983 forecasts the outlook for the worldwide mobile drilling rig fleet from 1982 to 1990. In the face of declining oil and natural gas prices along with falling demand, the outlook for mobile drilling rig activity appeared bleak this Spring. In fact, the industry was operating at about an 86% utilization rate, and new rigs being delivered were adding to the surplus.

An economic model was developed to forecast 1983-1990 oil company cash flow and spending. The oil industry spends about 20 percent of its cash flow for new exploration and about 20 percent of that amount for offshore exploration. We have assumed that the percentage of oil company spending going for offshore work will increase over the next few years from 20 percent to 30 percent. This assumption is based on a belief that oil companies have basically explored the onland area adequately and will need to hunt for reserves in the area where larger discoveries can be made, i.e., offshore. Also, acreage for exploration in this more promising area is being made available.

Based on assumptions of $28.46 per barrel oil and $1.86 per MCF of gas in 1980, oil and gas demand ten percent below 1980 levels, and oil company total exploration and offshore spending of 20 percent and 30 percent, respectively, we believe there will be sufficient funds available to profitably employ the entire mobile drilling rig fleet in 1985.

In the Gulf of Mexico, we believe the rig utilization rate recovery may come sooner than expected by many and possibly before the overall market. The two area-wide lease sales have laid the foundation for a strong recovery in exploratory drilling commencing in 1984. The number of wildcat wells to be drilled in the Gulf next year may reach a total of 550, up from 301 forecast for this year. A further increase in wildcat wells drilled can be forecast for 1985. While exploration drilling will be increasing, only a gradual recovery in development drilling will occur in 1984. The rate of improvement in the development drilling market will be the condition of the natural gas market. Based on an assumption that the gas "bubble" will not burst before 1986, Gulf of Mexico drilling activity offshore should employ between 180 and 200 mobile drilling rigs, which means between an 83% to 92% utilization rate for the fleet in 1984. A possible shortage of deepwater drilling rigs and large cantilever jackup rigs may develop next year, a pleasant change from the past 18 months. These prospective shortages could motivate rig owners to move idle foreign rigs back to the Gulf. Depending on the number of rigs moved, a lower utilization rate could occur.

Given the lag time between drilling and field development, the marine construction industry will probably have to wait until 1985 for any significant improvement in its outlook. This will be true also for the workboat and diving industries, although the workboat industry will benefit from the return to work of a number of mobile drilling rigs. The workboat industry's biggest problem is a severe capacity over-supply.

In conclusion, the 1984 recovery in the Gulf will provide help to what is at present "sick" industry. If companies can hang on for a while longer, better times lie ahead.

DIRECT EMPLOYMENT ASSOCIATED WITH GULF OF MEXICO OCS OIL AND GAS ACTIVITIES

J. R. MacGregor
ODECO

I have been asked to discuss direct employment for typical operations in the Gulf of Mexico OCS covering the whole field of operations, from geophysical surveying through the refining of oil and the processing and fractionation of gas. Since the wide variety of conditions in the Gulf, such as water depths, distance from shore, and both normal and abnormal pressures, causes atypical operations to be the norm rather than typical, I have chosen a field operated by Odeco which does permit tracing all categories of operations from geophysical through refining and gas processing/fractionation.

The Ship Shoal 113 Field, which through recent additions now includes some 47,500 contiguous acres, is located between 10 and 25 miles offshore, southerly from Houma, Louisiana. Water depths vary between 30 and 53 feet. The linear dimensions are roughly 6 miles by 18 miles. Daily production currently averages about 8500 bbls. of oil and 55 million cubic feet of gas. The geology is such that, with the exception of one 12-well platform, the development has been with individual wells drilled with mobile drilling barges. The large area to cover and the number of currently producing wells and operating structures require a rather large number of marine equipment pieces. With this general background as a basis, I will now discuss direct employment in the various operations needed to get from the discovery stage to cash in the bank.

Geophysical work has been done periodically throughout our development of the original 30,000-acre farming and more recently on the new acreage acquired as a southwest extension. A typical geophysical survey will begin and end with a Party Manager on land who handles the logistics between his company and the survey boat and who gets most of the records processed. The survey boat is a highly instrumented vessel operated by a marine crew of 2 captains, 1 engineer, 1 deckhand, and a cook. The survey crew usually includes the following additional personnel:

1-Coordinator
2-Observers or instrument technicians responsible for maintenance and the operation of the recording equipment.
2-Gunners who are responsible for whatever energy source is being used.
5-6- Helpers, who are assistant observers or gunners.
2-Navigation people who are responsible for course setting and shotpoint spacing.

This operation would generally be done around the clock, so probably a day and a night geophysical crew would be used while the marine crew would not have replacements aboard. Since either a 6 days on and 6 days off or an 8 and 8 schedule of crews would be used, the entire operation described above employs about 60 people.

To test the validity of the seismic indications, exploratory drilling in this field would be done with a mobile offshore drilling unit of the bottom supported type which would normally be crewed by the following:

1 - Toolpusher on duty around the clock.
1 - Driller
1 - Derrickman
3 - Floormen or roughnecks.

This drill crew would work twelve hours while a relief crew would be resting aboard. An engine room crew aboard the unit would include 1 rig mechanic, 1 electrician, 1 welder, and 3 motormen. A roustabout crew would include a pusher/crane operator and 3 roustabouts. This crew would normally work 12 hours plus any overtime required. A contract catering crew totaling about 5 people is necessary. Since an identical relief crew on the beach is required for the above, such a rig would employ a total of 52 people.

In water deeper than 300 feet either a drill ship or a semi-submersible barge would be required. This type of rig would use an additional on-board marine crew of 5 people plus 5 more roustabouts, 3 control room operators, and 1 barge engineer, all with relief on shore.

On both the floaters and bottom supported types, all Odeco rigs have aboard continuously one additional person, an Industrial Relations Representative, who is primarily concerned with training, safety, and first aid.

Often for an exploratory well in a new area, an operator will use a temporary service base. This will usually be the dock and loading facilities of the drilling mud company from whom he is purchasing mud supplies.

Following the exploratory drilling, development drilling would use the same type of mobile drilling unit. On the one multi-well platform in this field, the platform rig we used required about the same crew as is used on a bottom-founded mobile rig.

Each drilling rig in use would normally use 1 supply boat, 1 speed boat, and 1 standby boat. In Ship Shoal 113 Field, the proximity of the production boats makes it possible to eliminate standby boats, so the total crew of the boats with the 2 drilling rigs usually in use would be 28, counting their relief on shore.

Once production has been established and contract drilling operations have begun on a continuing schedule, permanent bases are usually established. Our main base for the Gulf at Amelia, Louisiana near Morgan City, services mostly our contract drilling business and our development drilling operations and to a lesser extent our production operations. This base employs 10 people continuously plus an additional average number of contract people such as crane operators and roustabouts totaling 14 men.

Production operations for the Ship Shoal 113 Field are supplemented by using a service company base at Dulac, where we have 4 of our own people employed, plus use of the service company personnel. Similarly the 2 rigs used fairly steadily in the field for development drilling are supplemented by using, along with our Amelia base, a mud company base at Dulac. Here we employ 2 dispatchers plus contract roustabouts when required.

Along with the experience of the general economy and because of overbuilding, the contract mobile drilling industry in the Gulf has suffered severely in the last year or so. In order to keep our well-trained people with us, both the management of Odeco and the rig workers themselves welcomed a work program which kept everybody working without layoffs but on a reduced time schedule. Where normally a rig uses 4 crews - 2 on the rig working 12 hours on and 12 off, with 2 replacement crews on land to relieve them every 7 days, we are now using 5 crews. Each crew works 7 days on, 7 off, 7 on and 14 off. With this schedule, each crew works (and gets paid for) only 80% of the time it would normally work, over a year's time, if 4 crews/rig were used, yet each crew has steady work.

Each rig in use causes additional employment besides the boats it uses, including the lease operator's representative, helicopters for crew changes, casing crews, pile driving crews, drilling mud technicians, and many other third party service representatives. These numbers are difficult to estimate.

To operate the 5 production platforms and 154 active well jacket structures in the Ship Shoal 113 Field requires a regular complement of 29 people, including gaugers, roustabouts, mechanic/electricians, and instrument technicians, all rotating every 7 days with an equal number who have been on their days off. In addition, 3 production foremen and one maintenance foreman work the field on an unscheduled, as-required basis. These men require partial use of 1 helicopter plus 6 utility boats and 2 speed boats to do their work. One pilot operates the helicopter, while the 8 boats use a total crew of 8, with another 8 on land for relief.

On the average, 2 lift boats are kept busy in the field with paraffin cutting, through-tubing workovers, and construction work. Each lift boat normally uses a crew of 3 plus 2 cooks. Their relief crews on land added to these come to 20 personnel for the 2 lift boats.

Catering crews, totaling 5 people on 3 of the production platforms, have an equal number ashore for relief. These caterers serve meals to the foregoing company production personnel plus an average of 35 contract personnel, such as divers, welders, painters, meter men, etc.

When a new structure is required in this field, fabrication is done ashore. One such fabrication yard in the Morgan City area employs about 1500 people. This yard is capable of fabricating about 10 100-foot water depth, 8-pile platforms in staggered fashion, simultaneously. In addition, another 10 could be prefabricated. A portion of the complement of this yard could thus be allocated to the one platform in question.

Once fabricated, a derrick barge would be used to install this platform A supply barge would be used in conjunction. Two tugs, each with a crew of four or five, would handle this equipment. The derrick barge might carry acrew of 80, counting both the working and resting crews. An equal number in each of 2 relief crews would be ashore, all working a 14 days on, 7 off schedule. Thus, the derrick barge crews ashore and aboard would total 240, plus the tug crews.

After installation, this platform would require flow lines to tie it in with the rest of the field. These lines would normally be laid in this field with a lift boat (due to their small size (3'6") and the shallow water) which again would employ 5 people per lift boat plus contract roustabouts. In deeper water and for larger lines, however, a typical lay barge might be used. The 2 crews aboard would total about 200, with 4 relief crews ashore to form the 7 days on, 14 off schedule. Such a spread, therefore, can employ about 300 people. Additionally, 4 tugs would be used, 2 with the lay barge and 2 with pipe hauling barges, each with a complement of about 5, for a total tug complement of 20.

Such a lay barge was used several years ago to lay the 8-inch, 30-mile pipeline connecting this field to our barging terminal at Cocodrie, Louisiana.

Before laying, this line required coating. One such coating yard in Houma which handles 2" - 16" pipe employs an average of about 20 people.

The Cocodrie terminal includes tanks with 120,000 bbls. of storage, a heater/treater and loading dock, from which the oil is transported by barges whose tugs utilize 4 people. The terminal itself uses a crew of 3, with the same number on their time off. A major portion of the oil from the Ship Shoul 113 Field goes to the Murphy refinery at Meraux, Louisiana.

The Meraux refinery has a daily throughput of about 70,000 barrels of crude and employs 283 people. About 58% or 41,000 barrels of the total throughput comes from OCS and State waters in the Gulf, some of which is from Ship Shoal 113. Therefore, some portion of the 283 persons refinery complement could be allocated to this field.

The gas production from Ship Shoal 113 is purchased in the field by 2 different gas purchasers and transported ashore by their lines. The majority of this gas goes through a processing plant near Gibson, Louisiana, which is partly owned by us and where we are entitled, by our gas purchase contract, to extract liquids. This plant has a daily throughput of 730 MMCF. It employs 35 people, a portion of which could be allocated to our field's production. Its daily output of 16,500 bbls. of "raw make" is transported to a fractionation plant on the Mississippi River near Geismar, Louisiana. This plant, also owned partially by us in proportion to our throughput, separates the raw make into ethane, propanes, butanes, pentanes, and heavier. Plant personnel totals 21 people.

A review of the foregoing discussion of direct employment in just one so-called "typical" OCS field indicates that depending on which period we examine during its recent life, from geophysical through product sales, the direct daily employment can vary between a minimum of 400 people to a total of 600 people.

In addition to the field personnel used for the 113 Field, a certain proportion, difficult to estimate, of Odeco's people in our New Orleans office would be directly attributable to operation of this field.

The employment numbers developed in the foregoing show why it was possible for Dr. Loren Scott of L.S.U., in his recent study, to determine that offshore Louisiana oil and gas operations directly and indirectly contribute 125,000 jobs to Louisiana's economy.

THE PETROLEUM INDUSTRY IN LOUISIANA

William C. Bailey, Jr.
Mid-Continental Oil and Gas Association

The Mid-Continent Oil and Gas Association recently commissioned a study on the economic impacts of the oil and gas industry in Louisiana. The study was conducted by Dr. Loren C. Scott of Louisiana State University. Results were published in a report entitled "The Petroleum Industry in Louisiana." The report dealt with the impacts of both onshore and offshore oil and gas operations.

Dr. Scott's study indicated that the oil and gas industry is the dominant economic force in Louisiana. In 1980, production and refining of oil and gas created more than 95,000 direct jobs paying wages and salaries of more than $1.9 billion. These direct benefits are multiplied as dollars spread through other sectors of the economy. For every dollar in new earnings created in the oil and gas extraction industry, $1.25 in additional new earnings is created elsewhere in the state. For every dollar in new earnings created in the petroleum refining industry, almost three dollars in new earnings is created in other sectors of the economy. Conversely, for every dollar lost to the oil and gas extraction industry, $1.25 is lost elsewhere in the economy, and a dollar lost in the petroleum refining industry means three dollars lost elsewhere in the economy.

New jobs are also created indirectly through multiplier effects. For every new job created from new sales in oil and gas production, two jobs are created elsewhere in the Louisiana economy. For every new job created in the petroleum refining industry via sales, almost six new jobs are created elsewhere in Louisiana. Conversely, loss of sales, earnings, or jobs in the the oil and gas industry has a large negative impact on other sectors.

The offshore oil and gas industry is a segment of the industry that is less understood than most. Assessing its economic impacts has been difficult. According to this study, in 1981, offshore Louisiana oil and gas production was valued at $19 billion. About $17.4 billion of this was generated in the federal OCS. Offshore production created $1.8 billion for Louisiana in household earnings. More than 55% of those earnings was created in other sectors of the Louisiana economy. The maintenance and construction, business services, and retail and wholesale trade categories were identified as the largest beneficiaries. In 1981, 125,343 jobs in Louisiana were directly or indirectly related to offshore oil and gas production. Of these, there were 41,781 people directly employed in the offshore oil and gas industry. Direct employment offshore earned $807.7 million. An additional 11,088 workers employed in maintenance and repair construction earned $183.6 million. In the business services sector, 10,280 jobs were created with a payroll of $124.8 million. In the retail trade sector, 11,161 jobs were created with a payroll of $102.8 million, and in the wholesale trade area, there were 4,479 jobs with a payroll of $73.4 million. In 34 other sectors of the economy combined, the presence of the offshore industry was responsible for the creation of 46,554 jobs with a payroll of $514 million.

The State of Louisiana derives much of its income from severance taxes and from royalty, rental, and bonus payments. In the 28-year period studied, the oil and gas industry's direct payments to the state often represented more than 50% of the total amount collected by the State Department of Revenue and Taxation and the State Mineral Board. In fiscal year 1981-1982, severance taxes and royalty income accounted for 49.6% of the funds collected by the two agencies. Because of the money collected from the petroleum industry, the tax burden on the individual citizen in Louisiana is among the lowest in the United States. In addition to these direct payments, the petroleum industry pays corporate income taxes and franchise taxes, as well as sales taxes on products purchased within the state. Employees also pay sales taxes and personal income taxes.

During one 12-month period, petroleum industry corporations paid over $23 million in corporate income taxes and over $16 million in corporate franchise taxes. In 1982, personal income taxes paid by petroleum industry wage and salary workers totaled $15.5 million, or 7.1% of total personal income taxes paid that fiscal year. These figure do not include data on payments made to the federal government in connection with OCS operations. Between 1953 and 1980, more than $26 billion was paid into the federal treasury from bonuses and rents on production in federal waters off the coast of Louisiana.

The presence of the oil and gas industry has been responsible for dramatic population shifts and a restructuring of areas of higher per capita income. Over the 40-year period under study, the group of parishes that were most dependent on agriculture or government employment declined in ranking. The parishes that gained most in per capita income were those whose economies are most closely related to oil and gas extraction or petroleum refining and petrochemical production.

Oil and gas operations provide the backbone of the State of Louisiana's finances. The oil and gas industry provides an important source of jobs, payrolls, and tax dollars. Given its massive influence on the state's economy, every effort should be made to ensure the continued contribution of the oil and gas industry to Louisiana's economic health in the future.

ECONOMIC IMPACTS OF THE OIL- AND GAS-RELATED INDUSTRIES IN TEXAS

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The Bureau of Business Research at the University of Texas at Austin has developed an econometric forecasting model of Texas economy. In development since 1979, the model has been used by business and government for long-term forecasting, conditional forecasting, and policy analysis. Summaries of the model's forecasts are available in printed form, and special analysis projects using the model can be arranged through the Bureau. For the purposes of this presentation, the model was used to demonstrate the importance of oil- and gas-related industries in the Texas economy.

The model is a system of simultaneous equations, estimated using ordinary least squares on annual data from 1960 to 1981. Unlike most regional models, which are demand-driven, this model is driven by both supply and demand. The supply side consists of a neoclassical production function, in which the stock of capital and labor are determined by investment and migration equations. The migration equations are the link between the economic and demographic aspects of the model. Most economic models take the population and its characteristics as given, whereas most demographic models ignore economics altogether. The Bureau's model is unique in that the economics and demographics of the state are jointly estimated in a consistent model that includes both.

The model is large, with 290 equations, and 140 exogenous variables. The exogenous variables include:

- U.S. Investment

- Texas' Relative Attractiveness to Business
(Markets, Wage Rates, Oil)

- Births and Deaths

- Texas' Relative Attractiveness to People
(Wage Rates, Cost of Living, Availability of Jobs)

- World Oil Prices and U.S. Rotary Rigs

- Interest Rates

- U.S. Wages and Prices

- Federal Spending

- Texas Agricultural and Oil and Gas Production

In order to determine the impact of the oil- and gas-related industries in Texas, the model was run three times. The first run was based on our expectations regarding the future values of the exogenous variables. We refer to this run as the baseline run. The two other runs were a low-oil-price run and a high-oil-price run. In the low-oil-price run, we assume that the price of oil will remain low as the world economy stagnates and the so-called oil glut continues. In the high-oil-price run, we assume that the world economy recovers, increasing the demand for oil, and that a crisis occurs in the Middle-East, resulting in a doubling of the price of oil in 1986. The baseline scenario was used to determine the direct impacts of the oil- and gas-related industry, and the differences between the high-and low-price scenarios were used to get an idea of the influence the industry has on other sectors of the economy.

DIRECT IMPACTS

The oil- and gas-related industries are defined for the purposes of this presentation as the sum of the oil and gas extraction industry, the petroleum refining industry, and the chemical industry. Thus defined, the industry employs about 5.2% of the labor force in Texas and produces about 21% of the gross product. The fact that the industry produces a greater percent of product than it uses of the labor force is a manifestation of the capital intensity of the industry. The total employment of the industry is about 354 thousand workers, two-thirds of whom work in oil and gas extraction. The output of the industry is about 11 billion, about half in extraction, one-third in chemicals, and the rest in refining.

INDIRECT IMPACTS

The indirect impacts of an industry are the changes induced in other industries and in the demographic characteristics of the population by the presence of that industry. We estimated these by comparing the changes in the oil industry to changes in other industries and the population when the price of oil was alternatively set to the low and high levels. We found that in the high price scenario, employment in the extraction industry rose markedly, while output rose only slightly. This phenomenon is the result of decreasing productivity as marginal fields are tapped. In the low-price scenario, both output and employment in the extraction industry declined markedly. In the refining and chemical industries, the low price scenario brought forth more employment as well as output, as the quantity of oil demanded increased with the decrease in price. With less extraction and more refining, more oil will be imported under the low-price scenario than under the high-price scenario--just as we would expect.

In the low-price scenario, the Texas gross state product in 1990 is estimated to be $152 billion, but in the high-price scenario, the figure is $163 billion. The overall economic production of the state is then increased by about $11 billion. This economic improvement is brought about by a $4.2 billion increase in oil-related production. Thus, for every dollar of production in the oil-related industries, the economy grows by about $2.63. Similarly, in the high-price scenario, the population of the state is projected to grow to 18.5 million in 1990. In the low-price scenario, the estimated population in 1990 is 17 million. Thus, the improved economic conditions in the state induced an additional 1.5 million people to migrate to the state over the period of the forecast. Thus, for every million dollars of additional product in the oil-related industries, an additional 360 persons migrated to the state.

A MODEL FOR PROJECTING ECONOMIC, DEMOGRAPHIC, AND FISCAL EFFECTS OF RESOURCE DEVELOPMENT

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The purpose of this paper is to describe the structure and applications of a model that projects economic, demographic, public service, and fiscal effects of resource development projects at the state, multi-county regional, county, and municipal levels. The sections which follow briefly summarize the model's analytical capabilities, its basic structure and logic, the procedures utilized in implementing the model in northern Louisiana, and empirical tests of model validity.

MODEL CAPABILITIES

The socioeconomic modeling system described here has been implemented and tested in six different states: Louisiana, Montana, North Dakota, Texas, Wisconsin, and Wyoming. These modeling efforts have been sponsored by the U.S. Department of Interior, the U.S. Department of

Energy, and several private firms. More detailed descriptions of the model and its applications are available on request from the authors.

The model provides baseline and single- or multiple-project impact projections for multi-county planning regions (functional economic areas), counties, and municipalities. The model takes into account nonenergy, as well as energy-related, development projects and allows for evaluation of decline (as well as expansion) in a region's economic base.

The user is allowed to select either a state planning region or a group of counties (up to 15 counties may be specified) as the basis for model output. Output reports are available as selected by individual user at the regional, county, and municipal levels and include such variables as type of employment, population, population by age and gender, school enrollments by age, housing requirements by type, public sector costs and revenues by type, and net fiscal balance. Requirements for medical and criminal justice services are available at the county level, and estimates of business activity and personal income are available at the regional level. The model provides annual projections of these indicators over a 25-year planning horizon (1981 to 2005).

The model provides both baseline and project-initiated impact projections to the year 2005. The baseline projections indicate the expected response of economic and demographic factors in a designated area if the economic and demographic trends of the 1960s and 1970s were to continue. The impact projections allow for the assessment of the effects of single or multiple developments at alternative sites.

The model is user interactive; the user has the option of altering a number of the model's assumptions and parameters and of choosing the output reporting options desired. Key parameters in all components can be altered, and reporting options allow the user to select certain types of output and to choose the specific areas and time periods for which outputs are desired.

MODEL STRUCTURE

The model consists of six basic components: 1) An Economic Input-Output Module; 2) A Cohort-Survival Demographic Module; 3) An Economic-Demographic Interface Module; 4) A Residential Allocation Module; 5) A Service Requirements Module; and 6) A Fiscal Impact Module. The economic module estimates the gross business volume by economic sector associated with a specified level of final demands for an area's products. Employment requirements by sector and development phase are then derived from the estimates of gross business volume. The demographic module projects population by age and gender and estimates the available labor force. The interface component links the projections of required employment from the economic module with the projections of available labor force from the demographic module to determine the level of employment needs that can be met by the indigenous population and those needs that must be met by the in-migration of new workers. The residential allocation module estimates the settlement patterns of new workers and their families, and the service requirements module projects the needs for selected services and facilities associated with project-related population growth. The fiscal impact module then projects changes in public sector costs and revenues resulting from the project-related economic and demographic change. These components operate differentially at the regional, county, and municipal levels. A generalized flow diagram of the model is shown in Figure 25.

ADAPTATION OF THE MODEL TO LOUISIANA

As a test of the model's adaptability, the system was implemented for a 29 parish area in northern Louisiana (Figure 26). This area was divided into three multi-parish regions, each approximating the service area of a major trade center. A 20-sector input-output (I-0) model was developed to approximate the interindustry relationships in the study area. Because of time and resource constraints, the I-0 coefficients were estimated from secondary sources. Sales to final demand for each sector were estimated

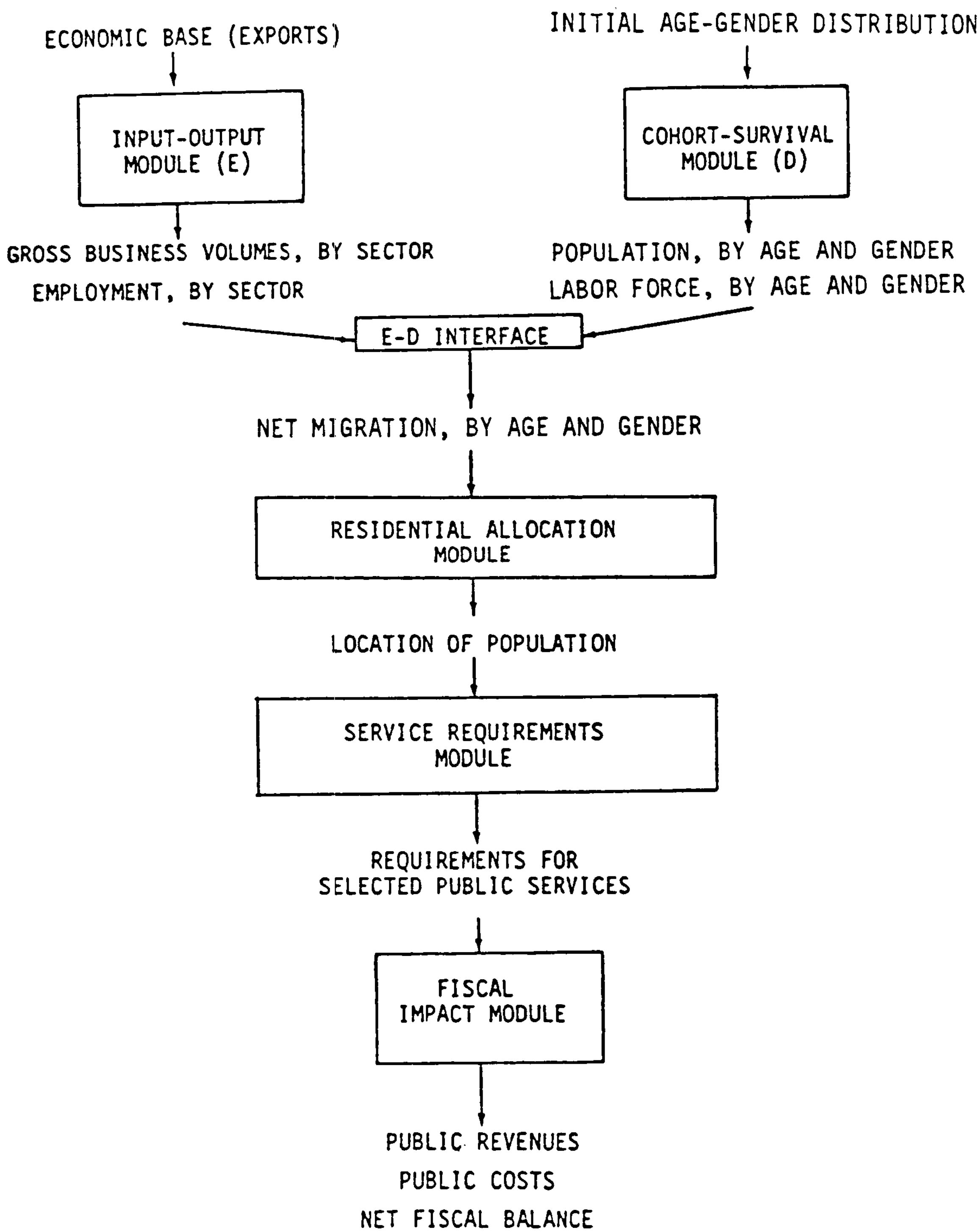

Figure 25. Data and Output Flows of Economic-Demographic Assessment Model

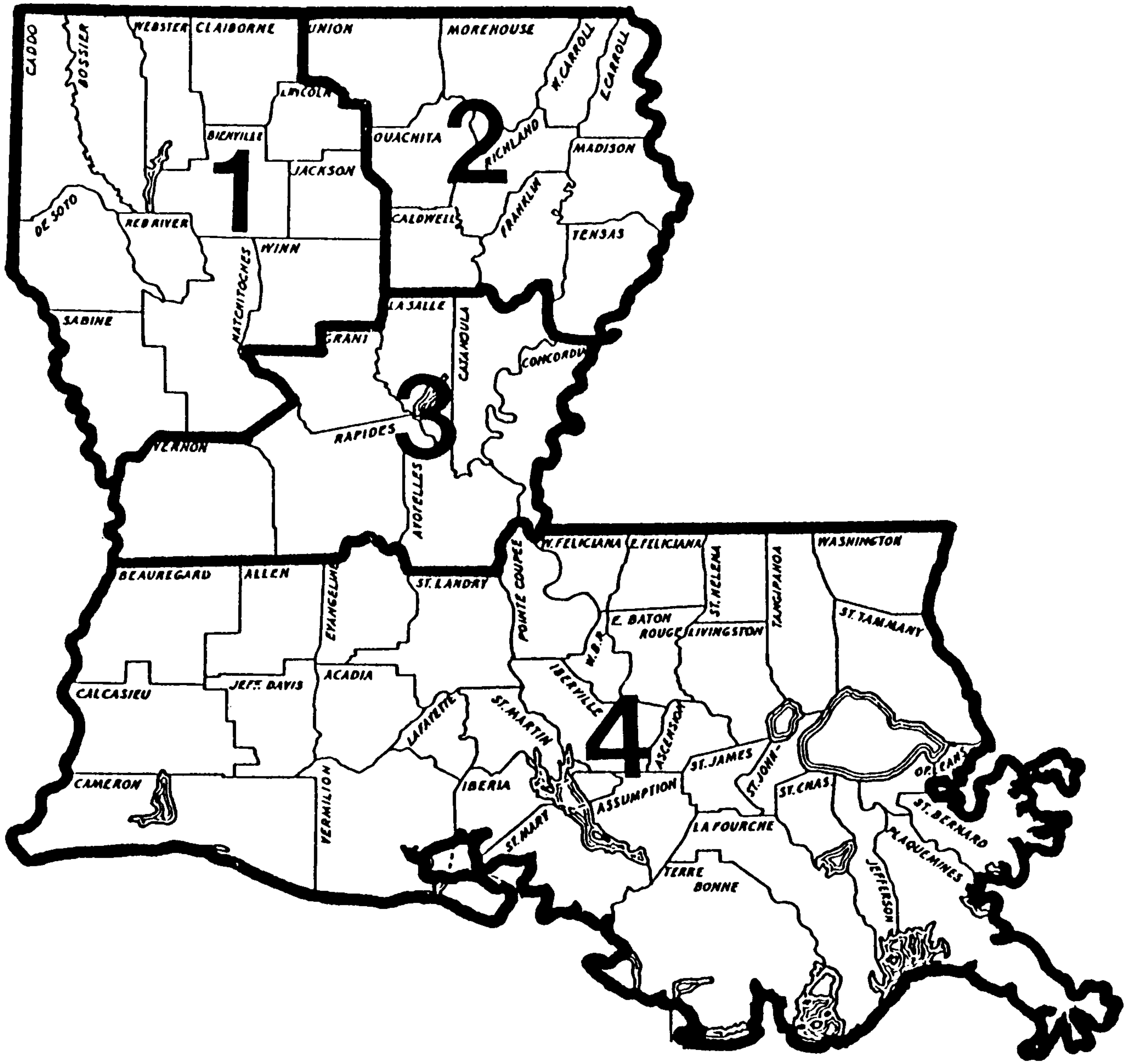

Figure 26. Regions for Louisiana Model Implementation

from secondary sources for the period 1970 to 1980. These historical estimates were then utilized in projecting future trends in sales to final demand (exports) for each sector. Information from the Louisiana Department of Labor was used to estimate statewide employment for each I-O sector for the period 1970 to 1980. State employment was allocated to parishes using information from the U.S. Department of Commerce County Business Patterns. These historical employment estimates were used in conjunction with estimates of gross receipts for each sector (from the I-O model) to estimate output per worker in each sector, and these historical estimates of output per worker were used in projecting future trends.

Key inputs for the demographic module include initial (i.e., 1980) population by age and gender and projections of rates of fertility, mortality, and nonemployment-related migration. These items of input information were derived from the 1980 Census of Population together with state vital statistics data. Projections by the U.S. Bureau of Census were used in trending birthrates for future years.

Implementing the public service and fiscal impact modules required estimates of various state and local tax rates, service utilization factors, and public service costs. These model parameters were developed using information from a variety of state agency reports and from the Census of Governments.

In summary, because of time and resource constraints the implementation of the model in northern Louisiana relied heavily on secondary data sources. This implementation effort provided a test of the feasibility of utilizing such a system in the absence of the resources to enable undertaking substantial primary data collection efforts.

MODEL VALIDATION

In order to test the historical accuracy of the system, the model was used to simulate economic and demographic changes for the period 1970 through 1980 for selected Louisiana regions, parishes, and cities. Parish and city populations for 1970 were used as starting values, and estimated sales to final demand for the years 1970 to 1980 were supplied as model inputs. Model-generated estimates of personal income for the years 1970 to 1980 were compared to those reported by the U.S. Department of Commerce, Bureau of Economic Analysis, while population estimates for the year 1980 were compared to corresponding census values. These comparisons are summarized in Table 10.

Examination of Table 10 indicates a reasonably close correspondence between estimated and reported values. For Louisiana personal income, the mean difference between the two sets of values was 2.2% at the state level and only one region had a difference of more than 10%. The mean absolute error (average of differences taken without respect to sign) also was less than 10% for all but one region. For population, the mean difference for northern Louisiana parishes was only 1.8% while the corresponding figure for municipalities was 6.3%. The mean absolute difference for parishes was only 8.4%, but the corresponding figure for cities was 21.9%.

Overall, the historical simulation analysis indicates that the model performed reasonably well in projecting economic and demographic changes at state, regional, and parish levels. At the municipal level, while there is no pronounced tendency to systematically over- or underestimate population levels, the percentage differences between estimated and reported population for individual communities often are substantial. These results indicate the need for socioeconomic analysts to give greater attention to factors influencing the distribution of economic and population changes and also a need for local planners and decision makers to carefully evaluate the reasonableness of such projections, particularly for small areas. Given the model's performance level for northern portions of the state, the model has great potential to be implemented in coastal Louisiana. The feasibility of utilizing the model will, of course, depend on such matters as developing appropriate input-output coefficients as well as reasonable demographic and offshore worker commutation assumptions.

TABLE 10

COMPARISON OF ESTIMATED AND REPORTED PERSONAL INCOME AND POPULATION[a]

Variable	Mean Percentage Difference	Mean Absolute Percentage Difference[b]
Personal Income		
Louisiana, 1970-1980:		
Region 1	- 3.5	3.5
Region 2	- 3.6	4.7
Region 3	+10.8	10.8
Region 4	+ 2.8	6.4
State Total	+ 2.2	5.3
Population		
Louisiana parishes, 1980[c]	+ 1.8	8.4
Louisiana municipalities, 1980[d]	+ 6.3	21.9

[a]Reported values of personal income are from U.S. Department of Commerce, Bureau of Economic Analysis, "Regional Economic Information System," Washington, D.C., various years. Reported values of population are from U.S. Department of Commerce, Bureau of Census, U.S. Census of Population, 1980.

[b]Computed by taking a simple average of individual differences (for years, parishes, or cities) without respect to sign.

[c]For 29 parishes (Regions 1, 2, and 3).

[d]For 160 municipalities.

THE TRAVEL AND RESIDENCY PATTERNS OF RIG WORKERSTHE GETTY OIL COMPANY EAST BAY PROJECTSANTA ROSA COUNTY, FLORIDA

Dr. Thomas Hebert
T. A. Herbert and Associates

The accurate prediction of worker immigration is a major consideration in the projection of the onshore impacts associated with the exploration and development of offshore oil or natural gas fields. Most socioeconomic predictions, i.e., the need for increased public services and new housing, are dependent on knowing how many new residents will move into an area because of a drilling project. Yet most frequently worker movement is projected on the basis of gross demographic statistics. Few studies have been done to document the number of workers attracted to a specific project or to determine where they lived in relation to where they worked.

This paper documents worker movement related to an inshore natural gas exploration project conducted by Getty Oil Company in East Bay, Santa Rosa County, Florida. Site construction for this project began April 9, 1983. The well was spudded on June 3 and plugged and abandoned November 14 after testing indicated it was a dry hole. Site restoration was completed in mid-December, 1983. As documented by records from environmental orientation forms, more than 700 persons traveled the 17 miles from the Getty shorebase in Pensacola to the East Bay well site in Santa Rosa County over that nine-month period; 649 of those were rig workers, employed by one of the 82 service companies, contractors and consultants that provided some drilling-related service, or by Getty Oil Company and its drilling partner, Exxon Company, USA. The term rig worker is used in this paper to include the drilling crews, caterers, boat and tug crews, service company employees, environmental specialists, construction crews, and other support workers required to conduct the East Bay Project.

Environmental concerns were of major importance to the Santa

Rosa-Escambia County area that attributes a sizeable share of its economic base to water-related industries such as tourism and commercial fishing. Employment issues or the prospect of new jobs for county residents were discussed during pre-permitting negotiations but were not formalized or made part of permit conditions. Getty Oil Company responded to the employment question by agreeing on an informal basis to use as many Florida-based firms as possible and to encourage all specialty and subcontracting firms "to hire Florida." This policy no doubt skewed the work force slightly in favor of Florida residents; otherwise the project is typical of inland water drilling operations.

Several factors should be understood before reviewing the results. This project was conceived after the fact, making collection of other demographic factors, i.e., age and sex, impossible without the development and administration of a survey instrument or other measures that would exceed the scope of this study. In addition, the population total does not reflect any adjustments for labor turnover during the project. The total number of workers is greater than for similar operations where stringent environmental stipulations are not required.

Of the 649 workers involved in the East Bay Project:

- Twenty-nine % lived aboard the rig or support boats on a regular basis, working shifts that ranged from the five days on/five days off (5/5) required of the Getty foreman to the 14/14 shift worked by some boat crews and captains. The drilling crews, employed by the rig owner, Atlantic Pacific Marine Corporation, worked a 7/7 shift.
- Twenty-four % of the workers traveled to the rig to perform a special service, i.e., set casing, and stayed over for one or more days, depending on the duration of the task at hand.
- Forty % visited the rig on an as-needed basis to perform a special service, i.e., repair communication equipment, but did not stay over.

- Seven % of the employees worked on or around the rig on a regular daily or monthly basis but did not stay over, i.e., the environmental monitoring crews.

The data indicate that 27 Florida businesses and 228 Florida workers participated in the Getty Oil Company East Bay Project; 201 of those workers were from the Pensacola-Northwest Florida area. Five oil field service companies now located in Santa Rosa County and five Pensacola marine transportation companies capable of serving the oil industry were used.

According to the environmental records, 228 or 35% of the 649 persons who worked on the rig lived in Florida; 201 of these were in the Pensacola-Northwest Florida area. Seventy-one of those persons who reported Florida addresses were employed by out-of-state, oil field specialty companies such as the drilling and catering contractors. Alabama was listed as home by 109 workers; 117 listed Louisiana, and 119 listed Mississippi. Two persons were from Georgia; 11 were from Texas; one from Arkansas; one from Massachusetts; one from New Mexico, and one from Alaska. No data concerning home addresses were available for 59 persons who signed environmental sheets and indicated that they represented one of the 82 participating businesses.

Worker travel and residency patterns did emerge from the data along with patterns in company locations. The data suggest that in-migration of workers may be minimal in the exploration phase of an oil and gas drilling project; commuting may be the preferred strategy. The travel and residency patterns for a single project are, however, but a first step in establishing a profile of those persons who work on oil and gas rigs. Standard demographic data will be needed, and a cross-section of project-specific data should be collected.

The comments solicited from rig workers attached to the East Bay Project suggest a context for such research. Priorities should include work to:

- identify and separate for analysis the phases of work involved in oil and gas projects

- determine the labor needs for each phase

- identify the population of workers that would be likely to participate in each phase

- determine worker strategies, by phase, regarding decisions to move/in-migrate versus commute from the present hometown

- compare the impacts of commuting workers versus in-migrating workers

Of particular importance will be the collection of strategies that individual workers use to make decisions on when to move versus when to stay in their present location. As noted, these may vary during the life of the project if drilling results in a discovery and a producing field is developed. This information will be vital to those professionals involved in the prediction of the onshore impacts of offshore oil and gas drilling projects.

PART II: COASTAL LAND USE AND COMMUNITY INFRASTRUCTURE REQUIREMENTS

SESSION OVERVIEW

Mary R. Bartz
MMS, Gulf of Mexico Region

The purpose of this session was to discuss the acreages, options, and permitting procedures for siting oil and gas industry-related facilities within the coastal zone, and their associated impacts to the environment and surrounding communities.

The opening remarks explained that MMS does analysis in their Environmental Impact Statements (EIS's) of potential land use requirements resulting from oil and gas activities in the Gulf of Mexico. At the present time, the land use statistical data base is being updated to reflect realistic acreages in the Gulf of Mexico where development has been ongoing over 30 years.

The agenda outlined a range of topics, such as industry rationale in the decision-making process to determine best facility siting options; discussion by several state representatives about the permitting processes used to control or mitigate impacts to their coastal areas; comparison of the standards used in our EIS analysis with those used by industry; studies completed in Florida which gave actual locations and types of areas best suited for development within industrial areas and ports; a study for a Louisiana Parish which is heavily impacted by oil and gas activities; and a Texas study which compared one of their inland cities to three coastal cities experiencing impacts from Texas offshore oil and gas activities.

The industry rationale discussed options for siting of temporary versus permanent support bases, whether space was better rented or facilities built, desirability of land types, and the associated advantages/disadvantages. Slides illustrated the types of industry requirements with explanations for their raison de être, i.e., type of operation to be conducted, enough land for parking lots to accommodate workers on 7-, 14-, and 28- day crews; heliport areas to transport maintenance and administrative personnel, as well as workers; dock footage; support facilities; number and distance of platforms to be serviced, and so forth.

The representative for the State of Alabama discussed the various regulatory agency policies dealing with oil and gas activities, mainly onshore wells, at the present time. Since 1979, however, gas was located in state waters and, in conjunction with recent and planned state federal offshore lease offerings, the permitting process has become more definitized. They are correlating state requirements to dovetail with federal regulations, wherever possible.

Mississippi has designated Special Management Areas and has implemented a process for developing and adopting management plans for these areas. The plans will improve permit decisions and resolve potential permit controversies prior to development. This process allows input by local governments regarding major decisions for their areas.

The Texas General Land Office has developed 70 two-digit codes for management decisions regarding resources specific to each submerged coastal tract. The system was designed through integrated efforts of State and Federal agencies upon their agreement of a rating system which is then coded for allowable activities within a specific area. Aided by the code system, the permittee can determine in advance the types of activities which are acceptable to the state standards. This provides a useful methodology to aid both the permitter and permittee and avoids unnecessary delays.

Regarding the acreage standards given by MMS in the EIS, the speaker indicated that in some cases there is no significant difference between some of the figures used and those historically used by industry. In other cases, recommendations were given for changes relative to the Central and Western Gulf; however, much smaller amounts would be considered in the Eastern Gulf because of existing facilities elsewhere. There was also agreement with our projection that certain types of facilities would not be needed in Florida, such as a platform fabrication yard, because of large facilities already existing in the Morgan City area and elsewhere. Comparative charts of the facilities requirements showed the acreages for both present standards utilized and those proposed for future EIS's.

The session included the results of three state studies. The State of Florida has indicated it would prefer that future oil and gas facilities be located in existing industrial area. In conjunction with this decision, studies have been completed by several of their Regional Planning Commissions which determined present land uses and acreages available for future sitings at these industrial areas. A site assessment matrix for evaluating the suitability of specific types of facilities was given. Existing local, regional, state, and federal regulations, policies and laws were cited as they related to OCS development. Potential impacts were discussed and recommendations were made regarding protection of Florida's resources.

Results were given of a study related to east St. Mary Parish, which includes the heavily industrialized Morgan City and surrounding communities. Because lower Louisiana is generally marshland with intermittent strips of high dry land, a land problem exists for those types of facilities which require a land/water interface. Water shortage, which is a problem in other areas of the Gulf, certainly is not there; however, future development dependent on this interface may be limited in some areas. Another significant finding of the study dealt with the commuting patterns of the workers: 25% of all workers in east St. Mary Parish lived 25 miles away, 20% beyond 100 miles--because the nature of offshore shift employment afforded them this advantage--, and 30% of workers with annual salaries greater than $15,000 lived outside of the parish, which results in an estimated $52 million/year salary drain. These commuting patterns should be another factor of consideration when developing projections of both new employment and housing needs in order to obtain realistic results. As for environmental concerns, the speaker stated that oil and gas operations are fairly clean, especially onshore. A negative effect is corrosion of land and canal banks due to passage of large vessels. However, it was maintained that areas of the marshland could be enhanced with careful and protective advance planning.

The study which compared an inland city with several coastal cities in Texas resulted in findings that adverse effects were not as great as originally expected or as other studies had projected. Sufficient water supply was the greatest factor and, secondly, the fiscal ability of the smaller communities to cope with the problem, such as financing for water treatment plants. A regional plan for water supply would be helpful in lieu of localized and/or area specific use plans, particularly as concerns salt water intrusion. Another problem occurs in coordination with regional authorities. A regional plan needs to be developed to make provisions for other future needs related to development of oil and gas resources. Net revenue losses at the local community level were another effect. Inland cities experienced more business opportunities within their immediate areas because many smaller companies generated local revenues through payrolls and other expenditures therein. Conversely, the coastal areas tended to attract larger national firms which did not depend on local businesses, thereby contributing less to local revenues while, nevertheless, requiring the same level of services as inland communities.

INDUSTRY METHODOLOGY FOR DETERMINING SITE LOCATIONS

Luther Kelly
Placid Oil Co.

In determining where to locate facilities to support their offshore activities, the oil and gas industry considers many factors, and each company has its own criteria. Some of these facilities are platform fabrication yards, pipeline laying support bases, gas processing and refinery plants, bulk oil marine terminals, and service and support facilities. These latter facilities respond to industry needs relative to boat rentals, fuel docks, shipyards (building and repair), drilling mud suppliers, waste treatment, and helicopter bases.

The three most important considerations in the decision-making process are the type of offshore activity, the general location of the site, and the length of stay. Some general requirements include accessibility to deep water and location site, availability of flat, solid ground, land costs, and ease and support of maintenance. Normally 15 to 20 feet of water with an existing channel, not too far from open water, will be adequate. There should be a good road with railroad and air transportation available within 30 minutes and an adequate number of supply stores within two hours. The site must be solid enough to erect buildings, store heavy equipment, and provide sufficient parking space for a large number of cars and trucks, at an affordable cost.

If the site is completely isolated, it will be difficult to operate; therefore, consideration must be given to:

Water - An adequate supply of potable water at the site for hauling to personnel offshore. A drilling rig will require large amounts of drill water which can be picked up in fresh water rivers or canals. It is used in the drilling mud on the rigs.

Electricity - Availability of commercial power will eliminate the need to purchase and operate your own generators.

Housing - Adequate housing for on-site personnel and for a portion of those working offshore.

Local Skilled Labor - Some labor can be brought in but a certain portion must be available locally for entry level jobs requiring only limited skills. Some higher skilled jobs would be available, but only to qualified personel. Skilled welders, electricians, plumbers, painters, radio, and radar repairmen, divers and crews for boats may also be needed.

Supportive Community - The oil field must run 24 hours a day, 365 days a year. If a problem arises, you must have the community capability to have the problem corrected quickly.

Ability to Get Permits - Permits are normally required when developing a site. If the permit application gets bogged down in red tape, the company may reject a site because of the difficulty in getting the necessary permits.

No one location fully meets all these requirements. Site selection is done individually by the companies; therefore, they may not all choose to locate in the same area. Since there is a great interdependency among companies in the oil field, especially for offshore support activities, each support site will endeavor to have easy access to the other support sites.

A company will normally try to minimize travel time to the offshore facilities when selecting an onshore permanent site. Most companies will use helicopters for transporting personnel offshore because of increased comfort and morale and to reduce the cost of travel time. If a crewboat ride over 12 hours is required to reach the offshore facility, frequently a temporary onshore facility is established which is closer. The crewboat rides are normally limited to 12 hours for the following reasons: daylight travel to avoid searching for a missing boat at night; reduced travel time the passengers; and avoiding seasickness due to prolonged trips.

ACTUAL LAND USE FOR INDUSTRY RELATED FACILITIES COMPARED TO ESTIMATES GIVEN IN THE GULF OF MEXICO LEASE OFFERING ENVIRONMENTAL IMPACT STATEMENT

Virgil A. Harris
Shell Oil Company

The U.S. MMS Final Regional Environmental Impact Statement (FREIS) for Gulf of Mexico Lease Offerings presents estimates of land use requirements for onshore support facilities as well as estimates of the total number of such facilities that would be required in the Eastern Gulf of Mexico, given two resource discovery scenarios. Shell Oil Company (SOC) and Shell Offshore Inc. (SOI) personnel have reviewed these estimates and compared them to SOC/SOI estimates of onshore support facility requirements.

The FREIS individual facility land use estimates generally exceed SOC/SOI estimates by a factor of 2 or more. Based on past industry experience and assumed development scenarios, it is believed that FREIS estimates overstate the land use impacts of OCS development in the Eastern Gulf.

The total number of facilities estimates developed in the FREIS and by SOC/SOI are generally in agreement. For the total (maximum) find scenario, FREIS estimates exceed those for SOC/SOI for pipeline landfalls and marine terminals. However, SOC/SOI estimates that up to two gas plants could be required, compared to the estimate of just one gas plant in the FREIS.

STATE PROCESS OF PERMITTING FOR OCS-RELATED INDUSTRY FACILITIES

Ernest A. Mancini, Douglas R. Hall, and Robert M. Mink
University of Alabama

With the discovery of oil in 1944 at the Gilbertown Field in Choctaw County, Alabama became an oil-producing state. Since 1970 the production of hydrocarbons has risen substantially, and Alabama is now considered an important oil and gas producing state. In 1970 there were only 564 producing wells and 24 oil and gas fields and pools in the State. By 1982, the number of producing wells had increased to 1,214, and the number of fields and pools had increased to 155. Between 1970 and 1982 production of oil, condensate, and gas in Alabama increased substantially: oil production increased from 7,291,098 to 8,111,952 barrels; condensate production increased from 18,898 to 11,901,952 barrels; and gas production increased from 883,948 to 134,026,117 Mcf (thousand cubic feet).

In 1979 with the discovery of gas in State waters approximately 2 miles east of Dauphin Island in lower Mobile Bay, attention was focused on the petroleum potential of Alabama's coastal waters. The interest which was generated from this discovery prompted the State to hold an oil and gas lease sale of selected state-owned tracts, and the State received $449 million in bonus monies for the leasing of rights to explore for hydrocarbons on these tracts. In September 1982, an additional tract was leased for $3.1 million in bonus money. Only 18 of the 133 tracts in Alabama offshore waters are currently leased.

To date, four appraisal wells and one Miocene well have been completed in the Lower Mobile Bay-Mary Ann Field. Three of the appraisal wells have been completed as successful gas wells, and a fourth appraisal well has been temporarily abandoned to be tested at a later date. Also, a wildcat well located immediately north of the Lower Mobile Bay-Mary Ann Field has been drilled and is presently temporarily abandoned. Currently, another wildcat well is being drilled near the western end of Dauphin Island.

Various aspects of oil and gas activities in Alabama waters are regulated by several state agencies, including the State Oil and Gas Board of Alabama, the Alabama Department of Environmental Management, and the Alabama Department of Conservation and Natural Resources. In addition, federal agencies, including the U.S. Army Corps of Engineers, have a role in the regulation of oil and gas activities in Alabama waters. The State Oil and Gas Board is responsible for regulating all oil and gas activities from exploration to production operations. Since up to this point no hydrocarbons have been produced from Alabama coastal waters, the State Oil and Gas Board has not yet had the opportunity to permit any production facilities. On the other hand, the drilling success thus far experienced by the companies prospecting in Alabama coastal waters has afforded the Board with numerous opportunities to permit exploratory operations.

In permitting an offshore well, the Board requires an application to drill with a location plat, an affidavit of ownership, a bond, and a company organizational report. Staff geologists and petroleum engineers of the Board review the company's casing, cementing, and mud programs, and evaluate the submitted blowout prevention program, drilling rig specifications, shallow geologic hazard survey, and hydrogen sulfide contingency plan. The hydrocarbon spill contingency plan and monitoring program along with the location of hydrocarbon spill equipment are also required by the staff of the Board. Upon receipt of a permit to drill, the overall review process usually takes 1 to 3 months for complete evaluation.

FLORIDA OCS FACILITY SITING STUDIES

Jeffrey L. Kiss
Florida Department of Community Affairs

The purposes of the six regional facility siting studies were to: (1) increase the understanding of the OCS development process and related activities, particularly onshore impacts; (2) further the promotion of orderly OCS-related development when it occurs in the state by identifying the more desirable onshore sites prior to actual discoveries; (3) develop an expertise in planning for onshore facilities siting at the regional and local levels; (4) identify the existing local, regional, and state-wide policies and regulations followed in the development of onshore facilities and make recommendations for changes if necessary; (5) in the case of one RPC, examine vessel traffic patterns to better understand the potential for oil spills off the southern coast of Florida due to hazardous intersections; (6) provide the most up-to-date information to industry on local attitudes; and (7) share data on onshore and community impacts with federal OCS regional offices to assist in preparing the EIS's for upcoming lease offerings. These studies addressed the potential siting opportunities and onshore impacts associated with potential offshore oil and gas exploration, development, and production for 23 of the 35 coastal counties in the state.

Generally, the methodology used for all the studies began with the hydrocarbon estimates found in the DOI FEIS's and related documentation. Scenario approaches (low, medium, high, for example) were used to differentiate the extent of potential onshore impacts. These impact levels were based on not only secondary sources (i.e., the New England River Basin Commission Factbook) but also on direct contacts with key industry personnel.

The next step in the methodology was to identify the existing local, regional, and statewide regulations affecting offshore and related onshore activities in the state. At the local level in Florida, where each of 461 local governments have prepared comprehensive plans, community attitudes toward industrial development are varied. Therefore, it was essential that the regional study examine individual comprehensive plans, land use regulations, and any other relevant policies which might affect onshore development (environmental resources protected by the state or local governments).

At the same time, local land use plans, zoning codes, port facilities, and transportation routes were studied to determine available industrial or other undeveloped acreage which might be suitable for onshore facilities. The siting process represented the major findings of these reports and included maps, aerials, and specific data critical to the potential of the site. It should also be noted that several regions found very few sites available for these uses or very few with potential.

A COMPARISON OF COASTAL AND INSHORE COMMUNITY IMPACTS

Ray Quay
Rice University

Impacts of offshore activity--defined as those measurable changes in oil-related employment, induced changes in other employment, and resulting population growth, with attendant costs and revenues for public service providers--were analyzed as onshore impacts of Texas offshore oil and gas activities. The implications of those findings were also addressed for policy development.

The study looked at communities along the Texas coast which were, or were likely to be, impacted by activities associated with offshore drilling and production. The project examined the general economic and demographic impact on the local area, and more especially, the impact on the local public sector to determine whether, and in what form, assistance might be needed by and warranted for coastal communities experiencing effects from offshore activities.

The findings of the study were as follows:

Coastal communities currently are experiencing impacts from Texas offshore oil and gas activities, but these impacts are less than anticipated by earlier studies.

Based on a forecasted moderate increase in Texas offshore drilling activity, coastal communities are expected to experience more pronounced impacts during the next eight years.

Small communities are expected to have difficulty meeting the demand for general services and capital improvements; all the coastal communities are expected to experience some difficulty in meeting the demand for fresh water supply.

The issue of water supply highlights a more general problem with financing of general capital improvements under conditions in which revenue streams are short-term or uncertain.

Although the coastal communities supporting offshore oil and gas activities were different from the inland community affected by traditional oil and gas development, similarities were noted with respect to these situations:

a large portion (50 - 60 %) of the labor force for the support service industries commutes;

a shortage of overnight accommodations was experienced;

a large increase in truck and air traffic occurred;

an increase in service demands was related to general as well as induced population growth.

The coastal communities were different from the inland community in the following areas:

the oil and gas reserves being developed are public in the coastal cases and generally are private inland;

offshore oil and gas development requires a more expensive and sophisticated technology than is the usual case for inland development;

offshore development requires the transport of all supplies, including fresh water, to remote areas, frequently utilizing several modes of transportation, whereas inland oil and gas activities usually occur in more accessible locales;

the offshore support industry is characterized by large national/international firms which are clustered in service bases that facilitate the transhipment of labor and supplies; businesses supporting inland operations were smaller, more numerous, likely to be independent and locally owned, and were more dispersed in the community;

because of the nature of offshore development, coastal communities' options for deriving revenues from the activities are limited; inland communities more successfully utilize traditional revenue generation techniques such as sales and property taxes to support their services.

COORDINATED FOREWARNING SYSTEM FOR MINIMIZING IMPACTS TO SENSITIVE AREAS

Mike Hightower
Texas General Land Office

The Texas General Land Office is responsible for the day-to-day management of 5800 submerged tracts totalling about 4 million acres in the 18 counties of the coastal area. Since 1972, the office initiated and currently maintains a "Resource Management and Recommendation Code System." The purpose of this system is to coordinate the various natural resource concerns of state and federal agencies, provide predictability for users, protect sensitive natural resources, avoid unnecessary permitting delays, and thus allow orderly growth and development to occur in the coastal area.

Basically one or more of the 70 two-digit codes are assigned to each submerged tract. The Texas General Land Office, Texas Parks and Wildlife Department, Texas Antiquities Committee, Texas Railroad Commission, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers all use the same system for coding and thus reviewing land-use applications and permits. Because of this forewarning system, users such as the oil and gas industry, industrial concerns, commercial endeavors, and the general public are notified in advance of the agencies' concerns for sensitive areas, anchorage and safety fairways, buried artifacts, etc. Thus, problems can either be avoided or properly planned for to minimize impacts.

The system is currently being revised to accurately reflect each agency's code placement and attendant justifications and to provide timely update and maintenance by computerization. In summary, the Texas General Land Office Resource Management Recommendation Code System provides:

- Consistency
- Predictability
- Accountability
- Expedited Permit Issuance
- Orderly Development

SPECIAL MANAGEMENT AREA (SMA) PLANNING FOR WATERFRONT AREAS

Jerry E. Mitchell
Chief, Coastal Programs Division, Bureau of Marine Resources
Department of Wildlife Conservation

The Mississippi Coastal Program (MCP) is the state's response to the Federal Coastal Zone Management Act and has been in effect as state policy since September, 1980. The MCP is implemented through wetlands permits which are based on a coastal wetlands use plan and guidelines, in addition to consistency certification on federal activities. Specific alterations to coastal wetlands are allowed only when the alteration would serve the higher public interest.

In order to supplement regulation with affirmative management efforts, the MCP designates "special management areas," and sets up a process for developing and adopting management plans for these areas. The SMA designation allows for a planning process to be undertaken by local, state, and federal entities to address environmental and developmental concerns within a planning context.

Special management area plans will improve the predictability of permit decisions in designated areas and will help resolve permit controversies in advance of specific development proposals. When approved as part of the MCP, special area management plans will serve as the basis for coastal wetlands permit decisions, and will guide other public decisions as well. Specific provisions of approved management plans will prevail over the general provisions of the coastal program. When approved by the federal government (OCRM/NOAA) as part of the MCP, area management plans will be recognized as official state policy by federal agencies.

The use of SMA plans is not limited to permit decisions. It is clear that local governments play a major role in the physical development and management of SMA's. In this light, SMA plans can be used by local governments to guide their development decisions and to coordinate the permitting procedures of state and federal agencies with these decisions.

OFFSHORE OIL AND GAS IMPACTS TO SEVERAL EAST ST. MARY PARISH COMMUNITIES

Dr. Robert B. Gramling, Jr.
University of Southwestern Louisiana

Because of its location on the Atchafalaya River, the closest land/water transition point to early (1947) offshore oil and gas discoveries at Ship Shoal and Eugene Island, the eastern portion of St. Mary Parish (county) was the first area to directly experience the impacts of offshore oil and gas exploration and discovery. As such, East St. Mary Parish (E.S.M.P.) provides an excellent case study of long term, extensive alterations which have occurred in the economy, population base, and infrastructure of several small communities.

The influx of offshore oil and gas activities brought employment, primarily in the mining (oil and gas extraction), transportation (water) and construction (metal fabrication) sectors of the economy. Employment opportunities were rapidly followed by immigration and a rapid population increase. Communities in E.S.M.P. began to exhibit most of the symptoms described in the "boom town" literature. Housing shortages, increased demands on utility systems, transportation networks, medical facilities, service agencies (police, fire, etc.) accompanied rising income. However, two phenomena distinguished E.S.M.P. from most boom town situations: shift work and a massive influx of commuters.

Shift work (as locally defined) means that the worker goes offshore for a period of time (usually seven days), resides there, and works 12-hours-on and 12-hours-off shifts. At the end of the seven days, the worker returns to shore and is off for seven days. Shift work disrupts life styles, interaction with family and friends, and recreational patterns. Because of this, only a certain percentage of the population is willing to engage in shift work, even though it pays better than comparable onshore employment. Thus, since in small communities there are not enough "willing" shift workers, and since individuals who are qualified and willing but live some distance away would need to commute only twice in a two-week period, and influx of communters has filled most of the offshore (shift work) jobs. Approximately 25% of the E.S.M.P. labor force are commuters (over 50 miles), and approximately 95% of these commuters work offshore. Twenty percent of the labor force commutes from over 100 miles from E.S.M.P., and this 20% accounts for over 30% of the jobs which pay more than $15,000.00 annually. About 50% of the over $15,000.00 annually jobs in E.S.M.P. are held by individuals who do not live and presumably spend their income in E.S.M.P. This has led to a rather obvious income drain out of the parish. Like most boom towns, communities in E.S.M.P. have become dependent on a single industry. Diversification is especially difficult as entrenchment of energy activities in the local economy has provided ample employment opportunities and has inflated wages above the competitive level.

The primary recommendation which follows from a case study of E.S.M.P. is that, to the extent possible, support facilities for offshore oil and gas activities should be encouraged to locate at larger established ports. There are four reasons for this recommendation. First, because of larger community size, the local economy does not become totally dependent on a single industry. Second, with a larger local labor force there will be a greater number of individuals willing to engage in shift work. This will tend to decrease income flow, in the form of commuters, out of the area being impacted. Third, in a larger community the influx of a new industry will not have the massive impacts on community resources and services that occur in a small community. Finally, offshore oil and gas exploration, at least as a land-based operation, is a very clean industry and is thus desirable from an economic and social standpoint.

Session: IMPACTS ON COMMERCIAL FISHERIES FROM OIL AND GAS ACTIVITIES

Chairmen: Mr. Jerry Brashier
Mr. Joe Perryman

Date: November 16, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Mr. Lawrence R. Handley and Mr. Jerry Brashier MMS, Gulf of Mexico Region
Oil Impacts on Commercial Fisheries	Dr. Gilbert W. Bane LSU, Center for Wetland Resources
The Relationships Between Oil and Gas Operations and the Oyster Industry in Louisiana	Dr. Edwin W. Cake, Jr. Gulf Coast Research Laboratory Mr. Ronald J. Dugas Louisiana Department of Wildlife and Fisheries
The Relationship Between Loss of Wetlands and Fisheries Production	Dr. R. Eugene Turner LSU, Center for Wetland Resources
The Use of Offshore Structures by Commercial Hook and Line Fishermen	Dr. Robert B. Ditton and Dr. Janice Auyong Texas A&M University
The Fishermen's Contingency Fund	Mr. Ray Montgomery National Marine Fisheries Service
Fish and Offshore Oil Development	Mr. Keith Hay American Petroleum Institute

IMPACTS ON COMMERCIAL FISHERIES FROM OIL AND GAS ACTIVITIES

SESSION OVERVIEW

Mr. Lawrence R. Handley and Mr. Jerry Brashier
MMS Gulf of Mexico Region

This session was held so information could be presented and discussions stimulated pertaining to impacts on commercial fisheries from oil and gas activities. Living marine resources in the Gulf of Mexico support the largest individual commercial fisheries in landings (menhaden) and in value (shrimp) in the United States. In 1982, these fisheries yielded 36 percent of the total ex-vessel value ($614 million) of the U.S. commercial harvest.

Possible adverse impacts on commercial fisheries include oil spills and leakage from platforms and transport systems, discharges from refineries and petrochemical units, discharge of formation waters, drilling muds and drill cuttings, space competition, and underwater obstructions. The loss of wetlands from oil and gas may also result in loss of fisheries production. Negative impacts of the oil and gas industry on the oyster industry generally fall into one or more of the following categories: siltation and burial problems associated with oil and gas field activities; pollution and contamination problems associated with oil and gas operations; alteration of natural estuarine flow patterns; reduction of cultch quantity and acceptability for continued spatfall; and increased population and pollution levels in otherwise unpopulated and unpolluted, pristine wetland areas that have traditionally served the oyster industry. Officials of the Louisiana Department of Wildlife and Fisheries have investigated many cases of oyster damage associated with oil and gas operations since 1940.

Some possible benefits to commercial fishing that result from Gulf OCS oil activities include improved shrimp trawling area along underwater pipelines, improved trucking access to previously remote ports, increased labor pool (displaced petroleum workers who wish to remain in the area), increased nearshore habitat for adult and large juvenile fishes (from creation of deepwater ports/harbors), and increased offshore reef habitat for important commercial finfishes. A substantial amount of commercial hook and line fishing is conducted offshore Louisiana around the platforms with Florida fishermen also participating in this activity.

Title IV of the Outer Continental Shelf Lands Act Amendments of 1978 (Public Law 95-372, enacted September 18, 1978) authorized the fishermen's contingency fund to compensate U.S. commercial fishermen both for actual property loss and consequential damages, including 25 percent of resulting economic loss caused by obstructions related to Outer Continental Shelf (OCS) oil and gas exploration, development, and production measures. Many of the conflicts between the oyster industry and oil industry could be avoided provided there is sufficient logistical planning and legal or economic incentives in place. More fisheries research related to OCS oil activities is needed including baseline and monitoring studies for levels of hydrocarbons in coastal and ocean pelagic fishes, reef fishes, coastal herrings and groundfish; determination of migratory patterns for most of these species; values of estuarine systems for groundfish and shrimp; and stock and fishing effort information for many of the coastal, reef, and pelagic resources.

There are conflicts between the oil industry and fishing industry. Their resolution primarily depends upon the quality of planning, communication, and willingness by those two users to make accommodations.

OIL IMPACTS ON COMMERCIAL FISHERIES

Dr. Gilbert W. Bane
Coastal Ecology and Fisheries Institute Center for Wetland Resources
Louisiana State University

Background information on the effects of OCS-related oil activities on commercial Gulf of Mexico fisheries is presented as part of the current effort by Louisiana State University's Coastal Ecology and Fisheries Institute to compile a bibliography of pertinent literature for use by regional planners and management agencies. This bibliography is worldwide in scope and focuses on all fisheries, resource and forage organisms, and four categories of effects: biological, ecological, socioeconomic, and mechanical.

Included in the discussion are an overview of Gulf fisheries and their importance to the regional and national economy, general and potential adverse effects of OCS activities on coastal ecosystems and the populations of organisms that inhabit them, factors determining the severity of oil impact on these ecosystems, key resources useful in assessing impacts on the environment, and possible benefits to commercial fisheries resulting from Gulf OCS oil activities.

A summary of major fisheries research needs relating to OCS oil activities in the Gulf is also offered. Highest priority needs include baseline and monitoring studies for levels of hydrocarbons in coastal and oceanic pelagic fishes, reef fishes, coastal herrings, and groundfish; determination of migratory patterns for most of these species; values of given estuarine systems for groundfish and shrimp; and stock and fishing effort information for many of the coastal, reef, and pelagic resources.

THE RELATIONSHIP BETWEEN OIL AND GAS OPERATIONS AND THE OYSTER INDUSTRY IN LOUISIANA

Dr. Edwin W. Cake, Jr.
Oyster Biology Section, Gulf Coast Research Laboratory

Ronald J. Dugas
Lousiana Department of Wildlife and Fisheries

Two important and highly successful industries in Louisiana indirectly compete with one another for natural resources that are often mutually exclusive: fossil fuels and oysters. The industries compete at an environmental rather than at a resource level; each utilizes coastal wetlands and estuaries below or within which their desired resources exist. The oyster industry utilizes coastal wetlands as a source of seed and mature oysters and as leasing areas for rebedding of seed oysters (on-bottom culture). The oil and gas industry utilizes the same wetlands during exploration, leasing, drilling, production, and transportation of fossil fuels that lie thousands of feet below. Their respective operations often conflict, and the conflicts may result in the loss or damage of oyster stocks and leases and civil damage claims against the responsible parties. Those conflicts take many forms and appear to be increasing in occurrence and severity.

By nature, the oyster-culture industry requires clean water and stable substrate (bottom) conditions in the estuaries for continued growth and production of its oyster stocks. It uses relatively simple husbandry practices (transplantation and shell planting) to enhance natural oyster growth and survival. By its nature, however, the oil and gas industry manipulates the wetlands and often reduces oyster habitat suitability thereby reducing the quantity and quality of oysters in the vicinity of oil and gas operations. As we approach the end of the twentieth century, the wetland conflicts between these two industries are increasing in number and severity because the number of oyster and petroleum leases are increasing, and the areas within which oyster culture can occur are being restricted by natural and artificial environmental phenomena.

The conflicts between Louisiana's oyster and energy-related industries can be characterized as competition for the use (or misuse) of coastal wetlands and estuaries. One industry requires excellent water quality and continued, high primary productivity to grow its product; the other industry utilizes the results of primary productivity millions of years ago, and must be continually aware that its efforts to locate, recover, and transport subsurface oil and gas deposits may reduce, negate, or otherwise adversely affect the right of the first industry to exist. While the oyster industry has a rather minuscule effect on the oil and gas industry, the oil and gas industry has a very substantial effect on the oyster industry in certain areas of coastal Louisiana (e.g., Barataria Bay).

Officials of the Louisiana Department of Wildlife and Fisheries have investigated approximately 350 cases of oyster damage associated with oil and gas operations since 1940. The largest proportion (75%) were the direct result of dredging and adverse siltation (oyster burial); 17% involved oil contamination of oysters (oily flavor); and the remaining 8% of the cases involved miscellaneous problems (e.g., oil spills, vessel groundings, seismic damages, etc.).

Conflicts between these two industries can be categorized on the basis of 1) positive versus negative impacts, 2) acute (rapid and pervasive) versus chronic (slow and longterm) impacts, and 3) avoidable versus unavoidable impacts.

Positive impacts of the oil and gas industry on the oyster industry include the following:

1) Increased and/or improved accessibility of traditional oyster lease areas to docking and processing facilities as a result of the number and location of artificial canals dredged by the oil and gas industry through Louisiana's wetlands. This impact is decptive,however, because of erosion, scouring, and siltation

problems fostered by the dredging and use of those channels.

2) Increased demand for and consumption of seafood products including oysters as a result of increased urbanization and community development that follow and/or support the oil and gas industry and its employees. This impact is ambiguous, however, Louisianans love oysters, but people pollute; their pollution renders nearby oysters unfit for human consumption, and their destructive wetland manipulations and modifications reduce oyster productivity.

3) Compensation to oystermen and to the state for oyster damages that may increase or improve affected leases or seed oyster grounds. That compensation usually results from previous negative conflict on the part of the oil and gas industry and is, therefore, an ambiguous and artificial situation.

4) Assistance provided by personnel at outlying oil and gas production facilities to oystermen with vessel, medical, or miscellaneous problems of an urgent nature.

5) Part- or full-time employment of oystermen in the oil and gas industry, especially during low production or oyster grow-out periods following transplantation. That employment may "tide them over" and foster continued oyster culture on a longterm basis, but it may also lure younger oystermen away from their traditional industry because of the higher wages and "regular" working conditions. Some oystermen may work fulltime on remote oil and gas platforms or as support-vessel crewmen and conduct oyster culture operations during their onshore furloughs.

6) Severence tax revenues from oil and gas production. Although severence tax revenues are not specifically designated for wetland improvement and management activities, the Seafoods Division of the Louisiana Department of Wildlife and Fisheries receives monies from the general fund, and the oil and gas industry can take some credit for those management and improvement efforts.

Negative impacts of the oil and gas industry on the oyster industry are numerous but generally fall into one or more of the following categories:

1) Siltation and burial problems associated with oil and gas field activities (channel and canal dredging, levee construction, vessel traffic and groundings, etc.).
2) Pollution and contamination problems associated with oil and gas operations that reduce environmental quality and the quantity, quality, and edibility of affected oysters.
3) Alteration of natural estuarine flow patterns and the resulting reduction of oyster production and increased salinization of lower estuary (bay) environments.
4) Reduction of cultch quantity and acceptability for continued spatfall, especially in areas with high density vessel operations and discharges of drilling wastes (fluids, muds, cuttings, etc.).
5) Increased population and pollution levels in otherwise unpopulated and unpolluted, pristine wetland areas that have traditionally served the oyster industry.

The negative impacts can be further defined in terms of their relative effects on oysters in general and oyster culture specifically. Those impacts that are sudden, pervasive, and cause oysters to die in a relatively short period of time (days) are considered acute and include the following:

1) Burial of oysters during dredge-and-fill operations, pipelaying activities, drill-site preparation.
2) Burial of oysters during vessel operations, groundings, and subsequent removal/rescue operations.
3) Mass mortalities and spatfall reductions caused by large-scale crude-oil spills and well blowouts.
4) Damages (sudden burial and death) caused by seismic activities with surface or nearsurface explosive charges in the immediate vicinity of oyster leases or reefs (especially with the use of "primacord" explosives).

Those negative impacts that are gradual, of a relative small scale, and/or that usually produce longterm modifications and mortalities are considered chronic and include the following:

1) Erosion of sediments, sloughing of channel, canal, and bayou banks, scouring of shallow bay/bayou bottoms, and subsequent downdrift displacement of those sediments and burial of adjacent oysters and cultch materials, and the eventual elimination of the bottom's ability to support oyster growth. The routine vessel traffic required to sustain oil and gas field activities is sufficient to create and sustain these problems.
2) Release of "pollutants," other drilling effluents, and other nonspecific debris and refuse that stress the local environment, including public and private oyster stocks.
3) Contamination of oyster meats (oil taste) and increased physiological stress caused by chronic (small-scale) oil spills, leaks, seeps, etc., from producing wells and tank batteries.
4) Contamination of nearby oyster stocks by inadequately-treated human wastes from manned platforms and production facilities in otherwise "open and approved" shellfish growing waters.
5) Contamination of nearby oysters by inappropriate or illegal releases of pesticides and other toxic chemicals and residues some of which kill oyster larvae and/or render commercial oysters inedible by federal and state standards.
6) Increased levels of all domestic and industrial pollutants that result from the location and growth of population centers in coastal wetland areas that serve and accommodate oil and gas field personnel and activities. The resulting "point" and "non-point" pollution discharges in otherwise pristine and productive estuarine areas may preclude and eventually eliminate commercial oyster culture in the vicinity of those population centers.
7) Alteration of natural estuarine flow patterns and salinity regimes that result from extensive wetland channelization and especially the long, north-south channels which encourage salinization of brackish waters with Gulf of Mexico waters and/or rapid influxes of freshwater and pollutants into upper estuarine areas from populated upland areas. Salinization increases the number and severity of high salinity predators and diseases of oysters, and increased inflow of land runoff reduces the areas of favorable salinity and increases pollution problems.

Most of the conflicts between these two wetland-dependent industries are avoidable provided sufficient logistical planning occurs and legal or economic incentives are operating. Those avoidable conflicts include the following:

1) Most grounding incidents involving oil and gas field vessels and the subsequent, intentional wheel-washing, scouring, and downdrift burial of oysters. Most groundings result from poor or inadequate planning on the part of survey and vessel crews and because of poor coordination with subcontractual service representatives.
2) Excessive wetland channelization and resulting modifications of salinity regimes and freshwater inflow patterns.
3) The release of drilling and production fluids, muds, cuttings, and other drill-site debris. (On-site containerization and off-site, upland disposal should be required.)
4) The discharge of domestic wastes and toxic chemicals. (On-site containerization and upland disposal should be required.)
5) The burial of oysters during dredge-and-fill operations. (This can be avoided by pre-activity harvest or transplantation elsewhere of oysters that may be affected.)
6) Damages and mortalities that result from seismic activities.
7) The general insensitivity of the oil and gas industry to the problems and requirements of the oyster industry. (This can be reduced through education workshops and information transfer meetings.)

Regardless of the regulatory, legal, or financial constraints on the oil and gas industry, the following conflicts with the oyster industry are probably unavoidable:

1) Accidental blowouts and oil spills.
2) Most channel scouring and sloughing, and the resulting downdrift siltation.
3) Accidental vessel or drill-rig groundings and the adverse siltation and oyster destruction that result from recovery and rescue operations.

4) Increased population growth and the resulting pollution from industrial and urban service centers and bedroom communities.

Problems encountered by the oil and gas industry as a result of the oyster industry include, but are not limited to, the following:

1) Spurious oyster-damage claims made by leaseholders who obtain unproductive leases or keep poor leases for the purpose of filing damage claims whenever oil and gas operations threaten their leases and/or their "non-existent" oysters.
2) The lack of coordination between the primary oil and gas leaseholders and the various subcontractors, service companies, etc., that may, through their individual or collective negligence, adversely affect nearby oysters and thereby precipitate a civil suit against the leaseholder.
3) Successful law suits for civil damages filed by honest oystermen that have established the right of the oyster industry to exist without harm in their traditional growing areas. Those precedent-setting cases often encourage other oystermen to file suits if their damage claims can be substantiated.
4) The failure or inability of the oil and gas industry (through its representatives) to negotiate fair and equitable pre-exploration, pre-drilling, or post-damage settlements with the "threatened" oystermen.
5) The apparent insensitivity of the oyter industry to the problems and needs of the oil and gas industry that must utilize the same wetland areas for their resource recovery operations.
6) The apparent lack of knowledge on the part of the oil and gas industry as to the needs and requirements of a viable oyster industry. There is a definite need for increased understanding, cooperation, and coordination between these two competing industries.
7) Unintentional or accidental crude-oil spills and/or blowouts that result in wetland (oyster) damage and the federal and state requirements that must be met when cleaning up those spills.

8) Accidental and/or intentional vessel groundings. Murphy's "laws of unavoidable oil and gas field problematics" tend to insure that those groundings will usually occur when and where they will most adversely affect the greatest number of nearby oysters (and leases).
9) The failure of both industries to take the necessary and progressive steps to reduce the conflicts between their respective industries and to promote better "working relations."

With the possible exception of spurious damage claims by dishonest oystermen, most claims in coastal Louisiana to date could have been prevented by one or more of the following preventive measures:

1) Locate all active, producing oyster leases in the vicinity of transit routes, pipeline routes, and drill sites, and plan accordingly. (Lease records and charts are available from the Seafoods Division of the Louisiana Department of Wildlife and Fisheries in New Orleans.)
2) Survey, plan, and mark navigation routes so as to avoid oyster leases and public reefs, especially those in shallow water that might be adversely affected by displaced bottom sediments.
3) Whenever and wherever possible, utilize shallow-draft vessels and/or flood-tide conditions, especially when moving drill barges over or through active oyster leases and public seed oyster grounds in natural channels and bayous.
4) Coordinate all transport and drilling activities that might adversely affect an oyster crop with the leaseholder (or the state in the case of public reefs) before beginning any and all such potentially damaging activities. (Letters of "no objection" to the oil and gas industry from the Louisiana Department of Wildlife and Fisheries require notification of the leaseholder or the state prior to any activity that might involve oyster damages.)
5) Plan and coordinate all activities with participating and supporting groups, companies, vessels, etc., so as to minimize or eliminate damage to nearby oyster leases and reefs.
6) Conduct pre-exploration, pre-transport, and/or pre-drilling surveys of the potentially impacted leases or reefs so as to accurately

assess the true value of any oysters that may be destroyed or damaged.

7) When oyster damages are unavoidable and/or when the expense of exploration and drilling activities and schedules far outweigh the potential value of the impacted oysters, negotiate ahead of time in good faith and/or assist the leaseholder with the removal of oysters and repair of the lease after any proven damages.
8) In the event of suspected damage, immediately notify the leaseholder or the Department of Wildlife and Fisheries (if public reefs are involved), and conduct an independent assessment of the damages.
9) Request assistance from the Louisiana Department of Wildlife and Fisheries on a first-come, first-served basis when attempting to assess oyster lease or seed grounds for potential or actual damages.
10) Educate field personnel, managers, subcontractors, and any other responsible personnel on the problems and conflicts that may affect their activities in the vicinity of oyster leases and reefs.
11) Establish an environmental ombudsman within the oil and gas industry to assist with problems that arise between these two wetland-dependent industries.

THE RELATIONSHIP BETWEEN LOSS OF WETLANDS AND FISHERIES PRODUCTION

Dr. R. Eugene Turner
Center for Wetland Resources, Louisiana State University

The implication is that man-made features, such as canals, related to oil and gas production contribute to loss of wetlands and, consequently, fisheries production. Juvenile finfish and shellfish are highly dependent upon the wetlands. In Louisiana and worldwide, the quantity and types of penaeid shrimp are directly related to the areas of vegetated wetlands. Tidal flood cycles over the wetlands offer food and hiding to finfish and shellfish; the edge of the wetlands is very important since it serves as an interface and is high in organic matter. In an altered wetland, the edge effect may be lost. Capture of prey species by predator species is much higher in unvegetated areas. The habitat value of wetlands as food and refuge for finfish and shellfish is becoming more and more obvious.

THE USE OF OFFSHORE STRUCTURES BY COMMERCIAL HOOK AND LINE FISHERMEN

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Texas A&M University

There are approximately 4,000 petroleum structures in state and federal waters in the Gulf of Mexico ranging in size and complexity from simple vertical pipes supporting small platforms to major platforms of considerable structural complexity. According to the U.S. Coast Guard list of lighted platform structures, there are 2,035 such structures in federal waters offshore Louisiana. Of these, 910 are classified as major structures because of their size and are marked with four or more navigation lights. Typically, these major platforms are large, multiwell production platforms.

During 1980 an effort was initiated by the Minerals Management Service (MMS) to evaluate the recreational and commercial fishing use of a sample of major petroleum structures on the federal Outer Continental Shelf (OCS). The study was to provide a descriptive understanding of fishermen who fish adjacent to petroleum platforms. In particular, there was a need to know which categories of platforms were used more frequently by various boat fishing types (recreational and commercial) and, from this, to develop some general criteria defining expected categories of use.

Data collection was accomplished by oil and gas company personnel who recorded daily incidences of fishing activity around the platforms. Initially, 72,000 daily and/or monthly records from almost 300 offshore platforms or platform complexes in the Central Gulf were obtained. These platforms were not chosen by MMS for their representativeness but rather because the respective companies were willing to involve their personnel in data collection.

An evaluation of reporting consistency and coverage yielded samples of 69, 68, and 27 reporting sources (platform and platform complexes) in the Delta, Bay, and Cameron regions, respectively. An evaluation of the extent to which each sample is representative of the population of major platforms in each region was completed and is useful to the interpretation of study results. From the sample of 164 reporting sources, a total of 19,617 records of positive sightings of fishing activity were logged during the study year (April 1980 - March 1981):

12,230 (62.3%) records -----------	positive boat sightings
7,388 (37.7%) records -------	cumulative number of days during which platform personnel were observed fishing
19,618 (100%) records ------------	Total

Observations were made of adjacent boat fishing activity (private recreational boats, charter/party boats, scuba boats, and commercial hook-and-line boats) as well as the fishing activity of platform personnel. Data were collected on the following use characteristics: (1) date, (2) day of the week, (3) state of origin of boat, (4) number of people per boat, (5) estimated length of boat, (6) type of boat, (7) type of fishing activity, (8) fish species taken, and (9) number of platform personnel fishing. Information about platform reporting sources was obtained from secondary records: (1) distance from shore, (2) depth of water, (3) year installed, (4) number of platforms in complex, (5) types of production, (6) extent that gas flaring occurs, and (7) relative platform size. Weather data for the survey period were obtained from the Office of State Climatology (Baton Rouge).

In the Central Gulf OCS study area, private recreational fishing boats were observed most often followed by charter/party boats, commercial fishing boats, and scuba boats. Over 1,000 observations of commercial hook and line boats were made with 630 being made in the Delta region, 313 in the Bay region, and 88 in the Cameron region. In the Delta region, 629 commercial hook and line boats were fishing near rigs. Most of these commercial boats were over 10 meters in length. Almost 47 percent of the observations recorded that there were from 5-8 persons aboard these vessels. The state of origin was not determined for almost 14 percent of the boats sighted in the Delta region. However, Louisiana and Florida accounted for a majority of the commercial vessels sighted. No boats were reported in this region from the Texas commercial fleet. Florida commercial hook and line vessels were very much attracted to this region.

In contrast to recreational fishing vessels, the commercial fishing boat observations were well distributed throughout the week and year. The majority of commercial boat observations were made beyond 30 kilometers offshore; one-third of the observations were made from 15-20 kilometers offshore. Commercial fishing generally took place in waters deeper than 40 meters. The majority of the observations were at platforms between 6-10 years old. Bottom fishing accounted for the vast majority of fishing observations. In the Delta region, snapper, croaker, and trout were taken most often and pompano, bluefish, and grouper less often. Primarily snapper were taken in the other regions.

THE FISHERMEN'S CONTINGENCY FUND

Mr. Ray Montgomery
National Marine Fisheries Service

PROJECT HISTORY

Title IV of the Outer Continental Shelf Lands Act Amendments of 1978 (Public Law 95-372, enacted September 18, 1978) authorized the Fishermen's Contingency Fund (FCF). The purpose of the fund is to compensate U.S. commercial fishermen both for actual property loss and consequential damages, including twenty-five percent (25%) of resulting economic loss caused by obstructions related to Outer Continental Shelf (OCS) oil and gas exploration, development, and production activities.

Final implementing rules were first published January 24, 1980. The lengthy time period between enactment of the statute and publication of final rules was caused by (1) complex statutory requirements which created a number of problems which could not be easily resolved, (2) the need to reconcile the opposing views of the fishing and the offshore oil and gas industries, (3) the need for coordination among various government departments and agencies, and (4) the development of quasi-judicial rules of procedure for claim adjudication.

On June 30, 1982, Title IV was amended (Public Law 97-212) to simplify the claim process. Claims are now adjusted by the National Marine Fisheries Service (NMFS), Financial Services Division (FSD), rather than by an administrative law judge. The time for fishermen to gain a presumption of causation by OCS related activities was increased from 5 days after discovering the damage to 15 days after the day the fishing vessel involved first returns to port. Compensation for economic loss is based on 25 percent of gross income lost, rather than on loss of profits.

Final rules implementing the amendments to Title IV were published with an effective date of October 28, 1982.

The fund is maintained by assessments against energy firms operating on the OCS.

ACCOMPLISHMENTS

As results of legislative, regulatory and procedural changes, average claim processing time was reduced from seven months to about one month after receipt of a complete claim.

The NMFS received 379 claims against the FCF from its inception in 1978 through the end of FY1983. Of these claims, 156 were approved for a total of $523,192.27. From FY83 to FY84, 23 claims were carried forward.

Claims submitted during FY83 were up 49 percent over FY82. The percentage of claims denied or abandoned has dropped from 71 percent to 28 percent.

SIGNIFICANT CHANGES

Significant changes included coordination of procedures with other government departments and agencies:

1. By agreement NMFS depends on the National Ocean Survey (NOS) to covert Loran C coordinates to latitude and longitude, advise whether or not an obstruction was previously charted or published in a current Notice to Mariners. NOS also causes reported obstructions to be published in the Notice to Mariners published by Defense Mapping Agency Hydrographic/Topographic Center (DMA). NMFS has agreements with NOS in which NOS agrees to provide this service within a week to 10 days or their receipt of our abstract of claim.

2. By agreement NMFS also depends on the Department of Interior's Minerals Management Service (MMS) regional offices to advise whether the hang site is in an area affected by OCS activities and to make reasonable efforts to notify all persons known to have engaged in activities associated with OCS energy activity in the vicinity where the damage or loss occurred (3-mile radius).

Without the advice in 1 and 2 NMFS cannot determine if claimants who file proper 15-day reports are entitled to a presumption that damages or losses were caused by items associated with OCS oil and gas activities.

SIGNIFICANT FINDINGS

Most denials of claims are for these two reasons:

1. The casualty occurred in state waters, and the claimant was unable to demonstrate that the item causing the damage or loss was associated with energy related activities on the OCS.

2. The claimant was unable to establish that damage or loss was associated with energy activities on the OCS and did not have the presumption of eligible causation which would have been available if a 15-day report had been filed.

The types of damages in most claims involve casualties related to the towing of mobile fishing gear over unmarked and unidentifiable underwater obstructions. In a few instances debris causing the damage has been recovered by fishermen. Recovered debris has included lengths of cable, tires, oil drums, steel plates, and sections of pipe. Obstructions not recovered but reported as observed by fishermen include capped wells, fuel tanks, pieces of iron, catwalks, pieces of cement, rope, and a sunken boat.

FISH AND OFFSHORE OIL DEVELOPMENT

Keith Hay
American Petroleum Institute

With the increasing exploration and development of America's offshore areas for oil and gas under the Five-Year OCS Accelerated Leasing Program, there is continuing concern about the operational impacts these activities have on the marine environment, fishery resources, and the commercial and sport fishing industries. This presentation addressed a series of questions posed by commercial and sport fishermen over the years:

How much undiscovered oil and natural gas is believed to lie under the OCS and how much is being produced from offshore wells?

Why jeopardize a productive fishing ground for only a few days' supply of oil?

What is the onshore impact of offshore oil and gas development?

How can fishing and oil industry vessels communicate at sea?

How do offshore operations benefit the fishing industry?

Are there employment opportunities for fishermen with the offshore petroleum companies?

Is there any danger to fish or fishermen from seismic exploration activities?

Is crude oil toxic to marine life?

If crude is toxic to fish, why haven't past spills resulted in large fish kills?

What are the effects of spilled oil on fish eggs and larvae?

Answers to the questions were taken from published literature and personal interviews with working fishermen in the United States and Europe.

As fisheries and offshore technologies advance, we are improving in our ability to resolve or minimize problems arising from the use of the same waters. The remaining conflicts are not new; most are practical and operational, and their resoluton depends primarily upon the quality of planning, communication and the willingness of the two users to make accommodations. In assessing potential harmful impacts on fisheries from offshore oil development, the author stressed the importance of developing a risk perspective, i.e., categorizing such impacts according to their level of risk or likelihood of occurence (1:100; 1:1,000; 1:1,000,000).

Session:	DETECTION AND EVALUATION OF INUNDATED PREHISTORIC SITES
Chairmen:	Ms. Melanie Stright Mr. Brent Smith
Date:	November 16, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Ms. Melanie Stright MMS, Gulf of Mexico Region
Testing the Model for Prehistoric Site Occurrence on the Gulf of Mexico Outer Continental Shelf	Dr. Sherwood Gagliano Coastal Environments, Inc.
A Predictive Model for Marine Sites in Washington State	Ms. Jacqueline M. Grebmeier University of Alaska
The Geologic Context of the McFaddin Beach Area, Southeast Texas	Dr. Saul Aronow Lamar University
Archaeology and Paleogeography of the McFaddin Beach Site, Jefferson County, Texas	Dr. Charles Pearson Coastal Environments, Inc.
The Effects of Sea Level Rise and Subsidence on Prehistoric Sites in Coastal Louisiana	Mr. Thomas Ryan U.S. Army Corps of Engineers New Orleans District
Potentials of Discovery of Human Occupation Sites on the Continental Shelves and Nearshore Coastal Zone	Dr. Daniel Belknap University of Maine
Submarine Stone Age Settlements in Denmark	Mr. Per Smed Philipsen Danish Ministry of the Environment

DETECTION AND EVALUATION OF INUNDATED PREHISTORIC SITES

SESSION OVERVIEW

Ms. Melanie Stright
MMS, Gulf of Mexico Region

For the last decade there has been a growing awareness among the professional archaeological community, that for time periods prior to about 5,000 B.P. (when sea level reached its current high stand) the subaerially exposed continental land mass was much larger than at present. Therefore, prehistoric site patterns, cultural contacts, and subsistence strategies observable on the present land mass only represent a portion of the archaeological record.

In response to this growing concern for inundated historic and prehistoric sites, and in order to comply with the requirements of Section 106 of the National Historic Preservation Act of 1966, as amended, the Department of Interior began requiring remote sensing surveys for the detection of historic shipwrecks and inundated prehistoric archaeological sites prior to lease development on the Outer Continental Shelf.

The technology and methods for locating and evaluating submerged prehistoric sites have developed rapidly and employ techniques from many other fields, e.g., geophysics, geomorphology, sedimentology, oceanography, and chemistry. These techniques and methods are employed in three major lines of analysis:

1) potential for site occurrence
2) potential for site preservation
3) potential for locating and evaluating sites when they occur.

Last year's session on prehistoric archaeology centered on techniques for locating and evaluating sites within areas having a high potential for site occurrence and preservation. Papers this year concentrated on techniques for predicting site locations and preservation potential.

The models and techniques presented in this session were particularly important and timely since a study designed to locate submerged prehistoric sites in the Central Gulf of Mexico is currently underway. This study will test our ability to predict site locations on the now submerged shelf, and determine the applicability and adequacy of current methods and technology for testing and evaluating these potential site locations.

TESTING THE MODEL FOR PREHISTORIC SITE OCCURRENCE ON THE GULF OF MEXICO OUTER CONTINENTAL SHELF

Sherwood M. Gagliano
Coastal Environments, Inc.

It has been hypothesized that prehistoric archaeological sites are preserved in certain locales on the northern Gulf of Mexico Outer Continental Shelf. A model of settlement and site preservation has been presented which relies on factors of sea level change, potential for preservation of landform features during marine transgression, and the relationship between prehistoric site occurrence and landforms as derived from terrestrial analogs. Prospecting for drowned terrestrial sites is possible with available geophysical techniques and identification of cultural deposits can be achieved through analysis of core samples. The buried Sabine Trench off of the eastern Texas coast has been selected as a suitable area for testing the proposed settlement model. The trench contains buried preserved landforms of late Pleistocene and Holocene age which correspond to high probability areas of site occurrence as defined in the model. The potential for site preservation in the Trench was discussed. The data collection and analytical techniques to be used, which include fine scaled seismic survey and the collection of vibra-cores, were reviewed.

A PREDICTIVE MODEL FOR MARINE SITES IN WASHINGTON STATE

Jacqueline M. Grebmeier
University of Alaska

During the Pleistocene sea levels were lowered several hundred feet opening up large areas of the continental shelf for human occupation. For many years archaeologists have assumed that coastal sites of late Pleistocene age were destroyed by rising sea levels at the end of the glacial period. Recent advances in marine archaeology have suggested however, that such sites may still be accessible for archaeological study (Ruppe, 1980).

At the Center for Marine Archaeology we have been developing a model to predict submerged prehistoric site locations in the Puget Sound Lowland as part of an overall inventory and management plan for the State of Washington. The Center for Marine Archaeology is directed by Dr. William C. Smith of Central Washington University and partial support for this research was provided by the Washington State Office of Archaeology and Historic Preservation. Following a brief discussion of the concept of predictive modeling I will comment on the Northwest Pleistocene environment, the environmental and cultural parameters used for site prediction, the results thus far obtained, and some direction for further research.

Predictive modeling in site location operates in the following manner. It identifies known prehistoric sites in an area, determines their relationship to identifiable features of the natural environment and extrapolates these factors to an entire study area so as to predict where sites may occur. The work of Gagliano et al. (1977) on the continental shelf of the Gulf of Mexico is representative of predictive survey methods in the study of submerged sites. This study established predictive zones based on the analysis of submarine topography and geology, eustatic sea level changes, and onshore prehistoric settlement patterns.

To develop a workable model for the Puget Sound area it is important to have an understanding of the geological history of the region. In northwest Washington the last glacial phase was dominated by the Cordilleran ice sheet moving down from Canada. The major glacial episode in the Puget Lowland and Strait of Juan de Fuca during this time was the Vashon Stade of the Fraser Glaciation. The ice mass split into two lobes: the Juan de Fuca lobe that moved westward to the Pacific Ocean, and the Puget Sound lobe that extended just south of Olympia. Glacial erosion expanded pre-existing river valleys, forming fjord-like troughs to depths of about 300 meters below present levels (Thorson, 1980).

Ice began receding at the toes of both lobes prior to 14,000 B.P., with the Juan de Fuca lobe at a faster rate. Once the ice dam at Admiralty Inlet broke, about 13,000 B.P., marine waters entered Puget Sound depositing glaciomarine sediments on top of Vashon till. As Vashon ice thinned and was bouyed up by marine waters, land level relative to the sea was approximately 80-140 meters lower than present (Easterbrook, 1969).

Once free of the weight of ice, the land began to rise or "rebound," with the rate of uplift greatest during and soon after unloading. These rebound rates, in conjuction with sea level rise, have located glaciomarine drift up to 140 meters above present sea level in the northern Puget Lowland. Figure 27 shows curves of isostatic rebound rate, eustatic sea level rise, and relative sea level estimates for various time periods at Whatcom County in the northern Puget Lowland (Larsen, 1972).

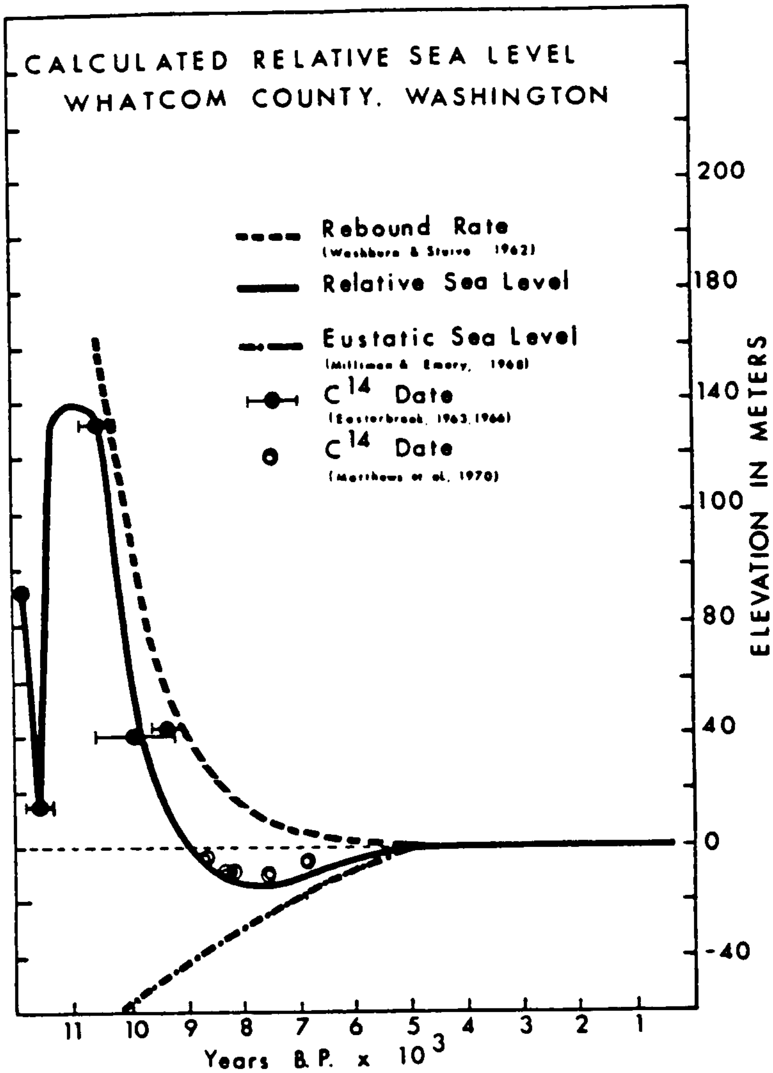

Figure 27. Calculated Relative Sea Level, Whatcom County, Washington. Reproduction by permission of author of graph.

It is important to note the major environmental changes--isostatic rebound, eustatic sea level rise, and to a minor degree tectonic movements--that occurred between 11,000 and 9,000 B.P. (Figure 27). A rapid relative sea level drop from 140 meters above present sea level at 11,000 B.P. to 10 meters below present sea level by 9,000 B.P. shows the dramatic effect where rebound rate exceeds sea level rise.

The goal of developing this predictive model is to delineate high probability areas for submerged prehistoric sites along the Strait of Juan de Fuca and Puget Sound Lowland. Present emphasis is on the northern Puget Sound.

In the development of the model certain assumptions and parameters were chosen as a baseline from which to work (Table 11). Ratings of 2, 1 and 0 are used to rank parameters as to their importance for site preservation and location. Two is considered the highest value. Prehistoric sites were rates as yes (2), and no (0), or unknown (1), depending on whether field data recorded the presence or absence of present coastal sites in the area. Unknown (1) rates are given to those areas where field observations are lacking. Bottom sediment type was divided into mud (2), sand (1), or gravel (0). A higher probability was assigned to fine-grained silt and mud sediment localities as they tend to provide better stability and likelihood of artifact preservation. Inundation rate was denoted as fast (2), intermediate (1), or slow (0), depending on bathymetery characteristics and their relationship to rate of inundation of shorelines by rising sea level. Exposure was listed as protected (2), seasonally variable (1), or open (0), to describe the physical relationship between site location and exposure to wind and wave action.

TABLE 11

RATING OF PARAMETERS TO DETERMINE PROBABILITY OF SITE LOCATION

PARAMETER	KEY	RATING
PREHISTORIC SITES:	YES	2
	UNKNOWN	1
	NO	0
BOTTOM SEDIMENT TYPE :	MUD	2
	SAND	1
	GRAVEL	0
INUNDATION RATE :	FAST	2
	INTERMEDIATE	1
	SLOW	0
EXPOSURE :	PROTECTED	2
	SEASONALLY VARIABLE	1
	OPEN	0

Data on the four parameters described, that is, prehistoric site location, bottom sediment type, inundation rate and exposure, as well as a projected lowered sea level contour of 10 meters from present, were plotted on baseline maps obtained from the University of Washington. Figure 28 is an example of one of these predictive maps for San Juan County. The lower sea level contours were drawn from Navy bathymetery maps and National Oceanic and Atmospheric Administration nautical charts. Bottom sediment data were analyzed from sediment maps from the University of Washington. Available data on prehistoric site distribution were obtained from the Washington State Office of Archaeology and Historic Preservation.

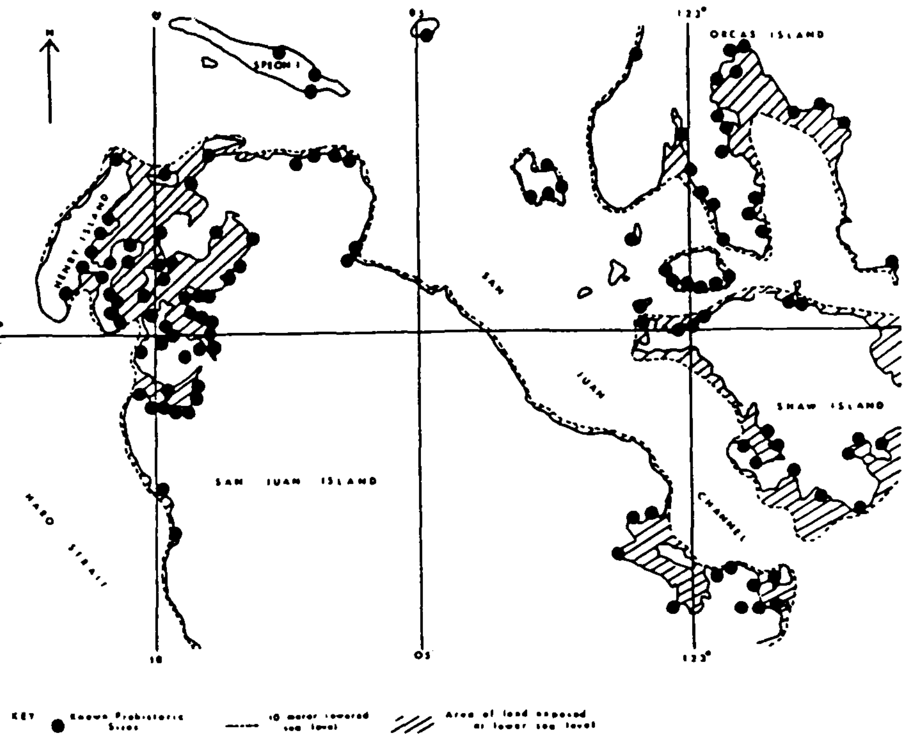

Figure 28. Predictive Map: San Juan Islands

Table 12 summarizes data related to various coastline sections in the Puget Sound Lowland. The four parameters of prehistoric site location, bottom sediment type, inundation rate and exposure were rated according to the data found for each section. Note that average values were given to bottom sediments depending on the variety of sediments found in a study zone.

Rating of probability of preservation was found by adding the values of the three environmental parameters of bottom sediments, inundation rate and exposure. The sum values were then rated as good, fair or poor. Probability of site location incorporates known prehistoric site information and environmental data; it is also rated good, fair or poor depending on the sum values. It should be noted that probability of site location nearly mirrors ratings for probability of preservation thus emphasizing the importance of environmental analysis for predicting site survival.

TABLE 12

PROBABILITY OF SITE LOCATION FOR ISLAND AND JEFFERSON COUNTIES (CHART 807)

( )= RATING

LOCATION	PREHISTORIC[a] SITES	BOTTOM[b] SEDIMENTS	INUNDATION[c] RATE	EXPOSURE[d]	PROBABILITY[b+c+d] OF PRESERVATION	PROBABILITY[a+b+c+d] OF LOCATION
DECEPTION PASS	YES (2)	GR.-SAND (.5)	S (0)	O (0)	(.5) POOR	(2.5) POOR
PT. PARTR.	NO (0)	GR.-SAND (.5)	F (2)	O (0)	(2.5) FAIR	(2.5) POOR
PENN COVE	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
SEQUIM BAY	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
PROTECTION IS.	NO (0)	GR.-SAND (.5)	S (0)	O (0)	(.5) POOR	(.5) POOR
PORT TOWNSEND	YES (2)	GR.-SAND (.5)	S (0)	SV (1)	(1.5) POOR	(3.5) FAIR
INDIAN I.	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
MARROW-STONE I.	UN. (1)	SAND-MUD GR. (1.7)	S (0)	SV (1)	(2.7) FAIR	(3.7) FAIR

RATING PROBABILITY OF PRESERVATION:		RATING PROBABILITY OF LOCATION:	
0-2.0	POOR	0-2.7	POOR
2.1-4.0	FAIR	2.8-5.4	FAIR
4.1-6.0	GOOD	5.5-8.0	GOOD

It is apparent from reviewing Table 12 that sites which have the characteristics of sand and mud bottom sediment types, in combination with a fast inundation rate and being located in a protected embayment, have a high probability for artifact preservation. One such site is Sequim Bay located along the Strait of Juan de Fuca.

Further research is needed in charting submerged river channels as a possible method for site location. Knowledge of sedimentation rates and geochemistry of sediment types for high site potential areas is required to determine the quality of site preservation and whether excavation would be feasible. Finally specific areas need to be investigated in the field to test the predictive capability of the model and to generate data in order to modify and refine it.

In conclusion the predictive model developed has generated a list of potential archaeological site locations under water in each of the Washington counties located along Puget Sound and the Strait of Juan de Fuca. The use of environmental characteristics of the area, coupled with known prehistoric sites, has enabled us to determine a preliminary evaluation of where potential underwater prehistoric archaeological sites may occur and the probability of site preservation. The next step is to carry out field investigations in specific regions of the Puget Sound Lowland to validate and upgrade the model. Only then can it develop into a viable research, as well as resource management, tool.

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THE GEOLOGIC CONTEXT OF THE MCFADDIN BEACH AREA, SOUTHEAST TEXAS

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McFaddin Beach on the upper part of the Texas coast lies between Sabine Pass and High Island, a salt dome-elevated Beaumont Formation inlier. The shoreline here is transgressive and the narrow beach deposits in successive hurricanes have moved inland over the Holocene marsh deposits that lie between the beach and the outcrop area of the Beaumont Formation to the northwest. The beach, especially after great storms and hurricanes, is the site of deposition of sparse vertebrate remains and prehistoric artifacts.

This portion of the Texas coast is about the only one in which a considerable width (1.5 to 15 km) of Holocene marsh separates the Beaumont outcrop area from the Gulf. Elsewhere the Gulf is bounded by barrier islands, peninsulas (long spits) or eroding Holocene delta plain deposits (Aronow and Kaczorowski, in press, and Morton 1979).

The Holocene marsh deposits in most places are probably less than 3 m thick and rest directly upon a shelf of Beaumont Formation. The seaward margin of the Beaumont outcrop area to the northwest has a digitate, highly crenulated pattern and represents a sequence of small birdsfoot deltas--the successive mouths of the laterally meandering paleo-Trinity River of Late Pleistocene age (Aronow, 1971, and Univ. Texas Bureau Economic Geology, 1968). The Beaumont Formation between the Holocene Neches River and Cedar Bayou (just east of the San Jacinto River) was laid down by a mainly suspended load (Galloway) paleo-Trinity River whose several deltas are roughly the size and shape of the modern delta of the Trinity.

This uniquely preserved--for the Texas coast--area may be explained by reference to the areal distribution and altitudes of the several portions of the Late Pleistocene Ingleside (Price, 1933, 1947, and Wilkinson, et al., 1975) barrier-strandplain system. South and southwest of West (Galveston) Bay the Ingleside is landward of and marginal to the several bays and lagoons of the Texas coast and is generally less than 3 m above sea level (Univ. Texas Bureau of Economic Geology, 1975). Northeast of Galveston Bay (Univ. Texas Bureau of Economic Geology, 1968) beginning at Smith Point the remnants of the Ingleside rise progressively from 3 m to more than 9 m above sea level and terminate in the vicinity of the Houston River in southwestern Louisiana (Price, 1947). With this increase in altitude the Ingleside is located increasingly inland from the Gulf and is enclosed by the Beaumont outcrop area. On the assumption that the fragments of the Ingleside were defined by the same water plane we may conjecture that either the local area has been uplifted or the rest of the Texas coast has subsided. In either case it led to the preserving of the McFaddin Beach area at the edge of the marsh. The beach and adjacent marsh area are underlain by a portion of the Beaumont that was offshore when the several Beaumont-age deltas to the northwest were deposited.

The vertebrate remains and prehistoric artifacts found along McFaddin Beach have been described (Long, 1977, and Russell, 1975). The vertebrate material, characterized as Rancholabrean, that is, post-Illinoian or Late Pleistocene, includes bones and teeth of large extinct mammals as well as smaller still extant forms from a variety of environments: South American tropical forest (e.g., capybara, jaguar, giant armadillo), grassland (e.g., bison, horse, mammoth), forest (e.g., mastadon), and arid to semi-arid (e.g., black-tailed prairie dog). These are believed to represent a temporal succession of environments rather than contemporaneously existing ones. The fossils and artifacts are transported to the beach as detritus by waves and currents and have not been found in place in any geologic unit.

Several scenarios for the source(s) of the fossils and artifacts can be suggested--bearing in mind that the offshore area was exposed from a sea-level "low" about 18,000 years B.P. to about 2500 to 3000 years B.P. when sea level was stabilized: (a) both artifacts and fossils derived from the Beaumont, (b) some of each derived from the Beaumont, and some of each from scattered surface sources when the continental shelf was exposed, (c) both fossils and artifacts from surface sources only, (d) some fossils from the Beaumont, and some fossils and all artifacts from surface sources, or (e) all fossils from the Beaumont and all artifacts from the surface sources. Scenarios (b), (c), and (d) are among the more plausible ones in light of a single radiocarbon date 11,100 + 750 years B.P. on an elephant tusk recovered from the beach (Long, 1977). The evaluation of the artifacts relative to these scenarios will not be attempted.

Because of the multiplicity of possible scenarios, the ages of the several geologic units in the region relative to a generalized Wisconsinan stratigraphic sequence (Beard et al., 1982) may be of interest.

The Beaumont Formation has yielded two sets of radiocarbon dates: (a) ~25,00 years B.P. to ~30,000 years B.P. and (b) greater than ~40,000 years B.P. and "dead." The younger dates might fall into the Farmdalian high-sea level stage; the older, the Mid-Altonian, or even the Sangamon high-sea level stages. The Ingleside depositional features could be placed in either of these older high-sea level stands. The radiocarbon dates for the Deweyville terrace complex (straths and large-radii meander scars, alluvial terraces containing relict channels with large-radii meanders) span~13,000 years B.P. to~25,000 years B.P., thus placing the unit partly in the Farmdalian high sea-level stage and partly in the Woodfordian low sea-level stage. These dates are all older than the Two Creekan (~11,500 years B.P.) and overlap the younger Beaumont dates. The Deweyville complex along the coast--at the mouths, for example, of the San Jacinto and Trinity Rivers--descends below sea level and was inundated by the post-18,000-year B.P. sea-level rise. Possibly some artifacts might be contemporaneous with part of the Deweyville complex. Should we choose to define the Gulf Coast Holocene as post-Deweyville, some fossils and artifacts might be considered as Early Holocene.

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ARCHAEOLOGY AND PALEOGEOGRAPHY OF THE MCFADDIN BEACH SITE, JEFFERSON COUNTY, TEXAS

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Archaeological and geological data from the McFaddin Beach site in eastern coastal Texas were examined in the context of the past 15,000 years of environmental history of the area. The site consists of wave-washed cultural deposits of Paleo-Indian age and later as well as large quantities of fossilized late Pleistocene faunal remains. The relationship of these materials to onshore and offshore late Pleistocene and early Holocene landform sequences were reviewed. The evidence suggests that cultural and faunal materials are being eroded from a number of locales on the surface of late Pleistocene, Trinity River deltaic formations and overlying Holocene deposits immediately offshore of the present beach. It is proposed that the Paleo-Indian cultural materials were associated with features such as the levees along channel courses, oxbow lakes, and marsh and swamp margins which remained as relict, though preferred, settlement habitats long after the Trinity River abandoned this area about 25,000 years B.P. It is highly likely that early man material will be found in association with similar relict deltaic features which are now exposed as the land surface just inland from the coast. It is anticipated, however, that these sites will be difficult to locate since they probably existed as brief, scattered occupations which have been obscured by processes of erosion and sedimentation.

THE EFFECTS OF SEA LEVEL RISE AND SUBSIDENCE ON PREHISTORIC SITES IN COASTAL LOUISIANA

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The Mississippi Deltaic Plain hydrologic regime integreates a set of complex ecological processes which control biological productivity as well as community composition and extent. Since most of the deltaic plain lies at or near sea level, any changes in the position of the land and sea would alter community composition over hundreds of square miles of the deltaic plain.

Recent work by Colquhoun and Brooks combining both geological and archaeological data supports the occurrence of late Holocene sea level fluctuations along the South Carolina coast. The available archaeological data suggests relatively high sea level stands during the temporal intervals from 4,200-3,700 years B.P., 3,100-2,850 years B.P., 2,250-1,750 years B.P., and 1,600-1,000 years B.P. The geological data indicates lower sea level stands at 3,100 years B.P. and between 2,695 and 2,330 years B.P., with higher stands before and after these dates. The observed fluctuations are between 1 and 2 meters and occur with a frequency of approximately 400-500 years. The South Carolina data correlate with the transgressive and regressive phases reported from Northwest Europe and the authors propose glacio-eustatic mechanisms to explain the fluctuations recorded from both coasts.

Excavation of Big Oak Island, a Tchefuncte Period shell midden located in the deltaic plain east of New Orleans, revealed a stratigraphic sequence of natural and cultural deposits. The basal component consists of a peaty muck rich in cultural remains. The basal component is sealed by a massive sterile shell beach which is in turn covered by a Rangia Shell Midden. The basal component holds a radiocarbon date of 2,470 + 65 years

B.P. while the Shell Midden which overlies the beach has dates of 2,325 + 60 years B.P., 2,220 + 200 years B.P., and 2,185 + 70 years B.P. The beach is a transgressive feature and dates between approximately 2,470 and 2,325 years B.P.

According to the Colquhoun-Brooks oscillation curve, the interval between 2,695 and 2,330 years B.P. was characterized by a low sea level stand on the South Carolina coast. The Louisiana data support a transgression during this interval rather than a regression suggestive of the South Carolina curve. This discrepancy may be the result of high regional subsidence rates which characterize the Mississippi Plain.

POTENTIALS OF DISCOVERY OF HUMAN OCCUPATION SITES ON THE CONTINENTAL SHELF AND NEARSHORE COASTAL ZONE

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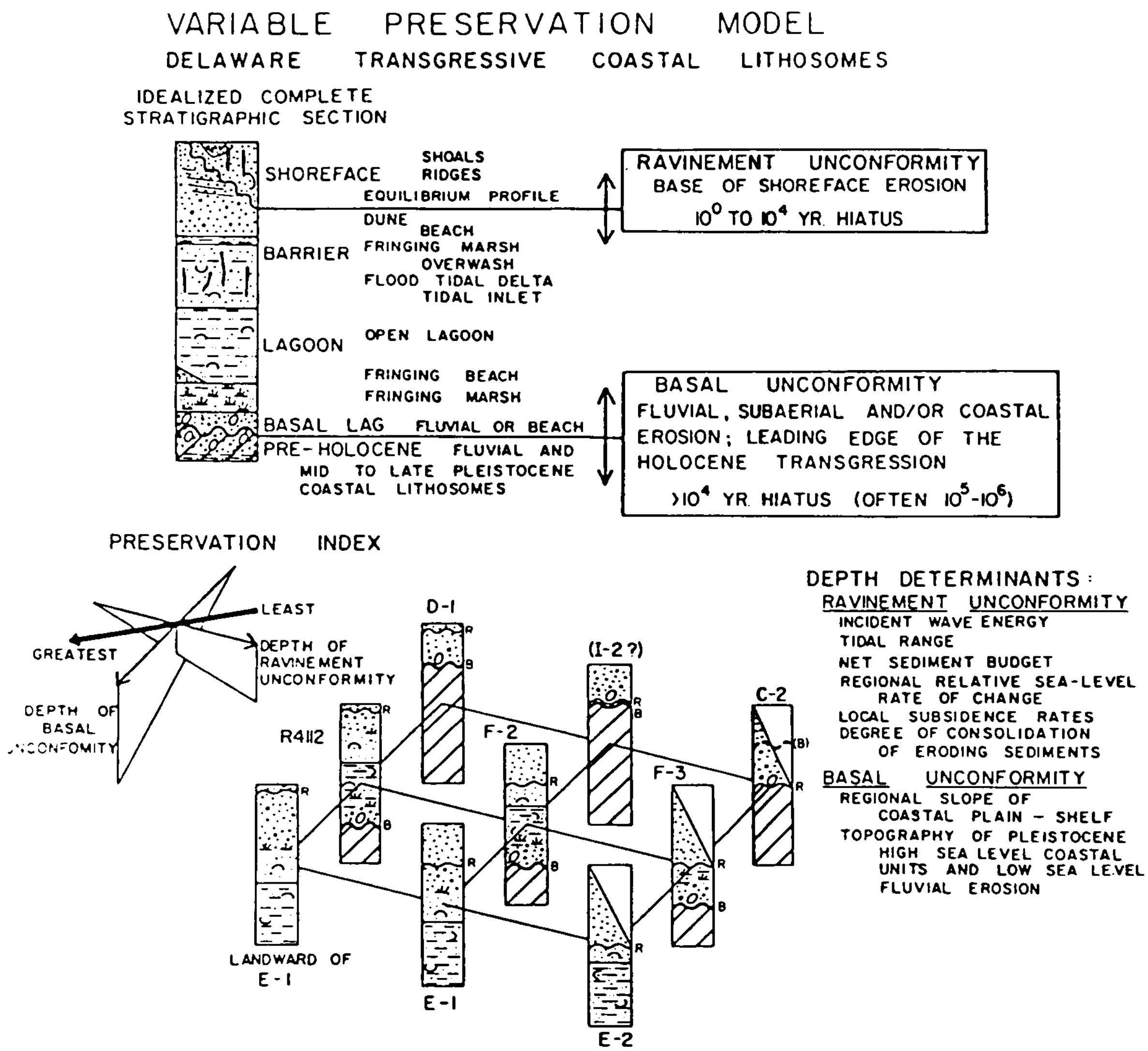
Archaeological sites on the continental shelf have been exposed to the Holocene transgression, as post-glacial sea level rose and drowned previously exposed sites. For these sites to be preserved the migrating zone of shoreface erosion must pass them by or they must be extremely resistant. Caves or quarried stone sites might be preserved in the eastern Mediterranean and elsewhere, but in the U.S. Gulf and Atlantic coastal plain it is extremely unlikely that middens and occupation sites on unconsolidated sediments would survive shoreface erosion.

To understand archaeological preservation potential general coastal lithosome preservation potential must be understood. Belknap and Kraft

(1981, 1984 in press) have modeled preservation potential of Delaware's transgressive barrier-lagoon and headland beach shoreline. Important factors in the model include rate of local relative sea-level rise, depth of shoreface erosion, which is in turn related to incident wave energy, tidal range, and sediment budget, and the factor of antecedent geology. The latter is a critical control. Deep pre-Holocene valleys contain more complete stratigraphic sections while there is no preservation of Holocene sediments over ancient interfluves now in the shoreface. Figure 29 is an idealized Holocene stratigraphic column for coastal Delaware which contains two unconformities: the ravinement surface (R) and the basal unconformity (B). The relative preservation potential (or, conversely, the length of hiatus in sedimentation) depends on position of these two unconformities. Below the idealized stratigraphic column are shown nine cores from the Delaware Atlantic shoreface which apply to this model, in a hierarchy of relative preservation. Maximum preservation occurs (Core E-1) where basal unconformity is deep, in pre-Holocene valleys, and where ravinement unconformity is shallow (shorthand notation B_dR_s). Conversely, minimum preservation occurs where basal unconformity is shallow and ravinement unconformity is deep (notation B_sR_d, Core C-2).

Seismic profiling and vibracoring on the shoreface and inner shelf off Delaware have allowed identification of the extensive paleofluvial Delaware River and its tributaries. The flanks of these valleys, filled with thick Holocene sediments, are the only likely locations for preserved archaeological sites offshore.

Figure 30 is a conceptual model of geologic evolution of coastal archaeological sites in the U.S. mid-Atlantic coast (from Kraft et al., 1983). The vertical axis represents the preservation potential of an archaeological site. The horizontal axis is a measure of the relative age of a site. For actual examples, this axis will stretch or shrink depending on rate of shoreline movement and original distance of the site from the shoreline. The relative shoreline position at present is shown below. The horizontal axis should not be misinterpreted as a strictly linear, quantitative measure of time. Similarly, the vertical axis is also relative: architectural ruins of



Depth of unconformities:

		RAVINEMENT	
	Shallow	Moderate	Deep
BASAL Shallow	B_sR_s	B_sR_m	B_sR_d
BASAL Moderate	B_mR_s	B_mR_m	B_mR_d
BASAL Deep	B_dR_s	B_dR_m	B_dR_d

Figure 29. Variable Preservation Model for CoastalLithosomes From Belknap and Draft, 1984 (in press).

quarried stone would be far more resistant to shoreline processes than Amerindian middens, but a midden or mound is more resistant to earthquakes. Thus, the relative preservation potentials are qualitative. Figure 31 shows 5 examples of archaeological sites in typical mid-Atlantic geographic settings. In addition, the positions of similar sites after sea-level rise and coastal erosion continue are shown within the faces of the block diagram.

On the mid-Atlantic coast, sites initially pass through a subaerial degredation phase (I, Figure 30; 1-5, Figure 31) in which running water, frost, and biological activity alter the site. Phase II is common for sites on the landward side of marshes and lagoons, such as Island Field, which are buried by tidal marsh or lagoon sediments with continuing sea-level rise (2',3',5', Figure 31). In these quiet environments preservation is enhanced (dashed line, Figure 30). Probability of discovery, however, falls with burial (dotted line). Phase III is as the erosive shoreface passes the site. Degree of preservation is dependent on the depth of scour, which reaches 10 meters on the Atlantic coast and 3 to 4 meters on the Delaware Bay coast. Thus, probability of destruction is dependent in part on whether a site is intersected by a deeply eroding oceanic shoreface (line a, Figure 30; e.g. Cape Henlopen lighthouse, 1926 or site 1', Figure 31) or a shallowly eroding estuarine shoreface (line b, Figure 30). Five to ten meters depth of scour is certainly sufficient to remove most Amerindian archaeological sites on a gently sloping coastal plain. Delayed arrival of the shoreface, however, such as in a valley floor on its flanks where it has been subsequently inundated by marsh or lagoonal mud (2', 3', 5', Figure 31) may allow preservation as the shoreface passes above the site. The zone of erosion passes above the site because sea level has risen in the interim. Discovery potential (dotted line, Figure 30) jumps briefly for buried sites if they are re-exposed at the shoreface, but declines as rapidly as a non-buried site thereafter.

These models have been used to predict locations of submerged archaeological sites on the U.S. mid-Atlantic coast and in the eastern Mediterranean (Kraft et al., 1983). To be useful, a detailed seismic profiling grid and long vibracores would be necessary to locate preserved sites. As

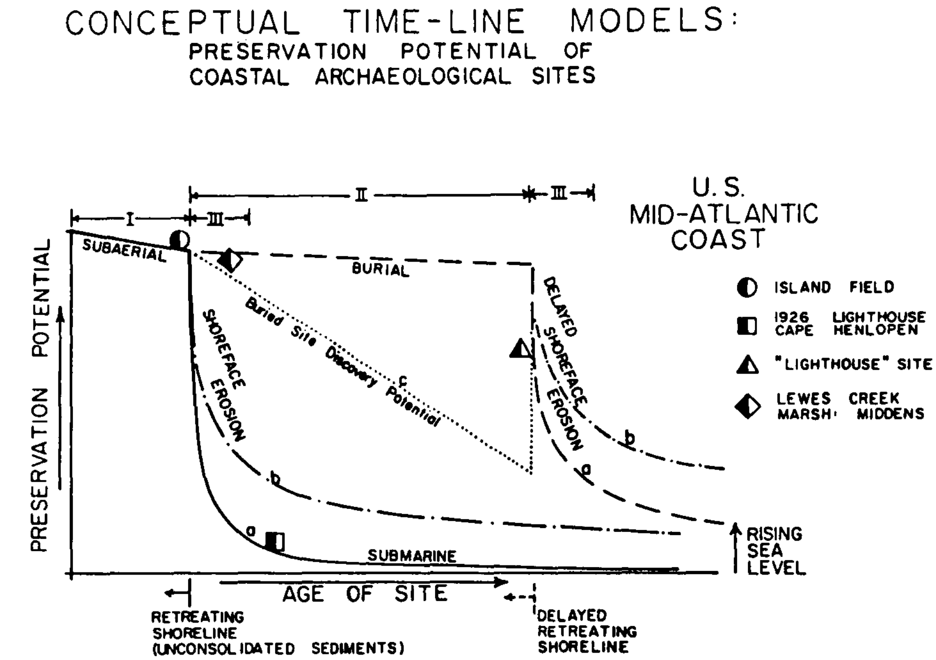


Figure 30. Archaelogical Site Preservation Model
From Kraft et al., 1983.

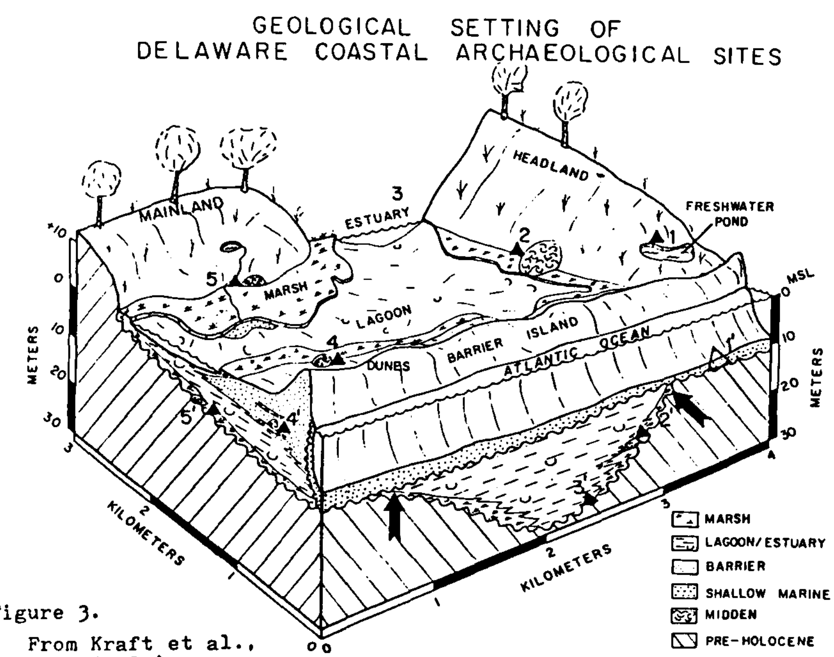


Figure 3.
From Kraft et al.,
(1983)

Figure 31. Archaelogical Site Geological Model
From Kraft et al., 1983.

yet this has not been attempted in the mid-Atlantic region. The model is clearly applicable to other areas, however, such as the Gulf coast. It is still unlikely that sites will be found, unless they are extremely densely distributed. Only likely potential sites for occupation or middens can be identified. It is extremely unlikely that a site exposed to shoreface erosion would survive. Only sites buried deep in valleys, bypassed by the shoreface erosion zone because of relative sea-level rise, will remain. Also, for these reasons older sites have a higher potential for preservation than younger sites.

This discussion has been based on several years of research at the Department of Geology, University of Delaware, and incorporates the ideas of co-authors John C. Kraft and Ilhan Kayan. The data was collected using Delaware Sea Grant, Office of Naval Research, and Delaware Department of Natural Resources and Environmental Control grants.

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SUBMARINE STONE AGE SETTLEMENTS IN DENMARK

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INTRODUCTION

During the last decades, several submerged Stone Age settlements have been detected in the vast areas of shallow water surrounding Denmark. Unlike most land sites, the submarine sites are very rich in artifacts of organic material, manily because the artifacts are embedded in gyttja-layers (mud and turf) extremely deficient in oxygen, resulting in the preservation of the artifacts until the present day.

PROJECT HISTORY

Although Denmark is a very small country (approximately 26,000 square miles), because of the many inlets, creeks, coves, and islands, the total length of today's coastline is more than 4,500 miles. The many sheltered parts of the coast protect most of the inundated sites from washing out (erosion).

From well-preserved artifacts washed ashore along the coasts we have obtained a rough knowledge of the location of the sites, but not why the location was chosen. The latter problem required actual excavations.

POTENTIAL

So far only a few sites have been excavated. Methods of excavation are identical to those used on dry land: fixpoints and systems of coordinates are laid out and attached to the seabed. Every square meter is systematically excavated, plans and sections are drawn upon the seabed, and the location of each find is measured vertically and horizontally. The excvavation techniques differ considerably from land excavations: above the site a ship or a raft with pump gear is anchored. The pumps supply the airlifts and the injectors with air and water. Every square meter is excavated with a traditional trowel or by hand. The two types of pumps are solely used for transporting excavated material away and maintaining good visibility.

The stratigraphy of these sites is extremely good. The deposits alternate between thin layers of coarse sand and thick layers of organic mud, peat, and turf (gyttja) with varying consistency and compositon. In the gyttja-layers Stone Age artifacts of all kinds of material are embedded. Especially organic material is well preserved. That is material such as wood and bark, bone and antler, bast and senew plus nuts, acorns, roots, leaves, insects, etc.

The wooden objects dominate the finds: paddles (among them one completely ornamented), dug-out canoes, bows and arrows, leister prongs for fishing spears, handles, etc. Tools of bone and antler are very common as well: axes, knives, needles and points, fishing hooks (one with the line preserved). Bones are found in large quantities. From these sites the bones are mainly from red deer, wild boar, and roe deer, as well as furred animals such as pine marten, wild cat, otter, and pole cat. Many of them bear distinct marks of butchering or fur skinning. In addition to several isolated finds of human bones embedded in the gyttja layers, a few human graves have been revealed.

PROBLEMS AND PROSPECTS

Most of the settlements detected until the present day date back to late mesolithic in Denmark, which in terms of years is approximately 5,800 - 5,100 B.P. The sites are all located close to the coastline of today (50 - 1,200 feet) and are situated in shallow water (5-18 feet). Until now no early

Mesolithic coastal settlements have been found under water, but several isolated finds of antler, bone, and flint embedded in submarine bogs have been brought to the surface from somewhat greater depth in the course of fishing or extraction of raw materials from the seabed. These older sites still need to be located.

Unfortunately, the older bogs (and thereby the settlements) are most often covered by sand--and today the seabed is completely flat. Thus it is impossible for divers to detect them. This job requires other methods.

One of these methods is seismic registration, mapping a given area with a low frequency echo sounder. The Danish Ministry of Environment is currently running a project designed to detect submarine sites and wrecks by means of a sub-bottom profiler and a side-scan sonar. This part of the project is still quite new and as yet only at an experimental stage.

The electronic registration forms part of a nationwide registration. All archaeological information is being computerized, and in a very short time it will be possible for industry and others to order a computerplotted sea chart with the archaeologically important areas plotted out. The only information needed to order charts like this will be dimensions and co-ordinates of the map corners. Besides continued registration, future research will be concentrated on attempting to develop new models for the detection of depth and possible location of the prehistoric settlements. This work requires close cooperation between marine archaeologists and quarternary geologists as well as industries involved in exploiting the resources of the sea. This cooperation seems to ensure that the main parties concerned--archaeology and industry--are aware of the interests of one another and accept these.

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Session:	PIPELINE EMPLACEMENT TECHNIQUES AND ENVIRONMENTAL CONCERNS
Chairmen:	Omar DeWald Heino Beckart
Date:	November 15-17, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Heino Beckart Omar DeWald
Mechanics of a Geophysical Survey for Pipeline Emplacement	Thomas W. Neurauter Racal Geophysics, Inc.
Data Acquisition for Pipeline Design Criteria on Mudslide Areas	Mark Everding Oceanonics, Inc.
Recent Improvements in High-Resolution Surveys for Offshore Pipeline Emplacement	Robert J. Floyd John E. Chance & Assoc.,Inc.
The Odom SEA MAG: A Case History	Harold L. S. Odom Odom Offshore Surveys, Inc.
New Advances in Flexipipe Methodology	Gerald Bordelon John Haynie Flexipipe International
Overview of the Gas Research Institute Pipeline Right-of-Way Research Program	Cindy A. Cahill Gas Research Institute Ralph P. Carter Argonne National Lab
Pipeline Planning and Design	M. Lee Hart Northern Engineering International Company

Environmental and Construction Techniques Involved with the Installation of Three Large Diameter Natural Gas Pipelines in Sensitive Coastal Areas	Gene J. Gonsoulin Southern Natural Gas Co.
Integrated Studies Applied to the Decision-Making Process Concerning Pipeline Placement in Coastal Waters	R. Warren Flint The University of Texas
Utilizing Conservation Planning to Evaluate Potential Onshore Pipeline Locations	Charles W. Savant USDA Soil Conservation Service

PIPELINE EMPLACEMENT TECHNIQUES AND ENVIRONMENTAL CONCERNS

SESSION OVERVIEW

Dr. Heino Beckert and Mr. Omar DeWald

The two sessions entitled "Pipeline Emplacement Techniques and Environmental Concerns" addressed phases of the pipeline industry dealing with planning, survey, design, construction, environmental impacts, and scientific studies. The following represents a synopsis of the talks given by the authors.

Geohazard assessment for engineering purposes and identification of existing cultural resources are better served when tools and techniques necessary for the survey task are selected on the basis of a resolution versus penetration trade-off. Simply stated, this trade-off is thus: the higher the frequency of the device, the less penetration possible for any one power output. For optimum resolution a variety of tools operating in several acoustical modes is desirable. Only one tool, the magnetometer, utilize field effects rather than acoustical effects.

An example of the high resolution survey is data acquisition for pipline design criteria in mudslide areas. Here a mosaic constructed from side scan sonar strips made along the proposed pipeline route would aid the engineers in determining their design criteria by showing the features of the mudslide. This, of course, would be accompanied by other data sources that show the sub-surface structure, composition of surficial sediments and objects below the mud line that could be potentially hazardous to the pipeline.

Since all of this depends on the accuracy of the positioning system, it is noted that there have been recent improvements in determining the absolute position of remote submarines and sonar equipment. This is achieved through the use of ultra-short baseline acoustic positioning systems integrated with conventional horizontal positioning systems.

As the petroleum industry network of pipeline extends seaward, the ability ot relocate these pipelines and related structures becomes increasingly important. The proton magnetometer is a primary tool for this purpose. Through cooperative efforts between design engineers and principal users, field survey personnel, and geophysical interpreters, what was once a flimsily housed magnetometer with a weakly connected tow system evolved into a rugged, digitized, and efficent system for use today. Some of its attributes are its increased electronic and mechanical stability compared to its predecessors. It simulates a dual-pen plotter with chart annotation of field strength and depth of tow. While this is not an unusual development related to the oil and gas industry, it does illustrate a product of necessity for which there was no off-the-shelf solution when the need arose.

The need of planning is paramount for the successful completion of a pipeline project. It requires the effort, coordination, and cooperation of many individuals and groups to make the project cost effective to the operator and mutually satisfactory to all parties concerned. This is true whether constructing production and/or transmission facilities offshore or on the shore.

By judicious environmental and construction planning, such a pipeline routing, facility siting, and wildlife-related construction timing considerations, adverse environmental impacts due to pipeline emplacements can be greatly reduced. Of great importance are special mitigative construction techniques that can be employed on pipeline projects that traverse sensitive coastal habitats.

Current pipeline emplacement techniques in offshore waters and in coastal wetlands were depicted in a slide presentation. The step-by-step procedures shown and the illustration of pipe laying equipment demonstrated in great detail the procedures currently employed in oil and gas pipeline emplacement.

The environmental manager has a legal mandate to predict environmental changes resulting from man's activities. In order to predict the deleterious long-term, and often subtle, impacts of oil/gas-related human activities in coastal ecosystems, reserch strategies have to be developed that consist of an holistic approach to understand how man-induced changes have altered the various ecosystem components and their dynamics. Of equal importance is the development of estimates concerning the recovery rate of a disturbed coastal ecosystem. As much information as possible has to be intergrated in order to develop a composite picture of an ecosystem, its components, and its functions if anticipated impacts from environmental perturbations are to be correctly predicted.

The Gas Research Institute (GRI) has initiated a program to address the environmental aspects of gas transmission pipeline installation and maintenance. Gas transmission companies are often faced with challenging requests from permitting agencies for information on disturbance caused by pipeline installation for which no comprehensive data base exists. An assessment study was conducted in 1982 in which 20 transmission companies were surveyed to determine major environmental research needs on pipeline rights-of-way. Five major research areas were identified: 1) terrestrial revegetation and edaphic changes related to pipeline installation; 2) evaluation of methods for improving soil stability and erosion control on pipeline rights-of-way; 3) documentation of successful reclamation on existing pipeline rights-of-way; 4) stream crossing research to document stream recovery after pipeline installation; and 5) reclamation of rights-of-way in wetlands. Research priorities were then formulated to develop a preliminary multi-year research plan.

The overall objective of the current Pipeline Right-of-Way (ROW) Research Program, based on the assessment study, is to develop and document methodologies that the gas transmission industry can apply to minimize costs and mitigate ecological impacts caused by pipeline installation and maintenance.

The U.S. Department of Agriculture's Soil Conservation Service provides basic research information and planning assistance that may be applicable to several aspects of mineral development activities, particularly in evaluating potential onshore pipeline locations and their resulting impacts. Additional information in this area may be obtained from the respective District Conservationists. These deal not only specifically with the private landowner, but also with those in the petroleum industry who may find a need for their service when pipelines cross the coastline form the marine environment.

A recent development in pipeline and pipeline emplacement technology is the use of a flexible pipeline in conjunction with specifically designed pipe laying vessels. These vessels will be capable of laying flexible pipe and commissioning their services in time periods to reduce the conventional pipe lay technique presently used. In addition to pipe lay, the Flexship vessels are designed to support a wide variety of construction and deep water diving operations, particularly in deep water developemtn of the offshore petro-chemical industry.

MECHANICS OF A GEOPHYSICAL SURVEY FOR PIPELINE EMPLACEMENT

Thomas W. Neurauter
Racal Geophysics, Inc.

High resolution geophysical surveys, prior to pipeline installation, are a requirement of the U.S. Government. These surveys are designed to detect possible hazards or constraints to pipeline emplacement and to protect possible cultural resources along the right of way. The Minerals Management Service defines the survey parameters in its latest Notice of Lessees, 83-3.

In general, a survey will include collection of data from the following instruments: 1) an echosounder; 2) magnetometer; 3) side scan sonar; and 4) subbottom profiler (7.0 or 3.5 kHz). Drop cores are usually taken every mile along the route to identify surficial sediments types and their geotechnical properties.

Cultural resources include objects or sites or archaeological value, both in a historic and prehistoric context. Historical sites are things such as ship or airplane wrecks. Thousands of ships have sunk in the Gulf of Mexico alone, many whose positions are poorly known, if at all. The possibility, even though slight, does exist that a pipeline route could cross over an uncharted wreck. Prehistoric sites are possible former locations occupied by prehistoric man in areas of the present day contintental shelf which at times of lowered sea level were dry land. Identification of these sites by high resolution geophysical methods is extremely difficult. The intent of the survey is not necessarily to discover actual sites but to define potential areas of former habitation such as along river channels, levees, beaches, or strand lines, etc.

Potential hazards or engineering constraints include a wide range of geologic structures and conditions. It should be pointed out that these surveys serve to inform the engineer of the geological environment so he can better design his pipeline rather than to tell him where he cannot place it. High resolution tools such as side scan sonar and subbottom profilers can define structures such as active mudflow gulleys, collapse depressions, and mudflow lobes such as those found off the Mississippi Delta. Other potential hazards consist of active faults, mud mounds, and gas seeps. Of concern to engineers as well as environmentalists are structures such as coral-algal reefs, patch or pinnacle reefs, and buried oyster or shell accumulations. The potential for active bottom transport can be detected in the form of sand waves or ripple marks on side scan sonar data. In conjunction with shallow coring or soil boring information, the subbottom profiler aids in correlation of lithologic or geotechnical interfaces over a wide area.

As the oil industry moves into deeper water, new survey equipment is needed to provide the resolution comparable to shallow water tools. RACAL GEOPHYSICS has been conducting deep-towed side scan sonar and subbottom profiler surveys in water depths up to 2,500 meters since 1981. The deep tow system employed by RACAL GEOPHYSICS was manufactured by EDO WESTERN CORP. (Model 4075) and consists of a positively bouyant towfish which is referenced to the bottom by means of a length of anchor chain. The signals are multiplexed and transmitted up a double armored co-axial cable for processing and display by various recorders. The position of the tow vehicle is determined by means of a short baseline system, the Navtrak V (EDO WESTERN) consisting of a 12 kHz responder in the fish and a series of transducers in an over-the-side mounted unit at the vessel. An elaborate winch system is needed to deploy and retrieve the long cable. Manufactured by CROSS LINE MANUFACTURING, this system consists of a storage drum, a traction unit, and a heave compensator.

RACAL GEOPHYSICS with this equipment has collected exceptional records in the rugged relief areas of Carteret Canyon on the Atlantic Margin (Coleman, Doyle, and Prior, 1982), on the Texas-Louisiana Contintental Slope (Prior and Coleman, 1981), and on the Mississippi Fan

(Neurauter et al., 1983). The records collected indicate features similar to those found on shelf areas, such as faulting gassy sediments and slumping, are present in the deep water areas and need to be defined for engineering purposes. These structures cannot be defined as well with conventional surface-towed instruments, which are limited in effectiveness in deep water due to signal loss by beam spreading and side-echo distortion along steep slopes. It is difficult and sometimes impossible for a free-flying, negatively bouyant towfish to maintain a constant altitude above the bottom in rugged areas with steep slopes.

Records from the Mississippi Fan indicate that unusual and as yet undefined structures and processes are present in deep water areas. These environments will need to be defined in order to emplace safe and cost effective structures on the seabed to produce oil and gas reserves from deep water environments.

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DATA ACQUISITION FOR PIPELINE DESIGN CRITERIA IN MUDSLIDE AREAS

Mark Everding
Oceanonics, Inc.

Slides of records and graphs emphasize and illustrate the design criteria used to design the first 36" gas pipeline in the mud slides of the South Pass area.

A general comparison is made between the lift and drag forces on a pipeline caused by hurricane-induced water currents and the forces on a pipeline caused by mud slides. A rational approach for the acquisition of data to better develop design criteria for gas pipeline design in mud slide areas is discussed.

Particular attention is drawn to the interaction between pipeline and the first few inches of the seafloor.

RECENT IMPROVEMENTS IN HIGH-RESOLUTION SURVEYS FOR OFFSHORE PIPELINE EMPLACEMENT

Robert J. Floyd
John E. Chance & Associates, Inc.

The use of ultra-short baseline acoustic positioning systems integrated with conventional horizontal positioning systems provides a valuable technique for determining absolute positions of remote submarines and sonar equipment. Applications for pipeline emplacement will be explored.

THE ODOM SEA MAG: A CASE HISTORY

Harold L. S. Odom,
Pres., Odom Offshore Surveys, Inc.

The key to the success of Odom's SEA MAG magnetometer design has been the interaction between the design engineers and the primary users, field survey personnel, and geophysical interpreters. The system has evolved from a prototype SEA MAG V acquired from Treasure Salvors in 1972 to its present SEA MAG IX configuration with reduced system complexity through the use of microprocessor technology. Important features of this new system include: ICD displays, dual scale, solid state, themal recorder, total magnetic field and tow depth annotation, instantaneous world-wide tuning, Reduced Tow system drag, and reduced power consumption.

NEW ADVANCES IN FLEXIPIPE METHODOLOGY

Gerald Bordelon and John Haynie
Flexipipe Intenational

Two presentations discussed a new venture using "State of the Art" technology not readily available in the U.S. today, with an interface between pipe laying off the stern side and thwart side of a ship especially designed to work in sea states up to 10 to 12 feet. This new venture will supply flexible pipe from a New Orleans manufacturing faciltiy that will add another U.S. dimension to installation of pipelines in the oil industry in both domestic and foreign waters through out the world.

In addition to the new manufacturing facility, two specifically designed "State of the Art" vessels are being built to provide a complete installation service to the industry, for the first time ever in the Gulf of Mexico.

These vessels will be capable of laying flexible pipe and commissioning their services in time periods to reduce the conventional pipe lay technique presently used. In addition to pipe lay, the Flexship vessels are designed to support a wide variety of construction and deep water diving operations, particularly in deep water development of offshore petro chemical industry. Particular reference is made and examples shown on the application of Flexpipe for Dynamic Riggers on floating production facilities.

A film presentation covered the theme of the new company, "We're coming to America."

OVERVIEW OF THE GAS RESEARCH INSTITUTE PIPELINE RIGHT-OF-WAY RESEARCH PROGRAM

Cindy A. Cahill,
Gas Research Institute

Ralph P. Carter,
Argonne National Laboratory

The Gas Research Institute (GRI) has initiated a program to address the environmental aspects of gas transmission pipeline installation and maintenance. Gas transmission companies are often faced with challenging requests by permitting agencies for information on disturbance caused by pipeline installation for which no comprehensive data base exists. An assessment study was conducted in 1982 in which twenty transmission companies were surveyed to determine major environmental research needs on pipeline rights-of-way. Five major research areas were identified:

1) terrestrial revegetation and edaphic changes related to pipeline installation;
2) evaluation of methods for improving soil stability and erosion control on pipeline rights-of-way;
3) documentation of successful reclamation on existing pipeline rights-of-way;
4) stream crossing research to document stream recovery after pipeline installation;
5) reclamation of rights-of-way in wetlands.

Research priorities were then formulated to develop a preliminary multi-year research plan.

The overall objective of the current Pipeline Right-of-Way (ROW) Research Program, based on the assessment study, is to develop and document methodologies that the gas transmission industry can apply to minimize costs and mitigate ecological impacts caused by pipeline installation and maintenance. To achieve this objective, GRI has established an industry steering committee to assist with selection, evaluation, and deployment of research projects to assure relevance to industry needs, and has contracted with Argonne National Laboratory to develop a comprehensive program plan and to implement specific research projects to resolve the environmental issues identified in the plan.

Recently, three of the five research projects have begun in conjunction with gas transmission line construction. Panhandle Eastern Pipe Line Company has offered its participation in one project to monitor crop yields and edaphic changes for two to five years following pipeline construction through agricultural lands in northern Oklahoma. Results from this project will enable the gas transmission industry to accurately predict the time required for crop yields to return to pre-construction levels, considering the variables of climate, soil type, and crop types.

Another project has been initiated with Columbia Gas Transmission Corporation to monitor pre-construction, construction, and post-construction impacts of a pipeline stream crossing of the Little Miami River in Central Ohio. Parameters to be measured include water quality, benthic macroinverterbrates, and fish populations as indicators of stream recovery over time.

Finally, projects to document successful reclamation on existing pipeline rights-of-way have begun with Northwest Pipeline Corporation and Natural Gas Pipeline Company of America. These projects involve semiquantitative documentation of sucessful reclamation activities considering ROW age, climate, soil type, and plant communities for early program output to the gas transmission industry.

Two additional projects will be incorporated into the program in 1984. A project to document rapid wetland revegetation following pipeline installation will be undertaken, dependent upon identification of construction projects. Secondly, a project to identify and evaluate existing and alternative nonvegetative methods to reduce erosion and improve soil/slope stability along pipeline rights-of-way will be initiated, providing useful, more general information to the gas transmission industry.

GRI is a private, not-for-profit membership organization that plans, manages, and develops financing for a cooperative research and development program in gaseous fuels and their use. The research program, which is designed to benefit the regulated natural gas industry and gas consumers nationwide, consists of over 350 active research projects in four major areas: supply options, efficient utilization, enhanced service, and fundamental research.

PIPELINE PLANNING AND DESIGN

M. Lee Hart
Northern Engineering International Company

An offshore pipeline project commonly originates as a gas sales opportunity. Companies interested in acquiring the gas evaluate different transportation options and prepare an in-depth study with costs, feasibility, capability, and system impact. If after this review, the project is still viewed favorably, contracts are drawn up and signed for the purchase and transportation of the natural gas.

For all applicable permits to be filed, information must be gathered from the hazard and archaeological survey report, from the platform producer, and from the other pipeline company into which the proposed pipeline connects.

All natural gas pipelines, both onshore and offshore, are regulated by DOT 192, Title 49, Code of Federal Regulations. These are the minimum safety standards as required by law, and Subpart C of the Regulations is the basis of pipeline design.

An offshore pipeline has many unique design considerations. To protect the pipeline against corrosion, a specific coating system must be applied to the pipe. In addition, to prevent the pipeline from floating, concrete coating is applied over the cathodic coating. Sacrificial anodes in the form of bracelets must also be designed such that the bracelet thickness matches closely to that of the concrete coating.

Fabricated assemblies, which would include the tie-in valving configuration and side valves for future tie-ins, must be designed to withstand the maximum pressure that the pipline will operate. Normally, ANSI 600# valves and flanges meet this requirement with a pressure rating of 1,440 psig. Because the tie-in assembly must be approved by the other pipeline company and because there are aspects of each tie-in that are very unique, close coordination between the two pipeline companies is important.

Lastly, the platform facilities must be designed to withstand an extreme corrosive environment and be installed in such a manner to minimize space whenever possible. The meter tubes are "piggybacked" or stacked and the meter building kept to absolute minimum dimensions to house the instruments and recorders. A corrosion inhibitor injection system, often provided to internally protect the pipeline against corrosion, consists of a storage tank for the inhibitor and a small pump. All of the above are skid mounted for ease of installation offshore. Platform piping, which is the portion of the pipeline from the metering facilities to the riser, often includes a pig or sphere launcher if liquids of any kind are to be reinjected into the pipeline.

Important design aspects with regards to the riser include reinforcement of the splash area which takes the brunt of wave action, clamps that must hold the riser securely to the platform let, and a riser protector which is installed at the water line to prevent boats from knocking against the pipe.

All the items mentioned with regard to platform facilities must be coordinated with and approved by the platform producer. For this reason, good communications early on in the detailed design can avoid costly changes later.

Two concepts are clear: an offshore pipeline project takes a great deal of planning and coordination; and we in the natural gas industry continue to work towards a safe, reliable, and cost effective way to transport natural gas from offshore.

ENVIRONMENTAL AND CONSTRUCTION TECHNIQUES INVOLVED WITH THE INSTALLATION OF THREE LARGE DIAMETER NATURAL GAS PIPELINES IN SENSITIVE COASTAL AREAS

Dr. Gene J. Gonsoulin
Manager of Environmental Affairs, Southern Natural Gas Co.

This presentation outlines and discusses the activities surrounding installation of three (3) large diameter natural gas pipelines traversing sensitive coastal habitats. Discussion is presented on the project's environmental and construction planning, pipeline routing, facility siting, wildlife timing considerations, and special mitigative construction techniques designed to minimize environmental impacts. The three projects presented are the Cognac Project, the Matagorda Project, and the Savannah Project.

The Cognac Project discussion presents the planning and installation of the 40-mile long, 18-inch diameter Cognac natural gas pipeline originating at Shell Oil's Cognac platform offshore Louisiana in 1,000 feet of water and proceeding northward to a landfall at the mouth of the Mississippi River, then traversing two wildlife refuge systems to a receiving station tie-in.

The Matagorda Project discussion presents the planning and installation of the 40-mile long, 24-inch diameter Matagorda natural gas pipeline originating offshore Texas, proceeding northward and crossing Matagorda Island, a natural barrier island, then proceeding across San Antonio Bay and through the critical habitat of the whooping crane adjacent to Arkansas National Wildlife Refuge to a tie-in point just north of the refuge.

The Savannah Project discussion presents the construction of an LNG facility and subsequent installation of two 30-inch diameter natural gas pipelines traversing the Savannah National Wildlife Refuge, a high energy tidal area.

INTEGRATED STUDIES APPLIED TO THE DECISION-MAKING PROCESS CONCERNING PIPELINE PLACEMENT IN COASTAL WATERS

Dr. R. Warren Flint
The University of Texas, Marine Science Institute

The demands of scientific inquiry and legal mandates upon environmental managers are not being met by methodologies able to detect ecosystem degradation from long-term, subtle impacts. There is a need in marine environmental assessment research to develop strategies that integrate various dynamics comprising the total ecosystem picture. For example, by concentrating on key processes in a coastal ecosystem, long-term fate of this system can be predicted, since these processes are important to the integrated health of that ecosystem. In contrast, this is not necessarily true for the long-relied-upon assessment approach of simply identifying, weighing, and counting organisms. Other than direct impacts to the organisms monitored, conclusions cannot usually be drawn concerning integrated effects to an entire ecosystem from environmental change.

The Texas coast of the Gulf of Mexico is a good example of an area where pressure from industrial growth is increasing daily on its coastal waters. Port facilities, the development of large petrochemical centers, harvest of fisheries, exploitation of mineral reserves, and coastal urbanization have all shown recent growth in this region. Characteristics associated with this development are often thought of as incompatible with the maintenance of these coastal areas as natural, productive systems. The ingenuity of the scientist is the key to holistically perceiving this environment, considering user's needs, assessing all forms of available information, and deriving tools that will provide a sound scientific basis for managers making decisions. Only then can realistic judgments be made which strike a fine balance between preservation of natural resources and continued economic growth in this region as well as other coastal regions of the world.

The placement of pipelines in coastal waters is an activity related to energy exploitation that may very likely alter these habitats. An appropriate area of assessment focus in these coastal environments is the seafloor because the majority of impact from pipeline placement would be directed to the bottom habitat. Emphasis is placed upon the seafloor here in order to gain a better understanding for ecosystem function because of its pivotal role in energy transfer through the production of carbon and nutrient recycling through such activities as bioturbation by the fauna inhabiting marine sediments. For example, data from a coastal Gulf of Mexico station indicates that production of carbon by benthic fauna is approximately 1,000 times more than carbon production by penaeid shrimp in this same habitat. Benthic nutrient regeneration can supply between 31% and 74% of the total nitrogen required by phytoplankton populations for production in these waters. In addition, the annual cycle of seafloor nutrient regeneration, compared with nutrient concentrations in the surface waters that are derived from other sources, suggests that benthic nutrient regeneration becomes most important to the coastal habitat during times of low nutrient contributions from these other sources.

With the environmental manager in mind, available information that provides insight toward coastal ecosystem function has been combined into a conceptual model. The purpose of this exercise was (1) to understand how components of the habitat interact and (2) to illustrate how information on fauna (e.g., life history cycles, standing stocks, etc.) within the ecosystem can be combined with information on dynamic processes (e.g., benthic production, nutrient regeneration, etc.) of the ecosystem in a conceptual scheme to provide a useable management tool for the decision-maker. An example of how this model can be applied as a decision-making tool is presented, and resiliency of the habitat after alteration is also discussed as a prime factor for consideration in the decision-making process.

Understanding how an environmental modification of coastal waters (e.g., pipeline placement) impacts the function and productivity of that habitat is not a simple task. It entails the development of a holistic approach to understand how the modification has altered material flows, food resources, community dynamics, and how long it will take for recovery to occur. Without the integration of as much information as is available into a composite picture of ecosystem function, including the definition of long-term variability, the ability to predict actual impacts from environmental modifications is extremely difficult, if not impossible.

UTILIZING CONSERVATION PLANNING TO EVALUATE POTENTIAL ONSHORE PIPELINE LOCATIONS

Charles W. Savant
District Conservationist, USDA Soil Conservation Service

The purpose of this presentation is to provide information concerning some of the basic soil conservation programs and services which may be of importance to your particular interests.

PROVIDING RESOURCE INFORMATION

As the local district conservationist representing the USDA Soil Conservation Service (SCS) in the New Orleans area, one of my major responsibilities is to provide basic resource information to the public for use in making planning decisions. These requests may be very general in nature, such as providing basic soils information to a potential homeowner. In another instance, a request may be from an individual landowner needing comprehensive resource planning assistance on a large unit of land. Regardless of the type of request, the individuals are usually looking for basic resource information which they can utilize in planning or in reaching resource management decisions. Requests from people in the oil and gas industry relating to pipeline locations or other proposed projects are very similar to these examples.

THE SOIL SURVEY -- A BASIS FOR RESOURCE PLANNING

Requests for soil survey information account for a large portion of the Soil Conservation Service workload in the New Orleans Field Office. This is due in part to the nature of the soils in the area and the types of development occurring on these soils. Development on drained organic soils which once supported swamp or marsh vegetation has resulted in serious soil subsidence problems in many residential communities. The soil survey of Jefferson Parish, Louisiana, received strong support from local officials looking for answers to developmental problems. Interim soil surveys for the east and west bank areas of Jefferson Parish were aimed specifically at urban related soil problems and have served as the basis for the creation of several parish ordinances.

How can a soil survey help with your specific needs? If you are a pipeline contractor or a consulting engineer assisting a contractor, you may find a modern published soil survey can answer many basic planning questions. In some cases, the soil survey will only be a starting point indicating a need for more detailed or site-specific information.

Most of the soil published by the Soil Conservation Service address one parish or county. Some surveys in Louisiana have combined two parishes with similar soils and resource areas, such as the St. James-St. John The Baptist Parishes Soil Survey. Each of these surveys contains a complete set of aerial photographs covering the entire parish land area. Soil lines and mapping unit symbols are indicated directly on the aerial photograph base. Section numbers, section corners, and range and township designations are also indicated on the maps. Most of these surveys utilize maps with a scale of 1:20,000 or 3.17"/mile. With such a survey, a project engineer or planner can simply plot a proposed pipeline route directly on the maps. Mapping unit descriptions for each soil are contained in the text of the survey manuscript. Each survey also contains sections on the general nature of the mapping area and includes basic soils information concernig use and management, soil properties, classification, formation, and other descriptive soils data.

The engineering section of a soil survey should be of particular interest to people involved in pipeline site assessments and construction activities. Information contained in this section is intended for land use planning, evaluating alternatives, and planning site investigations prior to design and construction.

The information does have limitations. For example, estimates and other data generally apply to a depth of five to six feet. Because of the map scale, small areas of different soils may be included within a particular soil mapping unit. The engineering information is not site-specific and does not eliminate the need for on-site investigation of the soils, or for testing and analysis by personnel experienced in the design and construction of engineering works.

Engineering index properties for each soil mapping unit are also described in the survey. This section includes USDA texture, engineering classification, particle size, liquid limit, and plasticity index for each soil in the survey.

The physical and chemical properties of the different soils are also described. This section should be relative to pipeline activity since it presents values for bulk density, permeability, shrink-swell potential, soil reaction, and other properties.

Published soil surveys may be obtained from the local Soil Conservation Service office in the parish or county where activity is being planned. If a detailed published survey is not available, a general soils map with some interpretations can usually be obtained. In Louisiana, published reports have been completed for 26 parishes. Field mapping has been completed in seven additional parishes, and these are scheduled for publication. Survey mapping is currently underway in 14 parishes with target dates set for completion. The entire state is scheduled for completion of mapping by 1990.

SITE ASSESSMENT AND EVALUATION

Site assessment and evaluation activity of the Soil Conservation Service is generally made available to the public as assistance to local soil and water conservation district programs. The priority placed on this type of assistance will depend on the long-range district program objectives, volume of requests, and available staffing to conduct the work.

Although most requests are from units of parish and local government, the potential exists for the Soil Conservation Service to provide more assistance in the field of site assessments in relation to proposed pipeline locations. Specifically, in relation to preliminary site reviews and the permit review process, the local district conservationists may be able to provide general planning assistance.

One example of how the Soil Conservation Service can interface with other agencies and an individual oil company on site evaluations occurred recently in St. Bernard Parish, Louisiana. Shell Oil Company was referred to the local office by another agency for vegetative recommendations prior to filing a permit for proposed pipeline activity. Personnel from the Louisiana Department of Natural Resources and the Soil Conservation Service made an aerial review of the proposed right-of-way with representatives from Shell Oil Company in order to make basic recommendations.

The proposed right-of-way was plotted on a general soils map which indicated the areas where practical revegetation after normal backfilling could be accomplished. The soils information indicated that a large portion of the proposed line was on organic soils which make normal backfilling and successful revegetation impractical. As a result, the appropriate agencies involved in the permitting process will pursue other alternative considerations and mitigation measures with the applicant on this project. The use of water control structures to reduce the threat of salt water intrusion and resulting loss of valuable wetland resources is one alternative being considered in this particular situation.

CONSERVATION PLANNING

The landowner or landuser being impacted by the placement of a pipeline on or near his land will certainly have a different perspective about the project as compared to the primary benefitting parties. Conservation planning assistance is provided to landusers cooperating with local conservation districts. To qualify for this type of assistance in most districts, landusers sign a cooperative agreement.

Many of the major land holding companies in coastal Louisiana are cooperators with local soil and water conservation districts. A large portion of the oil and gas activities in Louisiana occurs in the coastal area on company lands. Oil and gas exploration and resulting transmission needs are primary concerns of all of the major landowners. However, these same companies are also concerned about protecting the long-term productivity of their land. The land is their investment, not only for future oil and gas revenues, but also for surface revenues from waterfowl leases, fur production, and other renewable resources.

The Soil Conservation Service utilizes an interdisciplinary planning approach to assist coastal landusers in Louisiana. The 3.5 million acres of coastal marshlands in the state are very delicate and complex wetlands requiring special planning considerations. The typical planning team consists of a district conservationists, biologist, engineer, plant materials specialist, and a soil scientist if soils data is not available.

The planning team utilizes available resource data and makes on-site evaluations to determine needed conservation measures. The district conservationist utilizes this data to work directly with the landuser in developing a conservation plan for the particular land unit. Land use capability, individual management objectives, alternative conservation measures, and other factors are considered carefully in the planning process.

Spoil placement, water control structures, prescribed burning, critical area plantings and other conservation measures may be applicable components of a conservation plan on marshland. The ultimate goal of such a plan is to maintain marshland vegetation and reduce saltwater intrusion.

Due to the organic nature of marsh soils, pipeline trenches generally are more appropriately referred to as "pipeline canals" in Louisiana. Liquification of the disturbed soil and soil subsidence contribute to this condition. In order to prevent saltwater intrusion and the resulting acceleration of land loss, structures are needed at specific locations. The need and proper placement of such structures may be addressed in a conservation plan. The condition and effects of existing structures are also addressed during plan development. Water movement through natural waterways and existing man-made canals also influences hydrology in marsh areas. Low level water control structures are installed to improve habitat for waterfowl and fur bearers.

Landusers may utilize conservation plans to identify potential mitigation measures on their land. Several conservation plans developed with the Soil Conservation Services' assistance in Louisiana have been utilized by landowners in applying for coastal use permits with the Louisiana Department of Natural Resources.

RECOMMENDATIONS

Specific programs and services made available by the Soil Conservation Service through local soil and water conservation district programs may be useful in several areas of oil and gas development activities:

1. Soil surveys provide necessary soil interpretations for answers to many basic planning questions.
2. Site assessments and evaluations may provide additional planning assistance with basic recommendations. This service is particularly applicable in the area of permit review procedures with local, state, and federal agencies.
3. Conservation planning activities with individual landusers provides assistance in determining suitable resource management alternatives and appropriate conservation practices aimed at protecting the long-term productivity of the resource base.

Session: COASTAL ENVIRONMENTAL SENSITIVITY MAPPING AND INDICES

Chairman: Lawrence R. Handley

Date: November 15-17, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Lawrence R. Handley Minerals Management Service
Method for Ranking Biological Resources in Oil Spill Response Planning and Impact Assessment	J. Kenneth Adams U. S. Fish & Wildlife Service
Identification of Environmentally Sensitive Areas for Planning	Rod E. Emmer Coastal Environments, Inc
Environmental Sensitivity Mapping in the Gulf of Mexico: Local and Regional Oil Spill Response Planning	Thomas G. Ballou & Charles D. Getter Research Planning Inst.
Sensitivity of Alabama Coastal Shoreline Habitats to Spilled Hydrocarbons	Pat O'Neill Alabama Geological Survey

COASTAL ENVIRONMENTAL SENSITIVITY MAPPING INDICES

COASTAL ENVIRONMENT SESSION OVERVIEW

Lawrence R. Handley

The session on Coastal Environmental Sensitivity Mapping and Indices stemmed from a session on Coastal Mapping held at the 1982 Information Transfer Meeting. That session presented five major coastal mapping projects in progress, or completed around the Gulf of Mexico. These projects have been produced at varying scales with varying amounts of detail. However, the emphasis in all cases was placed on gathering and depicting the resource data. Resources included biological information, soils, socioeconomic information, climatology, hydrology, oil and gas, and other mineral resources.

Each of the programs was designed to meet the specific requirements of description or analysis of the environment of the organization that was doing the mapping.

It was agreed upon by all the participants that the projects complemented each other in the scales and in the data that were presented. From that discussion came the realization that with the amount of research data available, what is now needed is the ability to begin quantifying and categorizing the information.

This session focused on the need for the capability to map the sensitivity of the coastal resources and the development methods of quantifying that sensitivity through the use of various indexing schemes. Four projects have been completed for the Gulf of Mexico. Four different methodologies have been employed and, as a result, four different points of view regarding indices and sensitivity have emerged.

First, Ken Adams from the Fish and Wildlife, National Coastal Ecosystem Team, presented a project that the National Coastal Ecosystem Team in Slidell has completed for LOOP, Louisiana Offshore Oil Port, where they presented a mapping and an indexing scheme for sensitive environmental habitats within the coastal LOOP area. Basically, the information was of a biological nature with the development of an indexing scheme that was based on a high, medium, and low ranking system. This project was to determine the potential effects of oil spills from LOOP to these biological environments.

Secondly, Dr. Rod Emmer from Coastal Environments, Incorporated, presented a sensitivity scheme that has been prepared by Coastal Environments for Clean Gulf, Incorporated. The project was done in 1979-1980 as the response that Clean Gulf needs for oil spills. A ranking of the sensitive habitat was not done, but a depiction of particular habitats and the locations of sensitive environments of a biological-ecological nature was completed.

The third presentor was Mr. Tom Ballou from the Research Planning Institute, in Columbia, South Carolina. This was a MIRG Project (a conglomerate of oil companies) putting together an oil spill response scheme. The ranking they employed was based upon the clean up capabilities of particular coastal habitats, mainly the ability to clean-up fine sands, coarse sands, and vegetated coastlines, what we might refer to as the ability for oil spill clean-up, given the geomorphological and biological coastline resources.

The fourth presentation was by Mr. Pat O'Neill from the Geological Survey of Alabama on the Sensitivity of Alabama Coastal Shoreline Habitats to Spilled Hydrocarbons. This sensitivity mapping was formulated from a biological and ecological aspect, and a ranking was developed on a high, medium, and low sensitivity of each particular environment.

Regarding sensitivity mapping and the development of indexing schemes, several important points emerged from the session. Of first importance is the sufficiency of available resource data to develop indices.

The answer to that question depends, first, on what the indices are to focus on, whether it's oil spills, or pipelines or coastal infrastructure facilities. Second, it depends on the scope of the area that's to be covered. The scale of the mapping and the degree of detail required by the particular agency in need of the analysis are important considerations in focusing on the area to be covered. In some instances, the scope is dependent upon the information available around the Gulf coast. Some data are lacking, for instance, on bird colonies. Some data are missing on nearshore environments in some areas, and it is abundant in other areas. It was agreed, though, that even though the baseline studies exist, such as the ecological characterizations done by the Minerals Management Service and the Fish and Wildlife Service, by RPI, by the State of Alabama, and by other agencies, that the data does have to be continually updated.

A second question was whether common indices can be developed for oil spill sensitivity, pipeline corridors, and onshore/nearshore infrastructure sensitivity. It was generally agreed that a single index cannot be developed to include all of these, due to varying needs of each of the particular items and quite different vulnerability of the various environmental factors that are to be included and analyzed within each of these particular projects.

Third, socioeconomic factors should be included in the indices. The indices' previous studies have included socioeconomic factors, infrastructure factors, economic employment factors, or uses of beaches or fisheries. This information needs to be incorporated into a sensitivity ranking.

Fourth, the seasonality of the resources should be considered. Seasonality of the resources can affect the sensitivity of a resource at a particular time of the year. It may be sensitive to oil spills at one particular time of the year and not as sensitive at other times of the year.

Fifth, processes should be included in the indices. Process is vital, one area affecting another one. The recognition that a nearshore environment that is not sensitive may affect another area that is more sensitive is an important aspect that has not been considered in the previous indices.

Probably the most important question that arose from this discussion was: Who uses the maps and the indices once they're prepared? Oil spill contingency is probably the major use of the maps, Clean Gulf and the U.S. Coast Guard. State and federal OCS land managers developing management decisions for coastal locational analysis and for permitting could use these maps as well.

There was concern expressed regarding the training or the education of various users as far as mapreading, i.e., the ability to use the map and to understand the maps and the indices in a particular situation, be it a clean-up, the location of a pipeline, or a particular onshore facility. In most cases, a professional knowledgeable of the maps and/or resources may not be available, and one cannot always rely on a boat captain or the Coast Guard Commander to be in the right place at the right time. The final comment concerning users is this question: If in an oil spill response situation there are three men on the boat and each one of them has different indices and a different set of maps, then what happens?

METHOD FOR RANKING BIOLOGICAL RESOURCES IN OIL SPILL RESPONSE PLANNING AND IMPACT ASSESSMENT

J. Kenneth Adams
U. S. Fish and Wildlife Service
National Coastal Ecosystems Team

This presentation described a method for identifying and prioritizing biologically important geographic areas in spill response planning. Although this project was conducted to minimize environmental risks due to accidental spillage from the Louisiana Offshore Oil Port (LOOP) facility, the methodology is widely applicable. The method has three important characteristics. It is: (1) driven by the existing information base, thus easily updated; (2) applicable to all coastal and aquatic environments; and (3) capable of producing a prioritization within a specific spill response planning area.

The rationale of selecting ranking units and ranking criteria was presented. The habitat was selected as the best available ranking unit for oil spill response planning. "Habitat" was defined, and the attributes of habitats that make them useful analytical units were presented. The criteria selected for this method (habitat recovery, persistence of oil, cleanup damage, important species supported, and habitat rarity) were defined and their evaluation explained.

An application of the method was described for the LOOP spill response planning area. Habitats were identified and delineated, and values were assigned to the ranking criteria. The resultant habitat ranking was presented with recommendations for the incorporation of this analysis into a comprehensive oil spill contingency plan using a computerized geographic information system. This methodology is fully described and documented in the Fish and Wildlife Service's Publication FWS/OBS-82/61, available free of charge by request to the Information Transfer Specialist at the above address.

IDENTIFICATION OF ENVIRONMENTALLY SENSITIVE AREAS FOR PLANNING

Rod E. Emmer
Coastal Environments, Inc.

The U.S. Geological Survey, Conservation Division, issued Outer Continental Shelf (OCS) Order No. 7 effective July 1, 1979. OCS Order No. 7 applies to the exploration, development, production, and transportation of oil and gas from the OCS. The Order is designed to prevent pollution where possible and to control it when necessary. Of primary concern here was Section 3 of OCS Order No. 7, which requires the lessees to develop Oil Spill Contingency Plans for the reporting, cleanup, and prevention of oil and pollutant spread from a spill. To efficiently and effectively implement an Oil Spill Contingency Plan, the lessee must know the environmental parameters which may control the behavior of an oil spill and those physical, biological, and cultural features which will be impacted by an oil spill. The selected problem addressed is limited to the identification of special biologically sensitive areas along the coast of the Gulf of Mexico.

In 1980, Clean Gulf Associates contracted with Coastal Environments, Inc., an environmental consulting firm in Baton Rouge, to prepare a report on the Gulf of Mexico that identified biologically sensitive areas. The study area extended from the Rio Grande of Texas to southern Florida and was divided into three regions: Cost Participation Area (CPA) 1 - Offshore Louisiana; CPA 2 - Offshore Mississippi, Alabama, and Florida (MAFLA); and CPA 3 - Offshore Texas. The offshore study area boundary was the outer extent of the major lease blocks in CPA 1 and CPA 3 and followed mapping unit boundaries in CPA 2. The landward boundary was selected as the most probable inland extent an OCS oil spill may impact under normal climatic circumstances, not hurricane conditions when clean up modes are not safe or practical. In CPA 3 (Texas) the 100-year storm surge line defined by the Bureau of Economic Geology was used because no cultural features, such as a road or canal, was close to the shoreline. In CPA 1

(Louisiana) state highways were used across the Chenier Plain and the Gulf Intracoastal Waterway for the remainder of the state. For CPA 2 (MAFLA), federal and state highways were used exclusively.

Published and unpublished information served as sources for the project. The sensitive areas mapped meet one or more of the following criteria:

(1) zones designated by federal, state, or local agencies as areas of particular concern, such as grass beds;

(2) endangered species habitats which are known to be actively used or have a high potential of being used, for example nesting areas for sea turtles;

(3) administered and managed wildlife reserves, preserves, or ranges;

(4) parks, beaches, recreation areas, or other public lands, such as Padre Island or National Register sites.

(5) habitats which are known to be critical to the biological integrity of the wetland system and are under direct threat of elimination, such as barrier islands; and

(6) communities, habitats, or concentrations which would be devastated by an oil spill, such as sea bird colonies.

A series of 15 multicolored maps of the shore and nearshore were prepared using the USGS 1:250,000 maps as a base and were reduced to 11 x 16 format for ease of distribution and handling. Tables accompanied each map and included the name and location of the sensitive area, a brief description of each, the most critical season, and a reference to a more detailed report. Finally, complete citations were provided for each reference. Offshore maps showed general habitat zones for shrimp, bottomfish, menhaden, and reefs. Tables similar to those for the nearshore sensitive areas were provided.

This material was incorporated into the Clean Gulf Associates' spill response manual. In cooperation and coordination with Clean Gulf personnel, a table was compiled that recommended cleanup modes for protecting the sensitive areas. In addition, references to other manuals used in cleanup operations were provided.

In this study all sensitive areas were considered as equal in resource value to the total coastal system as each area has a constituency that strongly advocates protection of its special area before all others; therefore, there is no system for ranking the spectrum of mapped features. For example, along one section of coast the recreational beach and National Register site may be most important to the local economy and thus ranked high for protection by the Chamber of Commerce, but a biologically-oriented ranking would in all likelihood give the same area a low ranking. Protection of areas becomes a decision made at the time of the cleanup operation by the spill response leader in consultation with authorized federal and state personnel. The team can reach a consensus by considering the season of the year; the dominant physical, biological, and social uses of the area; the potential for irreversible impact; legal demands for protection; and the processes acting on the spill.

The Clean Gulf Associates' maps of sensitive areas identify locations and zones that should be protected from oil spills. The areas are not limited to one aspect of the coastal systems, such as biological entities, but include critical features in the physical and cultural systems as well as biological systems, and thus are comprehensive in scope, an approach that is not often used. As a common point of reference, the data permit easy communication between field personnel and those in the office. Citations are available and can be used to assemble more detailed information should it be necessary. Finally, by treating all areas as having equal resource value, decisions on priority for cleanup can be made in the field when more factors are known.

It is recommended that a comprehensive approach to sensitivity ranking be developed, one that includes all physical, biological, and cultural factors. If this is not possible, then simply ranking by one parameter should be avoided and only sensitivity maps be distributed.

ENVIRONMENTAL SENSITIVITY MAPPING IN THE GULF OF MEXICO: LOCAL AND REGIONAL OIL SPILL RESPONSE PLANNING

Thomas G. Ballou and Charles D. Getter
Research Planning Institute, Inc.

Research Planning Institute, Inc. (RPI) has developed and applied several environmental mapping methods for use in local and regional oil spill response and contingency planning in the Gulf of Mexico and elsewhere. The Environmental Sensitivity Index (ESI) ranks shoreline environments on a scale of 1 to 10 on the basis of biological sensitivity and the physical persistence of stranded oil in the absence of cleanup operations. Full-color atlases of 1:24,000-scale ESI maps identify and locate shoreline types, important resident oil-sensitive wildlife groups and habitats, launch and access points for spill response equipment, and positions for boom and skimmer placement.

ESI atlases are accompanied by a report that describes and evaluates local and regional physical environments, expected biological impacts from oil spills of each shoreline type, and suggested cleanup techniques. A combination of aerial reconnaissance information, ground surveys, and literature review is used to prepare the atlas and report. ESI maps have been prepared for the Gulf coasts of Florida, Alabama, and south Texas. They were first field-tested during the IXTOC I spill in 1979.

The ESI is readily applicable to all estuarine and riverine shorelines and has become part of many county, state, federal, and international spill response and contingency plans. By giving highly detailed resource information, the ESI allows prioritization of local spill response measures and guides response personnel in mobilization and placement of oil spill defense systems. In addition, the identification of individual shoreline types and wildlife resources allows ESI atlases to be used as a data source for many resource management planning activities.

Spill response planning on a regional basis has been conducted in the Gulf of Mexico using a technique which prioritizes large areas for protection. A 2-volume, regional spill response planning atlas was prepared for 45 oil-sensitive regions in the Gulf of Mexico in 1982 for the Marine Industries Group (MIRG). Volume I gives an overview of the important physical processes and biological resources of the Gulf, describes each habitat type, and discusses potential impacts and cleanup methods. Included is an extensive bibliography of over 500 citations concerning the biological and socioeconomic resources of the Gulf. Each title is accompanied by an abstract and can be referenced by author, subject, or region.

Volume II contains regional and area maps of six regions of the United States and Mexico and identifies high-priority areas on the basis of biological and socioeconomic sensitivity to spilled oil. Regional locator maps indicate the most sensitive regions of the Gulf, and the subregions of areas within each region are prioritized for protection during spills. A brief description of the important oil-sensitive biological and socioeconomic resources of the Gulf and information to guide response personnel are given for each area.

The 2-volume atlas serves as a data source and field manual for regional spill response planning in the Gulf of Mexico. By identifying broad, regional areas and focusing on the highly sensitive estuarine habitats, protection measures can be prioritized during regional response actions.

SENSITIVITY OF ALABAMA COASTAL SHORELINE HABITATS TO SPILLED HYDROCARONS

Pat O'Neill
Alabama Geological Survey

The purpose of this study was to identify the relative ecological sensitivity of Alabama's coastal shoreline habitats to spilled hydrocarbons, thereby assisting spill contingency planning and decision making. The potential effects of hydrocarbon spills on shoreline habitats include injury to or elimination of plants and animals and the fouling of habitats. This study addressed only the ecological sensitivity of natural shorline habitats to spilled hydrocarbons.

Collected information was synthesized onto NOAA navigation charts and the sensitivity of various shoreline and habitat types delineated by a three-color scheme. Criteria used to delineate sensitivity included substrate type, residency time of spilled hydrocarbons, the hydrologic environment, biological diversity, and biological productivity. Habitats and shorelines considered the most sensitive included marshes, grassbeds, oyster reefs, tidal flats, and coastal bird colonies. Shorelines considered the least sensitive were Gulf beaches, and areas of an intermediate sensitivity included estuarine shorelines of Mississippi Sound, Mobile Bay, and Perdido Bay.

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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 the wisest use of our land and water resources, protecting our fish and wildlife, 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 assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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