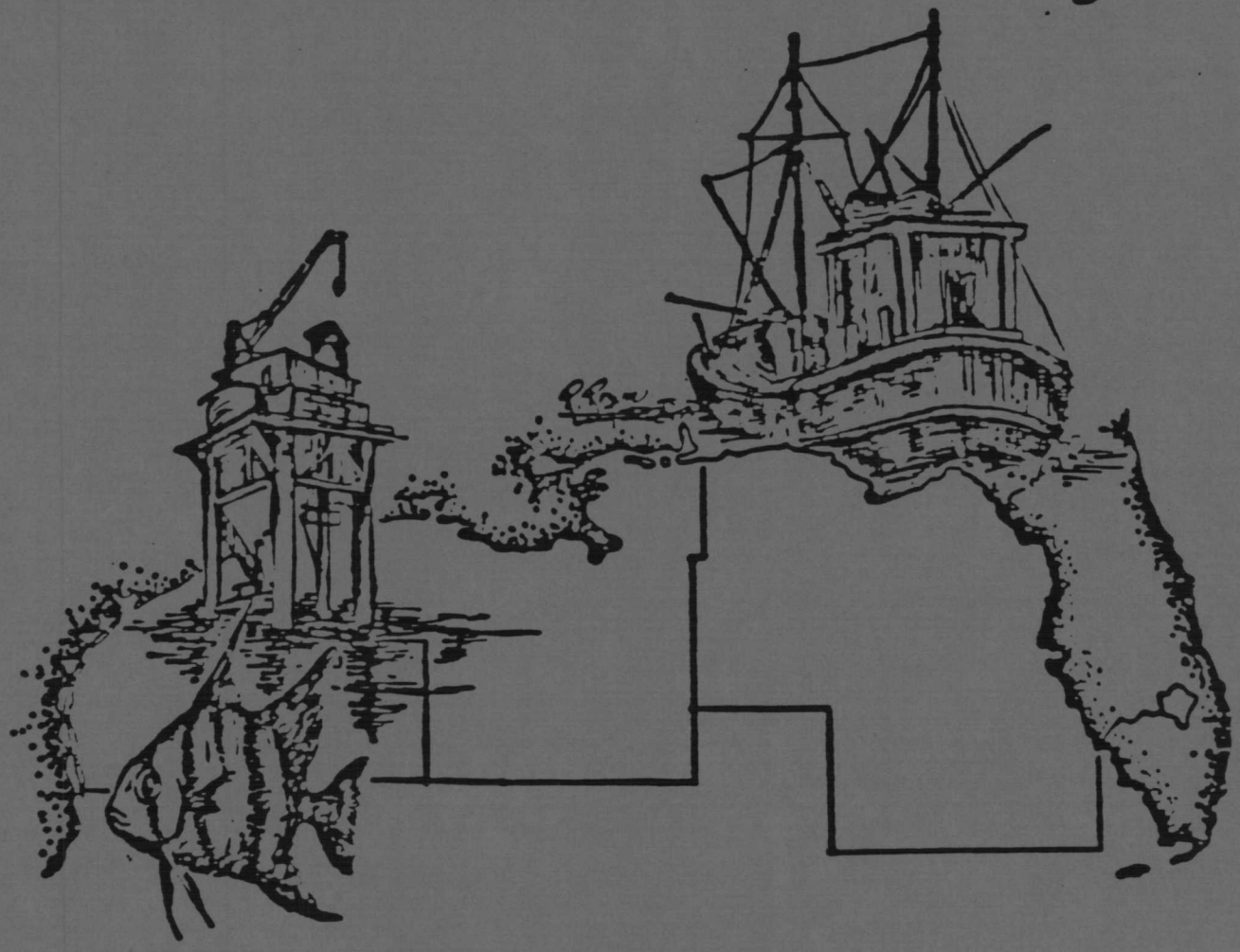
1982 - 42

GULF OF MEXICO
OUTER CONTINENTAL
SHELF REGIONAL OFFICE

PROCEEDINGS

Third Annual Gulf of Mexico Information Transfer Meeting



December 1982

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

PROCEEDINGS:
THIRD ANNUAL GULF OF MEXICO INFORMATION TRANSFER MEETING

August 24-26, 1982
New Orleans, LA

Sponsored by the
Minerals Management Service
Outer Continental Shelf Office
New Orleans, LA

Arrangements Handled by
Texas A&M University
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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 Third Annual Information Transfer Meeting held August 24-26, 1982. 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 Attendees List (Appendix A).

Special thanks are extended to session chairs and speakers, who are responsible for the success of the meeting and the timeliness of the Proceedings compilation. Dr. Rose Norman of Texas A&M University 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 Services (NTIS).

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GENERAL OPENING SESSION

Introduction to Information Transfer Meeting

Dr. Robert Rogers, Environmental Contract Studies Staff
MMS, Gulf of Mexico OCS Region, New Orleans, LA

Dr. Robert Rogers welcomed participants to this third annual Information Transfer Meeting and reviewed the history and purpose of these meetings. Arrangements for all three meetings have been made by Texas A&M University through the Texas A&M Research Foundation (MMS Contracts AA551-CT8-35, AA551-CT0-25, and AA851-CT1-55).

The first Gulf of Mexico Information Transfer Meeting was held May 12-13, 1980, for the purpose of providing a forum for exchange of current data and information generated through environmental studies in the Gulf of Mexico. Over 75 participants from industry, academia, and government attended that meeting. It was generally agreed that this meeting achieved the goals of providing information supportive of Gulf of Mexico lease sales 66 and 67, identifying future environmental study needs, and furnishing a forum for "scoping" as required by the Council of Environmental Quality (CEQ). Scoping is a formal process of gaining insight into what issues are important for generating Environmental Impact Statements and making environmental decisions.

The Second Annual Gulf of Mexico Information Transfer Meeting was planned to fulfill the same needs for exchange of current environmental information. Held April 30-May 1, 1981, the meeting was attended by 82 scientists and administrators from the public and private sector.

The present meeting was delayed until August to present a number of draft reports that are now available for review. These include the draft Regional Environmental Impact Statement (EIS), Regional Studies Plan for 1984, and a number of MMS open file reports. Participants in the meeting were strongly encouraged to review and comment on the reports. This was especially true of the Draft Regional EIS, of which numerous copies were distributed.

It was emphasized that the Information Transfer Meeting was designed to provide an opportunity for the free interchange of information on environmental studies research and how it relates to the solution of environmental problems. Such an overview is important in the formulation of future MMS studies plans and in environmental assessment associated with impacts of offshore oil and gas development.

In conclusion, Dr. Rogers thanked the staff of Texas A&M University for hosting the meeting, and complimented Ms. Sylvia Herrig for her work in making arrangements for the meeting.

Status of Minerals Management Service Organization/Streamlining

Mr. Harry Sieverding, Acting Manager
MMS, Gulf of Mexico OCS Region, New Orleans, LA

Organization

In January, 1982, the Secretary of the Department of the Interior established the Minerals Management Service (MMS) by Executive Order 3071. That order set up a board to govern the MMS and made the Conservation Division of the U.S. Geological Survey (USGS) the principal component of the MMS. On May 10, 1982, the Bureau of Land Management Offshore Oil and Gas Operation was brought into the MMS through Amendment #1 to the Executive Order. The second amendment to the order (May 26, 1982) established the organizational structure and hierarchy of the MMS.

The Director of the MMS is Mr. Harold Doley, of New Orleans. His Deputy is Mr. Dave Russell, formerly of the Department of the Interior. Three Associate Directors serve under the Director, one for Royalties, one for Onshore Minerals, and one for Offshore Minerals. The Gulf of Mexico OCS Regional Office reports to the Associate Director for Offshore Minerals, Mr. Robert Rioux, formerly of the USGS in Washington, D.C. The Gulf of Mexico is one of four regions under Mr. Rioux's jurisdiction; the other three are Alaska, the Pacific, and the Atlantic. The Gulf of Mexico Acting Regional Minerals Manager is Mr. John Rankin, formerly the Manager of the Bureau of Land Management's New Orleans OCS Office. All members of this staff are serving in acting capacities; no permanent appointments have been made. In mid-September, the New Orleans office was moved to the Imperial Office Building in Metairie, Louisiana (504/837-4720).

Streamlining

The new leasing schedule offers all the available acreage in the Gulf of Mexico for lease. The method for managing this large leasing schedule is called "streamlining." This new five-year schedule calls for three Gulf of Mexico sales in 1983. The first of these, Sale No. 72, includes unleased acreage in the Central Gulf of Mexico, which comprises the OCS off Louisiana, Mississippi, and Alabama. The second, Sale No. 74, is scheduled for the Western Gulf of Mexico, which is approximately the area off of the State of Texas. Sale No. 79, the third Gulf of Mexico sale, is scheduled for the Eastern Gulf of Mexico, which is generally the area off of the State of Florida.

Under the old system, each tract for sale was associated with a numbered lease block and assigned a unique tract number. For example, Vermilion Block 16 might be numbered Tract 1, and that tract number would be used in stipulations, bidding, and so on. This system will not work for the new leasing schedule because about 130 million acres are available for sale (about 23,000 blocks).

The new system, therefore, will provide a list that identifies areas for bidding by map area and block number. A separate map will show stipulation locations, bidding terms (five-year or ten-year), and the bidding system (one-eighth or one-sixth royalties, net profit shares, or fixed sliding scale).

The changed leasing system affects decisions about areas for Gulf of Mexico OCS studies. Previously, the studies program was somewhat geared towards blocks being offered for sale. That kind of specific information will no longer be available. Some general guidelines have been displayed in a visual showing areas of high, moderate, and low interest in the Gulf of Mexico. It is very likely that 75 to 80% of the blocks receiving bids will be in the high interest area, 10 to 15% in the moderate interest area, and 1 to 5% in the low interest area. This provides some guide to the geographic location, but not the topics of future studies.

The total amount of acreage that will receive bids and go under lease will probably be a function of industry's available funds, equipment, and personnel. Past sales of 1 to 1.5 million acres have received bids on 300,000 to 500,000 acres. There is no reason to expect a dramatic change in these statisitics.

Environmental Studies Program Overview

Dr. Richard Defenbaugh, MMS, Gulf Of Mexico OCS Region

A major goal of this meeting was to get more information for the MMS Gulf of Mexico OCS office to use in scoping environmental impact statements, planning regional studies, and so on. The overview of this office's Environmental Studies Program explains what this program is, how it works, and why the office is interested in the information provided by speakers and exchanges with other participants at this meeting.

Background on OCS Leasing

Offshore oil and gas activities began in the Gulf of Mexico in the late 1930's off of Louisiana and were authorized in federal waters in 1953 with the passage of the OCS Lands Act. The first Gulf sale was held in 1954. Since then, about 3,500 OCS leases have been awarded. Not all of those are now active, but they represent 77% of total U.S. OCS leasing. About nine million acres are presently under lease, and about 18,000 wells have been drilled in the Gulf of Mexico. At present, there are about 1400 major platforms and a total of 2800 platforms emplaced in the Gulf. As of a few months ago, there were about 4300 active producing wells and almost another 4000 that were shut-in, but capable of producing.

Total federal revenues generated to date approach $35 billion. Total production to date from the OCS is about 4.8 billion barrels of oil and 49 trillion cubic feet of gas, as well as other minerals and

petroleum products. Oil production in the Gulf peaked in 1973, and is on a decline, while gas production is still trending upward. Both are projected to decline in the future. To date, 44 OCS lease sales have been held, and 14 more are scheduled through 1987 at the rate of about two or three sales per year.

The leasing procedure is relatively lengthy and complex. Briefly, two types of studies are germane in the leasing process: pre-sale information gathering studies and post-sale environmental monitoring studies. An in-house analysis showed that these studies are primarily used for preparing environmental impact statements, developing leasing stipulations, and "Scoping" (the process currently used to define issues of true concern for analysis in environmental impact statements).

Studies Program

The MMS Studies Program in the Gulf of Mexico began in 1973 with literature surveys. The first field efforts began in 1974 with baseline studies. Large-scale, multi-disciplinary, baseline studies continued until about 1978. In response to criticism that large-scale baseline studies were providing information not immediately relevant to leasing decisions, smaller, more area or topic-specific studies were initiated in 1978.

Also in 1978, the OCS Lands Act Amendments were passed. This Act authorizes the Studies Program and gives three primary goals for the program:

1. to establish information for assessment and management of environmental impacts to human resources and the marine and coastal environment which might be affected;

2. to develop a predictive capability, especially regarding impacts to biota and coastal environments, with special emphasis on chronic low-level pollution, large oil spills, drilling muds and cuttings, and pipeline emplacement; and

3. to monitor human, marine, and coastal environments over time and provide information on significant changes in the quality or productivity of the environment.

Basically, the three goals may be summarized as to gather information for a management base, develop a predictive capability, and monitor for significant changes.

Presently, the studies program is operationally divided into eight study series. Through fiscal year 1981, which closed almost a year ago, about 63 contracts valued at about $40 million had been awarded for Gulf of Mexico studies. By the time fiscal year 1983 closes, about 70 contracts totaling about $44 million will have been awarded.

Nationally, the studies program allocation totaled $50 to $60 million in 1976, and about $30 million per year in more recent years. Of the four regional offices, most of the money (about 50% annually) goes to the Alaska Program because of the numerous leasing areas, the pristine nature of the environment there, and the difficulty in working in that climate. About 15% each is allocated to the Gulf of Mexico region and to the Atlantic Region. A bit less goes to the Pacific region, and the remainder stays in the Washington Office for contingencies. The funding level for the New Orleans Office has fluctuated, but has recently been about $3 to $5 million per year.

The planning process for regional studies for each fiscal year begins two years in advance with the development of preliminary study profiles. These are distributed for review and comment, then packaged for discussion in a workshop where a Draft Regional Studies Plan is developed. This Plan is then circulated for review and comment. Following the receipt of comments, the Regional Studies Plan for that fiscal year is finalized and incorporated into the National Studies Program at the Washington Office. All along, that office has reviewed drafts and ultimately works our studies plan into the national budget planning. Final approval of studies is determined by technical needs and funding availability. Not all studies described in the final Regional Studies Plan are funded.

The procurement procedure for funding studies described in the Regional Studies Plan is fairly straightforward. The Gulf of Mexico regional office designs each study, talking to relevant people in the Washington Office and other federal agencies. We then develop a procurement package, which includes a draft Request for Proposal (RFP) and provides rationale and justifications for the study. That package is sent to Washington for review and approval. Finally, the RFP is issued and advertised in the Commerce Business Daily. Proposals are reviewed and evaluated, and eventually a contract is awarded.

Technical people in our regional office monitor the contracts for technical aspects, and the Contracting Officer in Washington takes care of contractual and business matters. The Regional Office supervises the entire project from initiation of field efforts through laboratory efforts, interpretation of the results, review of the final reports, and final close-out.

The final report is available to the general public in three basic formats. A hard-copy original is printed in very limited quantity (due to government printing regulations) for distribution mostly to federal and state agencies and libraries. A hard-copy original is sent to NTIS and copies are available to the general public either as NTIS hard-copy reproduction or as microfiche.

Synopsis of Studies

A synopsis of the eight study series and a few selected studies should give something of the flavor of the program (see Table 1). The

TABLE 1
GULF OF MEXICO OCS ENVIRONMENTAL STUDIES PROGRAM SYNOPSIS

A. Habitat Mapping

1. General Program

CT8-22	Eastern Gulf of Mexico Marine Habitat Mapping Study	Completed
IA8-27	Remote Sensing of Seagrasses	Completed

2. Geohazards Program

MU5-20	South Texas OCS Baseline Study, Geology, FY 75	Completed
MU6-24	South Texas OCS Geological Investigations, FY 76	Completed
MU7-27	South Texas OCS Geological Investigations, FY 77	Completed
MU8-11	Western Gulf of Mexico Geological Investigations, FY 78	Completed
MU9-10	Northern Gulf of Mexico Geological Study, FY 79	Completed
MU0-8	Gulf of Mexico OCS Geological Investigations, FY 80	Completed
IA1-16	Gulf of Mexico OCS Geology Study, FY 81	Active
IA2-11	Gulf Benthic Habitat Mapping Study, FY 82	Active

B. Physical Oceanography

CT4-16	Eastern Gulf of Mexico Physical Oceanography Data Compilation and Summary	Completed
IA5-19	South Texas OCS Environmental Studies, 1975, Physical Oceanography	Completed
IA5-26	Model Studies of the Circulation in the Gulf of Mexico	Completed
IA0-11	Gulf of Mexico OCS Satellite Oceanography, FY 80	Completed
CT0-72	Southwest Florida Shelf Circulation Modelling Study	Active
CT2-77	Gulf of Mexico Physical Oceanography Program	Active
G-271	Gulf Circulation Modelling Study	Planned
G-273	Mud Plume Modelling Study	Planned
IA2-31	NMFS Ship-of-Opportunity Program	Active
IA2-43	Gulf Satellite-Tracked Drifting Buoy Program	Active
G-304	Physical Oceanography II	Planned
G-371	Gulf Circulation Model II	Planned
G-374	National Marine Fisheries Service Ship-of-Opportunity Program	Planned
G-376	NDBO Drifting Buoy II	Planned
G-377	NOAA/NESS/SSFC (Satellite Services Field Center) Program	Planned
G-378	Gulf Satellite Altimetry II	Planned

C. Marine Ecosystems

1. General Program

CT3-10	Gulf Environmental and Socioeconomic Baseline Study	Completed
CT9-35	Gulf of Mexico OCS Area Polychaete Study	Active
G-329	Tuscaloosa Trend Study	Planned

Table 1 (Continued)

2. Eastern Gulf of Mexico Benchmark Program

CT4-5	Marine Environmental Implications of Offshore Drilling, Eastern Gulf of Mexico	Completed
CT4-11	MAFLA OCS Baseline Study, FY 74	Completed
CT5-27	MAFLA OCS Multivariate Analysis of Water Column Data	Completed
CT5-30	MAFLA Environmental Monitoring Program, FY 75	Completed
CT5-43	MAFLA OCS Analysis of Hydrocarbons in Epifauna	Completed
CT7-28	Eastern Gulf of Mexico OCS Ichthyoplankton Study, FY 77	Completed
CT7-34	Eastern Gulf of Mexico OCS Benchmark Studies, FY 77	Completed

3. South Texas OCS Benchmark Program

CT5-17	South Texas OCS Baseline Study, Biology and Chemistry, FY 75	Completed
IA5-19	South Texas OCS Environmental Studies, 1975, Plankton and Fisheries	Completed
CT6-17	South Texas Monitoring Study, Biology and Chemistry, FY 76	Completed
CT 7-11	South Texas Monitoring Study, Biology and Chemistry, FY 77	Completed
IA7-3/IA7-21	South Texas OCS Fisheries Investigations, FY 76-78	Completed
CT8-51	South Texas Three-Year Data Synthesis Study, FY 78	Completed

4. Topographic Features Program

CT5-4	South Texas Topographic Features Study, FY 75	Completed
CT6-18	South Texas OCS Topographic Features Study, FY 76	Completed
CT7-15	Northwestern Gulf of Mexico Topographic Features Study, FY 77	Completed
CT8-35	Northern Gulf of Mexico Topographic Features Study, FY 78	Completed
CT0-25	Northern Gulf of Mexico Topographic Features Study, FY 80	Completed
CT1-55	Gulf of Mexico Topographic Features Data Synthesis	Active

5. Southwest Florida Shelf Program

CT0-50	Southwest Florida Shelf Ecosystems Study	Active
CT1-45	Southwest Florida Shelf Ecosystems Study, Year II	Active
CT1-45/Mod. 1	Southwest Florida Shelf Ecosystems Study, FY 82, Hydrography Component	Active
CT2-48	Southwest Florida Shelf Regional Biological Communities Survey, FY 82	Active
IA2-20	Southwest Florida Shelf Remote Sensing Survey	Active
G-361	Southwest Florida Shelf Reef Trend Study	Planned

6. Deep Gulf Program

CT4-12	Ecological Aspects, Gulf Upper Continental Slope	Completed
CT1-12	Gulf of Mexico Deep Sea Biology Study	Active
G-312	Northern Gulf of Mexico Continental Slope Study	Planned

7. Quality Control Program

CT4-15	Trace Metals Quality Control Analyses (MAFLA I)	Completed
CT4-13	Hydrocarbons Quality Control Analyses, FY 74	Completed
CT5-49	Trace Metals Quality Control Analyses (MAFLA II) (South Texas I)	Completed
CT6-19	Hydrocarbon Quality Control Analyses, FY 76-77	Completed
CT8-26	Hydrocarbon Quality Control Analyses, FY 78	Completed

Table 1 (Continued)

D. Coastal Studies

MU8-28	Mississippi Deltaic Plain Ecological Characterization, FY 78-80	Active
MU9-14	Texas Barrier Island Ecological Characterization, FY 79-81	Active
MU0-20	Northeastern Gulf of Mexico Coastal Ecological Characterization, FY 80	Active
MU0-48	Southwest Florida Shelf Coastal Ecological Characterization Study, FY 80	Active
G-311	Southwest Florida Characterization Study, FY 83	Planned
G-314	Northeastern Gulf Characterization Study, FY 83	Planned

E. Endangered Species

MU8-12	South Atlantic/South Texas Marine Bird Study, FY 78-79	Active
MU9-18	South Atlantic and Gulf of Mexico Endangered Species Pilot Study	Completed
MU0-21	Gulf of Mexico and South Atlantic OCS Study on the Distribution and Abundance of Endangered and Vulnerable Mammals, Birds, and Turtles, FY 80	Completed
IA1-24	Gulf of Mexico and South Atlantic OCS Endangered Species Study, FY 81	Active
IA2-13	Gulf of Mexico Study of Distribution and Abundance of Endangered and Vulnerable Mammals, Birds, and Turtles, FY 82	Active
G-316	Gulf of Mexico Endangered Species Study	Planned

F. Cultural Resources

MU5-40	Cultural Resources Evaluation of the Northern Gulf of Mexico	Completed

G. Recreation and Fisheries

IA5-19	South Texas OCS Environmental Studies, 1975, Plankton and Fisheries	Completed
IA7-3/IA7-21	South Texas OCS Fisheries Investigations, FY 76-78	Completed
CT7-28	Eastern Gulf of Mexico OCS Ichthyoplankton Study, FY 77	Completed
IA0-49	Recreational Fishing Survey, FY 80-81	Active

H. Effects of Oil & Gas Activities

1. General Program

CT8-17	Central Gulf of Mexico Platform Study	Completed
CT9-36	Gulf of Mexico OCS Reef Fish Study	Completed
MU0-37	Effects of O&G Development in the Offshore Texas and Louisiana Marine Ecosystem	Completed

2. IXTOC Program

CT0-65	Economic Impact of Oil Spills on the Texas Coast, FY 80	Completed
CT0-71	IXTOC Oil Spill Assessment Study, FY 80	Active

I. Environmental Information Management

CT2-78	Data Reformatting	Active
G-391	Information Management Program: NEDRES Update	Planned

Habitat Mapping Series consists of studies for gathering information on the physical habitat offshore, including both bathymetric mapping and geophysical surveys for geologic information and for biological and habitat information. The bathymetric effort has resulted in final topographic/bathymetric mapping sheets for almost the entire Gulf of Mexico. Revisions and corrections to the sheets are now being planned where needed. The geologic studies began as the geologic aspect of baseline studies, gathering information on sedimentary characteristics and geohazards. What has emerged is a series of environmental atlas studies for several areas. These studies, done generally by the USGS lab at Corpus Christi, provide very detailed maps of geologic and related information.

The Physical Oceanography Series is just getting off the ground. In the past, most of this office's physical oceanography studies have been literature summaries and preliminaries to modeling. A field program is now under procurement. The basic goal for physical oceanography studies is oilspill risk analysis as the basis for environmental impact statements. Also, an understanding of currents is needed for general environmental assessments, studies planning, and understanding studies results. The program is built on the recommendations of a workshop held two years ago in New Orleans, and includes field sampling, data gathering, model development, and so on. The idea is to gather data, develop and validate a model to understand three-dimensional circulation of the Gulf, and then feed that information into the oilspill trajectory and risk analysis model. The oilspill model presently used in environmental impact statements is a two-dimensional model of surface trajectories. It would be useful to understand the three-dimensional circulation of the Gulf, in order to determine where all the IXTOC oil went, for example.

The Marine Ecosystems Series includes all baseline studies and the ecosystem and related studies. The first study was a socioeconomic environmental baseline study completed in 1975. The environmental aspect was mainly a bibliography update. The Polychaete Study is aimed at standardization of the taxonomy of worms in the Gulf. Worms are ecologically important, and are sensitive indicators of environmental stress. Previously there were questions about the reliability of taxonomic identifications from study to study. This study should straighten out those problems.

The Eastern Gulf Benchmark Studies were a series of studies aimed at characterizing the geologic, biologic, chemical, and hydrographic aspects of the eastern Gulf of Mexico. The other series of Gulf benchmark studies was conducted off South Texas. These, too, were aimed at clearly characterizing the environment and the biologic communities.

The Topographic Features Study is a marine ecosystem study looking at the geology, biology, and local circulation for selected submarine banks offshore of Louisiana and Texas. To date, 32 of these banks have been examined, and there is a good understanding of how they are constructed, what lives there, and how the circulation might allow impact

to these banks if effluents or pollutants were in the water. This information is very useful for development of environmental profiles and for lease stipulations to protect the banks.

The Southwest Florida Shelf Program is similar to a baseline study but with less emphasis on the chemistry and quantification of habitats and biological communities. Results of this study have provided good information on distribution of benthic habitats and communities. This information will be useful in developing and administering stipulations in that area.

The Chandeleur Islands Program is in the very early stages of development. It will begin with the Tuscaloosa Trend Study. The Tuscaloosa Trend is a geologic structure that extends offshore in the area between the Mississippi Delta and Mobile Bay and may contain a lot of deep gas and deep petroleum. A status map of leasing in that area shows some leasing in the past; there is some production activity there now, and we anticipate there will be more in the future.

Another program that is just beginning is the Deep Gulf Continental Slope Program. Interest in the deep Gulf of Mexico stems from the presence of numerous major salt structures located there. The study will begin in fiscal year 1983 with field sampling at selected stations throughout the Gulf of Mexico. The planning for this is based on studies done by Dr. Willis Pequegnat that summarize what is known about the continental slope of the northern Gulf of Mexico.

The Coastal Studies Series is presently represented entirely by Fish and Wildlife Coastal Characterization Studies. These are detailed characterizations of coastal habitats and socioeconomic institutions throughout the entire U.S. Gulf of Mexico. BLM/MMS has funded these studies, with the exception of the Cheniere Plains Region of Texas-Western Louisiana, which was funded by EPA.

The Endangered Species Series concerns not only endangered species but also wildlife in general. This study has included both literature surveys and aerial field surveys. The literature survey provides very good information, especially on the distribution and ecology of birds throughout the Gulf of Mexico and as far north as Cape Hatteras, and their vulnerability to oil spills. The aerial overflights have been conducted in selected areas in the Gulf and have provided information on marine birds, mammals, and turtles.

The Cultural Resources Series consists of a single study of records of historic shipwrecks, probable areas of prehistoric early man activity sites, and so on. Completed in 1977, this has identified zones of potential sensitivity or occurrence of these resources, which has resulted in a "Yes/No" line. If a lease is shoreward of that line, "yes," a cultural resource survey is required; if it's seaward of that line, "no," it is not required.

The Recreation and Fisheries Series includes studies of recreational and commercial fisheries resources and activities in the Gulf. Included are recreational fisheries surveys for the South Texas OCS study area; studies of ichthyoplankton (fish eggs and larvae) occurrences throughout the South Texas and Eastern Gulf of Mexico study areas; and other biological information for fisheries resources. Other studies, included in other study series, provide additional ecologic and economic information on fisheries resources and activities in the Gulf.

The Effects of Oil and Gas Activities Series has faced some conflicts of opinion as to which agency should fund such studies. That seems to be resolved now, and our office plans to do some serious effects work in the Gulf in the future. To date, work has included exploratory rig monitoring studies around rigs off Texas, monitoring about two dozen production platforms off Louisiana, assessing the socioeconomic and environmental impacts of the IXTOC oil spill, and examining the effects that platforms have on reef fish populations.

This overview has shown what studies have been done and what is planned for the future. The next question is how to handle all that information, which will be our next study series; Information Management. This series will aim to use the information already gathered and manage it so that it can be used most effectively.

Regional EIS Status and Outline

Mr. Douglas Elvers
Chief of the Environmental Assessment Staff
MMS, Gulf of Mexico OCS Region

This Regional Environmental Impact Statement (EIS) started well before "streamlining" was used as a leasing term. The description of the environment and the mapping of some of the information in the visuals began before the Department had divided the Gulf of Mexico into three leasing areas. When streamlining came into being, the on-going Regional EIS was fitted to the streamlining concept so we could prepare a workable Regional EIS for the Gulf of Mexico. The idea of putting a major portion of the Gulf up for lease concentrated this office's efforts toward truly analyzing the whole Gulf of Mexico basin, each lease block in relation to the other lease blocks, and the total coastal environment.

The draft Regional EIS was prepared through cooperative efforts of the MMS staff, IPP members, states, the other federal agencies, and industry. That excellent cooperation has made it possible to take the time to go through all the "environmental what if's" for this large region.

A number of concurrent activites are presently progressing in our office. The Regional EIS is now quite well along when this Draft Environmental Impact Statement was printed. The hearings are begin-

ning on October 6,7, and 8, final comments are being requested, and this office is in the middle of the next document for lease sales 81 and 84. Collecting new environmental information for the Regional EIS and the NEPA document for sale 81/84 is a large part of what this meeting is all about. Some of the data that the experts are going to present at this meeting will be included in the Final EIS. Much of the information from this meeting will go into the report for lease sales 81 and 84 and in open-file reports that will accompany 81/84 and the Final Regional EIS.

At present, the 81 and 84 lease sales are at the stage of review and update of visuals. A Federal Register notice was published on May 7, resource geologists have been consulted, and a draft set of resource estimates has been prepared. The schedule for 81/84 was sent to the Washington Office for review, and has already been revised to fit departmental guidelines. A stipulations meeting was held August 23. This brings the process to Item 14 (of a 55-item procedure), which is re-doing the visuals, incorporating the latest information, such as what will be presented at this Information Transfer Meeting.

Bulk has been a problem with environmental impact statements. One draft EIS was over two feet thick. The shorter impact statements should be preferable. It is hoped that this most recent Draft Regional EIS will serve as the model for future ones, so that the impact statement for sales 81 and 84 will be a document that is easier to use. In any case it costs around $150 to $200 per page to have it typed, edited, re-typed, re-edited, and finally printed.

The open-file report system is another way of reducing the size of the EIS and providing more time and latitude for detailed analysis. These open-file reports are not tied to any specific schedule, except an internal one, and they provide more analysis than could be allowed in an impact statement. Open File Reports are on specific topics, are printed in smaller quantities, and are sold to those interested in those specific subjects. This mechanism provides more time to do detailed analysis, and they are more site-specific.

A packet of 14 visuals is available with the 1982 Draft Regional EIS. Information for these maps comes from many sources. For example, preparation of the Resource Development Potential map (visual no. 13) was coordinated with USGS, MMS, and geologists from industry. This is the map showing high, moderate, and low interest leasing areas. For 81 and 84 lease sales, even more detailed information should be available, showing where the geologists and geophysicists believe the oil and gas is or should be with even greater specificity. These visuals will continue to be updated during the coming months.

Another example of new information on visuals now available is the Oil Spill Risk Analysis Overlay (Visual No. 12). One concept that becomes overwhelming in working with the oil spill model is the fact that it is very difficult to look at the separate sales in the Gulf as any separate action that does not affect an adjoining area. In previous years, EIS's addressed only a single sale area, without account-

ing for possible impacts on neighboring areas. The Gulf of Mexico regional assessments that we presently are completing add an improved method to interpretation of environmental elements for the complete basin. Thank you again for your cooperation on this Draft Regional EIS review.

National Marine Sanctuaries Program

Dr. Thomas J. Bright
Texas A&M University, College Station, TX
Member, Resource Regional Evaluation Team for National Marine Sanctuaries in the Gulf of Mexico

The National Marine Sanctuaries Program is administered by the Office of Coastal Zone Management of the National Oceanic and Atmospheric Administration (NOAA). The program was developed to respond to a law passed by Congress, the Marine Protection, Research, and Sanctuaries Act (1972), which aspired to create sanctuaries in the marine environment. These sanctuaries would be directed toward the conservation of, possibly the preservation of, areas of the seabed which are unique or valuable from the standpoint of the ecology and national resources. The Congressional Act authorized the Secretary of Commerce to designate selected ocean waters as marine sanctuaries in order to protect and restore their conservational, recreational, ecological, or esthetic value.

Marine sanctuaries can be established anywhere from the outer edge of the Continental Shelf (a depth of some 600 ft) to coastal waters, where the tide ebbs and flows, which would include the state waters. They can also be established in the Great Lakes or connecting waters. The program has no jurisdiction over dry land, and cannot include dry land in sanctuary boundaries.

The Sanctuary Program is not very highly funded, and has to be refunded every two years or so. In December 1981, the program was funded for fiscal years 1982 and 1983 at a level of $2.235 million per year.

Plans to establish sanctuaries in marine waters where there is high user interest have caused a great deal of public reaction and controversy within the Federal Government and within industry, particularly the oil companies. Wherever a sanctuary is established, another adminstrative and regulatory process or group becomes involved in regulating that portion of the seabed. At present the Sanctuary Program is engaged in a new round of site evaluation and selection for nominations and designations.

Six National Marine Sanctuaries have already been established in the United States and its possessions. These are 1) Gray's Reef (off Georgia); 2) Key Largo Coral Reef, Florida; 3) Looe Key, Florida; 4) Channel Islands, California; 5) U.S.S. MONITOR; and 6) Point Reyes -

Farallon Islands, California. The Key Largo Sanctuary is one of the best established from the standpoint of its management plan and cooperation from the state government. It is managed as an area wherein a component of the marine environment which is considered to be fairly unique is preserved, conserved, and also used by those who are interested in using it. This sanctuary is adjacent to the Pennekamp Coral Reef State Park, which is managed by the State of Florida. Because many of the coral reefs in the vicinity of Key Largo happen to be in federal waters, the Key Largo Sanctuary was established as an adjacent or contiguous area to be protected. There's a very workable arrangement between the State of Florida and the federal government in the management of that area. It might be the model for management of other sanctuaries.

There is presently no National Marine Sanctuary in the Gulf of Mexico. The East and West Flower Garden Banks have been seriously considered at least twice in the past 10 years as possibilities. During the last phase of consideration, a Draft EIS was developed (1979), but serious concerns over boundaries and the regulation of the disposal of drill effluents caused NOAA and the Office of Coastal Zone Management to withdraw the Flower Garden Banks from consideration in May 1982. That nomination is now completely inactive.

Recently, NOAA initiated a new nomination and designation process. This new process identifies eight regions within the United States and its possessions which include sites to be considered for possible evaluation as National Marine Sanctuaries. These eight regions are 1) the North Atlantic, north of Cape Hatteras, 2) the South Atlantic from Cape Hatteras to the Florida Keys, 3) the Gulf of Mexico, 4) the Caribbean, 5) the Great Lakes, 6) the East Pacific (Oregon, Washington, and California), 7) Alaska, and 8) the Western Pacific (Hawaii, Guam, and American Samoa).

In each of these areas, a separate process is presently underway to identify and evaluate potential sites for consideration as National Marine Sanctuaries. The evaluation teams are working for a consulting firm in Washington, D.C., Chelsea International, which was hired by NOAA to identify and evaluate potential marine sanctuary sites in these eight regions. Chelsea, under direction from NOAA, selected regional resource evaluation teams composed of scientists from each of the regions, a separate team from each region.

The evaluation process involves a series of steps intended to give adequate opportunities for public response and consultation with federal organizations, industry, and the public. The site evaluation teams and the consulting firm are now gathering information on sites that could or should be made marine sanctuaries. The National Marine Sanctuary site identification criteria are shown in Table 2.

The Resource Regional Evaluation Team for National Marine Sanctuaries in the Gulf of Mexico is made up of people with no formal ties to either NOAA or Chelsea, though they are consultants to Chelsea. Right

TABLE 2

NATIONAL MARINE SANCTUARY SITE IDENTIFICATION CRITERIA

I. Natural Resource Values

A. Regional Representation

B. Subregional Representation

C. Community Representation

D. Biological Productivity

E. Biotic Character/Species Representation

F. Species Maintenance

G. Ecosystem Structure/Habitat Features

II. Human-Use Values

A. Fishery Resources of Recreational Importance

B. Fishery Resources of Commercial Imortance

C. Ecological/Aesthetic Resources of Importance for Recreational Activities Other Than Fishing

D. Research Opportunity

E. Interpretive Opportunity

F. Historical, Cultural, or Paleontological Importance

Additional Factors

III. Potential Activity Impacts

IV. Management Concerns

A. Relationships to Other Programs

B. Management of a Conservation Unit

C. Accessibility

D. Surveillance and Enforcement

E. Economic Considerations

now, the process for the Gulf of Mexico is somewhere between public review and final regional site selection.

Working from a list of potential sites in the Gulf of Mexico, the team has drawn up a list of seven sites for evaluation as National Marine Sanctuaries. These sites were described in a document sent out in July for public review. When public review is completed (in September), all the responses will be considered and additional sites may be added. Then another list of three to five sites will be delivered to NOAA as fairly firm recommendations. These sites are then up for serious consideration, and NOAA will select two or three of them for more detailed evaluation. Notices will be placed in the Federal Register, and other public announcements will be made before NOAA selects active candidates for nomination, insuring considerable evaluation and public consultation. Then there will be a series of meetings the development of a Draft Environmental Impact Statement. The impact statement will include a recommended management plan, production of which will require a great deal more consultation with the users, industries, and so on.

Presently, the management and use of these proposed sanctuaries is an open question. The aim is not to exclude potential users, but to maintain the environment. It need not exclude fisherman, divers, or even oil and gas development, so long as the environment is maintained and remains intact.

The seven sites that the Gulf of Mexico team recommended for further evaluation are as follows.

1. South Bay, Texas. This site is a pristine, shallow water embayment at the southernmost end of the lower Laguna Madre, with large beds of subtidal seagrasses surrounded by a narrow fringe of intertidal marsh and mangrove. It is a quasi-pristine bay of the Laguna Madre system and may be the most unspoiled hypersaline bay in America. The potential decline of portions of the lower Laguna Madre point to the urgency of preserving and conducting research in the largely unpolluted South Bay.

2. Seven and One-Half Fathom Reef. The proposed site is a small reefal structure 3.2 km offshore of Padre Island. It is an ecologically diverse and highly productive hard bank community, harboring many rare or undescribed invertebrate species not reported elsewhere within the Gulf of Mexico. The reef sustains a thriving sport fishery, and because of its beauty and accessibility is a popular recreational diving resource. Waters are unusually clear for a structure so near the Texas coastline.

3. Northern Harbor, Texas. This site incorporates some 21 km^2 of highly productive shallow marine seagrass beds and inter-

tidal marsh/mangrove habitats on and adjacent to northern Harbor Island, Texas, near Port Aransas. This area is controversial because of developing oil and gas operations and expansion of port facilities on south Harbor Island.

4. Flower Garden Banks. The East and West Flower Garden Banks are located about 184 km southeast of Galveston, Texas. The biological communities there represent the northernmost extent of tropical Atlantic coral reef communities in the western Gulf of Mexico, and afford great potential for scientific research. The boundaries now recommended for further evaluation as marine sanctuaries exactly correspond to the boundaries of NOAA activity as prescribed by USGS and MMS with reference to oil and gas development. The recommended no-activity zones encompass a total of 114 km^2 and are limited to the banks themselves, with no buffer zones.

5. Shoalwater Bay-Chandeleur Sound, Louisiana. This proposed sanctuary occupies approximately 207 km^2 of pristine, shallow-water seagrass beds and algae located on a subsiding remnant of abandoned Mississippi River delta. Another site, Chandeleur Islands off Louisiana, is already protected as part of the Breton National Wildlife Refuge. It has been suggested that this submerged land within the vicinity of the Chandeleur Islands deserves consideration.

6. Big Bend Seagrass Beds, Florida. These shallow-water seagrass beds extend up to 35 km off the northwest coast of Florida and constitute a vastly productive habitat supporting a rich diversity of marine organisms.

7. Florida Middle Ground. This is a highly productive coral and algae reef community covering some 1200 km^2, located about 150 km off the northwest coast of Florida.

One site, Baffin Bay, Texas, was not on the list but should have been. Several organizations in Texas have strongly recommended its inclusion, and there are some good management reasons for Baffin Bay having a federal management input. Baffin Bay will be added to the list.

The Florida Middle Ground and the Flower Garden Banks are in federal waters, and the Big Bend site is partly in the state waters of Florida. All other sites are in the state waters of Texas or Louisiana. Sites in state waters require cooperation and agreement of state governments.

All of these sites are being seriously considered for promotion to the next stage of evaluation, but only three to five of them will reach that stage. Marine sanctuary designation is highly dependent on public support for any proposed site.

MMS Scientific Advisory Committee

Dr. Donald Boesch
Director, Louisiana Universities Marine Consortium (LUMCON)

In 1973, the Bureau of Land Management (the predecessor or parent agency of what is now the Minerals Management Service with respect to offshore oil and gas leasing) began a very ambitious program of leasing frontier areas in the OCS. As a result of this leasing program, a number of scientific studies were funded. One of the first was the MAFLA Benchmark Program, concerning the tracts to be leased off Mississippi, Alabama, and Florida.

Thereafter, there were other benchmark or baseline studies programs around the country wherever there were plans for leasing offshore tracts for oil and gas. The program grew tremendously and became a very large, multi-faceted research program. It also drew some criticism about the quality, goals, and orientation of the studies. Critics questioned whether it was realistic to describe the environment before leasing, and then use that information to gauge impacts after leasing. The National Academy of Science Review Program studied the criticisms and concluded that the program was largely misdirected and ought to be more formally oriented toward specific questions and goals related to offshore leasing.

The Department of the Interior developed a set of guidelines and a strategy involving a series of management questions. Then they translated these into questions useful to scientists in addressing issues related to offshore oil and gas leasing and the related environmental decisions about that leasing. In the early days of the program, there was an advisory committee composed mainly of people representing state government, appointed by the governors or other high officials in the state, to represent their state's interests. Some of these people were scientists, but most were managers. That advisory committee ended in a fair amount of turmoil about the same time the benchmark studies program was discontinued. At that time, the Department of the Interior remapped the strategy on how these studies should be oriented. They saw a need for a committee to address policy questions (state and federal resource management issues), scientific questions, and regional questions about specific needs for studies. To this end, they formed the National OCS Advisory Board, which has three tiers of committees: a policy committee, a scientific committee, and regional technical working groups. These committees were formed in the fall of 1979. Both the scientific committee and the policy committee are nationally based.

Members of the scientific committee were appointed on a disciplinary basis to represent the various disciplines then involved in or thought to be needed in environmental studies to serve the Bureau's purpose. The committee reported to the Assistant Secretary of Land and Water Resources, who was responsible for the Bureau of Land Management's activities. Within the committee, several working groups were

formed, in order to deal with details of study design within disciplinary areas of expertise. Special care was also taken to have a specialist from another discipline on each working group. These working groups concentrated on such topics as environmental characterization, coastal characterization, oil spill hazards and endangered species, and other sorts of hazards.

One of the first things the committee addressed was the question of scientific quality and credibility, which was perceived as a serious problem with the Studies Program. Procurement procedures governing the Studies Program preclude scientific peer review of proposals outside of the government agency to which the proposal is addressed. This was a concern to many scientists, who felt that broader peer review would improve the quality of the science. It was also noted that for a program of its size, the Studies Program was resulting in relatively little being published in scientific journals. The committee was not able to alter procurement policy preventing broader peer review, but did make some inroads into publication.

The second major accomplishment of the committee has been in program direction. Any program requires periodic introspection and mid-course correction. The major one in this program was changing the direction from benchmark studies to something which would better serve decision-making. That had occurred in 1978, and it was time for introspection and revision. It happened that some of the members of the scientific advisory committee were also involved in another review of the total BLM OCS Studies Program and of the other federal programs related to oil pollution and oil and gas development. Out of that came some criticism of the orientation of, not only this program, but other federal programs. As a result, last year the leadership in the program announced a sort of mid-course correction regarding leasing procedures, changing to a more rapid leasing schedule.

This new leasing schedule leads to two major changes in the Studies Program: a greater regional orientation, and an emphasis on studies aimed at predictive capability. The reasoning was that the utility of descriptive studies in predicting fates and effects is limited. The increased emphasis on data and effects is important for several reasons. Many frontier areas are in the early stages of exploration and development, and most of the relevant offices are in the process of beginning and/or designing massive and expensive monitoring studies. These studies should be more than just window-dressing. There is a need to look at monitoring studies in a generic sense and to make the monitoring serve long-range goals. The fates and effects emphasis in the Studies Program is also important because such agencies as EPA and NOAA are cutting back on these studies, due to the economic crunch. This program is needed to take up the slack and to continue to advance knowledge.

The scientific advisory committee is no longer funded, and is therefore inactive at this time. There have been problems arising from the change of federal administration, from Secretary Andrus to

Secretary Watt. When the present administration came into office, there were questions about advisory committees in general, which resulted in a one-year gap between the formation of working groups and subsequent meetings. The committee met in October 1981 and February 1982, but a May 1982 meeting was cancelled because of questions as when members' terms of office expired. At present, the committee is not meeting, and its future is uncertain.

SESSION: OIL SPILL MODEL WORKSHOP
Chairman: Dr. David Amstutz
Scribe: Mr. Mike Burdette
Date: August 24, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Dr. David Amstutz, MMS Washington, D.C.
Gulf of Mexico Oil Spill Model	Mr. Robert LaBelle, MMS Reston, Virginia
Model Products and Their Uses	Mr. Mike Burdette, MMS Gulf of Mexico OCS Region
Shoreline Vulnerability	Ms. Gail Rainey, MMS Gulf of Mexico OCS Region
National Strike Force	Chief Warrant Officer William Rydblom, U.S. Coast Guard

SESSION SUMMARY

Dr. David Amstutz
MMS, Washington, D.C.

The Department of the Interior (DOI) oil spill model now used by the Minerals Management Service addresses the likelihood of spill occurrence as well as possible pathways (trajectories) which spills may follow. Because the model deals with numerous uncertainties, outputs are expressed in probabilities. The probabilities of spills contacting various portions of the shoreline and marine resources at sea are calculated. Spills are simulated from platforms, pipelines, and tankers. The prediction periods are defined by the time span required to complete production from an offshore lease, typically two to three decades. The purpose of the modelling work is to provide a quantitative basis for environmental analysis of potential impacts from offshore leasing. The model synthesizes enormous quantities of information dealing with ocean surface currents, local winds, locations and temporal sensitivities of marine resources, and the likelihood of spill incidence. The model has been successfully applied to nearly all regions of America's Outer Continental Shelf.

The workshop primarily addressed hypothetical spills and their potential environmental impacts. The recent application of the DOI oil spill model to the Gulf of Mexico was discussed by Robert LaBelle. The design and use of model products tailored to impact analysis were discussed by Mike Burdette. Gail Rainey discussed progress in quantifying shoreline vulnerability. The workshop concluded with Bill Rydblom's presentation on repsonses to real time oil spills.

GULF OF MEXICO OIL SPILL MODEL

Mr. Robert P. LaBelle
MMS, Reston, VA

An oil spill risk analysis was conducted for the Gulf of Mexico OCS lease area region. Results of the analysis can be used to determine relative risks associated with oil production in different regions to be offered in OCS Lease Sales 72, 74, and 79. The analysis considered the probability of spill occurrences based on historical trends; likely movement of oil slicks based on a climatological model; and locations of major environmental resources which could be vulnerable to spilled oil. The times between spill occurrence and contact with resources were estimated to aid in estimating slick characteristics.

Critical assumptions made for this particular analysis were 1) that oil exists in the lease area, and 2) that oil will be found and produced from tracts sold in sales 72, 74, and 79. On the basis of a most likely resource estimate of 241 million barrels of oil to be produced over an 18-year production life from sales to be held in 1983 (sales 72, 74, 79), it was calculated that approximately one oil spill

of 1,000 barrels or larger will occur. The estimated probability that one or more oil spills of 1,000 barrels or larger will occur and contact land after being at sea less than 30 days is 41%. For a high resource estimate case of sales to be held in 1983, 717 million barrels are estimated to be produced over an 18-year production life, with an 83% chance of one or more spills of 1,000 barrels or larger occurring and contacting land within 30 days. These results depend upon the routes and methods chosen to transport oil from OCS platforms to shore.

Given a total development scenario in which 5.6 billion barrels of oil are estimated to be present and produced, it was calculated that 18 oil spills of 1,000 barrels or larger will occur over the 40-year production life of the proposed lease area. The estimated probability that one or more oil spills of 1,000 barrels or larger will occur and contact land after being at sea less than 30 days is greater than 99.5% for this scenario. These probabilities also reflect the assumptions that oil spills remain intact for up to 30 days, do not weather, and are not cleaned up. It should be noted that the expected number of spills from the total development scenario is less than one-half that of the expected number from existing tanker transportation of crude oil imports in the Gulf area.

MODEL PRODUCTS AND THEIR USES

Mr. Mike Burdette
MMS, Gulf of Mexico OCS Region

The MMS oil spill model has three basic purposes. First, it is intended to aid decision-makers in considering the options and alternatives of offshore leasing actions. Second, it can aid the various types of analysts in assessing the impacts of proposed leasing actions. Third, it serves as an information tool for public understanding of the environmental implications of proposed leasing actions. For information purposes, the model has been published as an open file report, and may be integrated with environmental impact statements as an appendix or used in impact analysis.

The structure of the model is such that it provides three useful pieces of information:

1. Trajectory Simulation. This portion of the model consists of a large number of hypothetical oil spill trajectories that collectively represent both the general trend and the variability of winds and currents, which are described in statistical terms. This information helps the analyst by identifying the probabilities that an oil spill starting at a particular location will contact a certain land or target area within a given time frame (3, 10, or 30 days).

2. Combined Analysis of Oil Spill Occurrence and Oil Spill Trajectory Simulation. This portion of the model combines the risk of oil spill occurrence (based on rates of occurrence for platforms, pipelines, and tankers) and the trajectory analysis (probability that an oil spill starting at a particular location will contact a certain target via wind and current).

3. Total Expected Number of Spills. This portion of the model uses the estimated volume of resources, spill rate for platforms/tankers, and the expected production life of leases to project the total number of spills expected to occur from platform and import transportation over the expected life of the leases.

The output of the model is structured for maximum utility. Results are keyed to special identified targets, such as beaches and endangered species. Additionally, the output is keyed to specific counties onshore so that the results can be used in combination with inventories of important natural resources for impact assessment.

The numerical results of the oil spill risk analysis model were used as the basis for a visual display of the results in map form (Visual No. 12, Regional Environmental Impact Statement, Gulf of Mexico). All potential offshore spill areas shown on the map were ranked in order of decreasing "relative" risk that an area poses to "land" (as a collective target). All potential spill areas were then divided into quartiles for visual display. The information for the visual was formulated assuming a scenario that would develop 100% of the resources (oil) in all areas shown over a 40-year period. The visual includes bar graphs for each land segment (county) showing the comparison of risk between the proposed scenario, the proposed and existing activity, and the cumulation of proposed, existing, and tanker imports. The bar graphs compare the probabilities of one or more spills occurring from all spill areas and contacting any particular land segment within 10 days over the expected production life of the lease area (assumed to be 40 years). This assumes 100% development of the resources.

SHORELINE VULNERABILITY

Ms. Gail Rainey
MMS, Gulf of Mexico OCS Region

The oil spill trajectory model was coupled with a land segment oil sensitivity characterization in order to better evaluate the cumulative impact to the shoreline of the Gulf of Mexico from proposed federal OCS oil and gas leasing activities. This technique accounts for variability in spatial and temporal sensitivity of specific coastal segments and pinpoints critical areas where the worst environmental damage could occur.

The Minerals Management Service's Gulf of Mexico vulnerability analysis is a first step index based on the number of oil-sensitive or unique features that occur in a coastal segment (parish/county), the "protectability" of the coastline, and the likelihood of oil spill contact occurring. Environmentally important biological characteristics considered include the presence of 1) wetlands, 2) areas of high marine productivity, 3) high density shellfish areas, 4) seagrass beds, 5) endangered/threatened species, and 6) bird rookeries. Socioeconomically significant resources accounted for include 1) major recreational beaches, 2) designated environmental preservation areas, and 3) selected archaeological sites.

Only those identified resources occurring along the exposed coastline were considered in the inventory. The "exposed coastline" delineates the shoreline that could be directly contacted by an offshore oil spill if present containment capabilities were only minimally effective in protecting these resources. The analysts did take into account the fact that spilled OCS oil reaching coastal inlets and sheltered waters can be deflected or diverted by containment countermeasures.

This method, therefore, combines the results of the oil spill trajectory model with significant ecological, economic, or aesthetic characteristics of exposed coastline areas. The combination allows each county/parish to be rated according to its vulnerability to OCS oil spill impact. Predicted impact is greatest along the coastlines of Louisiana, Mississippi, and Alabama. Useful information is provided for environmental impact assessment, oil spill response planning, and offshore oil facility siting.

NATIONAL STRIKE FORCE

Chief Warrant Officer William Rydblom
U.S. Coast Guard

The National Strike Force (NSF) was formed in 1973 after the U.S. Coast Guard was charged with new environmental protection responsibilities under the Federal Water Pollution Control Act (FWPCA). The NSF is composed of the Atlantic, Pacific and Gulf Strike Teams, along with the NSF Dive Team. The strike force is an important federal resource available to pre-designated federal On-Scene Coordinators (OSC's). The three strike teams provide experienced personnel and sophisticated equipment. The dive team helps in assessing the condition of stranded or damaged vessels and provides other underwater activities needed during a pollution case.

The NSF is always on call and rapidly responds to cases when requested by an OSC. When not involved with actual spills, NSF members regularly attend advanced training courses for themselves and help in training other government and industry personnel through lectures and exercises dealing with pollution response. In addition, NSF members

are involved in testing and evaluation of equipment and response methods.

The NSF employs three major equipment systems designed for oil spill containment and clean-up. The Open Water Oil Containment and Recovery System is a floating, fencelike barrier designed to contain and skim oil in moderate sea conditions. This barrier, commonly called a boom, extends about two feet above and below the surface and was designed to contain oil in five foot seas and winds up to 17 knots. In some cases, it has been shown to exceed those limits. The Air Deliverable Anti-Pollution Transfer System (ADAPTS) is a portable yet powerful pumping system designed for removing oil and some chemicals from grounded or damaged vessels. Pumping capacity of the system averages 1,000 gallons of oil per minute. The Viscous Oil Pumping System (VOPS) is similar in concept to ADAPTS, but is specifically designed to handle heavier, more viscous oils, which sometimes present a problem for conventional pumping systems, particularly when the oil is cold.

The Coast Guard's National Response Center (NRC) in Washington, D.C. coordinates information and reports of pollution. The NRC's primary job is to receive reports of spills from around the country and pass this information to the proper EPA or Coast Guard field office. The center can also assist the OSC during an incident by providing communications links with government and industry computerized information systems and experts in the field of oil and hazardous substances. Anyone may use the NRC's 24-hour toll-free number (1-800-424-8802) to report spills.

SESSION: SOUTHWEST FLORIDA ECOSYSTEM WORKSHOP
Chairman: Dr. Robert Avent
Scribe: Mr. Les Dauterive
Date: August 24, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Dr. Robert Avent
Introductory Overview: Southwest Florida Shelf Ecosystems Study	Dr. Keith B. Macdonald Woodward-Clyde Consultants
Geophysical Studies of Seafloor Habitats	Dr. Keith B. Macdonald Woodward-Clyde Consultants
Live Bottom Biological Assemblages	Dr. David A. Gettleson Continental Shelf Associates
Macroinfaunal Communities	Dr. Selvakumaran Mahadevan Mote Marine Laboratory
Hydrographic and Primary Productivity Characteristics	Dr. Hong Chin, Woodward-Clyde Consultants; Dr. James Yoder and Dr. Larry Atkinson, Skidaway Institute of Oceanography; Dr. H. H. Kim, NASA
Zones of Faunal Similarity Within the Hourglass Study Area	Mr. William Lyons and David K. Camp, Florida DNR

SESSION SUMMARY

Dr. Robert Avent, MMS, Gulf of Mexico OCS Region

Study Design

The Southwest Florida Shelf Ecosystems Studies are a multi-year effort to describe the benthic habitats and associated flora and fauna of the Southwestern Florida continental shelf. Beginning in FY 1980, cruises were mounted to investigate benthic habitats with side-scan sonar and acoustic shallow sub-bottom profiling systems as well as underwater television and 35 mm photographic systems to provide ground-truthing. Seasonal biological sampling of hard-bottom and soft-bottom habitats was undertaken to determine population abundance, structure, and distribution. Additional photographic and videotape coverage was made at hard-bottom stations. These efforts were supported with descriptive hydrographic and geological data. Trace metal and hydrocarbon values were determined for each soft-bottom station. A modification of the FY 1981 effort provided for a study of phytoplankton primary productivity, nutrients, and hydrography over the shelf to determine the influence of the eastern leg of the Loop Current.

Findings

The results showed an unexpectedly complex matrix of bottom types and animal assemblages. Visually, at least five bottom types and nine biological assemblages were discernible. Only three of the biological assemblage types were found on all five east-west transects: inner and middle shelf sand bottom assemblage (20 to 100 m), inner and middle shelf live bottom assemblage "B" (25 to 95 m), and the outer shelf sand bottom assemblage ($\geq$ 75 m). Topographic relief in the region is generally low, and rocky outcroppings are uncommon. However, numerous attached organisms (e.g., sponges and alcyonarians) are seen in areas where the surface layer is unconsolidated sand, indicating the presence of underlying indurated substrata. Epifaunal community development and larval settlement in these regions, and the influence of this (motile?) sandy layer are the subjects of considerable conjecture. The presence of these epifaunal communities in a region without notable topographic relief (a situation very different from that in the western Gulf) is a cause of bemusement to those who must formulate biological stipulations for leasing submerged tracts for oil and gas development. Such low profile "live bottom" areas have been found in southwestern Florida and from eastern Florida northward to the Carolinas.

A marine habitat atlas at a scale of 1:48,000 is in production by MMS contractors. This atlas pictorially represents geophysical and visual records of all transects traversed. Detailed multidisciplinary reports are presently under review.

The Southwest Florida shelf epifauna and infauna together consist of about 3000 species, not including meiofauna and microfauna. Cluster analyses by the Florida Department of Natural Resources and MMS con-

tractors indicate that assemblage clusters are generally aligned parallel to the coastline and isobaths, the usual situation in the Gulf and U.S. South Atlantic continental shelves. In addition, the nine visually distinct biotic assemblages are found in discrete, rather small depth ranges.

Recent hydrographic studies indicate that water column structure over the outer shelf and upper slope has considerable fine structure with intrusions of Loop Current water into shelf waters. The Loop Current shows features similar to those observed at the edge of the Gulf Stream off north Florida. Doming of isotherms and nutrient isopleths demonstrated upwelling which brings nutrients into the photic zone as shallow as 50 to 70 m depth. Chlorophyll concentrations at this depth are very high, up to 20 times surface values, and primary productivity exceeds that at the surface despite low light levels. The effects of nutrient upwelling on benthic production are unknown.

Ocean color scanner records have been made over the study area to detect patterns of chlorophyll a distribution, using NASA U-2 aircraft. These again show dynamic circulation patterns and fine structure.

Workshop Discussions

Following presentations by MMS-contracted consultants and other interested individuals, group members informally discussed program status, data implications, and future information needs. The research, now in its third year, has provided a general environmental overview of the Southwest Florida shelf. Limitations in funding have precluded a more intense research effort. The five primary east-to-west transects spaced evenly across the shelf, however, are insufficient to delineate the areal extent of the various known habitat types and related biotic assemblages. It is now axiomatic that the Southwest Florida shelf is a patchy matrix of habitats and associated populations which can be mapped adequately only with high density surveys. However, by isolating areas corresponding to known depth distribution of habitats of greatest concern for further investigation, future work may reduce required cost and effort. Some participants felt that this mapping should continue at the expense of new, detailed taxonomic analyses. The latter effort, conducted by both Florida DNR personnel and MMS contractors for several years, will have resulted in an adequate taxonomic picture for major taxa of macrobenthos in the region.

The original series of studies was intended to study epibiota and macroinfauna, with little effort directed toward pelagic and demersal fisheries resources. The Southwest Florida shelf, Florida Keys, and Florida Bay areas account for a major portion of the state's fisheries products landed. These include, among others, mackerels, snappers, groupers, stone crab, blue crab, penaeid shrimps, and lobsters. Because these species are largely evasive or cryptic, little information has been collected during the surveys with the survey methods adopted. In Year III limited diver transects are being conducted to assess fish populations in selected hard-bottom areas less than 20 m in

depth. It was recommended that new studies include analyses of commercially exploitable stocks through field research, dockside interviews, and analysis of fisheries statistics. Additional data are needed on these species' habitat preference and distribution.

Some participants argued that because the shelf sediments off Southwest Florida are the least contaminated in the Gulf, the area should be considered a prime candidate for future long-term fates and effects research.

Because of the variability displayed in shallow (< 60 m) soft-bottom communities, a greater sampling intensity is planned in the Year III effort.

INTRODUCTORY OVERVIEW: SOUTHWEST FLORIDA SHELF ECOSYSTEMS STUDY

Keith B. Macdonald, Woodward-Clyde Consultants

The Southwest Florida Shelf Ecosystems study is a multidisciplinary OCS environmental program designed to be completed over a three-year time span. Years I and II of the program have described the seafloor substrate types and benthic communities represented across the Southwest Florida shelf and mapped their generalized distributions. Geophysical techniques, underwater television and still camera photography, and benthic biological sampling (triangular dredges, otter trawls, and box cores) have all been utilized in the program. Extensive water column data were also collected at each biological sampling station.

All field and laboratory work for Years I and II has been completed. Data analysis, interpretation, and report preparation are essentially complete for Year I, and well underway for Year II. All results and conclusions will be summarized in year I and II Annual Report narrative volumes and a large format Marine Habitat Atlas.

The third year of the program involves studying the impingement of the Loop Current on the Southwest Florida continental slope and shelf. Nutrient upwelling and enhanced primary production associated with Loop Current eddies that can move across the outer shelf have already been confirmed. The potential significance of this enhanced primary production to regional water column and benthic communities is now being examined.

Two important areas of the Year I and II studies not included among the abstracts here are the results of bottom sediment hydrocarbon and trace metal determinations. The Year I hydrocarbon analyses (Dr. R.H. Pierce, Florida Institute of Technology) confirmed very low levels of hydrocarbons at all 15 soft-bottom stations sampled. Natural biogenic marine hydrocarbons predominated at every station. Several outer shelf stations (water depths approximately 100 m) and the

southerly stations adjacent to the Florida Keys also yielded evidence of land-derived (terrigenous) natural hydrocarbons that were apparently transported south along the shelf break by the Loop Current, and offshore from the Everglades, respectively.

Only a single station, in the northwest corner of the study area, showed evidence of petrogenic hydrocarbons. These were most likely associated with the clay component carried southward from the Mississippi Delta region by the Loop Current. In summary, the types and levels of concentration of hydrocarbons identified from bottom sediment samples collected across the Florida shelf indicate that the seafloor habitats remain in pristine conditions.

A similar conclusion was reached from trace metal analyses performed by Dr. J.H. Trefry (Texas A&M University) on bottom sediments from the sample locations. As had been expected, the predominantly carbonate shelf sediments yielded very low trace metal concentrations, equal to about 5% of those recorded from terrigenous Mississippi Delta sediments.

In the event that OCS development introduces increased levels of hydrocarbons or trace metals in the surficial sediments of the Florida shelf, then this should be readily identifiable above the pristine background levels presently represented.

GEOPHYSICAL STUDIES OF SEAFLOOR HABITATS

Keith B. Macdonald, Woodward-Clyde Consultants

The principal goal of the geophysical studies has been to identify and map the distribution of major substrate categories and benthic communities across the Southwest Florida shelf. Underwater television and still camera observations were used to "ground truth" the geophysical data, each data set contributing to more accurate and complete interpretation of the other.

A secondary goal was to test the adequacy of standard marine geophysical techniques (side-scan sonar and sub-bottom profiler) for mapping various "live bottom" benthic habitats that occur across the Southwest Florida shelf. These live bottom assemblages consist of epibiota such as corals, gorgonians, and sponges, which require a hard substrate for attachment.

Mapping Techniques

The geophysical remote sensing data consisted of side-scan sonar surveys (EG&G Seafloor Mapping System and Klein Side Scan) and shallow sub-bottom profiler (UNIBOOM) records. The side-scan observations come from a 300 m wide strip of seafloor, while the UNIBOOM records subsurface structure to depths of 10 to 30 m below the sediment-water interface. Both units can be towed at 4 to 6 knots. The remote sens-

ing data can thus be characterized as relatively rapid to collect, readily covering large areas but with relatively low resolution.

Underwater (black and white) television videotape records and still camera photography (35 mm; color) provided ground truth data. These systems recorded observations from significantly smaller areas and were towed at 1.5 to 2 knots. The data characteristics are thus slower data collection over much smaller areas but with much higher levels of resolution (e.g., individual organisms to genus).

As the comparison of remote sensing and ground truth data sets continued, three key concerns emerged: 1) How should generalizations be developed from the specific data sets collected? 2) How should what is essentially a continuum of substrate types and benthic communities be divided into discrete, mappable units? 3) How well does the side-scan "see" what's really on the seafloor (i.e., with what limits of resolution)?

Results

The overall results of the geophysical, television, and still camera studies have already been summarized in a (draft) 45-page, large-format, Marine Habitat Atlas. Five substrate categories and nine benthic assemblages were described and mapped. The ability of the geophysical remote sensing techniques to distinguish among the various marine habitats encountered is reviewed below.

Rock Outcrops/Hard Bottom

This habitat includes local, continuous, bedrock outcrops; areas of scattered bedrock outcrops; and partially buried bioherms and (dead) coral pinnacles. These are readily recognized by both geophysical and "ground truth" systems. Side-scan permits accurate assessment of the extent of outcrops, etc.; UNIBOOM confirms subsurface relationships (bedrock outcrop/fault scarp/pinnacles, etc.); TV identifies distinctive "live bottom" assemblages attached to hard substrate.

Thin Sand over Hard Substrate

This habitat is a thin sand veneer over a "hard" substrate, i.e., bedrock, a calcrete layer, or calcareous rubble overlying softer sediment. This situation predominates over much of the study area in 20 to 100 m water depths.

This habitat shows up on the side-scan record as a striped mottling pattern in shallower water, replaced by a more subdued circular mottling pattern in deeper water. Short range (25 m) side-scan records show many small reflecting targets, possibly outcrops, coarse rubble, epibiota, etc. The UNIBOOM profile shows a thin sand layer over a stronger subsurface reflector (i.e., the "hard" bottom).

Other than the UNIBOOM profile, the key distinction of this bottom type is the presence of an attached epibiota (gorgonians, sponges), apparently anchored to the hard surface beneath the sand veneer. Both the sand veneer and epibiota are patchily distributed. TV records suggest that the mottling pattern seen on the side-scan does not correspond one-for-one with the epibiota patches.

Sand Bottom/Soft Bottom

This habitat is a "featureless" soft sediment bottom, with variable sediment composition and grain size. Side-scan records show a uniformly reflective bottom; UNIBOOM records show a layer of unconsolidated sediment, 0.5 m or more thick. Bedforms, such as ripplemarks and sandwaves, may be present. The key biological feature is the absence of any significant attached epibiota.

Coralline Algal Nodule Layer over Sand

Here a soft sediment bottom becomes covered with a variable thickness "crust" of coralline algal growth. Side-scan records fail to reliably separate this bottom type from the featureless sand bottom/soft bottom. Sometimes a more granular texture shows on the side-scan records, indicating many small, scattered surface reflectors. Uniboom profiles sometimes show a thin, highly reflective surface layer (the algal nodules) overlying a "transparent" soft sediment layer, but again this is not consistent. The TV ground truth data readily identify this bottom type because of its very distinctive biological assemblage.

Algal Nodule Pavement with Agaricia Accumulations

Here coralline algal growth, coralline debris, corals, and sponges all grow together, forming a fused pavement over softer sediments beneath. Encrusting growths of the Agaricia coral plates are characteristic.

Side-scan records show a high density of small individual reflective targets, probably the larger coral plates and rubble. UNIBOOM records again may show a highly reflective surface layer overlying "transparent" unconsolidated sediments. Neither geophysical method, however, can reliably separate this substrate from the coralline algal nodule layer, nor in some cases, from featureless soft bottom. In contrast, the TV and still cameras allow easy identification of the distinctive biological assemblage characteristics of this bottom type.

Other Features

Side-scan records reveal broad areas of the shelf in which shallow depressions or "pockmarks" occur. UNIBOOM records indicate the presence of buried channels and buried karst features.

Summary

Of five substrate categories identified from the southwest Florida shelf, a combination of side-scan sonar and UNIBOOM records allows the identification and mapping of: (1) Rock Outcrops/Hard Bottom; (2) Thin Sand over Hard Bottom; and (3) Sand Bottom/Soft Bottom. These same techniques appear unable to consistently identify and separate (4) Coralline Algal Nodule Layer over Sand, and (5) Algal Nodule Pavement with Agaricia Accumulations--either from each other, or from Sand Bottom/Soft Bottom (3) substrates.

The principal shortcoming of the TV and still camera "ground truth" systems is their failure in the absence of a distinctive hard bottom epibiota to reliably separate (2) Thin Sand over Hard Bottom, from (3) Sand Bottom/Soft Bottom. The UNIBOOM records nicely fill this data gap.

The usefulness of side-scan sonar for mapping substrates (4) and (5) apparently increases when it is set on short range; however, this significantly decreases the area of seafloor being mapped per unit time.

LIVE BOTTOM BIOLOGICAL ASSEMBLAGES

David A. Gettleson, Continental Shelf Associates, Inc.

The results of the underwater television and still camera data collected during Year 1 (Cruise - October 10-22, 1980) and Year 2 (Cruise - July 8-15, 1981) were presented. These data have been compared to the data (television videotapes and quantitative still camera photographs) and samples (triangular dredge and otter trawl) collected at the 15 selected live bottom stations that were sampled during Year 1. "Live bottom areas" are defined in the 1978 Federal Register as "those areas which contain biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anenomes, ascidians, sponges, bryozoans, or corals living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; or whose lithotope favors the accumulation of turtles and fishes." The selected stations were between 20 and 100 m water depths and were sampled from October 23 to November 22, 1980 (fall) and April 22 to May 5, 1981 (spring). Five of these stations were eliminated during Year 2 sampling and replaced by five deeper live bottom stations (100 to 200 m water depths). The resulting 15 stations were sampled during July 16 to August 5, 1981 (summer) and January 28 to February 15 (winter). The results of the Year 2 sampling effort are not complete and therefore cannot yet be discussed.

The underwater television and still camera data from the transects resulted in the identification of nine biological assemblages and five substrate types (Figures 1 and 2). A schematic representation of the gradational character of the substrate types is shown in Figure 3.

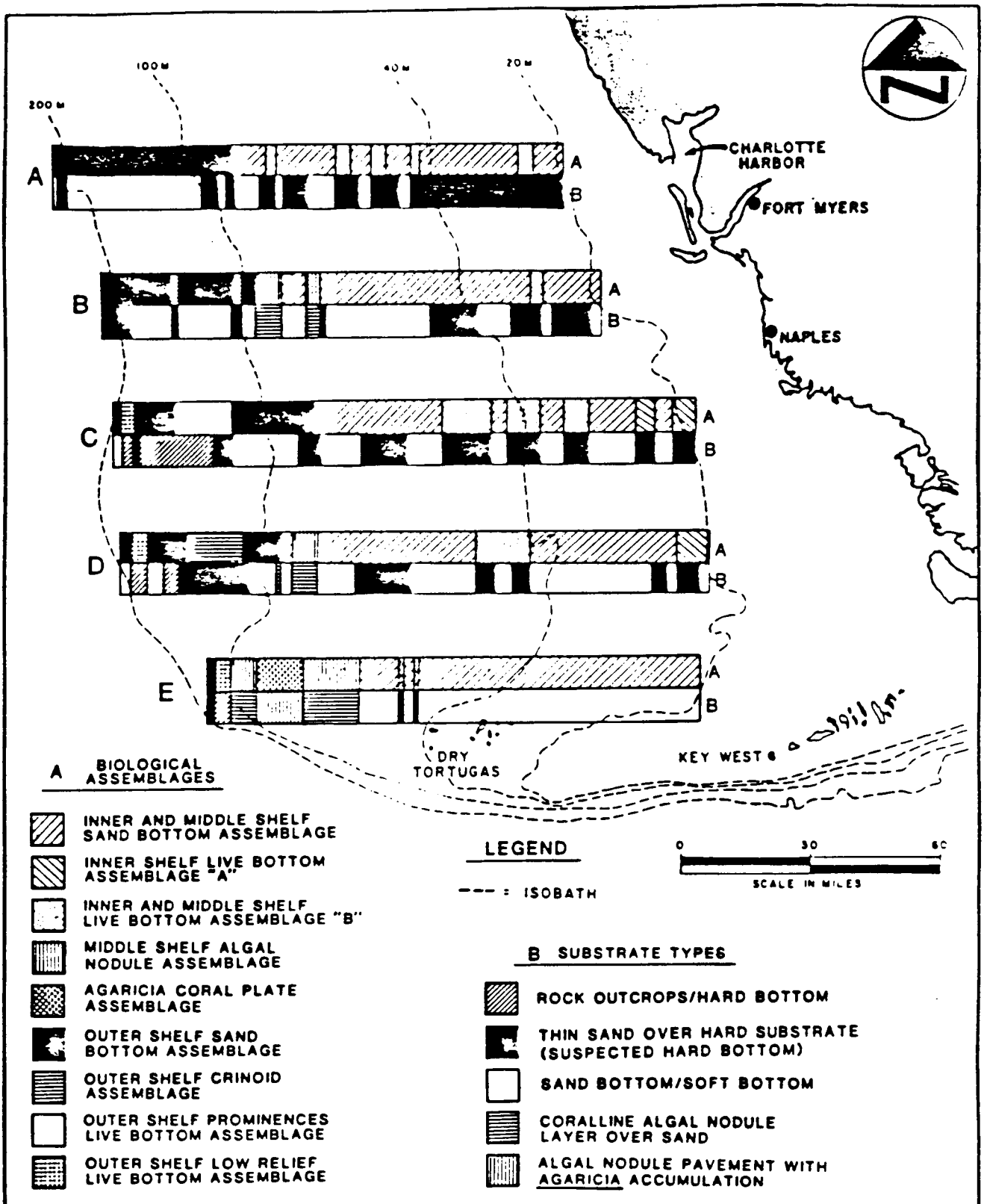


Figure 1. Geographic distribution of biological assemblages and substrate types on transects A-E (20-200 m depth).

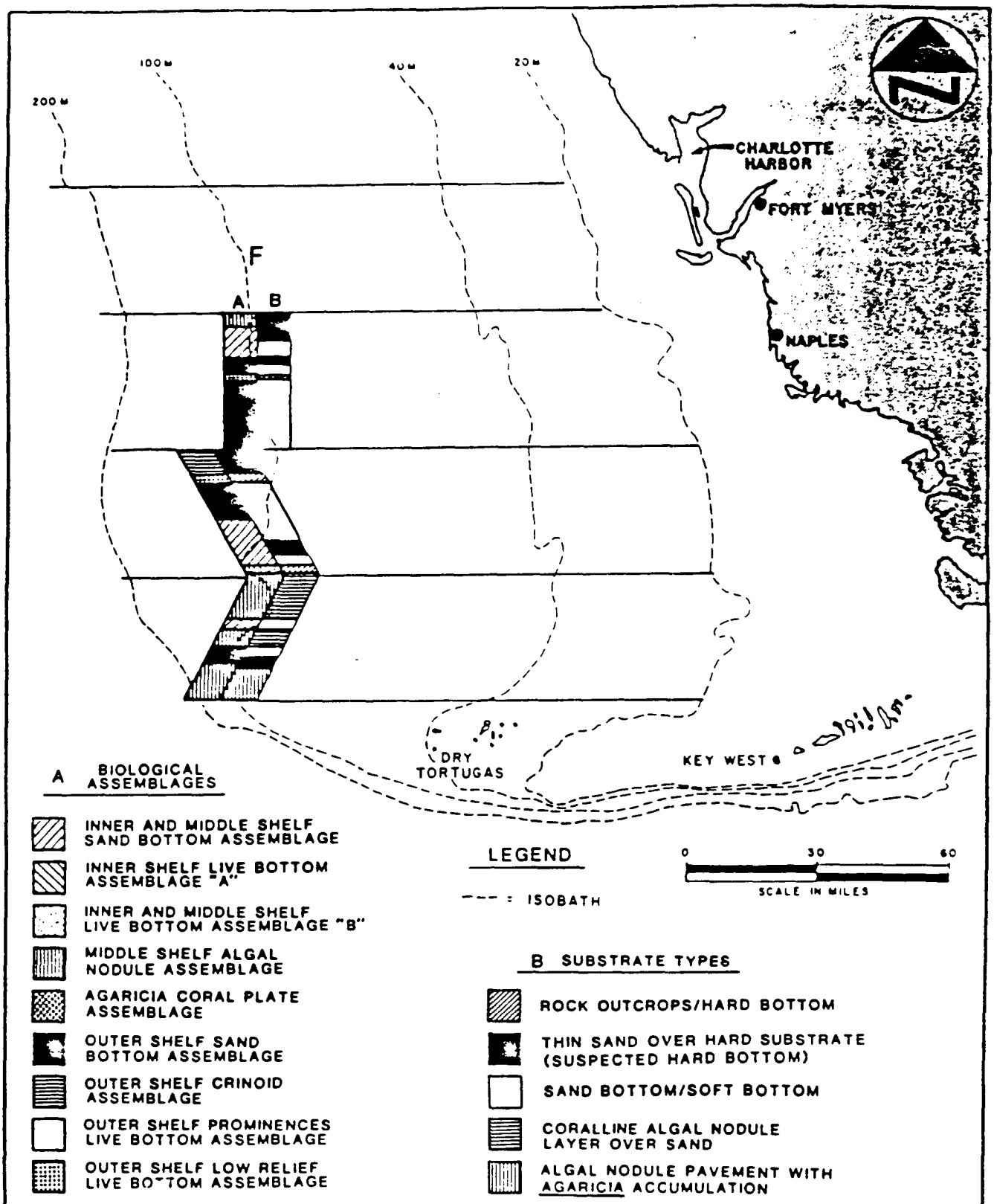


Figure 2. Geographic distribution of biological assemblages and substrate types on transect F (73-126 m depth).

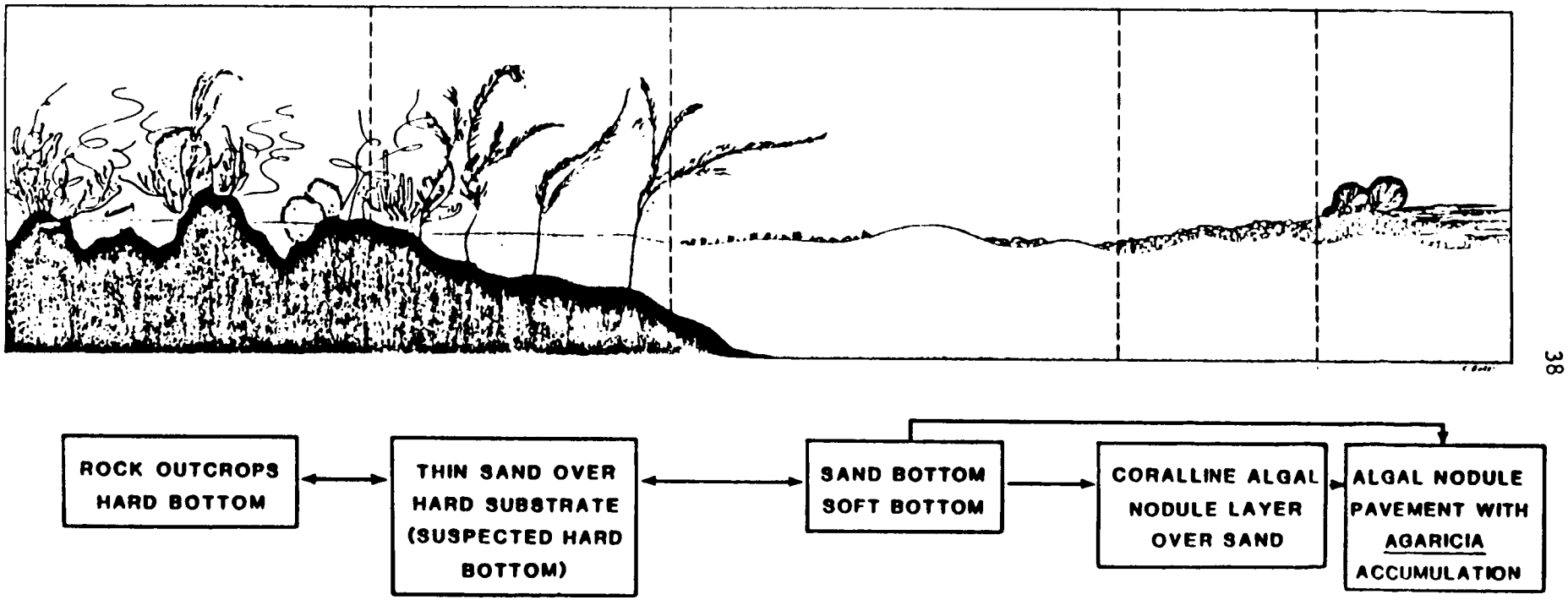


Figure 3. Generalized classification scheme for bottom type characterization of the southwest Florida continental shelf.

Table 3 lists the percentage of each type of live bottom assemblage along each of the transects.

Three major station groups (inner, middle, and outer shelf) were recognized from the clustering analysis. The station groups and additional sub-groups corresponded very closesly to the visually recognized assemblages identified along the transects.

Table 4 lists the percentages of live bottom types and the percent coverage of biota identified at each of the live bottom stations (Year 1).

MACROINFAUNAL COMMUNITIES

Dr. Selvakumaran Mahadevan, Mote Marine Laboratory

Project Objectives and Sampling Program

Specific objectives of the bottom biology studies were:

1. To quantitatively describe and characterize the macroinfaunal communities of the study area (with box-core samples).

2. To quantitatively characterize the sediment type, grain size distribution, and carbonate content in the study area (with box-core subsamples).

3. To quantitatively describe substrates, epifauna, and algae of the study area (with video records and bottom photographs).

4. To qualitatively characterize the algae, epifauna, and fishes of the study area (with otter trawl samples).

The study was divided into two one-year programs:

1. First Year. Sampling was conducted in fall 1980 and spring 1981; fifteen stations located on five east-west transects spanning the study area to a depth of 100 m were sampled.

2. Second Year. Sampling was conducted in summer 1981 and winter 1982; sampling was extended to a depth of 200 m.

This presentation desribes the results of the first year program and, specifically, only the macroinfaunal studies (corroborative sediment data are, however, considered).

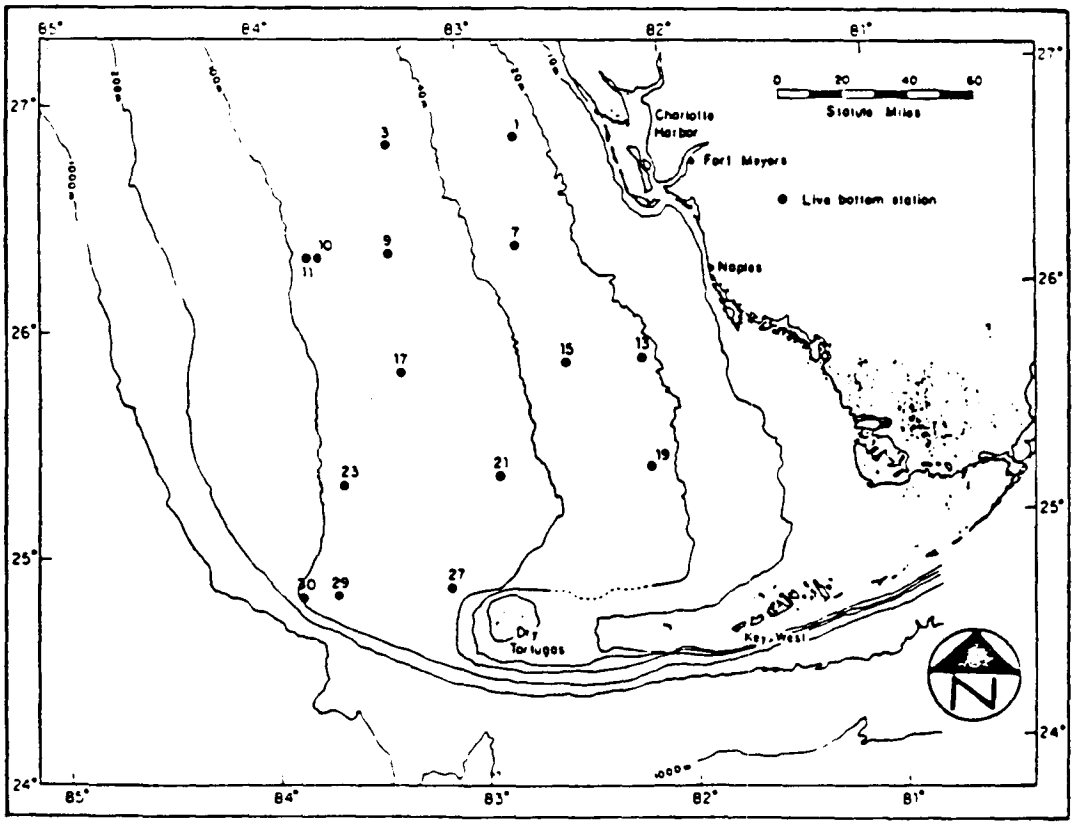
TABLE 3
PERCENT OF TRANSECT DESIGNATED "LIVE BOTTOM"

ASSEMBLAGE	TRANSECT					
	A	B	C	D	E	F
Live Bottom Assemblage "A"	-	-	5.9	4.4	-	-
Live Bottom Assemblage "B"	9.3	1.8	14.8	5.4	1.5	2.3
Algal Nodul Assemblage	-	7.4	-	6.0	16.2	28.5
Agaricia Coral Plate Assemblage	-	-	-	-	9.4	-
Crinoid Assemblage	-	2.3	3.1	9.0	-	5.3
Prominences Assemblage	-	-	10.3	-	-	
Outer Shelf Low-Relief Assemblage	-	-	1.1	3.5	2.3	1.7
Total Live Bottom	9.3	11.5	35.2	28.3	29.4	37.8

TABLE 4
PERCENT OF STATION DESIGNATED "LIVE BOTTOM"

STATION	LIVE BOTTOM "A" OR "B" (Emergent Rock)	ALGAL NODULE LAYER	ALGAL NODULE PAVEMENT WITH AGARICIA ACCUMULATION	PERCENT COVERAGE OF BIOTA
1	52.3 (0.3)	-	-	17.7*
3	18.2	-	-	12.0
7	21.8	-	-	15.3
9	61.0	-	-	15.5*
10	- (1.6)	53.0	-	16.8*
11	- (0.6)	61.1	-	24.2*
13	44.4	-	-	20.4
15	48.8 (1.7)	-	-	19.5
17	24.3	-	-	12.3
19	34.9	-	-	16.6
21	76.5	-	-	18.9
23	-	98.1	-	35.9*
27	3.9	-	-	9.5
29	-	-	100.0	72.1*
30	-	-	100.0	49.3*
$\overline{X}$	39.6	70.7	100.0	23.7

* Predominately Epiflora



Significant Findings

Significant findings from the study can be summarized as follows:

1. A total of 1,033 taxa were identified from 55,979 infaunal organisms collected in the study (fall, 1980: 678 taxa, 24,975 individuals; spring, 1981: 730 taxa, 31,041 individuals).

2. Polychaetes dominated the fauna (60% of total individuals collected).

3. Dominant taxa (> 5%) in the study area were Oligochaetes, Nemertines, Paraonids (Polychaeta), the Polychaetes, Synelmis albini, Prionospio cristata, Fabricia sp., Ampharete acutifrons, and the bivalve Lucina radians. Except for S. albini, greatest abundance of these dominant taxa were found in the shallower stations (< 60 m). S. albini was more abundant in the deeper stations (> 60 m). Seasonal variation in the dominant taxa was minimal. Spatial variations were high, with no specific geographical trend.

4. Faunal density ranged from 2012 to 8161 m^{-2} and generally decreased with depth (except for the southernmost transects). Seasonal variations were minimal. No specific geographical trend was evident.

5. Species richness ranged from 74 to 222 taxa and generally increased with depth. The southernmost transect was lower in species richness. No other specific geographical trend was evident. Seasonal variations were minimal.

6. A faunal similarity analysis indicated that the deeper stations were similar to each other, except for the southernmost transect station. The shallower stations (< 60 m) were generally dissimilar to each other. Within a station, seasonally, faunal similarity was high, with the exception of a shallow station where sediment heterogeneity was high.

7. Epifaunal abundance appears to influence the abundance and distribution of infaunal organisms.

8. Sediment characteristics (mean grain size and percent silt-clay content) appear to play a role in determining individual distribution and overall faunal density; however, water depth appears to be the controlling factor in macroinfaunal abundance and distribution. The influence of sediment characteristics is more important in the southernmost transect nearshore stations. These stations were substantially finer in grain size and had a greater amount of silt-clay fractions. Species composition and community parameters were considerably different at these stations when compared to all other stations in the study area.

9. The offshore areas of the study region (> 60 m depth) were characterized by communities exhibiting temporal stability and minimal spatial variations. The infaunal communities of these areas were dominated by Synelmis albini (polychaete). The nearshore areas (< 60 m) were characterized by communities that exhibited considerable spatial and temporal variations. The southernmost area in the study region (near Dry Tortugas) was inhabited by communities that were different from the rest of the study area.

10. In comparison to nearby bays, estuaries, and shallow coastal areas of the Gulf, the infaunal communities of the study area were considerably more diverse (higher species richness).

Recommendations/Data Needs

1. Temporal and spatial variability needs to be addressed in much greater detail for the shallow water areas of the study region.

2. The biology of the dominant polychaetes in the study area needs to be studied to provide a better understanding of their seasonal and spatial distribution patterns.

3. Trophic relationships between the infauna and the epifauna of the study area need to be evaluated.

4. Fulfilling the data needs listed above will enhance the existing baseline by providing a much better understanding of the causes and extent of natural variability in the study area.

HYDROGRAPHIC AND PRIMARY PRODUCTIVITY CHARACTERISTICS

L.P. Atkinson, Skidaway Institute of Oceanography
H. Chin, Woodward-Clyde Consultants
H.H. Kim, National Aeronautics and Space Administration
J.A. Yoder, Skidaway Institute of Oceanography

Within the last several years, a number of important studies have shown that upwelling near the shelf break in the vicinity of a major current can have pronounced effects on the marine productivity or biological activity of a continental shelf area. In the eastern Gulf of Mexico, this mechanism appears to be manifested by shelf break eddies that propagate along the Loop Current front. As a means of investigating the dynamic and productivity influences of this frontal area, and, in general, the productivity characteristics of the Southwestern Florida shelf region during different seasons, a series of coordinated investigations have been planned to augment the already existing hydrographic, geophysical, and benthic biological data base compiled for the Southwest Florida Shelf Ecosystems Study. The first of these investigations was completed in early April 1982. Data collected during this

cruise have now been analyzed through at least preliminary stages and form the general basis for this presentation.

Between April 1 and 7, 1982, a series of 110 study area stations located roughly between the 40 and 1000 m isobaths were sampled for hydrographic, primary productivity, and optical oceanographic properties. A number of crossings of the Loop Current front as defined by the 22°C isotherm at 100 m are evident in the data.

The cross-shelf cruise transects were situated in the general vicinity of two previous transects which were occupied repeatedly during Year 1 of the Southwest Florida Shelf Ecosystems Study. Cross-sections developed from these 20 to 100 m data provide a general picture of seasonal processes on the shelf in the April/May period. Of particular interest are the spring restructuring of the thermal field, localized subsurface salinity maxima, and cross-shelf distributions of transmissivity and chlorophyll *a* concentration. Each of these features is discussed below.

On April 1 and 2, NASA's U-2 aircraft carrying the Ocean Color Scanner was flown in support of the *in situ* sampling program. Approximately 10,000 square miles in an area bounded by 25°30' to 27°N and 84° to 85°W were surveyed. The processed ocean color images showed relatively weak chlorophyll gradient features across the frontal edges of the Loop Current and continental shelf. Ambient chlorophyll readings were estimated to be 0.25 mg/m^3 with very little variability, except for 0.50 mg/m^3 concentration patches which appeared in the northeastern corner of the test site. From this, it was speculated that a number of interesting dynamic features were located just north of the flight line flown by the aircraft.

Analysis of the cruise data showed that a subsurface intrusion of nutrient-rich offshore water covered the outer shelf as far shoreward as the 100 m isobath. Surface chlorophyll *a* concentrations were uniformly low across the shelf. However, a subsurface chlorophyll maximum was present at all stations and was associated with the nitracline. Maximum subsurface chloyophyll *a* concentrations occurred near the shelf break front, where levels were 10 to 20 times higher than surface values. Primary productivity ranged from 0.1 to 0.8 $gC/m^2/day$. No significant productivity gradients existed across the outer shelf.

ZONES OF FAUNAL SIMILARITY WITHIN THE HOURGLASS STUDY AREA

William G. Lyons and David K. Camp
Florida Department of Natural Resources

Lyons and Collard (1974) proposed that the fauna of the central West Florida shelf is arranged in five zones of faunal similarity: Shoreward, Shallow Shelf, Middle Shelf I, Middle Shelf II, and Deep Shelf. They suggested that these zones are delimited roughly by depths (0-10, 10-30, 30-60, 60-140, and 140-200 m) and result from differences

in such factors as substrates, temperature fluctuations, overlying water masses, and available light. Hopkins (1979) and Lyons (1980) presented additional evidence supporting the existence of various of these zones. However, Lyons (1980) modified previous estimtes, stating that the Shallow Shelf extended to 30-40 m, and the center of abundance for Middle Shelf I species seemed to occur at 50-60 m, diminishing soon thereafter.

To test this previously proposed arrangement, the present study examined the distributions and relative abundances of 221 species of benthic fauna analyzed to date from the collections of the Hourglass Cruises, a 28-month dredging and trawling program along two east-west transects, each with five stations in depths of 6, 18, 37, 55, and 73 m, on the central West Florida shelf. The 221 species included 89 crustaceans, 52 fishes, 41 echinoderms, 20 stony corals, 17 mollusks, and 2 brachiopods, representing all species for which final reports have been published or which have been totally identified and enumerated in manuscripts available. Only total abundances per station for each species were compared because of the nonquantitative nature of the sampling gear.

Intersite similarity coefficients and classifications were accomplished using the Czekanowski index for qualitative comparison and the extension of that index (often called the Bray-Curtis index) for quantitative comparisons. Qualitative and log-transformed quantitative comparisons were each generally adequate to define faunal zones. However, reduction to 53 most common species, thereby eliminating 76% of all species, masked faunal differences in that qualitative comparison. Quantitative comparisons using untransformed (raw) abundances were so sensitive to highly abundant species having a wide range of abundances between stations that intrazonal, local habitat differences were revealed, thereby masking broader zonal relationships. These comparisons were not suitable for determination of faunal zones.

Comparisons of different phyletic groups produced different indications of faunal zonation. Rock-dwellers demonstrated more distinct zonal distributional patterns than did sand-dwellers, and sessile species were more restricted to certain depths than were more mobile species. Zones of similarity were best discerned using faunal groups.

A strong relationship between faunal assemblages and individual depths was demonstrated. In the majority of comparisons, the fauna at a given station in a particular depth was indicated to be more similar to that at the complementary station in the same depth, but 160 km distant, than to the fauna at adjacent stations on the same transect which were geographically closer but in greater or lesser depths. Occurrences of individual species, as indicated by relative abundance, provided additional evidence of discrete, depth-related distribution patterns. More than half (28) of the 53 most common species demonstrated very high affinity to particular depth zones.

Three faunal zones involving stations at 6 m, 18-37 m, and 55-73 m were revealed. More species were captured at 37 m stations than at any other depth, but very few common species were actually characteristic of 37 m depths. Although most similar to fauna at 18 m stations, the fauna at 37 m stations was ecotonal between those at 18 and 55 m stations and was represented by many species more characteristic of those adjacent depths. It appears that the Shallow Shelf fauna is better expressed at depths less than 37 m. However, locations of all three zones (Shoreward, Shallow Shelf, and Middle Shelf I) were in close agreement with those previously proposed.

The three zones discerned within the Hourglass study area are, in general, related to recognized zoogeographic subdivisions. Species with high affinity for the Shoreward (6 m) zone are principally warm temperate (Carolinian) species that dwell upon quartz sand or shell rubble. The Shallow Shelf (18-37 m) fauna consists, to a great degree, of typically shallow water tropical species, including many stony corals, submerged to greater depths at these northern latitudes and thereby buffered against restrictive low temperatures which occur annually at shallower depths. Species characteristic of the Middle Shelf I zone (55-73 m) include an additional submerged tropical component and a resident shelf component which seldom occurs at lesser depths. Among these latter, at least for mollusks, is a pocket of relict species, or their direct descendents, which are characteristic of Tertiary fossil deposits on the Florida mainland.

Evaluation of the overall distributional affinities of the species is hampered to a surprising degree by the great number of undescribed taxa. Twenty-nine of the 221 species treated here (13%) were first detected in Hourglass collections. Many of these are not obscure species within the study area; 11% of the 53 most common species were among those previously undescribed. Lack of previous knowledge regarding the species generally increased with increasing depth of their principal occurrence. Of the 43 species whose abundances at 73 m stations constituted more than 50% of their total abundances, 37% were unknown prior to Hourglass collections. Little is known of the ranges or habits of these species outside of the Hourglass study area.

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SESSION: OFFSHORE FISHING WORKSHOP
Chairman: Mr. Villere Reggio
Scribe: Mr. Dick Miller
Date: August 24-25, 1982

Presentation Title	Speaker/Affiliation
Workshop Overview	Mr. Villere Reggio, MMS Gulf of Mexico OCS Region
Introduction to Meeting 1: Survey Results Relating Offshore Fishing to Petroleum Structures	
The 1980 Marine Recreational Fishery Statistics Survey	Mr. Malon Scogin, NMFS, Washington, D.C.
Collateral Uses of Offshore Oil and Gas Structures in the Central Gulf of Mexico	Dr. Robert B. Ditton, Texas A&M University
The Louisiana Scuba Survey	Mr. Mark E. Thompson, LSU
Survey of Snapper/Grouper Fishermen of the Northwest Florida Coast	Mr. Frank Dimitroff, Tallahassee, FL
Introduction to Meeting 2: User Views--Key Group Representatives	
Association Between OCS Activities and Commercial Fishing	Mr. Ellis Tate, Jelet Fishing Corp., Bridge City, Texas
Offshore Mineral Development and Private Boat Recreational Fishing in the Gulf	Mr. Maumus F. Claverie, Jr. New Orleans Big Game Fishing Club
Charter Boats and Offshore Oil and Gas Development	Capt. Charlie Hardison Hardison's Charter Boats
SCUBA Diving and Oil Rigs	Mr. Harry Caldwell Harry's Dive Shop
Introduction to Meeting 3: Structure Retention	
Use of Obsolete Offshore Production Structures in Artificial Reef Development and Enhancement	Mr. Steve Frishman, President Texas Marine Resources Foundation
Private Enterprise on Obsolete Oil and Gas Structures	Mr. Wayne Renger, President Replenish Ocean Systems, Inc.

WORKSHOP OVERVIEW

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

The Minerals Management Service has an objective to evaluate and document the scope and magnitude of the routine interrelationships between offshore oil and gas developments and fishing. The purpose of this workshop was to provide a forum where key investigators, representative fishermen, government and industry representatives could discuss pertinent research projects and share knowledge, experiences, observations, and proposals with each other and invited guests. The workshop considered three topics in three meetings. These proceedings are therefore organized in three sections.*

The results of completed and ongoing research on the fishing associated with offshore structures, along with testimonials by knowledgable and experienced fishermen representing a wide spectrum of offshore user groups, attest to the existing multiple use and compatibility between Gulf of Mexico fisheries and offshore energy developments. Final analyses of the research projects reviewed in Meeting 1 should document the scope and magnitude of these everyday interactions.

As was learned from Meeting 2, mutual respect and outstanding cooperation are the norm between offshore fishermen and energy developers on the OCS. Oil and gas structures and pipelines are magnets that attract fish and fishermen. Confrontations between and among the various fishing groups attempting to access the fishery resource directly associated with offshore structures appears far more likely than confrontation between industry and fishermen.

Meeting 3 demonstrated the willingness of government and industry to extend the useful and productive life of obsolete oil and gas structures on the OCS. Forced retirement, removal, and destruction of viable, non-producing petroleum structures could be prematurely wasting a national resource of tremendous public and private value.

The meetings identified need, opportunity, and broad support for government to take a leadership role in developing a policy and intergovernmental program and framework which would recognize, perpetuate,

*Names and addresses of speakers are included in the attendees list, should readers require further information on the edited summaries or discussion of topics. Presentations and follow-up discussion made within the Offshore Fishing Workshop are available on tape from the workshop chairman at the Minerals Management Service, 3301 N. Causeway Blvd., P.O. Box 7944, Metairie, LA 70010. Contact Villere C. Reggio, Tel. (504) 837-3995.

and geographicallly expand the fishery benefits of oil and gas structures.

INTRODUCTION TO MEETING 1: SURVEYS RELATING OFFSHORE FISHING TO PETROLEUM STRUCTURES

Several principal investigators and project administrators evaluating the "rig" fishing phenomenon reported on their objectives and preliminary findings in Meeting 1. Results of these investigations are expanding our knowledge of the intensive and extensive influence of petroleum structures on fishing. The MMS has contributed financial support to only two of these projects yet all four will produce valuable information to our understanding of the interrelationship between offshore structures and specific user groups attracted to the marine life associated with offshore petroleum structures.

THE 1980 MARINE RECREATIONAL FISHERY STATISTICS SURVEY

Mr. Malon Scogin
NOAA/NMFS, Washington, D.C.

Background and Overview

The objective of the marine recreational fishery statistics program is to develop a means for the continuous collection of data on the marine recreational fisheries (MRF) of the United States. More people are beginning to be aware of the impact that recreational fishing has on our marine fisheries resources and recognize the need for information regarding these resources. The Assistant Administrator for Fisheries, Mr. William Gordon, has established for NMFS (the federal agency primarily responsible for MRF) a policy for playing a key role in fostering MRF growth. This policy has led Mr. Gordon to appoint marine recreational fisheries coordinators in each region, and to require all programs within NMFS to consider and plan for MRF contingencies.

NMFS is authorized under three statutes to study and report on marine recreational fisheries: the Fish and Wildlife Act of 1956; the Migratory Marine Game Fish Act of 1959; and the Magnuson Fishery Conservation and Management Act of 1976. The data required by NMFS include: 1) catch by species/mode of fishing/area of fishing (these statistics are fundamental requisites for assessing the influence of fishing on any stock of fish); 2) effort (hours fished); 3) participation, by state of residence; and 4) socioeconomic characteristics.

These data are needed by such user groups as fishing organizations, business groups involved in marine recreation, and other federal agencies. Although various coastal states have their own data collection efforts, they also need these data because their efforts are very often limited geographically or spatially. The NMFS need the data for policy and planning, and the Regional Fishery Management Councils need

it as input into their Fisheries Management Plans. These data are used for the various planning and management requirements of the groups mentioned and to complement the existing commercial fishery statistics which have been collected on a continuing basis since 1880.

The problems in collecting MRF statistics begin with the sheer magnitude of the recreational fishery. It is a continuous activity which takes place all hours of the day, 365 days a year. Further, there is no identifiable population which can be contacted to obtain data (i.e., no saltwater license files). Fortunately, a low but significant proportion of the population involved in saltwater fishing is concentrated in the coastal zone. However, there is no central location where fishermen fish. They are scattered over more than 60,000 miles of coastline, fishing from boats, jetties, piers, docks, and the open beach. This is unlike the commercial fishery, which has a limited number of vessels, lands its catch at specific ports, and has an identified and limited number of buyers.

Given these problems, the only way to obtain data on MRF is by means of a sample of those who fish in saltwater. This requires establishing an estimate of the size of the population in order to formulate a sampling percentage, and sampling in such a way that information obtained may be expanded to represent the population, based upon acceptable techniques and available census data. Approaches to collecting these data include household surveys conducted by mail, telephone, or personal visit; on-site intercept surveys (often these are creel surveys); or a combination of household and intercept studies. The Fish and Wildlife Service's Survey of Fishing and Hunting uses a household survey.

Previous Surveys

The objective of previous surveys has been to obtain estimates of the catch by marine recreational fishermen in the United States. The first were the Saltwater Angling surveys conducted in 1960, 1965, and 1970. These were supplements to the National Surveys of Fishing and Hunting. Although they did provide data, these surveys were deficient in several areas. The surveys obtained data for large geographic regions with no further breakdown possible, and the results, based on small sample size, had high standard errors. Since the data were available only every five years, they proved inadequate for management purposes. The data were also unreliable because fishermen were required to recall detailed information for a one-year period (number of trips, number of fish, size of fish) and because species identification was sometimes questionable.

Regional surveys were conducted by NMFS in 1974 (northeastern coast) and 1975 (southeastern and Gulf coasts). The first phase of these surveys was a telephone screening survey of households to obtain information on participation and to provide a list of households which contained fishermen. In the second phase, a questionnaire was mailed

at two-month intervals to a sample of these households to obtain catch and effort data. A follow-up telephone questionnaire was used to sample the non-respondents to the mail questionnaire. The regional surveys were not entirely satisfactory, because of 1) a low response rate to the screening phase when the sample frame was determined, 2) a very low response rate to the mail questionnaire phase, 3) dependence on recall over a two-month period, 4) questionable species identification, and 5) inconsistencies in the sampling plan (e.g., some fishermen were interviewed more than once). These problems in the Saltwater Angling surveys and the regional surveys prompted NMFS to examine ways of improving the survey design to obtain more accurate data on marine recreational fishing.

The New and Improved NMFS MRF Survey Methodology

In August of 1976, Human Sciences Research, Inc. (HSR), under contract to NMFS, began a methodology study with three objectives: 1) to develop and pre-test various methodologies or combinations of methodologies for collecting marine recreational fisheries data; 2) to recommend the most cost efficient methodology, and 3) to develop sample sizes for the recommended approach. Their literature review concluded that more methodological inquiry in the conduct of marine recreational fishing surveys was needed. After the literature review, several methodological studies were conducted. These were designed to identify the most appropriate techniques for gathering data regarding: 1) the total number of marine recreational fishermen; 2) the number of MRF trips taken in specified time periods; 3) the total MRF effort for those time periods; 4) total catch of fish by species, weight, length, location, and method of fishing; and 5) disposition of catch. These items were determined to be the types of information needed for the effective management of MRF.

The third part of the HSR study was an estimate of fishermen's ability to recall catch and effort over time. It was determined that fishermen could accurately recall for a two-month period the number of fishing trips, the mode of fishing, and the location of fishing. However, they were unable to accurately recall the number of fish caught or the size of fish caught. Additionally, many fishermen were unable to correctly identify the species of fish caught.

After these studies and field testing on the Atlantic, Gulf, and Pacific Coasts, HSR recommended an optimum survey methodology. This was a "complemented survey" jointly using two different survey methods: an intercept survey and a telephone survey.

The on-site intercept survey is continuous throughout the year in each coastal county. Site selection is by mode of fishing (either jetty/pier/bridge, beach/bank, party/charter boat, or private/rental boat) and is a random sample of fishing trips, not fishermen. Information for each mode of fishing includes the location of fishing, the time spent fishing, the number/length/weight of each species caught,

and information on fish returned to the water. These data are used for determining fishing effort, distribution of catch by species ("average catch" per trip), average length and weight of catch by species, and location of fishing and catch.

The second method in the complemented surveys approach is a random-digit-dialing telephone survey of households in the coastal counties of the United States. The coastal counties were delineated as a boundary, based on studies which estimated that 70 to 90% of MRF live within the coastal counties. This also allowed the use of census data to expand estimates for the total population. Telephone exchanges were also found to be geographically similar to county boundaries. All counties wholly or partially within a 25-mile zone of the coast were included; this zone was extended to 50 miles in the South Atlantic and Gulf during the summer months. The telephone survey is done at the end of each two-month period (or Wave) based upon the constraints of a recall period of two months or less. Households are interviewed only once during the year.

Data collected are number of fishermen, number of trips, location of fishing, and mode of fishing. These data provide information on participation by geographical area and trips by state/mode/area.

At the end of the survey period, data from the intercept survey by mode of fishing are combined with data from the telephone survey by mode of fishing to produce estimates of the total catch. Thus the survey estimates, for each geographical area and state:

1. the number of fishermen and trips by state of residence;

2. the catch of finfish by species/area/state;

3. the distribution of catch by species for sounds, rivers, bays, and oceans;

4. disposition of catch (landed or released); and

5. the weight of fish landed.

The dual frame approach represents a significant improvement in methodology over past surveys to collect data on recreational fisheries. Interviewers in the intercept survey examine catches and identify the species of fish caught, not relying on the fishermen for identification. Similarly, the fishermen are not required to recall information over time on their catches. The level of precision for the resulting data will also be much higher than for previous surveys. However, the survey is not designed for the rare event fisheries, such as billfish and tunas.

Gulf of Mexico Survey Modification to Evaluate Oil and Gas Platform Fishing

During 1980 and 1981, NMFS signed an interagency agreement with the Dept. of Interior, BLM, modifying the NMFS survey to increase the sampling effort in the Gulf of Mexico, and to ask all people intercepted in boat modes who had fished in the Gulf whether or not they had fished near an oil/gas platform. All telephone interviews also added this question. The goal of this modification was to investigate the extent to which off-shore oil/gas platforms and rigs have an impact on MRF.

Collectively these platforms constitute a major change in the ecology of the Gulf. The offshore seafloor of the Gulf consists largely of a flat, soft-bottomed, gradually sloping plain. The oil/gas platforms appear to serve as artificial reefs to attract fish. BLM's ongoing program of environmental analysis of the offshore leasing program needs this information to assist their efforts. Preliminary results from the 1980-81 surveys would indicate that approximately one quarter of all the offshore ocean fishing orginating in Texas, Louisiana, and Mississippi is directly associated with oil and gas structures.

COLLATERAL USES OF OFFSHORE OIL AND GAS STRUCTURES IN THE CENTRAL GULF OF MEXICO

Dr. Robert B. Ditton
Texas A&M University

There are appoximately 3400 oil and gas structures in the Central Gulf of Mexico that serve as artificial reefs for numerous sport species. There are an estimated 400 oil and gas structures offshore Texas, many of which are used by recreational fishermen.

Currently, the Outer Continental Shelf Lands Act (OCSLA), the MMS lease agreement, and the Geneva Convention on the Continental Shelf require that companies remove production platforms after production ceases. The fact that a platform might be particularly well located and hence heavily used for sport fishing is of no consequence. The impact on communities whose economy is based on recreational fishing is not considered. Likewise, the platform's fishery enhancement capability is not taken into account.

It is not now possible to leave platform structures as artificial reefs; they must be removed to permitted locations as bottom or mid-level reefs. Someday, it may be possible to leave structures standing as designated artificial reefs. The current situation is this: the private sector has platforms they want to dispose of as artficial reefs at a net savings to each company, while public sector officials are in need of suitable materials for reefs to enhance fisheries and fishing.

This looks like an area where mutual interests can be served in the future.

In partial pursuit of these goals, an extensive data base was collected during 1980-1981 with the cooperation and assistance of the Offshore Operators Committee. Company representatives used a daily reporting form devised by the BLM to record observations on the number of boats, activity group, type of fishing, suspected target species, as well as the number of personnel fishing from the platform.

Dr. Ditton's group became involved when the data collection effort was completed. Their tasks were to develop a research plan for analyzing this data base and to conduct the necessary analyses so as to better understand the dynamics of platform use.

Project objectives were to determine:

1. who fishes around oil and gas structures (use by activity group);

2. where they come from (state of origin) and where they go (offshore area, distance from shore, water depth);

3. when they fish (seasonality, weekend/weekday);

4. what major target species do they seek and with what gear; and

5. what factors most affect the scope and nature of the fishery.

An incremental approach was taken in analyzing the voluminous data set. First, the study area was divided into distinct regions based on access points (quality of transportation links and location of marinas, charter boats, and launch sites), population centers, probable fishing destinations (river versus bay versus offshore), shelf characteristics, and distance from shore to platforms. This resulted in the designation of three regions: 1) the Delta region, extending east from South Pelto and South Timbalier lease areas; 2) the Bay region, from Ship Shoal west to Vermilion; and 3) the Cameron region (East and West Cameron lease areas). The Delta region was chosen for analysis first because of the large number of adjacent Standard Metropolitan Statistical Areas (SMSA's) and likely heavy fishing effort.

In the Delta region, representatives of 14 companies made 12,719 observations at 69 structures during the one-year study period. In the Bay region, 22 companies made 4,634 observations at 60 structures, and, finally, in the Cameron region, 19 companies made 2,274 observations at 27 structures. Summary preliminary findings were presented for each of the five activity objectives. Cross tabulations will be conducted to test for relationships between variables. Analyses will be conducted

for each study region as well as the overall area. A final report will be published by MMS in 1983.

Summary of Group Discussion

Dr. Ditton responded to several questions clarifying the mechanics of the survey and some of his preliminary findings. A discussion ensued on the relative merits of standing-in-place, emergent oil and gas platforms versus cut-off, lying down, submerged platforms as reefs. The general consensus was that platforms in place make better reefs because they attract a wider variety of fishes and because fishermen find them easier to locate. On the other hand, the point was made that bottom reefs are better than no reefs and are easier to manage and maintain. Dr. Ditton commented that in the present system of artificial reefs some are optimally constructed or located and others are not. The hope is to gather planning information through research such as this survey, which will facilitate better choices should it become possible to extend the life of a select few oil and gas structures as artificial reefs.

THE LOUISIANA SCUBA SURVEY

Mark E. Thompson (Ken J. Roberts, Co-Author)
Center For Wetlands Resources
Louisiana State University

The number and distribution of petroleum structures off Louisiana will change as production at certain locations terminates and new fields are developed in deeper water farther offshore. Petroleum structures are well known recreational resources to divers and anglers. Recreational values and use patterns are dependent on availability of resources. As resources change there are corresponding impacts on recreational opportunities. Because diving and angling off Louisiana are undocumented economic uses of the ancillary services associated with structures, fundamental baseline information was sought.

The Louisiana Sea Grant College program funded the initial economic research into the sport diving aspect of the petroleum structure resource. A mail survey of randomly selected sport divers from the National Association of Underwater Instructors and Skin Divers magazine lists began in the spring of 1982. Simultaneously, members of sport diving clubs were divided into two subsamples. One group of club divers received their questionnaire for completion via mail, while the others were interviewed. This procedure permits the testing of variation which may originate in interview methods. Using the mail questionnaire on both the non-club and club divers allows testing of hypotheses concerning membership as relates to activity level, investment, and value. Approximately a 33% response rate to the mail survey was experienced.

At the time of the Minerals Management Service Information Transfer Meeting, the questionnaire data had recently been coded, key punched, and transferred to tape. Research results relating to the 1981 calendar year diving activity should be available in the spring of 1983. The data and related analysis include: 1) years of diving experience as related to frequency of dive trips and value of structure diving; 2) the relationship of club membership to investment in diving equipment, dive trip frequency, value of the diving experience, target species, and expenditure; 3) the purpose of diving trips and location of frequented structures; 4) the species and total poundage of fish harvested; and 5) the valuation of the diving experience as related to the method of interview, purpose of the dive trip, and income level of divers.

As insight is gained on the economic aspects of sport diving around structures, other research on anglers using private and charter boats can proceed on tested methodologies. Comparison of valuation, investment, uses, and economic impact by user group can then be made for a complete understanding of recreational benefits of structures.

SURVEY OF SNAPPER/GROUPER FISHERMEN OF THE NORTHWEST FLORIDA COAST

Frank Dimitroff
Fisheries Specialists, Tallahassee, FL

Introduction

In the summer of 1981 when Frank Dimitroff was working for the Florida Sea Grant Program, he conducted a survey of commercial snapper/grouper fishermen in the coastal area of northwest Florida. Included in the survey were the counties of Escambia, Santa Rosa, Okaloosa, Walton, Bay, Gulf, Wakulla, and Franklin. Major snapper/grouper fishing port areas from west to east included Pensacola, Niceville, Panama City, Port St. Joe, Appalachicola, Carabelle and Panacea. Dimitroff's survey was composed of interviews with 150 full- and part-time vessel captains. Although the results of this survey have not been published, Dimitroff was able to use his preliminary findings to characterize the commercial snapper/grouper fishery in northwest Florida and show a definite relationship between this fishery and oil and gas development.

Findings

Dimitroff's overall findings indicate that one-third of the vessels in the fishery were full-time snapper/grouper fishermen; one-third were part-time commercial fishermen; and one-third were strictly sports fishermen. The obvious charter and headboats which cater to recreational fishermen were excluded from his survey, even though many fish heavily for snappers and groupers.

Dimitroff was able to discern a distinct difference in the character of the snapper/grouper commercial fishing fleets in the ports on the west end of the Panhandle from those on the east end. The vessels working out of Appalachicola, Carabelle, and Panacea were smaller, more antiquated, less sophisticated electronically, and did not seem to be very committed to market fishing. Boats from these ports averaged only 10 to 12 short trips per year. Dimitroff surmised that the area has been overfished and that the fishermen are generally apathetic about maximizing their economic returns. Interestingly, snappers and groupers caught off the Florida coast commanded a 10¢ price advantage over those harvested in the Central Gulf and landed at the same ports. Dimitroff attributed this to a firmer flesh rather than a noticeable difference in taste.

In contrast, those snapper/grouper fishermen out of ports on the west side of the Panhandle (Panama City, Niceville, and Pensacola) had a much stronger commitment to commercial fishing. A larger percentage of these fishermen were full-time participants in the fishery; the boats were larger, more modern and better equipped, and fishermen made longer trips. Virtually all of these boats had bottom profilers or some type of fish finders, and over 95% were equipped with Loran C navigation.

A very consistent facet of snapper/grouper fishing in the western Panhandle group was reliance on man-made structures. The snapper/grouper boats from Niceville and Pensacola fish the oil and gas structures in the central Gulf almost exclusively.

Dimitroff estimated that 112 Florida commercial snapper/grouper boats fish the offshore oil and gas structures off Mississippi and Louisiana on a regular basis. He determined that these boats catch an average of 50 pounds per day, per boat from beneath oil and gas structures. The average "rig" fishing boat fished three days a week and made 30 trips a year. A conservative estimate of 450,000 pounds of of snapper and grouper are caught by northwest Florida vessels from around oil and gas structures each year, and most are landed at, or marketed from, Florida ports.

The dockside value of the 450,000 pounds of snappers and groupers caught annually around oil and gas structures by Florida commercial fishermen approximates two million dollars. These fish help support a healthy tourist industry in Florida and are distributed to other major cities in the South and along the east coast, such as New Orleans and New York. Dimitroff concluded his remarks with a recommendation that some sort of interstate group or commission representative of all Gulf states take a leadership role in making a Gulfwide evaluation of man-made structures as to their true contribution and future potential to the fishing industry.

Group Discussion

Dimitroff responded to several questions on fishing gear used by the northwest Florida snapper/grouper fishermen. He indicated that the predominant rigging was multiple hooks and electric reels, especially among the deep water boats fishing the oil and gas structures. Although his survey did not query captains on the use of fish traps, Dimitroff was of the opinion that some were in use because in his former capacity as a marine advisory agent he had received several inquiries from commercial fishermen regarding the technology of traps.

Charles Lyles, Executive Director of the Gulf States Marine Fisheries Commission, commented that the snapper/grouper fishery in the Gulf of Mexico is a unique fishery and very difficult to assay. He noted that over the last 35 years many new "fish motels" (presumably oil and gas structures) have been created, and fishing pressures have increased. He said there is insufficient data on snapper/grouper migration patterns, fecundity, and other information that goes into the management of a fishery.

INTRODUCTION TO MEETING 2: USER VIEWS--KEY GROUP REPRESENTATIVES

Although no one individual can fully represent an entire group such as commercial fishermen, the session chair attempted to find experienced and knowledgable people who could speak with some authority about the group they represent. All key group representatives invited to participate were known to direct a large part of their fishing in close association with offshore oil and gas structures, and they each have a broad knowledge of their peer group. The following sections, prepared by the session chair, summarize testimonials by representative individuals whose lives and livelihoods have been significantly influenced by offshore oil and gas development.

ASSOCIATION BETWEEN OCS ACTIVITIES AND COMMERCIAL FISHING

Ellis Tate, Jelet Fishing Corporation,
Bridge City, Texas

Introduction

Ellis Tate is a college educated, commercial fisherman who owns and operates an 80-foot boat rigged for combination fishing (trawling and longlines). He has been a full-time commercial fishermen for about 10 years and currently fishes throughout the Atlantic and Gulf of Mexico. His principal target species are swordfish, which he pursues all along the east coast, and shrimp, snapper, and grouper, which he harvests mainly in the Gulf of Mexico. Tate, an extremely flexible fisherman, described the multidimensional effects of oil and gas

production, especially pipelines, on his livelihood. In his presentation, he demonstrated how a prudent, innovative, and adaptable fisherman can turn potentially and apparently adverse conditions resulting from oil and gas pipeline construction into more successful and productive fishing for shrimp and finfish.

Outline

An outline prepared by Mr. Tate reviews the effects he discussed at the meeting.

I. Pipeline canals through inland waterways

   A. They tend to make travel quicker and easier.

   B. However, they significantly affect the estuarine habitat of shrimp and other sealife dependent upon these ever changing nursery grounds.

II. Pipelines' effect on net dragging fishermen

   A. Older pipeline valves which are not properly covered act as bottom obstructions, causing loss of equipment.

   B. Freshly dug pipelines make passage impossible to conventionally rigged nets.

   C. However, the fisherman willing to add mud dragging gear to his nets will be rewarded by the extra shrimp which concentrate on each side of the pipelines' muddy bottom.

III. Pipelines' effect on longline bottom fishermen using this method to fish for snapper and grouper

   A. Older pipelines have a continuing positive effect because uncovered pipe has a "log in water" effect towards attracting fish. Also the valves which tend to trap light, current-driven materials (such as rope, plastic, and netting) act as small artificial reefs to collect fish. These situations persist long after the pipeline has been laid.

   B. New pipeline activity seems to have the most profound effect, as the newly broken up bottom tends to cause fish within its area to collect and forage through the disturbed bottom, searching out clams and other freshly exposed food sources. (Same principle as birds and other animals flocking to a newly plowed field.) Fishing greatly improves in the area until the bottom settles and exposed foods are eaten. Then fish scatter and remain only in the areas of the valve, any exposed pipeline, or anywhere the bottom was left uneven.

C. There is a direct correlation between the amount and size of current-driven materials trapped by valve stems and the amount of concentrated fish which can be sustained there. It is clearly evident that these accidentally constructed habitats are the most productive artificial reefs.

D. Without doubt, there are significant positive effects of oil production, but until now they represent only accidental effects of production. Considering the bad press the oil companies have suffered through the past fuel shortage, one can expect to see one of the more innovative oil companies take full advantage of the opportunity to be the first to purposefully enhance its own production grounds. One of these future conscientous oil companies will assume the lead, as well as the credit, for active participation in abandoned structure retention as well as construction of super-low cost, but highly productive, artificial reefs, thereby emphasizing the positive effects of oil production. Even though it will represent a "dollar savings" to the first oil company to embrace this change of direction, it will also determine which oil company will be remembered as being first to purposefully leave the Gulf better off than before production.

Discussion

After his formal presentation, Tate responded to several questions regarding his techniques in catching pipeline-associated fish and shrimp. He indicated that most of his bottom-set longlines for snapper and grouper are along pipelines in the 50 to 75 fathom depth range, where pipeline burial is not required. He reiterated that he has snagged anchors, nets, and longlines on pipes, but believes the rewards amply compensate for the occasional damage and loss of equipment. Carl Sullivan, from the American Fisheries Society, commented that there is currently some question as to the value of requiring pipeline burial, from the fisheries standpoint.

John Green from the Gulf of Mexico Fishery Management Council inquired about the incidental catch of marlin and sailfish during swordfish longline operations. Tate indicated there were some by-catches of billfish east of the Mississippi River and all along the east coast.

OFFSHORE MINERAL DEVELOPMENT AND PRIVATE BOAT RECREATIONAL FISHING IN THE GULF

Maumus F. Claverie, Jr., New Orleans Big Game Fishing Club

Introduction

Maumus Claverie has been fishing in the Gulf of Mexico and around the oil and gas structures since the mid 1950's. He fishes for fun, food, and fame and has come to be associated with both the New Orleans Big Game Fishing Club and the International Game Fishing Association. In 1982 he was appointed to the Gulf of Mexico Fishery Management Council. He also serves on the Department of Commerce's Marine Fisheries Advisory Committee (MAFAC). Speaking from 25 years of offshore fishing experience for everything from the most sought after speckled trout and redfish to the mighty blue marlin, Claverie attested both verbally and pictorially to the many ways the structures, personnel, equipment, and supplies of the offshore petroleum industry aid the private boat recreational fishermen.

Outline

I. Adverse Effects of Offshore Oil and Gas Developments

Prior to the Nixon era, offshore mineral pollution was frequent and severe. With the Nixon era, this pollution was rapidly terminated, showing that offshore mineral development can be clean neighbors.

II. Passive Assistance to Marine Recreational Fishing

A. Radio Weather Information

1. NOAA has recently included on-scene weather from Grand Isle 94B and Main Pass 6B in their hourly updates. This is very useful in providing information out toward where fishermen are going.

2. Vessels such as semi-submersibles, drilling ships, etc., maintain radio watch at all times. Offshore, they assist in increasing fishermen's VHF-FM range. This is also true for stand-by and workboats at platforms.

3. PennRod 72 broadcasts requests for assistance of small vessels in trouble.

4. Rig personnel advise fishing boats tied to platforms of approaching bad weather, announced on company radios.

B. Navigation Aids

The use of "A" overlay on charts and maps, coupled with signs on platforms, allows offshore navigation with no electronic

aids. This is especially useful in inclement weather, when critically low on fuel, or to determine the current set while trolling all day.

C. Protection

Platforms and drilling rigs can be used as storm havens and as lighting rods. Protection from severe waves can be found behind production barges in the Breton Sound area, and near large platforms offshore.

D. Other

The entrance channel maintained into Breton Harbon provides accessibility for fishing that area.

III. Active Help Incidents (Personal Anecdotes)

A. A woman with a leg injury was evacuated to a nearby platform and the oil company helicopter took her to a hospital.

B. A person with an eye injury was evacuated by Coast Guard helicopter via a stand-by boat and the Cognac landing platform.

C. During a Fourth of July storm, a crew abandoned a sport fishing vessel at a platform and took a helicopter to shore. The abandoned vessel was towed to Venice by the oil company boat that discovered it one week later in the Gulf.

D. A seasick child obtained ice cream, air conditioning, and TV aboard a platform.

E. A prototype 28-foot fishing yacht was saved from sinking by being towed from one installation to another where pumping facilities were available.

F. The PennRod semi-submersible hoisted the largest blue marlin ever caught in Texas, aboard the HATTERAS.

E. A fishing vessel obtained fuel from a stand-by boat.

IV. Big Fish and World Records: Catches Near Rigs

A. The woman's world record and largest blue marlin ever caught in the Gulf (1,018.5 lbs) was caught during the Ladies Tournament in July 1977 while trolling the anchor buoys around PennRod 72. PennRod radioed an offer to hoist the fish aboard their crewboat for the run to the Club's weigh station. The President of the United States and Secretary of

Commerce had visited this drilling rig the day before the record catch!

B. Numerous world records have been recorded from fishing around oil structures: speckled trout (green monster, April 1972); numerous king mackerel records at Grand Isle 32 and West Delta 41; two red drum records at West Delta (April 1973); jack cravelles in May and June 1978; bonita in July 1975 and 1976.

Discussion

After Claverie's presentation there was considerable discussion on offshore structures and how they have affected fish, fishing pressure, and boat sales.

John Green of the Gulf of Mexico Fishery Management Council asked Claverie if certain structures are more productive than others and if certain species of fish are associated with specific structures. Claverie indicated that while certain structures are more productive than others, that can change from day to day and season to season. By and large, water depth is a major determining factor for some species. King mackerel, for example, can most consistently be located around structures in the 90-110 foot depth range. Some structures seem to never produce fish, yet a closely associated structure could be a consistent producer. Certain factors, such as noise on platforms, seem to attract fish some days and scare them away on others.

Bethlyn McCloskey made the point that excellent big game fishing around the deep-water delta was well established prior to the introduction of oil and gas structures in this historical big game fishing ground. Claverie concurred, but expressed his firm belief that the offshore petroleum developments have only contributed to the private boat fisherman's ability to enjoy and participate in this fishery. He noted that some types of fishing, such as pompano fishing, did not exist offshore Louisiana prior to the introduction of oil and gas structures. He believes there are more fishermen, more boats, and more fish caught offshore because of, and not in spite of, the offshore petroleum industry. Although he has noted a slight decline in the quality of offshore fishing over the years, Claverie did not associate this in a negative sense with the offshore petroleum industry.

CHARTER BOATS AND OFFSHORE OIL AND GAS DEVELOPMENT

Capt. Charlie Hardison
Charlie Hardison & Sons, Inc.
Golden Meadow, LA

Introduction

Charlie Hardison has been in the charter boat business for the past 29 years. His business has grown and prospered in tune with the growth of the offshore oil and gas industry. Capt. Hardison owns and operates five charter boats, four of which fish offshore. His boats fish the rigs almost exclusively in a 130 mile arc (Ship Shoal 292 to Cognac) off the Louisiana coast. He takes over 10,000 people deep sea fishing every year and has never dropped an anchor in the Gulf of Mexico. Almost all of his fishing is done while he is tied up to oil and gas structures.

Summary

Capt. Hardison stressed, overall, the tremendous cooperation he has received from the petroleum industry over the years in every way imaginable. They have been most reliable in responding to emergency situations which have often arisen in his 29 years of "rig" fishing. In the past 10 to 12 years he has not observed major pollution coming from offshore structures. In the early years, such observations were frequent.

It is his belief that the by-product of some commercial fishing operations can seriously affect recreational fishing for some species. He cited the example of double-rigged trawlers hauling in hundreds of pounds of small red snapper with shrimp catches. Snapper fishing has been better in 1982 than in the past 15 years, and he attributed this to economic conditions such as fuel cost, which has depressed the trawling industry in the last few years. He also believes commercial menhaden fishing has seriously impacted tarpon fishing and has observed purse seiners catching tremendous quantities of redfish recently (offloading of 80 tons was noted). Over the years, Capt. Hardison has noticed a tremendous increase in non-Louisiana boats fishing the offshore platforms, especially the Florida snapper/grouper fleet.

It is his conviction that the problems with declining fish population in the offshore fishing industry are self-imposed and are not reflective of pollution from the offshore industry. He pointed out that he can still consistently catch plenty of fish but must regularly travel 30 to 40 miles, whereas in the early years he seldom traveled more than 10 miles.

Capt. Hardison indicated that he fishes different areas in the Gulf during different season and catches specific species at specific platforms. For example, he heads for the West Delta and Grand Isle

platforms to catch trout, croaker, and king mackerel; South Timbalier, South Pelto and Ship Shoal platforms for red snapper; and Ship Shoal, South Addition platforms for amberjack. He fishes further offshore in the summer time and closer in during the winter. In response to a question on platform removals, he said all structures are good fishing locations at some point during the year, and he would hate to see even one flare stack removed.

His clientele come from all over the United States. Over 95% of his winter business comes from the midwest, principally from northwest Illinois corn farmers. Tennessee, Kentucky, and Atlanta, Georgia also contribute regular weekday customers. His weekend business is almost totally fishermen from Baton Rouge, Louisiana.

Capt. Hardison attributes recent reports on the demise of offshore charter boats to economics and not to a significant decline in the resource base. He agreed that the industry has changed over the years for various reasons, but believes there are enough fish and customers to support more boats in the coastal Louisiana charter fleet. If people could afford to get started (Capt. Hardison's last charter boat cost $485,000; his first cost $2800), could find suitable dockage, knew what they were doing, and were willing to work 12 to 16 hours a day seven days a week, they just might make it in the charter boat business.

Discussion

During the discussion period, Carl Sullivan made the point that an obvious reason for trying harder and going farther to catch fish is that there is a lot more fishing today than in former years, hence a lot more competition for the most desirable fish.

The nature, extent, and probable cause of the offshore oxygen depeletion (or dead water) problem was discussed by Charlie Lyles as an implied cause of some fishing problems. Capt. Hardison said he had heard and read about the oxygen problem but could not tell if it was affecting his fishing success.

In response to other questions, Capt. Hardison explained his fee structure and said any serious fisherman could recoup his cost with fish in his freezer, and any novice could learn to be a successful fishermen in three minutes.*

*Note: The Minerals Management Service had a pending charter date with Capt. Hardison and told him they would hold him to that last statement. Villere Reggio reports that on October 11, 1982, the MMS party of 17 paid $730 and caught 600 lbs. of snapper in the South Timbalier area valued at $1500. Hats off to Capt. Hardison!

SCUBA DIVING AND OIL RIGS

Harry Caldwell, Harry's Dive Shop,
Metairie, LA

Introduction

Harry Caldwell, a native of Tennessee, began sport diving in Louisiana waters when he was transferred here by South Central Bell in 1959. He is a former military diver and has trained divers for the Apollo space program. He has been associated with the diving program at Scripps Institute and is a member of the physical education staff at Tulane University. Caldwell is a charter boat captain and currently owns and operates Harry's Dive Shop in Metairie, through which he trains aspiring recreational divers for SCUBA certification, and communicates with a large segment of the active sport divers in southeast Louisiana and beyond.

Summary

Mr. Caldwell recounted his experiences and impressions resulting from over 20 years of diving and from leading others to the excitment and wonders of the submerged environment of the steel reefs. He described the underwater petroleum structures as "cages without walls." Based on his many years of personal observation, his presentation offered a description of some of the more interesting fish life associated with the rigs:

> Fish congregate at certain levels along the vertical and horizontal support members of a rig; however, cruisers search all levels for prey. Barracuda prefer the upper 50 feet of water, although they occasionally swim to deeper depths. Groupers remain at or below the 50 foot depth. Snapper range throughout the water column but avoid the near-surface area. Cobia, which look like sharks to novice divers, congregate three to four feet below the surface at those times of the year when the water is warmer. The slow, cumbersome jewfish remain close to the bottom in muddy water. Amberjack cruise at 180 foot depths.

Caldwell went on to describe unique features of certain underwaters structures, such as inverted bells and giant underwater tanks which seem to attract the most sought after fishes. He noted the existence of coral, tropical fish, and spiny lobster around oil and gas structures, and associated their appearance with the Alaskan earthquake that caused a mild tidal wave in the Gulf. He has noted a change in overall water temperature over the years, with distinctly colder temperatures in 1982.

Caldwell characterized the people he knows who recreationally dive the rigs as "hard core divers." He further described these divers as well trained, physically fit, independent divers who know their equipment and the marine environment. Their primary interest in diving the rigs off Louisiana is spearfishing, which they conduct in a sportsmanlike manner. SCUBA divers selectively choose their targets. Caldwell described catches of sharks over 400 pounds, and jewfish large enough to swallow a diver in a single gulp. He discourages harvesting fish which are merely wasted or inappropriately disposed of.

Divers seek clear water for their diving, and so avoid the drilling rigs and working drilling platforms, preferring the older production platforms. Caldwell indicated that it is common practice for divers to establish contact with industry personnel prior to descending below their platforms. He indicated most of the diving takes place between 60 and 100 feet, and that divers may travel as far as 80 miles from shore to dive.

Caldwell expressed concern about offshore pollution, noting that divers can see certain types of pollution. However, he said that the most serious problems are shore-based. He believes diving is a very safe sport, although human error or unexpectedly, hazardous conditions cause serious accidents, as in any activity. He noted how some fishermen have a habit of innocently discarding overboard a "birds nest" of backlashed monofilament line. This line, as well as masses of loose cable around the bottom of structures, can and has bound the hands and necks of divers, leading to death by suffocation.

Caldwell discussed some instances of confrontation between sports divers and sports fishermen, and evidenced some longstanding animosity between a few charter boat captains and sport divers. He told of the time a fishermen snagged and reeled up a SCUBA diver, and another instance when a diver successfully guided a luckless fishing party to where they could catch some fish. He feels the charter captains have not made sufficient efforts to meet the needs of recreational SCUBA divers.

Caldwell believes there is a great future for sports diving in the central Gulf, and he attributes this potential entirely to the pervasive oil and gas structures. He believes recreational diving can have a perceptible impact on Louisiana's coastal economy. One of the greatest needs to realize this potential is a dependable charter service for divers. He intends to launch his own charter service in 1983 with a 59-foot boat catering specifically to SCUBA divers. He believes every oil and gas structure is good for fish and terrific for fishing and would hate to see any removed.

Discussion

Mr. Caldwell answered numerous questions about his years of observing in situ, the natural and man-caused conditions underneath

offshore petroleum structures and the relationships of divers with the industry above the water surface.

INTRODUCTION TO MEETING 3: STRUCTURE RETENTION

All Gulf states except Louisiana are actively seeking obsolete oil and gas structures for creation and enhancement of fisheries habitat. Two oil companies have already donated obsolete structures to the state of Florida for artificial reefs, and several more companies are currently considering additional transfers of platforms soon to be retired. Several federal agencies, local governments, congressmen, national associations and environmental groups, regional fishery councils and associations, and many private individuals are on record supporting artificial habitat enhancement projects making use of obsolete oil and gas structures.

In the third meeting, two individuals who are pursuing new and innovative projects aimed at extending the useful life of offshore structures in the marine environment were asked to share with the workshop participants their ideas and proposals for structure retention.

USE OF OBSOLETE OFFSHORE PRODUCTION STRUCTURES IN ARTIFICIAL REEF DEVELOPMENT AND ENHANCEMENT

Steve Frishman
President, Texas Marine Resources Foundation
Member, Texas Coastal and Marine Council

Introduction

For a number of years representatives of government, industry, and special interest organizations have discussed the possiblility of using obsolete offshore oil and gas production structures as structural materials for marine artificial reef development. The objectives of the parties in this type of activity are compatible. However, for the process to become routinely practiced, there must be identifiable benefits that serve all the participating parties and the general public.

Government and Industry Objectives

The practical objectives for government and special interests, related mainly to recreational and commercial fishing, and recreational diving, include:

1. development of new, accessible, productive artificial reefs and enhancement of existing artificial reefs;

2. the financial capability to adequately mark the reef sites; and

3. the ability to sponsor and direct research activities aimed toward identifying the biological, social, and economic value of artificial reefs, and research to assist reef managers in actions that encourage optimal biological and socioeconomic benefits being derived from reef development and enhancement.

Industry's practical objectives in participating in an artificial reef program that makes use of its obsolete structures include:

1. breaking even, or enjoying a cost saving over the expense of transporting the structures to shore for dismantling and disposal;

2. securing a release from future liability for the structures should they be diverted for use as artificial reef structures;

3. gaining all possible tax relief from the process of applying the structures to new, productive public use and benefit;

4. avoiding inconvenient, and possibly costly, delays caused by administrative and regulatory action impacting the artificial reef development program; and

5. enjoying the benefits of goodwill that will accrue from such a public-spirited action as enhancing marine fisheries and fishing and recreational opportunity.

Past Artificial Reef Development

The Texas Coastal and Marine Council, an advisory agency composed of executive and legislative appointees, developed four artificial reefs in approximately 100 feet of water off the Texas coast during the mid-1970's. The reefs, located about twenty miles offshore of the harbor entrances at South Padre Island, Port Aransas, Port O'Connor, and Freeport, were constructed by sinking surplus U.S. government Liberty Ships. The South Padre Island, Port O'Connor, and Port Aransas reefs each contain three of the ship hulls, measuring 430 feet long by 57 feet wide. The ship decks were removed for salvage, leaving the cleaned hull depth at about 30 feet and providing a water depth clearance of 70 to 80 feet over the reefs. The Freeport reef contains two cleaned Liberty Ship hulls located near, and parallel to, the sunken wreck of the tank ship V.A. FOGG, which exploded and sank after leaving Freeport Harbor. The Liberty Ships in the other reefs were also placed roughly parallel and approximately 400 feet from each other.

Following development of the reefs, it occurred to members of the Texas Coastal and Marine Council that the empty spaces between the

Liberty Ship hulls were suitable areas for the placement of obsolete offshore production structures for purposes of reef enhancement. In discussions of this possiblity, it became clear that a mechanism to satisfactorily deal with the various parties' objectives, as stated above, was needed and could not be entirely achieved through the Texas Coastal and Marine Council. It was recognized, however, that any mechanism developed would entail a close working relationship with the Texas Coastal and Marine Council, since the Council held the Corps of Engineers permit for placing structures at the Liberty Ship reefsites.

Texas Marine Resources Foundation

The mechanism that seemed to best fit the identified objectives was the establishment of a foundation, a non-profit, tax exempt corporation chartered in Texas, and operating in compliance with Internal Revenue Service requirements, which would permit nation-wide activity. Thus, the Texas Marine Resources Foundation was established, with three founding directors, and a provision to expand the Board of Directors to a total of nine members. The desired attributes met by the Foundation included:

1. the ability to receive and distribute tax-free donations;

2. the ability to manage and invest surplus funds for future distribution;

3. the ability to enter into legal agreements with industry and government;

4. the ablilty to make operational decisions at a pace equivalent to that of the industry when it needs to dispose of a structure; and

5. the ability to assist and negotiate industry objectives that are of mutual benefit to defined parties and interests.

In creating the Texas Marine Resources Foundation, the following objectives were adopted and placed in the foundation charter:

1. to coordinate and cooperate with agencies, organizations, institutions, industry, associations, and individuals with respect to the restoration, wise use, enhancement, conservation, and scientific management of fisheries, wildlife, and other coastal and marine resources;

2. to promote and support programs of scientific study and technical research for the advancement of restoration, wise use, enhancement, conservation, and management of fisheries, wildlife, and other coastal and marine resources; and

3. to inform and educate the public through the dissemination of pertinent facts, scientific and research discoveries, and

information that may contribute to the solution of problems related to the management of fisheries, wildlife, and other coastal and marine resources.

These objectives broaden the scope of Foundation activity in a manner that is discretionary with the Board of Directors, within a wide policy range and financial capability. In practice, the priority commitment of Foundation funds is to the support of the Texas Coastal and Marine Council artificial reef program obligation for maintaining navigational aids on reefs in accordance with U.S. Coast Guard requirements.

A conceptual plan for the interaction of the Foundation, industry, and the Texas Coastal and Marine Council is presented in Figure 4. The plan is dependent upon a number of administrative items being in place in order to meet the stated objectives. These items include the following:

1. a general permit (letter of permission format) to the Council from the Corps of Engineers for placement of structures at the designated reef sites, and setting conditions for such activity.

2. a method of calculating the cost differential between onshore disposal and offshore use of a structure;

3. a consistent and credible division of cost savings accrued in the offshore reef option, with the Foundation receiving a share of the savings as a direct cash donation along with the placement of the structure on a reef site;

4. standard conditions and terms of agreement between the industry donor and the Foundation for acceptance of title of the structure once it is in place at the reef site;

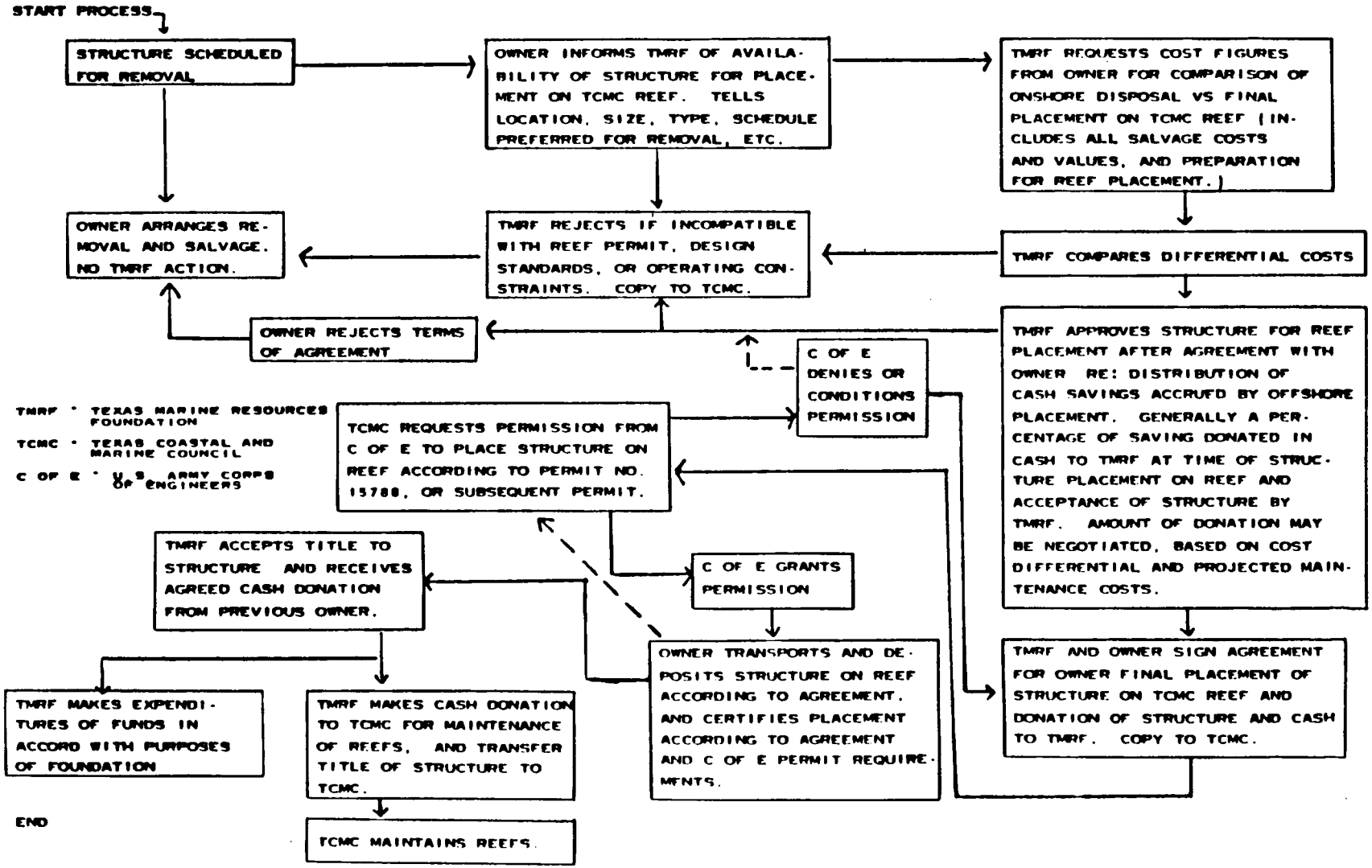
5. standard conditions and terms of agreement between the Foundation and the Council for acceptance of title of the structure, once accepted by the Foundation;

6. contingency plans for administrative and contractual actions in the event of unforeseen events resulting in the structure not meeting agreed specifications regarding its location and placement on the designated reef site.

A primary consideration in the development of this conceptual plan is that the use of the structures in a reef program must have "market acceptance." If the parties do not perceive and realize benefits from the programs, as outlined, the program does not operate, because one or all of the parties may choose not to participate. On the other hand, if the benefits, on a case-by-case basis, are demonstrable, then the program will go forward with all parties receiving predictable bene-

Figure 4.

CONCEPTUAL PLAN FOR ENHANCING AND MAINTAINING TEXAS COASTAL AND MARINE COUNCIL ARTIFICIAL FISHING REEFS WITH OIL AND GAS INDUSTRY STRUCTURES



fits. Throughout the conceptual plan, there are opportunities for the parties to withdraw from the process, based upon known decision options, with little if any time lost in the effort. It is estimated that, with the above stated administrative items in place (now nearly completed by the Foundation), the time needed to accommodate all administrative and regulatory needs associated with the conceptual plan is on the order of 17 to 35 days, depending on the time needed to secure a letter of permission from the Corps of Engineers, and the time necessary to negotiate the contract between the owner of the structure and the Foundation.

Current Reef Enhancement Projects

As of this date, two structures of interest for reef enhancement are the subject of bid requests: salvage operators are bidding costs for both shoreside salvage and offshore placement on a Liberty Ship reef. The test of the conceptual plan is under way. Once there is a resolution of the uncertainties in whether this plan is operable at the benefit levels expected, the next issues to be considered are the securing of permits for additional reef sites, and, of great industry interest, the option of retaining structures on original sites as artificial reefs.

Discussion

Mr. Frishman ended his presentation by asking for answers rather than questions considering the many known data gaps, sparse experience, and unresolved issues which led to the creation of the Texas Marine Resources Foundation. He responded to several inquiries clarifying the intent and proposed operation of the Foundation and indicated that the Foundation would have preferred several benthic reef transfers and some completed research prior to considering the acceptance of emergent structures "as is, where is" for artificial reefs.

PRIVATE ENTERPRISE ON OBSOLETE OIL AND GAS STRUCTURES

Wayne Renger, Replenish Ocean Systems, Inc., Victoria, Texas

Wayne Renger, an alumnus of Texas A&M University, has a broad background in business and industry. He specializes in marine aquaculture. Twelve years ago Renger responded to an ARCO advertisement for better ideas and convinced them to create a habitat for abalone culture under an oil production platform in the Santa Barbara Channel. Through this experiment, they were able to accelerate the growth of harvestable abalone from 7 to 3.5 years. This led Renger to consider additional uses for offshore structures.

Mr. Renger is professionally associated with Mr. Ronnie Staha, who has pioneered in commercial shrimp mariculture. Mr. Staha, starting from scratch, has profitably managed a successful shrimp mariculture

project in South America. Renger has consulted with Mr. Staha on the hatchery potential of oil and gas platforms for a national and international market.

Mr. Renger reviewed the multi-million dollar cost of recent and pending platform removals and referenced some industry estimates of from 20 to 50 years of remaining useful life on many platforms that have been declared obsolete. Mr. Renger noted that if he were able to extend the expected life of production platforms through continued use of a profitable non-oil and gas venture, the incidental public benefits of the reefal effects of the structure for fish and fishing would also be extended.

For 10% of the projected removal cost, Mr. Renger proposes to assume liability for obsolete structures suitable to his purposes. He would bear the cost of continued structural maintenance and guarantee operation of required navigational aids, such as lights and horns. In exchange, he would negotiate a lease purchase agreement for the platform for use in a potentially profitable enterprise.

Renger's most advanced project proposal is the development of a modular shrimp hatchery to be built and installed on available and selected platforms by Baker Marine Corp. of Ingleside, Texas. Renger stated that he has evaluated the technical and financial feasibility of his proposal with Baker Marine and has come up with the following facts and figures. Fifteen-to twenty-day-old post-larval shrimp can be sold on the world market for $10 to $15 per thousand. On an offshore platform with dimensions of 125 feet by 100 feet, Renger believes he can produce, from a modular hatchery system, anywhere from 15 to 25 million post-larval shrimp a month. These shrimp could generate an income of $12,000 to $15,000 a day for nine months a year. He foresees a gross income of $150,000 to $225,000 per month using these structures as bases for shrimp hatcheries. Renger believes this is sufficient income to meet labor, material, insurance, transportation, and platform maintenance expenses and still make a profit. He figures cost-per-day for such an operation would be from $1700 to $2250, leaving up to $10,000 a day profit, assuming a 65% survival rate on shrimp produced.

Mr. Renger indicated that he has established international market contacts with Abu Dhabi, India, and Indonesia, as well as Panama and other South American countries. If he can get industry and goverment to cooperate by allowing use of suitable obsolete platforms in exchange for 10% of the removal cost, he would be willing to accept title to the structure in three to five years and assume full responsibility for ultimate removal and disposal costs.

Mr. Renger went on to explain that spoil deposits make the bay side of the intracoastal waterway especially suitable for construction of grow-out ponds for shrimp maturation for marketing in the United States. Mr. Renger has already lined up a processor and seven prominent landowners between Corpus Christi and Freeport, Texas who are

willing to construct, at their cost, up to 400 acres of 50-acre, low density, grow-out ponds. Renger said that the processor, Mr. Sam Clegg of Port Lavaca, is willing to harvest and pay the land owners a 10% price premium on artificially cultured shrimp in these grow-out ponds from those shrimp harvested in the wild. Mr. Renger has also investigated marketing artificially cultured shrimp as live bait.

Mr. Renger concluded with a slide presentation and discussion on shrimp mariculture operations, including equipment, hatchery techniques, and the life cycle stages of shrimp. In summary, Mr. Renger believes that with minimal support from industry and government he can perpetuate the reefal value of some oil and gas structures and generate a profitable mariculture operation. He demonstrated that he has lined up the necessary private support and cooperation to construct, manage, grow, process, and market shrimp from platform-based shrimp hatcheries within a national and international market.

In response to questions from the floor, Mr. Renger indicated that sufficient demand for a steady and reliable source of post-larval shrimp exists to warrant the use of from 50 to 100 offshore platforms. He said the unique advantage of offshore platforms in shrimp hatchery operations is a reliable source of quality water with high nutrient potential. He reiterated his estimated cost of $2500 a day for maintaining a platform as a shrimp hatchery and said 20% of that, or approximately $500 a day, would maintain a platform. When questioned on the pitfalls of the shore-based grow-out process, he indicated that low density culture, as planned, should overcome the bacterial and molting problems experienced in some culture operations. Other possible private uses for offshore structures under consideration by Renger include commercial fish processing plants, recreational fishing "hotels," and permanent offshore marine research centers.

SESSION: FATES AND EFFECTS WORKSHOP
Chairman: Dr. Richard Defenbaugh
Scribe: Mr. Ken Adams
Date: August 24-25, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Dr. Richard Defenbaugh, MMS Gulf of Mexico OCS Region
Results of the BLM IXTOC Oil Spill Assessment Studies:	
Geochemical Studies	Dr. David Fiest and Dr. Paul D. Boehm, Energy Resources Company; Dr. Paul Mankiewicz and Dr. Ian Kaplan, Global Geochemistry Corp.
Biological Studies	Dr. George Lewbel LGL Ecological Research Associates
Fates & Effects Study Programs for the Gulf of Mexico	
Summary of EPA Drilling Fluid Research Activities	Dr. Thomas W. Duke U.S. Environmental Protection Agency, Environmental Research Laboratory
Summary Review of the Buccaneer Gas and Oil Field Environmental Assessment Program (NMFS/NOAA)	Dr. Charles Caillouet National Marine Fisheries Service, NOAA
Industry Accomplishments and Future Needs	Dr. James P. Ray Environmental Affairs Shell Oil Company
Summary of BLM Fates and Effects Studies in the Gulf of Mexico	Dr. Richard Defenbaugh, MMS Gulf of Mexico OCS Region
National and Regional Plans for Future Studies of Long-Term Effects of OCS Activities in the Marine Environment: MMS National Program	Mr. James Cimato, MMS Branch of Offshore Studies
MMS Long-Term Fates and Effects Studies Program for the Gulf of Mexico: Program Plan	Dr. Richard Defenbaugh, MMS

SESSION SUMMARY

Dr. Richard Defenbaugh
MMS, Gulf of Mexico OCS Region

The goals of this workshop were to share information on the accomplishments of recent, major studies or study programs designed to elucidate the fates and/or effects of Gulf of Mexico offshore oil and gas activities and effluents, and to discuss future work needed, in view of the existing information base. The workshop was planned to include three series of presentations. The first series consisted of summary results and conclusions from the BLM-funded studies of impacts of the IXTOC I oil spill on the environment and economy of the South Texas coastal and offshore areas. The second series of presentations included descriptions and summary accomplishments of major study programs conducted in the Gulf of Mexico by federal agencies and private industry regarding fates and/or effects of offshore oil and gas activities, especially of routine effluent discharges into the marine environment. In the last series, MMS representatives described national and regional plans for future studies regarding the overall effects of OCS oil and gas activities on the coastal and marine environments, and on the coastal economies and social fabric.

With the exception of scheduled presentations by Dr. Carlos Restrepo (IXTOC I Socioeconomic Studies) and Mr. Donald Day (NOAA Office of Marine Pollution), which were cancelled because of unavoidable conflicts, all speakers met the goal of informatively sharing with the audience the accomplishments of their respective studies or study programs.

The workshop presentations were consistently informative. Those on the impacts of the IXTOC I and BURMAH AGATE oil spills reported that the environmental and economic consequences of this massive spill were surprisingly minor to the offshore marine environment and to the Texas coastal economy. The presentations on major study programs supported by various federal agencies and industry, described completed or active studies which address the environmental effects of offshore oil and gas activities. In general, the speakers indicated that the short-term effects of routine offshore oil and gas activities are localized at the sites of the drilling rig or production platform, but that the long-term or cumulative effects are largely unknown. The presentations regarding MMS's future plans for effects studies indicated that at both the national and regional levels, the need for effects information is recognized and that programs are being planned.

The management implications of these presentations are clear. The Minerals Management Service is mandated to husband the orderly development of the oil and gas resources of the OCS to meet the energy demands of the nation. At the same time, MMS must provide for protection of the environment concomitant with OCS oil and gas exploration, development, and production. Protection of the environment requires a clear

understanding of the impacts to the environment of all actions resulting from resource development activities as well as unrelated activities and natural phenomena. Much of our understanding of the effects of OCS oil and gas activities on the marine and coastal environments, at least at the meso- or macro-scale, is intuitive or empirical. A better, more quantitative understanding is needed to allow development of a capability for predicting, within reasonable probability limits, the impacts which may result from planned activities.

RESULTS OF THE BLM IXTOC OIL SPILL ASSESSMENT STUDIES-- GEOCHEMICAL STUDIES

Paul D. Boehm and David L. Fiest
Energy Resources Co.

Paul Mankiewicz and Ian Kaplan
Global Geochemistry Corp.

Background

The blowout of the IXTOC I offshore drilling rig in the Bay of Campeche, Mexico on June 3, 1979, resulted in the release of 0.5 million metric tons (140 million gallons) of oil into the Gulf of Mexico and transport of a significant part of this oil northward into U.S. coastal waters. Surface oil entered U.S. waters on August 6, 1979, and continued to be seen in significant surface concentrations until the northward-flowing western Gulf of Mexico current reversed direction during September 1979. The well was finally capped on March 23, 1980.

During this period of time, approximately 4,000 to 11,000 metric tons of IXTOC oil (one to three million gallons) impacted the beaches and resided offshore in tar mats. Perhaps five to ten times as much oil passed through the Texas OCS region, largely in the form of small patches of emulsified oil (mousse), without affecting the shoreline. Approximately 180 tons of oil, or less than 5% of the total quantity of oil initially beached, was present in the tar mats. The beached oil was removed naturally and either redeposited in the nearshore bar/trough system or taken further offshore. The ultimate fate of the bulk of the oil remains unresolved, although the weathering and physical breakup process, followed by distribution of small tarry particles in surface and subsurface waters in the Gulf of Mexico, seems likely.

Early in November 1979, months before the IXTOC I well was capped, the tanker BURMAH AGATE collided with the freighter MIMOSA about five miles off Galveston, Texas. The collision released several million gallons of crude oil into offshore waters. Kana and Thebeau (1980) have estimated that approximately 21,000 metric tons (150,000 barrels) burned in the ensuing fire. Some 7,000 metric tons (48,000 barrels) dispersed offshore during northerly winds, according to their esti-

mates. About 10% of this oil was recovered offshore, leaving a large portion of the spilled oil to weather by evaporation, photochemical oxidation, etc., or to become mixed in the water column. The fate of the remaining oil includes 1) emulsification and dispersion, 2) mixing with sediment, followed by sinking to the benthos, or 3) direct sinking of partly combusted residual oil from the fire.

Objectives of the Study

The IXTOC assessment study had two primary objectives:

1. to examine and quantify the chemical impact of the IXTOC and BURMAH AGATE spills on the offshore benthic environment; and

2. to determine if such impacts resulted in sustained perturbation of the benthic biological community.

While the study relied heavily on information contained in samples from the Texas beaches and from the wellhead region, the assessment focused on the offshore Texas OCS from an area seaward of the offshore bars (about 3 m depth) to the 60 m depth contour some 30 to 40 miles offshore. A third objective was to determine to what extent and for what duration the shrimp fishery had been chemically affected as a result of these two spills. Accurate assessment of damages from these two spills was facilitated by information from baselines studies of the South Texas Outer Continental Shelf (STOCS) conducted from 1975 to 1977 as part of the BLM Environmental Study Program.

Damage Assessment Strategy

The integrated damage assessment strategy for this project involved the following elements:

1. determination of what habitats had been affected;

2. determination of the nature and extent of the chemical impact;

3. determination of whether biological and ecological perturbations resulted from this impact, as compared to both the pre-spill environment and the unaffected environment;

4. determination of a causal relationship between any observed biological changes and the chemical impact;

5. determination of damage to the shrimp fishery due to the chemical impact;

6. determination of the pre-spill value of the ecological and/or commercial resource and the extent to which its use and/or value had been diminished.

Two sets of environmental samples were used to achieve the program's objectives: 1) samples from the mid-spill time period (mid to late 1979); and 2) samples from the post-spill time period (late 1980). Information obtained from these samples was compared to the substantial pre-spill (1975-1977) data on similar samples.

Conclusions and Recommendations of the Study

The following conclusions outline the major findings of the chemical assessment segment of this study.

1. The use of the combined techniques of capillary GC, capillary GC/MS, and isotope mass spectrometry (isotope MS) to obtain detailed molecular (GC and GC/MS) and atomic (isotope MS) information on the n-alkane composition, aromatic hydrocarbon (two to five rings) composition, and stable isotope (C, H, S) ratios of suspect oils and tars, enabled definitive IXTOC/BURMAH AGATE match/no-match conclusions to be drawn. This combined use was equally effective in eliminating false-positive and false-negative results from any one of the three techniques.

2. With the availability of several weathered IXTOC reference oils/tars, n-alkane compositional plots were effective in source matching during the spill period (1979). As microbial degradation took place and the n-alkane fingerprint was lost, the use of GS/MS information in conjunction with stable isotope measurements was most effective in tracking IXTOC and BURMAH AGATE oils. Carbon isotope measurements on saturate and aromatic fractions were not alone sufficient to accomplish source-matching.

3. An examination of surface sediment samples from the mid-spill (1979) and post-spill (1980) sample sets by a hierarchical analytical scheme was successful in examining the sediment hydrocarbon assemblage and showed that no recent petroleum (>10 ng/g) additions from the IXTOC I or BURMAH AGATE spills were present in the primary study area.

4. Study area sediments do contain widespread evidence of geochemically distributed chronic pollution dominated by: chronic weathered anthropogenic saturated hydrocarbon residues; low levels of n-alkanes mostly of biogenic origin; and polynuclear aromatic hydrocarbon residues. Thus they are not pristine in terms of anthropogenic inputs.

5. Regressions of both gross chemical parameters or compounds with total organic carbon levels define the STOCS geochemical environment. Incremental additions of approximately 10 ppm of oil to sediments would be identifiable as "new" non-normal additions, based on the gross PHC/TOC regressions. This level

of oil could, of course, be detected easily by both FSCGC and GC/MS analyses.

6. IXTOC oil was present in the sorbent pad samples, apparently tied up in the suspended sediment material also captured in these samples. This significant finding indicates that there was IXTOC oil in the "system," associated with mobile sedimentary material.

In spite of the massive intrusion of petroleum hydrocarbon pollutants into the study region, chemical studies show that no definitive damage can be associated with the IXTOC I spill or other known spillage events (e.g., BURMAH AGATE) on either the epibenthic commercial shrimp population or the benthic infaunal community. Such conclusions have no bearing on intertidal or littoral communities, which were not the subject of the study. Drastic decreases were noted in infaunal community species abundance and diversity compared with extensive baseline information, but these changes must be ascribed to natural system variability.

Future damage assessment programs will be most successful and cost-effective if:

1. they are designed to be comparable with baseline data, but modified to take into account the realities of chemical fates of oil in offshore sediments (e.g., mobile floc layers);

2. they are initiated only after laboratory/field reconnaissance studies indicate likely impact based on chemical and toxicological data;

3. sufficient amounts of sample are available (small quantities of 1979 sediment samples precluded some isotope analyses);

4. they use comparable biological sampling techniques and collect equivalent numbers of replicate samples;

5. they are designed for high replication of each set of biological samples to cope with the expected natural variability;

6. sampling periods are scheduled to include samples collected at the same time of year or comparable seasons;

7. they continue for some period of time following the suspected impact, especially if pronounced faunal changes appear to have occurred, so that spill-impact recovery or natural variability trends can be determined;

8. a complete, validated reference collection of specimens is produced;

9. the program works in step-wise fashion, with chemical results preceding the further analysis of archived biological samples;

10. a multi-parameter oil identification analytical procedure is employed; and

11. a hierarchical screening/analysis chemical procedure is employed.

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RESULTS OF THE BLM IXTOC OIL SPILL ASSESSMENT STUDIES-- BIOLOGICAL STUDIES

Dr. George Lewbel
LGL Ecological Research Associates, Bryan, Texas

Introduction

Between 1979 and 1981, the Bureau of Land Management (BLM) sponsored a study of the effect of the IXTOC I oil spill upon the soft-bottom macroinfauna (i.e., organisms retained by a 0.5 mm screen) of the south Texas Outer Continental Shelf. This study was one component of a suite of studies to define the environmental and economic consequences of the spill in the south Texas coastal and offshore areas. The report summarized the major findings of that study in light of 1976-1977 (pre-spill) baseline data from BLM's South Texas Outer Continental Shelf (STOCS) program.

Benthic samples collected at 12 of the STOCS stations during the IXTOC I spill (November 1979) and one year later (December 1980) were compared to 1976-1977 samples from the same sites. The 1979 samples were taken by a multi-agency "Regional Response Team," while the 1980 samples were collectd by LGL Ecological Research Associates, Inc. and by Energy Resources Company, Inc. (ERCO). ERCO was responsible for chemical sample and data analysis; Geomet Technologies, Inc. for sediment texture analysis; and LGL for biological samples and data analysis

to determine if any effects of the IXTOC I spill on macroinfauna might be detected.

The circumstances under which this study was made could not practically be expected to have been better. The oil spill was massive; there was a large amount of baseline biological data on the area; and and the methods used in the baseline study were standardized and repeatable.

Discussion and Recommendations

The main goals originally set for LGL's portion of the BLM impact assessment program for the IXTOC I oil spill were to:

1. evaluate the mid-spill (November 1979) and post-spill (December 1980) macroinfaunal community at 12 stations previously sampled in the STOCS program;

2. compare pre-spill biological conditions with mid-spill and post-spill conditions; and, should the data from the chemical portion of the impact assessment program permit,

3. determine if observed differences in macroinfauna were correlated with the presence of IXTOC I residues.

Goals 1 and 2 were accomplished quite successfully, largely as a result of the use of standardized sampling methodology and coordination between STOCS personnel and LGL staff to keep taxonomic problems to a minimum. For LGL to complete Goal 3 would require quantitative information on amounts of IXTOC I residues at each station. Since the sediment samples collected on site did not contain any detectable traces of oil, it was not possible to associate any biological changes with the IXTOC I spill. Therefore, this report is perhaps best considered a source of follow-up baseline information.

There is no question that major changes have occurred through time at the 12 study stations. The differences were not confined to a few stations; whatever factors were influencing the community were acting without regard to depth or location. Furthermore, most taxa and major groups of taxa showed the same pattern of periodic increases or decreases while retaining their relative importance with respect to one another. This finding indicates that the differences between sampling periods were not due simply to changing abundances of a few particularly common organisms.

Unfortunately, it is impossible to assign any particular cause to the pronounced differences in community structure from one sampling period to the next. It is conceptually simplest to invoke physical factors rather than complex biological interactions, which are poorly understood for the great majority of the taxa in the area. That the differences in abundance and numbers of taxa were area-wide implies

strongly that some density-independent factor(s) rather than biological interactions were involved. The gaps in time between sampling periods after the conclusion of the STOCS program were lengthy, and intervening events left no clearly interpretable record. Consequently, any attempt to attribute the observations to their proper cause(s) would have a strong tautological element.

Pronounced cycles in abundance are the rule, rather than the exception, for many of the taxa in this study. It is entirely likely that the differences noted between sampling periods may be a product of natural variability rather than attributable to any single cause (human-induced or otherwise). Large fluctuations in abundance on monthly, seasonal, and annual bases are common for many infaunal taxa (Dexter 1969; Frankenberg and Leiper 1977; Moore and Lopez 1969; Penzias 1969; Tunnell et al., 1981; Wright and Moore 1970).

The types of physical factors which would be most likely to have significant effects on the benthic community would include major changes in bottom water characteristics (such as oxygen content, salinity, or temperature), or mechanical disturbance, especially if such disturbance altered the sediment composition (texture or organic content) to any great degree. Hypoxic bottom water, major tropical storms bringing low salinities, mechanical disturbance, and sediment loads, and sudden thermal changes due to "northers" were discussed in detail in the Final Report as possible causes for macroinfaunal changes.

Future damage assessment programs will be most likely to be successful and cost-effective if they:

1. use comparable sampling techniques and collect equivalent numbers of replicate samples;

2. are designed for high replication of each set of samples, to cope with the expected natural variability;

3. are scheduled to include samples collected at the same time of year or comparable seasons;

4. continue for at least a year or two following the suspected impact, especially if pronounced faunal changes appear to have occurred;

5. produce complete, validated reference collections of specimens; and

6. work in step-wide fashion, with chemical results preceding the further analysis of archived biological samples.

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SUMMARY OF EPA DRILLING FLUID RESEARCH ACTIVITIES

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The Environmental Protection Agency (EPA) has the responsibility to issue permits for discharge from drilling and production platforms under the National Pollutant Discharge Elimination System (NPDES) Program. The conditions established for these permits are to be based on technical guidelines required under provisions of Section 403(c)(1) of the Clean Water Act. Drilling Fluid Research activities related to drilling fluids at the Environmental Research Laboratory, Gulf Breeze (ERL-GB) are conducted to provide scientific data to those involoved in issuing the NPDES permits.

Drilling fluid research activities at this laboratory began in 1976 and are scheduled to terminate in 1982. The program is primarily extramural and designed to assess the potential hazard to the marine environment from drilling fluid discharge practices. Two recent activities sponsored by EPA are of particular interest: an Adaptive Environmental Assessment (AEA) workshop on the potential impact of drilling fluids on the marine environment, and a cooperative program with the Petroleum Equipment Suppliers Association and the American

Petroleum Institute to screen "spent" drilling fluids from wells in the Gulf of Mexico.

Adaptive Environmental Assessment Workshop

The AEA workshop was held in 1981 in an effort to synthesize the rather large data base of information on the short-term effects of drilling fluids and limited amounts of data on the fate of these materials. The AEA methodology was developed by environmental scientists and system analysts at the University of British Columbia. The workshop was attended by interested individuals from key agencies, industry, and academia. The focus of the workshop was on the construction of a quantitative, dynamic simulation model that should be refined before use as a regulatory tool. The model simulated fate and effects of discharge from a single rig into open waters of the Gulf of Mexico, and there was discussion of factors that might produce different fate and effects in enclosed areas such as bays and estuaries (Aubel et al., 1982). The model consisted of four connected submodels. A discharge/fate submodel dealt with discharge characteristics of the rig and subsequent fate of discharged material. Three effects submodels then calculated biological response in the water column, and in soft and hard-bottom benthos. The model did not evaluate ecosystem interconnects, but focused on direct linkages between discharge and various organisms.

Results of the simulation model indicated relatively localized effects of drilling muds and cuttings from a single platform into open water areas. Fate of the fluids in the water column and their effects on selected water column organisms were dominated by rapid dilution. Effects from deposition of spent mud and cuttings were spatially limited, with relatively rapid recovery, especially in soft-bottom benthic communities which were conceptualized as being adapted to frequent storms. This behavior was generated by the set of assumptions about linkages and functional relationships used to construct the model. Areas of uncertainty about the model included: methods for extrapolating 96-hr LC_{50} results to exposures of varying lengths and concentration; recovery rates of benthic communities; responses to various depths and rates of burial; and long-term and sub-lethal effects of slightly elevated concentrations of discharged materials. Evaluation of the assumptions of the soft-bottom submodel suggest that the assumptions used may have been relatively liberal estimates of resiliency of those communities and frequency of storms dispering the drilling fluids.

Discussions of "closed" water bodies such as bays and estuaries indicated several reasons to expect different and more complex fate and effects behavior in these areas. Those factors included different species and communities (such as aquatic macrophytes and oyster beds), more complex circulation and stratification patterns, and potentially more active resuspension processes. The complexity and variability of these areas notwithstanding, the workshop identified a large body of knowledge (such as that concerning fate and physical effects of dredge

spoil) that could be effectively employed in analysis of potential fate and physical effects in enclosed areas.

"Spent" Fluid Screening Program

Current research activities emphasize laboratory screening of a variety of "spent" drilling fluids from wells in the Gulf of Mexico and an on-site plume study of discharges from an operating well. The Petroleum Equipment Suppliers Association are collecting the drilling fluid samples for analysis at the Gulf Breeze EPA laboratory, and the American Petroleum Institute will conduct duplicative screening tests on a split sample basis.

The screening program sponsored by ERL-GB involves chemical and biological analyses. Concentrations of nine metals, hydrocarbons, and specific organics are determined in each sample. Biological screening includes: definitive tests on soluble, suspended particulate, and solid phases with Mysid shrimp; 96-hour acute and some chronic tests with grass shrimp; development of mussel larvae; development of echinoderms; and physiological studies with coral.

The National Oceanographic and Atmospheric Agency (NOAA) has been provided funds to make *in situ* observations of the concentration of drilling fluid particles in a shunted discharge from an operating well. These observations will include acoustical measurements of the particles as well as physical and chemical measurements.

Accomplishments

The following listing is representative of accomplishments of the ERL-GB Drilling Fluid Program:

1. evaluation of the impact of organic biocides, particularly pentachlorophenol, in drilling fluids;

2. contribution to scientific data base on fate and effects of drilling fluids through results of extramural and intramural projects;

3. synthesis of existing data on fate and effects of drilling fluid through an Adaptive Environmental Assessment Workshop;

4. provision of technical assistance for regulatory decisions made by EPA regional and headquarters staff; and

5. state-of-the-art report on the impact of drilling fluids on the marine environment.

Information Gaps

If one approaches the question of potential impact of drilling fluids on the marine environment through the use of a hazard assessment

procedure (scientific judgement regarding probability of harm to the environment from known or predicted environmental concentration), it is necessary to have data on both concentration and effects. Much information has already been collected, but needs for additional research were raised at the Adaptive Environmental Assessment Workshop. The following "information gaps" are taken from the Workshop report, with the exception of the last, which originated at the ERL-GB laboratory.

1. The extension of 96-hr LC_{50} results (or any fixed-concentration, fixed-interval toxicity test) to other exposure times at other, perhaps time-varying, concentrations is a central problem in estimating effects on field populations from predictions of environmental fate.

2. The relationship between variation in composition of discharged drilling fluids and cuttings (variation in additives, different sites, and across time and depth at one site) and variation in toxicity does not seem to be well-established.

3. Variations in the rate of recovery of disturbed benthic communities, sensitivity of these communities and their recovery rates to altered particle size distributions, and sensitivity to depth and rate of burial are all areas where additional quantitative information is needed for model construction.

4. Uncertainty exists about behavior of the plume at water stratification layers and possible effects of a potential higher concentration of discharged materials in areas where organisms might also tend to be concentrated.

5. Knowledge of the limits of applicability of laboratory-derived data on fate and effects to natural field conditions is lacking.

Some of these gaps in information are being filled by present research activities sponsored by EPA, industry, and others; these will appear in the final synthesis report from the ERL-GB laboratory. Information will also be available from monitoring studies underway at Georges Bank and the East and West Flower Garden coral reefs. These additional studies will provide input for a more accurate assessment of the potential impact of drilling fluids on the marine environment.

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SUMMARY REVIEW OF THE BUCCANEER GAS AND OIL FIELD ENVIRONMENTAL ASSESSMENT PROGRAM*

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The Buccaneer Field, occupied by Shell Oil Company operations, is located approximately 50 km south-southeast of Galveston, Texas, on the continental shelf of the northwestern Gulf of Mexico. It is isolated from other gas and oil fields. Development of the field began with exploratory operations using mobile drilling rigs in 1960. After sites were selected, two permanent production platforms were erected. Additional structures (quarters platforms, well jackets, and flare stacks) and pipelines are also contained within the field.

The environmental assessment of the Buccaneer Field was initiated in November 1979 and ended in September 1980. The project is an example of an environmental assessment of impacts of chronic, low-level contamination associated with an offshore gas and oil production operation in a long-established field. No major spills have been reported from the Buccaneer Field, though occasional minor spills have been documented. Operations began with the production of oil, but significant quantities of gas were located, and gas production eventually predominated.

The primary source of contaminants from the production operations is the produced brine or formation water, a saltwater solution produced in the process of extracting gas and oil. In addition to containing trace quantities of petroleum hydrocarbons and metals, the produced brine contains large quantities of elemental sulfur, requiring use of biocides to inhibit populations of sulfur-reducing bacteria, which produce highly corrosive metabolites. Except for its high sulfur content, the produced brine from the Buccaneer Field could be typical of producing fields in the Gulf of Mexico.

Objectives

Overall objectives of the environmental assessment of the Buccaneer Field were:

1. to identify and document the types and extent of biological, chemical, and physical alterations of various marine ecosystem components associated with the Buccaneer Field;

*This summary review is excerpted from Caillouet *et al.*, 1980.

2. to determine specific pollutants, their quantities and effects; and

3. to develop the capability to describe and predict fate and effects of Buccaneer Field contaminants.

A brief pilot study was conducted in November and December 1975 to determine whether the Buccaneer Field was an appropriate site for such an environmental assessment. Levels of hydrocarbons and peculiarities in distribution of sediment types and benthic infauna were found to be of sufficient concern to warrant further investigation. In 1976-1977 a survey compared environmental conditions in the Buccaneer Field to those of adjacent "control" areas. EPA, NOAA, and NMFS concluded that such a survey was not likely to detect environmental effects on the Buccaneer Field. Beginning in 1977, investigations were focused within the Buccaneer Field to compare conditions around production platforms, quarter platforms, and flare stacks (which release various discharges) with those around well jackets (which do no release effluents).

Results

Gallaway (1980) summarized the results of investigations of pelagic, reef, and demersal fishes associated with the Buccaneer Field. Production platforms and other structures served as artificial reefs around which fish aggregated. Structure-associated fish were either seasonal transients or residents. The transients appeared to be attracted to the structures intrinsically, while residents included those dependent on the structure-associated fouling community for both food and cover and those apparently attracted to the structures for cover alone. Beyond a radius of a few metres from the produced brine outfalls, Gallaway (1980) discerned no cause and effect relationship between produced brine discharge from production platforms and composition of fish communities. He attributed this to a rapid dilution and dispersion of discharged brine.

Harper (1977) described the distribution and abundance of benthic meio- and macrofauna in the Buccaneer Field. There was no clear relationship between proximity to production platforms and meiofaunal abundance in sediment samples. Abundance and diversity of benthic macrofauna appeared positively correlated with bottom water temperature, which changed seasonally. Benthic macrofaunal population density appeared depressed within a radius of 50 m from the production platforms as compared to the surrounding area. Harder substrate near production platforms may have been unsuitable habitat as compared to soft muddy sands observed elsewhere in the field, but Harper (1977) was not able to rule out possible effects of contaminants from metal debris below these platforms or produced brine discharge as possible causes.

Gallaway (1980) summarized the studies of the fouling community of the Buccaneer Field and the effects of produced brine discharge on this community. The community was diverse and abundant, composed of two main components: 1) shelled organisms, and 2) "mat" producing organisms. During all seasons, fouling community biomass was lower near the bottom than near the water surface. Produced brine discharge had a

detrimental influence on biomass and production rate of the fouling community within a vertical distance about 1 m and a horizontal distance about 10 m from the point of impact of discharged brine with the water surface.

Zein-Eldin and Keney (1979) conducted 96-h, static, acute toxicity bioassays on juvenile brown and white shrimp, using various dilutions of produced brine discharge in artificial seawater. The observed three-fold range in 96-h LD_{50} probably resulted from wide variability in composition of the produced brine as well as in methods and duration of its storage before the tests. LD_{50} ranged between 3,000 and 10,000 ppm (v/v).

Sizemore and Olsen (1980) reviewed the investigations of bacterial populations associated with seawater, suspended particulate material, sediment, and fishes collected in the Buccaneer Field. Taxa and population numbers showed no major differences between the Buccaneer Field and a control site about 9 km north of the field. There were no consistent differences among sampling locations in bacterial diversity or biomass, but seasonal variations occurred. Oil degrading and sulfur oxidizing bacteria were more abundant in sediments within the Buccaneer Field than in those at the control site. Sulfate reducing bacteria were especially abundant in sediments near production platforms. Bacterial isolates from the Buccaneer Field grew readily in diluted, produced brine discharge (filter-sterilized), and some were stimulated by high concentrations of the brine. Mixed cultures and some pure cultures of Buccaneer Field bacteria degraded the alkane fraction of diluted Buccaneer condensate (filter-sterilized).

No effects of production operations or discharges were discerned from patterns of abundance and distribution of:

1. demersal macro-crustaceans derived from trawl sampling; or

2. ichthyoplankton sampled with bongo nets.

Brooks *et al.* (1980b) summarized investigations of suspended particulate matter in the Buccaneer Field. They detected no measurable alterations in composition of suspended particulates or in biological activity (as measured by chlorophyll *a*, phaeophytin, ATP, and energy charge ratios) in the water column that could be attributed to proximity of Buccaneer Field production platforms or discharges.

The Buccaneer Field is a highly dynamic and passive sedimentary environment in which relict sediments are being redistributed across the seafloor. It is typical of Gulf Coast fields in that its production comes from traps created by tectonic activity associated with a salt dome. Wide variations in textural properties of these sediments reflected scouring and redeposition of ancient sediments. The sandy composition of the sediments indicated prevalence of high-energy bottom conditions, which were probably sufficient to resuspend and disperse from the field most contaminants deposited beneath the production platforms.

Radiocarbon and Pb-210 measurements suggest that erosion predominated over deposition in the Buccaneer Field, especially near production platforms, where more than one metre of sediment may have been eroded (Behrens, 1977; Brooks et al., 1980a). Stable carbon isotope ratios and results of radiocarbon dating of sediments did not indicate contamination by petroleum hydrocarbons. Sediment calcium carbonate concentrations were anomalously high beneath and near production platforms, suggesting high productivity by organisms containing calcium carbonate. Barite, a residual of drilling muds, was detected in a few samples near the production platforms.

Armstrong (1980) summarized studies of circulation and hydrography in and around the Buccaneer Field. Thermal stratification occurred during spring and summer, and a weak, inverted temperature structure occurred in autumn. The annual cycle of surface water temperatures closely paralleled that for air temperatures. Salinities were lowest in spring, resulting from increased river discharge, and showed a secondary minimum in autumn, reflecting the shelf-wide circulation reversal. Currents in and around the Buccaneer Field were influenced by alongshore flow toward the southwest. Current speeds generally were lowest in summer, highest in autumn, and almost as high in spring. Flow was most variable in autumn and spring, least variable in summer.

Conclusions

Impacts of the Buccaneer Field can be classified into those associated with the presence of the structures themselves and those associated with the Buccaneer Field contaminants from a number of sources. The presence of the structures contributed to scouring of surficial sediments and provided artificial reef substrate upon which a fouling community developed and to which a variety of fishes and other motile organisms were attracted or otherwise aggregated.

The Buccaneer Field study suggests that future assessments of impacts of offshore gas and oil production operations should concentrate on the components of the marine ecosystem in and around the production platforms and associated structures. The Buccaneer Field investigation was unable to detect impacts beyond 100 m from production platforms. Studies that do not include sampling in close proximity to the point sources of gas and oil field contaminants are not likely to detect significant impacts, when compared to regional background levels of contaminants in the marine ecosystem.

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INDUSTRY ACCOMPLISHMENTS AND FUTURE NEEDS

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Introduction

The purposes of this discussion were twofold. The first was to give a brief review of industry research which has either been recently completed or is currently in progress. The second was to discuss industry perceived research needs for the government's (MMS) OCS studies program.

The majority of the industry environmental research is in response to several factors. These include lease stipulations, permit requirements, and sometimes legal requirements derived from litigation. When all of these previous priorities have been met, the industry also engages in long-range research to fill identified data gaps. The contractors for this industry research in the OCS primarily come from academia and consulting firms. In general, the industry does not have the personnel to conduct their own programs. The funding for these studies can be derived by several means. Sometimes individual companies will fund research programs specific to their operating needs. Whenever possible and appropriate, research is funded by cooperative groups of companies who share common leases. For those research programs that are more expensive and are for the general benefit of a large segment of the industry, funding is usually obtained from large industry organizations such as the Offshore Operators Committee (OOC), the Alaska Oil and Gas Association, and the American Petroleum Institute (API).

Past and Current Studies

The industry has been involved in a broad variety of research programs. Some of them are directly involved in the Gulf of Mexico, and many others, although conducted in other parts of the country, are directly applicable to our understanding of fate and effects of pollutants in the Gulf of Mexico. Among the many programs are the following:

1. Discharge Monitoring Studies. Studies conducted at the Flower Garden Banks and Baker Bank have collected extensive data on the transport and contamination of sensitive biological areas. The "Maximum Mud Discharge Study" conducted by the Offshore Operators Committee was recently completed (Ecomar, 1980). This program was designed to obtain information on mud plume dispersion rates during normal discharge practices, including discharge rates up to 1000 barrels per hour. Another monitoring program will be conducted in Norton Sound (Bering Sea) in September 1982.

2. Sediment Contamination Study. This is a study by Texas A&M University for the American Petroleum Institute. It provides detailed sampling at two water depths around three different types of drilling operations: exploratory, development, and production. The final report will be available around January 1983.

3. Models. By early 1983, industry will make available to government agencies a copy of a sophisticated drill mud dispersion model for use in developing discharge regulations. Verification data for this model will come from the discharge monitoring program to be conducted in Norton Sound (Bering Sea). A discharge study program with an accompanying model is also being developed from a gravel island in shallow water in the Beaufort Sea.

Other current programs concern 1) acute bioassay techniques; 2) long-term chronic effects of drilling fluids on benthic communities; and 3) the effects of oil and oil plus dispersants on red mangroves in Florida.

Future Industry Research

Over the next several years, the industry will be focusing its research programs over several different areas. They feel that the information from these particular projects will provide important data to regulatory agencies to assist in the decision-making process.

In the near future, a number of programs will be designed to conduct field verification data for current modeling studies. An important area of future research is to study the effects of various cleanup techniques used in oil spills. It has been determined that quite often the cleanup techniques used in oil spills are more damaging than the oil itself. For several years, the industry has been conducting research into the fate and effects of chemical treating agents for oil spill usage. In addition to the well known dispersants, a number of other surface-active agents and emulsion breaking chemicals are being tested.

The industry will continue to conduct sensitive area planning programs, in order to map and identify various habitats along our coastal regions. This is very important for proper environmental planning, for oil spill response, and for the mitigation of oil spill impacts. Research will continue in the areas of produced water and drilling fluids fate and effects.

Emphasis for Future Government Research

Although asked to represent industry opinions on the topics of OCS research, it should be realized that most of the opinions expressed

here are personal opinions. Prior to this talk, it was not possible to discuss research needs with all of the companies and develop a list of consensus opinions. These opinions are probably fairly representative of most of the industry. The purpose of this discussion was to highlight those particular areas of study that the industry thinks are most important. Many of the recommendations made here have previously been identified by the Minerals Management Service (MMS) for the Studies Program.

The OCS study program is extremely important to the industry for several reasons. First of all, the data provided is necessary for proper environmental planning, both by government and by the industry. Information derived from this program is essential to allow the leasing process to go forward. It provides necessary background data which allows reasonable decisions to be made concerning tract deletions and appropriate biological stipulations. A longer range value is that data from this program also provide information necessary for the permitting process.

The industry feels that in some programs a shift in the ratio of basic to applied research needs to be made. Although a certain amount of basic research must be conducted to provide background information, it is also extremely important that the program be designed to answer specific regulatory questions. There should be an increasing emphasis in the program to understand the fate and effects of pollutants. This information will be very important in developing necessary regulations to reduce those pollutants which are really significant.

A basic premise recently adopted in Canada is that oil spills are going to inevitably occur, for one reason or another. It is very important to develop information so that mitigative measures may be taken to reduce the impact should such spills occur. This type of information should be developed as part of the United States OCS program.

The development of good predictive models will be very helpful in the future to incorporate the available information for making regulatory decisions. Efforts should continue in this area in conjunction with normal research programs.

Further assessment should be made of the alternate use of offshore platforms, including ways to make use of them in place, as well as depositing them at artificial reef sites.

With a new push to deeper water drilling, certain basic environmental information may be required for operations to proceed. Further information is going to be needed concerning marine mammals and turtles. In the Gulf of Mexico, the turtle question will probably be more important.

Acceptability of Research Results

One of the most important aspects of the OCS studies program is the availability and acceptability of research results. In the past, a large majority of the information has been available only in limited distribution reports, which have not been peer reviewed. A current step in the right direction has been made with the recently issued RFP, which provides money for small businesses to summarize previous data and have it published. Although this is a step in the right direction, many people feel that this is an unacceptable way to publish scientific information. Future contracts for OCS studies programs should include money in the original contract for the final publication of the project results. In general, the petroleum industry feels that the OCS studies program has provided much valuable information. We feel that in the near future through better focused programs, the information will be even more effective and useful in providing the information that is needed for successful OCS leasing and at the same time, providing reasonable protection for the marine environment.

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SUMMARY OF BLM FATES AND EFFECTS STUDIES IN THE GULF OF MEXICO

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BLM-funded studies of the effects of OCS oil and gas operations in the Gulf of Mexico began in 1975 with the award of that year's Mississippi-Alabama-Florida (MAFLA) Benchmark Study contract, which included study of effects of exploratory rig operations in the eastern Gulf. Other effects studies funded and completed to date include: 1) an additional exploratory rig monitoring study, conducted by the South Texas OCS (STOCS) Baseline Study contractors; 2) a central Gulf production platform monitoring study; 3) a synthesis and analysis of results from various Gulf of Mexico OCS oil and gas effects study programs; 4) a study of the effects of platforms on populations of reef fishes; and 5) studies of the environmental and economic consequences of the IXTOC I and BURMAH AGATE oil spills (Table 5). This presentation reviewed results of these programs.

Exploratory Rig Monitoring Studies

The MAFLA (SUSIO, 1977) and STOCS (UTMSI, 1977) studies assessed the environmental impacts of exploratory drilling operations on the

TABLE 5
MINERALS MANAGEMENT SERVICE FATES AND EFFECTS STUDIES IN THE GULF OF MEXICO

CONTRACT NO.	STUDY TITLE	CONTRACTORS	FINAL REPORT
CT5-30	Exploration Rig Monitoring Study: Component of MAFLA OCS Benchmark Study	State University System of Florida Institute of Oceanography Oceanography	SUSIO, 1977
CT6-17	Exploratory Rig Monitoring Program: Component of South Texas OCS Baseline Study	University of Texas, Texas A&M University, Rice University, University of Texas at San Antonio	UTMSI, 1977
CT8-17	Ecological Investigations of Petroleum Production Platforms in the Central Gulf of Mexico	Southwest Research Institute	SRI, 1978
MU0-37	An Ecosystem Analysis of Oil and Gas Development on the Texas-Louisiana Continental Shelf	U.S. Fish and Wildlife Service, LGL Ecological Research Association	Gallaway, 1981
CT9-36	A Study of the Effect of Oil and Gas Activities on Reef Fish Populations in the Gulf of Mexico OCS Area	Continental Shelf Associates	CSA, 1982
CT0-65	IXTOC I Oil Spill Economic Impact Study	Restrepo & Associates	Restrepo *et al.*, 1982
CT0-71	IXTOC I Oil Spill Environmental Assessment Study	Energy Resources Co., Inc.	ERCO, 1982

marine envrionment. Originally, the MAFLA study was to be performed in the eastern Gulf, and the STOCS in the western Gulf. Because there was no drilling activity in the eastern Gulf during the contract period, both were conducted in the western Gulf, roughly off Corpus Christi, Texas. Sampling designs were similar for the two studies, although the MAFLA study included sampling by divers as well as from shipboard, while the STOCS study relied solely on sampling from shipboard. Both studies sampled at fixed stations along transects radiating from the drill site. The MAFLA drill site was in 24 m of water at 27°37'N, 96°58'W; the STOCS drill site was in 33 m of water at 27°44'N, 96°43'W.

Significant findings for the MAFLA exploratory rig monitoring study included the following:

1. High molecular weight hydrocarbons in the sediments were variable; the variations were not associated with drilling activities or station locations. A large high molecular weight unresolved complex mixture was observed in sediments, indicative of previous contamination in the area, probably due to marine transportation. Post-drilling analyses for high molecular weight hydrocarbons in sediments did not indicate any contamination due to drilling activities.

2. Some changes in sediment texture/mineralogy were observed, although these may have been due to winter storms which passed through the area.

3. Low molecular weight hydrocarbons in the water column were present, but were attributed to an algal source.

4. 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.

5. 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. Three months after completion of drilling, concentrations of barium were normal, except in the immediate vicinity of the drill site.

6. Foraminiferal communities were typical of stressed environments, throughout the entire study.

7. Drill cuttings were observed in the benthic sediments after drilling was completed.

8. 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.

9. All other effects were attributed to storms and a stressed, but normal environment.

Significant findings for the STOCS exploratory rig monitoring study included:

1. 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 showed presence of oil, and may have been contaminated during the drilling activity, or may have been a drill cutting from oil-bearing ancient shales.

2. No meaningful results from analyses of sediment textures. Observed variations were attributed to sampling procedures, analytic variability, natural variability, or drilling operations.

3. No significant variations in low molecular weight hydrocarbons dissolved in the water column.

4. 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.

5. The area of discernible impact was less than 100 m radius from the drill site.

6. Diminished benthic communities at the drill site, but showing only normal seasonal variations at other stations.

7. Increases in montmorillonite (a clay mineral) and lead, zinc, barium, and cadmium at the drill site only, following completion of drilling activities.

Production Platform Monitoring Study

One major study designed to elucidate the regional effects of OCS oil and gas activities in the central Gulf of Mexico has also been performed (SRI, 1981). Specific study objectives included determinations of the distribution and abundance of petroleum hydrocarbons and petrogenic trace metals in sediments and biota of the study area; comparisons of benthic communities at platforms and at control sites;

investigations of the types, metabolic processes, and oil degradation potential of benthic microbial communities; examination of the distribution with depth in the benthic sediments of trace metals and hydrocarbons, to ascertain fate and persistence of these materials; and studies of the biofouling communities and "artificial reef" effect of the platforms themselves.

The study focused on twenty OCS petroleum production platforms and four "control" sites offshore Louisiana. Four of the platforms were studied intensively during each of three sampling periods (April/May 1978, August/September 1978, and January 1979) as were the four control sites. The other sixteen platforms were studied less intensively, only during the summer (August/September) sampling period. Study sites were selected to represent a wide range of water depths (6 to 100 m), sediment types, distances from shore, utilization as recreational fishing centers, number of wells, oil and gas production history, previous study (during GURC Offshore Ecological Investigations), and accident or spill sites.

Significant results of this study are summarized in six categories.

Hydrocarbon Chemistry Studies

1. Observation of a highly elevated baseline of low molecular weight hydrocarbons in the water column for the entire study area.

2. Contamination of the benthic sediments by high molecular weight hydrocarbons at six of the study platforms with evidence of concentrations of these compounds in the sediments diminishing with distance from ten study platforms.

3. Observation that organisms in the study area were exposed to low levels of both petroleum and pyrogenic hydrocarbons. No pyrogenic (combustion products) hydrocarbons had been found in the STOCS or MAFLA baseline studies.

4. At one study site, heavy contamination of sediments and of one pelagic fish by phenoxy-biphenyl, an organic compound not normally associated with offshore oil and gas activities.

5. Summary conclusions based on the hydrocarbon studies that any environmental effect observed was unrelated to the age of the platform, and that levels of hydrocarbons in the sediments were not attributable to the number of wells drilled or the volume of production.

6. Postulation of the Mississippi River as a major source of hydrocarbons to the central Gulf of Mexico study area.

Trace Metal Chemistry Studies

1. Possible contamination of benthic sediments by trace metals at seven platforms, considering concentrations of metals and evidence of a gradient of decreasing concentration with distance from the platform. The metals included one to five of the following at each implicated platform: barium, cadmium, chromium, copper, lead, nickel, zinc.

2. No meaningful results from studies of trace metals in biota because of the high intraspecific variability and limited number of samples collected. All observed levels were well below those which might cause public health concerns, however.

3. Irrespective of any platform being a source of contamination, there was no relationship between contamination of the sediments with trace metals and the age of the platform, the volume of production, or the type of production (oil, gas, or both).

4. Observation of a general trend for sediment trace metals burdens near platforms to be masked by trace metal contributions from the Mississippi River. For barium, cadmium, chromium, copper, lead, nickel, and zinc the masking effect decreased with distance from the Mississippi River Delta.

Microbiological Studies

1. Increases in several microbial communities characteristics with proximity to the Mississippi River, including total microbial counts per unit volume; percentage of oil-utilizing microbes; percentage of nitrate reducing hydrocarbon utilizers; and percentage of sulfate-reducing hydrocarbon utilizers.

2. Observation that most microbial activity occurred in the top few centimetres of sediments, which are easily influenced by currents, storms, etc. A tropical storm passed through the study area during one sampling period and radically changed the microbial communities at one study site.

3. No evidence that any reasonably active microbial processes were adversely affected by low concentrations of oil in the sediments. Oil degrading potential seemed to be limited in the field only by availability of oxygen.

Benthic Community Studies

1. The natural, local fauna is stressed, as indicated by a large number of opportunistic species. Major natural, recurrent stresses include flooding by the Mississippi and Atchafalaya Rivers (approx. once each 3.6 years) and annual occurrence of tropical cyclones. Recovery times for floods and associated

hypoxia were estimated at one year, and for hurricanes at two years. The result is a perpetually stressed and depressed local fauna.

2. Observations on a hypoxic event which occurred during the summer sampling period, affecting much of the study area, resulting in death of most macroinfaunal organisms in the area affected.

3. Increased diversities of both meiofauna and macroinfauna at platform study sites, as compared to control sites, apparently due to increased availability of various types of microhabitats.

Histopathology Studies

1. Evidence of highest numbers of pathologic conditions per organ in fishes at platforms, although this was highly skewed by high incidences of such conditions in spadefish and sheepshead, which were found only at platform sites and not at control sites. Whether these conditions were induced by oil and gas activities or by natural occurrences is not known.

2. In fishes, the organs most likely to be affected are the liver, gill, and gut; kidney and gonad tissues were affected to a lesser degree, and muscle tissue was only rarely affected.

3. The highest number of pathologic conditions in invertebrates occurred in bivalves from the control sites; however, these findings were heavily skewed by limited collecting success during the summer period because of the hypoxic event which decimated benthic populations throughout much of the study area.

Bifouling and Artificial Reef Studies

1. Platform-associated reef communities exhibit a faunal transition with depth. In nearshore coastal waters (0-30 m depth) the communities are typical of fish recreationally fished throughout the northwestern Gulf; in offshore waters (30-64 m depth), the fish communities are dominated by snappers; and in waters farther offshore (64 m to shelf edge) are under-fished populations of typical Caribbean reef fish communties.

2. Presence of platforms offshore increases the overall diversity of fishes, and of their abundance at that site. Types of fishes associated with platforms include baitfishes, which are generally planktiverous and seek cover within the platform structure; transient pelagics, which feed on baitfishes as they pass through the platform vicinity; and resident pelagics,

which also feed on the baitfishes but tend to remain at the structure.

3. Platforms may act as nutrient and/or energy traps. Within the resident food webs, contaminants might be recycled and accumulated. Ecosystem production may be increased by platform discharges of nutrient-laden effluents, including hydrocarbons, sulfur, and particulate organic material.

4. For habitat-limited species, presence of platforms probably increases population stocks since habitat is increased. For other species, populations may be dislocated and aggregated at platforms, but not increased. In the latter case, the presence of platforms may allow over exploitation of that species at that site.

5. Produced water discharges reduce the biomass and diversity of fouling organisms; the effect is limited to metres, or a few tens of metres from the discharge site, however.

Ecosystem Analysis of Effects of OCS Development

The study by Gallaway (1981) assembles and focuses much of the information generated by major environmental and effects studies in the northwestern Gulf of Mexico. The report includes descriptions of the physical environment of the northwestern Gulf continental shelf, and of the major faunal communities of the area. A simple conceptual model which demonstrates how the ecosystem functions under control by a variety of extraneous physical process, interrelated physical and biological processes, and anthropogenic pressures is presented. The potentials for effect to the system are discussed, based on the results of the Buccaneer Gas and Oil Field Assessment Program, the Offshore Ecological Investigations, and the Central Gulf Production Platform Study.

Significant effects are presented or postulated for presence of physical structures, discharges of drilling fluids and produced formation waters, accidental oil spills, and cumulative impacts from a variety of causes. Recommendation is made that future work emphasize ecosystem processes and function, so that the mechanisms and controlling forces by which the ecosystem maintains relative homeostasis and and continuity can be understood. The influence of the Mississippi River discharge and of major shelf-wide hypoxic events are briefly discussed and suggested as significant topics for continued study.

Study of Effects of Production Platforms on Reef Fishes

The reef fish study (CSA, 1982) was developed to provide information about effects on reef fish populations at natural submarine banks, due to nearby emplacement of a production platform. Additionally, the

efficacy of remotely operated photo-reconnaissance or sampling vehicles as tools for estimating fish stocks was tested, so that studies of fish stocks at depths greater than SCUBA-diving depths could be accomplished. The study design called for study of fishes at a few natural banks distant from any natural submarine banks, and for study of fishes at a few platforms and banks in close proximity. Because of a variety of limitations which became apparent after study initiation, reef fish standing stocks were extensively studied at only one natural submarine bank and at four production platforms, all offshore Louisiana.

Results of the study included descriptions of fish communities at the platforms studied, and enhanced understanding of distribution of fish populations with regard to certain physical habitat characteristics, such as the structure itself, currents, and turbid waters. Also developed were descriptions of submarine banks, their benthic faunal assemblages and associated fish communities. In general, remotely operated vehicles were felt to be potentially useful tools for assessment of fisheries stocks, but were handicapped by several limitations, including the field of study relative to overall size of the feature, ineffective fields of view in turbid offshore waters, and physical limitations of the vehicles themselves, such as the ship to ROV tether, photographic capabilities, etc.

Studies of Environmental and Economic Consequences of the IXTOC I and BURMAH AGATE Oil Spills

Two studies were developed to study the environmental and economic impacts, respectively, of the IXTOC I oil spill, and also to identify and quantify to the extent possible the impacts of the BURMAH AGATE tanker spill which occurred near Galveston during the period of the more massive IXTOC I spill. Reports on the environmental assessment study (ERCO, 1982) and the economic assessment study (Restrepo *et al.*, 1982) are included above in these proceedings.

Conclusions

These studies, other studies funded by BLM, and other available information have led to general conclusions about, and a general understanding of, the role that the offshore oil and gas industry plays in affecting the marine and coastal environments. Clearly, there presently exists a major and continuing oil and gas leasing, exploration, development, and production program in the Gulf of Mexico. The bulk of this effort is on the continental shelf offshore Louisiana and Texas. A certain degree of risk due to accidents exists. Some accidents result in oil spills or other environmentally damaging occurrences; others do not.

The major inputs of oil to the marine environment occur from inland and marine transportation sources, not from routine offshore oil and gas operations, or even from occasional catastrophic accidents. Routine offshore operations contribute effluents, such as drilling

muds, produced formation waters, platform wastewaters, etc., to the marine ecosystem. The effects of effluent discharges seem to be limited to the vicinity of the production platform, and are generally measured in terms of metres or tens of metres for discharges of produced formation waters. The effects of drilling muds and cuttings are measured in terms of metres to hundreds of metres for chemical effects on benthic sediments or biological effects on benthic communities; and in terms of hundreds to thousands of metres for effects on suspended solid loads in the water column. The effect on biologic populations in the water column is virtually negligible. All of these effects, singly, are local and ephemeral.

What are the long-term effects? Clearly, with the exception of space/use conflicts due to physical emplacement of permanent production platforms or other structures, the long-term effects are expressed in the coastal zone. These effects include habitat disruption due to massive oil spills, land use changes to accommodate the industry, and coastal socioeconomic development.

Certain effects of offshore activities can be predicted. Based on oil and gas resource data, assumptions may be reached as to the probable level and geographic location of future offshore and costal facilities. Based on these assumptions, predictions may be made of the social and economic effects of various scenarios of future production. Based on the resource data and on historic oil spill data, probabilities of oil spill occurrence may be made, and probable trajectories and landfall sites can be predicted using available information on air mass and water mass movement. Effects of predicted oil spills can also be predicted based on our understanding of local habitats, biologic resources, and coastal communities or industries at or near the predicted landfall. Our best predictive capability is for short-term effects. Predictions of longer-term effects on habitats, living marine and coastal resources, and local and regional economies are more problematic.

For the future, we must develop a better understanding of marine and coastal ecosystems: the resources present, the processes by which the systems function, the potentials for impact, and the significance of cumulative effects.

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STUDIES OF LONG-TERM EFFECTS OF OCS ACTIVITIES IN THE MARINE ENVIRONMENT: MMS NATIONAL PROGRAM

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Background

In 1978 Congress passed the National Ocean Pollution Planning Act, which provided an impetus for federal agencies to more closely coordinate research, development, and monitoring activities related to marine pollution. The Interagency Committee on Ocean Pollution Research, Development, and Monitoring (COPRDM) was then organized to assist NOAA in this task. Early in 1980, COPRDM initiated a review of all federal programs that dealt with petroleum pollution in the marine environment. The specific objectives of the review were to:

1. compare the goals and directions of current federal studies in oil pollution research, development, and monitoring with national needs in these areas;

2. assess the extent to which these studies satisfy the most pressing needs; and

3. recommend necessary changes.

The results of the review were published in the 1981 report entitled "Marine Oil Pollution: Federal Program Review." Of the sev-

eral recommendations found in the final report, the one that is particularly germane to this session reads as follows:

> That a 10 year interagency research program be initiated to investigate the long-term, low-level effects of OCS and other ocean use activities. For this purpose a committee will be established under COPRDM with the BLM in the leadership role. Clearly defined roles will be established for all participating Federal agencies and for private industry.

The recommendation also suggested that two study areas, one representative of a historic OCS area, and the other a frontier area, be selected for investigation. To improve on past efforts it was reiterated that adequate quality control, the use of monitoring as necessary, and synthesis and distribution of the resulting information should be integral parts of the program plan.

To initiate activities in support of the COPRDM recommendation, the MMS Branch of Offshore Studies, with support from the NOAA National Marine Pollution Program Office (NMPPO), sponsored a workshop in December 1981. Participants in the workshop were drawn from the COPRDM Petroleum Review Panel, the NAS Petroleum in the Marine Environment Workshop, the NAS Drilling Muds Review, and the Scientific Advisory Committee. Additional participants were selected to represent selected disciplines not covered by the first group. Finally, participants included staff from various MMS and NOAA offices. The mix of participants was designed to provide depth of knowledge in the technical aspects of petroleum and drilling mud fates and effects, as well as a breadth of knowledge in the management aspects of the leasing program and of scientific research programs.

The stated objective of the workshop was to outline approaches to detect and quantify the subtle long-term effects of OCS oil and gas activities. The workshop identified four assumptions upon which deliberations were based:

1. Long-term effects associated with oil and gas development have not been studied adequately.

2. It should be easier to detect OCS effects in frontier areas (than in those already developed).

3. Long-term environmental effects in offshore areas may not be the most important or the most likely effects of oil and gas development.

4. There may be subtle changes in OCS areas as a result of extended periods of OCS development, and these can be identified and quantified only through adequate study.

Long-Term Effects Studies Plan

Workshop Report

Given the workshop objective and assumptions, the objective for a long-term effects program was restated: "To detect and quantify ecological effects in terms of areal extent, severity, duration and significance to resources."

Figure 5 schematically portrays the strategy evolved from the workshop recommendations. To detect subtle effects, the study design should consider several potential indicators of those effects. As shown in Figure 5, these address the benthic, pelagic, and coastal ecosystems. Hydrocarbon and trace metal contaminants tend to associate with particulate material and settle to the bottom, and benthic fauna are a major food source for fisheries, so there is considerable logic in focusing studies on benthic effects. Two general questions that should be addressed are:

1. Are there effects beyond that area distinguished by conventional surveys around rigs or platforms?

2. What are the consequences of such alterations to the ecosystem?

Information on effects, sediment transport, recruitment, trophic interactions and physico-chemical processes should be synthesized before additional field studies are designed.

Exposure of organisms to contaminants in the pelagic system is typically transitory in nature. Thus, the workshop recommendations emphasized studies on transport of particles and the effects on benthos. However, recognition was given to studying the factors in the ecosystem which control the abundance and distribution of key secondary consumers to learn how OCS activity is most likely to affect the food chain.

The workshop report stated that "both evidence and public concern indicates that coastal effects may be more serious than effects on continental shelf systems." These effects may result from the two general categories of: habitat modification and pollutant contamination. It was suggested that a first-order impact analysis be performed based on a semi-quantitative description of habitat modification resulting from OCS activities. Pollutant contamination would be addressed in terms of studies on the long-term fates of petroleum and other drilling and production related contaminants in sediments.

Ancillary studies have been described in the report. These address issues of transport and transformation of contaminants, laboratory sub-lethal effects studies, and preliminary studies involving ecological characterization and data synthesis.

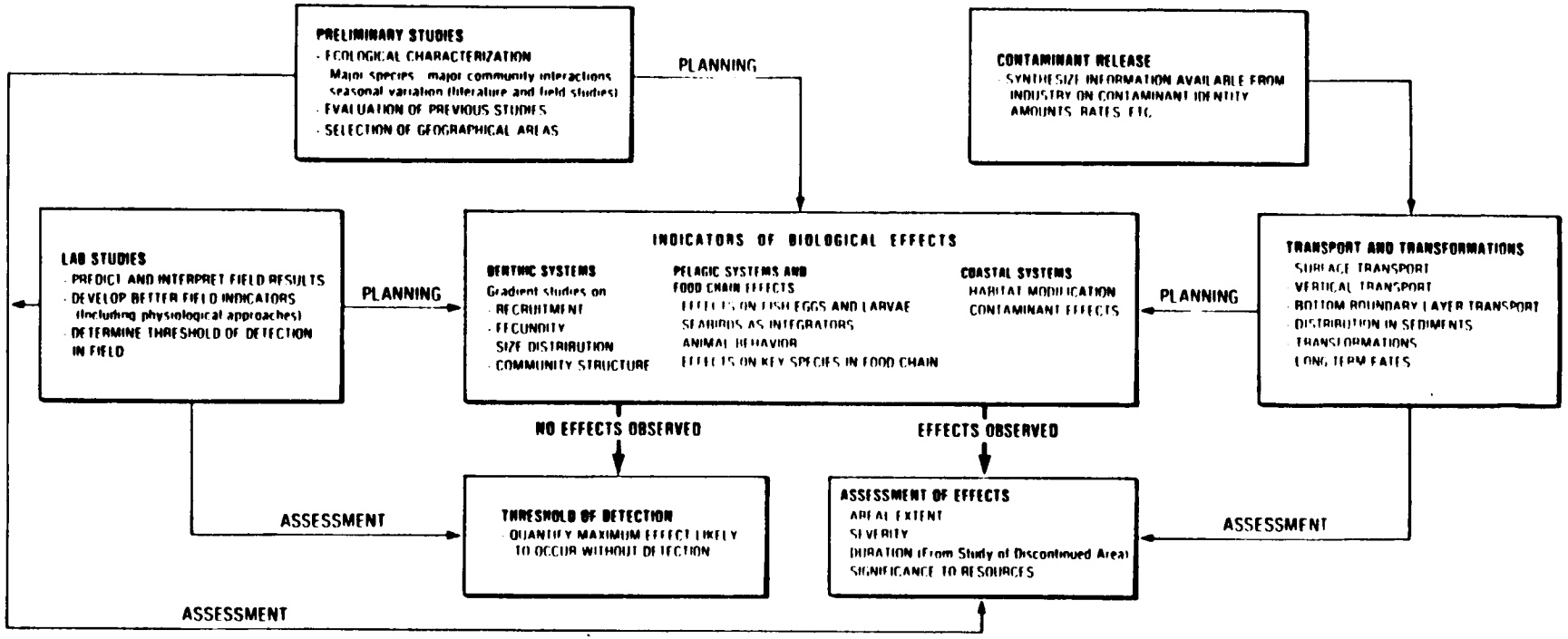

Figure 5. General strategy for OCS effects studies.

Current Activities

A literature and data analysis, and research design task will be initiated by the end of this fiscal year. The primary objective of this project is to develop recommendations for the design of an environmental research and monitoring program to quantify and evaluate the significance of subtle and long-term effects of OCS oil and gas activities. The long-term effects studies plan will be composed of a variety of studies, from conventional monitoring to applied research. Monitoring efforts may be experimental in nature and oriented towards identifying the causes or consequences of observed changes.

To achieve the primary objective, the project entails: 1) a synthesis of the current state of research and of scientific knowledge related to OCS oil and gas effects; 2) evaluation of past and ongoing research and monitoring programs; and 3) an overall assessment of the significance of OCS oil and gas impacts.

Six tasks are involved in this project.

Task 1. Review State of Knowledge. This review requires an assimilation and synthesis of several topics related to detection and quantification of the impacts resulting from OCS development. These topics include: 1) lab toxicity studies; 2) sub-lethal effects studies; 3) biological detoxification and depuration mechanism and rates; 4) platform discharge models; 5) oil spill trajectory and weathering models; and 6) physical alterations of coastal areas. This task will take advantage of the NAS petroleum and drilling mud projects and thus will not duplicate those extensive reviews.

Task 2. Review of Field Assessment Program. Plans for this task have been under way for two years and involve a critical evaluation of past and present field assessment efforts in terms of their goals, objectives, hypotheses tested, field sampling design, and data analysis and interpretation. This evaluation will assess the feasibility of quantifying contamination and biological effects, given limitations in sampling design and sampling variability. Three types of studies will be reviewed: 1) exploratory rig monitoring; 2) production impact assessment; and 3) oil spill case histories.

Task 3. Identify Trends in Industry OCS Development Activities. This is a compilation of future industry trends regarding operating practices, geographic areas of interest, and time schedules for development.

Task 4. Predict Impacts. Predicted impacts will be based on results of tasks 1, 2, and 3, as well as additional needed environmental information. This information will be used to predict the geographic area most appropriate for a long-term study.

Task 5. Review Current Research Programs for Cooperative Research. This task identifies relevant research being carried out or planned by industry or agency. It will supplement information from task 4. Tasks 4 and 5 provide input for task 6.

Task 6. Develop Research Recommendations for a Long-Term Effects Program. Based on tasks 4 and 5, this task makes final research recommendations for a long-term effects program, including study site(s), detailed descriptions of specific studies, and a suggested implementation schedule.

Before field studies on this COPRDM project are initiated, the programmatic justification will have to satisfactorily answer the following questions from a national perspective:

1. Is it scientifically feasible to conduct the long-term effects study?

2. Does the value of the information to be gained justify the estimated cost of the effort?

Once these questions have been addressed, the status of the program should be reassessed regularly, with options to modify or terminate being seriously considered.

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MMS LONG-TERM FATES AND EFFECTS STUDIES PROGRAM FOR THE GULF OF MEXICO PROGRAM PLAN

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Introduction

The presentation summarizing BLM fates and effects studies in the Gulf of Mexico ended with a goal for future work which stressed understanding of marine and coastal ecosystems as the avenue to understanding fates of contaminants and fates and effects of activities related to OCS oil and gas activities in the Gulf. Our office has initiated preliminary planning for a major program to be conducted in the Gulf of Mexico to assess the environmental and economic effects of the offshore oil and gas industry in the Gulf, should the opportunity and funds for such a program present themselves. In due course, some components of the program will be undertaken as components of other study programs, whether a major Gulf effects studies program is developed or not. The

following program considerations were presented with a request for thoughtful comment and critique by meeting participants.

Program Goals

The following program goals have been developed, and are presented in an approximate sequence of priority and chronology:

1. Coordination with other major study and management programs within the Gulf and perhaps adjacent regions. Program coordination is essential to prevent duplication of effort.

2. Development of comprehensive data and information bases from existing data sets and information sources. A tremendous amount of work has been accomplished in the Gulf by a variety of federal, state, academic, industry, and other sources. The pertinent data and information must be assembled, critically examined and validated, and managed in a timely and cost effective manner.

3. Development of an environmental information management capability for MMS. Clearly, a major environmental information management system must be developed to handle presently available and anticipated data and information. Information management needs vary from task to task, but are presently under study and preliminary development.

4. Development of environmental atlases depicting the nature and occurrence of various habitats at appropriate scales, and depicting biological resources, including seasonal variations in abundances, distributions, and sensitivities of these resources.

5. Development of ecosystem models. Initially, conceptual and simple mathematical models are needed for basic understanding of the system and for program planning. Such models are critical to the program, to elucidate the ways in which major, long-term effects to the environment may be induced by offshore oil and gas activities. Later, perhaps, more sophisticated prognostic models may be developed as management tools.

Program Planning and Initiation

The major milestones for program planning and initiation, as presently projected, are:

1. Matrix Analysis. Development and use of a matrix of impact producing activities versus resources, considering attributes of impact on resource, such as the likelihood of occurrence, probable frequency of occurrence, geographic extent of effect, duration of effect, severity of effect, magnitude of impact,

recovery period, and present control by routine or available mitigatory actions. The purpose of this analysis will be to identify those cause/effect situations which are probable and significant for further consideration, and to dismiss or assign low priority to situations where impacts are highly improbable or impossible, trivial, or ephemeral.

2. Data Base Consolidation. Relevant information and data will be gathered for immediate management use and for study planning.

3. Literature Summaries and Syntheses. To supplement the data base consolidation effort, and as a result of the matrix analysis, pertinent literature summaries and syntheses will be generated to provide concise information packages for immediate management use, and to further define information needs which must be addressed by additional field or laboratory work.

4. Environmental Information Management System. A capability to manage and manipulate data and produce appropriate information products must be developed, either as an in-house capability or through cooperative or contractual arrangements.

5. Environmental Atlases. Information on the nature of the potentially affected environment and its resources will be assembled and portrayed in atlas format, including such information as physical nature of the habitat, biological communities and their distribution relative to habitat type or other controlling factors, and distribution and abundance over time of important biological resources.

6. Model Development/Validation. To understand how the ecosystem functions and is liable to perturbation by non-natural interventions, there is a need to translate simple conceptual models into more complex and sophisticated mathematical models which can serve as both heuristic and management tools. Use of any such models for management purposes must be preceded by validation.

7. Additional Field and Laboratory Efforts. After learning as much as possible from the existing information, and focusing on what information is truly needed to provide pertinent facts to further understanding of the marine ecosystem and the potential for significantly impacting the system, additional field data gathering and field or laboratory experimentation can be planned.

8. Study Effort Prioritization. As additional field or laboratory efforts are planned, a number of criteria will be considered to ensure optimal results in return for study funding. These criteria include the following:

a. Study design validity. Appropriate statistical design for the study objectives; appropriate hypothesis testing for field or lab studies involving actual causes/effect experimentation.

b. Utility of results. Where possible, each study should contribute useful information for management or scientific purposes, even if a "no effect" conclusion is reached.

c. Translatability to other study areas. To the extent possible, results of studies should be applicable to other geographic areas within the Gulf of Mexico, or within other OCS leasing areas.

d. Time-Series information. Field data which contributes to defining trends over long periods of time provide boundaries on natural variability of normal communities, populations, or species.

e. Field/Laboratory Validation. One of the greatest limitations to presently available information regarding effect of various contaminants or activities to natural resources is the uncertain linkage between laboratory experimental results and their validity in field situations. Study design to provide such validation is highly desirable.

f. Definition of risk. Studies which can provide information not only on probability of an impact-producing situation occurring, but also on probability of the nature of the effect are needed to reduce uncertainty about the scope of an impact which might occur as a result of any given action.

Topics of Special Concern

Although the matrix analysis has not been completed, a number of topics of special concern have been suggested. Consideration will be given to these and other such topics during planning efforts, so that planning for the overall studies program can focus on issues of concern to managers. These topics include both generic and site-specific concerns:

1. Sensitivity of Resources to Perturbation. How can sensitivity to perturbation be predicted? This question applies at the local and regional levels, for both biologic communities and economic settings.

2. Biologic Effects of Various Contaminants. Acute, lethal effects are known for a variety of substances in the marine and coastal environments. Information is less readily available for effects over long periods of time, for sublethal

effects, for indirect effects, and for cumulative effects of repeated contamination over time or contamination in synergy with other contaminants.

3. Ecosystem Stresses. What is the total suite of stresses applied to the ecosystem in any locale or region? What is the degree of stress which may be sustained without permanent and lasting detrimental impact on the system?

4. Measures of Stress. What are the most useful measures of stress on an organism, on a population, on a community, or on the local ecosystem? Which measures allow extrapolation beyond the situation under immediate study?

5. Measures of OCS Impacts on Socioeconomic Conditions. What measures of socioeconomic activities provide a capability for predictions of future impacts? How can OCS-related effects be distinguished from other socioeconomic effects? What will be the effects of development in areas not previously impacted? What will be effects of declining OCS production on present support communities?

6. Effects of Mitigation. What are the short-term and long-term effects of mitigatory actions, both locally and regionally?

7. Public Perception of Impacts. What is the public perception of impacts from OCS oil and gas activities? Are public concerns being adequately addressed?

8. Coastal Subsidence. For coastal Louisiana, what is the natural rate of coastal subsidence? To what degree do OCS activities contribute to accelerated subsidence?

9. Offshore Hypoxia. What is the nature of hypoxic events on the Gulf OCS? What factors contribute to the occurrence of these events? How can these events be managed or mitigated? Do OCS activities contribute to these events?

0. Hard Minerals Mining. What is the potential for mining of hard minerals from the OCS of the Gulf of Mexico? What would be the environmental consequences of such mining?

Program Status

At present, a regional Fates and Effects Study Program for the Gulf of Mexico is in the very early planning stage. Clearly, information which would be derived from a major study program is desirable to support OCS leasing in the Gulf. The program which has been described here is an attempt to build on presently available information and study efforts presently under way to develop as efficiently as possible effects-type information that is managerially useful. Many of the program planning efforts are presently underway, in various stages of

accomplishment. An environmental information management system is presently being developed for management of data and information relevant to a variety of needs. Data and information bases for coastal and offshore areas are being assembled under many studies, and will be available from other studies presently planned for future procurement. Environmental atlas preparation has been initiated, including offshore habitat information, coastal habitat information, and offshore biological resources. Environmental models are being developed for coastal and marine ecosystems. Information on certain physical processes, especially water mass movement, is now being developed and refined. Results of studies are already being used to mitigate anticipated impacts to biological and cultural resources.

A major long-term effects program is presently being initiated by the national office of MMS. That program may include a major study effort for the Gulf, or the study may be conducted in another OCS leasing area. Results from that program should provide some information of use for Gulf of Mexico OCS management, irrespective of where the studies are performed. Even in the absence of the national effort for the Gulf, future study planning efforts by our office will include consideration of needed information on effects.

SESSION: COASTAL STUDIES
Chairman: Dr. Heino Beckert
Scribe: Mr. Mark Rouse
Date: August 24, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Dr. Heino Beckert, MMS Gulf of Mexico OCS Region
Causes and Consequences of Coastal Erosion and Wetlands Modification in Louisiana	Dr. Donald Boesch, LUMCON
Coastal Erosion and the Impact of Canals and Levees in Louisiana	Dr. R. Eugene Turner, LSU-CWR
The Potential Effects of OCS Activities on the Marine Wetlands of Southwest Florida	Dr. Charles Getter Research Planning Institute
Use of Remote Sensing Imagery for Documenting Coastal Habitat Loss and West Florida Shelf Frontal Systems	Mr. Kenneth D. Haddad Florida DNR
Aspects of the Function of Emergent Wetland Ecosystems	Dr. Leonard Bahr, Jr., LSU-CWR
Freshwater Introduction into the Marshes of Coastal Louisiana	Mr. Dennis Chew, U.S. Army Corps of Engineers
Contribution of Louisiana's Coastal Wetlands to Fish and Wildlife Resources	Mr. David W. Frugé U.S. Fish and Wildlife Service

SESSION SUMMARY

Dr. Heino Beckert, MMS, Gulf of Mexico OCS Region

The session on coastal studies pointed out a widespread concern about coastal erosion and land loss, especially in Louisiana, where the physiography makes coastal areas particularly vulnerable to erosion.

Coastal ecosystems, especially marshes and swamps, have sustained extensive acreage losses due to saltwater intrusion and mechanical disturbance. The dredging of canals, spoil deposition, prevention of overbank flooding of the lower Mississippi River, and other activities by man have caused widespread and large-scale conversion of marsh habitat to ponds and shallow bays. Current trends of coastal land loss indicate a worsening of this situation.

Wetlands have been defined in a number of ways, usually in the context of soils, hydrology, vegetation types, and vegetation tolerance to flooding. It has been suggested that rather than being tolerant to flooding, all wetland vegetation, regardless of make-up or location, is indeed dependent to varying degrees on fluctuating water levels or flooding. Changes in the natural watering and de-watering cycles are invariably detrimental to wetlands systems.

Other coastal habitat types of importance along the Gulf of Mexico coast are mangrove and seagrass beds. Both of these habitat types are characterized by their productivity and their vulnerability to man's activities.

Louisiana's coastal wetlands are of national importance to fish and wildlife in providing resting, feeding, and nesting areas for more than one-fourth of the North American duck population, almost 500,000 geese, and many other migratory birds. Louisiana's coastal marshes produce the largest fur and alligator harvest in North America, and support the largest volume of estuarine-dependent fish and shellfish landings in the United States. Fish and wildlife-oriented recreation typically amounts to over five million man-days of saltwater fishing and over 650,000 man-days of waterfowl hunting each year.

Naturally occurring and man-induced changes in coastal wetlands must be viewed against this background. Natural subsidence, erosion, and rising sea levels account for coastal wetlands losses. These natural losses pale in comparison to man-induced wetlands losses. Current coastal wetland loss rates are estimated at about 40 square miles per year and appear to be accelerating. The principal cause of wetlands losses is the construction of canals in marshes and swamps. Navigation and pipeline canals interrupt the natural hydrology of coastal wetlands and facilitate saltwater intrusion, changes in vegetation types and, ultimately, erosion of marsh soils and land loss. Marsh and swamp habitat is thus changed to shallow, openwater areas.

Marsh losses occur Gulf-wide, but have been best documented in Louisiana.

In Florida, losses of seagrass beds have been implicated in the reduction of commercial fishery catches. Exact data and correlations, however, have not yet been produced. Along the Florida Gulf coast, mangrove and seagrass bed losses over time have been documented by satellite imagery. The same technique is being used by the Florida Department of Natural Resources (DNR) in the identification and monitoring of blooms of red tides.

In view of the importance of coastal wetlands and the alarming rate of their disappearance, plans have been formulated by the U.S. Army Corps of Engineers to divert fresh water from the lower Mississippi River into the Barataria and Breton Sound basins in order to counteract saltwater intrusion and to introduce river-borne sediments into Louisiana's coastal marshes. Realization of large-scale freshwater introduction into these areas is years away. Factors such as the proverbial poor water quality of the Mississippi River, engineering constraints, and local political opposition are working against such freshwater introduction projects.

On a more optimistic note, it was pointed out that the mangrove stands along the Gulf coast have been spared extensive contamination by spilled oil. Unlike such areas as Nigeria, Puerto Rico, Mexico, and Malaysia, stringent safeguards and prompt oil spill cleanup and containment procedures along the U.S. Gulf coast have prevented major losses of our mangrove stands, despite the demonstrated vulnerability of these plants to petroleum hydrocarbons.

CAUSES AND CONSEQUENCES OF COASTAL EROSION AND WETLANDS MODIFICATION IN LOUISIANA

Donald F. Boesch
Louisiana Universities Marine Consortium (LUMCON)

Detailed coastal wetland habitat maps based on mid-1950's and late-1970's imagery, developed under the Bureau of Land Managment and U.S. Fish and Wildlife Service's Mississippi Deltaic Plain Coastal Characterization Program, allowed accurate determination of the rates of habitat change in coastal Louisiana. It is estimated that coastal wetland losses amount to nearly 40 square miles per year in 1980 in the Mississippi Deltaic Plain (southeastern Louisiana) alone, and perhaps 50 square miles statewide. These figures provide startling documentation of the rapid wetland degradation long appreciated by local marine scientists and resource managers. In addition to the outright change of wetland to open water habitat, there have been wholesale shifts in wetland type toward an increased proportion of saline relative to brackish and fresh wetlands as a result of saltwater intrusion.

The causes of these dramatic coastal habitat changes are multiple and complex but appear to be largely related to human activities interacting with natural delta-building and degradational processes. These causes include: channelizing Mississippi River flow, which prevents sediment enrichment of wetlands; dredging and canal development in wetlands for navigation and for oil and gas extraction and transport, which results in direct destruction, subsequent erosion, and interference with hydrological sediment flux and saltwater intrusion; subsurface fluid withdrawals which increase subsidence; draining and filling; and poorly designed coastal protection structures.

The direct and indirect impacts of the oil and gas industry are of major significance. Although this is mainly attributable to resource extraction in the wetlands, OCS-related activities also contribute. OCS-related impacts include pipeline routing; encroachment on wetlands by construction, supply and service industries, and related population growth; and the placement and maintenance of navigation canals largely used by the OCS industry. Examples of the latter are the Houma Navigation Canal and the Bayou Boeuf-Chene and Avoca Island Cutoff complex. These navigation canals cut across estuarine wetland gradients and therefore disrupt hydrology of the otherwise shallow, anastomosing network of water bodies, causing major wetland alterations due to saltwater intrusion.

The consequences of these major habitat alterations are significant with respect to fisheries productivity, wildlife resources, flood protection, transportation, and social and economic well-being. Louisiana leads the nation with 28% of the volume of fishery landings. The major fishery species are estuarine-dependent during juvenile stages (e.g., penaeid shrimp, menhaden, and blue crabs). Evidence strongly relates the catch of these species to available wetland habitat. As the habitat declines, it is reasonable to expect that the fisheries will as well.

Various options are being actively discussed and evaluated to slow or locally reverse the rate of coastal land loss in Louisiana. In 1981, Congress appropriated $35 million to a Coastal Environmental Protection Trust Fund established to support projects to control coastal erosion. Approaches such as barrier island nourishment and stabilization and lower river diversions are being actively planned. Other approaches, such as more rigid control of new dredging activities and management of the rapidly prograding Atchafalaya delta complex, are being urged and are likely to have more significant effects on slowing the rate of land loss.

Coastal habitat modifications in Louisiana are clearly among the most significant deleterious effects on marine resources currently faced in the U.S. The problem is of national as well as local significance and thus deserves the attention of all relevant federal, state, and local agencies. Furthermore, because the rate of coastal wetland loss is apparently increasing exponentially, the problem requires

immediate attention. However, long-term management plans, underpinned by sound understanding of the operative processes, must be developed in cognizance of the eventuality of wetland deterioration in abandoned deltaic lobes and basins.

COASTAL EROSION AND THE IMPACT OF CANALS AND LEVEES IN LOUISIANA

Dr. R. Eugene Turner
Center for Wetland Resources
Louisiana State University

Canals have increased in area from practically zero at the beginning of the century to about 2.4% of the Louisiana coastal land surface area in 1978. The annual increase in canal area is continuing to increase in 1981 as a result of new canal dredging and the widening of existing canals. Land loss rates are increasing geometrically, and the existing loss rates are about 0.8% annually. Land loss rates across the coastal zone since the 1980's, among hydrologic units and within areas of similar substrates and equal distances to the coast, are all positively related to estimates of canal density. Further, estimates of land loss at zero canal density (from regression equations) are similar to the 7000-year coast-wide rate of land gain. Within 7 1/2 minute quadrangle maps, the new small ponds in the marsh appear close to canals, not near natural channels. Coastwide, canal surface area is directly responsible for about 10 to 20% of the total land loss. Coastal erosion rates thus appear to be an indirect impact of canal dredging activities. The mechanism for the effect probably involves an alteration of natural wetland hydrology via the associated canal levees. A complete understanding is presently lacking. Thus corrective measures cannot be identified and implemented with confidence until more is known about the mechanisms of canal and spoil bank effects on wetland hydrology.

THE POTENTIAL EFFECTS OF OCS ACTIVITIES ON THE MARINE WETLANDS OF SOUTHWEST FLORIDA

Dr. Charles D. Getter
Research Planning Institute, Columbia, SC

Due to their productivity and vulnerabilty in coastal habitats, mangroves have been studied as important indicators of effects of oil production activities in tropical wetlands. The results of such studies are informative in identifying potential detrimental impacts from petroleum production activities in southwest Florida.

Numerous recent publications have summarized the effects of oil on mangroves (Getter, in press; Louis, 1980a,b; Ray, in press). Table 6 outlines the known effects of oil on mangrove ecosystems worldwide.

TABLE 6
COMPARISON OF OIL SPILLS IMPACTING MANGROVES
(Modified from Baker *et al.*, 1981)

SOURCE OF SPILL AND DATE	TYPE OF OIL	AMOUNT OF OIL	MANGROVE SPECIES AFFECTED	LOCATION	IMPACT ON MANGROVES	AUTHORS
Argea Prima, vessel, 7/16/62	Crude	10,000 tons	Unidentified	Guanica, Puerto Rico	"...this habitat was virtually destroyed."	Diaz-Piferrer, 1962
Whitewater, vessel, 12/13/68	Diesel oil & bunker C	20,000 barrels	*Rhizophora mangle* *Avicennia* sp.	Galeta Island, Panama	Death of young mangroves, loss of sessile animals and algae on prop roots (loss still visible 66 months after spill).	Rutzler and Sterrer, 1970; Birkeland *et al.*, 1976
Pipeline break, 1970	Light Crude	100,000 barrels	Unidentified	Tarut Bay, Saudi Arabia	Defoliation, but many survived.	Spooner, 1970
St. Peter, vessel, 2/76	Crude	243,442 barrels carried; quantity spilled unknown	*Rhizophora* sp. *Avicennia* sp.	Colombia/ Ecuador	No "noticeable long-term biological effects..."; temporary decline in fishery harvests and clam harvesting.	Jernelov *et al.*, 1976; Jernelov and Linden, 1980; Hayes, 1977
Garbis, vessel, 7/18/75	Crude oil & water emulsion	1500-3000 barrels	*Rhizophora mangle* *Avicennia* (referred to as *A. nitida*)	Florida Keys, U.S.A.	Death of young mangrove seedlings and some dwarf black mangroves.	Chan, 1976; Chan, 1977; VAST/TRC, 1975

TABLE 6 (Continued)

SOURCE OF SPILL AND DATE	TYPE OF OIL	AMOUNT OF OIL	MANGROVE SPECIES AFFECTED	LOCATION	IMPACT ON MANGROVES	AUTHORS
Santa Augusta, vessel, 1971	Crude	12.5 million litres	Rhizophora mangle	St. Croix U.S. Virgin Islands	5 ha completely destroyed; little or no recolonization after 7 years.	Lewis, 1979c; Lewis and Haines, 1980
Funiwa 5, offshore oil well, 1/17/80 to 2/1/80	Crude	8.4 million gallons	Unidentified	Nigeria	338.6 ha of mangroves killed; some recovery in process.	Baker, 1981; OSIR, 1980a; OSIR, 1980b; OSIR, 1982
Peck Slip, barge, 12/19/78	Bunker C	440,000 to 460,000 gallons	Rhizophora mangle	Between Punta San Agustin and Yabucoa, Puerto Rico	"Significantly affected mangrove, crab, snail, and epiphyte populations."	Gundlach et al., 1979b; Robinson, 1979; Getter et al., 1981
Howard Star, vessel, 10/5/78	20% diesel, 80% bunker C	40,000 gallons	Rhizophora mangle, Avicennia germinans, Laguncularia racemosa	Tampa, Florida	Death of all three species of mangroves, death of molluscs and polychaetes; root abnormalities.	Lewis, 1979; Gundlach et al., 1979a; Lewis, 1980a; Lewis, 1980b; Getter et al., 1980; Getter et al., 1981; Snedaker et al., 1981
World Encouragement, vessel, 9/10/79	Light Arabian crude	29,060 gallons	Avicennia marina	Botany Bay, N.S.W., Australia	Deaths of scattered mangroves 1-2 years after spill.	Firth and Williams

TABLE 6 (Continued)

SOURCE OF SPILL AND DATE	TYPE OF OIL	AMOUNT OF OIL	MANGROVE SPECIES AFFECTED	LOCATION	IMPACT ON MANGROVES	AUTHORS
Zoe Colocotronis, vessel, 8/18/73	Venezuelan crude	37,000 barrels	Rhizophora mangle, Avicennia germinans (referred to A. nitida)	Cabo Rojo, Puerto Rico	Death of adult trees (red and black) over an area of 1.0-2.7 ha within 3 years.	Tosterson et al., 1977; Nadeau and Berquist, 1977; Page et al., 1979; Page, 1979; Lugo, 1977; Voss, 1979a,b; Lewis, 1979b; Martinez et al., 1979; Gilfillan et al., 1981
Showa Mura, vessel, 1/6/75	Arabian light, Berri, and Murban crude	54,000 barrels	Sonneratia sp. Rhizophora sp.	Indonesia	Some dead trees (both species) unquantified; areas of greatest impact in sheltered bays; low numbers of crabs and snails associated with elevated oil in sediment.	Baker, 1981; Baker et al., 1981
Pipeline rupture, 10/13/76	Crude	377 barrels	Avicennia germinans	Corpus Christi, Texas	Mangroves burned to remove oil died; uncleaned mangroves recovered after minor defoliation.	Holt et al., 1978
Unidentified vessel, 3/77	Venezuelan crude	1000 barrels	Rhizophora mangle	Guayanilla Bay, Puerto Rico	Damage to mangrove root community; trees survived.	Lopez, 1978

TABLE 7
SOURCES OF OBSERVATIONS IN OIL SPILL CLEANUP EFFECTS
IN MANGROVE FORESTS

NAME	LOCALITY/DATE	CLEANUP OBSERVED	REFERENCES
Garbis	Florida Keys, 1975	Movement of heavy equipment, flushing, manual collection, sorbents, ditching, and pumping	Chan (1976)
Peck Slip	Puerto Rico, 1978	Sorbents, manual collection	J. Robinson (1979)
Howard Star	Tampa Bay, 1978	Flushing	R. Lewis, pers. comm.

TABLE 8
EFFECTS OF CLEANUP METHODS ON SUBSTRATES, BIOLOGICAL COMMUNITIES, CIRCULATION PATTERNS, OIL UPTAKE POTENTIAL, AND LIKELIHOOD OF REENTRY OF OIL INTO NEARBY ENVIRONMENTS

CLEANUP METHOD	SITE	OBSERVED EFFECTS				
		SUBSTRATE	BIOLOGICAL COMMUNITY	CIRCULATION PATTERNS	OIL UPTAKE POTENTIAL	LIKELIHOOD OF REENTRY OF OIL
Heavy Equipment	GARBIS	(-)[1,2]	(-)[3,4,5,6]	(-)[7,8]	(-)[1]	
Ditching & Pumping	GARBIS	(-)[1,2]	(-)[3,4,5,6]	(-)[7]	(-)[1]	
Manual collection	GARBIS					(+)
Manual collection	PEOX SLIP					(+)
Sorbents	GARBIS	(-)[1]		(-)[7]	(-)[1]	(+)
Sorbents	PEOX SLIP					(+/-)[9]
Low-pressure flushing	GARBIS		(+)		(+)	(+/-)[10]

KEY TO OBSERVATIONS:

(+) Improvement Observed

(0) No Change

(-) Deterimental Effects

LIST OF DETERIMENTAL EFFECTS:

1) Entrainment of oil
2) Disruption of sediment processes
3) Oiling of roots and burrowing animals
4) Breakage of plants, mortality, increasing stress, altered growth forms
5) Seedling trampling
6) Black mangrove root damage
7) Potential alteration of water quality (especially temperature and salinity regimes
8) Abandoned sorbent acts as point source
9) Failure to collect refloated oil

Few publications are available which deal directly with the effects of oil spill cleanup on mangroves. A summary of observations on oil spill cleanup effects and damages from clean-up efforts is included in Tables 7 and 8.

Recent studies by the Research Planning Institute, Inc. in Southeast Asia, West Africa, and throughout the Gulf and Caribbean indicate that there is a strong correlation between environmental safeguards and the impact of oil on mangroves. The proposed OCS activities off the coast of southwest Florida are adjacent to approximately one-half million acres of mangroves. It is clear, therefore, that safeguards to mangroves and contingency plans for protection, cleanup, and restoration should be carefully considered before each new phase of OCS development in the region. Researchers should examine risk factors which outline the precise nature of mangrove ecosystems in maintaining water quality, preventing coastal erosion, and providing a substrate for billions of coastal animals and plants.

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USE OF REMOTE SENSING IMAGERY FOR DOCUMENTING COASTAL HABITAT LOSS AND WEST FLORIDA SHELF FRONTAL SYSTEMS

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Florida's coastline (11,000 miles of tidal shoreline) is the second longest in the United States. The Florida coastal zone has become one of the prime locations for human development in the nation. The coastal areas are the preferred residency of 75% of the growing population. The State of Florida has overseen and regulated population growth, but it has been difficult to maintain a clear perspective on

the relationship between coastal development and the biological impact upon the coastal marine life.

Some impacts to coastal marine life are well known. For example, channel dredging with its resulting fill operations and siltation has destroyed acres of sea grass beds; seawalls have replaced miles of natural mangrove shorelines; extensive areas of salt marsh have been impounded to prevent breeding of mosquitoes; point and non-point source pollution such as industrial discharges, power plants, sewage disposal, and stormwater run-off have altered water quality. What is not known, however, is the amount of this coastal destruction, and what quantitative effect it has on recreation and commercial fisheries resources.

Since approximately 90% of the commercial fish in Florida are estuarine-dependent, spending all or at least a portion of their lives within the estuary, it has often been stated that fisheries decline must directly correlate to coastal habitat loss. However, very little scientific research has been done to test this hypothesis. The relationship is one of inference not demonstrated fact, and is based on animal needs, food availability and preference, protection from predators, and tolerances or responses.

The Florida Department of Natural Resources Bureau of Marine Science and Technology is currently under contract with the Florida Department of Environmental Regulation (FDER) to develop an assessment of fisheries habitat loss, construct a geographic digital data base, and establish a geographical information system to develop and house the data. The funding source for this project is the Federal Office of Coastal Zone Management, which disperses funds through FDER. Three Florida coast sites have been chosen as the designated study areas: Charlotte Harbor, Lake Worth, and Tampa Bay.

The Florida Department of Transportation's (D.O.T.) Remote Sensing Center is currently photointerpreting and digitizing aerial photographs from the early 1950's into a computer graphics system. In addition, D.O.T. is making updated overflights using color infrared photography, using the same photointerpretation and digitizing processes. The digitized products are statistically evaluated for accuracy in (94%) interpretation by ground truthing effort, and a final product is generated. Once the data are developed into the computer data base, they are capable of being statistically manipulated to not only ascertain the total amount of habitat loss but also the amount of loss of each habitat type, as well as habitat alteration.

In addition to the aerial data generated by D.O.T., the Florida Bureau of Marine Science and Technology has installed a computer system configured to run a software package (ELAS) developed at the NASA Bay St. Louis facility (Earth Resources Laboratory). This is a geobased information system capable of processing satellite imagery and integrating this with other data bases to provide an effective tool in the management of natural resources. The goal of this particular aspect of

the research is to develop an initial data base for the selected areas, using aerial interpretation from the 1940's to 1982. These data will be made compatible to ELAS format and integrated into the Geobased Information System. Processed LANDSAT Imagery (MSS) will then be compared to the 1982 aerials. Using the MSS will allow cost effective monitoring of the loss of habitat or habitat change in subsequent years.

By employing data obtained from the annual revised editions of NMFS's Florida Landings for each study site and using statistical manipulation of the NMFS data base, DNR biologists are attempting to discover if a decline in commercial fisheries is actually occurring in conjunction with habitat losses. The Tampa Bay area, both heavily populated and polluted as early as 1950, shows an almost steady decline in commercial catch of redfish and spotted seatrout. Preliminary data indicate that this decline correlates well with a severe loss of habitat and increased pollution experienced by Tampa Bay. In comparison, Charlotte Harbor remained a relatively undeveloped area until around 1970. Very little destruction of any kind has occurred in Charlotte Harbor. Commercial fish landings for this area have remained relatively stable.

No scientifically valid conclusion can be drawn at this point. Problems related to the commercial landings data are numerous and great. For example, since the data are obtained from reports made by commercial fishery dealers, reported weight values do not include other sale avenues, such as restaurants. In addition, the catch data do not include sport fisheries catch, which sometimes far exceeds that of the commercial efforts. These problems are compounded by the lack of data on exact relationships between specific estuarine environments and individual species needs for support.

Another use of the Geobased Information System is the West Florida Red Tide Study. The toxic dinoflagellate Ptychodiscus brevis periodically blooms on the west Florida shelf, producing massive fish kills, shellfish toxicity, and human respiratory irritation. In the early 1970's it was realized that satellite imagery could provide an avenue by which direct or indirect variables could be measured from space to possibly predict and monitor a bloom. Oceanic intrusion into the coastal waters and ocean frontal development has been observed to correlate with bloom development in almost all red tides since 1967. It also appears that these intrusions are the direct result of the Loop Current impinging on the shelf or eddies developing at the shelf break.

Preliminary satellite data have shown promising results for bloom prediction and monitoring. Data from both the Coastal Zone Color Scanner imagery and from GOES East thermal imagery have been used. Preliminary work with the Coastal Zone Color Scanner has shown it to be the most promising. It not only may be used to observe the hydrographic process of frontal development, but also will allow observation of

bloom development as chlorophyll concentrations increase at the frontal boundary. This will provide a method of prediction and monitoring now impossible due to the large geographical boundaries in which either the oceanic fronts develop or in which the blooms may be transported. Shipboard data can now be effectively analyzed in conjunction with satellite imagery in order to develop a conclusive method for predicting and monitoring these blooms.

ASPECTS OF THE FUNCTION OF EMERGENT WETLAND ECOSYSTEMS

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The definition of "wetlands" typically includes the phrase "habitat characterized by vascular macrophytes that are TOLERANT to flooding during at least part of the growing season" (emphasis added). This definition connotes the idea of stressed emergent plant communities surviving marginally under suboptimal conditions. This idea contrasts markedly with the fact that undisturbed coastal wetlands are known as much for their robustness and productivity as for any other characteristic.

Wetland management would benefit from greater emphasis on the theoretical basis for the high net productivity that characterizes wetland ecosystems. This theoretical basis includes the concept that the stress of alternating flooding and drying maintains wetland systems in a perpetual state of successional immaturity (and net productivity), analogous to the immaturity of an agricultural field. E.P. Odum (1969) called wetlands "fluctuating water level ecosystems" because of their ability to take advantage of water level change (tidal and/or seasonal) to increase their rates of primary production. H.T. Odum et al. (1974) discussed the competitive advantage that accrues to an ecosystem that co-opts energy stresses and converts them to sources. The single unifying thread by which virtually all coastal wetlands (including mangrove forests, saline, brackish, and freshwater marshes, and freshwater swampforests) are related is their fundamental dependence on fluctuating water levels. This dependence is the result of the highly successful adaptation by these plant communities to the stresses of periodic inundation and sediment waterlogging, such that flooding is obligate rather than facultative.

In addition to its water requirement, the following needs of each macroemergent wetland plant species are provided by the periodic inundation that results from tidal and/or meteorological inputs:

1. plant nutrients and sediments that help wetlands maintain their vertical elevation in the face of rising sea level;

2. mechanical pumping that oxygenates subsurface sediments, thus augmenting root production;

3. elevational gradients that drive lateral currents, stimulating gas exchanges, primary production, and waste removal;

4. "herbicide" in the form of salts that exclude non-halophytic plants, thus maintaining a low diversity plant community; and

5. access to the wetland ecosystem by two distinctly different consumer communities, one terrestrial and the other aquatic.

Guidelines for wetland management almost invariably include the paradigm that any alteration of hydrologic regime is likely to result in reduced viability of the system. This paradigm is based on both empirical observations of the negative effects of leveeing, canaling, or otherwise altering water flow in wetlands, and on modeling studies. Most alterations to water flow result in a decrease in the inundation frequency of a given area, which is the single best explanation for the observed reduction of net primary productivity that usually accompanies such change. The most obvious example of the influence of unimpaired inundation is the marked difference in standing biomass, stem density, and productivity between streamside and inland marshes. Every wetland system appears to have an optimum inundation frequency, above or below which the source becomes a stress.

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FRESHWATER INTRODUCTION INTO THE MARSHES OF COASTAL LOUISIANA

Mr. Dennis Chew, U.S. Army Corps of Engineers

Louisiana is experiencing rapid loss of coastal wetlands. Recent studies have shown the loss rate to be in excess of 39.0 square miles per year. These losses are due to natural processes such as subsidence, compaction, and erosion, as well as man's developmental activities, including leveeing, channelization, and petroleum exploration. Such activities have led to a reduction in overbank flooding and natural distributary flow which historically provided fresh water, sediments, and nutrients to estuarine areas. This process has resulted in conversion of fresh, intermediate, and brackish marshes to intermediate, brackish, and saline marshes, respectively. In addition, some

areas of wooded swamp have been eliminated due to saltwater intrusion. Saltwater intrusion and loss of wetlands have adversely affected wildlife resources such as waterfowl, furbearers, and small and big game animals. Increased salinity levels have reduced availability of low salinity nursery areas important to many shellfish and finfish species. The majority of recreationally and commercially important species are estuarine-dependent, utilizing the estuaries as nursery grounds. Influx of more saline waters is particularly harmful to the American oyster, due to increased predation and disease.

One way to ameliorate loss of wetland nursery areas and saltwater intrusion is timely introduction of fresh water and associated sediments and nutrients. The merits of freshwater introduction have been historically documented. Past openings of the Bonnet Carré Spillway have resulted in overall beneficial effects to fish and wildlife resources in years following the diversions. Operation of the State of Louisiana's Bayou Lamoque and other freshwater diversion structures have also resulted in beneficial impacts.

The U.S. Army Corps of Engineers, New Orleans District, has undertaken studies to investigate diversion of fresh water from the Mississippi River to coastal areas of Louisiana. The planning objectives to be satisfied by freshwater diversion measures include creation and restoration of coastal wetlands, enhancement of vegetative growth, creation of favorable salinity gradients (5 to 15 ppt), and increases in productivity of fish and wildlife resouces. Two prominent studies include the "Mississippi and Louisiana Estuarine Areas Study" (MLEA) and the "Louisiana Coastal Area Study" (LCA). The MLEA study area is located in southeastern Louisiana, southern Mississippi, and southwestern Alabama. The 4700 square mile area extends from Dauphin Island, Alabama, on the eastern end of Mississippi Sound, to the Mississippi River-Gulf Outlet on the west. The LCA study area encompasses that part of the Mississippi Deltaic Plain located in southern Louisiana, exclusive of the active Mississippi Delta, extending from the Atchafalaya River on the west to the Mississippi River-Gulf Outlet on the east.

Under the MLEA study, a total of 13 potential sites along the Mississippi River were investigated for diversion of fresh water to Chandeleur Sound and Lakes Maurepas, Pontchartrain, and Borgne. A final Reconnaissance Report on this study was completed in July 1981, and a Draft Feasibility Report is currently in preparation. The LCA study investigated a total of 17 potential sites for diversion of fresh water into the Barataria and Breton Sound basins. A Draft Feasibility Report on this study was completed in March 1982.

Diversion of fresh water into coastal Louisiana would benefit fishery resources. Reduced saltwater intrusion would increase availability of nursery habitat with optimal salinity regimes and would restore historically productive oyster reefs in areas where salinities are now too high. Increased sediment and nutrient input would reduce

the rate of marsh loss and enhance vegetative growth. Increased nutrient input would also increase phytoplankton and zooplankton populations. Increased marsh acreage and vegetative biomass would increase detrital input and fisheries production.

Wildlife resources would also benefit from the diversions. The majority of wildlife species prefer the wooded swamps and fresher (fresh/intermediate) marsh types. These include commercially important furbearers and alligators, as well as waterfowl and small and big game animals popular with sport hunters.

The concept of freshwater diversion is not without problems. A variety of institutional problems must be overcome. In addition, some adverse impacts would occur. Construction of the diversion structures and channel would result in loss or alteration of existing habitat. Potential adverse impacts could also result from poor water quality and lower temperatures in the Mississippi River as compared to adjacent estuaries.

CONTRIBUTION OF LOUISIANA'S COASTAL WETLANDS TO FISH AND WILDLIFE RESOURCES

Mr. David W. Frugé, U.S. Fish and Wildlife Service

The vast wetlands of the Louisiana Coastal Region (LCR) are of national importance to fish and wildlife. These wetlands winter one-fourth of the North American dabbling duck population, a large portion of the Mississippi Flyway's diving ducks, and over 400,000 geese. Coastal Louisiana also supports numerous other migratory birds, many of which nest in its wetlands. The LCR marshes produce the largest fur harvest in North America, and support the largest volume of estuarine-dependent fish and shellfish landings in the United States. The American alligator population in the LCR exceeds 500,000 individuals, and a controlled commercial hunt in 1981 yielded 14,600 alligators, worth almost $2 million. Fish and wildlife-related recreation in the LCR is also extensive, including nearly 3 million recreation-days of saltwater fishing in 1979 and 676,000 man-days of waterfowl hunting during the 1977-1978 season.

Prior studies documented an annual land loss rate of over 16.5 mi^2/year in the LRC. Most recent investigations indicate an average marsh-loss rate of over 39 mi^2/year since 1956. Wetland deterioration, which is partially attributable to natural causes, has been greatly accelerated by human influences, such as canal excavation, agricultural drainage, and construction of mainline Mississippi River levees that have prevented freshwater and sediment overflow into adjacent subdelta marshes. Continued wetland deterioration may lead to serious declines in estuarine-dependent fish and shellfish harvest, fur catch, waterfowl habitat, and related fish and wildlife productivity.

The U.S. Fish and Wildlife Service has long advocated freshwater diversion for habitat improvement in the Mississippi Deltaic Plain Region and is presently participating in the evaluation of several freshwater diversion sites being investigated by the U.S. Army Corps of Engineers. It is anticipated that marsh restoration measures involving freshwater diversion and other approaches will also be financed by the State of Louisiana through its Coastal Environment Protection Trust Fund. Mitigating measures must also be implemented to offset habitat loss associated with petroleum-related access canal dredging in wetlands. Such measures include creating marshes with dredged material, plugging abandoned access canals, and installing water control structures to reduce saltwater intrusion and undesirable fluctuation of water levels.

SESSION: COASTAL MAPPING
Chairman: Mr. Lawrence R. Handley
Scribe: Mr. Joseph Christopher
Date: August 24, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Mr. Lawrence R. Handley, MMS Gulf of Mexico OCS Region
Gulf Coastal Mapping: An Overview	Mr. Lawrence R. Handley, MMS Gulf of Mexico OCS Region
Mississippi Deltaic Plain Regional Ecological Atlas	Ms. Martha Young, USFWS, Slidell, LA
Habitat Mapping Program	Mr. Patrick E. O'Neil and Maurice F. Mettee, Alabama Geological Survey Tuscaloosa, AL
Coastal Ecological Inventory Mapping Program	Mr. Larry R. Shanks, USFWS, Slidell, LA
An Automated Geographic Information System for Coastal Resources	Mr. Robert R. Ader, USFWS, Slidell, LA
The Mapping of Sensitive Areas of the Gulf of Mexico	Dr. J. Bart Baca Research Planning Institute Columbia, SC

SESSION SUMMARY

Mr. Lawrence R. Handley
MMS, Gulf of Mexico OCS Region

The purpose of the session on coastal mapping was to look at what mapping is being done Gulf-wide on a regional scale, rather than dealing with county or city mapping units. The session viewed major groups of studies funded by the Bureau of Land Management (now MMS) through the U.S. Fish and Wildlife Service's coastal ecological characterization program. A basic concern mentioned in the session was that Gulf-wide regional mapping is being done at several different scales. The two basic scales are 1:100,000 and 1:250,000, but some detailed habitat mapping is being done at 1:24,000.

Martha Young opened the presentations with a description of the Mississippi Deltaic Plain Ecological Atlas. This atlas is one of five atlas series bordering the Gulf of Mexico. The atlas consists of 14 maps (scale = 1:100,000) dealing with six topics: biological resources, soils and land forms, active coastal processes, climatology-hydrology, socioeconomic features, and oil and gas infrastructure. Publication is expected by December 1982.

Another aspect of the coastal ecological characterization program is habitat mapping. This is being done at a scale of 1:24,000 for each area covered by the Coastal Ecological Characterization Program. The mapping uses aerial photographic interpretation for 1955 and for a year between 1976 and 1978 (depending on the particular area). Some of these maps are presently available.

Pat O'Neil, from the Alabama Geological Survey, made a presentation on the Alabama portion of the habitat mapping program. They have done the maps for the coastal Alabama area at a scale of 1:24,000 for the year 1955. O'Neil went through the methodology that was developed for interpreting and producing information and measurements needed to arrive at the habitat data.

Larry Shanks described the U.S. Fish and Wildlife Service's Coastal Ecological Inventory Program. This project is contracted by Dames and Moore Associates, and the mapping is at a scale of 1:250,000. Their work covers the whole Gulf Coast area, and should be published by the end of November 1982.

Computer mapping by the National Coastal Ecosystems Team was the next topic. Floyd Stayner gave a presentation for Robert Ader on the types of products that they have available through their MOSS-WAMS automated mapping systems. They have been doing a considerable amount of work for the Corps of Engineers, the State of Louisiana, and the Environmental Protection Agency, as well as for the Bureau of Land Management.

The final presentation was by Dr. Charles Getter, who was filling in for Dr. Bart Baca, of the Research Planning Institute (RPI), Columbia, SC. Dr. Getter described the coastal mapping that RPI is doing for the oil industries consortium group. The MERG Project, as this program is called, is mapping the critical habitat and sensitive areas around the Gulf of Mexico. These maps are designed for use by both industry and government to look at the critical habitat for oil spills and those areas that would be sensitive to oil spills. One of the interesting aspects of their program is that they are mapping not only the U.S. Gulf Coast, but also several areas along the east coast of Mexico around to Yucatan coastal areas.

Overall, the session provided a better understanding of the different approaches, scales, and final products of coastal mapping programs. Many of these products overlap, and in many cases they present similar information, but presenters found that the similarities provided an opportunity to verify information arrived at independently. There was surprisingly little contradiction among the different mapping studies.

GULF COASTAL MAPPING: AN OVERVIEW

Mr. Lawrence R. Handley
MMS, Gulf of Mexico OCS Region

Coastal Ecological Characterizations are a unique approach to information gathering, assimilation, and presentation. The approach was formulated by the USFWS Coastal Ecosystems Team in Slidell, Louisiana. In the past BLM/MMS has provided the majority of the funding for these projects.

The sequences in a characterization consist of 1) information gathering, 2) information assimilation, and 3) information presentation. The information gathering consists of a literature search and synthesis of socioeconomic data and environmental information. Data and sources gathered are assimilated into a socioeconomic synthesis report and an environmental synthesis report. Information on land use, oil and gas infrastructure, recreation and tourism, and land loss or gain are included in these reports. Information on habitat changes is gathered from aerial photographs for two dates and mapped on 1:24,000 topographic map overlays. The habitats mapped are planimetered to determine the acreage of each habitat for that map and year. The acreages for each habitat and map are then compared for the two years, and the change in acreage is determined. These habitat maps are then digitized for computer display. Information gathered is presented in an Ecological Atlas. These atlases cover the coastal areas at a mapping scale of 1:100,000. Topics mapped include: biological resources, hydrology and climatology, soils and landforms, oil and gas infrastructures, and socioeconomic facilities and features.

The coastal areas covered by the coastal characterizations include Texas, Louisiana, Mississippi, Alabama, and Florida. The first characterization was the Chenier Plain in Louisiana. This project began in 1978, funded by the Environmental Protection Agency, and was completed in 1980. Characterization of the Mississippi Deltaic Plain Region of Louisiana and Mississippi began in 1978, funded by BLM. The Texas Barrier Island characterization began in 1979. In the eastern Gulf, the southwest Florida characterization, extending from Pasco County to the Keys, began in 1980. The northeastern Gulf characterization, also begun in 1980, included coastal Alabama and seven of the Florida Panhandle coastal counties. In 1982, atlas mapping and environmental literature synthesis, only, were added to the northeastern Gulf characterization for Florida's Big Bend counties from Wakulla to Hernando.

The Minerals Management Service uses the products of these characterizations in various ways. Generally, they are used to help assess the onshore impacts of offshore oil and gas products. Recently, the available data from these characterizations was used in the development of the Regional Environmental Impact Statement. These data were also used in producing the Gulfwide visuals and in developing a table of measurements of environmental resources for use in the analysis of offshore oil and gas leasing.

MISSISSIPPI DELTAIC PLAIN ECOLOGICAL ATLAS

Ms. Martha Young
U.S. Fish & Wildlife Service
Slidell, LA

The Mississippi Deltaic Plain Ecological Atlas is the first in a series of atlas mapping projects at the 1:100,000 scale done by the U.S. Fish and Wildlife Service. The contract was completed at the end of FY81, and the maps will be published by January 1983. The study area covers coastal Louisiana and Mississippi from Vermilion Bay, Louisiana to the Mississippi-Alabama state line. Topics in the atlas include biological resources, soils and geomorphology, oil and gas infrastructure, active coastal processes, climatology and hydrology, and socioeconomic features. These maps will be useful to planners in the resolution of land-use conflicts.

HISTORICAL HABITAT MAPPING OF COASTAL ALABAMA WETLAND AREAS

Patrick E. O'Neil and Maurice F. Mettee
Alabama Geological Survey, Tuscaloosa, AL

The Alabama Coastal Characterization Study is conducted in three work phases: 1) environmental literature review and synthesis, 2) socioeconomic study, and 3) historical habitat mapping. The purpose of the historical mapping effort was to delineate wetland areas from circa

1955 black and white photography and compile total acreages by habitat, county, and topograhic map.

The mapping effort consisted of delineating wetland and upland areas of coastal Alabama according to Fish and Wildlife Service conventions outlined in Classification of Wetlands and Deepwater Habitats of the United States. The classification was limited for this study to class for wetland areas and subsystem for upland areas. Photo interpretation of the 1955 photography was done using a stereoscope. The original photography plus interpretation overlay were transferred to stable mylar bases using an autofocus projector or zoom transfer scope. Areas of specific interpretations were measured with an electronic digitizer.

Final products of the mapping effort consist of reproducible film overlays of 26 7 1/2-minute topographic maps delineating wetland and upland habitats as they existed in 1955.

THE COASTAL ECOLOGICAL INVENTORY MAPPING PROGRAM

Larry R. Shanks
U.S. Fish & Wildlife Service
Slidell, LA

Many proposals for the siting of major energy facilities on the coasts of the United States have resulted in conflicts between developers and environmental groups because of the ecological sensitivity of the areas selected. In part, this conflict is caused by the reactive posture into which environmental agencies and private groups are forced, reviewing each proposed permit as it is submitted, one at a time, without access to the developer's overall planning process. To circumvent this reactive mode of operation, the U.S. Fish and Wildlife Service concluded that it was necessary to provide developers and environmental interests alike with the best available information about location of fish and wildlife resource concentration areas. Such an indication of sensitive ecological areas allows planners and resource managers to locate development away from areas of conflict or be advised about methods to reduce damaging effects.

The Fish and Wildlife Service has recently completed its third mapping project of natural resource concentration areas and significant plant and animal habitats for the coastal United States. The first inventory mapped the area of 31, 1:250,000 quads from Maine to Miami. The second (30 maps) covered the Pacific coast from Canada to Mexico. The third and most recently completed project maps 183,400 square miles of the Gulf of Mexico coast, from the Marquesas Keys to the Mexican border. Information on the location of 538 plant and animal species is displayed, as well as significant habitats and areas of special concern. These several studies have mapped resource locations for all

of the marine coastline of the lower 48 states, representing approximately 10% of the U.S. land mass.

AN AUTOMATED GEOGRAPHIC INFORMATION SYSTEM FOR COASTAL RESOURCES

Robert R. Ader
U.S. Fish and Wildlife Service
Slidell, LA

Unprecedented demand on coastal resources in the 1980's has generated a need for valid information and analyses to support wise management of the coastal zone. Many government agencies throughout the United States are turning toward computer-assisted procedures to address coastal issues. The National Coastal Ecosystems Team of the U.S. Fish and Wildlife Service recently implemented a geographic information system to enhance its ability to analyze and display environmental information about the coastal zone. Outputs generated from this system have documented serious and widespread changes in Louisiana's coastal marshes. These have been presented to the State of Louisiana Senate and House Committees on Natural Resources and to the Congressional House of Representatives Committee on Merchant Marine and Fisheries. This presentation described the utility of the Analytical Mapping System and the Map Overlay Statistical System for addressing coastal issues.

THE MAPPING OF SENSITIVE AREAS OF THE GULF OF MEXICO

Dr. Bart J. Baca
Research Planning Institute
Columbia, SC

The mapping of biological and geomorphological characteristics of shorelines has undergone various changes in the past few years, and a great variety of methods are currently in use. A consortium of oil companies has produced a method designed for a particular purpose in the Gulf of Mexico. That purpose is to provide a concise written analysis and detailed data maps of the coastline for the use of oil spill contingency planners and those involved with oil exploration and shipping.

The information is contained in two volumes. Volume I is an environmental overview of the Gulf of Mexico, including physical processes that influence the movement of spilled oil, a description of Gulf of Mexico environments, an analysis of potential spill impacts, and spill cleanup considerations for each type of environment. This volume also includes a major literature base of over 700 citations and references. Volume II is divided into six sections. Each section includes: 1) overview maps of the area covered, 2) detailed maps of sensitive areas, and 3) accompanying data sheets which include reasons

for sensitivity, launch points for equipment, and countermeasure considerations. The volumes are outlined as follows:

Volume I: Environmental Overview Section
Literature Section

Volume II: Mexico-Yucatan Section
Mexico-East Coast Section
Texas
Louisiana
Mississippi/Alabama
Florida

Detailed data maps of each area show the distribution or location of the following biological components: 1) marshes, with the total coverage in acres; 2) seagrasses, also giving total coverage; 3) invertebrates, showing nursery areas, bay and nearshore distribution, number of economically important species, and seasonality; 4) fishes, showing both commercial and sport species, and the total number of species found in each area; 5) birds, including symbols for each type (sandpipers, gulls or terns, wading birds, diving birds, raptors, and migratory waterfowl) showing the nesting sites, number of species, and seasonality for each area; 6) endangered species, with symbols for birds, manatees, alligators, crocodiles, and sea turtles, showing the distribution of each in the area; 7) other data, including symbols for launches, USCG Stations, and state and federal parks, refuges, and preserves.

Each map has a facing page which explains these components in a concise and standardized format. The common names of organisms represented by symbols are given along with their seasonality and economic importance (where applicable). Endangered or threatened species of reptiles, birds, and mammals are listed under a separate heading. Practical application and field use of the data maps are facilitated by the following headings: 1) Sensitivity Ranking, which ranks the area (1-5) based upon data presented relative to area of exposed vegetation, direct or indirect economic importance, presence of coastal endangered or threatened species, and presence of parks, refuges, or preserves; 2) Likelihood of Impact, which ranks the area (1-5) according to proximity to oil drilling or shipping, and direction of currents and prevailing winds; 3) Response Priority, a ranking (1, 2, or 3) which gives the suggested order of response based upon a subjective analysis of the previous two headings, with emphasis on the first; 4) Suggested Countermeasures, or the placement and type of containment equipment, based upon physical data; 5) Launch Point for Equipment, the nearest USCG Station or public launch, also indicated on the map; and 6) Contact, the telephone numbers of the Gulf Coast or Atlantic Strike Teams (whichever appropriate), the nearest USCG Station, and the park or refuge headquarters (when approriate). Other parts of the facing page complement the area maps, and make the total product practical and simple to use without constant referral to keys and other pages of text.

SESSION: PHYSICAL OCEANOGRAPHY
Chairman: Dr. Murray Brown
Scribe: Mr. Mike Burdette
Date: August 25, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Dr. A. Dennis Kirwan
Informal Presentations	
*Loop Current Analysis	Dr. Stephen Baig, NESS/SFSS
NMFS Ship of Opportunity Program/ Ocean Monitoring Program in the Gulf of Mexico, 1971-1982	Mr. Steve Cook, NMFS/NEFC
Preliminary Results of a Drifter Study of a Loop Current Ring	Dr. A. Dennis Kirwan Department of Marine Science University of South Florida
SEASAT-A Scatterometer Wind Stress Measurements Used to Model Larval Transport Mechanisms in the Gulf of Mexico	Dr. John Brucks, NMFS
Hydrographic Data Distribution in the Gulf of Mexico	Dr. George A. Maul, NOAA/AOML
Hydrographic Studies in the Western Gulf	Dr. John Morrison, NSF Ocean Sciences Division
*Wind Forcing Determination and Gulf Modelling	Dr. Dana Thompson, NORDA
Progress Reports	
*Seamap Hydrographic Studies	Dr. Warren Stuntz, NMFS
Current Gulf Studies	Dr. Aubrey Anderson, ONR
Mexican-American Cooperation in the Gulf of Mexico	Dr. William Merrell, Texas A&M
*Loop Current Hydrography; Tarball Surveys	Mr. Ken Haddad Florida Institute of Oceanography
Satellite Derived Oceanographic Information Service for the Gulf of Mexico	Mr. Richard Barazotto NESS/SFSS

*No abstract submitted

SESSION: PHYSICAL OCEANOGRAPHY (continued)

Presentation Title	Speaker/Affiliation
Circulation Modelling in the Gulf of Mexico	Dr. Al Blumberg Dynalysis of Princeton
*Loop Current Time Series Analysis	Dr. Jeff Hawkins, NORDA
Recent NAVOCEANO Research in the Yucatan Strait	Mr. Ken Countryman NAVOCEANO
*Physical Oceanographic and Remote Sensing Studies	Dr. Oscar Huh, LSU Coastal Studies Institute
Loop Current Variability in the Gulf of Mexico: A Summary	Dr. Tony Sturges and Dr. J.C. Evans Florida State University
Current Gulf Studies	Dr. Will Schroeder University of Alabama Dauphin Island Laboratory

Panel Discussion

-Future SOOP Priorities
-Drift Buoy Deployment Priorities
-Coordination with P-O Programs at Other Agencies
-Meteorological Data Needs/Program Utility
-Remote Sensing Requirements

*No abstract submitted

SESSION SUMMARY

Dr. A. Dennis Kirwan
University of South Florida

During this all-day session, 19 reports were made on the physical oceanography of the Gulf of Mexico. The session began with discussions of observations or work on large-scale surface features of the Gulf. A number of reports concerned the use of infrared imagery, such as SEASAT information on the Gulf-wide wind field and satellite tracked drifters. Results from the Ship of Opportunity work were very interesting and may lead to expansion through more participation in the network. Other reports concerned XBT lines and the anticyclonic current rings that are spun off from the Loop Current into the central and western Gulf of Mexico. In the Yucatan Straits, the Navy has a very large current meter array planned and partially in progress. Apparently, this array will be maintained for some time, and it has important implications for a number of other studies in the Gulf.

There is other work being done on the historical data base in the Gulf of Mexico, principally by Dr. George Maul at AOML. Dr. Maul reported on his efforts to devise an "oceanographic" geoid for the Gulf of Mexico, an important reference level for work in oceanography and remote sensing. Because the Gulf of Mexico geoid is very poorly defined, the people at NOAA are using all available and unclassified data to establish a suitably precise and accurate geoid from the extremely sparse data on the Gulf.

On a smaller scale were reports from a number of projects investigating the lower shelf and estuarine circulation problems. Some work is designed to study the relationship of the larger, general circulation of the Gulf of Mexico to local and shelf situations. One study, for example, studies the influence of the Loop Current on the coastal currents off the west Florida shelf.

The other category of study was modeling efforts. Two large-scale, primitive equation numerical models for the general circulation of the Gulf of Mexico were reported. These models differ in important technical details, emphasizing different physical processes in the equations and motions. Nevertheless, they do produce a number of observed features. The lively discussion following these presentations indicated that they do not reproduce all the observed features in the Gulf.

A number of accomplishments were made during this workshop. Participants became aware that the general circulation of the Gulf of Mexico is surprisingly strong, perhaps much stronger than previously realized. In the eastern Gulf, typical currents in the middle of the Gulf are on the order of two knots. In the western Gulf, currents on the order of one knot would be common, especially when the intense anticyclonic features spun off from the Loop Current migrate into this

area. The space and time characteristics of these circulations in the eastern Gulf and the western Gulf, however, differ. That is to say, they are surprisingly strong.

A striking factor in the presentations was the heavy reliance on existing or ongoing remote sensing programs in the Gulf. Ten or twenty years ago, oceanographers saw remote sensing as the way to the future, but it has taken a long time for that technology to trickle down to the working level. It is now playing an important role in Gulf of Mexico physical oceanography studies.

The use of remote sensing has also reversed typical data sets. Classical data are typically obtained in the summer months, and sparse data are obtained in the winter months. With remote sensing, the best coverage is during the winter period, because of cloud cover, and so on, during the summer.

Discussion of projected activities brought out the point that a number of government agencies are involved in the physical oceanography of the Gulf of Mexico, and that they already have a high level of coordination. Three that have a very tight network are the Minerals Management Service, NOAA, and NORDA, and that cuts across three different departments at capital levels. The government of Mexico is also going to be much more heavily involved in observational programs in the Gulf. Some of the participants look forward to interaction with their efforts. In fact, a coordination workshop was held in Mexico City shortly after the Information Transfer Meeting.

NMFS SHIP OF OPPORTUNITY PROGRAM/ OCEAN MONITORING PROGRAM IN THE GULF OF MEXICO, 1971-1982

Steven K. Cook
National Marine Fisheries Service

In midyear of 1970, a cooperative expendable bathythermograph (XBT) program was initiated between the National Marine Fisheries Service (NMFS) 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 (MARMAP) of NMFS, involved the use of cadets from the Kings Point Maritime Academy to gather XBT data on board various merchant ships along the east and Gulf coasts of the United States. The objective of this cooperative program was to identify and describe seasonal and year-to-year variations of temperature and circulation in major current systems in the Gulf of Mexico and western North Atlantic, utilizing merchant ships as relatively inexpensive platforms for the collection of data.

The processed data were used to construct vertical sections of temperature and salinity. All data collected were archived by the National Oceanographic Data Center (NODC) and are available to inter-

ested persons through the NODC, Washington, D.C. Also, annual reports from 1971 through 1979 have been published (Cook, 1973, 1975, 1976; Cook and Hausknecht, 1977; Cook et al., 1979; and NOAA, 1978-1980).

From 1971 through the end of 1981, the Ship of Opportunity Program/Ocean Monitoring Program (SOOP-OMP) had collected over 150 XBT transects in the Gulf of Mexico. By far the most successful transect (in terms of the most complete and continuous coverage) has been the northwest to southeast transect collect by the EDGAR M. QUEENY. The "QUEENY" transect extends from the Dry Tortugas on the southeast end to about 90°00'W longitude on the northwest end. This transect usually provides a double crossing of the Gulf Loop Current System.

Preliminary results from this monitoring effort indicate that Loop Current sea surface temperatures ranged from a high of 30.5°C in August of 1980 to a low of 22.3°C in April of 1981; however, the annual average temperatures ranged from 25.0°C in February to 30.0°C in August. Sea surface salinities in the Loop Current System ranged from a high of 36.94 ppt in December of 1981 to a low of 35.03 ppt in September of 1980, with the annual average sea surface salinities ranging from 35.90 ppt in February to 36.41 ppt in December.

In an attempt to measure or test the periodicity of Gulf Loop Current expansion, an index of Loop Current positions was developed. From the 42 crossings of the Loop Current collected from January 1979 to May 1982, an average annual position was determined for both the inflow (farthest west) branch of the Loop Current (26°26'N-87°29'W) and outflow (farthest east) branch of the Loop Current (25°24'N-85°30'W). These two positions are an average of 230 km (124 NM) apart. By using the 230 km separation as the mean, anomalous values for the 42 crossings could be calculated. Crossing positions less than 230 km apart were considered as negative anomalies, and those greater than 230 km apart were considered as positive anomalies. Preliminary results generally show more positive anomalies occurring in the summer months than in winter, indicating greater northward expansion during the summer. However, within-month variations can also be large, up to 185 km (100 NM). Separation between Loop Current branches ranged from a minimum of 96 km (52 NM) in May of 1982 to a maximum of 471 km (254 NM) in May of 1979. The occurrence of both the maximum and minimum separation in the same month (but different years) gives insight into Loop Current variability.

Recommendations for improving the "QUEENY" data set would be to increase the transect frequency from monthly to twice monthly. This would increase the detail sufficiently to allow for reliable monthly monitoring and bring the "QUEENY" transect more into step with the other anticipated XBT transects to be collected in the Gulf.

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PRELIMINARY RESULTS OF A DRIFTER STUDY OF A LOOP CURRENT RING

Dr. A. Dennis Kirwan
University of South Florida

In November of 1980 the NOAA Data Buoy Office released three satellite track drifters in a warm core ring which had been shed by the Loop Current. These drifters tracked the ring for approximately six months. During this time, the ring migrated from approximately 92°W 24°N to 96°W 23°N.

There is considerable variation in the local characteristics of the paths traced by these drifters. During the same time period, some of the paths show migrating loops, some indicate sharp cusps or very small loops, while others indicate only the presence of gentle wave-like motion. Despite this local diversity, the paths of the larger-scale features are amazingly similar. The drifters start and end at the same general location. Furthermore, there is no permanent separation.

The translation velocities for the ring as estimated independently by the three drifters are in remarkable agreement for the first 90 days, with a slow west-southwest translation of the ring. Initially the translation velocity is about 3 cm/s, but it speeds up to about 10 cm/s as the ring migrates from 90°W to 93°W. After day 90, ring movement is greatly complicated because of its interaction with the Mexican Shelf break and a developing cyclonic circulation system to the north.

The absolute velocity records for the three drifters are also quite similar. Peak velocities are often in excess of 50 cm/s. The fact that this part of the Gulf of Mexico has such high currents is not well appreciated. In this case, they are clearly due to the presence of a ring. A second significant feature is the periodicity in the velocity record. There is a persistent anti-cyclonic rotation with a period of about 13 days. This period is remarkably stable, persisting for over four months.

A third characteristic is a high-frequency component in these records. The periods are on the order of a day or less, and characteristic speeds are on the order of 10 cm/s. This was a completely unsuspected result, and the cause of this phenomenon is being investigated. The mechanisms under investigation are: tides, satellite position errors, windage on the drifters, and ring shingles. The latter is certainly a factor since satellite infrared data show the presence of shingles on this particular feature.

Work is also continuing on refining the parametric model to obtain better accuracy and resolution on calculations for the ring shape factors. Analytical techniques are also being developed to combine the drifter data with satellite infrared data and XBT data.

SEASAT-A SCATTEROMETER WIND STRESS MEASUREMENTS USED TO MODEL LARVAL TRANSPORT MECHANISMS IN THE GULF OF MEXICO

Dr. John T. Brucks
National Marine Fisheries Service

Fisheries use of SEASAT-A Satellite Scatterometer (SASS) data was directed toward the development of a model to determine if scatterometer wind stress measurements could improve our knowledge of surface layer transport in the Gulf of Mexico. Knowledge of surface layer transport processes is important in fisheries research because dispersal mechanisms influence the distribution and recruitment of marine organisms with planktonic life stages.

The surface layer transport model is composed of an offshore and a coastal module to satisfy deep and shallow water responses to meteorologic driving forces. Hydrographic boundary conditions are essentially

fixed by monthly and/or seasonal averages of historical temperature and salinity data. Thus, surface transport is a function of the varying wind field.

In keeping with the theme of this session of the meeting, "offshore oceanography in the Gulf of Mexico," only the offshore portion of the Gulf model is presented.

The offshore module consists of the output of a diagnostic numerical model used to define thermohaline circulation at the surface of the ocean. Surface layer current vectors were calculated based upon historical data of temperature and salinity measurements obtained over a 40-year period in the Gulf of Mexico. The separation of thermohaline from wind-driven circulation is somewhat artificial but necessary to resolve boundary effects of strong oceanic currents that dominate or skew transport properties due to local wind fields. Model outputs consist of monthly mean current vectors on a .5° x .5° grid. A trajectory analysis package was developed and integrated by NMFS to portray current pathways of fish eggs and larvae in addition to the definition of impact areas. The trajectory analysis allows one to randomly select any number of starting points, track the dispersal routes, and show impact area or particle location between one and thirty days of drift.

The SASS data set for input to the model of surface layer transport was compiled by extracting scatterometer wind measurements from 70 revolutions over the Gulf of Mexico during September 1978, a total of 11,248 SASS measurements. The wind data were further processed in a manner acceptable for input to the oceanographic model. Composite plots of scatterometer measurements were generated to show spatial distribution, and frequency statistics were calculated to evaluate data density. The conclusion was that sufficient coverage of the Gulf is attained within five days. Longer periods merely add to the data density and do not improve the distribution of data. Thus, scatterometer wind measurements were sorted and packaged into five-day running averages that are gridded by .5° square. The result is a .5° gridded data set of 26, five-day running averages of scatterometer direct measurements of oceanic wind.

To complete the .5° square data matrix required for mode operation, data gaps were filled by interpolation and iteration. Interpolation was used to fill data gaps within the distributional limits defined by scatterometer measurements. In peripheral areas between scatterometer coverage and the model boundary, data gaps were filled by repeating the value of the nearest scatterometer measurement.

SASS monitoring of oceanic winds was used to derive ocean flow indices and to establish the variability of dispersal processes affecting the distribution, abundance, and ultimate survival of planktonic early life stages of marine organisms.

An example of the differences between the conventional, monthly data bases and the SASS data base for September 1978, is shown in Figure 6. The most obvious differences are reflected in the resolution of data and in the direction and magnitude of computed velocities. The SASS provided wind stress data with a spatial resolution on the order of 30 times that of the conventional method. Research products differ also. The standard data base depicts the Gulf as almost always convergent (approximately 4:1) with a mean and maximum vertical velocity (mm/day) of 257.3 and 1230.0, respectively. By comparison, calculations using the SEASAT data base define convergent and divergent aspects of the Gulf as generally equal (approximately 1.5:1). Additionally, the magnitude of vertical velocities is increased approximately twofold with a mean and maximum of 451.01 and 2710.37 mm/day, respectively.

SEASAT afforded new technology for fisheries applications to monitor, model, and predict environmental pathways by which offshore spawn of estuarine dependent shellfish and finfish find their way into coastal nursery grounds. Synoptic and repetitive direct measurements of wind stress provided 1) enhanced capability to determine wind-driven environmental events, including a pertinent measure of inherent variability, that influence recruitment processes of marine organisms and 2) a means of correlating significant interactions between subregions in the Gulf of Mexico. The effect of dispersal mechanisms is common to all major fisheries that have planktonic life stages. Knowledge of transport processes can, therefore, assist basic mission requirements for the management of fisheries resources.

HYDROGRAPHIC DATA DISTRIBUTION IN THE GULF OF MEXICO

Dr. George A. Maul
NOAA/AOML, Miami, FL

Data from the NODC file were combined with other (unarchived) data to form an XBT/STD base for the Gulf of Mexico. Distribution by month and year shows that the winter months are the least sampled, and that the five-year period 1969-1973 represents half of the combined data set. Over 7000 samples were taken in each season except winter, which had 3860 XBT's and STD's. While there are half again as much XBT data, only the STD/Nansen data give uniform areal coverage.

Distribution by depth of Nansen and STD stations was also determined. Over 26,000 samples are in the complete file. Data at the 450 m horizon (depth of T-4's), 750 m horizon (depth of T-7's), and at 1000 m (STD and Nansen only) were plotted. Figure 7 shows the mean dynamic topography relative to 1000 db.

The most obvious need is to increase the winter coverage and concentrate on the western Gulf. It should be noted that about 15% of the data in the NODC file were unusable after quality control at AOML.

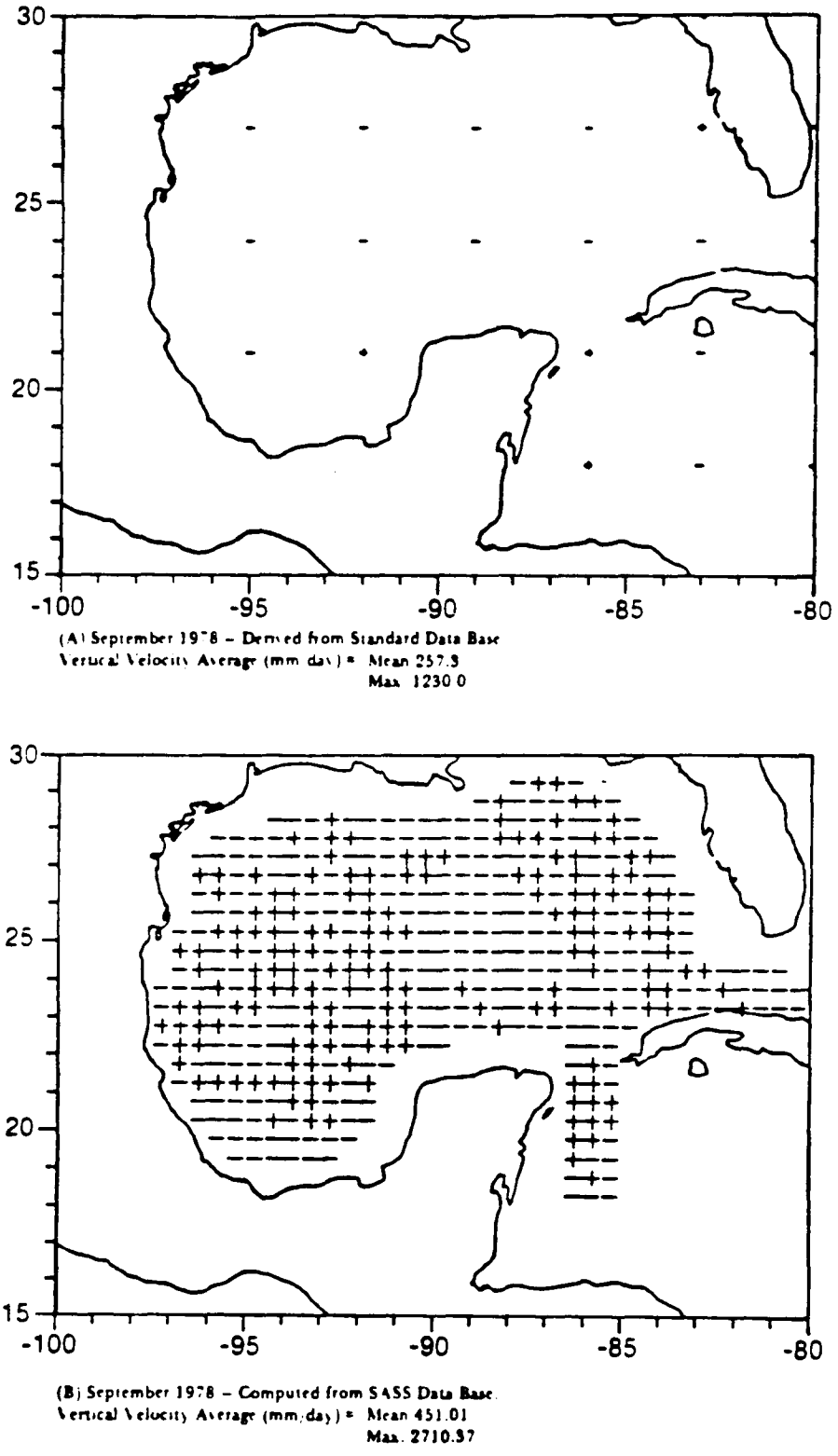

Figure 6. Comparison of standard and SASS data bases for calculation of the monthly averages for vertical velocity (+ upward, - downward) in the Gulf of Mexico for September 1978.

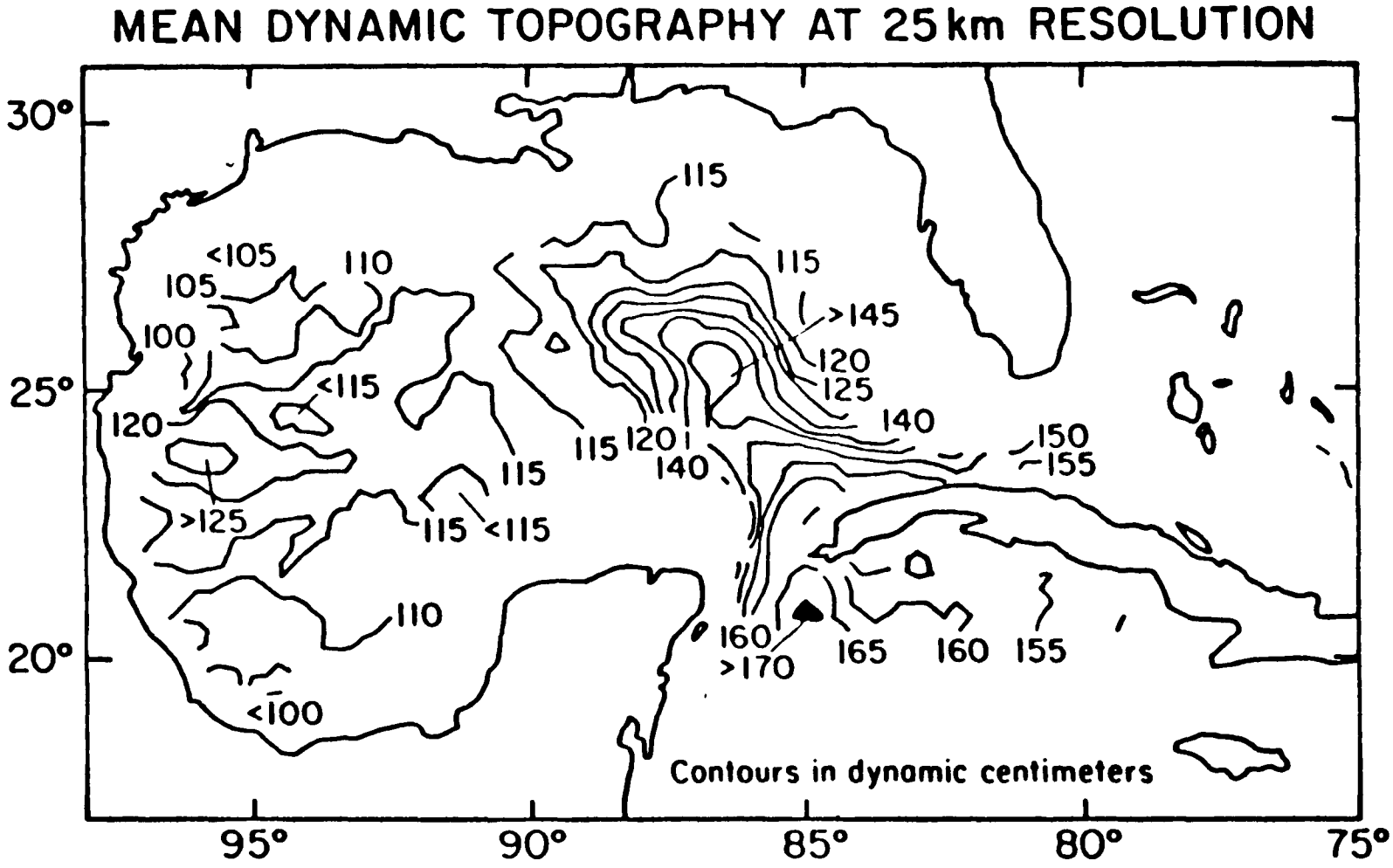

Figure 7. Mean dynamic topography based on acceptable NODC data plus contribution from sources not yet archived. Reference level is 1000 db. Calculations were made at 25 km × 25 km resolution, and the final result was processed through a 3 × 3 grid point median filter in 50 db layer increments. Errors are estimated at less than two dynamic centimetres.

HYDROGRAPHIC STUDIES IN THE WESTERN GULF OF MEXICO

Dr. John Morrison
National Science Foundation

This presentation reviewed data on the distribution of salinity, dissolved oxygen, nitrate, phosphate, and silicate for the western Gulf of Mexico in 1978. Plots of chemical concentration versus potential density were used to identify the presence of Gulf Water, Tropical Atlantic Central Water, Antarctic Intermediate Water, Carribbean Mid-water, and Upper North Atlantic Deep Water within the upper 1600 m of the western Gulf of Mexico (see Table 9). Property distributions were closely related to the current regime described by Merrell and Morrison (1981).

REFERENCES

Merrell, W.J., Jr. and J.M. Morrison, 1981. On the circulation of the Western Gulf of Mexico, with observations from April 1978. J. Geoph. Res., 86, 4181-4185.

TABLE 9

WATER PROPERTY EXTREMA IN THE WESTERN GULF OF MEXICO, ASSOCIATED WATER MASSES, AND POTENTIAL DENSITY SURFACES

WATER MASS	EXTREMUM	CONCENTRATIONS	σ_θ (mg cm^{-3})	DEPTH RANGE (m)
Gulf Water	Salinity maximum	36.4-36.5 ppt	25.40	0-250
Tropical Atlantic Central Water	Oxygen minimum	2.5-2.9 ml/l	27.15	250-400
Antarctic Intermediate Water	Nitrate maximum	29-35 µg-at/l	27.30	500-700
Antarctic Intermediate Water	Phosphate maximum	1.7-2.5 µg-at/l	27.40	600-800
Antarctic Intermediate Water	Salinity minimum	34.88-34.89 ppt	27.50	700-800
Mixture of Upper North Atlantic Deep Water and Caribbean Mid-water	Silicate maximum	24-28 µg-at/l	27.70	1000-1100

CURRENT GULF STUDIES

Dr. Aubrey Anderson
U.S. Office of Naval Research

Although there is no programmatic emphasis on the Gulf of Mexico, the Office of Naval Research (ONR) occasionally funds tasks for work in or related to the Gulf. One recent expansion of the ONR coastal program is in the area of sea straits. Interest in instrumentation for straits measurements led to ONR involvement with the Subtropical Atlantic Climate Study (STACS) program of NOAA. This program has focused on the Florida Straits as the prime area to monitor heat flux in the North Atlantic. Several techniques are being employed to monitor heat flux. ONR is engaged in joint programs for two techniques: acoustic tomography and current meter arrays. Harry DeFerrari of the University of Miami, with partial funding from the ONR Ocean Acoustics Program, is investigating reciprocal shooting as a technique for acquiring ocean current field data.

Fritz Schott and Phil Bedard of the University of Miami have proposed to deploy five current meter arrays in the Florida Straits, with the uppermost meters getting into the core of the Florida current. Two major steps were taken to produce a survivable mooring. The upper part of the wire is faired extensively, and the uppermost current meters are Niskin Wings which work on an inclinometer principle. In the test mooring, an Aanderaa meter was deployed within two metres of a Niskin Wing meter for intercomparison.

The test mooring was put in last fall, and results justified deploying the full suite of five moorings along the main study line. These moorings were in the water for two months and were recovered and redeployed in June.

It was estimated that the Florida Current would be over two of the moorings. The uppermost current meters at these locations were placed at about 150 m depth, within the core of the current, but where the maximum current speed should have been approximately 3 knots. As it turned out, during the period of deployment the Florida current was frequently over another array. The top meter of this mooring, at only 50 m depth, indicated maximum speeds near 5 knots, which is near the design limit of the Niskin Wing. It was exciting to acquire these data, but wire lengths were prudently changed for the redeployment.

The Florida Straits observations will continue for two years with support of the ONR Coastal Sciences Program Strategic Straits Special Focus Program and the NOAA Subtropical Atlantic Climate Study.

MEXICAN-AMERICAN COOPERATION IN THE GULF OF MEXICO

Dr. William Merrell
Texas A&M University

A United States/Mexico workshop on the physical oceanography of the Gulf of Mexico is now scheduled to take place in Mexico City on 20-22 November 1982. Present and planned physical oceanography programs in the Gulf will be discussed, and possible joint programs will be explored. Also, the Mexican scientists will outline plans for UNAM's new oceanographic research vessel, which will be based on the east coast of Mexico.

U.S. attendees, in addition to Dr. Merrell, include Mr. John Cochrane, Dr. Denny Kirwan, Dr. George Maul, Dr. Worth Nowlin, and Dr. Tony Sturges. The participation of the United States scientists in the workshop is sponsored by the National Science Foundation.

SATELLITE DERIVED OCEANOGRAPHIC SERVICES FOR THE GULF OF MEXICO

Mr. Richard Barazotto
NOAA/NESS/Satellite Services Field Center

On August 24, 1981, the National Earth Satellite Service (NESS) established the New Orleans Satellite Field Services Station (SFSS) at Slidell, Louisiana. This office is collocated with the New Orleans National Weather Service Forecast Office (WSFO). The primary mission of the SFSS is to provide oceanographic and meteorologic support by interpreting satellite data for the marine user community bordering the Gulf of Mexico. To effectively carry out this mission, personnel from both the SFSS and the WSFO have been combined to form an Ocean Services Center (OSC). One of the marine products that will be operationally available from the OSC will be satellite-derived, quantitative, sea surface temperature (SST) analyses. An analysis is produced from polar orbiting digital satellite data. The present operational, polar-orbiting satellite, designated NOAA-7, is the latest in NOAA's TIROS-N series.

The primary sensor aboard NOAA-7 relevant to ocean monitoring is the Advanced Very High Resolution Radiometer (AVHRR). The AVHRR measures energy in five spectral bands: one visible, one near-infrared, and three thermal infrared (IR). It is the three thermal IR-channels that are used to derive SST's. NOAA-7 digital satellite data are received at the Wallops Island, Virginia Command and Data Acquisition Station (CDA). From there, data are sent to the NOAA Computer Facility at Suitland, Maryland. At this facility, the IR digital data are processed on the NOAA IBM 360/195 computer, and SST's are derived. The temperature measurements are corrected for atmospheric attenuation by use of a multispectral algorithm. The processed

data are then sent to a line-printer terminal in Slidell, Louisiana. The "print-outs" take the form of gridded, alphanumeric representations of the SST's. The SST data are hand contoured to the nearest 0.5°C and registered to a base map.

Figure 8 is an AVHRR infrared image of the eastern Gulf of Mexico. Infrared satellite images are pictorial representations of the temperature distribution of the earth. The various shades of gray on the image depict different temperatures, with colder temperatures represented by lighter shades of gray. Owing to the large temperature difference between the cooler land and warmer water, the coastline is clearly discernible. Also visible are the more subtle gradations within the water areas. The gradation labeled "C" delineates the northward extent of the Gulf Loop Current.

Figure 9a is the contoured digital data field used to produce the infrared image shown in Figure 8. The contour lines connect areas of equal temperature. The contour interval here is 1°C, although the operational product is contoured to the nearest 0.5°C. Figure 9b represents the final product.

Another product that will be available from the New Orleans OCS is a Graphic Satellite Interpretation Message (SIM). This SIM is produced from geostationary satellite data and will be a graphic depiction of weather features that could impact marine operations. These features would include movement, trends, development/dissipation of thunderstorms, fog, gust fronts, frontal bands, and potential areas of atmospheric turbulence affecting helicopter operations.

Real time dissemination of these and other products is scheduled to begin the first week in January 1983. The methods of dissemination include automatic telecopier and radio facsimile (radiofax). The National Weather Service has contracted for the radiofax service with a commercial station (WLO) in Mobile, Alabama. The Gulf Environmental Radio Fax Program (GERAF) will cost the National Weather Service over $80,000 annually. The Weather Service has committed $50,000 toward this program, but needs funding assistance to insure year-round service.

Comments regarding transmission of OSC products on automatic telecopier and radiofax, especially those addressing possible sources of funding, should be forwarded to Richard M. Barazotto, Oceanographer, New Orleans SFSS, 1120 Old Spanish Trail, Slidell, LA 70458.

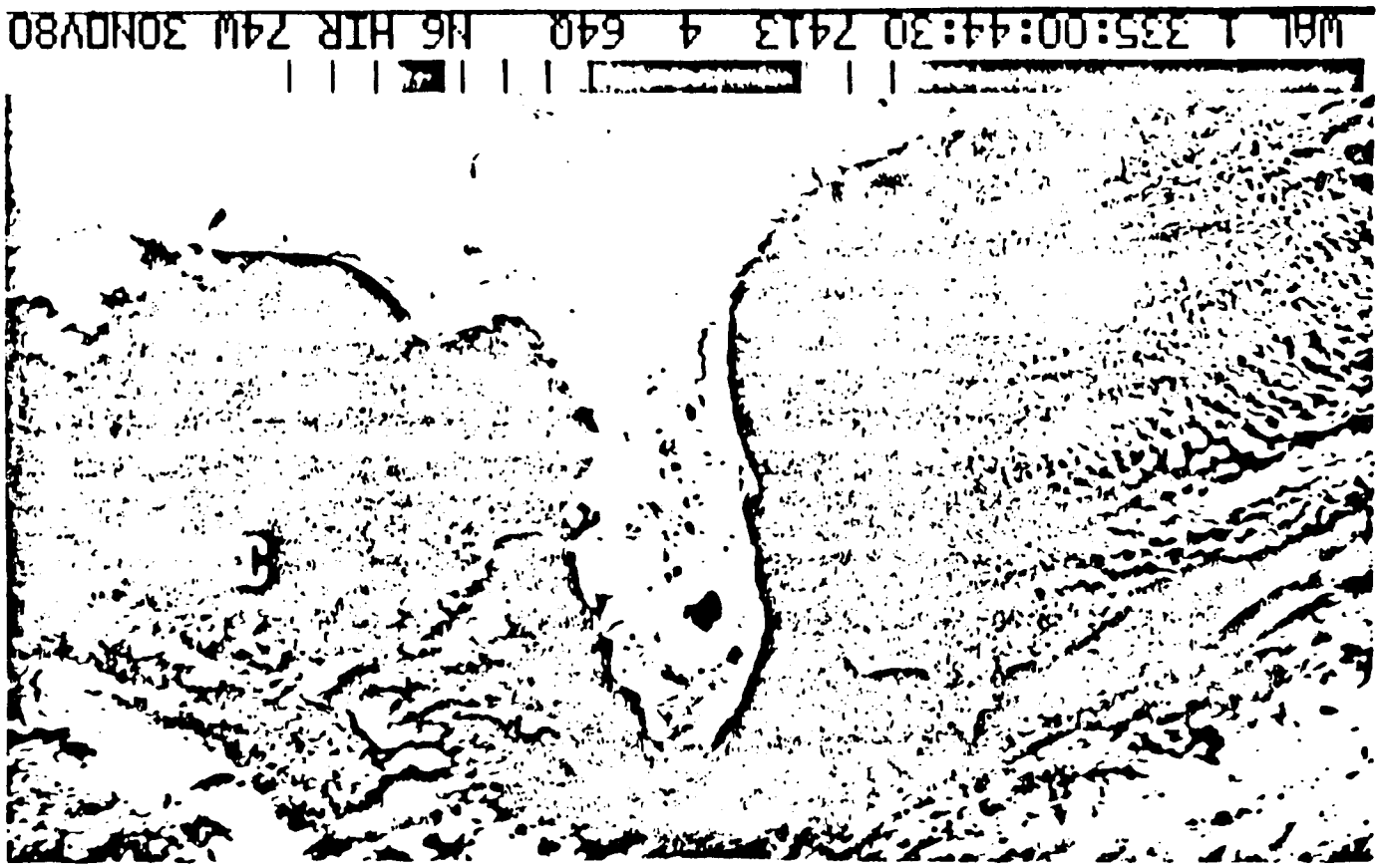

Figure 8. AVHRR infrared image of the eastern Gulf of Mexico.

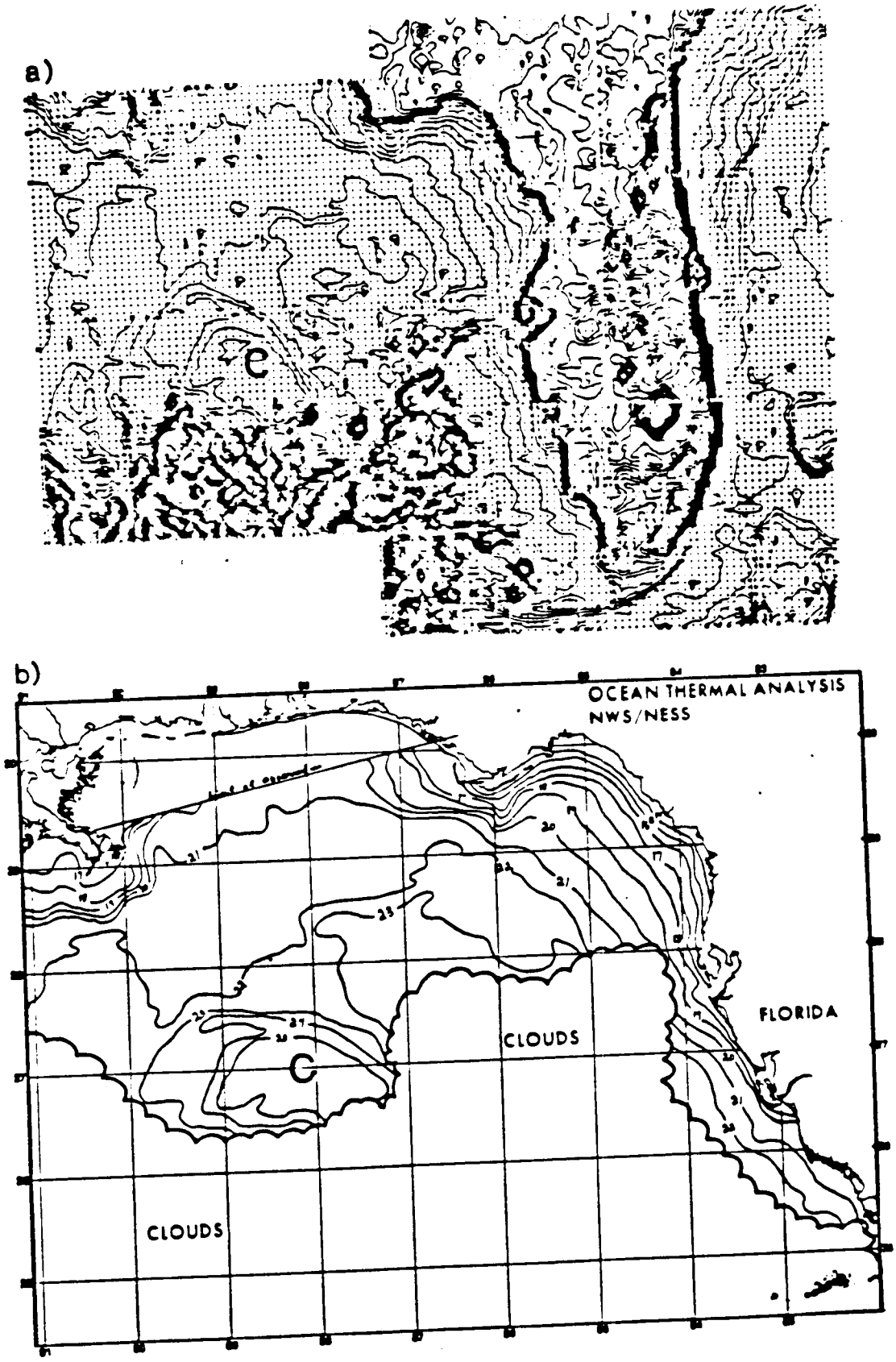

Figure 9. Contoured digital data field (a) and final product (b).

CIRCULATION MODELLING IN THE GULF OF MEXICO

Dr. Alan F. Blumberg
Dynalysis of Princeton

The research efforts described in this paper are directed towards developing a capability to simulate the circulation in the Gulf of Mexico. An efficient three-dimensional, time dependent prognostic model of the Gulf has been formulated. The model has a 50 x 50 km horizontal resolution and 16 levels in the vertical. It is driven by winds and surface heat flux derived from climatological, atmospheric surface data, the result of an intensive data analysis study. Mean velocity, temperature, salinity, turbulence kinetic energy, and turbulence macroscale are the prognostic variables. Lateral boundary conditions for temperature and salinity and geostrophically derived velocity at the Straits of Yucatan and Florida are obtained from climatological ocean data. An analytical second moment turbulence closure scheme embedded within the model provides realistic surface mixed layer dynamics. Free surface elevation distributions are calculated with an algorithm which calculates the external mode separately from the internal mode. The external mode, an essentially two-dimensional calculation, requires a short integrating timestep. The more costly, three-dimensional, internal mode can be executed with a long step. The result is a fully three-dimensional code which includes a free surface at little sacrifice in computer cost compared to rigid lid models.

The atmosphere imposes wind stress, heat flux, and effective salt flux boundary conditions on the model. The data sets used to supply these quantities were constructed from data files TDF-11 maintained by the National Climatic Center (NCC) and consist of over a million Gulf surface ship observations. The raw data were edited and converted with the aid of standard bulk aerodynamic and radiational exchange formulas to produce monthly estimates of the wind stress statistics, heat flux, and mass flux on a 1° square grid. The transfer coefficients in the formulas, however, are not standard; they vary with wind speed and stability in a manner similar to those of Bunker (1976). The stresses and fluxes were then placed on the finer resolution numerical grid by a statistical interpolation technique.

To complement the atmospheric forcing data, the complete set of Gulf temperature and salinity data files maintained by the National Oceanographic Data Center (NODC) have been processed. The edited raw data are averaged on a 1° square grid at the standard NODC depth levels. This new data set includes all the data which were archived prior to 1979 and consists of over half a million temperature and salinity observations. The amount of data is, however, insufficient to form meaningful monthly, Gulf-wide distributions. Seasonally varying distributions are therefore constructed in the upper 1000 m, while annual mean values are used between 1000 m and 1500 m. Below 1500 m, area averaged, annual mean values are used. This final data

set is also spread onto the model grid points via the statistical interpolation technique.

The procedure for prescribing boundary conditions is quite straightforward. An atmospheric data library consisting of the monthly mean values of the surface stress and the monthly heat flux distributions at all surface grid points is created. The seasonally varying velocity profiles and temperature and salinity distributions (inflow only) at the two Straits are stored in a similarly constructed oceanic data library. As the calculation proceeds, the proper data are selected from the libraries and inserted into the Gulf model by means of linear interpolation between bracketing time periods where the analysis exists.

The results from a one-year calculation appear, subjectively, to be a rather good simulation, although the Loop Current does not shed eddies. The horizontal coefficient of eddy viscosity will probably have to be lowered before eddy instability will occur. The model does seem to reproduce the large-scale features of the circulation, such as variability, intensity, and areal extent of major current systems as construed from comparisons with available observational data. The seasonal variation of the mixed layer and thermocline compares well, but not perfectly, with climatology. Most important, however, is the fact that one can now identify detailed deficiencies. This ability should lead to strategies for further model improvement.

REFERENCES

Bunker, A.F., 1976. Computations of surface energy flux and annual air-sea interaction cycles of the North Atlantic Ocean, Mon. Wea. Rev., 104, 1122-1140.

RECENT NAVOCEANO RESEARCH IN THE YUCATAN STRAIT

Mr. Ken Countryman
U.S. Naval Oceanographic Office

Because of time available during a May 1982 shakedown of a new computer system aboard USNS KANE, a survey was planned for Yucatan Strait utilizing various measuring systems. The survey resulted in six current meter array implants with a total of 32 VACM current meters, 40 CTD stations, 20 expendable shear probe drops, and 163 T-7 XBTs. The arrays will be retrieved this fall and several may be replanted for an additional four to six months.

LOOP CURRENT VARIABILITY IN THE GULF OF MEXICO: A SUMMARY

Dr. W. Sturges and Dr. J.C. Evans
Florida State University

It is of considerable interest to know to what extent offshore currents may drive flows on the continental shelf. The northernmost position of the Loop Current, from hydrographic data, was used to piece together a time series 13 years long. The "annual" variation of the Loop Current appears to be a broad spectral peak rather than a sharp spectral line. There is approximately as much power at periods near 30 months as at periods near a year. Both seem to be, at least in part, wind forced. There are also fluctuations having periods near 8 months that may be a beat frequency. As the 30-month and annual signals drift in and out of phase over about 5 years, the envelope of the 8-month signal varies from zero to a maximum of about 2.5° latitude, peak-to-peak, which is the same as the range of the 30-month signal, and larger than the mean annual signal.

The primary finding is that the fluctuations in Loop Current position are correlated with sea level at the coast, and presumably with coastal currents as well, at periods near 7 to 8 months, and 16 to 30 months. The results are essentially the same using tidal data at either St. Petersburg or Key West. The phase delay is such that the inferred southerly flowing currents on the shelf lead the changes in Loop Current position by one to three months. The intrusion of the Loop Current therefore may be in response to changes in the velocity of the Loop Current. If the Loop Current is inherently unstable, as the numerical model of Hurlburt and Thompson suggests, the wind forcing may merely set the frequency of the variability. Observations at the outer edge of West Florida Shelf have shown flow to the south of 10 to 20 cm/s, persistent over many months, which is consistent with this model.

CURRENT GULF STUDIES

Dr. William W. Schroeder
Dauphin Island Sea Laboratory

This presentation reviews research carried out by the physical oceanography section of the Dauphin Island Sea Laboratory. All of the research activities over the past three years, other than estuarine studies, have centered on continental shelf processes. Low-frequency current variability on the Alabama shelf (Anderson Reef study site) has been examined utilizing three years (1976, 1978, and 1979) of summer current, sea level, and meteorological records. This work was a cooperative effort with members of the Coastal Studies Institute of Louisiana State University.

Another cooperative effort is presently underway with members of the Department of Oceanography at Texas A&M University. This study is looking at the response of shelf waters in the Gulf of Mexico to the passage of tropical storms and hurricanes, during 1979. In that year, the Gulf of Mexico was subjected to the influence of two tropical storms and four hurricanes, including two class four hurricanes, David and Frederic. Current meter records from Anderson Reef, the Flower Garden Banks on the Texas-Louisiana shelf, and Station 247 in the Florida Middle Ground on the west Florida shelf are being examined.

Other research projects deal with: 1) the interaction between Mobile Bay and the coastal waters of the intercontinental shelf of Alabama; 2) the thermal structure of the continental shelf region between the Chandeleur Islands and the DeSoto Canyon; and 3) the meteorology of the coastal barrier island zone of Alabama and Mississippi. Proposed research projects are: 1) windforced currents over rough mid-shelf bathymetry; and 2) the circulation and hydrography of the Alabama, Mississippi, and eastern Louisiana intercontinental shelf regions.

SESSION: PREHISTORIC & HISTORIC CULTURAL RESOURCES
Chairman: Ms. Melanie Stright
Scribe: Ms. Anne Giesecke
Date: August 25, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Ms. Melanie Stright MMS, Gulf of Mexico OCS Region
Prehistoric	
Management Strategy for Prehistoric Sites on the OCS	Ms. Melanie Stright, MMS Gulf of Mexico OCS Region
Marine Geologic Mapping	Mr. Henry Berryhill, USGS
Sedimentary Studies of Prehistoric Archaeological Sites	Dr. Sherwood Gagliano Coastal Environments Inc.
Core Sampling of a Holocene Marine Sedimentary Sequence and Underlying Neolithic Cultural Material off Franchthi Cave, Greece	Dr. John Gifford Dept. of Geography & Archaeometry University of Minnesota
The Quantitative Analysis of Soil Phosphate	Dr. William Woods Department of Anthropology Southern Illinois University
Historic	
Management Strategy for Historic Sites on the OCS	Ms. Melanie Stright, MMS Gulf of Mexico OCS Region
National Park Service: Management of Shipwreck Sites	Dr. Daniel Lanihan National Park Service
Cultural Resource Management Factors for the OCS	Mr. J. Barto Arnold III Texas Antiquities Committee Austin, TX
Spatial Magnetics of Shipwrecks	Mr. Alan Saltus Archaeological Consultant Prairieville, LA

SESSION SUMMARY

Ms. Melanie Stright
MMS, Gulf of Mexico OCS Region

The cultural resources session was subdivided into prehistoric and historic archaeology sessions.

The major questions addressed by the participants in the prehistoric archaeology session included:

1. Where will prehistoric sites occur on the OCS?

2. Under what conditions will sites be preserved?

3. In what circumstances are prehistoric archaeological data recoverable?

4. What technology is available for data retrieval?

5. What type of site data is recoverable without complete excavation?

As a result of the presentations and discussions in the prehistoric archaeology session, four study needs were identified:

1. synthesize existing high resolution shallow seismic data on the OCS to more precisely delineate high-probability areas for the occurrence, preservation, and retrieval of prehistoric archaeological data in the Gulf of Mexico;

2. physically test relict landforms already identified through cultural resources surveys and evaluated as having a high probability for site occurrence, preservation, and data retrieval;

3. test the validity of geochemical test results from terrestrial sites on marine inundated sites; and

4. continue perfecting localized late Pleistocene/Holocene sea level curves for the northern Gulf of Mexico.

The historical archaeology session focused on management factors affecting preservation of known sites, and on the use of magnetometer data vs. side-scan data for identifying sites. Seven problems and study needs were identified:

1. Central storage locations are needed for remote sensing survey data so that these data will be accessible for future reference and analysis.

2. Peer review of contract archaeological reports is necessary to ensure the professional quality of the reports.

3. Federal agencies need more field-level archaeologists to handle the work load and to ensure quality control of the contract archaeology work.

4. Survey line spacing and tow fish height need to be regulated and tailored to the location of significant shipwrecks.

5. Federal legislation is needed to remove historic shipwrecks from consideration under admiralty salvage law and put them under antiquities legislation.

6. Groundtruthing of a selected sample of unidentified anomalies should be conducted.

7. Information should be compiled on horizontal and vertical distribution of wreck debris in sediments of varying thickness and composition, in order to determine what type of signatures, if any, should be expected on the various remote sensing instruments.

MANAGEMENT STRATEGY FOR PREHISTORIC SITES ON THE OCS

Ms. Melanie Stright
MMS, Gulf of Mexico OCS Region

As an introduction to the prehistoric session, Ms. Stright briefly outlined MMS's management strategy for prehistoric sites in the Gulf of Mexico. The 1977 cultural resources baseline study for the northern Gulf of Mexico proposed a series of management zones. These zones differ in the probability for occurrence of significant cultural resources on the OCS. According to existing sea level curves, the area of the shelf defined by zones 1 and 2 was subaerially exposed until approximately 12,000 B.P. As such, these two zones have potential for occurrence of prehistoric sites dating from 12,000 B.P. to 3,000 B.P. (depending on the position of the area on the shelf).

High resolution shallow seismic profilers are the primary instruments used in locating relict landforms with a high probability for associated prehistoric sites on the OCS. Remote sensing surveys conducted on OCS leases have recorded numerous examples of such relict landforms; however, virtually no further investigation of these landforms has been conducted. Therefore, no prehistoric sites have been identified on the OCS as a result of remote sensing surveys.

MARINE GEOLOGIC MAPPING

Mr. Henry Berryhill
MMS Office of Marine Geology, Corpus Christi, TX

Henry Berryhill reported results from regional habitat mapping studies funded through the BLM studies program. Possible archaeological applications of the results were also addressed.

Original high resolution seismic data were collected on three-mile and four-mile grids across large portions of the central and western Gulf of Mexico. From these data a series of interpretive maps was constructed. The most useful maps from this series are those showing post-Wisconsin sedimentation patterns and the paleogeography of the continental shelf during former periods of low sea stand.

These interpretive maps provide a regional geologic framework which serves as an interpretive base for data collected during cultural resource surveys. This regional framework allows data interpretation to go beyond a statement that a relict landform occurs within a survey area, to an assessment of its archaeological potential in terms of its general age, the type of system to which it belongs, and the geologic processes which formed and modified it.

The maps of post-Wisconsin sedimentation patterns, for example, help identify the depth below the seafloor of the late Wisconsin erosional surface and help identify the depth of sediments which would have to be penetrated to test for archaeological sites in association with this surface. The situation should never be oversimplified, however, by categorically excluding all post-Wisconsin (Holocene) sediments as "archaeologically sterile." In some circumstances, such as short reversals in sea transgression and deltas prograded to a level of subaerial exposure, surfaces inhabitable by prehistoric man may occur within the Holocene sequence. Likewise, maps of early and late Wisconsin fluvial systems help in interpretation of the general age of such features observed in the cultural resources survey data. From this information, it can be determined whether these features fall within the time frame of human occupation of the area.

Mr. Berryhill indicated that erosion has probably destroyed most prehistoric archaeological sites across the Gulf, and that thick accumulations of Holocene muds would probably preclude the discovery and evaluation of sites over some portions of the Gulf, particularly off of south and central Texas.

From the audience, Dr. Gagliano pointed out that although erosion is evident at the late Wisconsin surface, site preservation would be excellent in areas which subsided or were covered by sediment prior to transgression. Site materials may also be incorporated into the sedimentary sequences and preserved in point bar deposits, natural levee deposits, back-barrier lagoons, or channel fill material.

SEDIMENTARY STUDIES OF PREHISTORIC ARCHAEOLOGICAL SITES

Dr. Sherwood Gagliano
Coastal Environments, Inc., Baton Rouge, LA

Dr. Gagliano reported the results of his recent study for the National Park Service. Although numerous examples of relict landforms having a high probability for associated prehistoric archaelogical sites have been identified on the OCS, the resolution and line spacing of data currently being collected do not permit identification of actual sites on the records. The limited physical testing of these landforms has generally been unsuccessful in identifying sites. This failure is attributed to the extremely low probability of recovering artifactual material in a core-sized sample, and to the lack of established parameters defining cultural deposits with which to compare the soil matrices of the physical samples taken.

Based on the assumption that cultural processes, like natural processes, influence the physical and chemical makeup of sediments, this study was designed to develop procedures and criteria for distinguishing cultural deposits from natural deposits using core-sized samples.

Box cores were taken from 15 selected onshore prehistoric sites. Off-site control samples were also obtained. The sampled sites from Mississippi, Louisiana, and Texas represented eight different coastal landform types and conformed to the following criteria:

1. site is associated with a relict landform type identifiable on the shelf;

2. site is commonly associated with that type of landform; and

3. site occurs in a location which may be preserved on the OCS.

These samples were subjected to four levels of analysis from the least complex to the most complex:

Level 1: lithology and minor sedimentary structures;

Level 2: point count and grain size analysis;

Level 3: geochemical analysis; and

Level 4: evaluation of all data.

The findings of this study indicate that systematic analysis of core-type sediment samples provides a basis for distinguishing cultural deposits with a high degree of certainty. In addition, study results suggest that there is a high probability of being able to positively identify a cultural deposit as such prior to the need for geochemical

analysis (Level 3). Further, the study results indicate that 1) the statistical reliability of the 10 to 20 sized fraction analysis (Level 2) in yielding positive site identification may preclude the necessity for the smaller sized fractions in most cases; 2) grain size analysis is the least useful in sites where the soil matrix has a large proportion of greater-than-sand-size particles; and 3) bone or bone and charred material consistently separate site from non-site samples.

CORE SAMPLING OF A HOLOCENE MARINE SEDIMENTARY SEQUENCE AND UNDERLYING NEOLITHIC CULTURAL MATERIAL OFF FRANCHTHI CAVE, GREECE

Dr. John Gifford
University of Minnesota

Dr. Gifford reported the results of his work in Koiladha Bay off of Franchthi Cave, Greece during the 1981 field season.

A Neolithic settlement, the Paralia site, which lies downslope from Franchthi Cave on the shoreline of Koiladha Bay, was excavated by T.W. Jacobsen in 1973-1974. It was hypothesized that this Neolithic settlement extended farther downslope, beneath the waters of the bay, which formed during the post-glacial sea level rise. Records obtained with a 3.5 kHz acoustic profiler indicated that a river channel formerly cut through the present bay area, and that a wedge of Holocene sediment up to 5 m thick presently overlies the subaerially formed late Wisconsin surface with which the Neolithic site would be associated. To establish the presence or absence of this extension of the onshore Neolithic site, Dr. Gifford obtained two cores through the bay fill material, using a diver operated pulsing auger.

At the base of one core, 5.5 m below the present bay bottom, a stratum rich in mollusc shell fragments and subangular limestone pebbles was found to rest on a hard rock substrate. Thirty pottery shards were also recovered in the core from this stratum. Other materials recovered from this stratum through coarse fraction analysis included mud-building plaster, oxidized copper fragments, carbonized wheat grain, charred fish vertebrae, and a small burin. Dr. Gifford attempted to determine whether these cultural materials were downslope wash from the onshore Neolithic site, or were in situ materials from an underwater extension of the site.

Pot shards from the excavated portion of the onshore site which had been exposed to weathering and transport for only a few years were compared to the shards from the core sample. The marked angularity of the shards from the core in comparison to the shards from the onshore site indicates that the material from the core had been subjected to very little or no weathering and, therefore, was probably in situ.

Dr. Gifford's work has several important applications to the Gulf of Mexico. First, it establishes the presence of a preserved in situ cultural deposit in a bay fill situation. Second, the location of the site was predictable based on paleogeographic reconstruction and information provided by high resolution shallow seismic data. Third, the coring apparatus and methodology used are applicable in certain areas of the Gulf (depending on water depth and bottom sediment type). Fourth, the amount of site material and site information obtainable in a core-sized sample from a site buried by 5.5 m of sediment was demonstrated.

THE QUANTITATIVE ANALYSIS OF SOIL PHOSPHATE

Dr. William Woods
Southern Illinois University

Dr. Woods' paper detailed his work with geochemical analysis of soil samples in locating and evaluating terrestrial archaeological sites. This analysis is particularly useful in intrasite delineation or in locating sites with no surface expression. Although many soil components are evaluated, phosphate is one of the most useful indicators of cultural deposits because it is always present in high concentrations in areas utilized by humans, and because of its physical and chemical stability. Dr. Woods gave many examples of the success of geochemical analysis in delineating sites, distinguishing functional areas within a site, and determining site type. Experimental use of phosphate levels in estimating site population densities through time was also discussed.

The group discussed the possibility of using soil phosphate levels to locate buried sites on the OCS. Members of the group asked about the cost of obtaining soil samples. Dr. Woods indicated that the cost of lab analysis for a full battery of geochemical tests is only about $20 a sample, but the cost of collecting the samples offshore runs about $10 per foot, plus shiptime at about $6,000 per day. The question was then raised as to whether existing soil borings, collected by industry, could be used. Another question concerned the condition of the uppermost levels of deep soil borings, and whether sufficient stratigraphy would be preserved to permit archaeological analysis. The group agreed that these questions would have to be explored.

A second line of questioning was whether the results of the geochemical tests of terrestrial sites would apply to sites subjected to marine inundation. What would be the effect of the high phosphate levels of seawater on the use of phosphate levels as a site indicator? Dr. Woods stated that although the natural soil phosphate levels on the OCS may be high, they would result in a uniformly high background level from which even higher concentrations associated with cultural deposits could be distinguished.

Dr. Gagliano suggested that comparative core analysis be undertaken to determine the effects of saltwater inundation on the geochemical test results.

MANAGEMENT STRATEGY FOR HISTORIC SITES ON THE OCS

Ms. Melanie Stright
MMS, Gulf of Mexico OCS Region

As an introduction to the historic session, Ms. Stright briefly outlined MMS's management strategy for shipwrecks in the Gulf of Mexico.

The 1977 cultural resources baseline study for the northern Gulf of Mexico proposed a series of management zones having different probabilities for the occurrence of significant cultural resources on the OCS. Zone 1, closest to the shoreline, has a high probability for the occurrence of historic shipwrecks. Within this zone, MMS requires that a remote sensing survey be conducted at 150 m line spacing prior to development of a lease area, or as a condition of inter-lease pipeline permits.

The two principal instruments for shipwreck detection are the magnetometer and the side-scan sonar. At 150 m linespacing the magnetometer gives about 25 to 30% coverage of the seafloor which constitutes only a sampling survey. At this linespacing, however, side-scan sonar can cover well over 100% of the seafloor, with good resolution.

Conducting surveys at 150 m line spacing for the protection of historic shipwrecks is based on the premise that avoidance of all unidentified magnetic anomalies and side-scan contacts recorded within a survey area will result in the avoidance, and therefore the protection, of historically significant shipwrecks. This assumes either that all parts of a shipwreck are ferromagnetic and would be recorded by the magnetometer, or that all nonferromagnetic parts of a wreck would be evident on the side-scan records. Neither is necessarily the case.

In areas with a relatively hard bottom or in areas with only a thin veneer of unconsolidated sediments, it is probable that there would be some evidence on the side-scan sonar records of any shipwreck within the survey area. However, over large portions of the Gulf of Mexico, the thickness of unconsolidated sediments is sufficient to completely conceal debris from most pre-20th century wrecks of wooden or composite construction. The primary instrument for shipwreck detection in this case would be the magnetometer.

According to the results of studies conducted by the state underwater archaeologists for Texas and North Carolina, at 150 m linespacing it is possible to pass by an historically significant shipwreck with no indication whatsoever on the magnetometer record.

In addition to these survey limitations, Ms. Stright indicated that in areas where the magnetometer is the principal instrument for shipwreck detections, the 25 to 30% coverage does not allow any definitive statements concerning patterning of anomalies, or distinctions between modern debris and probable shipwrecks. These limitations result in recommendations for identification or avoidance of numerous anomaly locations. Ms. Stright concluded by stating that very little further investigation of unidentified anomalies is undertaken. Industry generally prefers to avoid the anomaly locations when developing their leases.

NATIONAL PARK SERVICE: MANAGEMENT OF SHIPWRECK SITES

Dr. Daniel Lanihan
Submerged Cultural Resources Unit, Santa Fe, NM

Dr. Lanihan discussed the management strategy for shipwreck sites in areas under National Park Service jurisdiction. Approximately 23 of the 45 submerged resource areas under Park Service jursidiction have potential for shipwrecks. These areas are actively inventoried by the Park Service. A key concept in the inventory of these resources is the identification of all unidentified anomalies recorded during the survey, with as little time lapse as possible. This provides immediate positive feedback into the system for the dollars spent.

The second major concept in the National Park Service's management of shipwreck sites is maximum data retrieval with minimum disturbance of the resource. This reflects both the emphasis on conservation of the resource and the third major management concept: interpretation of the resource for the public.

The smaller, well defined areas of National Park Service jurisdiction on the OCS make intensive survey techniques more practical. The fact that the Park Service also owns the resources within these well-defined areas makes protection of the resource possible.

Using the example of the Liberty ship, Dr. Lanihan stressed how rapidly we are losing our nation's maritime heritage and how important conservation and management of this resource is. During World War II, the Liberty ship was mass produced from identical plans. Today, only one unmodified example of the Liberty ship remains.

Even with the major differences in the management situations between the National Park Service and Minerals Management Service, Dr. Lanihan believes that the combined management of natural and cultural resources is an optimal and workable management strategy for both agencies.

CULTURAL RESOURCE MANAGEMENT FACTORS FOR THE OCS

J. Barto Arnold III
Texas Antiquities Committee
Austin, TX

Two significant government funded studies have appeared since the last Information Transfer Meeting, in 1981: "Sedimentary Studies of Prehistoric Archeological Sites" by Gagliano et al. (1982) and "An Assessment of Cultural Resource Surveys on the Outer Continental Shelf" by Ruppe (1982). These reports contain many suggested improvements which deserve support. Actual cultural resource management practices remain much the same, however. The recent reorganization of the Outer Continental Shelf (OCS) Offices under the Minerals Management Service represents an opportunity to make improvements in the management realm. A few suggestions regarding that topic are presented herein. Topics to be covered include line spacing, the relevance of the lack of side-scan sonar targets, archaeologists on federal agency staffs, archiving survey data, dissemination of reports, historic shipwreck management factors, and the need for ground truth studies.

Line spacing for the survey coverage on the OCS has been a perennial topic of discussion. It is now widely acknowledged that the 150 m line spacing used for years is not to be considered "complete" coverage, but only a sample relative to magnetometer data. An example comes from magnetometer data from a survey in Texas (Arnold 1979, 1980a, and In Press) from two tracks spaced at 100 m. The magnetometer data showed small anomalies on the order of 3 and 7 gammas. When these were ground truthed, over 1550 gammas were measured at the anomaly's center. The measurement of 1550 gammas was made at least 40 feet vertically above the target. This demonstrates the sampling nature of the 150 m line spacing. At 150 m this anomaly could have been missed altogether. The 300 m line spacing some propose would be a small sample indeed. Even so, a small, area-wide sample might be acceptable if a close-grained survey, on the order of 50 m line spacing, were performed in the more limited area where actual bottom disturbance is to take place. The matter of carefully controlling the distance of the magnetometer sensor from the bottom is of importance as well. A maximum of 30 feet for this distance would be ideal.

Apparently there are those who advocate the belief that if there is no side-scan sonar target then there is no wreck. The idea is that side-scan sonar survey tracks can be spaced much wider than magnetometer survey tracts and still obtain complete coverage. However, in ground truthing 47 significant anomalies in Texas waters, only six cases, or about 13%, showed any debris protruding above the bottom (Arnold 1976, 1977, 1978a, 1979, and In Press). Of course there would be no side-scan target if there is no debris standing proud of the sediments.

Returning to more mundane cultural resource management matters, let us consider the matter of qualified archaeologists on the staffs of the federal agencies involved in monitoring the OCS cultural resource program. It is absolutely essential that the number of archaeologists in the OCS offices and especially in the agency headquarters offices be increased. The few archaeologists currently employed in this capacity are greatly overworked and must often be loaned to other offices which have no archaeologist at all. One of the Minerals Management Service's new management guidelines calls for non-archaeologists to review data and reports resulting from the OCS cultural resource program. This can in no way be considered an adequate execution of the agency's responsibilities to protect cultural resources.

The archiving of the strip chart records or copies of those records is another area of concern. With each report on cultural resources to the MMS should come either the original data or a complete copy in some acceptable format. If these data are to be of use in the future for further study or synthesis, the data must be permanently archived in the same way that other archaeological collections are curated.

Regarding the archaeological reports generated by the OCS program, publication or other dissemination is a major problem. There has been some concern about the quality of many of these reports. This might be in part a self-correcting situation if MMS required that the reports be published. At an absolute minimum, copies should go to the National Technical Information Service, the relevant State Historic Preservation Office, State Archaeologist and/or State Marine Archaeologist, and perhaps the State Archives or a major state university library. In fact, an effort on the part of MMS to assemble microfilm or other copies of the backlog now on file and have them appropriately distributed should be a high priority and would correct a major deficiency in the program.

Historic shipwrecks present several management problems. The U.S. urgently needs a law asserting sovereign prerogative or ownership of historic shipwrecks in federally controlled waters (Arnold 1978b, 1982). This would remove such sites from the jurisdiction of admiralty salvage law, the law which has enabled commercial treasure hunters to pile up a dramatic string of court victories over the historic preservation interests of the state and federal government. Additionally, the compilation of a central historic wreck reference file complemented by a file of the anomalies already located through the OCS program would provide much needed management tools (Arnold 1980b).

Finally, ground truthing studies on anomalies located and simply avoided by industry during the OCS program should be a high priority. The MMS has a responsibility to find out what it is protecing. A sample of promising anomalies should be investigated and their causes identified.

The above represents a brief summary of a series of complex and convoluted factors related to the OCS cultural resource managment program. It is not an all inclusive list, but implementing these suggestions would significantly improve the situation.

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SPATIAL MAGNETICS OF SHIPWRECKS

Mr. Alan Saltus, Archaeological Consultant,
Prairieville, LA

Mr. Saltus reported on the results of numerous magnetometer surveys which he has conducted over the past several years. Although side-scan data may complement magnetometer data in shipwreck detection, Saltus identified two problems with side-scan data. First, these data are inconclusive in defining natural vs. cultural features. Second, there are problems with maintaining record quality through time. These factors make the side-scan less desirable than the magnetometer as an instrument for shipwreck detection.

Most of the surveys conducted by Mr. Saltus were at 70-foot line spacing. Positioning capabilities were excellent, allowing a diver to be put down within 2 m of a target. Average results showed a 90% find rate of objects causing the anomalies.

The major point made by Mr. Saltus was that of 11 wrecks located, dating from the 16th to the 20th century, the largest area of magnetic disturbance caused by wreck debris was 130 by 150 m. Thus, the 150 m line spacing required for surveys on the OCS for the detection of shipwrecks could, theoretically, completely miss all 11 wrecks. Should one survey line cross such a wreck, the only evidence of the wreck may be a 5 to 10 gamma anomaly. These findings put into proper perspective the discussion of anomaly clusters and random versus non-random distributions of anomalies from surveys at 150 m line spacing.

SESSION: TOPOGRAPHIC FEATURES DATA SYNTHESIS
Chairman: Dr. Robert Rogers
Scribe: Mr. Charles Hill
Date: August 25, 1982

Presentation Title	Speaker/Affiliation
Application of the Topographic Features Studies Series to Biological Resources Protection	Dr. Robert Rogers, MMS Gulf of Mexico OCS Region
Interrelationships Among Geological, Physical, and Biological Processes Related to the Nepheloid Layer at OCS Banks	Dr. William Merrell, Dr. Tom Bright, Dr. David McGrail, and Dr. Richard Rezak, Texas A&M

APPLICATION OF THE TOPOGRAPHIC FEATURES STUDIES SERIES TO BIOLOGICAL RESOURCE PROTECTION

Dr. Robert Rogers
MMS, Gulf of Mexico OCS Region

Since 1974, Texas A&M University has been contracted by the MMS to investigate potentially sensitive topographic features on the OCS. Through a series of five contracts, investigators have located and mapped features of significant relief, characterized community zonations through geological and biological surveillance, and described current and sediment movement in the vicinity of the banks. The East and West Flower Garden Banks have received particular attention due to the presence of extensive reef-building corals and their potential sensitivity to nearby oil and gas operations. Biological monitoring at the Flower Garden Banks has produced a better understanding of community processes and of unique features such as the high salinity brine seep.

This environmental information has contributed to the development of lease stipulations associated with oil and gas leasing. In any biologically sensitive area, the potential for damage exists for smothering of organisms from drill muds and cuttings, reduced photosynthesis from increased turbidity, toxic effects from petroleum products and trace metals, and direct mechanical damage from drilling or anchoring. To avoid such adverse effects, a number of measures may be adopted to protect the biota. These measures include the relocation of operations, shunting or transportation of fluids and cuttings away from the area, and monitoring of areas to assess the adequacy of mitigation measures and the impact of drilling activities. Mapping information and community delineations gathered from this studies series have been used extensively in the implementation of such mitigating measures to topographic features on the OCS.

For full utilization of information previously gathered under topographic features study contracts, a synthesis and integration of data is presently being carried out. This contract is scheduled to continue to 1983, with a final report due in May. The synthesis effort emphasizes processes and trends among the submarine banks. Discussions during the Information Transfer Meeting emphasized recent trends of interest uncovered as the existing information is analyzed.

INTERRELATIONSHIPS AMONG GEOLOGICAL, PHYSICAL, AND BIOLOGICAL PROCESSES RELATED TO THE NEPHELOID LAYER AT OCS BANKS

Background and Geological Factors

Dr. Richard Rezak

Relief is a major factor affecting sediments, currents, and biota at OCS banks. Salt tectonics (doming), sea level changes, biological

activity, or any combination of these produce relief. Doming creates relief that steers currents, increases current velocity, and winnows fine sediments, leaving a lag of coarse sediment which permits the growth of benthic calcareous organisms. These serve as substrates for larger calcareous organisms, and the continuing process can raise the bank well above the level of turbid water--the nepheloid layer. Similarly, a rise in sea level submerges bedrock and allows it to be populated by reef-building organisms. If the rate is slow enough, these organisms can create a large structure. Otherwise, they become drowned reefs populated by deep water assemblages. Once biological activity begins, the reef will grow upward and outward until encountering such limiting factors as low tide level, low temperatures, or excessive turbidity.

At the base of banks, the nepheloid layer creates a transition zone between sediments associated with reef-building organisms (carbonate sediment) and muds associated with the OCS (terrigenous sediments). Carbonate sediment facies are controlled by the biotic assemblages present and are therefore directly related to biological depth zonation. Terrigenous sediments come from the outflow of major streams entering the Gulf and are transported by currents in the nepheloid layer. In the transition zone at banks, carbonate and terrigenous sediments are mixed.

The availability of fine sediments (mud) at a bank controls the density of the nepheloid layer. At high relief banks like Geyer, less fine sediment is available over much of the bank than at low relief banks like Coffee Lump. High relief, therefore, means that more of the bank is above the level affected by the nepheloid layer.

Physical and Sedimentary Factors Affecting the Nepheloid Layer

Dr. David W. McGrail

These studies of the nepheloid layer are based on vertical profiles of transmissivity, velocity, and density distribution at various OCS banks; time series velocity, temperature, and transmissivity data from moored instruments in the Flower Garden Banks region; dye studies in the boundary layer at the Flower Garden Banks; and side-scan sonographs of the Flower Gardens Banks.

The term "nepheloid layer" describes a layer of turbid water composed of suspended matter (sedimentary and biogenic). In this study, the nature and presence of this turbid layer has been measured in terms of transmissivity (XMS), a measurement of percent light transmitted through the water column over a given path length. A reading of about 46%/m on an L.E.D. transmissometer with a 25 cm pathlength usually signals the presence of a nepheloid layer.

Nepheloid layers may be derived from local resuspension (this occurs only near the bottom), advected resuspension, or both. At the Flower Garden Banks, advected resuspension never occurs more than about 20 m from the bottom. A strong nepheloid layer is usually found at the

base of banks because more fine sediment (silt and clay) is available in this substrate. Above 20 m from the bottom at the Flower Garden Banks, currents winnow fine sediments and there will be no nepheloid layer, though currents may be strong. No correlation has been found between current velocities and transmissivity values from moored arrays, except at low frequencies. Correlation of transmissivity with velocity at low frequencies suggests that the source of suspended matter is not local, but is advected. This drop in transmissivity is related to doming in the nepheloid layer, not to increased local resuspension.

Measurements from a cross-shelf transect indicate westerly flow on the shelf inshore of about 70 m, and easterly flow offshore of about 70 m, with a convergence midway and at the shelf edge. The nepheloid layer bulges upward at these convergences. The correlation of transmissivity with low speed reversals probably reflects migration of the convergences with changes in shelf circulation or changes in location of the front. A well-defined nepheloid layer extending well off the bottom would engulf low relief banks. A plume of sediment extending across the shelf break was identified. This plume would affect even deep shelf-edge banks like Geyer.

Biotic and sediment zones at the East Flower Garden Bank reflect flow patterns and dependence on the nepheloid layer. The nepheloid layer causes a decrease in light penetration and an increase in sediment loading. These effects increase with increasing sediment load. Above 80 m the nepheloid layer is so diffuse and velocities so great that no silt and clay are deposited and light can therefore penetrate.

Quantitative Analysis of Benthic Populations

Dr. Thomas J. Bright

Bray-Curtis cluster analysis of taxon-relative abundance characteristics of quasi-quantitative data derived from visual assessment of benthic invertebrate and plant assemblages on Outer Continental Shelf hard-banks in the northwestern Gulf of Mexico indicate that:

1. Discrete, depth-related, assemblages exist on the banks.

2. The banks are biologically separable into three groups (South Texas Carbonate Banks, Mid-Shelf Siltstone Banks, and North Texas-Louisiana Shelf-Edge Carbonate Banks).

3. Within the North Texas-Louisiana Shelf-Edge Carbonate Bank group, biotic assemblages dominated by coralline algae tend to extend to deeper depths on those banks having greater base depths (surrounded by deeper water).

The last observation (3) is supported by statistical trend analysis, and is thought to result from a decrease in available light due to bottom nepheloid layers around the bases of the banks. Where a bank's base is relatively shallow, peripheral bottom turbidity may limit both the depth to which coralline algae extend on the bank, and their population levels.

SESSION: OXYGEN DEPLETION ON THE OCS
Chairman: Mr. J. Ken Adams
Scribe: Dr. Richard Defenbaugh
Date: August 25, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Mr. J. Ken Adams U.S. Fish & Wildlife Service
Oxygen Depletion as Influenced by the Mississippi River Outflow	Mr. Tony Drake U.S. Army Corps of Engineers
Oxygen Concentration and Plankton Respiration in the Mississippi River Delta Bight	Dr. R.E. Turner, LSU Center for Wetland Resources
Observations of Oxygen Depletion in Louisiana Offshore Waters	Ms. Karen Foote Louisiana Wildlife and Fisheries
Coastal Anoxia in the Northern Gulf of Mexico	Dr. Warren Stuntz NOAA/NMFS/SEAMAP
Some Causes and Effects of Oxygen Depletion on the Benthic Biota of the Upper Texas Coast	Dr. Don Harper and Larry D. McKinney Texas A&M Marine Laboratory
Physical Processes which may Impact the Oxygen Depletion Zone over the Louisiana Shelf	Dr. William J. Wiseman, Jr., LSU, Coastal Studies Institute
Causes and Effects of Shelf Oxygen Depletion: Lessons from the 1976 New York Bight Episode	Dr. Donald Boesch, LUMCON
Defining and Obtaining Management Information Related to Oxygen Depletion	Dr. Benny Gallaway LGL, Inc.

SESSION SUMMARY

J. Ken Adams
U.S. Fish and Wildlife Service, Slidell, LA

Seasonal oxygen depletion has been known to occur on the Texas-Louisiana continental shelf since the early 1930's. Whether or not it is increasing in severity and areal extent is unknown. The purpose of this session was to present recent observations and stimulate discussion regarding the importance of this phenomenon to resource management, regulatory, and development agencies.

The nearshore continental shelf environment west of the Mississippi River Delta can be characterized as a special-case estuarine ecosystem. Factors which are correlated with river discharge--such as extreme vertical density stratification, the organic content of suspended sediment, and nutrient enrichment with a resulting large plankton standing crop--all lead to the potential for oxygen depletion of bottom waters with the resultant mass mortality of benthic organisms.

As a group, the eight speakers who participated in this session addressed all of these factors in a very professional and scientific manner. The information provided characterized the Mississippi River discharge as high in suspended sediment, dissolved oxygen, and nutrients. This freshwater input forms a cap over the shelf, thus reducing turbulent mixing and aeration of bottom waters. Channel development activities were projected to increase velocities in Southwest Pass, leading to greater penetration of direct freshwater flows over the shelf and altered patterns of suspended sediment dispersion.

Several speakers presented observations of bottom water oxygen concentrations below the critical level of 2 mg/l. To summarize, oxygen depletion is known to occur from just west of the Mississippi River Delta to Freeport, Texas, inshore of the 20 m isobath, predominantly in late summer, with the areal extent varying from year to year.

Opinions were expressed concerning the source of oxygen-demanding material. In general, this is thought to be labile organic material composed of plankton and plankton degradation products which settle into the benthic boundary layer. Impingement of a deep-water oxygen minimum layer onto the shelf was not considered to be a major contributing factor.

The effects of oxygen depletion were graphically described for an incident offshore Freeport, Texas, in which dead and moribund macrobenthic organisms were directly observed. The nearshore benthic community demonstrated a two-year recovery period to regain normal species composition. More generally, oxygen depletion was hypothesized to be a major contributing factor to fluctuations in shrimp landings and anomalous migration patterns for brown shrimp on the Texas-Louisiana shelf.

Thus, oxygen depletion is currently thought to be a major environmental problem which has received remarkably little scientific or public attention. The need has now been recognized for a research program which would provide:

1. a more comprehensive delineation of the temporal and spatial extent of the problem, and

2. an understanding of the functional ecosystem processes controlling it.

The first step of this research program should be a modeling workshop to define specific information needs. This approach would be efficient in focusing the efforts of state and federal agencies who must be concerned with the effects of oxygen depletion on the accomplishment of their widely divergent mandates for resource management, regulation, and development.

OXYGEN DEPLETION AS INFLUENCED BY THE MISSISSIPPI RIVER OUTFLOW

Mr. Tony Drake, U.S. Army Corps of Engineers

This paper characterized the lower Mississippi River with respect to oxygenation and reoxygenation, reviewed historical and future trends, described effects of dredging, and outlined the Corps of Engineers project to deepen and make other navigational improvements to the river. Conclusions as to the possible effects of this project and conclusive chemical/biochemical analysis of the water cannot be made until further information on the interaction of physical and chemical forces is gathered. Samples are chiefly from the Venice, Louisiana gauging station.

Results of Sample Analysis

Observed parameter levels for the 1973-1982 period were compared and evaluated on the basis of known patterns of natural and artificial pollutant inputs. Only water temperature was shown to have a consistent influence on dissolved oxygen (DO) levels at Venice. Statistical comparisons of DO with other parameters (biochemical oxygen demand, chemical oxygen demand, and total organic carbon) were quite poor. The data indicate that the river is well-equipped by nature to assimilate the high loadings of oxygen-demanding wastes that it receives. Only during low-flow and high-temperature periods does there appear to be reasonable risk of oxygen deficits. These would probably be restricted closely to the time and place of abnormally high waste loadings or spills.

Historical and Future Trends

Historical and anticipated future trends were briefly considered. Changes in land-use patterns and construction of navigation and flood

control improvements in the basin have effected a decrease in total sediment loads by the Mississippi River and its tributaries in recent decades. Nevertheless, indications have been that the river's ability to effectively dilute and neutralize pollutant loadings has not diminished. Although industrial waste production has increased since the 1960's, improved treatment practices have produced lower levels of toxic substances in the river.

Effects of Dredging

The particular effects of dredging and dredged material disposal were discussed. Monitoring during both dredging and non-dredging periods was conducted in the lower Mississippi River and its distributaries in 1976 and 1977. In each case, little or no change in organic or other pollutant loading was observed in the water column at and downstream of the dredging and/or disposal site.

Corps of Engineers Project

The plan of the Corps of Engineers for deepening the river and Southwest Pass to 55 feet, along with other navigational improvements, was outlined. The ways in which these changes in the lower river's flow and sediment transport regime would be altered were then related to processes known to occur in the receiving waters of the Gulf of Mexico. Although impacts to the Gulf of Mexico's dissolved oxygen regime are difficult to predict with present knowledge, some of the pathways by which changes might be effected were presented. The most important physical changes that these projects will produce with respect to the Gulf of Mexico appear to be:

1. increased velocities in the Southwest Pass, leading to greater penetration of direct freshwater flows into the Gulf;

2. altered patterns of sediment transport (suspended and bed loads) into the Gulf; and

3. altered patterns of lateral outflow into the Gulf.

Need for Future Study

Until the prevailing deltaic sedimentation regime is much better understood, one cannot reliably assess riverine influences under existing or project conditions. With regard to the marine ecosystem, it would be difficult at this time to predict whether such a project would have a net adverse or beneficial influence. In the absence of firm conclusions about the nature and degree of impacts, there is a need for further scientific study of the interrelationships of riverine and marine physicochemical and biological phenomena in the western Gulf of Mexico continental shelf area.

OXYGEN CONCENTRATION AND PLANKTON RESPIRATION IN THE MISSISSIPPI RIVER DELTA BIGHT

R. Eugene Turner and Robert L. Allen
Center for Wetland Resources
Louisiana State University

Bottom oxygen concentrations on seven cruises within the Mississippi River Delta Bight (MRDB) are observed to be commonly below complete saturation. Hypoxic conditions (less than 3 mg/l) most often occur in shallow depths, west of the delta, during summer. The hypoxic layer may be only a few metres thick and located near the bottom. An unusual midwater oxygen-depleted zone was observed south of Mobile Bay during July. The oxygen-minimum layer from deep water in the Gulf of Mexico may connect with low oxygen zones at the shelf break.

Community plankton respiration (CPR) rates in the bottom waters of the MRDB ranged from 0.12 to 8 mg oxygen/m^3/hr in July and in November 1976. Mean values were similar on both cruises, and between east and west halves of the delta in July. The observed rates are high enough to significantly influence and possibly dominate factors influencing bottom water oxygen concentrations, although benthic oxygen demand is also a major additional factor. The role of suspended sediments in driving variations in average CPR rates appears to be of minor importance since equal rates occurred in areas with and without a nepheloid layer. In July, CPR was correlated with variations in chlorophyll *a* concentrations, thus indicating that phytoplankton sinking is probably a major factor determining regional variations in CPR. Lack of vertical mixing due to stratification also probably contributes to hypoxic summer conditions.

OBSERVATIONS OF OXYGEN DEPLETION IN LOUISIANA OFFSHORE WATERS

Karen Foote
Office of Coastal and Marine Resources
Louisiana Dept. of Wildlife and Fisheries

Low dissolved oxygen concentrations were found yearly in Louisiana offshore waters from 1978 through 1982. Samples were taken from the coastline to 20 fathoms between Grand Terre Island and Timbalier Island. Concentrations of dissolved oxygen $\leq$ 2 mg/l were found in July and September 1978; June, July, August, and November 1979; June, July, and August 1980; May through October 1981; and May through August 1982.

Catches of demersal nekton, near-bottom zooplankton and benthos, were significantly lower during periods of low bottom dissolved oxygen. The relationships of seasonality and salinity stratification to bottom dissolved oxygen concentration were shown in an empirical model developed by step-wise multiple regression with log-log transformed water chemistry and temperature data. Bottom dissolved oxygen concentration

was inversely related to water temperature, conductivity, the difference between bottom and surface salinities, and concentrations of ammonium, orthophosphate, and silicates.

COASTAL ANOXIA IN THE NORTHERN GULF OF MEXICO

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A large area of low oxygen was found along the coast of Louisiana in June and July of 1982. The anoxia was restricted to the bottom waters in depths from 46 m shoreward. Samples were not taken inside of 9 m, nor west of 91°30.1'W, so the shoreward extent and the westward length of the anoxia was not determined.

Bottom trawl samples were taken at each of the stations. In areas where the oxygen levels were less than 2 ppm, the catches of fish were very low and were made up mostly of pelagic species. No commercial shrimp were taken in the low oxygen areas. Other invertebrates were also in low numbers as compared to areas having more than 2 ppm of oxygen.

The area in which the low oxygen occurred was observed via satellite during the sampling period. Water temperatures were very high in the area, which may indicate an area where circulation is limited, at least during some periods. The biological implications of this situation are of considerable interest, due largely to the potential impacts on the commercial shrimp species.

CAUSES AND EFFECTS OF OXYGEN DEPLETION ON THE BENTHIC BIOTA OF THE UPPER TEXAS COAST

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Hypoxia occurring in June 1979 at two sites off Freeport, Texas caused extensive mortalities of soft-bottom and hard-bottom organisms. Events of this kind, which appear to occur nearly annually off the Louisiana coast, indicate a need for monitoring leading to predictive modelling. Ability to predict hypoxia would greatly benefit the fisheries economy of the northern Gulf.

Sampling

Beginning in September 1977, benthic samples were collected from a nearshore site (8 km offshore) and an offshore site (19 km offshore) off Freeport, Texas. The nearshore site was in 15 m of water and had a mud bottom, while the offshore site was in 21 m of water and had a muddy sand bottom. Benthic assemblages at the two areas were dissimi-

lar in terms of composition and total abundance, but displayed relatively uniform seasonal trends, most of the time.

Hypoxic Bottom Water Event

In June 1979, the interaction of several biological and abiotic conditions resulted in the bottom of the water column becoming hypoxic (dissolved oxygen < 2.0 ppm). Abiotic conditions preceding hypoxia included a strong halocline at 10 m depth produced by large-volume discharges of the Mississippi-Atchafalaya River system and local rivers, increased nutrient concentrations, and intensified thermal-haline stratification caused by a three-week period of relatively calm weather. Evidence suggests that decline and decay of a phytoplankton bloom was the principal biological agent responsible for hypoxia, while decay of killed benthic organisms was a secondary cause. The hypoxia apparently began nearshore and spread offshore. It persisted until late July 1979, when storm waves from Tropical Storm Claudette disrupted the thermocline-halocline that prevented overturn. Reoxygenation of bottom water began inshore and progressed offshore.

Hypoxia and/or decay-generated hydrogen sulfide caused extensive mortalities of both soft-bottom organisms in the study areas and hard-bottom benthos on a small reef-like lump between the two areas. Nektonic species apparently abandoned hypoxic waters for more oxygenated areas: virtually no fish or shrimp were collected along a transect between depths of 9 and 45 m, and commercial catches decreased along the Texas coast from Sabine Pass to Matagorda Bay. After hypoxia abated, the deeper, offshore assemblage appeared to be relatively normal within six months, while the nearshore site required about two years to return to normal.

Need for Predictive Modeling

It is recommended that a concerted efort be made to develop a method of predicting both the occurrence and extent of hypoxia, particularly off the Louisiana coast, where hypoxia appears to occur nearly annually. The ability to predict hypoxia would be of great benefit to the fisheries economy of the northern Gulf. First, if commercial fishermen knew where hypoxia occurs, they would not waste valuable fuel and time trawling and fishing where nothing would be caught. Second, fisheries management personnel might benefit by being able to more accurately estimate potential catch from affected areas and economic effects.

Recommended Study Plan

Such a study should be multi-disciplinary and synoptic. Samples should be collected at least monthly before and during the hypoxia-susceptible period, and at least quarterly when hypoxia is least likely to occur. Factors most likely involved in causing hypoxia should be studied intensively. These include freshwater discharge, nutrient load, temperature and/or salinity stratification, phytoplankton densi-

ties, and weather conditions. Extent, duration, and effects of hypoxia should be determined by studying distribution of dissolved oxygen (DO), nekton, and benthos. Predictive ability is likely to improve markedly with a multi-year study. There is probably more than one single cause, or hypoxia may be caused by synergistic effects of two or more of a number of potential causes.

To minimize costs, scientific cruises should be limited in scope and should collect samples along transects through areas most susceptible to hypoxia. The program would be greatly enhanced if commercial fishermen assisted in data collection. Fishing boats equipped with water samplers and Hach DO kits could monitor bottom water DO concentrations over a much greater area than scientists alone could hope to cover. Oxygen data, with LORAN coordinates, could be transmitted to a central receiving location and plotted on a chart.

After data have been collected for several years, it should be possible to define the variables causing hypoxia. From this information, a model could be constructed. Thereafter, routine monitoring of important variables would provide data to be plugged into the model, which would estimate both the probability of occurrence and areal extent of hypoxia.

PHYSICAL PROCESSES WHICH MAY IMPACT THE OXYGEN DEPLETION ZONE OVER THE LOUISIANA SHELF

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To date, there is no clearly demonstrated relationship between physical processes on the Louisiana shelf and the oxygen depletion zone found in the same region. One can, though, speculate about quite plausible interactions. Any process which provides a source of carbon for the inner shelf waters, or which isolates these waters from processes which renew the dissolved oxygen concentration, will contribute to an oxygen depletion zone. Three such mechanisms have been observed in the Louisiana Bight, the area immediately west of the Mississippi River Delta.

The effluent from the Mississippi River flows westward over the mid and inner shelf. Organic detritus which sinks from this plume will tend to lower dissolved oxygen concentrations in the near-bottom waters as the detritus is reduced. Furthermore, the suspended sediment in the plume will reduce the amount of incoming radiation reaching the bottom waters with a resultant reduction in oxygen production by photosynthesis. Most important, though, is the strong stability of the water column due to the haline stratification associated with the plume. This isolates the bottom waters from direct mixing with surface waters and oxygen renewal by air/sea interaction. It also isolates the bottom

waters from direct momentum exchange with the atmosphere. The deeper waters, thus, move much more sluggishly than the surface waters.

A second process which may be important is the intrusion of high salinity water along the bottom from farther offshore. During both years when we have adequate data to resolve the bottom salinity field, we find a significant summertime intrusion of water with salinities higher than 36 ppt onto the inner shelf. This water sets up a near-bottom pycnocline which tends to isolate the deeper waters from the overlaying waters. Current measurements across this halocline show that it has a strong effect on current speed and direction. Current direction is reversed, suggesting strong baroclinic effects, and speeds are reduced, presumably due to frictional dissipation near the bottom.

Finally, a well-mixed bottom layer has often been found throughout the Lousiana Bight. It varies in thickness from 1 to 10 m and is capped by a significant pycnocline. No explanation for either the temporal or spatial variations of the characteristics of the layer has been determined. The presence of this boundary layer, though, isolates near-bottom waters from overlying waters which may be richer in dissolved oxygen. Motion within this layer is responsible for the resuspension of organic bottom sediments. It would seem that an understanding of the dynamics of this benthic boundary layer would be a fruitful area of research in any effort to understand the dynamics of the oxygen depletion zone.

CAUSES AND EFFECTS OF SHELF OXYGEN DEPLETION: LESSONS FROM THE 1976 NEW YORK BIGHT EPISODE

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Severe depletion of dissolved oxygen in open continental shelf waters is known from only very few areas in the world, mostly regions of pronounced coastal upwelling. Hypoxic or anoxic bottom water on the inner shelf of the north-central Gulf of Mexico is apparently a regular occurrence, although it is scarcely reported in the formal literature and has been little studied. Unusual and widespread oxygen depletion of bottom waters in the New York Bight occurred during the summer of 1976 and was relatively well studied because of the substantial ongoing research programs in the area. The findings of these studies are reviewed with regard to the environmental conditions and biological phenomena which caused oxygen depletion and resulting effects on benthic organisms.

Warmer than usual sea-surface temperatures in the New York Bight during the winter of 1976 resulted in early, strong vertical stratification, which was maintained by the relative lack of storms. In addition, unusual and persistent south to southwesterly winds resulted in current reversals and unusually long residence times of bottom water. A dense and widely distributed bloom of the large dinoflagellate

Ceratium tripos developed concomitant with these conditions for, as yet, unknown reasons. This primary production went largely ungrazed by zooplankton and resulted in the accumulation of large quantities of particulate organic carbon which ultimately sank below the pycnocline and, on decomposition, consumed most of the dissolved oxygen in the isolated bottom waters off New Jersey. Evidence did not indicate that the bloom conditions were directly related to waste discharges or to river inputs.

In the most severely affected areas, dissolved oxygen levels were nil, and free sulfide was found in the water column for a period of weeks. Mass mortalities of benthic crustaceans and echinoderms resulted. Metabolically active molluscs, including the commercially important surf clam, Spisula solidissima were killed (over 60% of biomass off New Jersey was lost). Some molluscs that adapted to withstand low dissolved oxygen levels (e.g., Astarte castanea) survived. Annelid species also showed different degrees of susceptibility. Subsequent recruitment and community dynamics of the benthos were influenced by: 1) dispersal mechanisms (species with planktonic larvae quickly recolonized; those without pelagic dispersal did not return for, in some cases, four or more years); 2) relaxed predation pressure; 3) organic enrichment resulting from the bloom; and 4) establishment of dense populations of tubicolous animals.

Development of hypoxia in continental shelf waters depends on 1) intense stratification which reduces eddy diffusivity, and consequently, oxygenation of bottom waters, and 2) an ample supply of labile organic material resulting from ungrazed phytoplankton production, rather than inputs of fluvial organic material.

DEFINING AND OBTAINING MANAGEMENT INFORMATION RELATED TO OXYGEN DEPLETION

Dr. Benny J. Gallaway
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Development of hypoxic conditions off the Louisiana coast, together with some major biological changes in the northwestern Gulf, suggest the need to quantitatively define the oxygen dynamics of the shelf for the purpose of assessing impacts and planning management strategies. This paper surveys the historical data associated with changes in the Mississippi River waters, summarizes reports of hypoxia and major biological changes in Gulf water, and suggests development of an assimilative capacity model for the Texas-Louisiana shelf ecosystem through a series of modeling workshops.

Historical Background

Development of hypoxic conditions off the Louisiana coast has been suggested to be of recent origin, related to flood control development

of the Mississippi River. The construction of a flood control levee dates back to around 1717, and the river system was more or less stabilized in the 1930's. Prior to completion of the flood control system, the river flooded its banks over lateral distances of up to 50 miles. This lateral flooding allowed for sediment deposition, greatly reducing the amounts of sediments, nutrients, and organic materials carried by the river into the Gulf of Mexico.

Channeling of the river increased flow rates and reduced sediment deposition in the channel so that now large amounts of sediments, oxidizable materials, and nutrients are transported directly into the Gulf. The increased channeling has also funneled more water down the Atchafalaya River, thereby extending effects considerably west of the mouth of the Mississippi River. Collectively, these rivers comprise about 90% of the total discharged to the northwestern Gulf of Mexico, and influence surface salinities over much of the Texas-Louisiana continental shelf.

Hypoxic Bottom Layers

Hypoxic bottom layers are created during calm periods of pronounced stratification accompanied by the influx of high levels of river-borne, oxidizable organic matter, as well as nutrient loads which may stimulate primary production to a level contributing to eutrophic conditions. Conditions contributing to the establishment of hypoxia were greatly enhanced by man through modification of the Mississippi River, culminating about 1930. Aside from the occasional excursion of the oxygen-minimum layer onto the deep shelf (known since 1935), hypoxic conditions were not reported until the early 1970's. Since that time, the condition has been documented to be a recurring phenomenon offshore of Louisiana, with the intensity and extent varying from year to year.

Apparently, 1973 and 1978 were particularly severe years in terms of known biological effects. These years were characterized by high discharge. Harper (see above) provided the first report that hypoxic conditions occurred over a rather extensive area of the upper Texas coast during the spring and summer of 1979. Although perhaps only an artifact of incomplete and patchy data, these observations provide a basis for speculation that: 1) large-scale and severe hypoxia is a recent phenomenon resulting from extensive modifications and inputs of major rivers draining into the northwestern Gulf, dating from the 1930's, and 2) the severity and areal extent of hypoxia is increasing over time.

Major Biological Changes

Some major biological changes have occurred in the northwestern Gulf in recent times. These changes may or may not be in any way related to hypoxia, but deserve some mention because the animals used as examples have been historically dependent upon the shelf offshore of Louisiana for habitat.

Shrimp

Landings of white shrimp, once the dominant commercial species off Louisiana, peaked in the early 1940's at about 65,000 metric tons. Landings declined markedly in the late 1940's, and catches have fluctuated erratically since that time (e.g., 14,000 to 36,000 metric tons between 1957-1965). Regardless of the role of hypoxia (if any) in the initial decline and subsequent fluctuations, the present Louisiana landings pattern for white shrimp suggests a potential relationship between hypoxia and the catch of shrimp. Judging from comparisons of brown shrimp migration data of 1978 and 1979, it appears that migrations of brown shrimp may also be influenced by hypoxia.

Kemp's Ridley Sea Turtles

Kemp's Ridley sea turtle populations have declined markedly in recent years. Over 40,000 nesting females are known to have occurred about 20 years ago, compared to about 1000 known to occur at present. The coastal waters of Louisiana were considered an important feeding area for this bottom-feeding species, which preys upon epibenthic crustaceans and fish. Recent aerial surveys of Texas and Louisiana yielded no observations of this species offshore of Louisiana, and only two observations offshore of Texas, in the Brownsville area. Further, the number of strandings of dead turtles offshore of Louisiana and Texas has been shown to be disproportionately high.

Need for Quantitative Definition of Shelf Oxygen Dynamics

In light of the observed and documented effects of hypoxia, the veracity of the speculations presented above is almost irrelevant. Whether an historical or a recent phenomenon, hypoxia is presently a major environmental problem affecting the shelf ecosystem and one which has received little attention. Given the potential for confusion of the effects of hypoxia with those resulting from existing and/or planned developments, it would seem important that the oxygen dynamics of the shelf be quantitatively defined in a fashion enabling impact assessments and management strategies.

Although there is a rich literature concerning the Gulf of Mexico, little information describing the processes which govern the fluctuations in abundance or status of important species has been presented. Existing data and information and new studies should be viewed from the context of attempting to estimate the assimilative capacity of the Texas-Louisiana shelf.

What appears to be needed with regard to dissolved oxygen is how many increments of the total capacity are available for additional activities in light of the increments already being used by the natural system and existing activities. Even though any specific activity may require only a small increment of the total capacity of the system, and may be insignificant as compared to the demand of other activities,

only small (if any) increments may be available, at least during some seasons and conditions.

Workshops to Develop an Assimilative Capacity Model

This question probably could best be addressed by attempting to develop an assimilative capacity model for the Texas-Louisiana shelf ecosystem during the course of a series of modeling workshops. This approach has been recently used by the EPA as a tool for addressing the impacts of drilling muds and cuttings on marine systems, and has resulted in meaningful progress toward the resolution of this controversial problem.

The goals of the initial workshop would be to:

1. bound the system in time and space;

2 select indicators that would reflect the health of the system in terms perceived important (e.g., dissolved oxygen levels, shrimp population levels, benthic fauna, etc.);

3. develop process submodels describing the dynamics of each indicator; and

4. integrate the submodels to provide a system model.

As the conceptual process models for each indicator are developed and translated to mathematical models, the specific data and information needs required for making the assessments would emerge.

These needs could guide the planning of future research, insuring that all information obtained would be directly useful for environmental assessment purposes. This initially crude model could subsequently be revised and updated in a second workshop convened upon the acquisition of new data. Ultimately, through a series of information-gathering periods and modeling workshops, a good model could emerge--one with reasonable predictive capabilities.

A major advantage of this approach would be to provide a clearly defined focus for the research and monitoring programs being performed by different federal and state agencies involved in certain aspects of the problem. This would enable integration of program results at a level heretofore unachieved. Given the cutbacks in environmental research programs, focus and integration of surviving programs are badly needed.

SESSION: MARINE STUDIES
Chairman: Dr. Rezneat M. Darnell
Scribe: Ms. Gail Rainey
Date: August 25, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Ms. Gail Rainey, MMS Gulf of Mexico OCS Region
Biological Resource Mapping on the Continental Shelf	Dr. Rezneat M. Darnell Texas A&M University
Some Aspects of the Ecology of the Deep Gulf of Mexico	Dr. Willis E. Pequegant TerEco, Inc.
SEAMAP Program	Mr. Perry Thompson Gulf States Marine Fisheries Commission
An Ecosystem Model for the Northwestern Gulf of Mexico	Mr. Ken Turgeon, EDIS/NOAA
Fishery Management Council Activities	Mr. Corky Perrett Louisiana Wildlife & Fishery Commission
*Overview of Brine Disposal Monitoring	Ms. Melissa Smith U.S. Department of Energy
Brine Disposal in Texas Coastal Waters: Bryan Mound	Dr. Robert Randall Texas A&M University
Evaluation of Brine Disposal from the West Hackberry Site of the Strategic Petroleum Reserve Program	Dr. Roy Hann, Jr. and Dr. Charles P. Giammona, Texas A&M University
Brine Disposal in Louisiana Coastal Waters	Dr. Dennis Casserly McNeese State University
Marine Research by a Consulting Firm	Dr. Larry Reitsema LGL, Inc., Bryan, TX

*no abstract submitted.

SESSION SUMMARY

Ms. Gail Rainey
MMS, Gulf of Mexico OCS Region

The purpose of this workshop was to present a review of major ongoing projects which in some way expand our understanding of the Gulf of Mexico's chemical, biological, or physical properties. The program included studies or discussions either too unique or too broad to fit into any specific category and be part of another session. The presentations were as diversified as data presented were abundant and included such unrelated topics as resource mapping projects, marine fisheries related programs, and studies monitoring brine disposal activities.

In general, the talks were of two types, those describing a particular ongoing research project, or those summarizing federal, academic, or private environmental monitoring programs or management responsibilities.

The first two talks concerned biological resource mapping. Dr. Rezneat Darnell discussed his mapping work on the continental shelf, particularly his determination of seasonal distribution patterns of nine selected species on the northwest Gulf continental shelf. His work, under an IPA appointment with MMS, has distinguished biological zonations related to Gulf of Mexico depth, season, east-west geography, and substrate type. He noted high seasonal densities often occurred off the mouth of passes and major rivers, and the occurrence of a phenomenon termed "population insularization" off south Texas. A portion of the species are estuarine dependent and another portion are associated with reefs and rocks. Dr. Willis Pequegnat presented data on biological resource distributions on the slope and abyss from about 120 m to depths greater than 3,000 m. He showed a clustering of species by depths. Dr. Pequegnat presented both bottom photographs and movies showing some fascinating shots of species in their natural habitats in the ocean depths.

Two marine fisheries-related programs were discussed. Mr. Perry A. Thompson explained SEAMAP 1982 (Southeast Area Monitoring and Assessment Program). SEAMAP is a cooperative program among federal, state, and university participants designed for the collection, management, and dissemination of fishery-independent survey data and associated information in the southeast region. Current activities that are going on under SEAMAP include ichthyoplankton surveys and data transmission activities. Mr. C. Perrett of the Louisiana Wildlife and Fishery Commission gave a talk on the Gulf Fishery Management Council responsibilities since its establishment by the Fishery Conservation Act in 1976. The Gulf Council includes five Gulf states composed of representatives of the federal and state governments, with input from scientific committees and an advisory council which is based upon user group participation. Mr. Perrett provided some insight into the difficulties involved in the implementation and enforcement of fishery

management plans developed or currently being developed by the council and based on Congressional guidelines.

The next series of projects presented at the session have their origin in the development of the Strategic Petroleum Reserve (SPR) in Texas and Louisiana. DOE, EPA, and NOAA have developed programs for assessing and predicting the potential impacts of the required disposal of concentrated brine leachate from the salt domes (SPR) into the offshore coastal waters of the Gulf. Ms. Melissa Smith (DOE) gave an overview of all brine disposal monitoring activities. Currently, six strategic petroleum reserve sites have been designated. So far, only two sites are actively disposing brine to the marine environment: 1) Bryan Mound (southeast Texas), 12 miles offshore and two years in operation; and 2) West Hackberry (southwest Louisiana), 5 miles offshore and one year in operation. A third brine line site not in operation is Big Hill Salt Dome in Jefferson County, Texas. Five types of studies are being undertaken: shrimp, menhaden, red fish, site-specific monitoring studies, and computer simulation modelling.

Mr. Ken Turgeon discussed GEM, the Gulf Ecosystem Model, developed for the northwestern Gulf of Mexico. Still in an unfinished state of development, GEM is a static, steady-state model which is initialized for averaged fall conditions at the Bryan Mound diffuser site. There are four environmental driving variables, four ecological submodels, 43 state variables, and ten biological processes. The model simulates the flow of carbon among compartments. Turgeon emphasized that the model is not useful for prediction yet, but is useful as an initial diagnostic tool. It can be made more sophisticated to simulate a real-life environment.

Dr. Robert Randall discussed the more recent result of Texas A&M's site-specific monitoring study of leach operations occurring during the Bryan Mound cavern formation. Six types of monitoring studies are underway: tracking of the brine plume, and studies assessing physical oceanography, water quality, nekton, benthos, and zooplankton. He concluded that there have been no significant effects so far from the leaching operations. An Associate Ocean Engineer, Dr. Randall also summarized the unique engineering specifications associated with such an operation. The brine discharge rate began at 230,000 barrels per day and is now up to one million barrels per day, with brine water concentrations approaching 100% saturation.

Dr. Dennis Casserly discussed McNeese State University's involvement in the SPR monitoring program, emphasizing the methodology developed to do a site-specific study of the West Hackberry SPR site. Results are provided in his abstract. Dr. Charles P. Giamonna showed underwater films of West Hackberry on-site monitoring activities. These films demonstrated the "CDC" system, which automatically monitors temperature, salinity, pH, turbidity, and depth; showed an example of brine plume movement made visible by addition of dye at a diffuser outlet; and showed underwater monitoring activities being conducted to measure associated bio-fouling growth by use of terra-cotta plates.

The final speaker of the day explained the role of his consulting firm in government-sponsored marine research in the Gulf of Mexico. Larry Reitsema, representing LGL Ecological Research Associates, Inc., summarized LGL's environmental monitoring contracts with the federal government. LGL has done quite a number of *in situ* field studies for various agencies, some of which were quite innovative.

BIOLOGICAL RESOURCE MAPPING ON THE CONTINENTAL SHELF

Rezneat M. Darnell
Texas A&M University

Information concerning broader patterns of the distribution of biological resources on the Gulf of Mexico continental shelf have not been pulled together, analyzed, and displayed in a form suited to the purposes of management. To remedy this situation, the investigator was provided an IPA appointment with the Minerals Management Service to locate, acquire, analyze, and interpret existing biological data pertaining to the U.S. Gulf continental shelves from the Rio Grande to Key West, Florida.

The first phase of this study, which is essentially complete, covers the northwest Gulf shelf from the Rio Grande to the Mississippi River. It involves analysis of data derived from a five-year trawl survey of the demersal shelf fauna based upon monthly sampling transects throughout the area, carried out by the National Marine Fisheries Service. Over two million penaeid shrimp and fishes are represented in the data sets.

Data manipulation consisted of the following steps: 1) standardization of all stations to 60 minutes of trawling effort; 2) determination of seasonal average catch within each year by species and by station; 3) determination of seasonal averages, all years combined, by species and by station. Thereafter, seasonal distribution maps were prepared for the combined fish catch, for six important families, and for all species that were present in sufficient abundance. For the species occurring less frequently, annual distribution maps were drawn; for the very rare species, maps were prepared giving capture locations only. All told, 346 distribution maps were completed. A narrative text has been prepared describing the distribution patterns of all species and major groups, as well as broader faunal patterns discernible from the maps. Attention has been given to a general ecological classification of the demersal macrofauna as well as patterns of depth, seasonal, and coastal distribution. Management implications have also been addressed.

This volume, which is the first formal product of the study, should be available for distribution by December 1982. Data collection and analysis for a companion volume on the eastern Gulf shelf has already begun.

SOME ASPECTS OF THE ECOLOGY OF THE DEEP GULF OF MEXICO

Dr. Willis E. Pequegnat
TerEco Corporation
College Station, TX

This study is concerned with primarily the megafauna and to some extent the macrofauna of the deep Gulf of Mexico north of the 25th parallel and west of the east wall of DeSoto Canyon. The results of some ten years of deep-sea sampling in the Gulf of Mexico are briefly presented here to emphasize the deep-Gulf faunal zonation. These were supplemented with slides of deep-sea photographs of characteristic organisms from these faunal zones.

The physiographic units of the Gulf of Mexico are the continental slope, the continental rise, and the abyss. Each of these units tends to support a unique complex of species, and within each unit there are further faunal divisions. Since the slope has the greatest depth range of the three units and a steeper gradient, it is characterized by a relatively tight zonation.

Deep-Gulf faunal zones generally follow those described for the North Atlantic by Menzies et al. (1973), with the only major differences being within the abyssal zone, since the Gulf is some 1600 m shallower than the North Atlantic. The causes of deep-sea faunal zonation have been postulated from several different angles, but the true picture is probably a combination of several factors. Among the more important of these factors are:

1. Input and cycling of organic matter. The low organic input into the deep-sea is reflected in low biomass.

2. Influence of bottom currents on egg and larval distribution, and distribution of organic detritus.

3. Biological interactions, especially competition and predator-prey interactions.

4. Pressure range limits on individual species, due to the functioning of enzymes only within certain pressure ranges.

In the Gulf of Mexico, the most pronounced transition in megafaunal species composition occurs at the shelf-slope boundary. Another rapid transition occurs around 1000 to 1100 m depth, which corresponds to an increase in steepness of the slope and a change in sedimentary characteristics. Megafaunal distribution on the slope is characterized by regions of rapid change separated by coherent assemblages. At the rise-abyssal junction and on the abyssal plain, the rate of change becomes considerably less, and zonation becomes less pronounced.

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SEAMAP PROGRAM

Mr. Perry A. Thompson
Gulf States Marine Fisheries Commission

SEAMAP is an acronym for Southeast Area Monitoring and Assessment Program. This is a state/federal/university program designed for the collection, management, and dissemination of fishery-independent survey data and associated information in the Southeast region. The SEAMAP strategic plan document was presented to the Technical Coordinating Committee (TCC) of the Gulf States Marine Fisheries Commission in January 1981. By March of 1982 three survey activities (ichthyoplankton, shrimp and bottomfish, and environmental) were planned and organized by the subcommittee and presented to the TCC. SEAMAP accomplished the goal of bringing the Gulf states and federal government together to organize SEAMAP. SEAMAP also successfully completed three surveys and distributed the data to the fishing industry on a real-time basis. It will be six months before all the SEAMAP data can be analyzed. One significant finding was the re-occurrence of low oxygenated water off the coast of Louisiana. SEAMAP should be continued so that the states, federal government, and universities can work together in order to reduce research costs and make sound management decisions in fisheries.

AN ECOSYSTEM MODEL FOR THE NORTHWESTERN GULF OF MEXICO

Kenneth W. Turgeon, EDIS/NOAA

Introduction

The development of the Strategic Petroleum Reserve (SPR) in Texas and Louisiana requires the disposal of concentrated brine leachate from salt domes into the offshore coastal waters of the Gulf. DOE, EPA, and NOAA recognized the need to develop a capability for assessing and predicting the potential impacts of offshore brine disposal on the regional marine ecosystem. The expressed concern was that elevated salinities attributable to the offshore disposal of large quantities of concentrated brine might exert a negative impact on the economically important fisheries species and the ecosystem as a whole. The worst case to date was observed at the Bryan Mound diffuser site, where elevated bottom salinities were observed on June 13, 1980, coincident with several days of stagnation (bottom current velocities were at or near zero). Thus, the potential for brine impact on the biota does exist, especially in the immediate vicinity of the brine diffuser.

Ecosystem Modeling

Because of the complex nature of the potential brine impact, assessment and analysis can best be addressed through use of a computer simulation model of the inner shelf ecosystem of the northwest Gulf of Mexico. The Gulf Ecosystem Model (GEM) discussed in this report is a static, steady-state model which is initialized for averaged fall conditions at the Bryan Mound diffuser site. The model does not incorporate spatial and temporal dynamics (e.g., schooling by ichthyofauna and migration), or ecosystem dynamics (e.g., adaptation). A dynamic version of the GEM has recently been developed and should be operational on the NOAA computer later this year.

The Conceptual Ecosystem Model

Conceptually, the GEM is formulated within an ecological hierarchy of interrelated and interactive biotic and abiotic components. The first level hierarchy differentiates the ecosystem from the surrounding external environment. The second level partitions the ecosystem into four ecological assemblages. These are: nekton, plankton, benthos, and organic complex (nonliving organic carbon plus the associated microbial populations). Each of these four assemblages or submodels is further partitioned into 7 to 13 ecological guilds or compartments. The total number of ecological guilds or compartments is 43.

In a practical sense, the most useful information for application to DOE's SPR brine disposal concerns is the predicted alteration of standing stocks for various brine impact conditions. The other outputs are of primary interest to the research ecologist and ecosytem analyst.

Two constraints on the decision-making application of the steady state GEM are the lack of resolution about the behavior of the system as it goes from the initial state to the final impacted state, and the length of time it takes the system to reach the new steady state. Thus, the model predictions for various brine impact scenarios must be evaluated and interpreted with an understanding of the underlying assumptions and inherent limitations of the static steady state GEM.

Discussion of Ecosystem Model Results

The deterministic results presented indicate that brine-induced elevations in salinity would negatively impact the marine communities in the vicinity of the Bryan Mound diffuser. However, the model predicted impacts are not sufficient to cause the ecosystem to crash. It is important to note that even at the 40 ppt perturbation salinity (10 ppt above ambient) the ecosystem maintains its structure and function; none of the 43 compartments are stressed to zero, and all carbon flow pathways remain viable.

Given the "worst case to date" brine field observed at the Bryan Mound diffuser site on June 13, 1980, when near-field salinities were

5.6 ppt above ambient, it should be apparent that this magnitude of salinity pertubation is the most probable maximum which should be expected to occur with any frequency and duration. Brine diffusion modeling results support this expectation, as do the two years of field observations. The deterministic model predictions for a 6 ppt above ambient salinity regime indicate ecosystem biomasses would be altered by 20% or less, with only a few biotic compartments showing larger changes. The nekton compartments, which contain the valuable commercial and recreational fisheries species, would show an approximate 16% decrease in biomasses. When the stochastic components (i.e., variances) of the model-predicted biomasses are taken into consideration, it is difficult to attach any brine impact significance to the deterministic results.

A crucial aspect in the interpretation of the model results is that predictions are reflective of worst case impact scenarios. The basis for this contention is that the structure of the model is rigid and unyielding in its formulation of brine impact effects. The model "assumes" that brine-induced excess salinities will be homogeneously distributed both vertically and horizontally, that the time period of exposure is near infinity, and that the biota, including the nekton, cannot escape the elevated salinities. These harsh conditions are not representative of the real brine disposal environment, where excess salinities rapidly diminish along vertical and horizontal gradients, biota move (either passively or actively), and time periods of exposure to elevated salinities in excess of 3 to 4 ppt above ambient are measured in hours rather than infinity.

In addition, the high variances associated with the model-predicted deterministic steady state biomasses suggest that the natural variability of the ecosystem may mask or overshadow any measurable impacts that could be attributed to brine disposal. This interpretation and assessment of the model-predicted brine impacts are corroborated by the postdisposal field observations and data analyses by Texas A&M University scientists. Their findings to date indicate no measurable brine impacts on the biota.

FISHERY MANAGEMENT COUNCIL ACTIVITIES

Mr. Corky Perrett
Louisiana Wildlife and Fishery Commission

The passing of the Fishery Conservation and Management Act of 1976 accomplished two major acts. It established a claim to the fishery resources in a 200 mile fishery conservation zone, and it established a regional council approach for fishery management within that zone.

The Act provides that each Council prepare and submit to the Secretary of Commerce a fishery management plan with respect to each fishery within its geographical area of authority. For the Gulf Council, this area is defined as being within the Fishery Conservation Zone in

the Gulf of Mexico seaboard of the five Gulf states of Texas, Louisiana, Mississippi, Alabama, and Florida.

Plans developed for fishery stocks endemic to the Gulf of Mexico include those for shrimp, reef fish, groundfish, sharks, stone crabs, and coastal herrings. Additionally, the Gulf Council has taken the lead responsibility for joint development of plans, with the able assistance of the South Atlantic Council for Common Stocks that include mackerel, spiny lobster, coral, billfish, calico scallop, and swordfish resources.

BRINE DISPOSAL IN TEXAS COASTAL WATERS: BRYAN MOUND

Dr. Robert Randall, Texas A&M University

The Department of Energy's Strategic Petroleum Reserve Program began leaching the Bryan Mound salt dome and discharging brine into the coastal waters of Freeport, Texas on March 10, 1980. This report describes the findings of a team of Texas A&M University scientists and engineers who have conducted an 18-month environmental study to evaluate the effects of the Bryan Mound brine discharge. The study addresses the areas of physical oceanography, analysis of the discharge plume, water and sediment quality, nekton, benthos, phytoplankton, zooplankton, and data management.

The physical oceanography and the water sediment quality studies include the analysis of data from biweekly, monthly, and quarterly sampling cruises and from continuously recording in situ current meters. The biweekly salinity data show the presence of the brine discharge during September, October, and November 1980, and March, April, July, and August 1981. Only in November 1980 and March, July, and August 1981 were the effects outside the normal salinity range. The current meter data show that the near-bottom currents are strongly correlated with the alongshore component of wind stress and are much more important than the tidal component in the advective transport of the brine plume. The monthly water quality data and quarterly sediment quality data show a slight increase in total dissolved salt, and, on occasion, an increase in several of the major ions, but otherwise there has been little evidence of brine impact in the water and sediment quality of the area.

Data from the analysis of the discharge plume study show the largest areal extent was 17.9 km^2, which was measured within the +1 ppt above-ambient salinity contour in December 1980. The largest vertical extent was 7.6 m, measured in August 1980 and June 1981, and the highest above-ambient salinity contour (+6 ppt) was measured in April 1981.

The monthly day and night nekton sampling indicate that there has been no dramatic lethal effect at any station within any cruise nor any unusual behavior in captured specimens. The evaluation of data on dis-

tribution, size composition, abundance, and diversity of shrimp indicate that brine disposal has no influence on the shrimp in the diffuser area. The groundfish and the highly migratory pelagic fishes seemed to avoid the brine plume during the initial twelve months of brine disposal, but this behavior was not observed during the succeeding six months. There was no indication that the shrimp avoided the brine plume.

The monthly benthic data indicate that there is little evidence to suggest that the brine produced a deleterious effect on the benthic community. Both diversities and abundances were higher near the diffuser than at most farfield stations. The amphipods did not appear to be adversely affected by the brine, and a numerical analysis did not indicate that any nearfield stations had dissimilar assemblages. The only indications of adverse effects were the higher percent decrease of individuals at some nearfield stations between lower and higher brine discharge rate periods, and the tendency for the monthly index of diversity of brine-affected stations to occur in the lower half of Duncan's multiple range test hierarchies.

There was no change in species dominance or in diversity of the phytoplankton. Cell densities were lower near the diffuser than in the control area, but the cause of the reduced cell densities could not be related to the brine discharge. No measurable brine impact on the zooplankton community was detected.

EVALUATION OF BRINE DISPOSAL FROM THE WEST HACKBERRY SITE OF THE STRATEGIC PETROLEUM RESERVE PROGRAM

Dr. Roy W. Hann, Jr. (co-author) and Charles P. Giammona (speaker)
Texas A&M University

The Department of Energy's Strategic Petroleum Reserve Program began leaching the West Hackberry salt dome and discharging brine into the coastal waters of Cameron, Louisiana in May 1981. Texas A&M and McNeese State University scientists and engineers recently completed the first year of post discharge environmental studies to determine if the brine was having any adverse effects on the surrounding environment. The studies address the areas of physical oceanography, analysis of discharge plume, water and sediment quality, nekton, benthos, phytoplankton, zooplankton, and data management.

Underwater color video and 16 mm camera systems have been used to verify the accuracy of sampling methods, as well as to inspect the actual dispersion of the brine from the diffuser pipeline. A dye study has been photographed showing the rapid settling of the brine waste as it is dispersed from the pipeline.

In addition, an ancillary sampling program was initiated to test an *in situ* biological sampling device whereby one could adequately and cost effectively carry out a monitoring study using the recruitment

rates of biofouling organisms within and around areas of potentially stressful natural or anthropogenic activity. Recruitment arrays with settling plates and floats provide monthly, quarterly, semi-annual, and annual data on the recruitment, growth, and distribution of fouling organisms in the vicinity of the brine disposal pipeline.

This method provides standarized sampling that eliminates the input of certain often confounding variables. Grain size, substrate porosity, sediment chemicals (besides salt), and surface irregularities need not be considered in cause-effect relationships. Short term patchiness, which is a common problem in discrete biological sampling, also can cause a considerable amount of noise in those data sets. This problem is also eliminated with this sampling array.

Standardization, along with the fact that the sampling includes long-term samples and is site-specific, results in less variable monthly and seasonal replicate samples. In this respect, the sampling system provides a continuous recording of the biological recruitment in the area.

One can therefore detect not only the chronic effects of exposure to brine (or other stresses), but also catastrophic impacts that may have occurred between sampling efforts, even though recolonization may have also occurred.

BRINE DISPOSAL IN LOUISIANA COASTAL WATERS

D.M. Casserly and G. Stacy
McNeese State University

A Strategic Petroleum Reserve brine disposal site is located 11.4 km off the southwest coast of Louisiana. A grid of stations centered at the brine diffuser was monitored monthly for biological attributes during a 12-month period. Temporal and spatial distributions in species abundances and diversity were measured for the following: 1) macrobenthic invertebrates, 2) fishes and nektonic macrocrustaceans, 3) phytoplankton, and 4) zooplankton. These assemblages were studied relative to physical and chemical variations occurring in the study area.

The marine fauna and flora of the diffuser area are characteristic of coastal assemblages of the northwestern Gulf coast. Population fluctuations were attributed to seasonal and hypoxic conditions. The macrobenthic community was dominated by polychaetes and phoronids. The nekters were typical of the white shrimp community; the phytoplankton community was dominated by estuarine and neritic species; and the zooplankton community was dominated by copepods, with Penaeus spp. and Brevoortia spp. common in the area.

MARINE RESEARCH BY A CONSULTING FIRM

Dr. Larry Reitsema, LGL, Inc., Bryan, TX

Dr. Reitsema described six major marine research projects that his firm has undertaken since 1976 in the northwestern Gulf of Mexico. From 1976 to 1980, they participated in the environmental assessment of the Buccaneer gas and oil field, funded by EPA through NOAA/NMFS. They have also characterized artificial reefs, participated in Department of Energy SPR brine discharge studies, monitored the East and West Flower Garden reefs, assessed the IXTOC oil spill, and performed ecosystem analysis of oil and gas development on the Texas-Louisiana continental shelf.

SESSION: BIOLOGICAL STIPULATIONS WORKSHOP
Chairman: Mr. Charles Hill
Scribe: Mr. Les Dauterive
Date: August 25, 1982

Presentation Title	Speaker/Affiliation
Session Summary	Mr. Charles Hill, MMS Gulf of Mexico OCS Region
Florida's Perspective of Biological Stipulations	Ms. Debbie Tucker, Office of the Governor State of Florida
Biological Stipulations: An Industry Prospective	Mr. James P. Ray Shell Oil Co.

SESSION SUMMARY

Mr. Charles Hill, MMS, Gulf of Mexico OCS Region

The purpose of this workshop was to discuss the biological stipulations which have been utilized in the past and which are being considered for application on future leases. These stipulations have been developed during the past nine years to protect valuable, unique, and productive biologically sensitive areas in the Gulf of Mexico from potential adverse impacts of oil and gas exploration and development activities.

Charles Hill opened the workshop by presenting a brief overview of the history of the stipulations and their current status. It was pointed out that in the central and western Gulf, the biological stipulations apply to areas on and near topographic features (banks) which have been mapped and studied through the MMS (formerly BLM) studies program. The stipulations are based on the fact that at similar depths, banks in similar water conditions exhibit similar biotic communities. Hence the stipulations provide for a "No Activity Zone" based on depth, and, in most cases, a "1 Mile Zone" and "3 Mile Zone" in which certain restrictions apply.

In the eastern Gulf the areas of biological significance and sensitivity are less well known, are of low relief (about 1 to 3 m), occur in patches with no apparent pattern, and vary considerably in the make-up of their biotic communities. Thus the stipulation on leases in the eastern Gulf requires the lessee to determine if there are any so-called "live-bottom" areas near any proposed drilling activities. If there are, then MMS can take appropriate action to protect the biota of the live-bottom area.

The results of both government and industry funded monitoring studies seem to indicate that these stipulations are indeed working. The high value biological communities of topographic features and live bottoms are not being adversely affected by nearby oil and gas activities carried out in compliance with the biological stipulations.

After that introduction, state and federal agency representatives made brief statements regarding their agencies' views of the biological stipulations. Ms. Debbie Tucker, of the Florida Governor's office, stated Florida's concern about impacts to the Agaricia and algal nodule biological assemblages going undetected with the present language of the live-bottom stipulation. Ms. Tucker reiterated Florida's recommendations to extend the stipulated requirements to 200 m for development, and to expand the stipulation to require photo-documentation for activities in water depths greater than 70 m. Ms. Tucker stated that in a letter from the Governor of Florida to the Secretary of the Interior, the Govenor requested that the Secretary include these changes to the live-bottom stipulation for Sale No. 69 lease tracts. Ms. Tucker's statement is included below.

Mr. Pat O'Neil stated that the Alabama state agencies involved would be meeting in the future to develop a state policy. He did note that Alabama has a no-discharge policy in state waters and that they are very concerned about discharges in federal waters adjacent to state waters. [As of this writing Alabama has not expanded on this concern except to say they are still concerned.]

Mr. Jim Franks noted that Mississippi is also concerned. Like Alabama, Mississippi has a no-discharge policy in state waters, and so is concerned about discharges in nearby federal waters. Both Alabama and Mississippi expressed concern that such discharges in nearby federal waters may somehow be taken into their estuaries in concentrations high enough to cause ecological damage.

Reginald Rogers of EPA, Atlanta, and Bob Vickery of EPA, Dallas, briefly presented an overview of EPA's NPDES general and individual permit programs presently in effect for coastal Texas and Louisiana and the Western and Central OCS. Mr. Rogers predicted coastal NPDES general permits for the States of Mississippi and Alabama in 1983. Mr. Vickery stated that he initiated a recommendation to EPA, Washington, to revise individual permit requirements for exempt leases around biologically sensitive areas to be more consistent with MMS lease stipulation biological requirements.

A discussion then followed on EPA's ocean discharge permit issued to Mobil Oil Company for drilling waste generated from drilling in Mobile Bay. The point was made that the permit was issued (by the EPA Washington Office) without DOI review, and in an area of the OCS that requires the application of the live-bottom stipulation.

Dr. Jim Ray of Shell Oil Company made the statement that industry considers biological stipulations necessary but questions the necessity of duplicative monitoring plans. Mr. Ned Parker (Marathon Oil) expressed concern and questioned the application, duplication, and use of biological monitoring requirements and data results. Dr. Ray stated that the present stipulated monitoring requirements may be endless, and suggested that a Government-Industry cost-share monitoring arrangement may be a feasible approach to pursue. The point was made that monitoring programs must be "meaningful" and well planned so that all interested parties will agree that the results of a monitoring study are valid. Dr. Ray's statement is included below.

The general discussion which followed make the following points:

1. Shunting the drilling effluents to near the bottom is clearly working to protect biological resources on high relief banks, and is considerably cheaper than monitoring.

2. Impacts (and alleged impacts) must be kept in context: fishing is "good," but roller trawling by fishermen may cause far more damage to live bottom areas than oil and gas industry operations.

3. Monitoring, as such, does not protect areas, but only verifies protection or damage.

4. The NAS study on drilling muds should be completed in late spring of 1983. It will review existing literature and knowledge, identify data gaps, and try to form a consensus of opinion.

FLORIDA'S PERSPECTIVE ON BIOLOGICAL STIPULATIONS

Ms. Debbie Tucker, Office of the Governor of Florida

The Biological Stipulation for the Eastern Gulf of Mexico currently applies only to those blocks in water depths of 100 m or less and reads as follows:

> Prior to any drilling activity or the construction or placement of any structure for exploration or development on this lease, including but not limited to well drilling and pipeline and platform placement, the lessee will submit to the Deputy Minerals Manager (DMM) a bathymetry map, prepared utilizing remote sensing and/or other survey techniques. This map will include interpretations for the presence of live bottom areas within a minimum of 1,820 m radius of a proposed exploration or production activity site.
>
> For the purpose of this stipulation "live bottom areas" are defined as those areas which contain biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans, seagrasses, or corals living upon and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; or whose lithotype favors the accumulation of turtles, fishes, and other fauna.
>
> If it is determined that the remote sensing data indicate the presence of hard or live bottom areas, the lessees will also submit to the DMM photo-documentation of the sea bottom near proposed exploratory drilling sites or proposed platform locations.
>
> If it is determined that live bottom areas might be adversely impacted by the proposed activities, then the DMM will require the lessee to undertake any measure deemed economically, environmentally, and technically feasible to protect live bottom areas. These measures may include, but are not limited to the following:
>
> (a) the relocation of operations to avoid live bottom areas;

(b) the shunting of all drilling fluids and cuttings in such a manner as to avoid live bottom areas;

(c) the transportation of drilling fluids and cuttings to approved disposal sites; and

(d) the monitoring of live bottom areas to assess the adequacy of any mitigation measures taken and the impact of lessee initiated activities.

Florida is uncertain about the necessity of the biological stipulation for exploratory drilling activities. The state has requested the use of lease stipulations and other mitigative measures to compensate for a lack of adequate environmental data available at the time of each sale. Until questions concerning the effects of single well exploration drilling and the cumulative effects on highly productive live-bottom areas can be better answered for the citizens of the state, the state considers this to be a necessary stipulation.

In this light, Florida has worked in the past and will continue to work with individual lessees, their contractors, and the Minerals Management Service (MMS) to determine if and where monitoring studies can be used to help in answering these questions. Florida does not wish to "burden" lessees with monitoring requirements just for the sake of monitoring. Instead, the intent is to see that well designed monitoring studies take place only in areas where meaningful answers can be produced. For example, Florida has recently requested that a monitoring study be required during exploration drilling of Tarpon Springs Block 277. Monitoring on this block was requested for the following reasons:

1. Block 277 contains areas of high biomass live bottom as well as scattered live bottom.

2. Water depths in Block 277 vary from 63 to 76 feet.

3. Seagrass beds are located close to Block 277.

4. Block 277 lies in the migration route of the blue crab.

5. Block 277 is approximately 37 miles from the nearest shore.

Florida has worked with the Minerals Management Service, the lessee, and the contractor in designing a good, meaningful monitoring study for Block 277.

Florida has recently recommended changes in the biological stipulation for the Eastern Gulf of Mexico based on the preliminary data from the MMS-funded Southwest Florida Shelf Ecosystems Study. This study shows the presence of significant live-bottom assemblages in water depths of 100 to 200 m. Therefore, Florida recommended that the stipulation apply to leased tracts in water depths of 100 m or less for

exploration and development, and to leased tracts in 200 m or less for development and production.

In addition, the Southwest Florida Shelf Study indicates that some significant live-bottom assemblages cannot be detected by remote geophysical sensing means (sub-bottom profiler and side-scan sonar) alone. These assemblages basically occur in water depths greater than 70 m. Florida therefore recommended that photo-documentation be required for activities which occur in water depths greater than 70 m, regardless of the geophysical interpretation.

Both the "old BLM" and the USFWS were in agreement with Florida's two recommended changes, but these recommendations were rejected by the Washington Office without a final report from the study. Florida feels these recommended changes are necessary at this time to protect the sensitive, high value, live-bottom areas in the Eastern Gulf.

BIOLOGICAL STIPULATIONS: AN INDUSTRY PERSPECTIVE

James P. Ray
Shell Oil Company

In general, the petroleum industry agrees with the philosophy of imposing biological stipulations on areas that have been identified as being of special importance. The key to the biological stipulations program is that these decisions be made on sound scientific information. One facet of the biological stipulation program that the industry does not agree with is the imposition of biological monitoring programs. When programs are scientifically justified, the industry can understand the implementation of monitoring programs; but, when lacking proper justification and without good scientific design, monitoring programs are virtually useless. A distinction between politically motivated programs versus scientifically motivated programs should be made.

The average monitoring program in the OCS these days, if it provides any valuable information at all, costs $250,000 or more. Although this is not a large sum of money in relation to other drilling costs, it still adds up to a considerable sum when all monitoring programs in all OCS areas are combined.

Another question often asked by the industry is how much monitoring is enough? When many programs have been conducted to provide the same information, repetition of the same programs is meaningless. Especially during this period of time when the economic conditions are tight, careful scrutiny should be paid as to whether or not monitoring is really necessary and will provide useful regulatory information. Industry feels that prior to the imposition of any type of monitoring program, the scientists from government and industry should sit down and discuss the proposed program and determine whether or not it is really worthwhile.

SESSION: MARINE MAPPING
Chairman: Mr. Lawrence R. Handley
Scribe: Mr. William Sweet
Date: August 25, 1982

Presentation Title	Speaker/Affiliation
Exploration of the Continental Shelf/Slope Interface	Mr. Lawrence R. Handley, MMS, Gulf of Mexico OCS Region
Geologic Mapping: Overview	Mr. Lawrence R. Handley, MMS Gulf of Mexico OCS Region
Geologic Processes and Shelf-Edge Evolution off Southwest Louisiana	Mr. Henry Berryhill, MMS, Corpus Christi, TX
Geohazard Interpretation of the Continental Slope, Texas to Florida	Dr. Louis E. Garrison, MMS, Corpus Christi, TX
Depositional History of the Louisiana-Mississippi OCS	Ronald J. Miller, Jack L. Kindinger, Charles E. Stelting, and Arnold H. Bouma, MMS, Corpus Christi, TX
Deltaic Influences on Shelf-Edge Instability Processes	Dr. J.M. Coleman and Dr. D.B. Prior, LSU Coastal Studies Institute

EXPLORATION OF THE CONTINENTAL SHELF/SLOPE INTERFACE

Lawrence R. Handley
MMS, Gulf of Mexico OCS Region

The emphasis of this session was to provide a synthesis of information that has been gathered and mapped for the continental shelf/slope interface. A primary aim was to develop an understanding of the general structure, ages, and processes that have influenced in the past, and are affecting today, the evolution of the continental slope. Such a synthesis of information provides an important perspective for understanding the future trends of oil and gas production. Those scientists, engineers, and managers dealing with the geology of the continental slope, geohazards, and the engineering of platforms and pipelines, know that this is primarily an area of deep water, tremendous rates of sedimentation, and tectonic movement. They recognize that the continental shelf/slope interface is, therefore, a primary area where geologic hazards, engineering problems, and operational constraints are to be encountered.

A major point dealt with in the session concerned surveying methods and the availability of data. The synthesis attained for the western and central Gulf of Mexico could not have been possible without the data gathered through the MMS Studies Program.

A second point made by all the speakers was that understanding the processes at work in the Gulf is important. Since 1977, when the major input of information into the geologic program began, the evolution of ideas associated with massive sediment accumulations, deltas, mass movements of material, and tectonic variations has provided a greater understanding of certain processes in the Gulf of Mexico.

Another major aspect of the Gulf of Mexico is not only the occurrence of ancient deltas that are present in these studies, but also the presence of the very active delta of the Mississippi River. The Mississippi River Delta is the foundation of data and information related to sedimentation, delta front features, and seafloor instabilities. Because the delta overlaps the shelf/slope interface; it provides a good model from which to extrapolate descriptions and analyses of structure and processes of development for the ancient deltas that prograded the continental shelf of the northwestern Gulf of Mexico.

Ancient delta areas along the continental slope are an area of major geohazards. The fine-grained silts and clays deposited in often massive accumulations are correlated with major areas of subsidence landslides, mudflows, gas accumulations, and compaction faulting.

Deltaic deposition, as a major agent prograding the continental shelf, has played a major role in the northwestern Gulf of Mexico. Studies and surveys have revealed major deltaic sediment accumulations that have yielded landslides and slumping in the old Rio Grande delta, in the East Breaks, along the southwest Louisiana slope, and, of

course, in the present Mississippi River Delta. Related to these massive deposit centers is the weight of the sediment causing tectonic uplift of many of the salt diapirs along the slope. This diapiric activity has influenced ancient river channels on the shelf, and the location and extent of sediment basins have been affected. Thus, the density of the faulting pattern and the areas of biogenic gas accumulation are effected.

Two controversial points raised were 1) the formation of Mississippi Canyon, and 2) Pleistocene changes in sea level. Mississippi Canyon, long believed to have been eroded by the ancient Mississippi River during a low stand of sea level, appears to have been formed through the process of mass movement. A major trough, 15 miles long, 5 miles wide, and over 600 feet deep, is the result of a major submarine landslide. This information requires the re-thinking of all canyon development along the shelf edge (many buried and many exposed) as these canyons are related to the process of mass movement, rather than the more traditional stream or submarine current erosion. Evidence indicates that there have been more dramatic changes in sea level during the Pleistocene than previously thought. The Wisconsin low stand of sea level has previously been described at 120 m below present sea level at about 18,000 years B.P. However, with the present studies on the slope, erosional surfaces indicate that the lowest stand of sea level occurred in the early Wisconsin at 100,000 to 125,000 years B.P at about 325 m below present sea level.

GULF OF MEXICO GEOLOGIC MAPPING: OVERVIEW

Lawrence R. Handley, MMS, Gulf of Mexico OCS Region

Regional geologic mapping in the Gulf of Mexico has mainly involved the USGS Office of Marine Geology in Corpus Christi, Texas, and the Minerals Management Service's Gulf of Mexico OCS Region office in New Orleans, Louisiana. The major areas of concentration in the Gulf are at the shelf-slope interface for these studies. Primarily, three areas have had detailed surveys and mapping completed. These areas are South Texas, the Outer Shelf and Upper Slope of Southwest Louisiana, and the area around the Mississippi River Delta. Utilizing the studies of these three areas, and other data gathered by USGS, by industry, and from a scattering of other studies, a regional physiography and a series of seafloor geohazard maps can be constructed for the Gulf of Mexico.

The discussion of geological mapping basically focused on the seafloor morphology and shallow geology of the continental shelf-slope interface. The major points addressed were: 1) where the coverage has been, 2) what products are or will be available, and 3) how the information is used in the MMS regional office.

The mapping completed by the Minerals Management Service has provided an understanding of the tectonics, the shallow geology, the seafloor morphology, and the processes involved in sedimentation and mass movement of the Gulf of Mexico. The emphasis of mapping has been on the continental shelf/continental slope interface, where the major shelf-building processes are at work, and where the focus of oil and gas exploration and production is moving in the future.

GEOLOGIC PROCESSES AND SHELF-EDGE EVOLUTION OFF SOUTHWEST LOUISIANA

Henry L. Berryhill, Jr., MMS,
Corpus Christi, TX

The processes that have molded the geologic framework of the continental margin in the northwestern Gulf of Mexico are sea level fluctuations, diapirism, and high rates of sedimentation. The continuing interaction of these processes has caused shelf-edge accretion and modification. The modification is caused by sediment loading, diapirism, and faulting, all having a direct bearing on petroleum exploration and production along the shelf edge and on the upper slope.

The late Pleistocene and Holocene history of a 210 km segment of the continental shelf and upper slope off southwest Louisiana has been interpreted from 10,569 km of high-resolution seismic reflection profiles arranged in a 4.5 x 4.5 km grid of east-west and north-south lines. Aspects relevant to the geologic history and to the understanding of the processes involved have been summarized in a series of topical maps. The maps have been designed as overlays to serve two uses: as a management guide in the offshore leasing process; and as general use geologic maps to show cause and effect relationships and to quantify the geologic processes. Topics included are: 1) extent of diapiric deformation and location of interdiapiric sediment basins; 2) location of faults; 3) location of ancient river systems (buried stream channels) and deltaic deposits of early Wisconsin age; 4) location of ancient river systems and deltaic deposits of late Wisconsin age; 5) seafloor features indicating positions of ancient shorelines on the Outer Continental Shelf; 6) distribution of Holocene sediments; and 7) distribution of surficial slides, buried slides, and shallow gas.

GEOHAZARD INTERPRETATION OF THE CONTINENTAL SLOPE, TEXAS TO FLORIDA

Louis E. Garrison, MMS, Corpus Christi, TX

The geology of surface and near-surface sediments in the planning areas for Lease Sales 81 and 84 in the Gulf of Mexico is known in some detail in places, but only poorly in others. In those areas where closely spaced geophysical surveys have been made and regional tie lines provided, information on geohazards is adequate. In areas where

such data are lacking, predictions of geohazards must be made by extrapolation or by comparisons based on environmental similarities to better known areas.

This paper summarized in general terms what is known about the seafloor environment, the dynamic geologic processes which affect it, and the geohazards which may be encountered in developing OCS planning areas. These subjects were discussed under four headings: 1) seafloor instability; 2) gas seeps and shallow gas accumulations; 3) shallow faulting; and 4) texture of surface sediments.

Information comes from the published literature and open file government data. Although brief discussions of some of the geological processes and mechanisms were included, this was not intended as an exhaustive report.

DEPOSITIONAL HISTORY OF THE LOUISIANA-MISSISSIPPI OCS

Ronald J. Miller, Jack L. Kindinger, Charles E. Stelting, and Arnold H. Bouma,
MMS, Corpus Christi, TX

A geological study was undertaken in 1981 on the Louisiana-Mississippi Outer Continental Shelf for the Bureau of Land Management (now MMS). The study included a high-resolution seismic-reflection survey, surficial sediment sampling, and surface current drifter sampling. Approximately 7100 km^2 of the Louisiana-Mississippi shelf and upper slope were surveyed.

The seafloor of the entire area is relatively smooth except for occasional areas of uplift produced by diapiric intrusion along the upper slope. Characteristics of the topography and subsurface shelf sediments are the result of depositional sequences due to delta outbuilding over transgressive sediments, with intervening periods of erosion during low sea level stands. Little evidence of structural deformation such as faults, diapirs, and shallow gas is present on the shelf, and only a few minor faults and scarps are found on the slope.

Minisparker seismic records in combination with air gun (40 and 5 $in.^3$) and 3.5 kHz sub-bottom profile records reveal that seven major stages of shelf development have occurred since the middle Pleistocene. The shelf development has been controlled by the rise and fall of sea level. These stages are defined by four major unconformities, several depositions of transgressive sediments, sequences of river channeling, and progradational delta deposits.

Surficial sediment samples and seismic records indicate that the last major depositional event was the progradation of the St. Bernard Delta lobe. This delta lobe covered the northwestern and central regions. Surficial sediments in most of the study area are the product

of the reworking of the St. Bernard Delta lobe and previous progradations.

DELTAIC INFLUENCES ON SHELF-EDGE INSTABILITY PROCESSES

J.M. Coleman and D.B. Prior
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Large river systems deliver significant quantities of fine-grained sediment to continental shelf regions. In specific areas off deltas, deposition rates are rapid and the delta sediments are commonly involved in a variety of mass-wasting processes on the subaqueous slopes (slumps and slides, debris flows, and mudflows). These processes cause rapid sediment accumulation at shelf-edge depths and result in active progradation of the shelf edge. Seismically, the deposits appear as large-scale foresets and are commonly composed of *in situ* deep-water deposits alternating with shallow-water sediments transported by mass movement. Progradation of the shelf-edge deposits is generally accompanied by oversteepening and large-scale instability of the upper shelf-edge slopes. Deep-seated and shallow rotational slides move large volumes of sediments and deposit them on the adjacent slopes and upper rise. Extensive contemporaneous faults commonly form at the shelf edge. Continuous addition of sediment to the fault scarps, particularly by mass movement from nearby delta-front instability, causes large volumes of shallow-water sediment to accumulate on the downthrown sides of the faults, mostly forming large-scale rollover structures. Continued movement along the concave-upward shear planes commonly results in compressional folds and diapiric structures.

Massive retrogressive, arcuate-shaped landslide scars and canyons also form at the shelf edge, owing to slumping and other mass-movement processes. Such canyons or channels can attain widths of 10 to 20 km, depths of 800 m and lengths of 80 to 100 km. It is considered that the Mississippi Canyon originated in this manner. The creation of such features by shelf-edge instability results in the yielding of exceptionally large volumes of shallow-water sediment to the deep basins in the form of massive submarine fans. The infilling of depressions by deltaic progradation is rapid, forming large foresets near the canyon heads. The low strength of the rapidly infilled, underconsolidated sediments causes downslope creep or reactivation of failure mechanisms, resulting in multiple episodes of filling and evacuation.

APPENDIX A

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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.

DEPARTMENT OF THE INTERIOR

MINERALS MANAGEMENT SERVICE